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TECHNICAL REPORT
71-18-CE

DEVELOPMENT OF A DURABLE PRESS SUMMER UNIFORM

by
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and
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UNITED STATES ARMY
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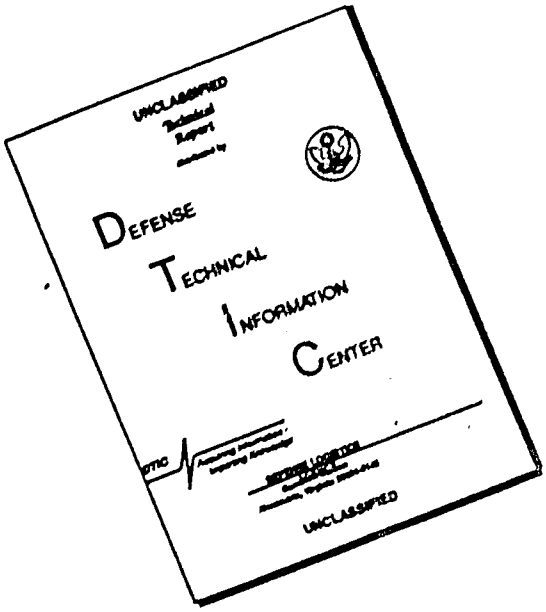

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DEVELOPMENT OF A DURABLE PRESS SUMMER UNIFORM

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Textile Research and Engineering Division

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Clothing and Personal Life Support Equipment Laboratory
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FOREWORD

Advances in the technology involved in durable press finishes applied to textile materials have led to a widespread acceptance for civilian clothing. Garments made from such fabrics are capable of maintaining an acceptable appearance even after a significant number of launderings and wear cycles. This prompted a reappraisal of the summer uniform currently issued to Army troops which is made from cotton fabric and requires starching and pressing to attain a proper military bearing.

This report is concerned with the development of a polyester/cotton fabric with a durable press, soil release finish as a candidate to replace the standard all-cotton summer uniform fabric. It is anticipated that the studies reported here will lead to the selection and adoption of a suitable fabric and process for producing a durable press treated summer uniform for military personnel.

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ABSTRACT

This report describes the development of a suitable candidate durable press fabric for the summer Army uniform.

Many commercial fabrics were examined and analyzed before the selection of a prototype fabric was made. The preferred candidate is a 7.0 oz/yd^2 2/1 RH twill composed of a blend of 50/50 polyester/cotton treated with a durable press, soil release finish. This fabric was dyed with a special all-vat dye formulation to a tan shade using a continuous thermofixation-pad-steam system. The reactant used to impart durable press properties was dimethyloldihydroxy ethylene urea (DMDHEU) and the soil release agent was a fluorochemical. The post-cure method of obtaining durable press properties was selected.

DEVELOPMENT OF A DURABLE PRESS SUMMER UNIFORM

1. Introduction

The summer uniform presently in use is made of 100 percent cotton and must be heavily starched and pressed to attain a distinctive military bearing. Even in this state, the appearance attained is only temporary as such materials are very vulnerable to crumpling and wrinkling. Maintenance of appearance becomes extremely difficult and requires a significant expense to the individual soldier. This condition coupled with the fact that newly-developed civilian durable press garments have excellent appearance and maintenance properties have caused troops to be severely critical of the presently issued uniforms.

These Laboratories have been investigating fabrics and functional finishes for several years in an attempt to find a more suitable material for summer wear. The initial successful application was the development of the polyester/rayon blended fabric with durable press and anti-soil finish used by officers and drill sergeants. This uniform was well received and offered encouragement for increased efforts to develop a summer uniform for army-wide use which would impart a similar sharp military appearance, be easily maintained, and endure extended laundering and wear cycles. Some of the limiting problems encountered with the polyester/rayon fabric, such as marginal colorfastness, shade variations, and critical control of the pressing and curing conditions, served as primary considerations in the development of a new fabric.

Industry experience has shown that a 100 percent cotton fabric is not suitable because the amount of reactant resin necessary to give good durable press properties will embrittle and weaken the fibers to the degree that the fabric is rapidly abraded. A fabric containing high energy absorbing polyester or nylon is necessary to provide reinforcement to the material for strength and abrasion resistance. However, a sufficient quantity of cotton is desirable to absorb moisture for comfort considerations and as a finish-receptive ingredient. Initial efforts were directed toward the evaluation of numerous civilian fabrics with varying polyester/cotton blends and in a number of textures. For shade selection and the development of a finishing system, a 65/35 polyester/cotton fabric showed a success potential. However, in the anticipated service of military garments, a higher percentage of cotton should result in more receptivity of the reactant and produce garments with better durable press properties. Therefore, the blend composition under consideration was changed to a 50/50 blend of polyester/cotton.

This report is concerned with the development of a fabric with a durable press, soil release finish to replace the all cotton khaki twill fabric currently used in the summer uniform. It is divided into four general parts as follows:

a. development of fabric
b. development of dyeing and finishing system
c. development of functional finish
d. assessment of sewability and fabrication of garments

2. Background

The original concept for improving the appearance and reducing the maintenance of clothing fabrics was to apply a cross-linking reactant resin to the fabric. This is commonly referred to as a "wash and wear" finish[1]. Cross-linking can be considered as the establishment of covalent chemical bonds among the molecules of the individual fibers[2]. These cross-links take place between the fibrils of the cellulose molecule primarily in the randomly ordered (amorphous) regions which are more reactive than the highly oriented (crystalline) regions[3]. These interlocking chains of molecules account for good wrinkle resistance and recovery as well as dimensional stability in a cellulosic fabric. This idea of crease resistant fabrics was first conceived by Foulds, Marsh, and Wood in the 1920's and the fundamental basis of the process remains essentially unchanged[4]. These wash and wear fabrics were finished flat, i.e., the curing operation which sets the resin was done on open width fabric. The stabilized fabric was later cut and sewn into garments. After laundering the garments it was found that the creases no longer had a sharp edge and the seams puckered[1]. These difficulties resulted in consumer dissatisfaction with this type of garment because pressing was still necessary to obtain an acceptable appearance.

With subsequent improvements in technology, one garment manufacturer made garments successfully from resin treated, uncured fabric and then oven heated the garments to complete the cross-linking of the finish[1]. These garments retained the intended sharp creases after many washes and tumble dryings. This was the beginning of what is now referred to as "post-cured durable press" material. To achieve durable creases and reduced wrinkling required the application of about twice as much resin reactant than was used in regular wash and wear finishes. When applied to a 100 percent cotton fabric, the resin embrittled and weakened the fibers to the degree that the creases were rapidly abraded. In some cases, the abrasion resistance and tearing strength was reduced 50 percent from that of the untreated state[5].

The use of high energy absorbing but non-receptive man-made fibers, such as polyester and nylon, blended with cotton provided reinforcement to fabrics having little strength and abrasion resistance. These fabrics contained a sufficient quantity of cotton as a finish-receptive ingredient and to absorb moisture for comfort considerations. In addition, the man-made fibers have a lower density thereby allowing for a reduction in fabric weight which contributes to increased comfort and ease of laundering. Durable press garments made of 65 percent polyester and 35 percent cotton or rayon have become a popular combination while a 50-50 blend of these fibers is also quite common. Most of the commercial uniforms and casual wear clothing are now using durable press finished fabrics.

The methods of obtaining durable press garments using resins are classified into two groups: post-cure and pre-cure(6). The post-cure is probably the method most commonly used. This consists of resin treatment of the fabric, drying, fabrication of garment, pressing of garment and oven-curing of the resin. Some difficulty has been experienced in obtaining durable creases in shirts, especially in the area of the pockets due to the multiple layer construction. In the pre-cure technique the fabric is resin treated and cured before fabrication of garments. Intended creases are then put into garment using high temperature presses or by using standard presses and oven heating. A third method utilizes heat-settable fibers primarily, and does not depend on chemical treatment. These fabrics are made into garments and then pressed at high temperatures (300-400°F).

Impetus for application of durable press technology to Army uniforms resulted from a tour of military installations in Southeast Asia by the Army Chief of Staff who saw officers wearing a uniform made of a wash and wear polyester rayon fabric which was purchased on the local civilian market. These uniforms were worn instead of the authorized cotton khaki or wool tropical worsted material because of the ease of maintenance compared to that of the standard uniforms which must be starched and pressed or dry cleaned. A few yards of this polyester/rayon fabric was acquired by the Chief of Staff and sent to these laboratories for analysis. This fabric was reproduced by representatives of the U. S. textile industry, and after laboratory evaluations was fabricated into garments which were approved by the Army Uniform Board. A test quantity of some 800 uniforms were made and submitted to U. S. Army Test Evaluation Command for wear testing.

It was originally expected to use this fabric in uniforms to replace the current standards on an army-wide basis. However, since this material must be dyed and finished in relatively small lots, problems in controlling the shade within acceptable tolerances were

encountered which made it difficult to produce uniforms with matched components. This deficiency would be further amplified in large scale procurements. As a result, a decision was made to test the durable press polyester/rayon garments as a replacement for the limited-issue drill sergeants' uniform since some shade difference between shirt and trousers could be tolerated with a select group. Another factor which prompted this decision was that the authorization for wear of the Army tan tropical worsted wool uniform for drill sergeants was scheduled for expiration in a short time and the supply was minimal.

Wear tests were conducted at three test sites under weather conditions ranging from hot-humid to hot-dry. The results of the tests showed that the durable press polyester/rayon garments met all of the established criteria and were considered suitable for wear by drill sergeants. This fabric was recommended and adopted as the standard summer uniform for this limited use.

3. Fabric Development

Although the polyester/rayon fabric was acceptable for the limited use drill sergeants' uniform, it was not considered fully satisfactory for general use for all military personnel. Several factors account for this decision such as the difficulty in shade control through the dyeing, finishing, curing and pressing stages used for the polyester/rayon fabric, the desire to retain the particular esthetic qualities of cotton in the fabric, the ready availability of polyester/cotton blends, the greater durability of cotton over rayon, and the policy of using cotton unless the desired properties could only be obtained with a man-made fiber. The use of a polyester/cotton blend allowed the fabric to be dyed by a continuous method which not only permitted the use of fewer and cheaper dyes, but also provided better shade control and colorfastness.

Several candidate fabrics were selected from an analysis of over fifty industry-supplied fabrics for which there is production history and user experience. Many of the fabrics submitted were eliminated from consideration because of technical and esthetic factors enumerated in subsequent paragraphs. The initially selected candidate fabrics have been evaluated and the data appear in Appendix I together with the data for comparable standard fabrics.

a. Basis for Comparison

One basis for comparison was the presently specified cotton 3/1 twill, "chino" fabric which sets the standard for quality of surface appearance and for drape and general sharpness when in a

starched and pressed condition. This fabric is also the basis for comparison of durability in that any replacement fabric should render adequate service life commensurate with relative cost. In addition, the base of supply should be as broad and competitive as that of the cotton twill. The polyester/rayon tropical, plain weave fabric with durable press and soil release finish used in the drill sergeants' uniforms was taken as the basis of comparison for freedom from wrinkling, retention of intended creases, and ease in laundering plus reduction in the frequency of laundering compared to that of the cotton standard.

b. Weight

In selecting the fabric weight, it was recognized that one effect of the durable press treatment was to increase the apparent body and firmness of the fabric to levels exhibited by untreated fabrics that are approximately 1 to 1.5 oz/yd^2 heavier. Accordingly, the weight target was taken as 7.0 oz/yd^2 for the uniform fabric which will be used in both the shirt and trousers.

c. Weave

A 2/1 twill fabric in the selected weight range gives the optimum interlacing density necessary for firmness, drape and overall appearance. Compared to the plain weave drill sergeants' uniform fabric, the slight shadow line of this twill adds to the surface character and will tend to conceal light soilage, abrasion marks, and mussing. The shorter warp yarn float of the 2/1 twill will minimize the effects of fuzzing compared to twills with longer floats.

d. Construction

The use of high energy absorbing polyester fibers in the yarns results in a fabric with slightly fewer warp ends and filling picks than the standard cotton twill and still maintains durability characteristics. Accordingly, a texture in the range of 108 ends and 52 picks was selected for the proposed durable press fabric to keep within the weight range selected using commercial yarn sizes. The candidate fabrics from industry contained a variety of yarn types ranging from 2-ply yarns in the warp and filling to singles yarns in both directions and a few were made with a 2-ply warp and singles filling. Quality considerations from a broad base of supply indicated that a 2-ply warp yarn would be necessary. However, a singles filling yarn appeared to be satisfactory.

e. Fiber Blend

The most popularly promoted blend of durable press civilian fabrics is a 65/35 polyester/cotton; however, 50/50 blends of these

These are also very common. As there are no clear cut indications of the superiority of one blend over the other, a 50/50 blend was selected for indicated advantages in economy, comfort in hot climates and adaptability to durable press and soil release treatments. If further data and experience should indicate that some other blend is superior in military usage, the modification could be made later with no upset to the supply and issue basis.

f. Wear Patterns

The usual "end points" for durable press garments in service will be considerably different than those for the current standard "chino" garments. Whereas, the chino fabrics are usually worn until holes actually appear and/or the fabric is thinned down in relatively large areas (knees, seat), durable press garments are more commonly downgraded or discarded for appearance considerations such as fuzziness, pilling, frosting (lighter appearance of abraded areas), accumulated unremoveable stains and seam failure which now occurs before actual failure of the basic fabric. Experience with polyester fiber blend fabrics generally confirms that they will outwear similar cotton fabrics if subjected to normal wear histories. However, the differences in actual service life will be much greater since the frequency of washing is much less for the durable press polyester blend fabrics which greatly reduces the large proportion of total wear attributed to laundering.

g. Comfort

It is commonly but not universally acknowledged that the dominating factors affecting comfort in warm climate clothing are fabric thickness and weight. However, there are wide variations in wearers' sensitivity to other factors such as tactile sensations and moisture absorbency. In the overall combination of trade-offs, it is expected that most wearers will prefer to wear durable press garments rather than the cotton standard even though under some conditions they may be slightly less comfortable. New draftees and recruits who are by now thoroughly accustomed to durable press type garments will probably not be aware that any comfort has been sacrificed. There may be some veteran soldiers to whom the traditional feel of well-worn chino is the ideal of comfort, and who will be consciously less content with durable press garments. However, there is no reason to believe that the durable press uniform will be entirely unacceptable to any wearers or that there will be a physiological disadvantage in their efficiency or endurance.

h. Laboratory Evaluation

The data in Table I below show the physical properties of the durable press polyester/cotton fabric (0389) considered to be a suitable

TABLE I

	DURABLE-PRESS FABRIC CODE 0389	PROPOSED SPECIFICATION REQUIREMENTS
Weave	2/1 twill RH	2/1 twill RH
Weight, oz/yd^2	7.0	6.75 min.
Fiber Content, %	50/50 P/C	50/50 P/C
Texture, W x F	112 x 50	104 x 50 min.
Yarn Ply, W x F	2 x 1	2 x 1
Breaking Strength		
Grab, lbs, W x F	187 x 89	170 x 80
Tear Strength - original	5.3 x 3.0	5.0 x 3.0
Elmendorf, lbs, W x F - 15 launderings	5.5 x 3.3	-
Abrasion Resistance		
Sand Cycles	2000	-
Taber Cycles	490	-
Laundering, Yarn Breaks 50 cycles	8	-
Water Absorption, secs.	100	-
Air Permeability, ft3/min/ft2	14.3	-
Burn Hole	Med. Hole	-
Shrinkage, %-Curing	0.5 x 0.0	1.5 x 1.0
W x F - 15 Launderings	2.2 x 0.5	2.5 x 1.5
Appearance - 15 Launderings	4.0	4.0
Crease Retention - 15 Launderings	4.0	4.0
Soil Release - 15 Launderings	4.0	3.5
Spray Ratings - 3 Launderings	50, 50, 50	70, 70, 70
Seam Efficiency %	100	90 min.
Yarn Severance	0	-
Colorfastness - Light	40-60 Hrs.	-
* Crocking	5.0	-
* Perspiration	5.0	-
* Laundering	4.0	-
* Frosting	4.0	-
Pilling	Negligible	-

* AATCC Ratings
5. practically unaltered
4. slightly altered
3. appreciably altered
2. considerably altered
1. much altered

candidate for the summer uniform material. These data are compared with the requirements established in the proposed specification. An analysis of these data shows that the candidate fabric equals or exceeds the specification requirements. Appendix 1 contains the results of the laboratory evaluation of various durable press fabrics, the cotton standard and two sateen fabrics. These data also show the importance of blend composition, yarn size, yarn ply and texture on the durability properties of the durable press fabrics. For example, it is noted that the fabrics with higher percentages of polyester have higher tear and abrasion resistance than fabrics with lower percentages of polyester fiber provided that the other parameters are about equal. The burn hole resistance follows a general trend in that the fabrics with the higher polyester content show larger sized holes. Approximately half of the candidate fabrics have shrinkage values that exceed the proposed specification requirements. The water absorption ratings were inconsistent among the polyester/cotton fabrics which is probably due to the particular type of finish used.

4. Dyeing and Finishing System

a. Shade Selection

Simultaneously with the development of a suitable fabric, a study was made to establish the exact shade which would be acceptable for the proposed new summer uniform. At the present time, the Khaki 1, M-1 and Army Green Tropical (polyester/wool) uniforms are being worn by either officers or enlisted men. It was planned to divert from these traditional shades and introduce a new and novel shade which would be distinctive as well as durable. Accordingly, with the above concepts in mind, various hues and chromas of blues, greens, grays and tans were dyed for review by the Army Uniform Board. Also included were heather blends with one fiber of the blend preferentially dyed. At this time, the fabric blend and functional finish were ignored as shade selection was the basic criterion.

Another aspect considered in this initial effort to find a suitable shade was the feasibility of a two-tone uniform, i.e., trousers of one shade with a shirt of a different tone or contrasting color. It was believed that such a uniform would significantly overcome the problems of shade variation found with the Polyester/Rayon Drill Sergeants' Uniform, Tan 445. In addition, a tone-on-tone uniform would register less visual shade difference and be more uniform in appearance than the current cotton twill. These ideas were presented to the Army Uniform Board, but the decision was to continue using a monotone uniform.

General experience has indicated that dark shades give less trouble in shade control than light shades. Saturated colors or dark

shades were included in these shade trials, but other problems were created. For instance, it was found that colorfastness to washing and frosting due to edge wear would be a problem after repeated laundering and wear cycles. Also, it was more difficult to obtain uniformity of dyeing in a blended fabric dyed to a darker shade than in one dyed to a medium or pastel shade using the continuous methods that must be applied for large scale production. Moreover, a summer uniform in a light shade is preferred for esthetic properties.

Several commercial fabrics were dyed or procured in popular civilian shades and depths. However, none of these were completely acceptable for military wear because they were used normally for high styling.

From these investigations, a tan shade different from that of Khaki 1 and Army Tan M-1 was selected and designated as an interim standard. This shade was somewhat redder in tone than the current Khaki 1 shade, thus giving an appearance of richness in character. The present Khaki 1 shade was originally selected for field use.

b. Continuous Dye System

A considerable amount of experience has been gained in the dyeing of the polyester/rayon Drill Sergeants' uniform fabric. For this fabric, a direct/disperse dye system applied in dye becks has been used. Some of the difficulties encountered in this system are shade variation from lot to lot and within the lot, cross-staining effects initiated by the dyeing method, shade change in resin finishing, further shade change on pressing and curing and marginal colorfastness. These problems served to establish basic guidelines for the dyeing and finishing system used with a new summer uniform fabric for enlisted personnel. They are as follows:

1) The fabric should be prepared, dyed and finished in a continuous thermofixation-pad-steam system which would insure adequate yardage in the expected large procurements and minimize shade variation over several hundred thousand yards.

2) The dye system should exhibit minimum shade change when sensitized with the resin, pressed in garment form and cured.

3) The dye system should yield fabrics that exhibit maximum colorfastness to light, repeated home launderings, crocking, perspiration and frosting.

4) The dye formulation used should contain a minimum number of dyestuffs, be relatively simple to apply and be reproducible from plant to plant.

c. Dye Formulation

The application of various dye classes which might conform to the above criteria were investigated. Included in this investigation were resin-bonded pigment, reactive-dye/dispersed-dye combinations, soluble vat, vat/dispersed dye combinations and finally a special all-vat dye formulation.

The resin-bonded pigment systems have been used extensively on a commercial basis to dye fast pastel shades on various fiber-blend fabrics. This dye system is easy to apply and results in good lightfastness with minimum shade change after application of resin finish and good shade control in curing. However, the fiber-to-fiber shade balance and the abrasion resistance tends to be poor. Trousers fabricated from fabric dyed with this type of dye showed a white line on the crease after a few launderings. Consequently, this system did not meet the established criteria and was rejected.

The reactive dispersed classes of dyes applied to polyester/cotton fabrics were relatively easy to apply, but fastness properties and cross-dyeing effects were unsatisfactory. It was difficult to improve upon the marginal colorfastness of the Tan 445 shade of the Drill Sergeants' fabric.

The soluble-vat dyes are limited in availability, expensive and difficult to apply and control. The colorfastness obtained was no better than with other dye classes that are easier to use.

The thermosol-applied dispersed/vat dye combinations are currently used by most commercial dyers of polyester/cotton fabrics. The range of colorfastness attainable with these combinations is dependent upon the selection of dyes. Cross-staining of each individual dye class onto the other fiber is apt to occur in the thermosol process and the various components of the finishing formulation as well as the dyeing conditions affect the shade. The colorfastness of polyester/cotton blended fabrics ranged from poor to excellent depending on the control of these factors.

Early in the work on the dyeing of fiber-blend fabrics, the dyeing of polyester/cotton fabrics with an all-vat formulation had been considered. The colorfastness of vat dyes absorbed by the polyester component of a blended fabric was normally of a low level and appeared to be a problem. A company was located that marketed a line of vat colors which are lower in molecular weight than the usual anthraquinone types and have a special particle size. This dye class was considered because it was thought possible to dye both fiber components easily to the same tone with equal colorfastness.

Dyeing trials on small sized swatches of 65/35 polyester/cotton twill fabrics were carried out. The swatches showed excellent colorfastness; dye application was easy; the shade was reproducible from run to run, and a minimum number of dyes were sufficient to control the shade. The shade change following curing of the applied resin was minimal also. To demonstrate the characteristics of the proposed durable press summer uniform, the Army Uniform Board was permitted to examine and evaluate complete uniforms. These were produced from 200 yards of the proposed fabric continuously dyed at a commercial finishing plant on production equipment using the formulation of special all-vat dyes. The resin treatment applied to this fabric was proved with the Tan 445 Drill Sergeants' fabric. The treated fabric was given comprehensive testing and the results confirmed the previous findings regarding superior colorfastness.

Five one-yard cuts of the resin-treated material were sent to five different cutting plants and portions cured under the manufacturers' normal procedures. This material was evaluated visually and spectrophotometrically; shade change results on curing in different plants were excellent. The balance of the fabric was made into garments which were pressed and cured. These uniforms were shown to the Army Uniform Board and were approved. The Uniform Board requested that the requirements for possible volume procurement of this fabric be established expeditiously and left the technicalities of fabric and finish to the judgment of Natick Laboratories' personnel. The shade of this fabric in the demonstration uniforms was adjudged to be more desirable than the one originally selected and, accordingly, it was designated as the new interim standard for shade, finish and colorfastness.

At the same time, the problem was presented to the National Research Council Committee on Textile Dyeing and Finishing. A small quantity of 65/35 polyester/cotton was supplied to a number of industry representatives to dye samples to match the new interim standard for shade or to submit any other shades that were believed desirable. After receipt of these submittals, all of the fabrics were given a durable press, soil release resin treatment and then pressed and cured under carefully controlled conditions. These samples were measured visually and spectrophotometrically for color difference comparing material dyed only with dyed, resin treated material both before and after pressing and curing. The samples were also tested for colorfastness to light, laundering, perspiration and frosting. Out of the 22 dye formulations submitted and tested (See Appendix 2), five formulations with the highest ratings were selected for further study.

At this time, the fabric was changed to a 50/50 polyester/cotton blend in a 2/1 twill weave and the additional work was done with the five selected formulations on this material. A production run in a commercial finishing plant was conducted using 200 yards of fabric for each of the 5 selected formulations. The dyed and resin-treated fabric was sent to the Natick Laboratories for curing and testing. (See Appendix 1) A five yard cut of dyed, untreated fabric was also submitted for resin application and curing by these Laboratories. After resin treatment and curing, these short cuts were correlated for shade against a small piece from each formulation cured at the finishing plant.

Two of the five formulations evaluated against the established criteria were satisfactory. Of the two best, one formulation was selected because of its ease of application, simplicity and minimum number of dyestuffs. (See No. 10, Appendix 2) Approximately 4500 yards of fabric have been dyed with this formulation and durable press, soil-release-treated. Uniforms are being made from this material for wear testing.

5. Durable Press Finish

While durable press fabrics were being considered in military uniforms, the advice of industry representatives was requested because of their wide experience gained from similar-type civilian fabrics. The reactant recommended as the basic ingredient of the durable press formulation was dimethyloldihydroxy ethylene urea (DMDHEU). This reactant was considered to be readily adaptable to the post-cure process which would be necessary for uniforms to obtain the required military creases in shirts and trousers. Fabrics treated with this agent may be kept in storage for relatively long periods of time without self-curing of the reactant taking place. Fabric in a sensitized state has been stored in a warehouse for several months at temperatures not exceeding 110°F at these Laboratories and was still capable of yielding good durable press qualities. Another advantage attributed to DMDHEU is its low level of formaldehyde odor compared to other resins used for durable press purposes.

In addition to the reactant, a catalyst, softener agent and hand builder are added to make up the basic formulation. (Appendix 3). A soil release agent was also added to the formulation because the polyester fibers in the fabric have a high affinity for oily-type soilage and the reactant in the cellulosic fibers reduces their hydrophilic properties and thus also makes this component susceptible to oily stains. Both acrylic and fluorochemical soil release agents were tried. It was found that the fluorochemical agents were more suitable as they do not break down at the high temperatures required for curing the reactant.

Much experience with this reactant (DMDHEU) was gained through work done on the polyester/rayon drill sergeants' uniform fabric. For this fabric, the recommended curing temperature of 340°F for 10 minutes was found to be too high for the direct/dispersed dyestuffs used and caused shade variations. This temperature was reduced to 325°F for 12 minutes and resulted in better shade control. Since the curing operation would normally be done after the garment is fabricated and pressed it was difficult to control the process in the individual garment plants. On visits to various garment manufacturers, differences of as much as 100°F from the top to the bottom of curing ovens were found. However, if the recommended curing conditions regarding temperature and time were closely followed, there was better shade control of the garments and better durable press properties. To further improve shade control on curing, a more highly buffered reactant was used which regulates the pH of the formulations in a narrow range. This durable press formulation with soil release was applied on 65/35 polyester/cotton samples submitted by industry members for shade consideration. Also, in a further study of the five best dye formulations, (previously referenced) the durable press, soil release treatment was applied industrially to 200 yards of 50/50 polyester/cotton fabric from each of the five dye shades selected. These fabrics were evaluated for durable press properties after 15 home launderings and were rated as unsatisfactory especially regarding crease retention. Additional experimentation was done on the durable press formulation using a higher percentage of reactant and several different combinations of softeners.* Nine variations of the basic formulation were tried on polyester/cotton fabric and evaluated. The formulation which produced the best durable press properties with the minimum effect on shade was selected (No. 7 from Appendix 3). This new formulation was applied to a second run of 200 yards of fabric from each of the 5 dye shade formulations, but with the soil release agent omitted. Analysis of these fabrics showed that they had good durable press properties but poor soil release properties. This same formulation but with soil release agent added was subsequently applied to a 4500 yard run of the selected shade. Tests show that the fabric has good durable press and soil release properties (Appendix 1). Uniforms are being made from this fabric for further testing.

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* Natick Laboratories' Report (In Review) - "A High Performance Durable Press Finish for Polyester-Cellulosic Blend Fabrics," Francis A. Hoffman and Harold J. Monahan

c. Sewability

In general, fabrics treated with a durable press finish require more attention in the sewing operation than with the same fabrics without reactant finish. The stiffness and flatness imparted to the material leads to differential feeding of the layers of fabric to the stitching elements of the sewing machine and results in seam puckering. Thus, proper control of sewing machine speeds and settings are essential to good appearance in the seams of garments. Operators' skills or techniques must be more refined to reduce their influence on the flatness of the seams.

Modern sewing machines have been developed for use on durable press fabrics. These machines take into consideration the necessity of feeding both plies of material evenly thereby minimizing seam puckering from this source. Smaller needles, finer feeds, smaller throat plate holes and lower thread tension devices are integral parts of these machines. Feed mechanisms, such as top feeds, pinch feeds and needle feeds, improve the sewability of durable press fabrics by reducing the operators' influence such as stretching or pushing the fabric.

With the advent of durable press fabrics, two new types of sewing threads were developed. One of these threads is made by wrapping cotton fibers around a core of multifilament polyester yarn. Two or more of these composites are plied together to make the final sewing thread. The other thread is made of spun polyester staple fibers. The principal reasons for the extensive use of these sewing threads are their reputed stability (resistance to shrinkage) to wet and dry heat and resistance to degradation by any acidity developed during the pressing and curing processes.

Tests conducted on pre-cured, polyester/cotton fabric show high losses in seam efficiency with attendant high increases in yarn severance compared to fabrics without a durable press finish. The resin finish used immobilizes the yarns of the fabric and causes them to resist the penetration of the needle and become subject to rupture. The same tests made on the polyester/rayon, drill sergeants' uniform fabric which was sensitized with resin, but not cured, show no losses in seam efficiency and very little, if any, yarn severance. Since the resin was not polymerized, the fabric was fairly soft and pliable and the yarns could deform or move away from the impact of the sewing needle. Tests were also made on this fabric to determine the amount of seam shrinkage due to the sewing operation and to pressing and curing. Fabric strips were seamed together with the line of stitching thread parallel to the warp yarn, parallel to the filling yarns and on a slight bias to the warp yarns. The seamed strips were then

pressed and cured. The amount of shrinkage after sewing and after pressing and curing were recorded for each seam condition above. In each case, the combined seam shrinkage did not exceed 2 percent which was within the limits of acceptability. The only sewing tests completed at this time on the 50/50 polyester/cotton candidate fabric have been seam efficiency and yarn severance (Appendix 1). The results are 100 percent seam efficiency and 0 percent yarn severance, which far exceeds the minimum requirements specified for the cotton uniform twill presently being used in the summer uniform.

7. Garment Fabrication

The post-cure technique was selected as the method to be used for the durable press summer uniform. This method is preferred because the distortions sewn into the garment are pressed out while the reactant is flexible and after the reactant is properly cured and set, it prevents the distortion or seam puckering from returning. Intended creases are pressed in after the garment is made and the curing or setting of the reactant causes them to resist removal in laundering. Durable press garments made in this manner have certain limitations in that alterations are precluded because of the durable creases originally pressed into the garment prior to curing. The garment must be properly fitted to the individual as there is no provision for the seat seam outlet in the trousers nor can any components be lengthened. The garment patterns have incorporated a compensating allowance for the small amount of anticipated shrinkage which occurs in the pressing and curing operations.

Durable creases in the trouser legs can be readily obtained since the fabric in this garment is folded in a relatively sharp angle in a restricted area. However, the military creases required in the shirt fronts and backs are more difficult to maintain because of the several layers of fabric necessary to make the front pockets and also because the fabric of this garment lies in a fairly flat and open condition.

8. Future Work

An experimental quantity of a series of durable press fabrics made with varying percentages of two different types of polyester fiber blended with cotton will be evaluated for physical and mechanical properties, dyeability, shade control, colorfastness, durable press and soil release properties and sewability upon their receipt at these Laboratories. In addition, one fiber producer is experimenting with a special type of polyester fiber which when blended with cotton in a fabric imparts durable press

properties without the addition of a reactant. The blend proportions to be investigated are 80 percent of the special polyester and 20 percent cotton. This new polyester fiber is not yet sold on a commercial basis, but a small quantity of blended fabric using this fiber and cotton has been ordered and will be evaluated when available.

Some work has been done on fabrics with the view of incorporating durable press properties in work and training-type uniforms. The shirts of this uniform may be made from pre-cured durable-press-treated fabric because military creases are not required. However, it is desirable to have sharp creases in the trousers and the post-cure durable press fabric will be used. At this time, no definite decision has been made regarding the fiber blend to be used. A polyester/cotton twill weave fabric and a nylon/cotton sateen are under consideration. Additional work is necessary to improve on the technique of insertion of military creases in open panels such as shirt fronts and backs.

9. Summary

After an extensive evaluation of many proposed fabrics, a 7 oz/yd^2 50/50 polyester/cotton 2/1 twill fabric treated with durable press, soil release finish was selected as the preferred candidate for the summer uniform issued to enlisted Army personnel. This fabric is made with 2-ply warp and singles filling yarns in a texture of approximately 108 ends and 52 picks. The physical and mechanical properties of this fabric meet or exceed the requirements established in the proposed specification.

The fabric was dyed to a tan shade using a continuous thermofixation-pad-steam system. A special all vat dye formulation containing a minimum of three dyestuffs was used because it was thus possible to dye both fiber components easily to the same tone with equal colorfastness. The shade was reproducible from run to run. Also, there was less shade change during the pressing and curing of the sensitized fabric than with other dye formulations tried.

The reactant used as the basic ingredient of the durable press formulation was dimethyloldihydroxy ethylene urea (DMDHEU) which is readily adaptable to the post-cure process necessary to maintain the desired creases in military uniforms. Fabrics in a sensitized state may be stored at room temperature for relatively long periods of time without polymerization or self-curing of the reactant taking place. To minimize soiling, a fluorochemical soil release agent was added to the basic formulation. A catalyst, softener agents and hand builders were also included in this formulation. A curing temperature of

325°F for 12 minutes in an oven proved satisfactory for good durable press properties and shade control.

The sewing characteristics of the treated, uncured fabric show a seam efficiency of 100 percent with no yarn severance. However, modern sewing machines with skilled operators are required in the fabrication of any durable press garments to minimize seam puckering. Either a plied polyester/cotton wrapped thread or a plied spun polyester thread is necessary in garment seams to resist degradation by acidity developed in pressing and curing the garments.

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APPENDIX 1
FABRIC PROPERTIES

Fabric Code	0389	2051	D. S.	2565	2566	2567	2569	2570	2572	2573	Spec. Fab.	1715	1420	Proposed Spec. Requirement
Weight, oz/yd^2	7.0	7.1	6.5	5.0	7.0	6.8	6.4	6.5	7.8	7.2	8.2	8.5	8.8	6.75 min.
Weave	2/1 twill	2/1 twill	Plain	3/1 twill	2/1 twill	Poplin	2/1 twill	Plain	3/1 twill	2/1 twill	3/1 twill	Sateen	Sateen	2/1 twill
Fiber Content, %	50/50 P/C	50/50 P/C	65/35 P/R	65/35 P/C	65/35 P/C	50/50 P/C	65/35 P/C	65/35 P/C	50/50 P/C	75/25 P/C	100 Cotton	100 Cotton	50/50 N/C	50/50 P/C
Texture W x F	112 x 50	108 x 52	93 x 56	116 x 52	123 x 5[illegible]	76 x 37	84 x 48	90 x 48	123 x 49	89 x 52	112 x 56	85 x 50	122 x 75	104 x 50 min.
Yarn Ply W x F	2 x 1	2 x 1	2 x 2	1 x 1	1 x 1	2 x 1	1 x 1	2 x 2	1 x 1	1 x 1	2 x 1	1 x 1	1 x 1	2 x 1
Breaking Strength Grab, lbs, W x F	187 x 89	185 x 102	212 x 152	157 x 61	230 x 71	140 x 62	221 x 180	177 x 161	133 x 95	250 x 133	203 x 140	160 x 123	187 x 194	min. 170 x 80
Tear Strength W x F, orig.	5.3 x 3.0	5.5 x 3.3	7.1 x 5.1	9.5 x 5.6	8.8 x [illegible]	6.9 x 4.5	12.8 x 9.5	6.2 x 4.4	5.5 x 6.9	13.6 x 5.6	7.3 x 11.9	7.5 x 6.8	7.9 x 10.7	5.0 x 3.0 min.
15 Launderings Elmendorf, lbs.	5.5 x 3.3	5.5 x 3.6												
Abrasion, Sand Cycles, 3 Launderings	2000	2000	1500	1000	2500	1500	1900	1700	1800	4000	3500	2000	4000	-
Abrasion, Taber Cycles, 3 Launderings	490	495	345	550	645	350	565	285	709	690	405	400	1980	-
Abrasion, Laundering Yarn Breaks - 50 cycles	8	16	2	5	0	15	0	8	11	0	11	4	0	-
Water Absorption Sponge, secs.	Poor >100	Poor >100	Poor >100	Excellent 15 secs.	Fair 25 secs.	Poor > 300	Poor > 200	Poor > 130	Excellent 7 secs.	Poor >100	Excellent 1 sec.	Excellent 2 secs.	Poor > 300	-
Burn Hole Test	Med. Hole	Med. Hole	Large Hole	Med. Hole	Large Hole	Med. Hole	Small Hole	Large Hole	Small Hole	Large Hole	No Hole Singed	No Hole Singed	No Hole Scorched	-
Shrinkage During %	0.5 x 0.0	0.5 x 0.0	—	0.8 x 2.1	0.9 x 0.6	0.8 x 1.0	0.7 x 0.9	1.0 x 0.2	1.5 x 0.3	1.6 x 1.0	-	-	-	1.5 x 1.0
15 Launderings	2.2 x 0.5	2.0 x 0.5	1.9 x 0.5	1.8 x 2.6	2.2 x 0.8	3.5 x 1.2	2.5 x 1.9	2.2 x 0.5	3.2 x 0.7	3.2 x 1.6	2.0 x 0.8	-	-	2.5 x 1.5
Appearance 15 Launderings Rating	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	-	-	-	4.0
Crease Retention 15 Launderings Rating	4.0	4.0	4.0	3.0	4.0	4.0	4.0	4.0	4.0	3.0	-	-	-	4.0
Soil Release 15 Launderings Rating	4.0	4.0	4.0	-	-	-	-	-	-	-	-	-	-	3.5
Spray Ratings	50, 50, 50	50, 50, 50	70, 70, 70	0, 0, 0	0, 0, 0	W. R. 100, 100, 100	0, 0, 0	W. R. 100, 100, 100	0, 0, 0	0, 0, 0	-	-	-	70, 70, 70 max.
Seam Efficiency %	100	100	100	90	94	100	99	100	100	93	80 min.	80 min.	80 min.	90 min.
Yarn Severance %	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	-
Shade	Matches Std.	Matches Std.	Matches Std.	Tan	Blue	Tan	Green	Tan	Tan	Blue	Std.	O. D.	O. D.	-
Colorfastness Rating*														
Light	40-50 hrs	40-60 hrs	20 hrs	-	-	-	-	-	-	-	40-60 hrs.	-	-	-
Crocking	5.0	5.0	5.0	-	-	-	-	-	-	-	5.0	-	-	-
Perspiration	5.0	5.0	4.0	-	-	-	-	-	-	-	5.0	-	-	-
Laundering	4.0	4.0	3.0	-	-	-	-	-	-	-	3.5	-	-	-
Frosting	4.0	4.0	3.5	-	-	-	-	-	-	-	-	-	-	-
Pilling	None	None	None	-	-	-	-	-	-	-	-	-	-	-
Air Permeability ft^3/min/ft^2	14.3	14.4	15.4	33.9	19.0	31.2	48	25.1	28.3	28.2	10.5	37.3	4.8	-

* AATCC Ratings - 5.0 - practically unaltered; 4.0 - slightly altered; 3.0-appreciably altered.

APPENDIX 2 - EXPERIMENTAL DYE FORMULATIONS - TAN 443

Dye Formulations Submitted by Individuals and Members of the NRC Committee on Dyeing and Finishing Associated with:

1. Allied Chemical and Dye Corporation (Mr. James E. Loughlin)

   Pad - Thermosol - Chemical Pad - Steam Method

   Grams per liter:

   2.25 Polynal Blue E 50% Paste

   2.75 Polynal Golden Brown RA 50% Paste

   22.50 Cibanone Brown BG Paste

   1.25 Carbanthrene Khaki 2G Double Paste

2. American Cyanamid Company (Dr. Edwin I. Stearns)

   Pad - Thermosol Method

   Ounces per gallon:

   0.80 Calcoloid Brown GL Double Paste

   Mixture of Vat Brown 3 and Vat Black 27

   0.50 Calcosperse Orange RLK Paste

   0.60 Calcosperse Blue BGLK Paste

   Dispersed Blue 27

3. Ciba Chemical and Dye Company (Mr. David M. Freedman)

   Pad - Thermosol - Chemical Pad - Steam Method

   Ounces per gallon:

   0.83 Cibanone Brown GR Double Paste - Vat Brown 3

   0.74 Cibanone Olive 2 RM Double Paste - Vat Black 27

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0.40 Terasil Yellow CWN Liquid 50% - Disperse Yellow 42

0.10 Terasil Red 2 GL Liquid 50% - Disperse Red 72

0.10 Terasil Blue GLF New - Disperse Blue 27

4. Dan River Mills, Inc. (Dr. R. Lee Wayland Jr.)

Continuous Thermosol - Pad - Steam Method

Grams per Liter:

2.00 Disperse Blue 60 50% Paste

1.70 Disperse Brown 3 Paste

1.20 Disperse Yellow 42 Paste

11.00 Cibanone Brown BG Paste*

2.00 Vat Brown 3 Double Paste

*Cibanone Brown BG is a commercially mixed dye containing:

Vat Brown 3

Vat Black 27

5. E. I. DuPont de Nemours & Co. (Dr. Paul L. Mennier)

a. Pad - Thermosol Method

Ounces per Gallon:

0.46 Latyl Blue 5 GS 50% Paste

0.38 Latyl Brown Y-FS Paste

0.138 Latyl Ruby Red BR-FS 50% Paste

0.575 Ponsol Brown ARN Double Paste

0.53 Ponsol Olive AR Double Paste

b. Pad - Thermosol

Ounces per Gallon:

0.48 Latyl Blue FLW 50% Paste

0.38 Latyl Brown Y-FS Paste

0.14 Latyl Ruby Red BR-FS 50% Paste

0.575 Ponsol Brown ARN Double Paste

0.53 Ponsol Olive AR Double Paste

c. Pad - Thermosol Method

Ounces per Gallon:

0.44 Latyl Blue 4 - GFS 50% Paste

0.44 Latyl Blue Y-FS Paste

0.04 Latyl Ruby Red BR-FS 50% Paste

0.575 Ponsol Brown KRN Double Paste

0.53 Ponsol Olive AR Double Paste

6. Geigy Dyestuffs No. 1 (Mr. Robert C. Allison)

a. Pad - Thermosol - Chemical Pad - Method Grams per Liter:

2.00 Setacyl Orange P-GRL No C.I. number

2.50 Setacyl Blue P-GL 50% Paste Disperse Blue 27

5.00 Tinon Brown GRND-F Vat Brown 3

5.00 Tinon Olive SRR Vat Black 25

b. Pad - Thermosol - Chemical Pad - Steam Method

Grams per Liter:

2.50 Setacyl Blue P-GL - Disperse Blue 27

1.50 Setacron Yellow T-3GL 100% Paste No C.I. number

0.80 Setacron Red BL 90% Paste No C.I. number

5.00 Tinon Brown GRND-F Vat Brown 3

5.00 Tinon Olive SRR Vat Black 25

c. Pad - Thermosol - Chemical Pad - Steam Method

Grams per Liter:

2.00 Setacyl Blue P-GL 50% Paste - Disperse Blue 27

0.20 Setacron Red BL 90% Paste - No C.I. number

2.00 Setacyl Yellow Brown P-2RFL Disperse Orange 30

5.00 Tinon Brown GRND-F Vat Brown 3

5.00 Tinon Olive SRR Vat Black 27

d. Pad - Thermosol - Chemical Pad - Steam Method

Grams per Liter:

2.50 Setacyl Blue P-GLP Disperse Blue 27

0.80 Setacron Brilliant Orange 2RL 70% Paste - No C.I. number

0.80 Setacron Golden Yellow RL 80% Paste - No C.I. number

5.00 Tinon Brown GRND-F Vat Brown 3

5.00 Tinon Olive SRR Vat Black 27

e. Pad - Thermosol - Chemical Pad - Steam Method

Grams per Liter:

0.70 Setacron Brilliant Orange 2 RL 70% Paste - No C.I. number

1.40 Setacyl Brilliant Blue P-GG Disperse Blue 60

0.60 Setacron Golden Yellow RL 80% Paste - No C.I. number

5.00 Tinon Brown GRND-F Vat Brown 3

5.00 Tinon Olive SRR Vat Black 25

f. Pad - Thermosol - Chemical Pad - Steam Method

Grams per Liter:

0.40 Setacron Red BL 90% Paste - No C.I. number

2.00 Setacyl Yellow Brown 2 RFL Disperse Orange 30

2.00 Setacyl Turquoise Blue 2 GL - No C.I. number

5.00 Tinon Brown GRND Vat Brown 3

5.00 Tinon Olive SRR Vat Black 25

7. General Aniline and Film Corporation (Dr. Stiles M. Roberts)

Pad - Thermofix Method

Ounces per Gallon:

0.08 Genacron Yellow 4 RLP Paste

0.03 Genacron Turquoise BP Paste

0.02 Genacron Pink RL Paste

1.20 Indanthrene Brown G Infra Double Paste

0.90 Indanthrene Olive T Infra Paste

8. Sandoz Inc. No. 2 (Mr. Alfred J. Carbone)

a. Pad - Dry - Thermofix - Oxidize Method

Grams per Liter:

13.00 Indigosol Brown 13B

1.50 Indigosol Grey 13F

1.50 Indigosol Yellow 2GB

30.00 Kromfax

100.00 Sodium Vanadate 1% Solution

125.00 Activator 929

b. Pad - Thermofix - Chemical Pad - Steam Method

Grams per Liter:

3.08 Foron Yellow Brown S-2RFL Paste

4.73 Foron Turquoise Rubine S-3GL Paste

0.86 Foron Rubine S-2BFL Paste

6.50 Sandothrene Brown NBG Double Paste

c. Pad - Thermofix - Chemical Pad - Steam Method

Grams per Liter:

4.20 Foron Yellow Brown S-2RFL Paste

6.45 Foron Turquoise S-3GL Paste

1.17 Foron Rubine S-2BFL Paste

9.75 Sandothrene Brown NBG Double Paste

9. Sherwin-Williams (Mr. Kenneth J. Broden)

Pad - Dry - Cure Method

Grams per Liter:

17.50 Sherdye Yellow PC3W

5.00 Sherdye Scarlet GR3W

0.75 Sherdye Blue GH3W

1.875 Sherdye Grey GH3W

30.00 Sherdye Emulsion 8900

10. Sou-Tex Chemical Inc. (Mr. Harry M. Thompson)

Pad - Thermosol - Chemical Pad - Steam Method

Ounces per Gallon:

2.80 Polyestren Brown C-GR Paste

0.30 Polyestren Grey C-GN Paste

0.85 Polyestren Yellow GG Paste

11. Verona Dyestuffs No. 1 (Mr. Joseph C. King)

a. Pad - Thermosol Method

Ounces per Gallon:

0.28 Resolin Brilliant Yellow C-6GL 50% Paste

0.18 Resolin Brilliant Pink GBLS Paste

0.13 Eastman Polyester Blue GLF

1.55 Veranthrene Brown G Double Paste

0.22 Sandothrene Olive N2R Double Paste

b. Resin Bonded Pigment Method

Ounces per Gallon:

2.50 P/C Pink

0.66 P/C Blue

1.60 P/C Yellow

12. U. S. Army Natick Laboratories

Pad - Thermosol - Chemical Pad - Steam Method

Ounces per Gallon:

2.80 Polyestren Brown C-GR

0.60 Polyestren Green C-5G

	Formulation	Percent
3.	Reactant (Permafresh 113B)	30
	Catalyst (Zinc Nitrate)	6
	Soil Release Agent (FC-218)	4
	Wetting Agent (Triton X-155)	.05
	Softener (Mykon SF)	4
4.	Reactant (Permafresh 113B)	30
	Catalyst (Zinc Nitrate)	6
	Soil Release Agent (FC-218)	4
	Wetting Agent (Triton X-155)	.05
	Softener (Valsoft FR-4)	4
5.	Reactant (Permafresh 113B)	30
	Catalyst (Zinc Nitrate)	6
	Soil Release Agent (FC-218)	4
	Wetting Agent (Triton X-155)	.05
	Softener (Silkand 40)	4
	Hand Builder (Rhoplex HA-8, acrylic resin)	4
6.	Reactant (Permafresh 113B)	30
	Catalyst (Zinc Nitrate)	6
	Soil Release Agent (FC-218)	4
	Wetting Agent (Triton X-155)	.05
	Softener (Mykon SF)	4
	Hand Builder (Rhoplex HA-8, acrylic resin)	4

	Formulation	Percent
*7.	Reactant (Permafresh 113B)	30
	Catalyst (Zinc Nitrate)	6
	Soil Release Agent (FC-218)	4
	Wetting Agent (Triton X-155)	.05
	Softener (Valsoft FR-4)	4
	Hand Builder (Rhoplex HA-8, acrylic resin)	4
8.	Reactant (Permafresh 113B)	30
	Catalyst (Zinc Nitrate)	6
	Soil Release Agent (FC-218)	4
	Wetting Agent (Triton X-155)	.05
	Softener (Solupon T)	4
	Hand Builder (Rhoplex HA-8, acrylic resin)	4
9.	Reactant (Permafresh 113B)	30
	Catalyst (Zinc Nitrate)	6
	Soil Release Agent (FC-218)	4
	Wetting Agent (Triton X-155)	.05
	Softener P&G Finish #4	4

*This formulation selected for use on candidate fabric.

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13. ABSTRACT

This report describes the development of a suitable candidate durable press fabric for the summer Army uniform.

Many commercial fabrics were examined and analyzed before the selection of a prototype fabric was made. The preferred candidate is a 7.0 oz/yd^2 2/1 RH twill composed of a blend of 50/50 polyester/cotton treated with a durable press, soil release finish. This fabric was dyed with a special all-vat dye formulation to a tan shade using a continuous thermofixation-pad-steam system. The reactant used to impart durable press properties was dimethyloldihydroxy ethylene urea (DMDHEU) and the soil release agent was a fluorochemical. The post-cure method of obtaining durable press properties was selected.

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