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A PROCEDURE FOR LAUNDERING OIL-STAINED DURABLE PRESS UTILITY UN--ETC(U)
JUN 75 H T SKERRITT

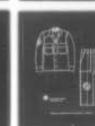
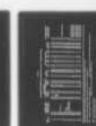
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) During the summer of 1973, durable press, cotton/polyester utility uniforms were field tested (TECOM) at Fort Benning, Georgia. Tests showed that the prescribed laundry procedures did not remove oil and grease stains from these garments. Stain removal was accomplished by treating the stains with several liquid commercial detergents prior to laundering. US Army Natick Development Center initiated an investigation of this problem. → next page		

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20. Abstract (cont'd)

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→ The results of this investigation, which included an evaluation of both specification and commercial laundry detergents and spotting agents, show that a conventional laundry procedure utilizing combinations of laundry detergents and alkalies and a moderate washing temperature 71°C. (160°F.) is not 100% effective in removing oil and grease stains from cotton/polyester garments.

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A procedure for removing heavy oil and grease stains without affecting either the color or finish of durable press garments has been developed. This procedure utilizes a spotting agent which is applied to the stained areas prior to laundering. Technical requirements for this spotting agent have been prepared for use in the preparation of a specification.



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PREFACE

An Engineer Design Test conducted at Fort Benning, Georgia shows that current laundry procedures prescribed for durable press, cotton/polyester uniforms do not completely remove body oil and petroleum oil stains from these garments.

An investigation into this problem was requested by the Textile Research and Engineering Division, Clothing and Personal Life Support Equipment Laboratory (C&PLSEL) and was carried out by the Chemical Products Group, Chemical Products Research and Engineering Division, C&PLSEL. (C&PLSEL is now known as CE&MEL, Clothing, Equipment and Materials Engineering Laboratory.)

The author wishes to acknowledge the contributions of time and skill made by Messrs. Glen Kidder and Curtis Blodgett, Chemical Products R&E Division, during Phase 2 of this study. Through their efforts, equipment deficiencies encountered during the operation of the washer-extractor were successfully overcome and the work was completed on time.

He also wishes to acknowledge the assistance of Mr. Francis Hoffman, Textile Research and Engineering Division, in rating the appearance of the durable press uniforms after multiple prespotting and laundering operations.

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A PROCEDURE FOR LAUNDERING OIL-STAINED DURABLE PRESS UTILITY UNIFORMS

I. Introduction

During the summer and fall of 1973, an Engineering Design Test (TECOM Project No. 7-EI-485-000-011) on durable press fatigue uniforms was conducted at Fort Benning, Georgia. This test, initiated by Natick Development Center, showed that the current laundry procedures for home and post laundries do not completely remove body oil and petroleum oil stains from these garments. However, these oil stains were removed if the stains were prespotted with one of several commercial liquid cleaners such as "Wisk", "Lestoil", or "Spray n' Wash", prior to laundering.

This study was undertaken to develop a procedure to remove heavy oil stains from durable press clothing without damaging the color and finish, and to furnish the technical requirements for a specification covering a prespotting agent and a technique for its use in home and post laundries.

II. Scope of the Investigation

The study was conducted in two phases. In Phase 1, both new and previously worn, laundered durable press utility uniforms were oil-stained and laundered. The wash formulas used in this study (Appendix A-I) were selected so as not to have a deleterious effect upon the fabric or finish of durable press garments. They employed high water levels, moderate wash temperatures, detergents with limited amounts of added alkali, and a gradual reduction in the temperature of rinse water. Using this wash formula, both commercial and specification laundry detergents were evaluated. When these conventional laundry procedures proved inadequate for removing oil stains, liquid detergents, cleaners, and spot removers were evaluated as prespotting agents. As a result of these tests, a laundry procedure incorporating a prespotting operation was developed. This procedure was more thoroughly evaluated in Phase 2 of this study (Appendix A-II).

In Phase 2, two sets of new durable press garments were repeatedly stained and laundered. One set of test garments was laundered at a wash temperature of 38°C. (100°F.), and the second set at 60°C. (140°F.), using the prespotting procedure developed in Phase 1. After ten launderings at each temperature, the test garments were evaluated on the basis of appearance, noting the presence of wrinkles, sharpness of creases, puckering at seams, and presence of residual oil stains.

III. Result

A. Results: Phase 1

The data from twenty laundry wash tests recorded in Table 1 include information on spotting agents, the kind and amounts of detergent and alkali, wash temperatures, suds and final rinse pH values and average stain removal rating.

Wash tests #1 thru #6 were identical in procedures but differed in the kind and amounts of detergents and alkalies used. The higher stain removal values (7.2 and 6.6) were obtained in wash tests #4 and #5 by the use of laundry detergent with and without added sodium orthosilicate. However, even with the high pH (11.8) and moderately high wash temperature of 71°C. (160°F.) the stains were not completely removed. It was believed that a higher wash pH and a higher wash temperature would be detrimental to the durable press finish.

In wash tests #8 thru #13, the oil stains were prespotted prior to laundering. Detergent, Laundry, Powdered, Type I* and Alkali, Laundry w/CMC** were used in amounts of 3-2-1 ounces and 6-4-4 ounces, for 1st, 2nd and 3rd suds respectively, and the wash temperature was 71°C. (160°F.) Prespotting agents, "Wisk", "Lestoil", and "Spray n' Wash" were equally effective, having stain removal ratings of 7.4 to 7.6. The Waterless Hand Cleaner and Paint, Oil and Grease (POG) Spot Remover were slightly less effective with stain removal ratings of 6.8 and 6.2. Complete stain removal was obtained in wash test #8 using NDC Spotting Agent.

In wash tests #14 thru #20, oil stains were prespotted with NDC Spotting Agent then washed with Detergent, Laundry, Powdered, Type I, and Alkali, Laundry w/CMC. The detergent usage was maintained constant at 3-2-1 ounces in the 1st, 2nd, and 3rd suds. The amounts of alkali in 1st, 2nd and 3rd suds were varied from 6-4-4 to 4-2-4 to 0-0-0 and the wash temperature was varied from 71°C. (160°F.) to 60°C. (140°F.) to 49°C. (120°F.) to 38°C. (100°F.). Complete stain removal was observed in all wash tests including wash test #20, in which no added alkali was used and the wash temperature was 38°C. (100°F.).

Table 2 covers wash tests #1 thru #6 and contains much information available in Table 1. However, Table 2 focuses attention on differences in stain removal obtained with shirts S₁ and S₂. Test shirts S₁ and S₂ were made of fabric processed by two different companies. Both companies used the same process for a durable press finish. The reasons why oil stains were removed more completely from S₂ shirts than from S₁ shirts are not known. In addition, these data indicate that the used motor oil was the most difficult to remove and the white mineral oil, the easiest.

*Military Specification MIL-D-12182, Detergent, Laundry, Powdered

**Federal Specification P-A-450, Alkali Laundry

TABLE 1

LAUNDERING OF NEW OIL-STAINED SHIRT, UTILITY (DURABLE PRESS)

Lab. Wash No.	Prespotting Agent Applied to stain before laundering	Washing Supplies			Suds Temperature °C. (F.)	pH Suds & Final Rinse			Test Shirt Code No's.	Stain Removal Rating ⁷ Average Value 5 stains on 2 shirts
		Oz. added 1st, 2nd, & 3rd Laundry Detergent	Laundry Alkali	Suds		1st Suds	2nd Suds	3rd Suds		
1.	None	DLP	3-2-1 ³	SOS	4-2-2 ⁴	71° (160°)	11.6	11.4	11.3	7.2
2.	None	LAUD	4-3-2	SOS	4-2-2	71° (160°)	11.8	11.6	11.5	7.2
3.	None	DLP	3-2-1	AL	4-2-2 ⁵	71° (160°)	10.7	10.5	10.7	7.3
4.	None	BRAWN	4-2-2	None	0-0-0	71° (160°)	11.1	10.8	10.8	7.3
5.	None	BRAWN	4-2-2	SOS	2-2-2	71° (160°)	11.8	11.8	11.8	7.5
6.	None	DLP	4-3-2	AL	6-4-4	71° (160°)	11.3	11.2	11.3	7.5
7.	Dilute Emulsion ¹	DLP	3-2-1	SOS	4-2-2	71° (160°)	11.7	11.6	11.6	7.3
8.	NDC ²	DLP	3-2-1	SOS	4-2-2	71° (160°)	11.8	11.6	11.5	7.3
9.	Wisk	DLP	3-2-1	AL	6-4-4	71° (160°)	11.5	11.4	11.3	7.6
10.	Lestoil	DLP	3-2-1	AL	6-4-4	71° (160°)	11.4	11.4	11.3	7.6
11.	Spray n'Wash	DLP	3-2-1	AL	6-4-4	71° (160°)	11.6	11.5	11.4	6.7
12.	P.O.G. Spot Remover	DLP	3-2-1	AL	6-4-4	71° (160°)	11.6	11.5	11.4	7.5
13.	Waterless Hand Cleaner	DLP	3-2-1	AL	6-4-4	71° (160°)	11.5	11.5	11.5	6.8
14.	NDC ²	DLP	3-2-1	AL	6-4-4	71° (160°)	11.5	11.5	11.4	7.2
15.	NDC ²	DLP	3-2-1	AL	6-4-4	60° (140°)	11.5	11.5	11.4	7.2
16.	NDC ²	DLP	3-2-1	AL	4-2-2	60° (140°)	11.3	11.1	11.0	7.4
17.	NDC ²	DLP	3-2-1	AL	6-4-4	49° (120°)	11.4	11.4	11.4	7.1
18.	NDC ²	DLP	3-2-1	AL	4-2-2	49° (120°)	11.3	11.1	10.9	7.1
19.	NDC ²	DLP	3-2-1	AL	4-2-2	38° (100°)	11.3	11.2	10.9	7.1
20.	NDC ²	DLP	3-2-1	None	0-0-0	38° (100°)	9.9	9.9	9.5	7.0

¹Washer load (test garments plus Ballast) treated in a dilute emulsion prepared by adding NDC Spotting Agent (500 mls.) to water in washer at 6-inch water level for 5 minutes at 100° F. Then raising level to 10 inches and adding the detergent and alkali for 1st suds.

²NDC Spotting Agent (95% Stoddard Solvent, 5% Nonionic Surfactant — see Appendix C).

³DLP — Detergent Laundry Powder, MIL-D-12182, Type I

LAUD — Built Laundry Detergent, BASF Wyandotte Chemical Company
BRAWN — Built Laundry Detergent, Philadelphia Quartz

⁴SOS — Sodium Orthosilicate, Anhydrous

⁵AL — Alkali Laundry w/CMC P-S-450

⁶Each shirt stained with 0.5 gram amounts of each of 5 staining materials: White mineral oil, Lanolin USP, Anhydrous, Used motor oil, Wesson oil, and Lard.

⁷Stain Removal Ratings:

Complete Removal	— 10	Stain Faint	— 4
Stain Just Visible	— 8	Stain Distinct	— 2
Stain Very Faint	— 6	Stain Very Distinct	— 1

TABLE 2

EASE OF STAIN REMOVAL AS AFFECTED BY FABRIC FINISH

Lab. Wash No.	Washing Supplies, Oz. added		Suds Temperature °C. (°F.)	pH Suds & Final Rinse			Identification Stained Shirt Code No.	White Min. Oil	Stain Removal Ratings ⁴			5 Stain Average Value
	1st, 2nd, & 3rd Suds Laundry Detergent	Alkali		1st Suds	2nd Suds	3rd Suds			Landolin USP Anhydr.	Used Motor Oil	Oil	
							3					
1.	DLP 3-2-1	SOS 4-2-2	71° (160°)	11.6	11.4	11.3	1S ₁ 1S ₂	6 10	4 8	1 2	4 6	3.4 6.0
2.	LAUD 4-3-2	SOS 4-2-2	71° (160°)	11.8	11.6	11.5	2S ₁ 2S ₂	8 10	2 6	1 4	4 6	3.8 6.4
3.	DLP 3-2-1	AL 4-2-2	71° (160°)	10.7	10.5	10.7	3S ₁ 3S ₂	6 8	2 6	1 2	4 6	3.0 5.2
4.	BRAWN 4-2-2	None 0-0-0	71° (160°)	11.1	10.8	10.8	4S ₁ 4S ₂	8 10	2 10	2 10	6 10	4.4 10
5.	BRAWN 4-2-2	SOS 2-2-2	71° (160°)	11.8	11.8	11.8	5S ₁ 5S ₂	10 10	2 6	4 6	6 8	5.6 7.6
6.	DLP 4-3-2	AL 6-4-4	71° (160°)	11.3	11.2	11.3	6S ₁ 6S ₂	8 6	2 2	2 2	6 6	4.4 4.0

¹DLP - Detergent Laundry Powder MIL-D-12182, Type 1

BRAWN - Built Detergent Philadelphia Quartz Co. LAUD - Built Detergent BAFS Wyandotte Chemical Co.

²SOS - Sodium Orthosilicate, Anhydrous³S₁ and S₂ indicate shirts were made of fabric processed by two different companies.⁴Stain Removal Ratings - Visual Observations:

Degree of Stain Removal	Numerical Rating
Complete Removal	10
Stain Just Visible	8
Stain Very Faint	6
Stain Faint	4
Stain Distinct	2
Stain Very Distinct	1

AL - Alkali Laundry w/CMC P-A-450

B. Results: Phase 2

After ten staining, prespotting and laundering operations, the two sets of test garments [38°C. (100°F.) and 60°C. (140°F.) wash temperatures] were inspected for residual stain and to determine the effect that this repeated treatment had on the durable press finish. As is shown in Table 3, the used motor oil stains on both shirts and trousers were, with one exception (trace amounts) completely removed when washed at 60°C. (140°F.) (see Figures 1, 2, 3, and 4). At a washing temperature of 38°C. (100°F.), the stains were almost completely removed from the trousers but incompletely removed (from trace amounts to distinct rings) from the right arm area of the shirts.

Durable press performance characteristics such as seam appearance, crease retention and fabric appearance were not reduced to any greater extent than those expected as a result of recommended home laundering procedures. American Association Textile Chemists and Colorists Appearance Ratings assigned to each garment for overall durable press characteristics are shown in Tables 4 and 5. From these, it can be seen that ratings in most categories were within satisfactory limitations of 3.5 or above for both the 38°C. (100°F.) and the 60°C. (140°F.) washes. A slightly lower rating is evident in several areas after washing at 60°C. (140°F.); however, this is not considered significant and is within experimental error. Lower ratings are also evident in garments manufactured with double-felled seams and in front closure areas of trousers. These, of course, are attributable to seaming methods and not to laundering procedures.

IV. Conclusions

From the results of this investigation, it is concluded that a laundry procedure applicable to both post and home laundries has been developed which will satisfactorily remove heavy oil and grease stains from durable press, cotton/polyester, utility uniforms without damaging the fabric, color, and finish (see Appendix B). This work has also resulted in the development of an effective spotting agent for the removal of oil and grease stains and technical requirements for a specification covering this product (Appendix C). This spotting agent will find use in the laundering of grease-stained items such as sleeping bags, duffle bags, lightweight load-carrying equipment, and other items which must be laundered at moderate wash temperatures and in mildly alkaline solutions.

V. Future Work

The procedure for removing heavy oil and grease stains, as reported here, is a special treatment to use on those oil-stained garments not adequately cleaned by the prescribed standard washing procedure and should be used only when absolutely necessary. If possible, the standard wash formula should be improved so as to reduce to a minimum the need to use this special procedure. Accordingly, it is proposed, as future work, that this laboratory evaluate a wash formula which the Navy recommends for laundering white

TABLE 3

UNIFORM, UTILITY (DURABLE PRESS) -- RESIDUAL OIL STAINS AFTER TEN LAUNDERINGS¹

Test Garment No.	Washing Temperature		Residual Oil Stains on Utility Uniforms (Durable Press)				
	°C.	(°F.)	Neck Band	10 Shirts	Right Arm	Right Knee	Left Knee
1S ₁	38°	(100°)	None		Distinct Ring	None	Trace
2S ₁	38°	(100°)	None		Trace	None	None
3S ₁	38°	(100°)	None		Distinct Ring	None	None
4S ₁	38°	(100°)	None		None	None	None
5S ₁	38°	(100°)	None		Trace	None	None
6S ₂	38°	(100°)	None		Trace	---	---
7S ₂	38°	(100°)	None		None	---	---
8S ₂	38°	(100°)	None		None	---	---
9S ₂	38°	(100°)	None		Trace	---	---
10S ₂	38°	(100°)	None		Trace	---	---
1S ₁	60°	(140°)	None		None	None	None
2S ₁	60°	(140°)	None		None	None	None
3S ₁	60°	(140°)	None		None	None	None
4S ₁	60°	(140°)	None		None	None	Trace
5S ₂	60°	(140°)	None		None	None	None
6S ₂	60°	(140°)	None		None	---	---
7S ₂	60°	(140°)	None		None	---	---
8S ₂	60°	(140°)	None		None	---	---
9S ₂	60°	(140°)	None		None	---	---
10S ₂	60°	(140°)	None		None	---	---

¹ Visual Inspection of Test Garments

After 10 treatments (each treatment-staining, prespotting and laundering)



Figure 1.



Figure 2.



Figure 3.



Figure 4.

TABLE 4

SHIRT, UTILITY (DURABLE PRESS) - APPEARANCE RATINGS AFTER TEN LAUNDERINGS

Shirt No.	Seam Type or Stitch	AATCC APPEARANCE RATINGS*					
		Seams		Pockets		Fabric	
		Washing Temperature 38°C. (100°F.)	Washing Temperature 60°C. (140°F.)	Washing Temperature 38°C. (100°F.)	Washing Temperature 60°C. (140°F.)	Washing Temperature 38°C. (100°F.)	Washing Temperature 60°C. (140°F.)
1.	Double Felled	3.0	3.0	3.0	3.0	3.5	3.0
2.	Double Felled	3.0	3.0	3.0	3.0	3.5	3.5
3.	Double Felled	3.0	3.0	3.0	3.0	3.0	3.5
4.	Double Felled	3.0	3.0	3.0	3.0	3.5	3.0
5.	Double Felled	3.0	3.0	3.0	3.0	3.5	3.5
Average Rating		3.0	3.0	3.0	3.0	3.4	3.3
6.	Single Needle	4.0	3.5	4.0	4.0	4.0	3.5
7.	Single Needle	4.0	3.5	4.0	4.0	3.5	3.5
8.	Single Needle	4.0	3.5	4.0	4.0	4.0	3.5
9.	Single Needle	4.0	3.5	4.0	4.0	3.5	3.5
10.	Single Needle	4.0	3.5	4.0	4.0	4.0	3.5
Average Rating		4.0	3.5	4.0	4.0	3.8	3.5

*Appearance Ratings 3.5 and above are satisfactory.

TABLE 5

TROUSERS UTILITY (DURABLE PRESS) - APPEARANCE RATINGS AFTER TEN LAUNDERINGS

Trousers No.	AATCC APPEARANCE RATINGS*					
	Seams		Crease Retention		Front Closure	
	Washing Temperature 38°C. (100°F.) 60°C. (140°F.)	Washing Temperature 38°C. (100°F.) 60°C. (140°F.)	Washing Temperature 38°C. (100°F.) 60°C. (140°F.)	Washing Temperature 38°C. (100°F.) 60°C. (140°F.)	Washing Temperature 38°C. (100°F.) 60°C. (140°F.)	Washing Temperature 38°C. (100°F.) 60°C. (140°F.)
1.	4.0	4.0	4.0	4.0	2.0	4.0
2.	4.0	4.0	4.0	4.0	3.0	4.0
3.	4.0	4.0	4.0	4.0	2.0	3.0
4.	4.0	4.0	4.0	4.0	2.0	4.0
5.	4.0	4.0	4.0	4.0	3.0	4.0
Average:	4.0	4.0	4.0	4.0	2.4	3.6

* Appearance Ratings 3.5 and above are satisfactory.

and colored polyester/cotton clothing* and which is claimed to be very effective in removing oil stains. In this wash formula, a liquid, water-soluble, nonionic detergent is added with the load prior to admitting the water. In this way, the garments are treated with a concentrated detergent solution at a temperature which will not set the oil stains.

*Letter, April 1974, C.O. Navy Resale System Office, Brooklyn, N.Y. to Officer in Charge, US Navy Clothing and Textile Research Unit, Natick, Massachusetts.

w/Incl. 1 - Draft NAVSUP Instruction on Shipboard Laundering Incl. 2 - Navy Wash Formula for Laundering Cottons, Synthetic and Synthetic Blend Fabrics (White and Colored).

APPENDICES

Appendix A

Experimental Section - Phase 1

In Phase 1, a series of laundry tests was performed in a 9.1-kilogram (20-pound) capacity, reversing-type washwheel. The wash load (2/3 of rated capacity) weighing 5.6 kilogram (12 pounds 5 ounces) was made up of two new oil and grease-stained durable press shirts, one pair of worn, stained durable press trousers and ballast consisting of seven trousers and three shirts. After washing, the test garments were extracted, tumble dried, and rated with respect to degree of stain removal.

A. Test Procedures

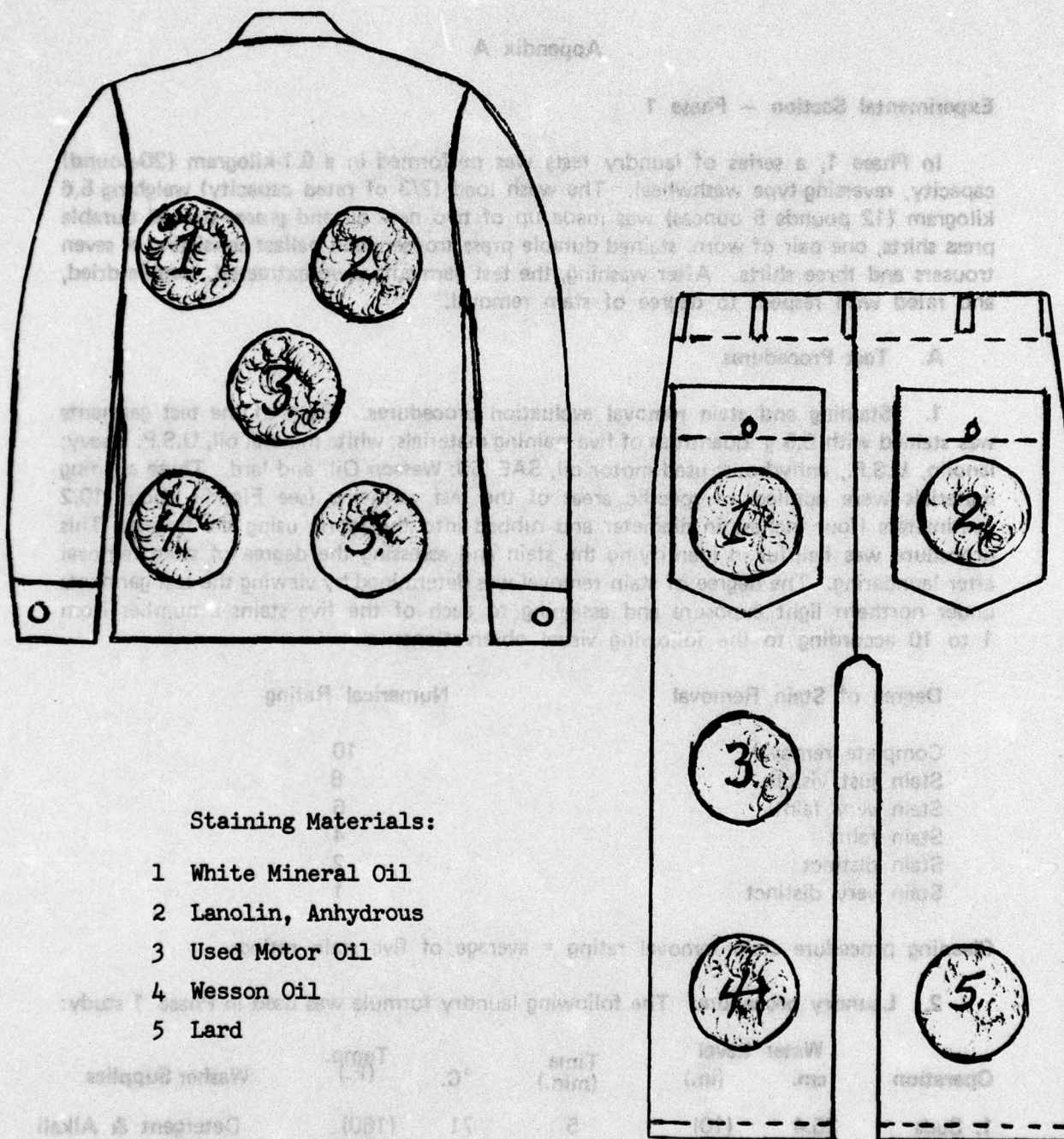
1. Staining and stain removal evaluation procedures. Each of the test garments was stained with 0.5 g. quantities of five staining materials; white mineral oil, U.S.P. Heavy; lanolin, U.S.P., anhydrous; used motor oil, SAE 30; Wesson Oil, and lard. These staining materials were applied to specific areas of the test garments (see Fig. 5) about 10.2 centimeters (four inches) in diameter and rubbed into the fabric using the fingers. This procedure was helpful in identifying the stain and assessing the degree of stain removal after laundering. The degree of stain removal was determined by viewing the test garments under northern light exposure and assigning to each of the five stains a number from 1 to 10 according to the following visual observations:

Degree of Stain Removal	Numerical Rating
Complete removal	10
Stain just visible	8
Stain very faint	6
Stain faint	4
Stain distinct	2
Stain very distinct	1

Cleaning procedure stain removal rating = average of five stain ratings.

2. Laundry procedure. The following laundry formula was used in Phase 1 study:

Operation	Water Level cm.	Water Level (in.)	Time (min.)	°C.	Temp. (F.)	Washer Supplies
1. Suds	25.4	(10)	5	71	(160)	Detergent & Alkali
2. Suds	25.4	(10)	5	71	(160)	Detergent & Alkali
3. Suds	25.4	(10)	5	71	(160)	Detergent & Alkali
4. Rinse	25.4	(10)	3	71	(160)	None
5. Rinse	25.4	(10)	3	63	(145)	None
6. Rinse	25.4	(10)	3	54	(130)	None
7. Rinse	25.4	(10)	3	46	(115)	None
8. Rinse	25.4	(10)	3		Tap	None



Staining Materials:

- 1 White Mineral Oil
- 2 Lanolin, Anhydrous
- 3 Used Motor Oil
- 4 Wesson Oil
- 5 Lard

Figure A-1 Staining of Test Garments — Phase 1.

3. Prespotting procedure. About five minutes prior to laundering, the liquid cleaning agents were applied to the oil-stained areas using a 2-inch paint brush. Sufficient amounts were used so as to thoroughly wet out the fabric.

B. Testing Materials:

1. Test garments.

a. Shirt, Men's, Utility, Durable Press Cotton/Polyester (S₁), Fabric processed by J.P. Stevens Company.

b. Shirt, Men's Utility, Durable Press Cotton/Polyester (S₂), Fabric processed by Reigle Company and tailored by the Hayes Garment Company.

c. Trousers, Men's Utility, Durable Press Cotton/Polyester, Fabric processed by Reigle Company and tailored by the Hayes Garment Company.

2. Detergents.

a. Detergent, Laundry, Powdered, MIL-D-12182, Type I.

b. "Laud", a commercial built laundry detergent, BASF Wyandotte Co.

c. "Brawn", a commercial built laundry detergent, Philadelphia Quartz Co.

3. Laundry alkalies.

a. Sodium orthosilicate, anhydrous, Federal Specification P-S-651.

b. Alkali, Laundry w/CMC, Federal Specification P-A-450.

4. Prespotting agents.

a. NDC spotting agent. Laboratory preparation.

b. "Wisk", liquid laundry detergent, Lever Bros.

c. "Lestoil", liquid heavy duty cleaner, Noxell Corp.

d. "Spray n' Wash", prespotting agent, Texize Chemical.

e. Paint, Oil, Grease Spot Remover FSN 6850-598-3041.

f. Waterless Hand Cleaner, Radiator Specialty Co.

Experimental Section — Phase 2

In Phase 2, the laundry tests were performed in a 27.2-kilogram (60-pound) capacity washer-extractor, a unit from the current, single-trailer Army field laundry. The 18.2-kilogram (40-pound) washer load consisted of 14 pounds of new, durable press, cotton/polyester, utility uniforms (10 shirts and 5 trousers) and a ballast of 11.8 kilograms (26 pounds) of previously laundered uniforms (15 shirts and 15 trousers). One washer load was laundered at a wash temperature of 38°C (100°F.) and a second load at 60°C. (140°F.). The test garments in each washer load were oil-stained with used motor oil, prespotted, washed, extracted, and tumble dried. This procedure was repeated for a total of 10 launderings at each of the two wash temperatures. The test garments were then evaluated for stain removal and the effect on the durable press finish based on their appearance.

Test Procedures

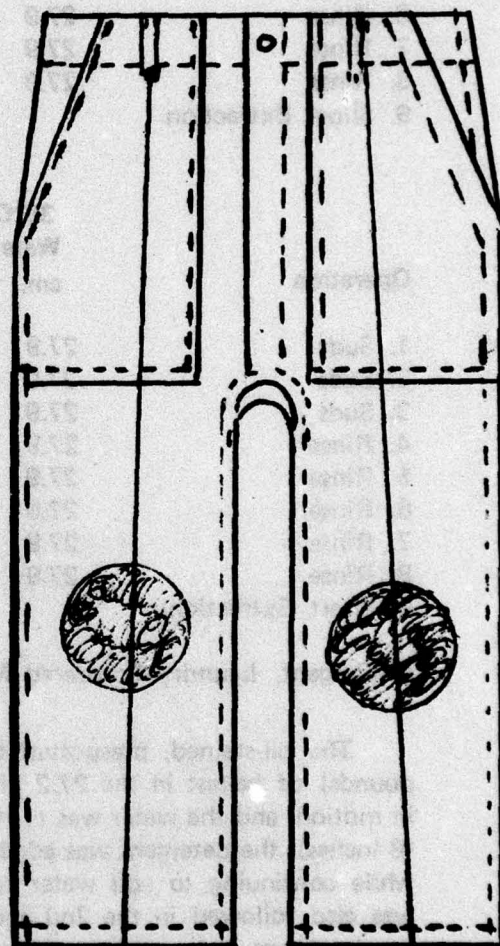
1. **Staining and prespotting procedures.** The test garments were stained with a used motor oil, the staining material which, in Phase 1, proved to be the most difficult to remove. Approximately 1 ml. of oil was applied by eyedropper to an area 4 inches in diameter. The oil was rubbed into the fabric using the fingers, the shirts were stained in the neck band area and on the outside crease of the upper right arm. The trousers were stained on the creases of the right and left legs in the knee areas (see Fig. 6).

The oil stains were allowed to set for 20 to 22 hours. About 5 minutes prior to laundering, the stained areas were wet out by brushing a solution consisting of 95 percent Stoddard Solvent and 5 percent of an oil-soluble nonionic surfactant** prepared by the ethoxylation of petroleum derived C₁₁ to C₁₅ linear alcohols.

2. **Laundry procedures.** The test garments in Phase 2 were laundered in accordance with either of the two wash formulas shown below.

*Detergent, Laundry, Powdered, MIL-D-12182, Type I.

**In this case, Tergitol 15-S-5, which is a commercial surfactant conforming to this chemical description as described in Appendix C, para. 3.2. was used.



Oil-Stained Areas
Used Motor Oil

Figure A-2 Staining of Test Garments — Phase 2.

Operation	60°C. (140°F.) Wash Formula					Wash Supplies
	Water Level		Time	Temp.		
	cm.	(in.)		°C.	(°F.)	
1. Suds	27.9	11	5	60	(140)	5 oz. Detergent*
2. Suds	27.9	11	5	60	(140)	2½ oz. Detergent*
3. Suds	27.9	11	5	60	(140)	1½ oz. Detergent*
4. Rinse	27.9	11	3	60	(140)	None
5. Rinse	27.9	11	3	52	(125)	None
6. Rinse	27.9	11	3	43	(110)	None
7. Rinse	27.9	11	3	35	(95)	None
8. Rinse	27.9	11	3		Tap	None
9. Short Extraction						

Operation	38°C. (100°F.) Wash Formula					Wash Supplies
	Water Level	Time	Temp.			
	cm. (in.)		°C.	(°F.)		
1. Suds	27.9 (11)	5	38	(100)	5 oz. Detergent*	
2. Suds	27.9 (11)	5	38	(100)	2½ oz. Detergent*	
3. Suds	27.9 (11)	5	38	(100)	1½ oz. Detergent*	
4. Rinse	27.9 (11)	3	38	(100)	None	
5. Rinse	27.9 (11)	3	29	(85)	None	
6. Rinse	27.9 (11)	3		Tap	None	
7. Rinse	27.9 (11)	3		Tap	None	
8. Rinse	27.9 (11)	3		Tap	None	
9. Short Extraction		—		—	—	

*Detergent, Laundry Powdered MIL-D-12182, Type I

The oil-stained, prespotted test garments were placed with the 11.8 kilograms (26 pounds) of ballast in the 27.2 kilogram (60-pound) washer-extractor; the wheel was set in motion, and the water was turned on. When the water level reached 20.3 centimeters (8 inches), the detergent was added, marking the beginning of the 5-minutes suds operation while continuing to add water to the 27.9 centimeter (11-inch) level. This procedure was also followed in the 2nd and 3rd suds operations. After the final rinse operation, the load was given a short extraction so as not to set wrinkles in the garments. The test garments were tumbled in a dryer for about 20 minutes at a temperature not exceeding 66°C. (150°F.). The garments were tumbled another 10-15 minutes with the steam turned off so as to cool the garments to near room temperature. When cool, they were immediately removed from the dryer and placed on coat hangers.

Shortly, usually about 1 hour, after removal from the dryer the test garments were restained with motor oil in the designated areas and were ready to be prespotted and laundered on the following day. This procedure was repeated for a total of 10 launderings for each of the two wash temperatures. After the 10 launderings, the test garments were rated for appearance considering the presence of wrinkles, sharpness of creases, puckering at seams, and degree of stain removal.

Appendix B

Procedure for Removing Heavy Oil and Grease Stains from Durable Press, Utility Uniforms, Cotton/Polyester

1. **Prespotting garments for laundering.** Inspect garments for heavy oil and grease stains. Thoroughly wet out the stained areas by brushing them with Spotting Agent (For Removal of Oil and Grease Stains)*.

2. **Laundering procedure.** Load washwheel with prespotted garments to not more than 2/3 of rated capacity.

1st Suds Operation. With washwheel motionless, add water to a low level**, start the washer and add the prescribed laundry detergent and run for 2 minutes. Add more water to bring to a high level** and run an additional 5 minutes. Continue the laundering in accordance with the following wash formula:

Operation	Water Level**	Time (Min.)	Temp. °C.	Temp. (° F.)	Supplies per 45.4 kilograms (100 lbs) of Clothing
1. Suds	low	2	54	(130)	(see instructions above)
	high	5	60	(140)	1 pound Detergent, Type I
2. Suds	high	5	60	(140)	1 pound Detergent, Type I
3. Suds	high	5	60	(140)	½ pound Detergent, Type I
4. Rinse	high	3	60	(140)	None
5. Rinse	high	3	52	(125)	None
6. Rinse	high	3	43	(110)	None
7. Rinse	high	3	35	(95)	None
8. Rinse	high	3		Tap	None
9. Short Extraction (see note below)					

Note: The garments should be extracted for not longer than to let the extractor reach top speed and cut off to prevent setting of creases. Dry the garments in a tumble dryer loaded to not more than 2/3 of rated capacity. When exhaust temperature reaches 60°C. (140°F.) to 66°C. (151°F.), the heat should be turned off and the garments tumbled until they are cooled to near room temperature, and then should immediately be placed on hangers.

*As in Proposed Federal Specification — Appendix C.

**Low level is 12.7-15.2 centimeters (5-6 inches). High level is 27.9-35.6 centimeters (11-14 inches) depending upon the washer.

Appendix C

Proposed Federal Specification: Spotting Agent, Laundry (For Removal of Oil and Grease Stains)*

1. Scope and classification.

1.1 **Scope.** This specification covers a liquid spotting agent for removing oil and grease stains from washable fabrics including durable press when applied to stains prior to laundering.

3. Requirements.

3.1 **Material.** The spotting agent shall be a clear, single-phase liquid consisting of a solution of an oil-soluble nonionic surfactant in an aliphatic petroleum distillate and shall conform to the requirements in Table I.

TABLE C-1. - Composition

	Percent by Weight	
	Min.	Max.
Matter nonvolatile at 95°C. (203°F.)	4.9	5.4
Aliphatic petroleum distillate ¹	94.5	95.0
Oil-soluble nonionic surfactant ²	5.0	5.5
Flash point, Tag Closed Cup, °C. (°F.)	60°C.(140)	—
Chlorinated solvents, qualitative test	"negative" test	

¹ Shall conform to the requirements of Federal Specification P-D-680, Type II.

² See Par. 3.2.

3.2 **Nonionic surfactant.** The surfactant contained in the Spotting Agent shall be an oil-soluble surface active agent prepared by the ethoxylation of petroleum derived linear alcohols in the C₁₁ to C₁₅ range and containing an average of 5 moles of ethylene oxide. It shall meet the following requirements:

*Only those areas concerned with the technical requirements of this product are covered in this proposal.

	Minimum	Maximum
Molecular weight	400	425
Water, percent	---	0.5
Specific gravity 25/25°C.	0.960	0.980
pH, 1% solution at 25°C.*	6	8
Biodegradability, percent	90	---

*Determined in a 10:6 isopropanol:water solution.

3.3 Odor. The spotting agent shall have a mild odor essentially that of Stoddard Solvent.

3.4 Labeling. In addition to the markings specified in Section 5, each container shall be durably and legibly labeled with the following directions:

"Directions for Use

Apply the spotting agent to oil and grease stains using a paint brush or other soft bristled brush. Thoroughly wet out the stained fabric. Allow to set for about 5 minutes; then place the treated garments in washer and launder in accordance with the established washing formula."

Also include the following cautionary statements:

"Caution. Contains flammable solvent. Keep away from flame and extreme heat. Use only with adequate ventilation. Avoid prolonged breathing of vapor.

Contains petroleum distillate. If swallowed do not induce vomiting. Call physician immediately.

Keep out of reach of children."

3.5 Workmanship. The spotting agent shall be a clear liquid, free from sediment, suspended matter and undissolved water as determined by visual inspection.

Section 4

4. Testing of the end item. The spotting agent will be tested for the characteristics specified in Table II.

TABLE C-2. - Instructions for Testing

Characteristic	Spec. Reference Requirement	Test Method	Number of Determinations	Pass or Fail	Results Reported as Numerically to Nearest
Matter nonvolatile at 95°C. (203°F.)	Table I	4.4.1	2	—	0.1
Aliphatic petroleum distillate	Table I	*	—	—	—
Oil-soluble nonionic surfactant	Table I	*	—	—	—
Flash point, tag closed cup	Table I	**	—	—	—
Chlorinated solvent	Table I	4.4.2	1	x	—

*The supplier shall furnish a certificate of compliance covering this requirement.

**ASTM Method D56-64.

4.4 Test procedures.

4.4.1 Matter nonvolatile at 95°C (203°F.). Into a tared, low-form weighing bottle (70 mm inside diameter and 33 mm height) weight to the nearest 0.1 milligram a 10-ml. sample of the spotting agent. Remove the glass stopper and place sample on a billowing steam bath for one hour. Remove from steam bath and place in a forced-air-circulation oven at $95^{\circ} \pm 1^{\circ}\text{C}$. for 15 minutes. Remove sample from oven; replace glass stopper; cool in desiccator, and weigh the nonvolatile matter. Calculate as follows:

$$\text{Percent matter nonvolatile at } 95^{\circ}\text{C.} = \frac{\text{Weight of nonvolatile matter} \times 100}{\text{Weight of sample}}$$

4.4.2 Detection of the presence of chlorinated solvents. The following qualitative test shall be applied to the spotting agent:

a. Adjust a Bunsen flame to the non-luminous condition. Heat a piece of copper wire in the flame, and plunge it into ethyl alcohol (two inches in a small test tube is sufficient). When the wire itself imparts no color to the flame, it is clean.

b. Dip the cool, clean wire into the spotting agent, and insert it into the edge of the flame. Observe closely at the moment of insertion.

c. A green color imparted to the flame, sometimes only a momentary flash, is due to the volatilization of copper chloride and is considered a "positive" test for chlorinated solvents.

Section 5

Spotting agent shall be packaged in 1-gallon and 5-gallon metal containers.

Section 6

6. Notes

6.1 Intended use. The spotting agent covered by this specification is intended for use by institutional and home laundries for the removal of oil and grease stains from washable fabric items including durable press garments, sleeping bags, duffle bags, and lightweight load-carrying equipment.