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THE SUB-FABRIC FLASH BURN: A STUDY OF COVER FACTOR
IN ITS EFFECT ON PROTECTIVITY OF COTTON OXFORDS

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E R R A T U M

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An error has been noted on page 9, line 10.

Reference (4) of the Bibliography should read:

Mixter, G. Jr., and Krolak, L. J. Studies of
Flash Burns: The Influence of Transmittance of
Fabrics on Protectivity. University of Rochester
Atomic Energy Project Report, UR-388, (1955).

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ABSTRACT

Using the clipped, anesthetized white pig as an indicator, the protectivity from thermal radiation of a series of cotton oxford fabrics was studied. No gross qualitative or quantitative relationship between cover factor and burn protection was observed in the series of fabrics available.

NOTE: This study was carried out through the facilities of the University of Rochester Atomic Energy Project, under contract with the U. S. Atomic Energy Commission, and a portion of its expenses defrayed under a grant from the Quartermaster Corps, U. S. Army.

Table 1

Designation of Fabric	Surface Density (oz/yd ²)	Reflectance	Transmittance	Cover Factor K	Thickness (in.)
CF ₁	7.96	.658	.201	44.2	0.016
CF ₂	7.54	.666	.201	46.1	0.015
CF ₃	7.58	.685	.198	47.1	0.016
CF ₄	7.11	.664	.206	47.9	0.015
CF ₅	7.08	.649	.204	49.1	0.014

Table 2

Sub-Fabric Burn Thresholds

Fabric (Contact)	0.5 Sec. Exposures		5.0 Sec. Exposures	
	2+ EE ₅₀ (cal/cm ²)	95% C. I. (cal/cm ²)	2+ EE ₅₀ (cal/cm ²)	95% C. I. (cal/cm ²)
CF ₁	6.95	6.6 -7.35	7.2	6.73-7.7
CF ₂	7.45	6.9 -8.0	7.8	7.3 -8.35
CF ₃	6.75	6.35-7.2	7.8	7.3 -8.35
CF ₄	7.05	6.53-7.6	7.6	7.05-8.2
CF ₅	6.55	6.1 -7.05	7.4	6.95-7.9
None (Control)	3.1	2.87-3.34	4.3	3.9 -4.75

INTRODUCTION

Cover factor is a numerical expression for the tightness of weave of fabrics, and is related to the ratio between the total space and the covered space per unit area. It is defined (1) as:

$$K = \frac{\text{mean no. of threads per inch of warp or filling}}{\sqrt{N}}, \text{ the yarn no. for warp or filling}, \text{ and}$$

the mean cover factor, $\bar{K} = K_w + K_f$.

The purpose of the present study was to determine what, if any, was the effect of this parameter so defined upon the protectivity to living skin of cotton cloth from radiant thermal energy.

Materials and Methods

From the Quartermaster Corps, U. S. Army, was obtained a series of five unbleached cotton oxfords, treated with a water repellent, but undyed; these encompassed the widest possible range of cover factors that could be applied with relatively constant fabric weights and reflectances. The average surface density in oz/yd², the reflectances and transmittances for the University of Rochester arc source (2) were all determined in this laboratory (3, 4). Table 1 presents the physical characteristics of these five fabrics.

Determination of the EE_{50} for sub-fabric 2+ burns in anesthetized young white pigs was carried out for 0.5 and 5.0 sec. trapezoidal exposures with fabric in contact with skin, using methods previously described (5, 6). Graphical probit analysis of the exposure-response data was carried out by the method of Litchfield and Wilcoxon (7).

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EFFECT OF COVER FACTOR OF FABRIC ON SUB-
FABRIC BURN THRESHOLDS OF PIGS.

5

6

EFFECT OF COVER FACTOR, CORRECTED FOR EXPOSURE
TIME, REFLECTANCE AND FABRIC WEIGHT.

x—x 0.5 Sec.

o--o 5.0 Sec.

RESULTS

MOISTURE

The exposure-response data obtained from burns on pigs are presented in the Appendix. Table 2 gives the $2+EE_{50}$ estimates and the 95% confidence limits about them. Figure 1 shows a plot of $2+EE_{50}$ as a function of cover factor. Previous studies have shown the quantitative significance of reflectance and of the weight of fabric; since these were not constant throughout the cover factor series, an attempt has been made to allow for these parameters in the evaluation of cover factor alone. In a manner similar to that previously employed (6), the expression

$$Q = \frac{At^{\alpha} (k + k'd t^{\beta})}{1 - R}$$

is calculated for each situation, where

(1) A and α are constants derived from bare skin

t = exposure time

R = reflectance of fabric

k = k^2 , the "apparent reflectance" of bare skin (8)

k' and β are constants derived for cotton sateens (6)

Now let

$$Q_{if} = \frac{At^{\alpha} (k + k'd t^{\beta})}{1 - R} x$$

where

Q_{if} = the observed $2+EE_{50}$ of pig skin under these fabrics,

and

x = the correction factor for this series.

We may now plot x as a function of $\bar{K}$, the mean cover factor, eliminating the factors of fabric weight, reflectance and exposure time in accordance with previously established principles. Figure 2 shows such a plot of the data of this experiment. It would be difficult to conclude from this chart that, in the small range studied, cover factor had any significant systematic effect upon the protective quality of fabrics, once other known parameters are allowed for.

DISCUSSION

While it appears from this study that the tightness of weave, considered by itself after elimination of the known effects of other cloth parameters, does not affect protectivity to a significant degree or in a systematic fashion, one must admit a) that the actual range of cover factors studied is relatively narrow, and b) that the fabrics studied were highly transmissive, whatever the cover factor.

Speaking in terms of energy, it would appear logical that the burn produced would be the result of the summation (in some as yet undetermined fashion) of energy directly transmitted by the fabric, with that absorbed by fabric and transported by Newtonian transfer to the skin. The data here presented have been treated thus in another publication (4); without a completely satisfactory resolution of the problem. This is probably due, in part at least, to differences in weave (oxford is a simpler, less compact weave than sateen) and treatment (these fabrics contain no carboxymethylcellulose, and do have an added water-repellent chemical). In any case, it would seem rational to express the transmissive qualities of fabrics rather in terms of spectral transmittance than in terms of "cover factor", for which, optically speaking, there is no absolute frame of reference.

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APPENDIXBARE SKIN CONTROL

Exposure Time (sec)	Q (cal/cm ²)	Burn					
		0	1+ Mild	1+ Sev	2+ Mild	2+ Mod	2+ Sev
0.5	2.58	1	2	4			
	2.85		3	2	2	1	
	3.17		1	3	4	1	
	3.55			2	5	2	
	3.95				1	1	1
	4.35				1	1	
	4.80						1
5.0	2.85		6				
	3.25		8				
	3.60		3	3	2		
	4.5			3	3	2	
	4.95			1	1	7	
	5.45				1	2	
	5.95					1	
	6.50					1	
	7.25					1	

APPENDIX (Continued)

CF₁, Contact

Exposure Time (sec)	Q (cal/cm ²)	Burn					
		0	1+ Mild	1+ Sev	2+ Mild	2+ Mod	2+ Sev
0.5	5.9		2	4			
	6.5		2	4	3		
	7.15			4	5		
	7.7			1	5	3	
	8.45				6	2	1
	9.2					3	
5.0	5.45	1	2	3			
	5.95	2	1	4	1		
	6.5	2	2	3	1		
	7.25		2	4	0	2	
	8.0			1	6	1	1
	8.75				1	2	
	9.7					1	
	10.5						1
	11.5						1

APPENDIX (Continued)

CF₂, Contact

Exposure Time (sec)	Q (cal/cm ²)	Burn					
		0	1+ Mild	1+ Sev	2+ Mild	2+ Mod	2+ Sev
0.5	5.35		1	1			
	5.9		1	1			
	6.5		1	8			
	7.15		3	2	4		
	7.7			2	6	0	1
	8.45		1	2	4		
	9.2				4	3	
5.0	5.95	1	0	3			
	6.5		1	6	2		
	7.25		2	5	1		
	8.0			1	4	4	
	8.75			3	2	4	
	9.7					4	
	10.5						1
	11.5						1

APPENDIX (Continued)

CF₃, Contact

Exposure Time (sec)	Q (cal/cm ²)	Burn					
		0	1+ Mild	1+ Sev	2+ Mild	2+ Mod	2+ Sev
0.5	5.35	1	5	2			
	5.9	1	2	4	1		
	6.5		1	3	5		
	7.15		2	1	5	1	
	7.7			3	6		
	8.45				1		
	9.2					1	
5.0	5.95	1	1				
	6.5	2	1	5	1		
	7.25		3	3	2		
	8.0			6	1	2	
	8.75			1	4	3	1
	9.7					2	5
	10.5					1	
	11.5						1

APPENDIX (Continued)

CF₄ Contact

Exposure Time (sec)	Q (cal/cm ²)	Burn					
		0	1+ Mild	1+ Sev	2+ Mild	2+ Mod	2+ Sev
0.5	5.35		2	1			
	5.9		3	2	1		
	6.5		3	2	3	1	
	7.15		1	4	4		
	7.7			3	4	2	
	8.45			1	5		
	9.2				3		
5.0	5.95		4	2			
	6.5		2	5	1		
	7.25		2	2	3	1	
	8.0		1	3	3	2	
	8.75				7	1	1
	9.7					4	
	10.5						1

APPENDIX (Continued)

CF₅, Contact

Exposure Time (sec)	Q (cal/cm ²)	Burn					
		0	1+ Mild	1+ Sev	2+ Mild	2+ Mod	2+ Sev
0.5	5.35		2	1			
	5.9		3	2	1		
	6.5			1	5	2	
	7.15			1	5	3	
	7.7		1	1	3	1	
	8.45				2	1	
	9.2					1	
5.0	5.95	1	3	3			
	6.5		1	6	1		
	7.25			4	4		
	8.0			4	4	1	
	8.75				4	5	
	9.7					2	
	10.5						1
	11.5					1	