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PROTECTION FROM RADIANT THERMAL ENERGY BY FABRICS USED AS A SHIELD

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ABSTRACT

The behavior of three important fabrics exposed to thermal energy from the explosion of 150 gms. of magnesium flash powder at a distance of 25 cm. from the cloth and the ability of these fabrics to protect pig skin against such heat have been investigated.

In this experiment the fabric at 25 cm. from the flash received from 16 to 18 cal/cm², and the unshielded pig's skin, which was 5 cm. farther away, received 13.5 cal/cm².

If the fabric ignites and burns slowly, the cutaneous burns behind it are deeper than those produced on the unshielded skin. If the fabric burns rapidly, either no burn or a relatively mild burn results.

INTRODUCTION

The relative value of fabrics in providing protection from flashes of thermal radiation has been studied by numerous observers (1, 2, 3, 4, 5, 6). Many fabrics are currently being evaluated for their protective value as well as for their effect on the cutaneous burn which might result beneath them. The present experiment evaluates the behavior of three fabrics of army issue when used as a draped shield and exposed to thermal radiation from burning magnesium. The effectiveness of these fabrics as protection against radiant energy burns is determined.

MATERIALS AND METHODS

The materials tested were supplied by the Quartermaster Corps., U. S. Army and were identified as:

1. Cloth, cotton poplin, 5 oz. O.G. 116, fire resistant treated, w/Lynrus S 123P.
2. Cloth, cotton sateen, 8.5 oz. O.G. 107, wind resistant, untreated.
3. Neoprene-coated Fortisan, 7.7 oz., TDA 1139.

The experimental animals were young Chester White pigs which were anesthetized with 60 - 65 mgm/Kg. of Dial with urethane (Ciba) intraperitoneally. The hair was closely clipped from their sides and the skin was gently washed. They were placed behind a transite shield with a circular exposure port three inches in diameter.

The energy source was 150 gm. charges of magnesium flash powder ignited in a Y-shaped tray (7). This quantity of magnesium has been found to

deliver 13.5 cal/cm^2 in approximately 0.7 seconds to an object 30 cm. away (7). A 36 inch square of the fabric being tested was hung from two of its corners at a distance 25 cm. from the magnesium source and 5 cm. in front of the pig's skin. It was estimated by interpolation from previous work (7) that the cloth received 16 - 18 cal/cm^2 . The 5 cm. distance between the energy source and the fabric should avoid direct contact between the two during the explosion.

Three exposures with each of the three fabrics and of one bare skin control were randomly assigned sites on both sides of one pig. These ten exposures were replicated three times for a total of 30 burns on three pigs. The lesions were evaluated by surface appearance at 24 hours after burning according to the method established in this laboratory (8):

- 0 - No burn
- 1+ - Erythema
- 2+ - Spotty white coagulation
- 3+ - Complete coagulation
- 4+ - Steam bleb formation
- 5+ - Charring

Burns with surface assessments of 1+ and 2+ have been found to represent at most superficial dermal damage (9). Because of this, only burns of greater surface severity were biopsied. These biopsies were taken 24 hours after burning and included normal skin adjacent to the burn. They were stained by Hinshaw's Method (10) for differentially staining burned tissue. The maximum depth of damage as well as the proportion of the thickness of the dermis burned was measured and the results tabulated.

In addition, a color motion picture was taken to record in detail the behavior of the fabrics during and after the exposure.

RESULTS

The behavior of the three fabrics and the skin reactions observed behind them are recorded in Tables 1 and 2.

The unshielded skin exposures result in uniform 4+ burns which are 0.3 to 0.4 mm. deep or approximately 1/4 full dermal thickness.

The 5 oz. fire resistant material bursts into flame during the magnesium flash and sustains the blaze for several seconds after the flash is over. A strip down the center of the fabric chars for about the length of the magnesium tray and, though intact, it fragments on the slightest manipulation. Either no burn or 1+ burns occur behind this fabric.

The 8.5 oz. untreated fabric bursts into flame and burns relatively slowly until it is consumed. Three plus burns varying in depth from 0.6 mm. to 2.1 mm. result. This represents dermal damage from 1/4 full thickness to full thickness.

The neoprene-coated fabric also bursts into flame, burns briskly for several seconds after the flash, and produces a moderate amount of acrid smoke. It usually fragments very quickly so that the flaming material falls away from the exposure port. The skin is not usually burned, except where the hot material comes in contact with the skin. In these instances 1+ to 3+ burns are produced over a small area of the exposed surface and microscopic assessment shows either no dermal damage or damage up to 1/4 the total dermal thickness.

TABLE 1

RESULTS OF ASSESSMENT OF THE PIG'S SKIN AFTER NINE EXPOSURES WITH EACH OF THESE FABRICS EXPRESSED BY SURFACE SEVERITY, DEPTH OF DERMAL DAMAGE IN MILLIMETERS, AND PROPORTION OF TOTAL THICKNESS OF DERMIS DAMAGED. MAGNESIUM IN 150 GM. CHARGES DELIVERED 16 - 18 CAL/CM² TO THE FABRICS AT 25 CM. AND 13.5 CAL/CM² TO THE BARE SKIN AT 30 CM.

Cloth	Surface Severity**	Depth of Dermal Damage in Millimeters**	Proportion of the Total Thickness of Dermis Damaged**
1. 5 oz. O.G. Cotton, Poplin, Fire Resistant	0, 0, 0, 1+*, 1+*, 1+*, 1+*, 1+*, 1+	No Dermal Damage	No Dermal Damage
2. 8.5 oz. O.G. Cotton Sateen, Untreated	2+, 3+, 3+, 3+, 3+ 3+, 3+, 3+, 3+	.2, .6, .9, 1.0, 1.2, 1.4, 1.7, 2.0, 2.1	1/4, 1/4, 1/2, 1/2, 1/2, 1/2, 3/4, 3/4, 4/4
3. 7.7 oz. Neoprene-coated Fortisan Poncho	0, 0, 0, 0, 0, 1+, 1+, 2+, 3+*	-, -, -, -, -, -, -, -, .4	-, -, -, -, -, -, -, -, 1/4
4. Bare Skin, Control	4+, 4+, 4+	.3, .4, .4	1/4, 1/4, 1/4

* This represents maximal severity over 1/2 or less of the total areas exposed.

** These burns are all listed in the same sequence.

TABLE 2

THE BEHAVIOR OF THE FABRICS UPON EXPOSURE TO 16 - 18 CAL/CM²
FROM A MAGNESIUM FLASH 25 CM. AWAY

1. Cloth, cotton poplin, 5 oz. O.G. 116, fire resistant treated,
w/Lynrus S 123P.

The cloth bursts into flame during the magnesium flash and a central strip about the width of the magnesium tray blazes briskly for several seconds after the flash. Flames come from both surfaces of the cloth and some smoke is produced during the burning. After the exposure, tar is present on the pig's skin, and the fabric is charred and brittle.

2. Cloth, cotton sateen, 8.5 oz. O.G. 107, wind resistant, untreated.

This fabric bursts into flame during the magnesium flash and burns with a well sustained flame until the cloth is entirely consumed.

It remains intact and in position for a long period of burning. Tars are in some instances noted on the burned skin.

3. Neoprene-coated Fortisan, 7.7 oz. TDA 1139.

This fabric bursts into flame during the flash and a central area burns briskly. The fabric burns in two and falls away from the exposure port. The damaged area is charred, brittle, and blistered on the side opposite the flash. A moderate amount of acrid smoke is produced.

DISCUSSION

It would seem that burns produced behind these three fabrics result from flaming cloth rather than from any significant amount of the initial radiant dose reaching the skin through the fabric. If the material burns very quickly, as does the 5 oz. fire resistant fabric, or falls away from the skin before burning for a prolonged time, as does the neoprene-coated poncho, no burn or only slight burns result. On the other hand, if the cloth remains in position and burns slowly, as does the 8.5 oz. untreated fabric, the shield can be a hazard since severe burns result. Fabrics like the poncho, which burns in two and falls, may also be hazardous if used overhead.

These data indicate that shielding with fabrics draped at a distance from skin can provide a very high degree of protection if the skin is 5 cm. or more behind the shield and if the shield itself burns briefly, or not at all. None of the fabrics tested retains enough strength to be serviceable after exposed to the amount of thermal energy applied in this experiment.

SUMMARY AND CONCLUSIONS

1. Three important fabrics were placed 5 cm. in front of white pig's skin and exposed to 150 gm. magnesium flash powder explosions that delivered 16 - 18 cal/cm² to the fabric. The behavior of the fabric was recorded and photographed and the cutaneous burns were evaluated by surface and microscopic assessment at 24 hours after burning.
2. Burns of greater depth than those on bare skin occurred behind 8.5 oz. O.G. untreated cotton sateen which was consumed slowly by flame. Thus, this material was hazardous when used to shield the animal.

3. Five oz. O.G. fire resistant treated cotton poplin blazed briefly but provided almost complete protection to the animal. The center of this fabric was charred and useless after the explosion.
4. When the third fabric, a neoprene-coated poncho material, was exposed it burned in two and usually fell away from the pig so that only an occasional burn resulted from contact with the flame or hot fabric.
5. We believe that the cutaneous burns observed were the result of flaming rather than the energy transmitted through the cloth.

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