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THE HAZARD OF USING THE GOVERNMENT ISSUE CREAM
FOR PROTECTION AGAINST FLASH BURNS

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THE HAZARD OF USING THE GOVERNMENT ISSUE CREAM FOR PROTECTION
AGAINST FLASH BURNS

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ABSTRACT

Our recent study of burns under black and white paint films indicated that energy absorbed by the films contributes greatly to burn severity. This led to an evaluation of the flash cream issued by the Government for military use. Because it was impossible to apply the recommended 1/16 inch layer of cream even with a template and spatula, a thinner, more realistic layer was used in these experiments. The median effective exposures necessary to produce 2+ burns at exposure times of 0.3 sec., 3.0 sec., and 30.0 sec., were determined for bare skin and for skin covered with the Government Issue cream.

At the two shorter exposure times, only one-half as much energy is required to produce a 2+ burn on skin treated with the "protective cream" as is needed when the skin is bare. This conclusion was so startling that the results were checked in another way. A constant radiant exposure of 3.5 cal/cm² was delivered in 0.3 seconds to a number of bare and cream-covered exposure sites. Surface and microscopic evaluations of the severity of the burns revealed that burns under the cream were about two times deeper than those produced on bare, unprotected skin.

In addition, it was found that the cream can be ignited with a match and, if it is applied to the skin in the thickness recommended, it will burst into flame at exposures of 15 cal/cm² delivered in one second. Thus, this cream, which is issued as a protective device, is actually a hazard.

INTRODUCTION

The attack on Pearl Harbor resulted in many flash burns of Navy personnel from bomb bursts, ignition of gasoline and explosion of ammunition. The burns usually occurred on skin unprotected by clothing, and those of the hands and face were particularly incapacitating. As a result of this experience, the Naval Medical Research Laboratory initiated experiments to develop a cream for the protection of exposed body areas. The formula for such a cream was reported by Fauley and Ivy (1), and the specifications of this formula were subsequently approved by the Departments of the Army, Navy and Air Force. It was procured for government issue under specification number MIL-C-12140A which was last revised on 31 January 1953.

The atomic bombing of Hiroshima and Nagasaki caused many thousands of casualties from flash burns, making an increase in our knowledge of this condition imperative. Since 1948, we have studied this lesion and how it might be modified by environment, radiant dose, time of exposure, clothing and medical management. During this time we have received samples of various flash creams for evaluation, but have never done this because their composition was either unknown or too complex for analysis. Recently we decided to approach the problem by studying the effect on burn severity of black and white films painted on the skin (2). India ink and titanium dioxide were used to give maximum differences in reflectance, and burns under these coated surfaces were compared to those on bare skin. Analysis of the results showed a complex situation in which reflectance, transmittance and absorptance of the film played a part. Consideration of all of these factors allowed the formulation of a mathematical expression which should be useful in evaluating any existing flash cream or in selecting the desirable components for a new cream.

We were interested in checking this hypothesis on creams of known composition. The logical one to use was the government issue cream which was available. We were startled to find that this so-called "protective flash burn cream," which was stated to "provide good protection to the skin when applied before exposure to high temperature flashes" was in reality a hazard. Not only was it flammable, but the burns beneath it were twice as deep as those on bare skin.

This led to our comparing the effect of one of the first non-flammable, experimental creams developed by the Quartermaster Corps of the Army. The results from using this cream were better at longer exposure times. It should be emphasized that this particular cream is still in an experimental stage. Results from its use are reported here only to give a comparison with the government issue flash cream.

METHODS

Materials

The two creams which were used for study were identified as:

1. Cream, Protective, Flash Burn, 51-C-1690

This is a gray, water soluble cream packed in 4.5 oz. O. D. cans and is currently the government issue protective cream. The following composition appears in a military specification, MIL-C-12140A 31 January 1953:

<u>Ingredients</u>	<u>Parts by Weight</u>	<u>Tolerance Plus or Minus</u>
Shellac	13.70	0.1
Isopropanol, 99 per cent	28.48	.1
Linseed oil, bodied	3.50	.1
Stearic acid, triple pressed grade	0.15	.01
Triethylene glycol di-2-ethylbutyrate, (triglycol dihexoate)	.80	.05
Diethylene glycol monoethyl ether	1.10	.05
Titanium dioxide	37.00	.1
Borax	2.25	.05
Magnesium stearate	8.00	.05
Homo menthyl salicylate	2.50	.05
Sodium lauryl sulfate	.30	.05
Mineral black	2.22	.05

This formula is identical with that published by Fauley and Ivy (1) except for the addition of the tolerances allowed. Ingredients of the highest purity are specified, yet one wonders why some of these compounds are included. Certainly the flammable ones, i. e., shellac, isopropanol and linseed oil, would not appear desirable for protection against burns. Titanium dioxide is apparently used for its high reflectance, but the addition of mineral black in part vitiates this.

This cream will hereafter be called G. I. in this paper.

2. Non-flammable Experimental Cream #200-X

This is one of a series of experimental "flash creams" prepared by the Quartermaster Corps; it is water soluble and flesh colored. The composition is:

<u>Ingredients</u>	<u>Parts by Weight</u>
Methocel	1.78
Sorbitol (70% solution)	8.17
Chlorowax 40	12.00
Freon 112 emulsion	10.20
PVP	1.63
Titanium dioxide	24.50
Magnesium carbonate	10.40
Iron oxide	0.42
Water	24.70
Isopropanol (99%)	6.20

This will be identified as "Exp. Pink" cream.

Animals

Young Chester White pigs weighing 8 - 12 Kg were anesthetized with intra-peritoneal Dial in Urea-urethane (Ciba) in doses of 70 mg/Kg. The hair was closely clipped from both sides of the animals and the skin was gently sponged with water and a detergent. The ambient temperature of the laboratory was controlled to decrease the effects of variation in skin temperature (3).

Heat Source

Burns were produced with a modified 24 inch Army carbon arc searchlight (4, 5).

Experimental Design

Exposure times of 0.3 sec., 3.0 sec., and 30.0 sec. were used. Each skin condition, the two test creams and a bare skin control, was exposed to four irradiances, separated by 10% increments, for each time. This made a total of 36 treatments. All treatments were assigned to a randomized block on the side of a pig and 15 replications were performed, giving a total of 540 burns. In addition, a random block of 30 burns, 15 on bare skin and 15 under the G. I. cream, was given a uniform 0.3 sec. exposure to 3.5 cal/cm² so that the injuries could be compared directly, both by surface and microscopic evaluation.

The instructions for the G. I. cream as it is now issued call for an application of 1/16 inch thick on the skin. Why and when this requirement was added is not clear. We found that a 1/16 inch layer was impossible to achieve with any degree of uniformity even with the use of a template and spatula. The cream is thick and sticky so that any application results in ridges and valleys. Finally a more realistic but less scientific method was used. The cream was dipped up on the fingers and smeared over the surface as was recommended by the Navy in 1945 (6). This gave a thinner, fairly uniform application but the absolute thickness of the layer was not controlled. Due to its consistency, the layer of G. I. cream was usually thicker than that of the experimental pink cream; the latter also tended to flake and come off with drying.

All burns were assessed by surface appearance 18 - 24 hours after exposure according to the criteria established in this laboratory (7):

- 0 - No burn
- 1+ - Erythema
- 2+ - Patchy whiteness
- 3+ - Uniform whiteness
- 4+ - Steam bleb
- 5+ - Carbonization

The 30 burns produced by a uniform exposure to 3.5 cal/cm^2 in 0.3 sec. were biopsied at 24 hours. Specimens were fixed in 10% formalin and stained by Hinshaw's Method to differentiate burn damaged tissue (8). Damage in each section was measured at the point of greatest depth with a micrometer in the eyepiece of the microscope.

The data were analyzed by the graphic probit method of Litchfield and Wilcoxon (9) to obtain an expression of the median effective radiant exposure for 2+ burns for each exposure time and skin condition.

Reflectance and transmittance values for both creams were determined by a method which Krolak has previously described (10).

RESULTS

The experimental data are listed in a dose-response table (Appendix 1) which is arranged according to exposure time, skin covering and radiant exposure. From these data it was possible to obtain, by graphic probit analysis, an expression of the median effective radiant exposure for 2+ burns for each cream at each exposure time. These values, and 95% confidence limits, are listed in Table I.

It is apparent that for 0.3 sec. exposures the median effective radiant exposures for both creams are significantly lower than that for the bare skin control. Particularly noteworthy is the finding that approximately half of the energy required to produce a 2+ burn on bare skin will do equivalent damage under the G. I. cream. Further, at both 3.0 sec. and 30.0 sec. significantly less energy is required for the 2+ burn under the G. I. cream than on bare skin. On the other hand, at 3.0 sec. the pink cream coincides with bare skin in median effective exposure and at 30.0 sec. requires a significantly greater exposure for a 2+ burn than does bare skin.

TABLE I

MEDIAN EFFECTIVE RADIANT EXPOSURES FOR 2+ BURNS AND PROTECTIVE
INDICES FOR EACH EXPOSURE TIME AND SKIN SURFACE

Exposure Time (sec)	Surface	2+ Median Effective Exposure (cal/cm ²)	95% Confidence Limits	Protective Index
0.3	G. I. Cream	1.5	1.4 - 1.7	.56
	Bare Skin	2.7	2.6 - 2.9	1.00
	Exp. Pink	2.3	2.1 - 2.4	.85
3.0	G. I. Cream	2.3	2.1 - 2.4	.56
	Bare Skin	4.1	3.9 - 4.3	1.00
	Exp. Pink	3.8	3.6 - 4.1	.93
30.0	G. I. Cream	5.0	4.6 - 5.3	.74
	Bare Skin	6.8	6.4 - 7.1	1.00
	Exp. Pink	8.4	7.7 - 9.2	1.23

These differences may be conveniently expressed as a "protective index" which is derived by dividing the median effective exposure for the cream by that of bare skin for the same exposure time. These values are also listed in Table I.

It should be noted that the data on bare skin controls are in very close agreement with our previous experience (2, 11).

Krolak determined the reflectance and transmittance of both creams and bare skin to the wavelength distribution of the 24 inch arc as follows:

TABLE II

Surface	Reflectance	Transmittance
G. I. Cream	.22	.02
Exp. Pink	.65	.14
Bare Skin	.40	

The reflectance value for bare skin agrees with previous findings (10).

For a direct comparison of burn damage, both bare skin and skin covered with the G. I. cream were exposed to 3.5 cal/cm^2 in 0.3 sec. Damage was evaluated by both surface appearance and microscopic measurement. These results are listed in Appendices 2 and 3. Expressions of the median depth of damage as well as the most severe damage for both skin conditions are given in Table III where it is seen that, by either criterion, significantly greater damage occurs under the G. I. cream. This is illustrated in Fig. 1.

Pilot sutides included layers of cream up to $1/16$ inch in thickness. It appeared that increasing thickness increased protectivity, but uniformity could not be achieved. Thick layers of the G. I. cream burst into flame

TABLE III

MEDIAN DAMAGE FOR 0.3 SEC. EXPOSURE TO 3.5 CAL/CM²

BY BOTH SURFACE AND MICROSCOPIC CRITERIA

Skin Surface	Median Surface Grade	Most Severe Surface Grade	Median Depth of Damage	Most Severe Dermal Damage
Bare Skin	2+ Mod	2+ Sev	Partial Epidermal Separation	.15 mm
G. I. Cream	2+ Sev	3+	.12 mm	.37 mm

Fig. 1

Bare Skin - X 120

Skin covered with G. I. Flash Cream - X 120

A comparison of the median, microscopic, depth of damage in bare skin and that covered by G. I. "protective" flash cream with an exposure of 3.5 cal/cm^2 in 0.3 sec. The greater damage under the G. I. cream is obvious.

with an exposure of 15 cal/cm^2 or more delivered in 1.0 sec., and continued to burn with resultant severe damage to the skin. The cream may be ignited with a match and will burn vigorously (Fig. 2).

DISCUSSION

It should be emphasized that the present directions on the G. I. flash cream call for a $1/16$ inch thick application. But a layer of any cream $1/16$ inch thick is an elusive thing. We could not achieve this under controlled conditions in the laboratory. How much less chance there would be of doing it in the field under the stress of battle conditions! Nor can we find where this requirement of $1/16$ inch was advocated by the Navy. In 1945, a picture of Lt. Comdr. Fauley (6) shows him applying the cream with his fingers. Beneath this is the statement: "All that is required for protection is about an ounce and a half smeared on the face, neck, forearms, and hands." Yet the results of our experiments show that if the G. I. protective flash cream is smeared on the skin with the fingers the burns are often twice as bad beneath it. If a thickness of $1/16$ inch is achieved, exposures approaching 15 cal/cm^2 in one second cause ignition of the cream and severe burns on the skin. The soldier would be penalized either way, so would be better off if he did nothing.

It is probable that a thick layer of any inert, non-flammable substance covering the skin will give some protection against flash burns. But a thick layer of a water soluble material on the skin begins to crack and flake off as it dries. This cracking is accelerated by motion or contact. If protectivity results from the thickness alone, then this is soon lost with drying unless the subject remains immobile and untouched. The drying may be uncomfortable because of the drawing, prickling sensation which is

Fig. 2

G. I. cream - #51-C-1690 - After ignition with a match showing its flammability.

produced. We have found that the G. I. cream is particularly unpleasant to keep on the skin for any length of time, possibly because of the shellac in it.

A high reflectance is another quality of a cream which should enhance its protectivity, since energy which is reflected from the surface will not damage the underlying tissue. However, it does not necessarily follow that a cream with a reflectance greater than bare skin will automatically afford protection. If the energy reflected by each of these two creams and by bare skin is subtracted from the median effective exposure, an effective radiant dose is obtained for each. These values are listed in Table IV where it is seen that a smaller radiant dose than is required for a 2+ burn on bare skin will usually produce this burn under the creams. It is obvious that a high reflectance alone cannot be relied upon for protection.

The conditions of this experiment do not allow further breakdown of the radiant dose since the G. I. cream was usually thicker than the pink cream. However, in a previous paper (2) dealing with thin paint films, we suggested that the radiant dose might be divided into two fractions: that which is transmitted through the film, and the remainder, which is absorbed by the film. Comparison of potency ratios of the two fractions suggested that they were related by a time-dependent constant, with the absorbed fraction contributing more to the burn, particularly at shorter exposure times. It appeared that, in addition to a high reflectance, a high transmittance might be a desirable quality in a protective cream.

The G. I. "protective" cream developed by Fauley and Ivy (1) for the Navy was, so far as can be determined, never tested with bare skin as a control. The Navy used this cream in World War II, and one report (12)

TABLE IV

MEDIAN EFFECTIVE EXPOSURE COMPARED WITH MEDIAN EFFECTIVE DOSE
FOR 2+ BURNS FOR EACH EXPOSURE TIME AND SKIN SURFACE

Exposure Time (sec)	Cream Surface	2+ Median Effective Exposure (cal/cm ²)	2+ Median Effective Dose (cal/cm ²)
0.3	G. I. Cream	1.5	1.17
	Bare Skin	2.7	1.62
	Exp. Pink	2.3	.81
3.0	G. I. Cream	2.3	1.8
	Bare Skin	4.1	2.46
	Exp. Pink	3.8	1.33
30.0	G. I. Cream	5.0	3.9
	Bare Skin	6.8	4.08
	Exp. Pink	8.4	2.94

claimed "75% protection." A final Navy report (13) in 1945, did not regard this cream as "suitable under the conditions of modern naval warfare." The Armored Medical Research Laboratory reported favorable tests on the G. I. flash burn cream in 1943 (14) but there were no quantitative tests of the relative protection afforded. The Army Chemical Corps performed developmental work on protective flash burn creams from 1944 to 1946. Limited tests were conducted on animals, but the test program was stopped in 1946 due to lack of funds.

The Quartermaster Research and Development Command has recently reopened the study of protective flash burn creams and several experimental creams have been compounded. The Quartermaster Corps has been most helpful to us in supplying material and background information for this study, and it is hoped that in the future a really protective flash burn cream will be developed.

SUMMARY AND CONCLUSIONS

1. Two creams designed for protection against radiant thermal burns, the G. I. cream prepared to military specifications, and a pink colored, non-flammable experimental cream, were evaluated by comparing the median effective exposure for 2+ burns under the creams with that for bare pig skin. Exposure times of 0.3, 3.0 and 30.0 seconds were used.
2. In practically all cases, less energy was required to produce 2+ burns under the creams than on uncovered skin. The G. I. cream was especially bad for, at the two shorter exposure times, skin beneath it required only half the radiant exposure needed to produce equivalent burns on bare skin.
3. An irradiance of 3.5 cal/cm^2 delivered in 0.3 sec. to bare skin and skin covered with the G. I. cream inflicted significantly greater damage under the latter. The more severe lesions were twice as deep.

4. Reflectance studies revealed that the G. I. cream had a lower reflectance and the pink colored cream a higher reflectance than bare skin. Correction for reflected energy failed to account for the differences in median exposures for equivalent burns.
5. It was impossible to apply the recommended uniform thickness of 1/16 inch of the G. I. cream. A thinner layer applied with the fingers was used in these experiments. This was considered to be a more realistic simulation of field conditions.
6. The G. I. cream is flammable. It burns when lighted with a match and if applied in a thick layer on the skin, as recommended, it will burst into flame at exposures of 15 cal/cm² delivered in 1.0 sec.
7. The G. I. cream does not "provide good protection to the skin when applied before exposure to high temperature flashes." Our experiments indicate that it enhances the burn damage and is a hazard.

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APPENDIX 1

DOSE-RESPONSE BY SURFACE GRADING FOR BARE AND CREAM COVERED PIG SKIN

Exposure Time (sec)	Surface	Radiant Exposure (cal/cm ²)	0	1+		2+			3+	Total No. of Burns
				Mild	Sev	Mild	Mod	Sev		
0.3	G. I. Cream	1.3	1	5	4	1				11
		1.5		2	1	6	2			11
		1.7		3	4	3	4	1		15
		1.8			2	7	4	2		15
		2.0			1		2	1		4
	Bare Skin	2.5		2	7	6				15
		2.8		2	7	3	3			15
		3.1			1	8	6			15
		3.5				3	10	2		15
	Exp. Pink	2.0	1	3	5	1	1			11
		2.3		7	3	1				11
		2.5		3	1	8	3			15
		2.8	1			7	6	1		15
		3.1					2	2		4
3.0	G. I. Cream	2.0	4	4	7					15
		2.2		6	4	2	2	1		15
		2.5		1	1	7	5	1		15
		2.8			1	4	8	1	1	15
	Bare Skin	3.8		3	9	2	1			15
		4.2			7	5	2	1		15
		4.7			1	4	9	1		15
		5.2				1	5	7	2	15
	Exp. Pink	3.1	2	1	1					4
		3.4	3	7	3	2				15
		3.8	3	2	2	6	2			15
		4.2	2	2	1	1	7	2		15
		4.7		1	1	3	4	2		11
30.0	G. I. Cream	4.1	2	3	1	1				7
		4.6	4	2	5	3		1		15
		5.1	1	3	2	4	3	1	1	15
		5.7			1	4	6	2	2	15
		6.3				1	1	3	3	8
	Bare Skin	5.7		3	11		1			15
		6.3		3	10	2				15
		7.0			3	3	6	3		15
		7.8			1	6	5	1	2	15
	Exp. Pink	6.3	3	1						4
		7.0	5	3			2	1		11
		7.8	3	3	3	4	1		1	15
		8.7	2	2	1	1	2	3		11
		9.6			1	1	3	3	3	11
		10.1				1	1	1	1	4

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APPENDIX 2

DOSE-RESPONSE (SURFACE GRADE) FOR 0.3 SEC. EXPOSURE TO
3.5 CAL/CM²

Surface	1+		2+			3+
	Mild	Sev	Mild	Mod	Sev	
Bare Skin			4	7	4	
G. I. Cream		1	2	3	3	6

APPENDIX 3

DOSE-RESPONSE (MICROSCOPIC GRADE) FOR 0.3 SEC. EXPOSURE TO 3.5 CAL/CM²

Surface	Partial Dermal-epidermal Separation	Dermal Damage in Millimeters							
		.01-.05	.06-.0.1	.11-.15	.16-.20	.21-.25	.26-.30	.31-.35	.36-.40
Bare Skin	8	3	2	2					
G. I. Cream	2	1	3	4	1	2	1		1