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Lab. Project 5046-3, Part 33
Final Report
NS 081-001
AW-7

MATERIAL LABORATORY

NEW YORK NAVAL SHIPYARD
BROOKLYN 1, N. Y.

TECHNICAL REPORT

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SECURITY INFORMATION

CRITICAL THERMAL ENERGIES OF ALUMINIZED FABRICS SUBMITTED BY THE MINNESOTA MINING AND MANUFACTURING COMPANY

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ABSTRACT

For the purpose of determining the effectiveness of the aluminizing process on fabrics, the Material Laboratory investigated the resistance to thermal radiation offered by several metallized fabrics, submitted by the Minnesota Mining and Manufacturing Company. The critical thermal energies, optical transmittance and absorptance, together with the heat transfer characteristics of the fabrics were determined. It was found that the aluminizing process reduces the optical transmittance to a negligible value. The aluminized cotton materials offer less resistance and the aluminized asbestos materials offer greater resistance than the corresponding untreated materials. The transfer of heat through the metallized cotton and asbestos fabrics is less than that through the untreated cloths.

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Ref: (1) COMNYKNAVSHIPYD ltr S99/L5, Ser 960-92, of 15 Mar 1950
(2) BUSHIPS restr spdltr S99-(0)(348), Ser 348-75 of 6 Apr 1950

Encl: (1) Critical Thermal Energies of Aluminized Fabrics
(2) Physical Constants of Aluminized Fabrics
(3) Apparent Transmissions of Aluminized Fabrics

AUTHORITY

1. This investigation is part of the program proposed by reference (a) and formally approved by reference (b). The general Thermal Radiation program is under the supervision of the Armed Forces Special Weapons Project.

INTRODUCTION

2. As part of the Material Laboratory's program to develop methods to protect personnel and materials against the effects of high-intensity thermal radiation, a number of aluminized fabrics prepared by the Minnesota Mining and Manufacturing Company, Minneapolis, Minnesota, were evaluated. The evaluation included measurements of the critical thermal energies, heat transfer, and optical reflectance and transmittance of the cloths. The characteristics of the untreated materials also were measured. The temperature-time characteristic of a skin simulant behind the cloth was not determined at this time.

CRITICAL THERMAL ENERGIES

3. The critical thermal energies of the fabrics were determined by irradiating them with the Laboratory carbon-arc source of thermal radiation, employing the moving-strip method of exposure, which has been described in previous reports of this series. For these exposures the materials were cut into 1x8-inch strips and mounted on holders of glass melamine provided with central cut-outs to furnish an air background. The occurrence of flaming was determined by visual observation during the exposures.

4. The critical thermal energies of the metallized and control fabrics are listed in Enclosure (1). The critical energies are those which will produce certain characteristic, reproducible effects on the materials, such as charring, flaming and destruction. The critical energies were determined for exposures to the carbon-arc source at an irradiance of 85 cal/cm^{2}sec. Analysis of the data indicates that metallizing alone does not in every case reduce the destructive effects produced by high-intensity thermal radiation.

OPTICAL TRANSMISSION AND REFLECTION

5. The total optical reflectance and transmittance of the fabrics for a carbon-arc source were determined from measurements of the spectral transmittance and reflectance, using the General Electric Recording Spectrophotometer in the spectral range from 400 to 1,000 millimicrons, and weighing these measurements over the spectrum of the carbon arc, determined experimentally. The total absorptance was computed from the transmittance and reflectance.

6. The transmittance, reflectance and absorptance values of the several fabrics are listed in Enclosure (2). The weight and thickness of the fabrics are also given. It is to be noted that aluminizing the fabric surface does not always reduce the absorptance appreciably, since that of the original fabric may be low.

TRANSFER OF HEAT

7. The apparent transmittances of the fabrics were determined using carbon paper under the cloth as a heat indicator. The "apparent transmittance" of a cloth is defined as the inverse ratio of the energy incident on the outer layer which would produce certain effects on the paper indicator, mounted behind the material with an air gap of 1/16-inch, to the energy required to produce the same effects directly on the paper. The paper indicator employed in these measurements was black carbon paper.

8. The apparent transmittances of the several fabrics are given in Enclosure (3). In general, metallizing a fabric reduces its apparent transmittance, although there are some exceptions to this observation, particularly for low radiant exposures. The maximum apparent transmittance of a metallized fabric was 6.2 per cent, while the maximum apparent transmittance of the control fabrics was as high as 56 per cent.

ANALYSIS OF DATA

9. While the optical transmittance of the control cloths may be as high as 6.3 per cent, metallizing of the cloth reduces its transmittance to almost zero. It is to be noted that the absorptances of the treated cloths are not significantly different than those of the control cloths. The absorptances of the control fabrics vary from 29.2 to 38.1 per cent; those of the metallized fabrics from 20.9 to 29.6 per cent. In particular, the absorptances of the two treated cottons are approximately the same as those of the two untreated fabrics. The absorptances of the metallized asbestos fabrics are smaller than those of the untreated fabrics.

10. For the fabrics investigated, the metallized cottons are less resistant and the metallized asbestos fabrics more resistant than the corresponding untreated fabrics. The reason for this behavior probably lies in the difference in the melting (or ignition) temperatures of the several fabrics. Cotton disintegrates considerably below the melting point of aluminum (658°C.), asbestos considerably above this temperature.

CONCLUSIONS

11. The following conclusions are derived from the results of this investigation:

a. The metallizing process reduces the optical transmittance of cotton and asbestos fabrics to almost zero. In general, the apparent heat transmission of metallized fabrics is less than that of non-metallized cloths in the ranges investigated. On the other hand, reducing the porosity of cloths by metallizing may cause undesirable physiological effects, since the sealing of clothing precludes ventilation.

b. The critical thermal energies of cotton materials are less if the material is metallized, but the critical energies of metallized asbestos fabrics are greater than those of the untreated materials.

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3. Material Laboratory, New York Naval Shipyard. Critical Thermal Energies of Clothing Materials Submitted by the Surgeon General, Dept. of the Army. Report 5046-3, Part 8 (Oct 1951).

Approved:

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CRITICAL THERMAL ENERGIES OF ALUMINIZED FABRICS

Material	Effect on Material	Critical Energy (cal/cm^2)	
		Material	Control
Glass cloth 138, 131 Finish	Sporadic charring	14-17	---
	Regular charring	17	Material not available
	Flaming during exposure	20	
	Turns brittle and breaks	41	---
Cotton duck, 10 oz., flameproofed	Dulling of aluminum	4.3	---
	Sporadic charring	5.2-14	5.8-17
	Regular charring	14	17
	Flaming during exposure	27	27
	Turns brittle and breaks	28	28
Asbestos-glass, S-915A	Sporadic charring	---	3.7-16
	Regular charring	22	16
	Flaming during exposure	22	28
	Turns brittle and breaks	69	41
Asbestos-herring-bone, 24-H-20	Sporadic charring	27-34	5.7-8.8
	Regular charring	34	8.8
	Flaming during exposure	30	27
	Turns brittle and breaks	91	83
Asbestos, 35-BT-115	Regular charring	21	8.2
	Flaming during exposure	21	28
	Turns brittle and breaks	94	82
Cotton drill, 275, flameproofed	Dulling of aluminum	2.2	---
	Sporadic charring	---	6.7-21
	Regular charring	4.0	21
	Flaming during exposure	7.2	20
	Turns brittle and breaks	16	23

PHYSICAL CONSTANTS OF FABRICS

Material	Weight (oz/yd.^{2})	Thickness (in.)	Absorptance	Reflectance (per cent)	Transmittance (per cent)
Glass cloth #138, 131 Finish	7.6	0.008	20.9	79.1	0.0
Cotton Duck, 10 oz. Flameproofed	10.5	0.024	29.6	70.2	0.2
Control	10.2	0.025	30.6	65.0	4.4
Asbestos-Glass, S-915A	9.3	0.015	24.1	75.9	0.0
Control	9.3	0.017	29.2	68.1	2.7
Asbestos-Herringbone 24-H-120	16.9	0.029	22.5	77.5	0.0
Control	17.6	0.028	38.1	60.2	1.7
Asbestos 35-BT-115	19.6	0.035	21.4	78.6	0.0
Control	19.5	0.036	37.8	60.5	1.7
Cotton Drill #275	6.1	0.017	29.3	70.4	0.3
Control	7.3	0.017	29.2	64.5	6.3

APPARENT TRANSMISSIONS OF FABRICS

Material	Description of Effect on Carbon Paper	cal/cm^2	Non-Aluminized Untreated Fabric: Radiant Exposure cal/cm^2	Non-Aluminized Untreated Fabric: Apparent Transmission %	Aluminized Fabric: Radiant Exposure cal/cm^2	Aluminized Fabric: Apparent Transmission %
Glass Cloth #138, #131 Finish	Faint Dulling	0.059			6.5	0.91
	Dull Wedge	0.28			7.8	3.6
	Destroyed	0.78			22	3.5
Cotton, Duck, 10oz. Flameproofed	Faint Dulling	0.059	---	---	6.4	0.92
	Dull Wedge	0.28	0.80	35	7.2	3.9
	Destroyed	0.78	6.5	12	40	1.9
Asbestos-Glass S-915A	Faint Dulling	0.059	---	---	14	0.42
	Dull Wedge	0.28	1.2	23	15	1.9
	Destroyed	0.78	8.6	0.9	23	3.4
Asbestos Herring-bone 24-H-120	Dull Wedge	0.28	2.3	12	20	1.4
	Destroyed	0.78	40	1.9	40	1.9
Asbestos 35-BT-115	Dull Wedge	0.28	1.4	20	21	1.3
	Destroyed	0.78	15	5.2	64	1.2
Cotton Drill #275 Flameproofed	Faint Dulling	0.059	0.46	13	3.5	1.7
	Dull Wedge	0.28	0.50	56	4.5	6.2
	Destroyed	0.78	4.5	17	18	4.3

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