U. S. Department of Commerce National Bureau of Standards

RESEARCH PAPER RP1529

Part of Journal of Research of the National Bureau of Standards, Volume 30, March 1943

ADVANTAGES OF A BLANKET-AND-SHEET COMBINATION FOR OUTDOOR USE

By Herbert F. Schiefer

ABSTRACT

Blankets varying greatly in air permeability were tested alone and in combination with one and with two sheets for air permeability and thermal transmission. The air permeability of the sheets was low in comparison with that of the blankets. The results show the effect of moving air on the thermal transmission of the blankets and of the blankets between two sheets. The effect of laundering on the weight, thickness, compressibility, compressional resilience, breaking strength, air permeability, and thermal transmission of the blankets is also reported.

It is concluded that for outdoor use, where protection against the wind and rain or snow is important, as in an open lifeboat at sea, a combination of a blanket and sheet or wind-resistant cloth would afford far more protection than a blanket alone.

CONTENTS

I. INTRODUCTION

Blankets are used by the armed forces under many different conditions, and are relied upon considerably to afford the soldier warmth and comfort and to protect his health. A blanket which keeps a person warm when he is shielded from the elements may not give sufficient protection to one exposed directly to the wind and snow or rain. This is particularly true in an open lifeboat, in which blankets are a part of the regular provisions.

Although blankets are commonly used in conjunction with sheets in homes, hospitals, and barracks, the possibilities of a sheet-blanket combination for outdoor use, where protection from wind and rain or snow, as well as cold, is important, apparently has not received very serious consideration.

An extensive study of the properties of blankets, recently completed at the National Bureau of Standards, included tests of combinations of blankets and sheets. The results of these tests are presented in this paper.

II. MATERIALS TESTED

Five all-wool blankets that differed very greatly in air permeability were selected for systematic testing in combination with one and two sheets. Their properties were measured when new and also after 1, 5, and 10 washings. Twenty-two additional blankets and combinations of these blankets with one and two sheets were measured for thermal transmission only. The sheets used in the combinations conformed to Federal Specification CCC–S–271,[1] which requires a minimum of 74 threads per inch in the warp and 66 in the filling, a minimum weight of 4.6 oz/yd^2, and a minimum breaking strength (grab method) of 70 pounds in the warp and filling directions.

III. TESTING PROCEDURE

The weight, thickness, compressibility, compressional resilience, breaking strength, air permeability, and thermal transmission of the blankets, when new and after 1, 5, and 10 washings, were measured. The air permeability of combinations of one and two sheets with the five all-wool blankets, when new and after washing, was measured. The thermal transmission of these five blankets when new and the combinations with one and two sheets were measured in still air and also in air moving 15 miles per hour.

The blankets were conditioned by exposure to air having a relative humidity of 65 percent and a temperature of 70° F, with a tolerance of ±2 percent in relative humidity and a temperature tolerance of ±2° F and, except for thermal transmission, were tested under these conditions.

The thickness, compressibility, and compressional resilience were measured with the compressometer.[2] The thickness measurements were made at increasing pressures, namely 0.10, 0.20, 0.35, 0.50, 0.75, 1.00, 1.50, and 2.00 lb/in.,^{2} and again at these pressures but in reversed order. These measurements were repeated at five random positions. The average of the five values at each pressure was taken as the thickness of the blanket at that pressure. The compressibility [3] was computed by dividing the decrease in thickness when the pressure was increased from 0.50 to 1.50 lb/in.^{2} by the thickness at a pressure of 1.00 lb/in.^{2} A high value indicates a greater amount of napping and less felting. The compressional resilience was taken to be the work recovered when the pressure was decreased from 2.00 to 0.10 lb/in.^{2}, expressed as a percentage of the work expended when the pressure was increased from 0.10 to 2.00 lb/in.^{2} A high value indicates greater ability of the blanket to return to its initial state upon release of a compressive load.

The thermal transmission was measured with the equipment described by Cleveland.[4] It consists essentially of a square metal plate, in a horizontal position, provided with heating elements and thermostats for heating it to a predetermined temperature, approximately 113° F, and maintaining it at this temperature. Loss of heat from the plate in all directions except upward through the specimen is prevented by guard elements heated to the same temperature as the plate. A metal hood is provided to eliminate the influence of air

---

[1] Federal Specification for Sheeting: Cotton, Bleached, Wide, Superintendent of Documents, Washington, D. C. Price 5 cents, January 6, 1931.

[2] Herbert F. Schiefer, *The compressometer—An instrument for evaluating the thickness, compressibility, and compressional resilience of textiles and similar materials*, BS J. Research **10**, 705 (1933) RP561.

[3] "Compressibility" is defined as the decrease in thickness in unit thickness per unit pressure, dh/hdP, where h is the thickness at a pressure of P, and dh is the decrease in thickness corresponding to an increase in pressure of dP. In this paper P and dP are taken as equal to 1 lb/in.^{2}

[4] Richard S. Cleveland, *An improved apparatus for measuring the thermal transmission of textiles*, NBS J. Research **19**, 675 (1937) RP1055.

currents. The plate and the inside and outside of this hood are painted with carbon-black lacquer to produce a surface having an emissivity between 0.95 and 1.00. Means are provided for determining the amount of heat supplied to the plate, the temperature of the top of the hood, the temperature difference between the plate and the top of the hood, and the temperature difference between the plate and the guard elements. The amount of heat supplied to the plate per unit of time divided by the difference in temperature between the plate and the hood and by the area of the plate is taken as the thermal transmission of the blanket in still air.

Some of the blankets were tested on similar equipment at the U. S. Testing Co.[5] in still air and also when the hood was removed and a stream of air moving 15 miles per hour was directed across the sample.

The air permeability was measured with the instrument described by Schiefer and Boyland.[6] It consists essentially of a suction fan for drawing conditioned air through the blanket, a circular orifice 2.75 in. in diameter over which the blanket is clamped, a means of measuring the pressure drop across the blanket, and provision for measuring the volume of air flowing through the blanket. The air permeability of the blanket is the volume of air passing through 1 sq. ft. of fabric per minute when the pressure drop across the blanket is equal to 0.5 in. of water.

The breaking strength (grab method) and the weight of the blankets were measured in accordance with the methods of Federal Specification CCC–T–191a.[7]

The blankets were washed 10 times in a commercial laundry. They were not renapped after washing. Marks were sewed on the blanket, and the distances between them were measured before and after laundering. The shrinkage of each blanket was computed from these dimensions.

IV. RESULTS

The results of the tests are given in table 1. The following conclusions may be drawn from them.

The air permeability of the combination of a blanket and one or two sheets was found to be practically independent of the air permeability of the blanket and was equal to or slightly less than that of the sheet or sheets alone.

The thermal transmission in still air decreased considerably when one or two sheets were used in combination with a blanket. The average decrease in thermal transmission for all the blankets tested was 7 percent when the sheet was used under the blanket, 15 percent when the sheet was used over the blanket, and 19 percent when the blanket was used between two sheets. The results obtained at the U. S. Testing Co. did not show as marked a decrease when the tests were made in still air. However, the thermal transmission of the blankets between two sheets, tested in air moving 15 miles per hour, decreased an average of 60 percent, and the value for the most permeable blanket was less than that of the least permeable and heaviest blanket. The thermal transmission of the blankets when tested alone in moving

---

[5] The assistance of the U. S. Testing Co., Inc., Hoboken, N. J., is gratefully acknowledged.

[6] Herbert F. Schiefer and Paul M. Boyland, *Improved instrument for measuring the air permeability of fabrics*, NBS J. Research 28 637 (1942) RP1471.

[7] Federal Specification for Textiles; General Specifications, Test Methods, April 23, 1937. Superintendent of Documents, Washington, D. C. Price 5 cents.

TABLE 1.—*Results of tests on 5 all-wool blankets*

Blanket	Number of washings	Weight	Thickness at pressure of—		Compressibility [a]	Compressionae resilience [b]	Breaking strength (grab)		Shrinkage	
			0.1 lb/in.^{2}	1.0 lb/in.^{2}			Warp	Filling	Warp	Filling
		oz/yd ^{2}	*in.*	*in.*	*in.*^{2}*/lb*	%	*lb*	*lb*	%	%
A	0	12.6	0.231	0.122	0.34	47	37	39		
	1	13.9	.238	.147	.29	49	52	53	6	0
	10	13.8	.265	.155	.32	46	53	61	12	0
B	0	9.8	.193	.102	.40	50	34	13		
	1	10.6	.183	.112	.31	51	43	27	5	3
	10	11.3	.173	.107	.28	51	38	30	7	5
C	0	14.9	.230	.128	.37	50	56	36		
	1	15.4	.261	.150	.38	50	59	35	3	1
	10	17.3	.265	.173	.29	49	66	43	8	3
D	0	14.7	.233	.157	.28	50	56	48		
	1	16.1	.216	.167	.18	52	74	60	4	6
	10	18.0	.215	.163	.18	53	79	75	10	9
E	0	16.5	.151	.100	.22	48	68	71		
	1	17.5	.171	.121	.23	54	68	70	6	3
	10	18.1	.167	.119	.19	52	68	77	8	3

Blanket	Air permeability [c] ft ^{3}/(min × ft ^{2}) at 0.5-in. H_2O pressure			Thermal transmission, Btu/(^{0}F × hr × ft ^{2}) [d]							
								Blanket alone		Blanket between two sheets	
	Blanket alone	Sheet 1 under blanket	Sheet 2 over and Sheet 1 under blanket	Blanket alone	Sheet under blanket	Sheet over blanket	Sheet over and under blanket	Still air	Moving air [e]	Still air	Moving air [e]
	498	19	11	0.74	0.71	0.62	0.61	*0.80	*1.74	*0.77	*1.03
A	427	19	11	.74							
	435	19	11	.72							
	326	18	10	.82			.66	*.86	*1.95	*.81	*1.13
B	257	18	10	.86							
	242	19	10	.81							
	212	18	10	.78	.73		.62	*.78	*1.91	*.76	*1.06
C	192	18	10	.74							
	183	19	11	.73							
	127	17	10	.82	.76		.66	*.79	*1.38	*.74	*1.00
D	99	16	10	.82							
	92	16	10	.78							
	45	13	8	.95	.88	.79	.77	*1.00	*1.64	*.88	*1.20
E	41	12	8	.95							
	41	12	8	.89							

[a] A high value for compressibility indicates a greater amount of napping and less felting.

[b] A high value for compressional resilience indicates greater ability of the blanket to return to its initial state upon release of a compressive load.

[c] The values for sheet 1, sheet 2, and the combination of sheet 1 and 2 were 19, 23, and 10, respectively.

[d] A low value for the thermal transmission indicates a high insulating value. The value for the sheet alone was 1.36. The asterisk indicates that the value was obtained by the U. S. Testing Co., Inc.

[e] The speed was 15 miles per hour.

air was over 100 percent greater than when they were tested in still air. The thermal transmission of the blankets when tested between two sheets in moving air was only 37 percent greater than when the combination was tested in still air.

The thermal transmission values obtained at the United States Testing Co. are consistently higher than those obtained at the National Bureau of Standards. The higher values probably result because the heat loss from the sides of the hood, which are continually exposed to moving air, is greater than that which is lost when the hood is in still air. A slight leakage of air into the hood may also have contributed to the observed differences.

The weight, thickness, and breaking strength of the blankets increased with the number of washings, and the compressibility and air permeability decreased. These changes are attributed to the shrinkages of the blankets during laundering. The compressional resillence of these blankets and the air permeability of the combination of a blanket and one or two sheets were not affected significantly by the number of washings.

For outdoor use where protection against the wind and other elements is important, as in an open lifeboat at sea, a combination of blanket and sheet would afford far more protection than the blanket alone. Such a combination would permit the use of a medium-weight blanket, and the blanket need not be greatly felted. The combination would not only be more flexible and easier to wrap around the body, but it would also be much warmer in a strong breeze. The sheet would provide additional strength, 60 lb or more per inch of width, and it could be made water repellent. This combination would effect a substantial saving in wool, which might be important in the event that the supply of wool should become a critical problem.

WASHINGTON, December 8, 1942.