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EFFECT OF LAUNDERING UPON THE THERMAL INSULATING VALUE OF COTTON BLANKETS

BY

PHILIP RUDNICK, Junior Physicist
Bureau of Standards

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EFFECT OF LAUNDERING UPON THE THERMAL INSULATING VALUE OF COTTON BLANKETS

By Philip Rudnick

ABSTRACT

A study was made of the effect of repeated laundering upon the value of cotton blankets. The sample materials used in the experiments were representative of most common blanket types, and the laundering process corresponded to a good commercial practice. Thermal resistances were measured by means of equipment developed earlier at the Bureau of Standards, but the method of measurement was modified. Washing was found to cause small losses in thermal resistance, which were almost completely restored by the subsequent process which raised the nap on the laundered fabric. The net losses in thermal resistance after four applications of washing and renapping processes were negligibly small. The results indicate the importance of a process for restoring the nap after washing. Shrinkage resulted in thickening the blanket, with a corresponding gain in thermal resistance.

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I. INTRODUCTION

Information regarding the impairment of the thermal insulating values of blankets which may occur when the material is laundered would be of great value to housekeepers and also to hotels, educational and other institutions maintaining dormitories, railway sleeping car companies, etc.

Blankets are designed primarily to retain the body heat. Appearance and durability are other qualities to be considered, of course, but no one would select the tightly woven duck for a blanket material despite its great strength. To enhance the heat-retaining qualities blanket manufacturers use such features as loosely spun yarn and felting or napping of the surface. The reason for these measures is obvious, because textile fabrics possess their value as thermal insulators in substantial part by virtue of such structural features.

It can readily be seen that the thickness of a blanket and, consequently, its insulating value can be altered easily by compressing or compacting in use or storage, by abrasion of soft surfaces, and by changes incident to laundering. With the exception of the laundering, these processes are not easily reproducible, because they vary greatly from case to case. However, in the normal laundering process (which in itself may also vary to a large extent) there are many agencies which may alter the structure and consequently the insulating value of the blanket and which can be controlled and studied. Among such may be mentioned: Contact with water, soap, and possibly other chemicals; mechanical agitation; elevated temperatures; tension during drying; and carding or brushing. Shrinkage is one example of structural modification brought about by laundering and is itself one source of changes in insulating power.

Acknowledgment is to be made for the many samples of blanketing materials which have very kindly been furnished by their respective manufacturers for the purposes of this investigation and for much valuable information concerning laundry practices which has been supplied by blanket manufacturers, users, and launderers.

II. PRELIMINARY CONSIDERATIONS

The general problem of the effect of laundering on the thermal insulation values of blankets introduces a number of preliminary considerations. These may be listed as follows: The method of determining heat-insulating values, the process of laundering, the types of blankets to be considered.

1. MEASUREMENT OF HEAT-INSULATING VALUE

The apparatus described by Sale [1] was used, but the method of measurement was modified to make it less dependent upon the judgment of the observer. In the apparatus an electrically heated copper plate surrounded by a suitable heated guard ring is kept at a uniform temperature, measured by means of a thermojunction attached to the plate. A piece of the blanket material is stretched over the plate and the rate of heat flow is measured after a steady state has been established. This rate of heat flow through the test area will, in general, be proportional to the difference between the temperatures on the two sides of the blanket material. One of these temperatures is that of the copper plate, the other may be taken as that of the exposed surface of the blanket, or it may be taken as that of the air in the room. In either case the heat flow through the test area will be proportional to the temperature difference, so that if T_1 is

[1] Sale and Hedrick, Measurement of Heat Insulating and Related Properties of Blankets, B. S. Tech. No. 266; 1924. Sale, Specifications for Constructing and Operating Heat Transmission Apparatus for Testing Heat-Insulating Value of Fabrics; B. S. Tech. No. 269; 1924. Influence of Sheeting Upon the Heat-Retaining Properties of Blankets, B. S. Letter Circ. No. 193, Feb. 8, 1926.

the temperature of the copper plate, T_2 is a temperature on the other side of the blanket, then H, the heat flow, is given by the equation

$$H = C(T_1 - T_2) \tag{1}$$

C is the constant of proportionality. It will be convenient to use the expression $C = 1/R$, and to write equation (1) in the form

$$H = (T_1 - T_2)/R \tag{2}$$

From inspection of equation (2) it is apparent that for a given temperature difference large values of R will correspond to small values of H, so that R is a measure of the resistance to heat flow. If T_2 is measured at the exposed surface of the blanket, the corresponding R is a measure of the insulating value of the blanket alone, but if T_2 is the temperature of the air in the room, the corresponding R is the resistance of the blanket plus the resistance from the outer surface of the blanket to the air. This last-named resistance is to be distinguished from the surface resistance mentioned in the publication by Sale and Hedrick, as the latter was calculated by an extrapolation which is now considered as unwarranted. In the work of Sale and Hedrick the temperature T_2 was that measured at the exposed surface of the blanket. Although it would appear preferable to measure the resistance in this manner, the method is open to the objection that the upper surface of the blanket is not sharply defined, and the result obtained will depend to a large extent upon the distance between the thermocouple used to measure T_2 and the copper plate. The consistency of the results obtained will thus depend upon the ability of the user of the apparatus to duplicate the position of the thermocouple in successive experiments.

For the reasons stated above the temperature T_2 in the present series of experiments was taken as the temperature of the air in the room, as measured by a thermometer suspended a few feet away from the apparatus. In using this method the quantity measured is the resistance of the blanket plus the resistance incident to the presence of the outer surface. Since in this investigation the object was to measure changes in the blanket, this method serves the purpose, although the percentage changes in the blanket itself will be somewhat larger than those measured. With the apparatus in its present form no method adapted to measuring the resistance of the blanket alone is available at this time.

2. LAUNDERING PROCEDURE

Information was obtained from a large number of sources regarding methods which were in use for laundering blankets. In collating this the following principal features were found:

(*a*) In most cases identical treatment of cotton and wool blankets or mixtures. Some instances were noted where it was urgently set forth that wool blankets should be washed by hand methods rather than by subjecting them to mechanical means of agitation. Some others advocated dry-cleaning methods.

(*b*) The use of a neutral soap and no alkali or other detergent.

(*c*) The avoidance of high temperatures, abrupt changes in temperature, and excessive mechanical agitation in the wash wheel especially in the case of wool materials.

(*d*) Drying on frames at room temperature.

(*e*) A brushing device or, in the case of cottons, a hand or machine device to restore the original napped surface of the blanket, which may have become matted during the washing process.

In accordance with these points, a process was selected which would, within the limitations of equipment available at this bureau, be equivalent to the procedure of a commercial laundry

The laundry apparatus used was the cylinder type, 24 inches wide by 24 inches diameter, with a capacity of 3 to 10 pounds per operation and a speed of 25 revolutions per minute. The machine was one-third full of water of a 5-drop hardness, at a temperature of 38° C. The total weight of samples represented a light load for the cylinder. A copious suds was produced with a good grade of chip soap, in the form of thin flakes, containing about 94 to 95 per cent of anhydrous soap, about 2 per cent of moisture, no free alkali, and a small amount of sodium carbonate. The titer (melting point) of the fatty acids was 42° C. The soap conformed to Federal Specifications Board master specification No. 245.

The procedure used was as follows:

(*a*) Wash for 10 minutes in soap and water under the conditions just described.

(*b*) Two runs of one minute each in clear rinse water, also at 38° C., and brought to the same level in the cylinder.

(*c*) A very short run in the hydro-extractor, to remove only the gross excess of water.

(*d*) Dry on frames at room temperature, stretched as nearly as possible to the original dimensions.

(*e*) Renapping with a soft wire brush just sufficiently to raise the nap of the blanket to its original fluffiness.

3. SELECTION OF BLANKET TYPES

Samples of five cotton blanket materials, designated as Nos. 1 to 5, were employed in the investigation. Table 1 gives some of the physical characteristics of the fabrics, and in Figure 1 their magnified cross sections taken in the direction of the filling have been reproduced. The photographs serve to show something of the structures of the various samples.

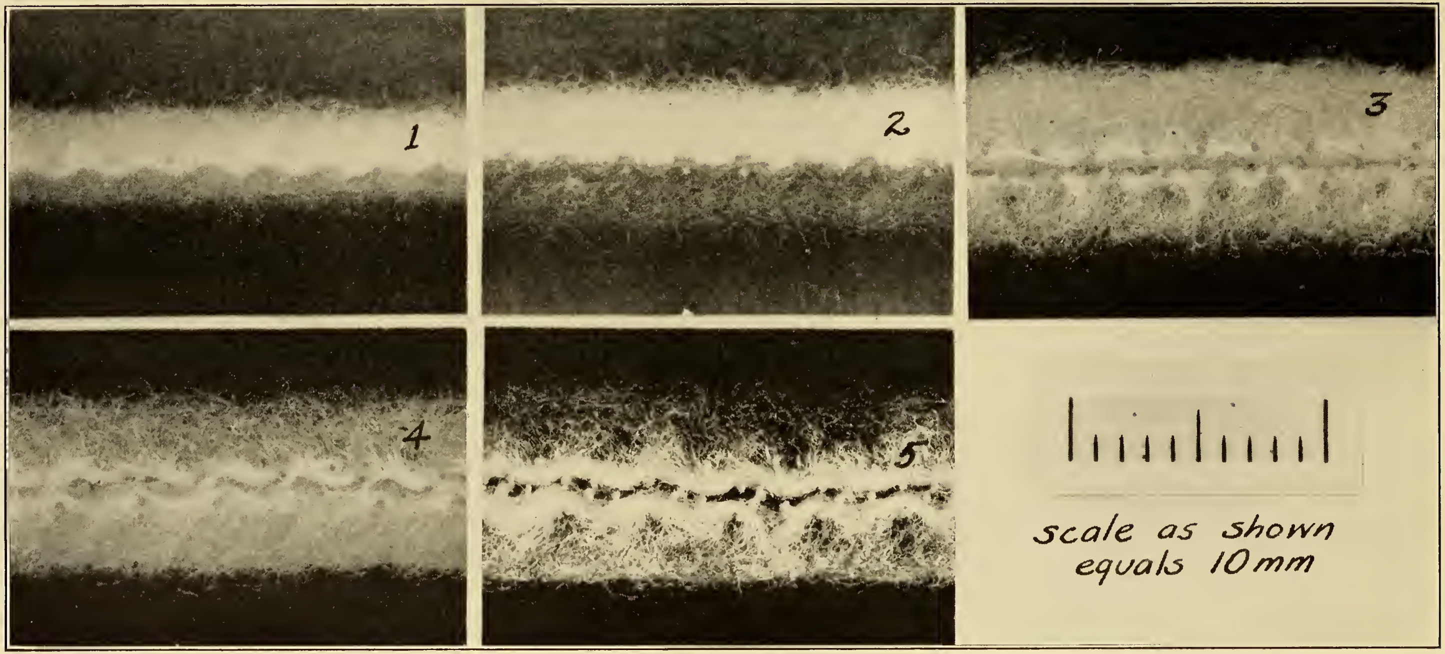

FIG. 1.—*Cross section of the blanket materials cut in the direction of the filling yarns*

TABLE 1.—*Physical tests of cotton blanket materials*

Sample No.	Weave	Weight per square yard	Thickness	Warp threads: Number per inch	Warp threads: Weight of threads per square yard of cloth	Filling threads: Number per inch	Filling threads: Weight of threads per square yard of cloth
		Ounces	*Inch*		*Ounces*		*Ounces*
1	Plain	8.1	0.14	44	1.6	16	6.5
2	Double filling	8.3	.20	45	1.6	[1] 23	6.7
3	Double filling, wrapped	9.9	.26	33	1.5	[1] 18	8.4
4	do	11.1	.28	48	1.6	[1] 16	9.5
5	Double filling	12.1	.27	48	2.0	[1] 18	10.1

[1] Thread count for each face.

Three general types of fabric are represented in these test materials. No. 1 is a single weave with a comparatively light nap. Nos. 2 and 5 are a double-filling weave with hard-spun threads quite similar to those of the warp. The wrapping may be most clearly seen in the photograph of No. 3. Samples 2 and 5 contrast chiefly in weight, 3 and 4 in the number of warp threads per inch, and 4 and 5 are quite similar, with the single difference that No. 4 has the wrapped filling. All of the materials were new when taken for the investigation.

III. TEST PROCEDURE AND RESULTS

Thermal resistance, length, width, and weight were determined for each of the test specimens before the first application of the laundering process. The samples were then washed and dried, reweighed, remeasured, and the thermal resistance, R, determined again. Then they were napped, and the same set of measurements carried out a third time. Thus the changes in thermal resistance occasioned by washing and by napping were separately determined and the accompanying shrinkages and changes in weight noted. The laundering process was then applied to the same specimens a second and a third time. The measurements of weight and dimensions were continued for all samples, but as a matter of expediency R was measured before and after each napping process for only one blanket. Finally, a fourth laundering was given, and this time, as at first, all five values of R were measured.

Table 2 gives the value of R, expressed as percentage of the original values, following the washings and renappings as indicated. The percentages of shrinkage in the area, S, likewise referred to the original samples, are also shown. No appreciable changes in weight were observed throughout the experiments.

TABLE 2.—*Values of thermal resistance, R, and changes in area, S, caused by laundering*

	Sample									
	1		2		3		4		5	
	R	S	R	S	R	S	R	S	R	S
	P. cent	*P. cent*	*P. cent*	*P. cent*	*P. cent*	*P. cent*	*P. cent*	*P. cent*	*P. cent*	*P. cent*
Original	100	0	100	0	100	0	100	0	100	0
First washing	99	4	98	0	97	10	97	9	93	5
First napping	106	4	107	1	102	11	103	9	100	4
Second washing	-------	-------	-------	-------	-------	-------	94	-------	-------	-------
Second napping	-------	5	-------	2	-------	12	100	9	-------	6
Third washing	-------	-------	-------	-------	-------	-------	96	-------	-------	-------
Third napping	-------	3	-------	3	-------	13	101	10	-------	5
Fourth washing	101	-------	92	-------	95	-------	92	-------	89	-------
Fourth napping	101	6	99	3	95	12	101	8	97	5

In all cases the principal shrinkage occurred in the direction of the warp. Figure 2 presents graphically the behavior of samples 1 and 5, roughly extreme cases, and of No. 4, for which the most complete data were taken.

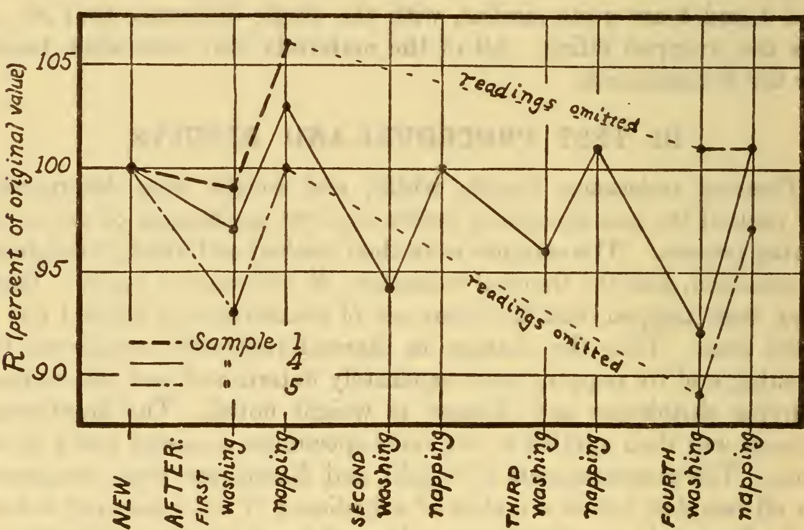

FIG. 2.—*Changes in thermal resistance caused by laundering*

The final shrinkage for sample No. 1 was 6 per cent; for No. 4, 8 per cent; and No. 5, 5 per cent.

IV. DISCUSSION

It is to be noted in Table 2 that the washing process is accompanied in all cases by a loss in thermal resistance, and that napping almost as uniformly produces a compensating increase. This phenomenon is added evidence for the importance of thickness as a factor in blanket warmth and emphasizes the necessity for features in the launder-

ing process which will restore the fluffiness of naps which may have become matted in use or in the washing.

By referring again to Table 2 it will be seen that the characteristic trend of the thermal resistance shows an initial increase and then a gradual decline, both of comparatively small magnitude. The greatest net change in R after the fourth application of the laundering process is a decrease of 5 per cent. This result appears in spite of the fact that at this stage of the investigation some of the samples showed a considerable amount of wear from napping, certainly more than would be tolerated in any actual practice, indicating that the chosen method of hand napping was more severe than the machine practice it was intended to simulate. Thus it appears that in the present experiments any losses in thermal resistance occasioned by the wear of washing and abnormally severe napping are almost negligibly small, or at least substantially counteracted by compensating influences.

Among such influences the only obvious and definitely predictable one is that of shrinkage which results in thickening the blanket. This leaves the subsequent declines to be interpreted as the deleterious effects of the laundering, perhaps, partially masked by further shrinkage.

It was hoped that the different types of blanket construction represented among the test specimens might show some contrasts in behavior, but the results are very nearly uniform and the small differences between samples do not seem an adequate basis for comparisons.

V. CONCLUSIONS

It is concluded from the results of this investigation that an adequate process for laundering cotton blankets must provide means for either preserving or restoring the original fluffiness of the nap. Further, such a laundering process may effect a slight decrease in thermal resistance, probably not more than 2 or 3 per cent for each application. This amount has little practical significance and may be partially or totally counteracted by the effects of moderate shrinkage. Even the largest changes noted during these experiments are probably too small to affect noticeably the comfort of the user of the blanket. It is believed that the laundering process here employed fairly represents current practices, at least in so far that the latter are no more severe mechanically, and, further, it is thought that the sample materials used are of sufficiently varied construction to warrant the application of the results of this investigation to most commonly used cotton blanket materials.

WASHINGTON, May 5, 1926.