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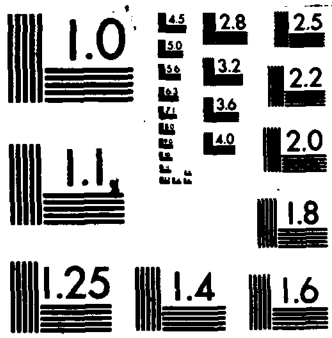
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by

R.J. Osczevski

DEFENCE RESEARCH ESTABLISHMENT OTTAWA

TECHNICAL NOTE 82-34

Canada

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Environmental Protection Section
Protective Sciences Division

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ABSTRACT

The daily accumulation of moisture in Arctic sleeping bags used during a cold weather exercise is reported. Insensible evaporative cooling is estimated. The possible benefit of a vapour barrier is discussed.

RÉSUMÉ

Le présent rapport porte sur la quantité d'humidité qui s'accumule chaque jour dans des sacs de couchage pour l'Arctique utilisés pendant un exercice mené par temps froid. On évalue l'importance du refroidissement par évaporation et on étudie les avantages qu'il y aurait à utiliser un matériel imperméable à l'humidité.

INTRODUCTION

Exercise Gatineau, a cold weather familiarization exercise, took place at Taylor Lake, in Gatineau Park, in January of 1974. Participants were members of the Environmental Protection Section supported by the DREO Test Team. During the exercise, a daily record of the masses of the sleeping bags used by the participants was kept.

METHOD

The subjects slept in unheated five-man tents, in sleeping bags on air mattresses. A 7 cm thickness of synthetic, fibrous packing material, commonly known as "horse-hair" was used between the bag and the air mattress. Three of the eight bags were the standard down-and-feather insulated two-layer bag with a short zipper (NSN 8465-21-842-6078 and -6079). The other five were the older style of bag (also double) which was 0.5 kg lighter, and which had no zipper. The bags had similar cotton flannel liners. The standard sleeping hood (NSN 8465-21-842-6081) was worn but not included in the mass measurements.

No artificial preconditioning of the bags was attempted prior to deployment. As soon as the occupants had arisen in the morning, the bags were packed into their carrying bags, and weighed a short time later. During the day, the packed bags were used with the air mattresses to make benches in the tents.

RESULTS

Table I lists the mass of each bag initially and after each use. The mass includes the mass of the inner and outer bags, the flannel liner and the carrying bag.

The changes in mass are tabulated in Table II. The bags gained an average of 170 ± 30 g on the first night, and 40 ± 15 g on succeeding nights.

DISCUSSION

The pattern of weight gain is similar to that reported by Eliot and Winik (1), as shown in Figure 1. There is a high initial weight gain followed by a slower increase. It is possible that the initial gain in the present study may have been due to the high temperature experienced on the first night when the subjects may have been actively sweating. The common shape of the curves in Figure 1 suggests however, that this is a feature of sleeping bag use, possibly due to the change in regain of the down-and-feather insulation. In the earlier study (1) the sleeping bags were initially dry, and the initial high gain lasted for two nights.

Initially, the sleeping bags can pick up moisture from two possible sources, the body and the atmosphere. The contribution of these two sources to the initial gain is probably about equal, making the evaporation rate from the body of the order 100 g/night.

After the filling material comes to moisture equilibrium, its hygroscopic nature becomes unimportant, if conditions remain relatively constant. The weight gain is then 40 to 50 g per night. Evaporation still amounts to about 100 g per night, but only half condenses in the bag, on average, about two-thirds of the way through.

The effectiveness of the evaporation at removing heat from the body is reduced as condensation gives up the heat of vaporization in the filling. In this case the effectiveness is reduced to about 80% (see Appendix I). The cooling caused by the evaporation of 100 g per night

TABLE I

Mass of Sleeping Bags (grams)

Day	A	B	C	D	E	F	G	H
0	5359	5252	5414	4875	4912	4836	4852	4961
1	5500	5479	5593	4983	5088	5024	4997	5149
2	5570	5552	5613	5015	5125	5102	5051	5171
3	5616	5553	5643	5030	5139	5172	5089	5198
4	5679	5621	5684	5059	5165	5212	5129	5208

TABLE II

Changes in Mass of Sleeping Bags (grams)

Day	A	B	C	D	E	F	G	H	Mean	Outside Temp (°C)
1	141	227	179	108	176	188	144	188	169	- 7
2	70	73	20	32	37	78	54	22	48	-18
3	46	1	30	14	14	70	38	27	30	-26
4	63	68	41	29	26	40	40	10	40	-29

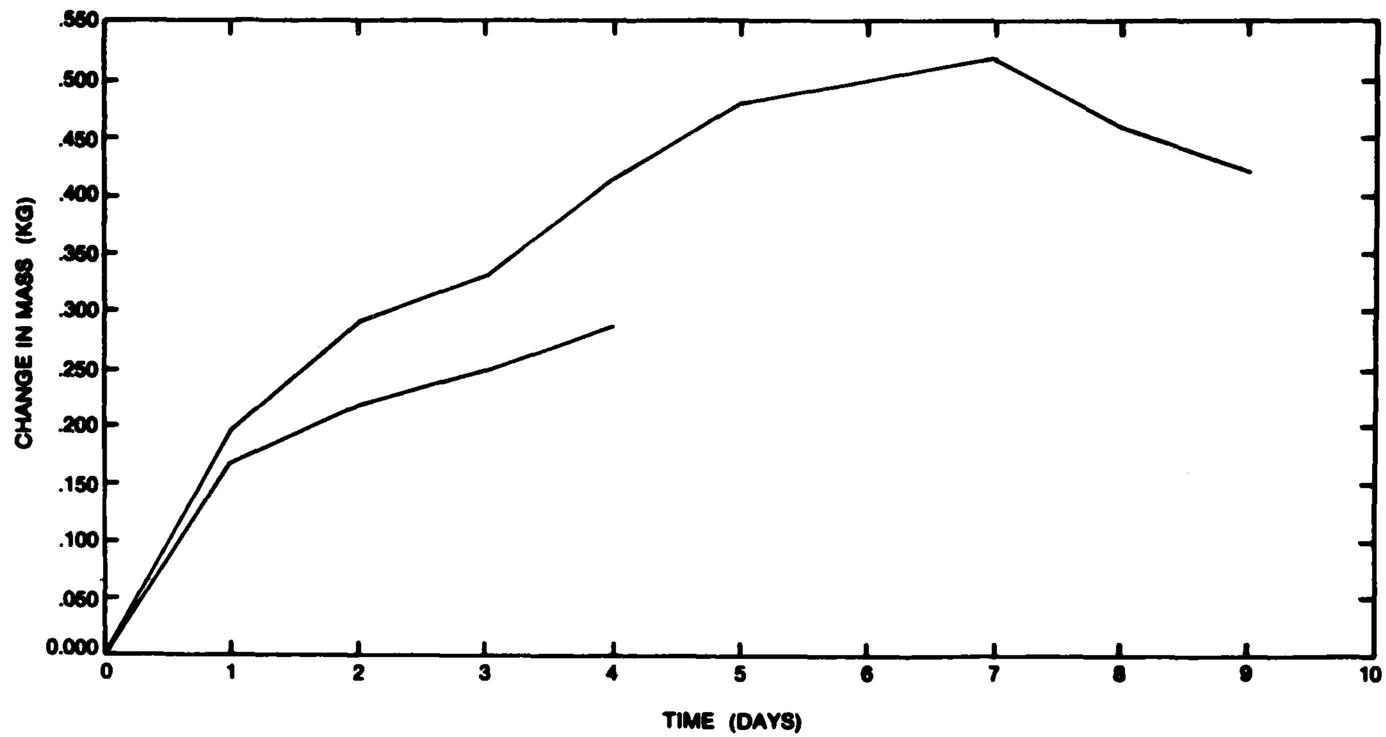

Figure 1: Moisture retention of sleeping bags used in the cold. The upper curve is from reference 1. The data of the present study are represented by the lower curve.

(8 hours) is, from equation 1, 7 watts. This is a rough estimate. The intent is to assess the magnitude of evaporative cooling.

$$E = aHr \qquad [1]$$

where E is the evaporative cooling,
a is the effectiveness of the evaporation,
r is the rate of evaporation,
H is the heat of vaporization, 2.5 kJ/g.

A significant effect of the presence of water in the insulation, particularly of down, will probably be the effect of packing and compressing a damp bag for 16 h per day in its carrying bag. This is likely to reduce the thickness of the bag (the loft) when it is next used for sleeping.

After a week the volume of accumulated water will be about one quarter of the fibre volume. As the ratio of the conductivity of water to fibre is about four, the conduction of heat by water and fibre will be about equal at 3% of the total heat flow, or 3 watts. This increase may be offset by decreased radiative heat flow as the batting will be less transparent.

The evaporative heat loss may be somewhat greater than that estimated from mass changes. Over the period during which the bag is packed possibly in a heated tent or vehicle, the moisture will tend to diffuse from the wetter outer regions back to the relatively drier inner regions. On the next use, this water re-evaporates and recondenses or escapes, further increasing the heat-loss. Further work would be required to quantify this effect.

A change in body heat content of -300 kJ will awaken the average sleeper (2). If the heat loss rate exceeds the heat production rate by an amount H, the time, t, in seconds, to produce a change of 300 kJ, D, is given by equation 2

$$t = D/H \qquad [2]$$

If evaporative heat loss is excluded by a vapour barrier and the environmental conditions are such that H is 10.5 watts, the duration of sleep will be 8 hours. Without the vapor barrier, assuming the skin temperature and air temperature are the same, and that the filling is at moisture equilibrium, the additional heat loss of 7 watts caused by evaporative cooling reduces the period of sleep to 4.8 hours. Siple (2) noted differences in the duration of comfortable sleep of this magnitude when bags were tested after being conditioned to a high relative humidity, as compared to when conditioned to a low relative humidity. In the former instance, the filling would be already at a high regain, and evaporation would be more effective at body cooling.

The same effect should occur after the first one or two nights. This might be of importance when physiological measurements are made of the protective value of sleeping bags in controlled environmental conditions. Unless the bags are used several nights without drying, or are preconditioned to high relative humidity, the test will not relate to general field experience.

Recently, extravagent claims have been made for the benefits of vapour barriers in sleeping bags. The claim is based on unspecified tests which show that about 1.8 kg of water is lost by a sleeper in a normal sleeping bag during the night, and that 900 grams condense in the bag each night (3). The subjects of these tests must have been actively sweating. It is obvious that a vapour barrier is most effective when the user is sweating and has considerable potential for evaporative heat loss. It is also obvious that if the user is sweating, he does not need a vapour barrier to help him keep warm. If the user is not sweating, and is cooling, the direct benefit of a vapour barrier would be a saving of about 7 watts or 8% of the sleeping heat production. As has been shown, when the total heat loss does not greatly exceed the heat production, small changes in the total heat loss may have a significant effect on the duration of restful sleep. From a thermal stand point, a vapour barrier appears to have some merit when used in a sleeping bag.

The vapour barrier is not a new idea. Its merit was discussed by Kephart in 1917:

"Innumerable expedients have been tried to keep down bulk by using impermeable insulators, such as paper, oiled cotton or silk, and rubber or rubberized fabric, but all such "skins to keep heat in" are total failures. The vapour from one's body must have an outlet or a man will chill, to say nothing of other unpleasant consequences." (4).

Probably these vapour barriers were used on the outside of the bag rather than as a liner, so that water condensed in the insulation resulting in a "chill".

Non-thermal "unpleasant consequences" may militate against the use of vapour barriers.

REFERENCES

1. Eliot, Capt. J.W., L.J. Winik, Office of the Quartermaster General, Climate Research Laboratory, Environmental Protection Section Special Report #31, 1950.

2. Siple, P., in "Clothing Test Methods", eds. Newburgh, L. and Harris, H., N.R.C. CAM 390, Washington, D.C., 1945.

3. Stephenson, J., Summit, Jan-Feb 1982, p. 8.

4. Kephart, H., "Camping and Woodcraft", The MacMillan Company, New York, 1917.

APPENDIX I

EFFECTIVENESS OF EVAPORATIVE COOLING

The effectiveness was estimated by making the ap ximation that the condensation all occurred two-thirds of the way throug che bag, which is about the average distance from reference 1. The total at flow from skin, Q_s, is

$$Q_s = \frac{T_s - T_c}{\frac{2}{3} R} + HM \qquad [1A]$$

where T_s is the skin temperature,
T_c is the temperature at the point where condensation is occurring,
H is the heat of vaporization of water,
M is the evaporation rate from the skin,
R is the total thermal resistance.

The heat flow out to the environment (at a temperature T_A) is

$$Q_o = \frac{T_c - T_A}{\frac{1}{3} R} + \frac{HM}{2} \qquad [2A]$$

The first term in each equation is the sensible heat flow, the second term is the evaporative heat flow. At steady state Q_s and Q_o are equal. Equating 1A and 2A and solving for T_c yields 3A

$$T_c = \frac{T_s}{3} + \frac{2T_A}{3} + \frac{HMR}{9} \qquad [3A]$$

Substituting 3A into equation 1A yields the total heat flow

$$Q_T = \frac{T_s - T_A}{R} + \frac{5}{6} HM \qquad [4A]$$

The first term is, effectively the sensible heat flow. The evaporative heat flow, the second term, is reduced by one sixth so that the effectiveness is approximately 80%.

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THERMAL INSULATION

VAPOUR BARRIER

WATER VAPOUR

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