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DEVELOPMENT OF AN ARCTIC SLEEPING BAG

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ABSTRACT

The development of a new arctic sleeping bag for the Canadian Forces has been motivated by both the excessive cost and the less than optimal performance of the current sleeping system. It was desired to design a sleeping system that would be superior in warmth, weight, packed volume, reliability and cost to the current combination of double down-filled sleeping bag and air mattress. The performance of available insulating materials was analysed for use in both the upper portion of the bag which is over the user and so is uncompressed, and the lower portion of the bag which is below him where it must support his weight. It became clear that the overall performance of the sleeping system would most strongly depend on the ability of the insulation under the user to retain its thickness during use and yet be amenable to packing into a small volume for transportation.

The latest prototype consists of a polyester batting filled bag with a built-in sleeping pad made from a combination of closed-cell polyethylene foam and polyester batting. This prototype outperforms the existing system in terms of warmth and weight but is somewhat bulkier. Cost and reliability have yet to be determined.

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1. In a previous paper (1) we analysed the heat flow through sleeping bags from the body into the air or ground. We compared various insulating materials for their effectiveness in supplying the required insulation with minimum mass or with minimum packed volume. In practice, the user requires a sleeping bag that has both of the above qualities at a minimized cost. During the course of our investigations, it became apparent that the key to producing a successful sleeping system lies in providing insulation below the user which does not greatly compress under his weight but which may be compressed when packed for transportation. Since the pressures exerted during packing are not much greater than those exerted by the weight of the body, the two requirements would seem to be in conflict, at least for simple isotropic materials.

2. Our latest prototype sleeping system is an attempt to provide reasonable thermal insulation from the ground without excessive packed volume. It contains two features that make this possible. One is that the sleeping pad is built into the sleeping bag. The other is that while the pad is incompressible vertically under the user's weight, it can be compressed horizontally for packing.

3. When a sleeping bag is constructed with the same compressible material throughout and used in conjunction with a sleeping pad or mattress, the part of the sleeping bag under the user is compressed to such an extent, perhaps by a factor of 10, that the insulation below the body is not much greater than that of the pad alone. This material is therefore

adding to the mass and packed volume of the bag without greatly increasing its insulation. By building the pad into the bag we prevent the user from rolling the bag over while sleeping and remove the need to make the bottom and top of the bag interchangeable. We can therefore eliminate the compressible insulation underneath.

4. Building the pad into the bag has also enabled us to make it narrower. The canonical width of a sleeping pad, judging from the commercial products available, is 51 cm. We have found, from the experience of the six people who have used our bags, that a built-in pad is acceptably wide at 42 cm. The difference is probably due to the ways in which the user turns over in the two cases. With a separate bag and pad, the user takes the bag with him when he rolls so that both may be displaced relative to the pad. Extra width is required to allow for slight shifts in position without moving off the pad. With the pad built-in, the user must roll over within the bag and so does not move laterally relative to the pad which can therefore be narrower.

5. We have tried a variety of designs for sleeping pads that are compressible horizontally but not vertically. The only design without any apparent defects is a rather complex structure of closed-cell polyethylene foam, polyester fibre-fill and a stretch fabric. The foam, available in 1 cm thick sheets, is cut into 5 cm wide strips and glued as illustrated in Figure 1(a). When the assembly is stretched it resembles an egg crate with 10 cm squares as in Figure 1(b). These are filled with polyester fibre-fill (Polarguard or Qualofil) to a density of 500 g/m^2. A layer of stretch fabric is then glued on each side of the pad to retain the fibre-fill and add some rigidity to the structure but still allow for compressibility horizontally (Figure 1(c)). The complete pad is 180 × 42 × 5 cm, has a mass of 1.36 kg, a thermal resistance of 1.3 m^2K/W and can be compressed by

hand by about a factor of three.

6. The complete bag is shown in cross-section in Figure 2. The pad is enclosed in a pouch of 160 g/m^2 polyurethane coated nylon fabric. The coating on the outside layer prevents the entry of water from melted snow. The inner layer is coated to prevent water vapour from the body which would condense in the insulation of the pad. Because of the coating on the outer layer, such water would have no means of escaping. During compression along its length, the pad expands in width by about 15%. Therefore the pouch has to be made wider than the elongated pad to permit the expansion. To prevent the pad moving during use, the width of the pouch is reduced by fastening buckles on the lower surface to introduce a fold. These are released for packing. The pad, which is inserted into the pouch through a slit in the inside layer of nylon near the foot, is removable for laundering of the bag. It is fastened to the bag by buckles at the ends only.

7. The upper portion of the bag is three layers of 200 g/m^2 Polarguard insulation between two layers of 70 g/m^2 rip-stop nylon. Two insulation layers are quilted to the outer shell fabric, one to the inner. The inner layer is made to overlap the pad as indicated in Figure 2 in order to prevent noticeable gaps developing in the all-round coverage of the body by insulation. The bag is differentially cut with an inside circumference of 145 cm and an outside of 200 cm at the chest, tapering to 125 and 175 cm respectively at the foot. There is a half-length zipper with draught tube and a draw string at the neck. The system is equipped with a sleeping hood which is similar to the current CF issue hood but is insulated with 200 g/m^2 of Polarguard. We have used Polarguard insulation because it has both low mass and packed volume per unit thermal resistance and requires minimal quilting. Qualofil is an alternate with equal thermal performance.

8. The bag and pad are packed into their carrying case as illustrated in Figure 3. First the buckles on the underside are undone. The bag is then folded in two with the pad on the inside of the fold. They are then loosely stuffed into the carrying case and its opening closed with a draw string. The bag is then compressed by tightening 3 straps which run completely round the carrying case. The Polarguard of the upper portion of the sleeping bag surrounds the pad during compression ensuring that it is compressed along its compressible direction without buckling.

9. Two prototypes were used by one of the authors and another DREO scientist during a 12 day period in January 1984 on a military exercise (Kovik Return) near Rankin Inlet, NWT. Sleep was in an unheated tent on all nights except for one night in a snowhouse (igloo). The qualitative assessment of the bag was that it was adequate. No operational problems were encountered. The ambient temperatures were in the -35 to -45°C range.

10. The physical characteristics of the complete bag are compared to those of the existing CF Arctic sleeping system in Table I. The method of assessing thermal performance is that described in another conference paper (2).

References

1. R.J. Osczevski and B. Farnworth, "Thermal Properties of Battings and Their Potential in Improved Sleeping Bags", CDA 16, Thirteenth Commonwealth Defence Conference (OCCE), Malaysia, 1981.

2. B. Farnworth and R.J. Osczevski, "Heat Transport in Cold Weather Clothing", CDA 8, Fourteenth Commonwealth Defence Conference (OCCE), Australia, 1985.

TABLE I

	CF Double Bag with Air Mattress	CF Double Bag with 1 cm Foam Pad	Prototype
Mass (kg)	6.8	5.9	4.8
Packed Volume (l)	40	52	47
Thermal Resistance Up (m^2K/W)	2.8	2.8	2.0
Thermal Resistance Down (m^2K/W)	0.6	0.6	1.3
Thermal Resistance Overall (m^2K/W)	1.13	1.13	1.64
Temperature for 5 h Sleep* (°C)	-30	-30	-60
Temperature for Thermal Balance** (°C)	-15	-15	-35

* Based on heat production of 60 W/m^2, respiratory heat loss of 17 W/m^2, skin temperature of 30°C, rate of change of body heat content of 11 W/m^2.

** Based on heat production of 56 W/m^2, respiratory heat loss of 13 W/m^2 and skin temperature of 34.5°C. The effective area of the body is considered to be 1.5 m^2.

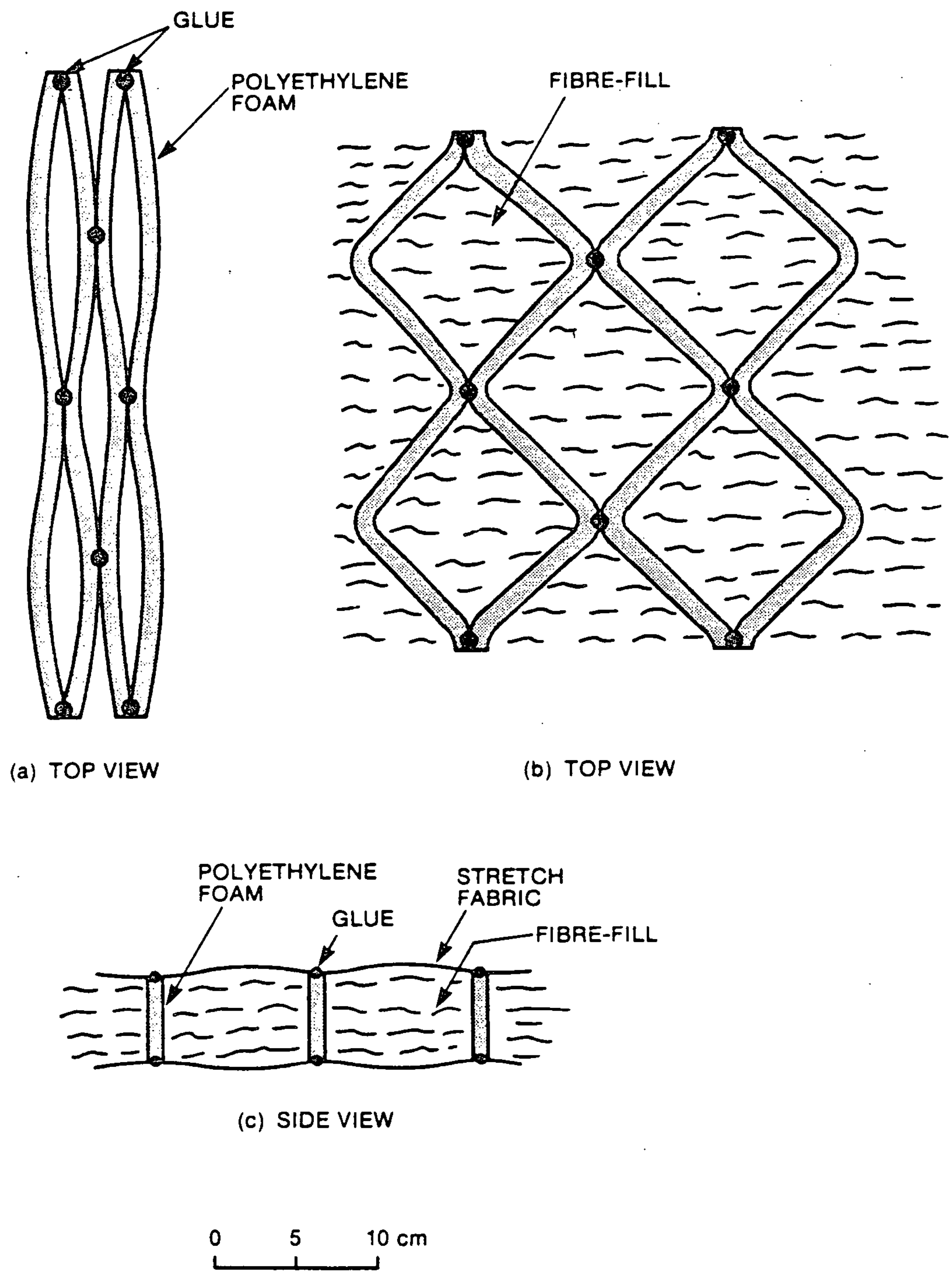

Figure 1: Construction of the sleeping pad.

(a) Strips of polyethylene foam are glued together.
(b) The structure is expanded and the spaces filled with polyester batting.
(c) Layers of stretch fabric are glued to the top and bottom surfaces.

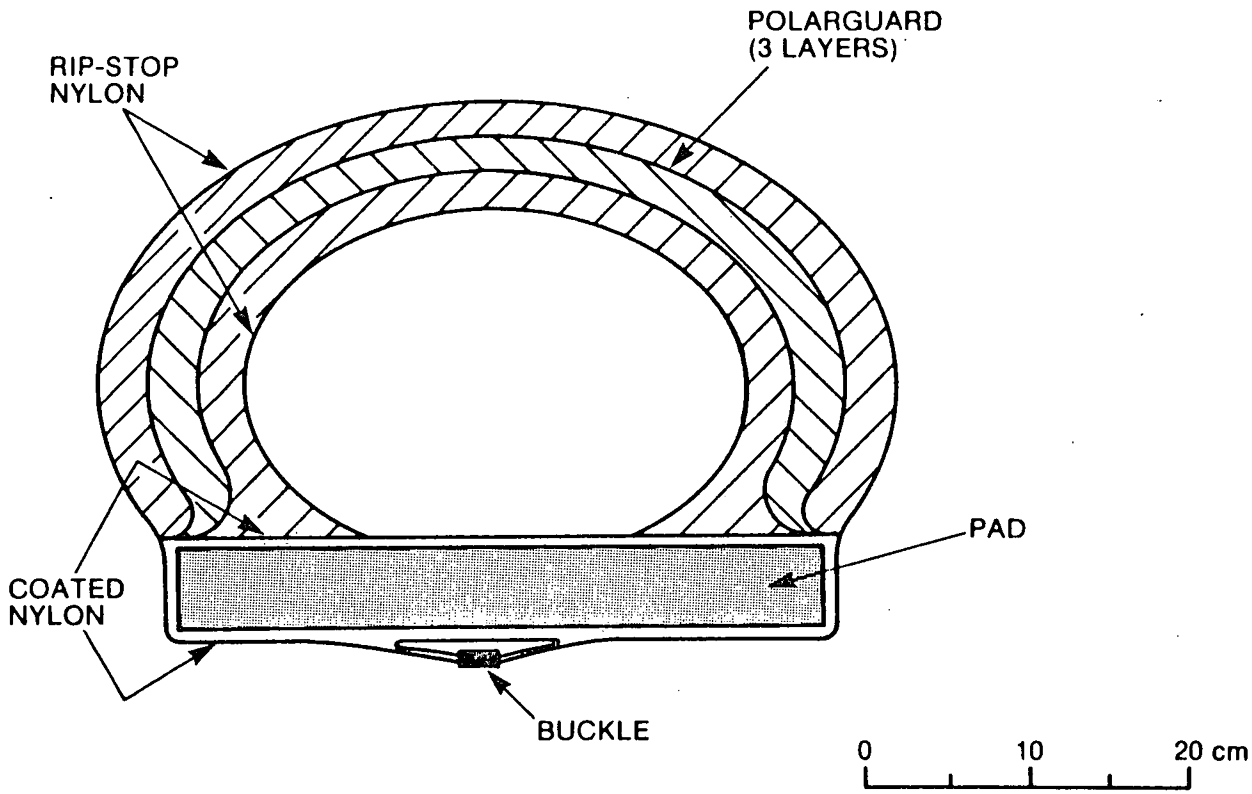

Figure 2: Cross section of the bag and pad combination in use.

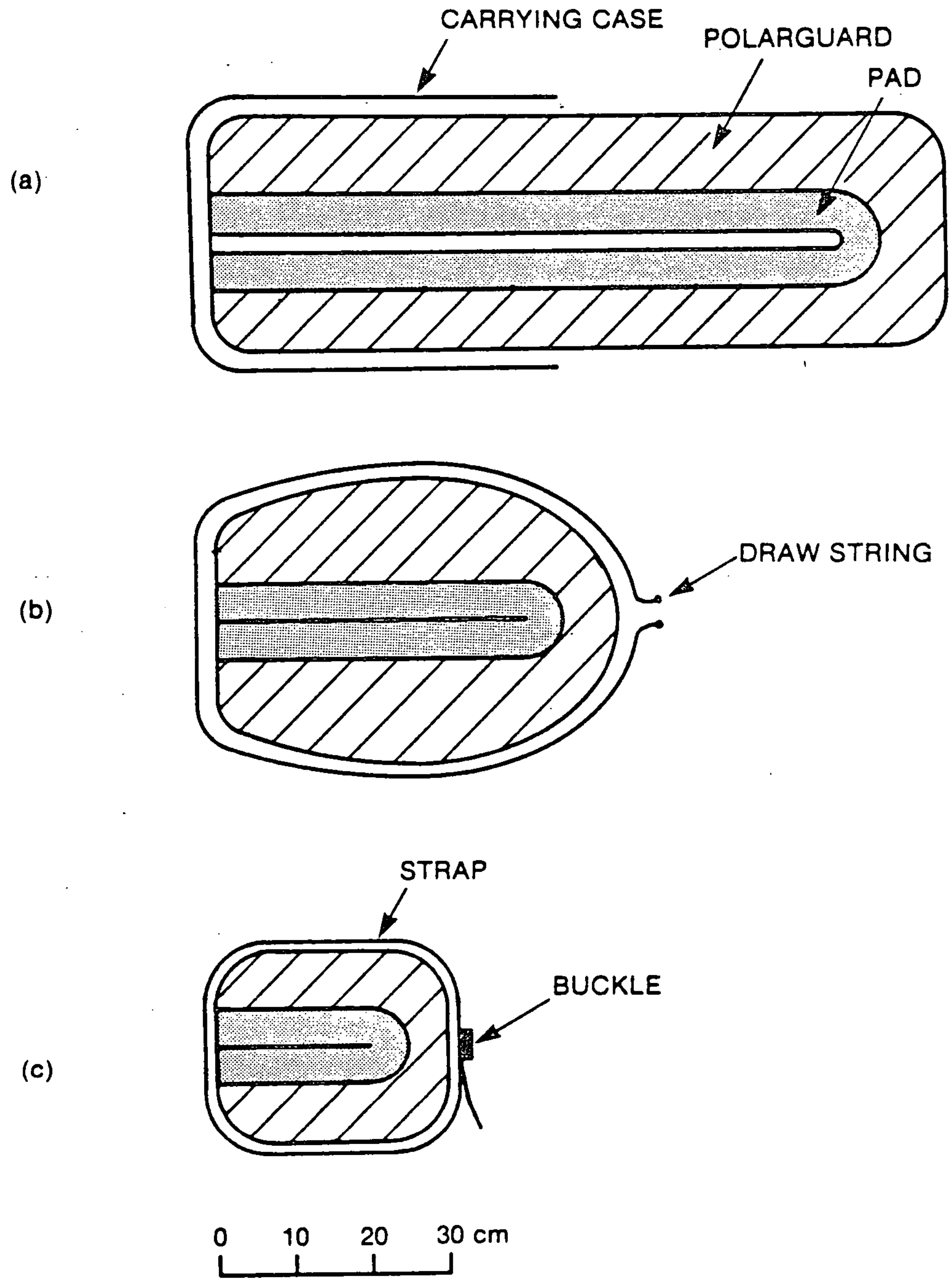

Figure 3: Packing the bag into its carrying case.

(a) The bag is folded in two and the ends put into the case.

(b) The bag is loosely stuffed into the case which is closed with a draw string.

(c) The bag is compressed by three straps encircling the carrying case.