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TECHNICAL REPORT

TR 76-41-CEMEL

# BATTING TYPE FILLING MATERIALS FOR SLEEPING BAGS

February 1976

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UNITED STATES ARMY
NATICK RESEARCH and DEVELOPMENT COMMAND
NATICK, MASSACHUSETTS 01760

Clothing, Equipment & Materials Engineering Laboratory

CEMEL 162

U.S. DEPARTMENT OF COMMERCE
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# Batting Type Filling Materials for Sleeping Bags

Army Natick Research and Development Command Mass

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This report summarizes work carried out by the US Army Natick Research and Development Command to evaluate and develop synthetic type filling materials and constructions for improved military sleeping bags. Several types of developmental and newer commercial synthetic filling materials were evaluated in various configurations and combinations. Tests included laboratory hot plate, manikin (copper man) tests in sleeping bag form, and user tests under field conditions. Battings made from either crimped continuous polyester

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filaments or unbonded cut staple polyester fibers, when assembled in selected constructions, resulted in sleeping bags that, in their overall characteristics, offer economical and functional improvements over the standard Tan-O-Quil-QM treated feathers and down mixture used in the standard military sleeping bag.

## PREFACE

This report covers exploratory development work conducted under US Army Natick Research and Development Command (NARADCOM) Project No. 1J662713DJ40 and related efforts under 1J664713DL40 and 728012.12 to develop a replacement for the waterfowl feather and down blend currently used as filling materials in military sleeping bags. While waterfowl feathers and down have excellent insulation properties, they are limited in supply, expensive, and variable in quality. The Tan-O-Quil-QM treatment of feathers and down, which was developed earlier under a related program, significantly improved the performance quality of waterfowl feathers and down and made it possible to reduce the proportion of down in the blend used to fill military sleeping bags. This greatly reduced the cost, but did not reduce the dependence on a critical natural material from primarily off-shore sources. Accordingly, the search was continued for a suitable filling material which would be readily available at a moderate cost from domestic sources. It was found that batting and other synthetic filling materials of types and qualities then being used in moderately priced civilian sleeping bags and quilts did not meet the combination of military requirements for high bulk and insulation efficiency in use, low bulk when packed, and launderability. Efforts were directed to the evaluation of newer forms of filling materials being developed by leading industry sources. The more recent evaluations reported herein show that the best of the new polyester fiber battings, properly assembled and constructed into sleeping bags, approach and in some respects surpass the Tan-O-Quil-QM feather and down mixture in their essential performance characteristics.

The prior contributions of Dr. S. J. Kennedy and Mr. George Cohen, and of Mr. Charles Sorrento of the current Clothing, Equipment and Materials Engineering Laboratory staff are acknowledged; also those of Dr. Ralph Goldman and others of the Military Ergonomics Laboratory of the Army Research Institute of Environmental Medicine.

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## I. INTRODUCTION

### A. Scope

This report summarizes work directed to the development of improved and more economical outdoor sleeping gear for military use. It deals primarily with the insulating filling materials themselves and their positioning and assembly within the bag structures, and only incidentally with overall concepts of sleeping bag shape and design. The objectives of these studies were to investigate the potential of several of the new prototype synthetic filling materials being developed by prospective commercial suppliers, and to evaluate their overall suitability in actual sleeping bags in comparison to the standard M-1949 bag with waterfowl feather and down blended filling. While foams, felts, creped paper waddings, and various fiber blended fillings have had at least cursory evaluation concurrently, the major effort has been directed to the more promising types of battings made from polyester filaments and fibers which have come the closest to duplicating the desirable characteristics of waterfowl plumage in providing high bulk at low pressures and low bulk at moderate packing pressures.

### B. Basis

The standard US Army outdoor sleeping gear taken as the basis for comparison consists of a basic mummy-shaped 'mountain' sleeping bag designed to give adequate protection for sufficient sleep in ambient temperatures down to -10°C (+ 14°F), and an 'arctic' sleeping bag of larger dimensions designed to be used over the basic mountain bag in combination to give protection from -10°C to -40°C. An outer water-repellent cover case, a pneumatic mattress, and a waterproof carrying bag complete the assembly. Though the criteria for protection are not precise, the performance objectives are to provide conditions which for trained and conditioned users will allow six hours of sleep before body temperature is lowered to an uncomfortable or unacceptable level for maintenance of health and effectiveness.

Both sleeping bags as specified in Military Specification MIL-S-830, Sleeping Bags, M-1949 are made of cotton balloon cloth in overlapping channel construction with full-length zipper closure at top center. They are provided in regular and large sizes. The regular size basic mountain bag contains 1304 g (46 oz) and the large size 1474 g (52 oz) of a blend of Tan-O-Quil treated waterfowl feathers and down. The supplementary regular size arctic bag contains 992 g (35 oz) and the large size 1162 g (41 oz) of the same blend. In normalized units comparable to textile products, these filling materials are equivalent to 441 $g/m^2$ (13 $oz/yd^2$) and 295 $g/m^2$ (8.7 $oz/yd^2$), respectively. These filling weights have been kept constant over the years, with feather and down proportions and specific blend lot formulas being adjusted according to available types and qualities in order to yield a standardized filling power and insulation level for these bags.

### C. Material Characteristics

Prime goose down has traditionally been considered the standard of excellence as the filling material in outdoor sleeping bags and in comforters. It gives the highest bulk and insulation (for a given weight) in use, and the lowest bulk when compressed for portage or storage, of any practical materials which have been available. Because goose down is expensive and has been in very limited supply from domestic sources, the Military elected to extend the pure down by blending with the more readily available and economical waterfowl feathers. Also, for a brief time, chemically treated (Tan-O-Quil—QM) crushed chicken feathers were included in the blend. However, for lack of a full replacement material, both waterfowl feathers and down have been classed as critical materials of largely off-shore origin, and have been stockpiled for a number of years by the General Services Administration to provide for emergency military requirements.

Though not all significant characteristics of filling materials for sleeping bags are easily defined, the following criteria are to be recognized:[1]

| | |
|---|---|
| **Filling Power** | – Ability to maintain a large volume under relatively low pressure |
| **Compressibility** | – Ability to be reduced in volume under moderate pressure |
| **Resilience** | – Ability to return to original volume when pressure is removed |
| **Durability** (stability) | – Ability to maintain physical and mechanical properties, through long-term use and handling |
| **Launderability** | – Ability to maintain physical and mechanical properties through multiple launderings |

[1] Cohen, G., Tan-O-Quil-QM Treatment for Feathers and Down, US Army Natick Laboratories, Clothing and Organic Materials Laboratory, Technical Report TS-159, August 1968, pp 1-2.

| | |
|---|---|
| **Softness** | – Freedom from irritating elements such as stiff quills |
| **Warmth (Insulation Value)** | – Total resistance to heat transmission including conduction, convection, and radiation |
| **Insulation Efficiency** | – Insulation value (clo) normalized to unit weight or to unit thickness as the basis for comparison |
| **Clo** | – The amount of insulation or resistance that will allow the passage of one kilogram calorie per square meter per hour with a temperature gradient of 0.18 degree centigrade between the two surfaces |

Secondary characteristics to be considered in varying degrees, depending on the application and usage, are:

Drapeability

Low water absorption

Quick drying

Flame resistance

Mildew and/or insect resistance

Freedom from allergenic or odorous substances.

Insulation value is generally considered as directly proportional to bulk or thickness, and insulation efficiency (per unit weight) inversely proportional to bulk density.[2] These relationships have been useful rules of thumb and hold surprisingly well for a considerable variety of filling materials of differing composition. However, internal air-flow impedence and reflective surface area also affect insulation efficiency. Because of its high internal

[2] Fourt, L. and N. R. Hollies, The Comfort and Function of Clothing, US Army Natick Laboratories, Clothing and Personal Life Support Equipment Laboratory, Technical Report TS-162, June 1969, pp 46.

surface area, waterfowl down itself falls slightly above the normal insulation/thickness ratio (0.15 clo/per mm or 3.75 clo/per in.) for conventional fibrous materials. Research is being conducted under other programs to develop new materials and systems which will attain even higher ratios. However, the present report deals with more conventional materials and forms in various blends and constructions for which the normal insulation/thickness relationship generally applies.

### D. Evaluation Criteria

Insulation as related to clothing and sleeping gear is commonly expressed in terms of "clo" units. Clo is defined as "the amount of insulation or resistance that will allow the passage of one kilogram calorie per square meter per hour with a temperature gradient of 0.18 degree centrigrade between the two surfaces" (reference 2). For rough comparative purposes, one clo can be equated with the overall insulating value of a man's ordinary business apparel. In terms of sleeping gear, it has been calculated that the clo values shown in Figure 1 are required for thermal equilibrium or to keep a man in a sleeping bag warm enough for 6 hours of sleep, within the indicated range (approximately 15° to -62°C or 60° to -80°F) of ambient temperature.[3,4]

Another property of practical significance is the material response to the several levels of pressure which are involved in sleeping bag usage. As shown by Roberts and Edelman (reference 3) and illustrated in Figure 2, the pressure applied to the filling material in a sleeping bag by the occupant may vary from practically nothing at the top of the bag, to 21 kPa (3 psi) in local areas at the bottom. Since pressures control the thickness and resulting effective insulation in local areas, resistance to compression is favorable in the actual use situation. On the other hand, pressures in a rolled-up sleeping bag, though varying somewhat with the person who does the rolling, are only approximately 2 kPa (0.3 psi) as an order of magnitude (reference 3).

It is obvious that the characteristic of good compressibility of the insulation filler under roll pressure is in conflict with desired low compressibility under the weight of

[3] Roberts, N. E. and N. B. Edelman, Quartermaster Research on Down and Feathers and Other Filling Materials for Sleeping Bags, Headquarters, Quartermaster Research and Engineering Command, Natick, Mass. Textile Series Report 43, Reprinted October 1957, pp 45, 46 and 57.

[4] Private Communication, Dr. A. H. Woodcock, US Army Natick Laboratories, October 1955.

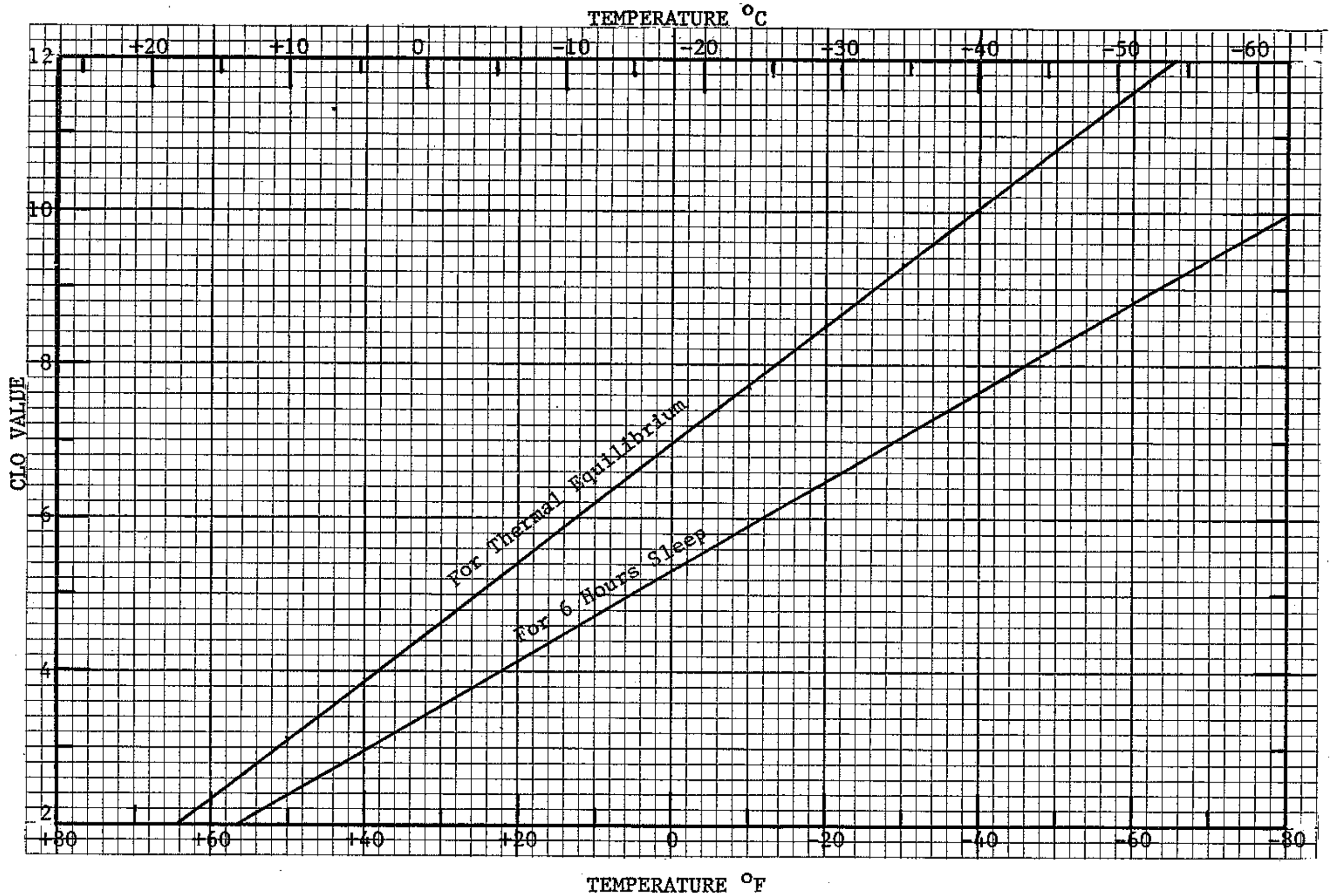


FIGURE 1. THEORETICAL CLO VALUES FOR COMFORTABLE SLEEP

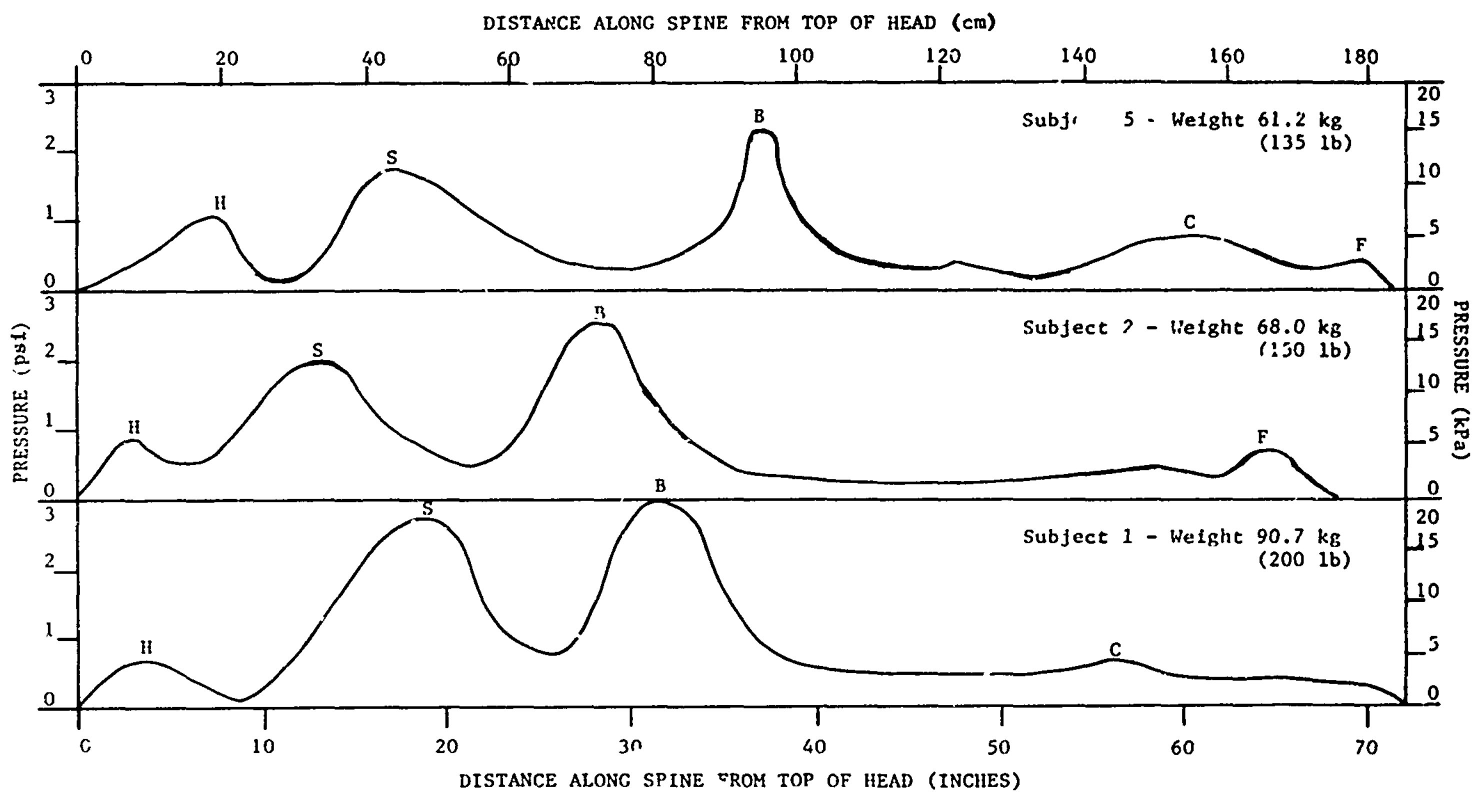


FIGURE 2. DISTRIBUTION OF PRESSURE ON BOTTOM OF SLEEPING BAG
(PRESSURE MEASUREMENTS ALONG SPINE OF SLEEPER)

the sleeper. (For this reason, where easily compressed fillers such as down are used, auxiliary cushioning such as a pneumatic mattress, clothing, or fir boughs may be needed to improve effective insulation under the sleeper.) The major technical objective of these studies was to develop filling materials and systems which would provide the optimum balance of these characteristics. As a class, the original commercial synthetic filling materials were too low in compressibility for acceptance under military field conditions.

## II. TYPES OF BATTING

The polyester fibers have shown the most appropriate characteristics of modulus and resiliency as generally compared with cellulosics, acrylics, and polyolefins, and consequently have had the most rapid rate of growth in filling and insulation applications. Resin-bonded polyester staple-fiber battings have already been adopted for military use in quilted poncho liners (replacing wool blankets) and the original quilted winter clothing liners (replacing pile fabrics), but had not proved suitable for the sleeping bag application. Primary faults have been poor compressibility and resulting excessive bulk of the rolled bag, and partial collapse or loss of effective thickness occurring in use and laundering. However, the resin-bonded staple polyester batting has provided a point of departure and a secondary basis for comparison in evaluation of other batting forms.

### A. Resin-bonded Cut Staple Battings

This common commercial type is made of crimped staple fiber which is dispersed and then laid down as a batt by a garnetting, carding, or airlay process. The batting is then treated with a resin binder, generally by spray application, then dried and heated to cure the resin while the batting is in an uncompressed condition. One commonly used binder system is an acrylic base with an addition of melamine for crosslinking. The resin add-on is limited to 18% in the Military Specification MIL-B-41826 (Batting, Synthetic Fibers: Polyester, (Quilted and Unquilted), Types I, II and III) which covers this type of batting.

Resin-bonded staple battings made by conventional process are generally not made in weights over 136 grams per square meter because in practice the bulk density tends to increase as actual weight (areal density) increases. The data for a controlled series made to investigate this relationship is shown in Table 1.

## TABLE 1

**Weight, Thickness and Bulk Density of a Series of Resin-Bonded Polyester Staple Battings**

| Areal Density | | Thickness @ 0.07 kPa | (0.01 psi) | Bulk Density @ 0.07 kPa | (0.01 psi) |
|---|---|---|---|---|---|
| g/m$^2$ | oz/yd$^2$ | mm | in | kg/m$^3$ | lb/ft$^3$ |
| 68 | 2 | 7.37 | 0.29 | 9.46 | 0.59 |
| 102 | 3 | 9.91 | 0.39 | 10.10 | 0.63 |
| 136 | 4 | 13.21 | 0.52 | 10.26 | 0.64 |
| 170 | 5 | 13.97 | 0.55 | 12.18 | 0.76 |
| 203 | 6 | 14.99 | 0.59 | 13.63 | 0.85 |

Applications involving much over 136 g/m$^2$ areal density are usually obtained by use of two or more layers of lighter batting.

Resin bonded polyester staple battings are relatively low in cost particularly when they incorporate waste or reclaimed fiber. They are also easy to cut, quilt and fabricate, and do not require a carrier fabric or a diaphragm when used in alternating channel constructions.

### B. Needle-Loomed Battings

Needle-loomed or needle-punched battings are made by a machine in which the loose batt of staple fibers is presented to a series of barbed needles which are repeatedly forced through the batt and then withdrawn. Due to this repeated and progressive action of the barbs as the batt moves along, a chain or mesh of interlooped and entangled fibers is formed. The density of the batt is controlled by varying the spacing of the needles, depth of penetration, and number of penetrations along the batt. These battings characteristically have excellent drape, but also have relatively high bulk densities if needled sufficiently to have reasonable integrity and resilience.

### C. Unbonded Cut Staple Battings

A newer type of batting made available for this evaluation and now in commercial production consists of unbonded cut staple polyester fiber treated for fiber-to-fiber cohesion without actual adhesive bonding. The fiber has a pronounced sawtooth crimp and can be made into battings on any conventional equipment. These battings resemble waterfowl down in that they have unusually high loft at low pressures and compress readily at intermediate pressures. Due to the special finish, they can not be stabilized with supplemental resin binders and so are supplied with a cheesecloth cover which serves as a carrier for shipping, handling and the quilting operation, and remains in the end-item.

## D. Continuous Filament Battings

The other new type is continuous filament polyester batting made from tow. The filaments are crimped transversely as a group across the tow band, spread to a uniform width and thickness by an air jet, and then fed between pairs of steel rolls threaded in opposite directions. As the crimped tow passes through the nip of the rolls it is spread in such a manner that the crimps are out of register with one another, producing a lofty batting. The original continuous filament battings did not contain a bonding agent. The individual filaments, although partially entangled, were relatively free to move in a lateral direction so that they distorted easily and the layers clung together in a shipping roll. A carrier such as paper was used to separate and deliver the batting into the quilting operation. Continuous filament battings are now processed without a supporting layer if about 6 percent (based on batting weight) of a resin binder or stabilizer is applied to each surface. No loss in the more favorable characteristics of this structure form is caused by this minor addition.

Another original problem with continuous filament quilted battings was excessive shrinkage during laundering and drying. It was found, however, that if the batting was heat set before quilting by exposing it to a temperature of 163° to 177°C (325° to 350°F) for 3 to 5 minutes, the shrinkage in quilted form was reduced to about 4 percent in the length and 6.5 percent in the width. This compares to about 2 percent in the length and 5 percent in the width for the standard bag filled with waterfowl feathers and down. This type of batting is now Type IV in MIL-B-41826, and is currently used in the quilted cold weather clothing liners where its characteristic drape and suppleness, also excellent retention of thickness through multiple launderings, are particularly advantageous.

# III. TEST METHODS – LABORATORY

## A. Insulating Value

The two procedures used for determining the basic insulating values of the filling materials under study are the "Guarded Hot Plate"[5] and the "Copper Man" (reference 3). In the Guarded Hot Plate method, samples are placed on a flat horizontal heated plate, about 51 cm (20 in.) square, in a chamber maintained at 10°C (50°F). The surface of the heated plate is maintained at 33°C (92°F). The plate is insulated so that all heat losses occur through the upper surface which is in contact with the sample being evaluated.

[5] Weiner, L. I., A Guarded Hot Plate Apparatus for the Measurement of Clo and Moisture Permeability Index, US Army Natick Laboratories, Clothing and Personal Life Support Equipment Laboratory, Material Examination Report No. 8389, February 1969.

The electrical energy required to maintain the 33°C (92°F) at the surface of the center portion of the plate as heat escapes through and from the sample being evaluated is determined. This value is substracted from that needed to maintain the bare plate at the same temperature, and the difference is used to compute the insulating value of the sample. This method is suitable for comparing the basic insulating value of reasonably similar materials in flat uncompressed form, but is not valid for determining the insulating value to be expected in a sleeping bag with its complex contours and pressure patterns.

In the Copper Man Test, a heated copper manikin (clothed in a standard manner) is placed in the sleeping bag in a climatic chamber, and the heat input to maintain the original temperature is determined. The chamber temperature for these tests was held at −6.7°C (20°F) with a wind velocity of 0.20 m/sec (40 ft/min), while the copper man was maintained at 29°C (85°F). This intermediate comparative test simulates actual conditions of use more closely than the plate test. However, since the available manikin weighed only 32.99 kg (72 3/4 pounds), and is not deformable like a human body at points of pressure, measurements do not correspond fully with values and performance which might be obtained in a real-use situation.

The Copper Man evaluations for this program were conducted under contract by the Military Ergonomics Laboratory, US Army Research Institute of Environmental Medicine.

For the plate tests, samples were made up in simulation of the basic assemblies to be used in the sleeping bags. For the Copper Man tests, the bags were made up in the Standard M-1949 overall design, with assembly details as appropriate for the filling. All filling materials were inclosed between two layers of 132 g/m² (3.9 oz/yd²) cotton balloon cloth stitched into parallel overlapping channels, 15.2 cm (6 inches) wide. A single cheesecloth middle diaphragm was used for the feathers and down, and double cheesecloth (carrier cloths, quilted in) for the continuous filament batting which at that time was not resin stabilized. No diaphragm was used for the self-supporting resin-bonded and needle-loomed battings.

### B. Laundering

The laundering test used to determine any shifting, redistribution or loss in thickness was two cycles at low temperature launderings by Formula G, Department of Army Field Manual 10-17.

## IV. EVALUATIONS

The several evaluations under this program involved initial basic material characterizations by laboratory procedures, followed by tests for insulation performance in the full sleeping bag configuration using the Copper Man method in a climatic chamber and finally by actual service tests under field conditions. Since each sub-project had somewhat distinct rationale and circumstances, they are discussed separately with the findings and conclusions for each in the following sequence:

A. All-batting (four types) vs. standard feather and down blend, in standard bag design.

B. Combination bags with batting in bottom sections.

1. Original design
2. Modified design

C. Combination bags with batting in inner layer, top and bottom.

1. Experimental design
2. Prototype (LINCLOE system) design

A. **All-Batting Systems**

The descriptions and test results of the four basic polyester batting types included in the investigation are summarized in Table 2 in comparison to the 80/20 feather/down blend control samples which represented the typical standard M-1949 Army sleeping bag. Because of characteristic sample variability and the inherent imprecision in this type of testing, these data are to be taken only for rough comparative guidance and not as absolute or fully duplicable values. However, for the sake of relating properties of specific samples, the data are expressed as normally read and recorded, rather than being rounded to grosser figures.

The clo insulation data are shown in both actual values for the specific samples, and in normalized values based on a standard areal density (441 $g/m^2$ or 13 $oz/yd^2$) and on unit areal density ($g/m^2$ or $oz/yd^2$) and unit thickness (millimetres or inches). These normalizations are useful as indicators of relative insulation efficiency, and are reasonably predictive within an areal density range close to the samples providing actual data. However, particularly since the clo data includes the relatively constant insulation contribution of the still air layer adjacent to the sample, extrapolations beyond the immediate range may not be reliable.

It is seen that the clo and normalized clo values for the polyester type battings in simulated assembly form approximate those of the 80/20 feather/down. However, the apparent superiority of the resin-bonded batting in the plate test did not hold for the clo value of this bag in the copper man test. A possible explanation is that the greater stiffness of the resin-bonded battings prevented a good drape or "fit" for the bag over the contours of the manikin, thus increasing heat loss by convection. This discrepancy

## TABLE 2

**Summary of Comparative Data on Various Polyester Batting Filling Materials**

| Plate Data (Simulated Assembly) | Control, Std 80/20 Fea/Down | Continuous Filament | Needle Loomed Staple | Resin Bonded Staple | Unbonded Staple |
|---|---|---|---|---|---|
| Areal Density, | | | | | |
| $g/m^2$ | 427 | 441 | 400 | 342 | 407 |
| $(oz/yd^2)$ | (12.6) | (13.0) | (11.8) | (10.1) | (12.0) |
| Thickness @ | | | | | |
| 0.014 kPa, (mm) | 44.7 | 38.9 | 29.9 | 45.2 | 53.3 |
| (0.002 psi), (in.) | (1.76) | (1.53) | (1.18) | (1.78) | (2.10) |
| Bulk Density, | | | | | |
| $kg/m^3$ | 9.62 | 11.4 | 13.3 | 7.53 | 8.02 |
| $(lb/ft^3)$ | (0.60) | (0.71) | (0.83) | (0.47) | (0.50) |
| Total Clo | 6.61 | 6.90 | 5.76 | 6.83 | 5.87 |
| Normalized Clo @ | | | | | |
| 441 $g/m^2$ | 6.83 | 6.90 | 6.35 | 8.81 | 6.36 |
| (13 $oz/yd^2$) | (6.82) | (6.90) | (6.35) | (8.79) | (6.36) |
| Clo per $g/m^2$ | 0.02 | 0.02 | 0.01 | 0.02 | 0.01 |
| (Clo per $oz/yd^2$) | (0.52) | (0.53) | (0.49) | (0.68) | (0.49) |
| Clo per mm | 0.15 | 0.18 | 0.19 | 0.15 | 0.11 |
| (Clo per in.) | (3.76) | (4.51 | (4.88) | (3.84 | (2.80 |
| **Copper Man Data (Std Bag Configuration)** | | | | | |
| Filling Weight, | | | | | |
| g | 1389 | 1389 | 1644* | 1389 | 1389 |
| (oz) | (49) | (49) | (58) | (49) | (49) |
| Total Clo | | | | | |
| Initial | 5.85 | 5.72 | 5.95 | 5.60 | 5.98 |
| Laundered (twice) | 6.01 | 5.80 | 6.12 | 5.70 | 5.99 |

*Higher weight due to error in fabrication between the clo values by the plate and the Copper Man method illustrates the dangers of predicting service performance from data obtained in test procedures.

Additionally, Table 3 shows the related Copper Man and the user test results on the all-batting (standard design) sleeping bags incorporating three of the four basic batting types. The user tests for these comparisons were conducted by the General Equipment Test Activity (GETA) of the US Army Test and Evaluation Command at Fort Lee, Virginia, under Project Nos. 8-8-7111-01 (letter report 9 July 1968)[6] and 8-8-7111-03 (letter report 17 June 1969)[7]. Temperatures ranged from −12° to +13°C (10° to 55°F) in the series #1 and from −6° to +16°C (21° to 61°F) in the series #2. Bag types were rotated among test personnel following five nights of use and one cycle of laundering.

Due to varying weights of filling, the shrinkage in laundering of the continuous filament batting bags caused uncomfortable restriction in the shoulder areas. For other variables of tests, subjects, and ambient temperatures, no close rankings or comparisons are attempted. The conclusions are that all of the batting bags in the studies are at least equally as satisfactory to the users as the standard bag with respect to warmth and comfort in sleeping bags of M-1949 general design. All of the batting bags initially were substantially bulkier in the rolled condition. However, they tended to reduce in rolled bulk with continued use and launderings, and the user test reports concluded that they were compatible with the load-carrying system. Though the overall development objective to reduce the bulk and profile of the living-load assembly was not satisfied, it was considered by the investigators and management that one or more of the polyester batting types would be an acceptable substitute for the waterfowl feathers and down, at least in an emergency supply situation.

Review of comparative data on the several polyester batting types at this time indicated that the continuous filament and the unbonded staple system offered the greatest development potential for improved performance in use and for overcoming remaining deficiencies. The needle-punched battings were found to be intrinsically of higher bulk density if needled adequately for sufficient cohesion for handling in sleeping bag manufacture and stability during long-term service and laundering. Also, in these relatively

[6] Final Letter Report dated 9 July 1968, Product Improvement Test of Synthetic Batting Type Filling Materials for Sleeping Bags, USATECOM Project No. 8-8-7111-01.

[7] Final Letter Report dated 17 June 1969, Product Improvement Test of Synthetic Batting Type Filling Materials for Sleeping Bags, USATECOM Project No. 8-8-7111-03.

## TABLE 3

**Summary of User Tests for Various All-Polyester Batting Filled Sleeping Bags**

| Filling Material | Control, Std 80/20 Feathers & Down | | Continuous Filament | | Needle Loomed Staple | Resin Bonded Staple |
|---|---|---|---|---|---|---|
| **Field Test Series #** | **1** | **2** | **1** | **2** | **1** | **2** |
| Total Bag Weight, | | | | | | |
| g | 2750 | 2807 | 3572* | 3175* | 3147* | 2693 |
| (oz) | (97) | (99) | (126) | (112) | (111) | (95) |
| Est. Filling Weight, | | | | | | |
| g | 1332 | 1389 | 1985 | 1588 | 1758 | 1361 |
| (oz) | (47) | (49) | (70) | (56) | (62) | (48) |
| Rolled Volume, Initial | | | | | | |
| $m^3$ | 0.021 | 0.021 | 0.032 | 0.027 | 0.031 | 0.032 |
| ($ft^3$) | (0.75) | (0.74) | (1.13) | (0.95) | (1.08) | (1.13) |
| Rolled Volume, After Use | | | | | | |
| $m^3$ | 0.021 | 0.024 | 0.025 | 0.024 | 0.025 | 0.025 |
| ($ft^3$) | (0.73) | (0.83) | (0.88) | (0.85) | (0.88) | (0.87) |
| Clo, Copper Man | | | | | | |
| Initial | 5.58 | 5.32 | 6.66 | 5.60 | 5.95 | 4.70 |
| After Use | 5.17 | 4.47 | 6.47 | 5.80 | 5.65 | 5.30 |
| Thickness, Initial | | | | | | |
| @ 0.07 kPa, (mm) | 11.2 | 10.2 | 22.9 | 14.7 | 19.3 | 19.3 |
| 0.01 psi, (in.) | (0.44) | (0.40) | (0.90) | (0.58) | (0.76) | (0.76) |
| Thickness, After Use | | | | | | |
| @ 0.07 kPa, (mm) | 12.2 | 9.65 | 20.8 | 14.7 | 14.5 | 10.2 |
| 0.01 psi, (in.) | (0.48) | (0.38) | (0.82) | (0.58) | (0.57) | (0.40) |
| Comfort Rank | | | | | | |
| Series #1 | 3 | | 2 | | 1 | |
| Series #2 | | 1 | | 1 | | 1 |

*Higher weight due to error in fabrication

**Higher weight intentional to compensate for higher bulk density low areal densities, their density and thickness tended to vary considerably. Accordingly, these were not included in the subsequent sleeping bag developments. The resin-bonded staple battings were continued as a secondary control for comparison, and as potentially the least costly and most widely available type. The unbonded staple was withheld for awhile awaiting further progress in its development which subsequently qualified it for the second series of combination bags.

### B. Combination Filling System with Batting in Bottom

The evaluation of the several synthetic and natural insulative filling materials showed varying combinations of bulk density, compressibility, and resilience. Since these characteristics would be of differing relative significance according to the locations within the sleeping bags, it was concluded that there might be possible advantage in using different filler types in different portions of the bag, according to the varying significance of the requirements for these positions.

One concept was that of a sleeping bag containing polyester batting in the bottom (underneath the sleeper) and head portions, with feathers and down in the sides and upper portions. This arrangement would have the prospective advantage of utilizing the less compressible batting where the filling is subjected to the greatest pressure, and the bulkier but more compressible feather and down filling where the least pressure is exerted during use. Used in this way, a more efficient and compressible 50/50 feather and down blend might be warranted economically for these portions, and the rolled bulk or volume of the combination bag would presumably be closer to the compactness of the standard bag than any of the all-batting bags of equivalent weight and insulative performance.

While putting this concept into practical terms for evaluation, questions arose as to what area constitutes the "bottom" of a mummy-type sleeping bag, and whether typical sleepers turned over within or with the bag. Accordingly, three differently designed bottom widths of batting filling were tried in the experimental bags, with the 50/50 mixture of treated waterfowl feathers and down in the sides and top panels. As shown in Table 4, there were no apparent differences in Copper Man clo values between the experimental bags with the three different batting-filled bottom widths. Consequently, sleeping bags of the 60.9 cm (24 inch) bottom width only were made up with the resin-bonded staple and the continuous filament polyester battings for user testest conducted by GETA under Project No. 8-EG-985-000-003 (Letter Report April 1970)[8]. As before, the combination and control standard bags were rotated following five nights of use and one laundering. Temperatures ranged from −10° to +4.4°C (14° to 40°F).

[8] Final Letter Report dated April 1970, by J. B. McAuley, Product Improvement Test of Synthetic Batting Type Filling Materials for Sleeping Bags, USATECOM Project No. 8-EG-985-000-003.

## TABLE 4

**Combination Sleeping Bags with Polyester Batting in Bottom and Head Portions, Feathers and Down in Sides and Top**

| **Laboratory Test Bags Filling Material** | **Control, Std 80/20 Fea/Down** | **Experimental Combination, Continuous Filament** | | | **Experimental Combination, Resin-Bonded** | |
|---|---|---|---|---|---|---|
| Bottom Width, | | | | | | |
| cm | 91 | 61 | 76 | 91 | 76 | 91 |
| (in.) | (36) | (24) | (30) | (36) | (30) | (36) |
| Total Weight, | | | | | | |
| g | 2722 | 2977 | 3147 | 3175 | 2722 | 2807 |
| (oz) | (96) | (105) | (111) | (112) | (96) | (99) |
| Rolled Volume, | | | | | | |
| $m^3$ | 0.021 | 0.025 | 0.024 | 0.024 | 0.024 | 0.026 |
| ($ft^3$) | (0.75) | (0.88) | (0.87) | (0.87) | (0.86) | (0.93) |
| Clo, Copper Man | 5.40 | 6.20 | 6.10 | 6.20 | 5.80 | 5.60 |

| **Field-Use Test Bags** | **Control, Std 80/20 Fea/Down** | **Experimental Combination, Continuous Filament** | **Experimental Combination, Resin-Bonded** |
|---|---|---|---|
| Bottom Width, | | | |
| cm | 91 | 61 | 61 |
| (in.) | (36) | (24) | (24) |
| Total Weight, | | | |
| g | 2863 | 3033 | 2977 |
| (oz) | (101) | (107) | (105) |
| Rolled Volume, Initial | | | |
| $m^3$ | 0.021 | 0.025 | 0.025 |
| ($ft^3$) | (0.75) | (0.90) | (0.91) |
| After Use* | | | |
| $m^3$ | 0.020 | 0.023 | 0.025 |
| ($ft^3$) | (0.73) | (0.83) | (0.89) |
| Clo, Copper Man | | | |
| Initial | 5.60 | 6.30 | 6.50 |
| After Use* | 5.70 | 5.70 | 5.90 |

*After 12 weeks of field use and 12 laundry cycles

The test data and user test opinions showed that the combination bags with both types of polyester batting in the bottom section and 50/50 feather/down blend in the sides and top were at least equivalent to the control standard bags in effective insulation, both initially and following use and multiple launderings. Another significant finding was that the rolled bulks of the combination bags were indeed closer to that of the standard bag than any of the previous all-batting bags of equivalent weight and performance.

Critical examination of the test sleeping bags following use, and laundering disclosed an undesirable migration of feather and down filling materials even through the cheesecloth diaphragm. In the course of correcting this condition, additional combination bags were made for test. In these modified bags using a lighter and finer texture 29.8-g/m$^2$ (0.88-oz/yd$^2$) nylon flare parachute fabric for the diaphragms, one set contained continuous filament polyester with the new lightly resin-stabilized treatment which avoided the weight of the carrier fabric. The other set contained an improved unbonded staple batting type which by small-scale laboratory evaluation appeared to offer more potential in overall properties than the resin-bonded staple for military type sleeping bags though still penalized on a weight basis at the time by the need for carrier fabric layers in order to fabricate the bags in a practical manner. In each set, one was made in the combination with batting in the bottom and the 50/50 feather/down blend in sides and top, and the other with batting throughout so as to provide a two-way comparison. The data from this series are shown in Table 5. They generally confirmed the equivalence of these polyester batting types in effective insulation, both in the all-batting and the combination bag configurations.

**TABLE 5**

**Laboratory Results of Modified-Combination Sleeping Bags**

| Filling Material | Control, Std 80/20 Fea/Down | Continous Filament All Batting | Continous Filament 50/50* Fea/Down | Unbonded Staple All Batting | Unbonded Staple 50/50* Fea/Down |
|---|---|---|---|---|---|
| Total Weight, | | | | | |
| g | 2750 | 2778 | 2948** | 3090 | 3232** |
| (oz) | (97) | (98) | (104) | (109) | (114) |
| Rolled Volume, | | | | | |
| $m^3$ | 0.021 | 0.027 | 0.022 | 0.026 | 0.025 |
| ($ft^3$) | (0.75) | (0.95) | (0.80) | (0.93) | (0.90) |
| Clo, Copper Man | | | | | |
| Initial | 5.71 | 5.75 | 6.16 | 5.98 | 6.42 |
| After Laundering | 5.55 | 5.80 | 6.28 | 5.99 | 6.61 |

*Modified-Combination bags with polyester batting in the bottom and head portions, feathers and down in the top and sides.

**Heavier weights due to extra layer of diaphragm material for containment of feather/down mixture.

The results at this point indicated more clearly a significant superiority of the continuous filament batting form, once free of the weight penalties for carrier fabric. Particularly notable was the high efficiency and low rolled bulk of the combination of this resin-stabilized continuous filament polyester and the 50/50 feather/down blend. The new type of unbonded staple filler also was found to warrant further interest because of its relatively high bulk (low density) under low or zero pressure as well as compressibility in laboratory evaluation of pressure/thickness relationship as shown in Figures 3, 4, and 5. However, with the restraints and extra material then required to incorporate the unbonded staple into the bag construction, the rolled bulks of the sleeping bags made therefrom were still rather high both in the all-batting and combination constructions.

### C. Combination Filling System with Batting in the Inner Layer

With the finding that sleeping bags containing a combination of polyester batting together with a mixture of waterfowl feathers and down performed significantly better than similar bags completely filled with batting, it was decided to evaluate an earlier suggestion for sleeping bags containing the 50/50 mixture of waterfowl feathers and down as the outside layer (top and bottom) and polyester batting as the inside layer. Such a concentric bag would be easier to manufacture than the feather and down top and batting bottom combination. Also, it would provide the same type and amount of insulation throughout the bag, should the bag turn "with" the occupant during sleep.

Another factor in the rationale for the concentric combination sleeping bag was the consideration of fire hazard. Though no firm requirements or criteria for fire resistance of military sleeping bags had been established, a working policy for development guidance was agreed upon. This was not to increase the hazard nor decrease the protection afforded by the standard bag. The protein nature of the natural feathers and down gave the standard bag rather slow ignition and burning rates, and also, an odor which alerted the occupant and others in the area as an early warning system. By continuing the use of the protein material in the outer layers, these features are maintained with respect to external sources of ignition such as sparks or stove contact.

Following this concept, five bags each of two types of experimental bags were fabricated and evaluated in comparison to the standard 80/20 feather and down bag. One type contained resin-stabilized continuous filament polyester, the other contained unbonded staple polyester in the inner layers. Both types contained the 50/50 feather/down blend throughout the outer layers. The results of this evaluation are shown in Table 6.

The laboratory results showed the redesigned concentric combination-filled sleeping bags to have slightly higher clo values than the standard both before and after laundering. It is interesting to note that in this series with identical filling weights, the clo values varied in the same ranking as the thickness at low pressures, and fairly closely in proportion as indicated by clo/inch value.

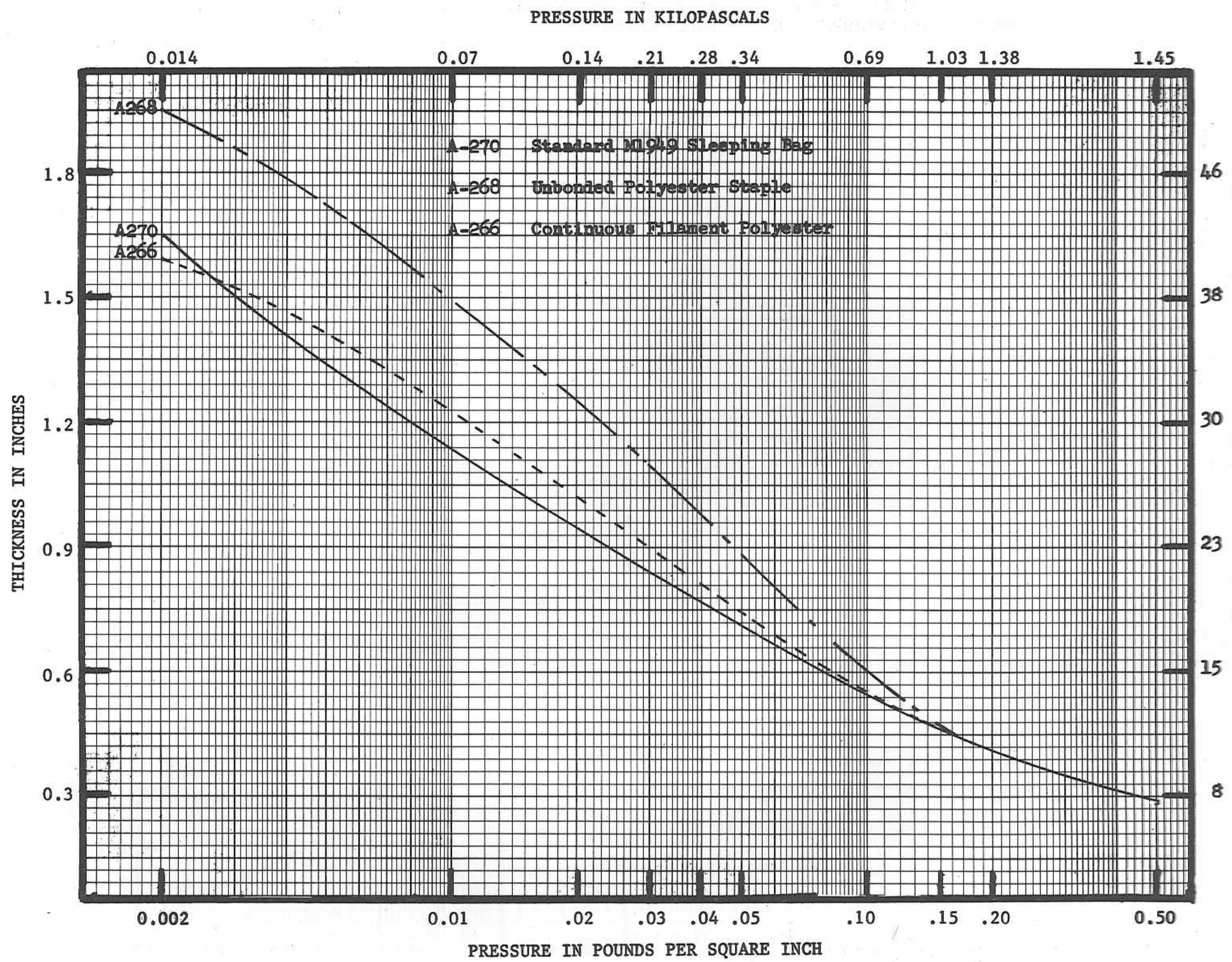


**FIGURE 3 - PRESSURE/THICKNESS RELATIONSHIP OF SLEEPING BAGS WITH BATTING FILLERS**

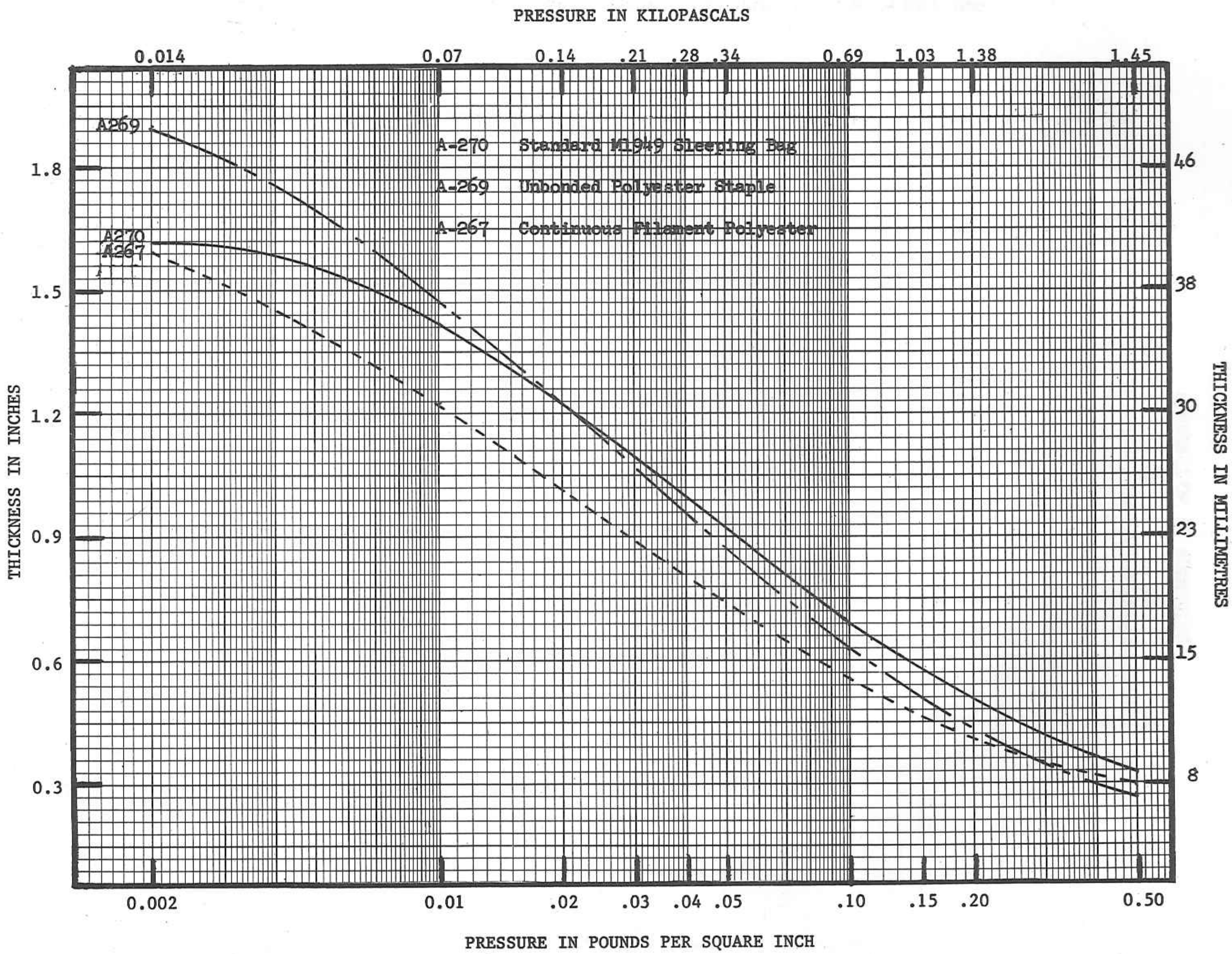


**FIGURE 4 - PRESSURE/THICKNESS RELATIONSHIP OF COMBINATION SLEEPING BAGS WITH POLYESTER BATTING IN BOTTOM AND HEAD PORTIONS, FEATHERS AND DOWN IN SIDES AND TOP**

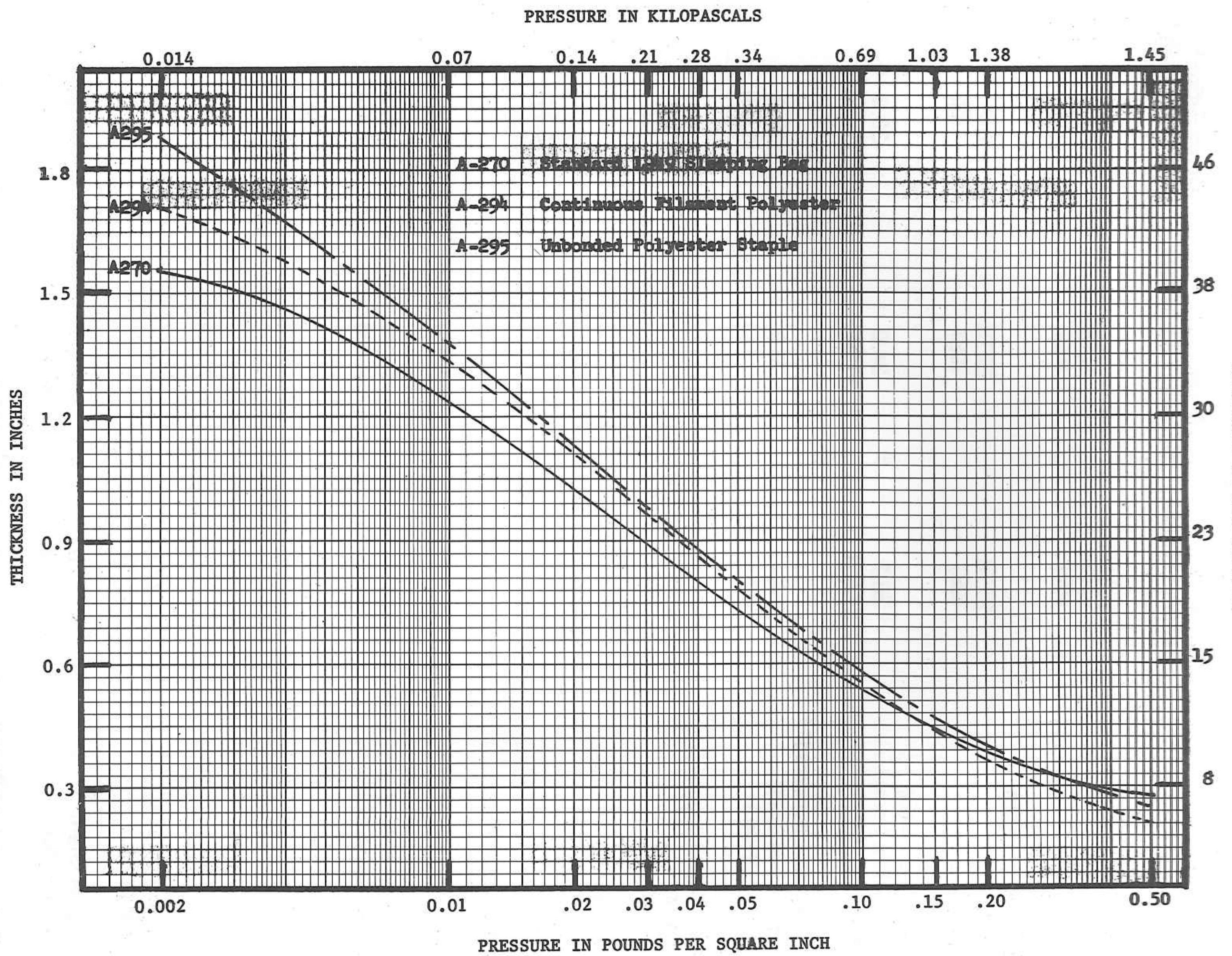


FIGURE 5 - PRESSURE/THICKNESS RELATIONSHIP OF MODIFIED-COMBINATION SLEEPING BAGS

**TABLE 6**

**Laboratory Results of Concentric-Combination Filled Sleeping Bags**

| | **Control, 80/20 Feathers & Down** | **Combination* Continuous Filament** | **Combination* Unbonded Staple** |
|---|---|---|---|
| Filling Weight, | | | |
| Grams | 1389 | 1389 | 1389 |
| (oz) | (49) | (49) | (49) |
| Total Bag Weight, | | | |
| Grams | 2778 | 2778 | 2920 |
| (oz) | (98) | (98) | (103) |
| Thickness, Initial | | | |
| @0.07 kPa (mm) | 30.7 | 34.0 | 35.3 |
| (0.01 psi) (in.) | (1.21) | (1.34) | (1.39) |
| Thickness, Laundered** | | | |
| @0.07 kPa (mm) | 24.4 | 26.9 | 33.8 |
| (0.01 psi) (in.) | (0.96) | (1.06) | (1.33) |
| Shrinkage, Percent** | | | |
| Width | 0 | 5.0 | 3.0 |
| Length | 0 | 2.5 | 5.0 |
| Rolled Volume, | | | |
| Cubic meters | 0.021 | 0.019 | 0.022 |
| ($ft^3$) | (0.75) | (0.68) | (0.77) |
| Clo, Copper Man | | | |
| Initial | | | |
| Total Clo | 5.70 | 6.10 | 6.20 |
| Clo per mm | 0.186 | 0.179 | 0.176 |
| (Clo per in.) | (4.71) | (4.55) | (4.46) |
| Clo per Gram | 0.0021 | 0.0022 | 0.0021 |
| (Clo per oz) | (0.058) | (0.062) | (0.060) |
| Laundered** | | | |
| Total Clo | 5.60 | 5.80 | 6.00 |
| Clo per mm | 0.230 | 0.217 | 0.178 |
| (Clo per in.) | (5.83) | (5.47) | (4.51) |
| Clo per Gram | 0.0020 | 0.0021 | 0.0021 |
| (Clo per oz) | (0.057) | (0.059) | (0.058) |

* Concentric-Combination bags with polyester batting in the inner layer, 50/50 blend of waterfowl feathers and down in the outer layer.

** After two low-temperature laundry cycles by Formula G of FM 10-17.

The bag containing continuous filament batting weighed exactly the same as the standard bag, but its rolled up volume was slightly less. This is attributed to the more compressible 50/50 feather and down mixture in the outside portion of this bag, whereas the standard bag filling contains only 20% of the more compressible down vs 80% of the stiffer feathers.

The bag containing unbonded staple batting weighed slightly more than the standard, which is attributed to the weight of the four layers of scrim cloth required to support the unbonded batting. The rolled volume of this bag was practically the same as the standard bag.

The thicknesses of these bags at various pressures is shown graphically in Figures 6, 7, 8, and 9 indicating that they have similar compressional characteristics. At low pressures such as are present in the upper part of sleeping bag in use (0.014 to 0.07 kPa or 0.002 to 0.01 psi), both of the combination filled bags were thicker than the standard bag. As the pressure increased, all of the bags decreased in thickness to about the same level indicating that none of these would offer much insulation at areas of pressure underneath the occupant. This, of course, has long been recognized as a limitation of the system.

All bags showed less than 0.5 percent loss in clo value after two launderings, which is negligible. The shrinkage of the experimental bags, while more than the standard bag, was within the 5 percent usually considered to be satisfactory. Visual examination of the bags did not reveal any evidence of shifting or lumping of the filling materials.

### D. Lightweight Cold Weather Sleeping Gear System (LINCLOE)

The good performance shown by the concentric combination feathers/down and polyester filled sleeping bags in the laboratory (Table 6) and limited field tests was sufficient recommendation to warrant the use of the concept in the development of lightweight sleeping bags for the Lightweight Individual Clothing and Equipment (LINCLOE) system.

Earlier attempts to develop a lightweight system were based on the concept that considerable weight could be eliminated by utilizing environmental clothing to complement the sleeping gear equipment. However, an engineering design field test of this system during winter of 1968–69, indicated that the sleeping bag failed to provide adequate protection and capacity to accommodate the occupant while wearing the required cold weather clothing for –40° to –54°C temperatures. A review and analysis of the test results indicated that a significant increase in weight and bulk was required to overcome these serious deficiencies. Since this was counter to the developmental objectives of the LINCLOE program, the concept of including clothing as part of the sleeping gear system was abandoned and the development proceeded on a two-bag sleeping gear system.

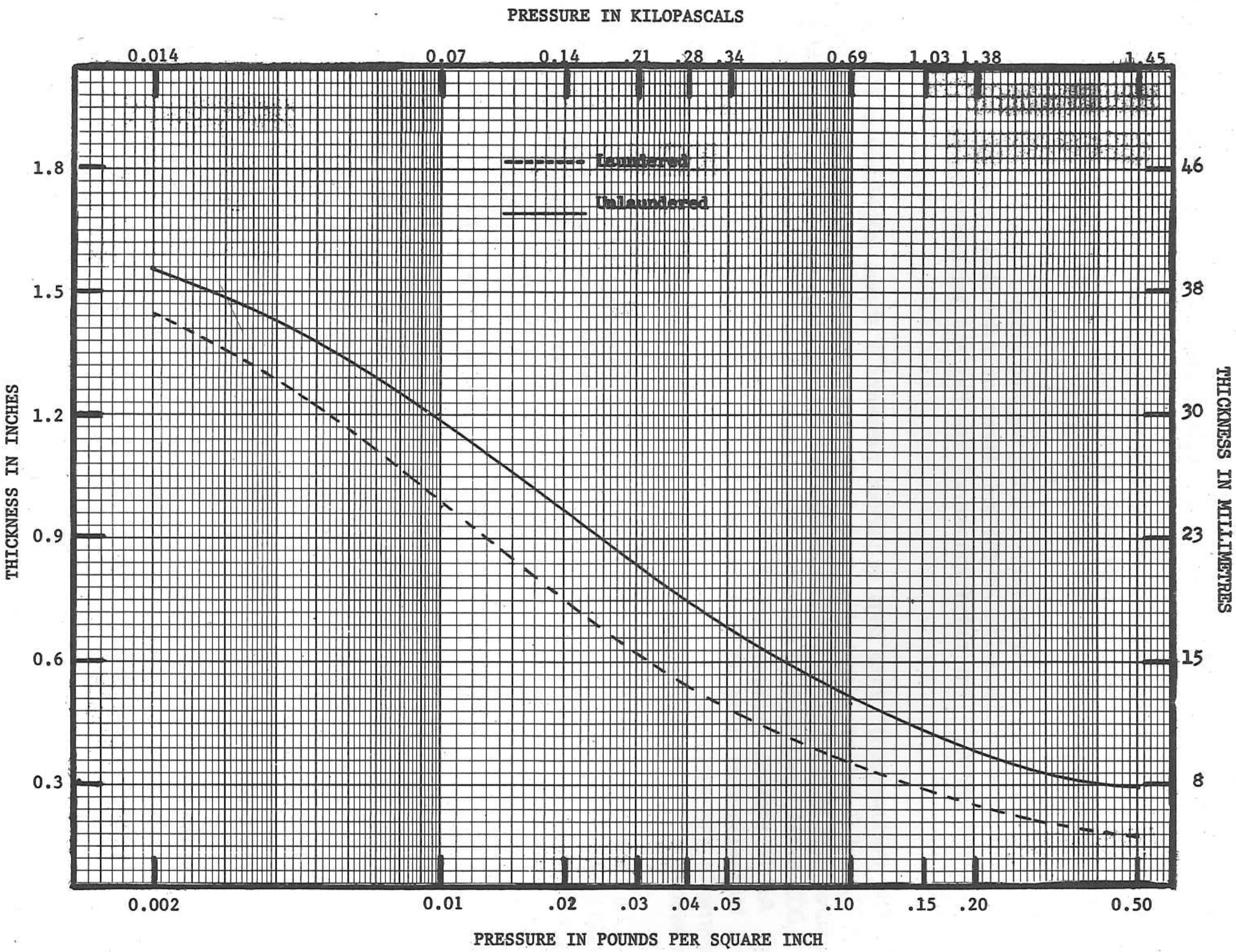


FIGURE 6 - THICKNESS OF STANDARD M1949 SLEEPING BAG FILLED WITH 80/20 MIXTURE OF FEATHERS AND DOWN

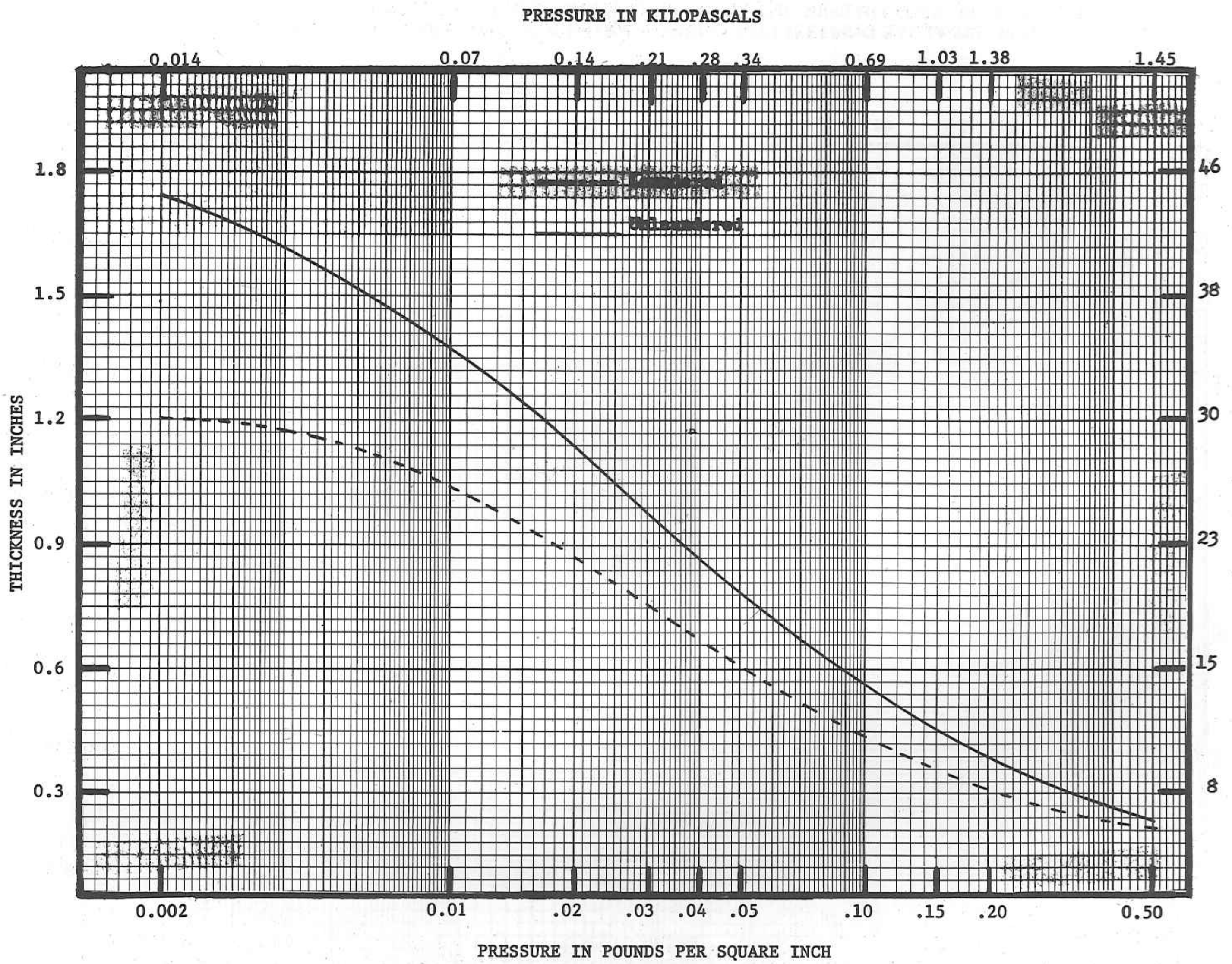


FIGURE 7 - THICKNESS OF CONCENTRIC-COMBINATION SLEEPING BAG (A-294) WITH CONTINUOUS FILAMENT BATTING ON INSIDE AND 50/50 MIXTURE OF FEATHERS AND DOWN ON OUTSIDE

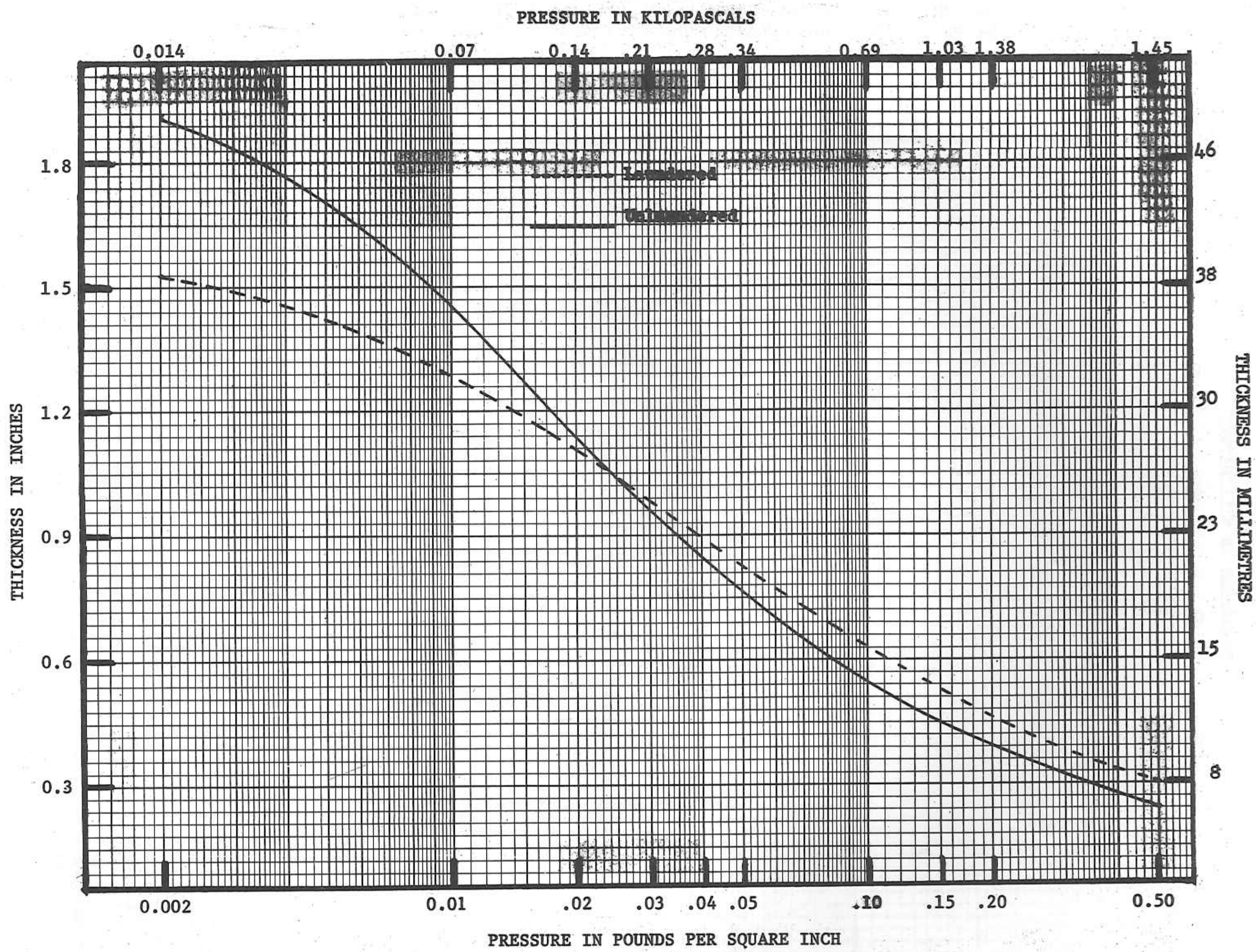


**FIGURE 8 - THICKNESS OF CONCENTRIC-COMBINATION SLEEPING BAG (A-295) WITH UNBONDED STAPLE BATTING ON INSIDE AND 50/50 MIXTURE OF FEATHERS AND DOWN ON OUTSIDE**

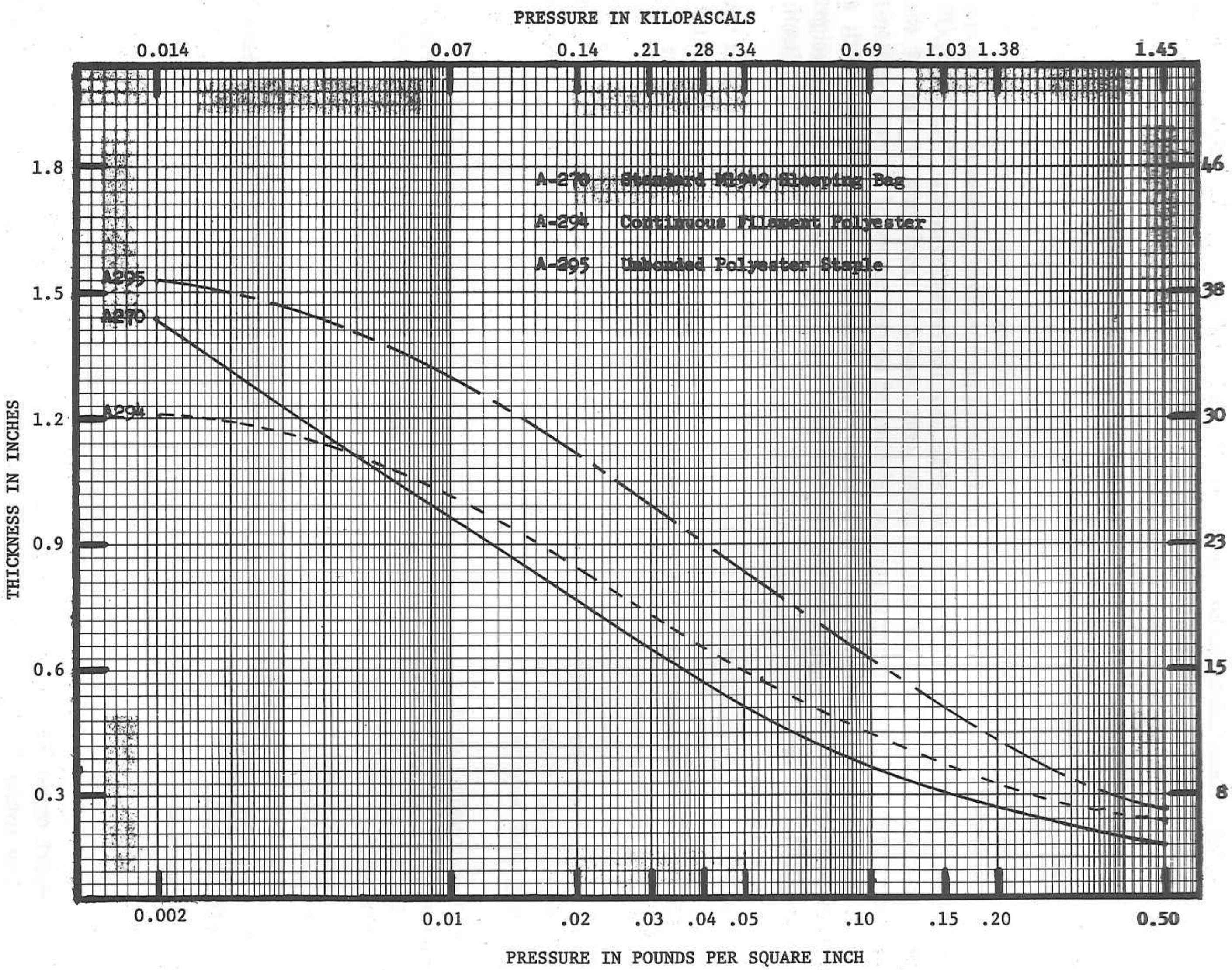


**FIGURE 9 - COMPARATIVE THICKNESSES OF CONCENTRIC-COMBINATION SLEEPING BAGS AFTER LAUNDERING**

Accordingly, these Laboratories developed an integrated sleeping bag design consisting of two discrete bags; one for an intermediate cold temperature range of +7° to −12°C and the other for an extreme cold temperature range of +7° to −40°C with additional shelter being provided for temperatures below −40°C.

The basic design features of the M-1949 standard mummy-shaped bag were retained, since they exibited the optimum utility in regard to weight and bulk. However, two distinct layers of insulating material were provided by incorporating the concentric-combination filling system. The inner layer contained polyester batting and the outer layer contained a 50/50 mixture of waterfowl feathers and down. The LINCLOE system of two separate bags for the cold-wet and cold-dry conditions, in lieu of the double-bag standard mountain/arctic system, eliminated several layers of fabrics and items of hardware, thus making it possible to provide more insulating filler material with a significant reduction in the weight of the extreme cold bag. A further reduction in weight was realized by consolidating the water repellent outer case in the sleeping bag itself.

This new version of lightweight sleeping gear has the distinct advantage in that the bags are lighter in weight, less bulky and simpler to use than the standard system. Also, both the intermediate cold bag and the extreme cold bag are ready to use without the need for adding or removing components to meet varying climatic conditions.

As a result of the foregoing, prototypes of the new lightweight intermediate cold and extreme cold sleeping gear systems were fabricated and subjected to concurrent engineering and service tests during the winter of 1972–73.[9,10]

The lightweight cold weather sleeping gear system consists of an intermediate cold and an extreme cold ensemble of four components: a sleeping bag, sleeping hood, insulated pneumatic mattress, and a waterproof carrying bag. A description of the components is as follows:

(1) **Experimental Items**

a. **Sleeping Bag, Intermediate Cold.** This bag is designed in a mummy-shaped configuration, 288.6 cm (90 in.) long and 76.2 cm (30 in.) wide, for medium size. The

[9] Final Report dated 31 May 1973, Development Test II (Service Phase) of Cold Weather Sleeping Gear under Arctic Winter Conditions, USATECOM Project No. 8-EI-515-000-002.

[10] Final Report dated August 1973, Development Test II (Engineering Phase) of Sleeping Gear, Cold-Weather, USATECOM Project No. 8-EI-515-000-006.

outer fabric is a water-repellent-treated 186.5-g/m² (5.5-oz/yd²) 50/50 cotton/nylon oxford cloth; the inner fabric is a water-repellent-treated 132.2-g/m² (3.9-oz/yd²) cotton balloon cloth. The inner channels, front and back, are quilted with 203.4-g/m² (6-oz/yd²) continuous filament polyester batting; the front and back outer channels, with 29.8-g/m² (0.88-oz/yd²) nylon diaphragm filled with a 50/50 mixture of waterfowl feathers and down. A full-length slide fastener is provided as the front closure; a snap fastener closure is also provided for emergency use should the slide fastener fail. The face opening is equipped with a drawstring closure to prevent the flow of cold air into the bag and to restrict the outward flow of warm air. Two tie tapes are attached at the foot of the bag for tying the bag in the rolled-carrying configuration. Two sizes of bag are provided, medium and large. The medium size bag weighs 3.4 kg (7.5 lbs).

b. **Sleeping Bag, Extreme Cold.** This bag (as tested) is identical in design and configuration to the intermediate cold bag, except that more insulation is provided. The medium size extreme cold bag weighs 4.3 kg (9.5 lbs).

c. **Hood, Sleeping.** The sleeping hood is made of a knitted 194-g/m² (5.75-oz/yd²) nylon/triacetate tricot fabric designed to cover the head, leaving only the face exposed. It is secured snugly around the face by means of chin flaps with a velcro-type fastener. It weighs 0.045 kg (0.1 lb).

d. **Bag, Waterproof (Standard A).** The waterproof clothing bag is made of a coated nylon fabric. It is 76.2 cm (30 in.) long and 42.55 cm (16.75 in.) in diameter. The bag weighs 0.4536 kg (1.0 lb).

e. **Insulated Pneumatic Mattress.** The mattress is made of rubber-coated nylon cloth. It has an octagonal shape, measuring 185.4 cm (73 in.) long by 83.8 cm (33 in.) wide. The mattress contains a layer of 169.5-g/m² (5-oz/yd²) resin bonded polyester batting insulation laminated to the inner top surface of each channel. The mattress weighs 1.598 kg (3.5 lb).

**(2) Standard Items (Controls)**

The standard items provided for comparison purposes consisted of the following:

a. Mountain Sleeping Bag M-1949, MIL-S-830

b. Arctic Sleeping Bag, Outer Shell M-1949, MIL-S-830

c. Case, Sleeping Bag, M-1945, MIL-C-707

d. Bag, Waterproof, Clothing, MIL-B-3108

e. Mattress, Pneumatic, MIL-M-10747

The standard sleeping bags were provided in large and regular sizes.

The Development Test II (Service Phase) (reference 9) under arctic winter conditions was conducted by the US Army Arctic Test Center from 1 October 1972 to March 1973 at Fort Greely, Fort Wainwright and None, Alaska. Temperatures ranged from –51.7° to +4.4°C (–61° to +40°F). The purpose of the test was to determine the performance characteristics of the experimental test sleeping gear system as compared to the standard system. Fifty intermediate cold sleeping systems and 47 extreme cold sleeping systems (plus 12 additional modified extreme cold systems midway through the test) were utilized. Eighty-nine standard intermediate cold (M-1949 Mountain) systems and 53 standard extreme cold (M-1949 Arctic) systems were tested.

The Development Test II (Engineering Phase) (reference 10) was conducted at Aberdeen Proving Ground and Natick Laboratories during the period of 17 November 1972 to 27 July 1973. The purpose of the test was to provide a technical evaluation of the performance of the experimental items in comparison to their standard counterparts and to determine the capability of the test items to meet the Technical Characteristics for lightweight, cold-wet and cold-dry weather sleeping gear approved by OCRD. Seventeen each of the experimental and standard intermediate cold and extreme cold systems were used in this evaluation.

The US Army Institute of Environmental Medicine at Natick conducted copper manikin studies to determine the insulation values for both types of experimental sleeping gear and their standard counterparts. Insulation values (clo) were obtained on the experimental bags before and after service use as well as representative items subjected to six-month storage tests. A summary of the data is shown in Table 7.

It was concluded from the results of the service and engineering tests that (1) the experimental sleeping gear was an acceptable replacement for the standard sleeping gear under arctic winter conditions, (2) the experimental sleeping gear including the modified test sleeping gear was at least equal to the standard sleeping gear in respect to environmental protection qualities, the amount of sleeping comfort afforded, maintenance required, moisture uptake and drying time, flammability, donning and doffing characteristics, and stability.

The experimental sleeping gear is superior to the standard system in the area of man-portability because of its lighter weight and greater troop acceptance. The intermediate cold sleeping gear system weighs 0.581 kg (1.28 lb) less than the standard, and the extreme cold sleeping gear system weighs 2.54 kg (5.6 lb) less than the standard.

At the Formal In-Process Review Meeting for Sleeping Gear, Cold Weather, Lightweight (LINCLOE) held at Natick on 5 March 1974, the following changes to the tested cold weather sleeping gear were approved by IPR members:

## TABLE 7

**Summary of Comparative Data for Service/Engineering Tests of LINCLOE Sleeping Bags**

| | Standard Mountain Type I, M-1949 | | LINCLOE Intermediate Cold Type I, M-1972 | | Standard Arctic Type II, M-1949 | | LINCLOE Extreme Cold Type II, M-1972 | |
|---|---|---|---|---|---|---|---|---|
| Size | Reg. | Large | Med. | Large | Reg. | Large | Med. | Large |
| Total Weight (kg) | | | | | | | | |
| Initial | 4.00 | 4.11 | 3.30 | 3.49 | 6.41 | 7.16 | 4.13 | 4.37 |
| After Field Use | | | 3.29 | 3.40 | | | 3.99 | 4.52 |
| After Storage | | | 3.29 | 3.49 | | | 4.06 | 4.35 |
| Thickness (mm) @0.07 kPa | | | | | | | | |
| Initial | 26.7 | 22.9 | 24.6 | 26.2 | 41.9 | 41.7 | 39.1 | 35.3 |
| After Field Use | | | 25.7 | 24.1 | | | 31.8 | 30.5 |
| After Storage | | | 26.4 | 27.9 | | | 35.8 | 34.3 |
| Rolled Volume ($m^3$) | | | | | | | | |
| Initial | 0.024 | 0.028 | 0.024 | 0.024 | 0.039 | 0.050 | 0.032 | 0.034 |
| After Field Use | | | 0.022 | 0.024 | | | 0.35 | 0.037 |
| Clo, Copper Man | | | | | | | | |
| Initial | 5.55 | 5.24 | 6.45 | 6.4[illegible] | 7.07 | 7.12 | 7.17 | 7.31 |
| After Field Use | | | 6.31 | 6.37 | | | 6.98 | 7.19 |
| After Storage | | | 5.70 | 5.79 | | | 6.75 | 6.64 |

(1) The outer covering fabric weight of 186.5 g/m$^2$ (5.5-oz/yd$^2$) was increased to 220.4 g/m$^2$ (6.5-oz/yd$^2$), the reason being that industry has advised that high volume production of the 5.5 oz fabric is not commercially feasible at the present time. While the use of the heavier fabric will result in an increase of 113.4 g (4 oz) per bag, the T. C. criteria for maximum weight will still be met.

(2) The insulating material for the outer panels of the extreme cold bag was changed from a 50/50 blend of waterfowl feathers and down to a 100 percent down content. The change was made to extend the clo value of the sleeping system for use in extreme cold climates. Copper-manikin tests showed that the extreme cold bag filled with 100 percent down attained an 8.08-clo value which provided 0.78-clo more than the same type bags evaluated during the engineering test phase.

As a result of the full scale development activities and subsequent changes, Military Specification MIL-S-43880 for Sleeping Bag (Feathers/Down and Polyester Batting), covering the requirements for the new lightweight sleeping bags, has been adopted and approved for use by all Departments and Agencies of the Department of Defense.

## V. FLAMMABILITY

Laboratory tests have shown that neither the feather and down mixture nor polyester battings encased in the standard 3.9-oz/yd$^2$ cotton balloon cloth will ignite when exposed to a lighted cigarette. However, if exposed to an open flame until the cover fabric ignites, both types of fillers will then burn until completely consumed, even if the igniting source is removed. A flammability test has been developed by NARADCOM (Appendix) to determine whether a low heat flux ignition source such as a match flame will ignite certain fabrics and spread flame to other component materials when these fabrics are placed over a standard batting. Cotton fabrics will not pass this test, but an untreated 6.5-oz/yd$^2$ 70/30 nylon/cotton (NYCO) blend fabric will. If the fabric is water-repellent-treated, the water-repellent finish must be specially selected so as not to increase flammability. While fabrics can be treated to improve their flame resistance and water repellency, the ideal treatment is one which does not increase the weight nor adversely affect the physical properties, such as strength, tear and abrasion resistance.

## VI. CONCLUSIONS

This report summarizes work to develop a synthetic batting type filling material for Military sleeping bags. The most promising materials to replace water fowl feathers and down are batts made from crimped continuous filament or unbonded cut staple polyester fibers. Sleeping bags filled with these types of batting are durable and have insulating value (clo) equal to bags filled with the standard feather and down mixture. When rolled up, their bulk is 20% to 30% greater than the standard bag. However, field tests have shown that sleeping bags completely filled with these battings are compatible with the load carrying system.

Sleeping bags filled with resin-bonded cut staple polyester battings have also been evaluated in field tests and found to be fairly satisfactory. The insulating value (clo) is slightly lower and the draping qualities are poorer than the continuous filament or unbonded cut staple polyester battings. However, due to their greater availability and lower price, this type of batting should be considered as an alternate filling material.

The concept of a sleeping bag containing a 50/50 mixture of waterfowl feathers and down in the outside layer and polyester batting in the inside layer is practical and offers significant advantages over the bag with feather and down "top" and batting "bottom" construction. Sleeping bags made in this manner have slightly higher clo values than the standard bag with little if any increase in weight or bulk when rolled for carrying. There is no significant reduction in clo value after laundering. The shrinkage due to laundering, while greater than the standard bag, does not exceed 5 percent in the length or 3 percent in the width.

## REFERENCES


1. Cohen, G., Tan-O-Quil–QM Treatment for Feathers and Down, US Army Natick Laboratories, Clothing and Organic Materials Laboratory, Technical Report TS-159, August 1968, pp 1–2.

2. Fourt, L. and N. R. Hollies, The Comfort and Function of Clothing, US Army Natick Laboratories, Clothing and Personal Life Support Equipment Laboratory, Technical Report TS-162, June 1969, pp 46.

3. Roberts, N. E. and N. B. Edelman, Quartermaster Research on Down and Feathers and Other Filling Materials for Sleeping Bags, Headquarters, Quartermaster Research and Engineering Command, Natick, MA, Textile Series Report 43, Reprinted October 1957, pp 45, 46 & 57.

4. Private Communication, Dr. A. H. Woodcock, US Army Natick Laboratories, October 1955.

5. Weiner, L. I., A. Guarded Hot Plate Apparatus for the Measurement of Clo and Moisture Permeability Index, US Army Natick Laboratories, Clothing and Personal Life Support Equipment Laboratory, Material Examination Report No. 8389, February 1969.

6. Final Letter Report dated 9 July 1968, Product Improvement Test of Synthetic Batting Type Filling Materials for Sleeping Bags, USATECOM Project No. 8-8-7111-01.

7. Final Letter Report dated 17 June 1969, Product Improvement Test of Synthetic Batting Type Filling Materials for Sleeping Bags, USATECOM Project No. 8-8-7111-03.

8. Final Letter Report dated April 1970, by J. B. McAuley, Product Improvement Test of Synthetic Batting Type Filling Materials for Sleeping Bags, USATECOM Project No. 8-EG-985-000-003.

9. Final Report dated 31 May 1973, Development Test II (Service Phase) of Cold Weather Sleeping Gear under Arctic Winter Conditions, USATECOM Project No. 8-EI-515-000-002.

10. Final Report dated August 1973, Development Test II (Engineering Phase) of Sleeping Gear, Cold-Weather, USATECOM Project No. 8-EI-515-000-006.

# APPENDIX

## TABLET FLAMMABILITY TEST FOR SLEEPING BAG CLOTHS

# TABLET FLAMMABILITY TEST FOR SLEEPING BAG CLOTHS

## 1. SCOPE

1.1 This method is designed to determine whether a low heat flux ignition source, such as a match flame, will ignite certain cloths, especially cloths used for sleeping bags, and spread the flame to other component materials when these cloths are placed over a standard batting.

## 2. TEST SPECIMEN

2.1 The specimen shall be a 9 inch by 18 inch (23 cm by 46 cm) rectangular piece of cloth with the long dimension parallel to the warp or filling direction of cloth. No two specimens shall contain the same warp or filling yarns in the longitudinal direction of the specimen.

## 3. NUMBER OF DETERMINATIONS

3.1 Unless otherwise specified, five speciments from both the warp and filling directions shall be tested from each sample unit.

## 4. APPARATUS

4.1 Two 12 inch by 12 inch (30.5 cm by 30.5 cm) square, 1/4 inch (6.35 mm) thick asbestos plates (see 7.1).

4.2 A draft-free inclosure (a hood) with an exhaust to remove fumes developed during the test.

4.3 Standard batting (see 7.3) – A 9 inch by 18 inch (23 cm by 46 cm) rectangular piece of polyester batting conforming to MIL-B-41826, Type V (6 oz. continuous filament batting without the cheesecloth).

4.4 A scale to measure angles to ± 1 degree.

4.5 Stop watch which will measure to 1.0 second.

4.6 Scale graduated to 0.1 inch (0.25 mm).

4.7 No. 1588 methenamine timed burning tablet or equal (see 7.2 and 7.2.1).

5. PROCEDURE

5.1 The test specimens shall be dried in a circulating air oven at a temperature of 105 ± 5°C for one hour before testing.

5.1.1 Only one specimen shall be removed from the oven at a time and tested immediately upon removal.

5.2 Place one of the asbestos plates in the draft-free inclosure (with exhaust off) with the back of the plate raised so that the front edge forms a 15° angle with the horizontal (see Figure 5907).

5.3 Preparing the test specimen. Superimpose the test cloth on the batting and fold in half with the batting on the inside of the folded ensemble. The specimen shall be handled carefully and not compressed by hand after folding.

5.4 Position and center the folded test ensemble on the inclined asbestos plate so that the folded edge of the ensemble is aligned with the lower edge of the plate. Check the alignment by using the second asbestos plate, held perpendicular to the horizontal, at the bottom edge of the inclined plate.

5.5 Place the ignition tablet at the center of one edge of the second asbestos plate. With the asbestos plate resting on the table surface, a few inches away from the test ensemble, ignite the tablet and slide the horizontal asbestos plate forward so that the leading edge, with the ignited tablet, contacts the lower edge of the inclined plate and the flame of the tablet contacts the test ensemble. The burning time of the tablet shall be measured, by means of a stopwatch, from the moment its flame touches the specimen until the moment it no longer touches the specimen. If the flame-to-specimen contact time is less than 90 seconds the results shall be rejected and an additional specimen tested.

5.5.1 The specimen shall remain in the test position until all flaming of the ignition tablet and the specimen has ceased. Should smouldering or after-glow of the specimen continue after the end of flaming, allow sufficient time to elapse to insure combustion has ceased.

5.6 Record the length of time the specimen continues to flame after the tablet flaming has ceased.

5.7 Record the length of time the specimen continues to glow after all flaming has ceased.

5.8 After both flaming and glowing have ceased, the specimen shall be removed from the batting, unfolded and placed on a flat surface to determine the char length. The char length shall be the length which is the greatest distance between any two points of charred area.

5.9 After each specimen is removed, the test area shall be cleared of fumes and smoke prior to testing the next specimen.

5.10 A new piece of batting shall be used for each specimen tested.

6. REPORT

6.1 The after-flame time, after-glow time and the char length of sample unit shall be the average of the results obtained from the individual specimens tested.

6.1.1 All values obtained from the individual specimens shall be recorded.

6.2 The after-flame time and after-glow shall be reported to the nearest 1.0 second.

6.3 The char length shall be measured to the nearest 0.1 inch (0.25 mm).

7. NOTES

7.1 Asbestos base plates used in the Department of Commerce Carpet and Rug Test; DOC 1-70 are satisfactory for use in this test.

7.2 A "timed burning table" may be obtained from Eli Lilly Co., Indianapolis, Indiana 46206. Product Number 1588 in Cat. No. 79, Dec. 1, 1969.

7.2.1 The burning tablets shall be stored in a desiccator over a desiccant for 24 hours prior to use. (Small quanitites of sorbed water may cause the tablets to fracture when first ignited. If a major fracture occurs, any result from that test shall be ignored and the test shall be repeated.)

7.3 The standard batting may be obtained from Celanese Fiber Company, P.O. Box 1414, Charlotte, NC 28201.

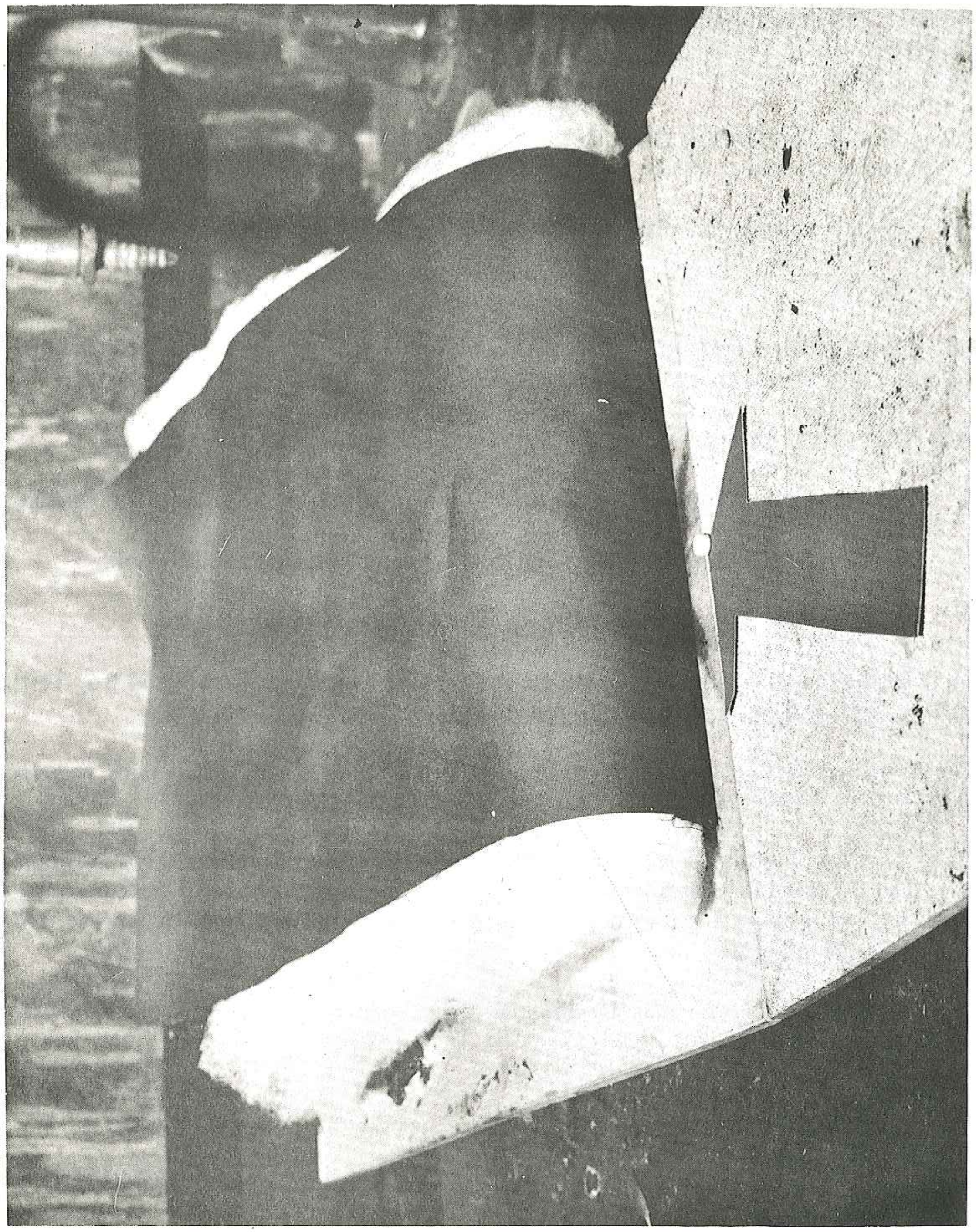

FIG. 5907 – TABLET FLAMMABILITY TEST FOR SLEEPING BAG CLOTHS