HOME ECONOMICS GUIDE

Published by the University of Missouri-Columbia
Extension Division
College of Home Economics

Insulated Outerwear: Fabrics and Fillings

Betty Feather
Clothing & Textiles Specialist

Shopping for outerwear such as a winter jacket, vest, ski pants or sleeping bag can be a difficult task with the many choices of fabrics and fillings. Kits are available for constructing many of these items at home with excellent savings for the consumer but again decisions must be made concerning the most appropriate fabrics and fillings. Once the choice has been made, satisfaction can be maintained if the garment is properly cleaned and stored.

Keeping Warm

How do we keep warm? The body produces heat by metabolizing food and this heat is maintained or eliminated by the amount and type of clothing. The amount of heat retained varies by the clothing insulation value, gament design and whether the garment is clean or soiled, wet or dry.

Insulation value is determined chiefly by the amount of air incorporated within the fiber or fabric as well as between the fabric layers. Garment design affects heat loss—garments which close at the wrist, ankles and neck prevent heat loss more than those that are open in these areas. Cleanliness or dryness affect heat loss because if available air pockets are filled with dirt particles or moisture, the insulation value is reduced.

Air is the key to warmth. Heat passes through air very slowly making it an excellent insulator. Another way of stating this would be that air is a poor heat conductor. To compare the insulation value of air with other common materials, look at the accompanying chart. Metal is an excellent conductor which is why it is used for cooking. Glass conducts heat efficiently which is the reason for covering windows to prevent heat loss. Note that air is a poorer heat conductor (or better insulator) than either leather or wool; this is the reason why several light layers of clothing may be warmer than one heavy wool garment, because layering creates air pockets.

Thermal Conductivity of Common Materials*[1]

Silver	0.99
Glass	0.0025
Human tissue	0.0005
Leather	0.0004
Paper	0.0003
Wool felt	0.000125
Pure wool	0.000084
Still air	0.000057

[1]Calories per second, per square centimeter per degree centigrade, per centimeter of thickness

*Marilyn J. Horn, THE SECOND SKIN, 2/ed. Copyright 1975 by Houghton Mifflin Company. Used by permission.

Individuals react differently to temperature changes. Body metabolism, age, physical activity, and body weight are some of the variables that affect how one reacts to temperature change. For instance, research results indicate that older persons feel more comfortable at slightly higher temperatures than younger persons. The more active a person is, the greater the amount of body heat generated and eliminated through evaporation of perspiration.

Body heat is lost through a variety of physical mechanisms that will serve as important guidelines in fabric and filling selection.

Conduction is the direct transfer of heat from a warm object to a cooler one. The rate of conduction depends upon the difference in skin and the surrounding surface temperatures as well as the nature of the insulator. As the air or surrounding temperature decreases the rate of heat loss increases; for example, heat loss from the unprotected head at 60° (15C) is 33 percent compared to 75 percent when the temperature is 5F (-15C).[1] Head coverings will reduce this heat loss, but the reduction will vary with the insulating qualities (see chart) of the head covering and the fit. The closer the fit, the smaller the air layer and the greater the heat loss.

Convection involves transfer of heat similar to conduction but air movements are an essential factor in the rate of heat lost. Heat transfer increases as air velocity increases. For example, at 10F with a wind speed of 20 miles per hour the effective wind chill temperature is -25F. Therefore when wind is a prime concern, tightly woven fabrics and fabrics with special finishes that resist the wind would reduce heat loss.

Radiation involves transfer of heat or energy from a hot object to a cooler one by means of electromagnetic waves. The body can absorb heat from the sun or radiate heat to the environment. Heat can be lost by holding the arms away from the body, or reduced by holding the arms close to the body. The arms, legs and head lose heat by radiation. This is the reason why mittens are warmer than gloves—the fingers radiate less heat in a close position.

Evaporation is a method of reducing body heat. Due to physical activity, body heat is increased and the skin temperature becomes greater than the surrounding air temperature. Body heat is given off through perspiration which depends to some degree upon the surrounding humidity. If body heat is given off too quickly, chilling will result. Clothing can retard this evaporation rate and keep the body warm. When clothing becomes damp with perspiration the insulating ability is drastically reduced. Therefore, when physically active, insulation which absorbs moisture is desirable for garments.

From these physical mechanisms suggestions can be obtained in selecting fabric and fillings. A desirable filling would be one that retains its resiliency (loft or bulk) thus holding more air and providing greater warmth (reduces conduction). A fabric that reduces the amount of heat loss because it is wind resistant is important (reduces convection). Garments that are designed to cover key heat loss areas (head and torso) will provide warmth (reduce radiation). Fillings which absorb some perspiration will slow down evaporation and thus reduce the chance of chilling (reduce evaporation).

When selecting an insulated outerwear a person needs to consider the activities it will be used for as well as the relative temperature where it will be used (Texas or Minnesota). If a person is planning to do physical work which generates more body heat, then less insulation or absorbent insulation may be appropriate. Whereas if a person plans to use a jacket chiefly for sitting at a football game when it is cold, more insulation and heat retaining designs will be needed.

Some jackets are marked with a suggested comfort range, although there are no current standards for determining this, it may serve as a guide within the same brand. Comfort range is only determined by temperature and does not take into account wind movement, anticipated activity nor radiation; generally comfort ranges are for the entire body excluding uncovered feet, hands and head. Comfort ranges in sleeping bags therefore may be more accurate than jackets or vests. These ranges can serve as guides rather than accurate indexes.

Insulation

Insulation is designed to trap air into tiny spaces or sections; it is this trapped air which provides warmth. The oldest, best known and most expensive insulator is **down.** In recent years various polyester fiberfills have been introduced that are considerably less expensive than down but provide excellent warmth for the dollar investment. A recent newcomer is a polyolefin whose microfibers provide an excellent network for capturing and holding air.

Down quality is determined by its air-holding capacity known as "cluster or fill power." A federal standard is used to evaluate cluster, the number of cubic inches an ounce of down will fill. To qualify as prime quality one ounce of down should fill at least 500 cubic inches. Many reputable down manufacturers will indicate what the fill power of the down is and what their standards are since there is no required industry-wide standard. Another misconception is the term "northern" down. In general, any fowl raised north of the equator can be labeled "northern" which does not support the idea that "northern" birds have thicker coats thus greater insulating power than others. Historically, the finest quality down was from the eider duck, hence the term eiderdown; these are almost nonexistent today. For the general market, goose down is considered slightly better than duck down.

Federal guidelines require the percentage of down be marked on a down product. Down is defined as an undercoating of water fowl without any quill shaft which makes down lighter and more resilient than feathers. The guidelines require a product labeled "100 percent down" contain at least 80 percent down and no more than 20

[1] *Lyman Fourt and Norman R. S. Hollies,* Clothing: Comfort and Function *(New York, Marcel Dekker, Inc. 1970) p. 61.*

percent feathers, dust or miscellaneous insulation. There has been considerable fraud in the down product industry, particularly with imported garments.

Desirable Characteristics of Down

- Light weight insulation material for retaining body heat
- Compresses exceptionally well (600 cubic inches can be compressed by hand pressure to 15 cubic inches)
- Breathes—body moisture escapes freely
- Resilient—compresses readily but expands to full thickness quickly
- Can be hand washed and dryer dried

Limitations of Down

- Most expensive insulation material
- Absorbs moisture
- Mats and loses insulating ability when wet
- Dries slowly
- Will mildew if not completely dried or stored in moist areas
- Aggravates allergy-prone persons

Approximately 80 percent of the down used in this country is imported, thus the domestic down price is affected by the value of the dollar. The largest suppliers of down include China, Eastern Europe and Canada. As down has increased in popularity as a fashion item the price has paralleled this trend. The price of down has increased threefold from 1975-1978.

Polyester fiberfill accounts for the major share of the 25 million pound apparel insulation market. Polyester fibers are assembled into sheet form and partially stabilized by either bonding or needling to facilitate handling. PolarGuard, Hollofil II and Polyslim are examples of trademarked polyester fibers. Trademarks provide some assurance to consumers that certain manufacturers' quality standards have been met.

Polyester and polyolefin fiberfills have characteristics that make them desirable as insulators.

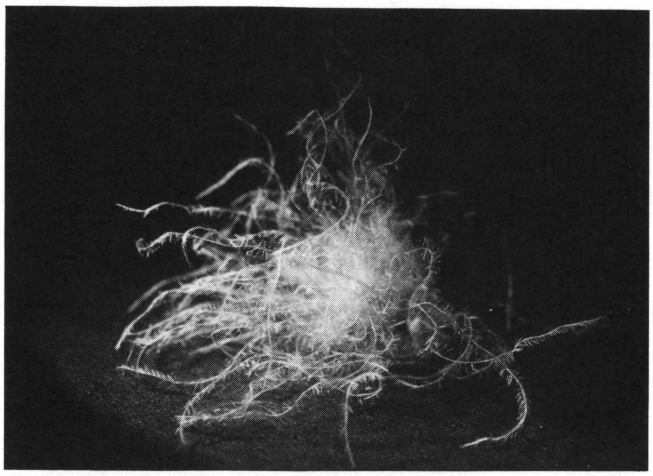
Desirable Characteristics of Fiberfills

- Maintains loft when wet
- Dries quickly
- Does not mildew
- Non-allergenic
- Provides adequate insulation for unit weight
- Machine washable and dryable
- Less expensive than down.

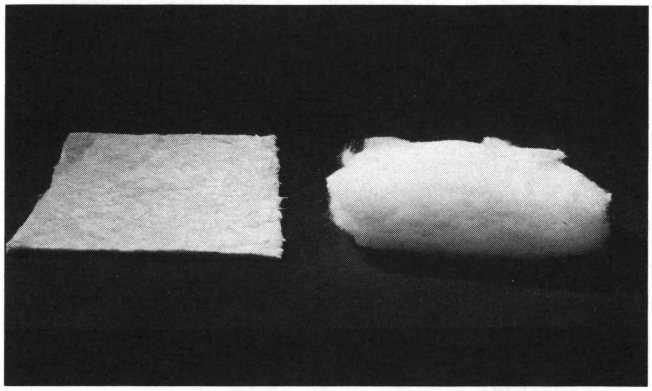
Limitations of Fiberfills

- Heavier and less compressable than down
- More likely to mat than down
- Does not absorb perspiration readily
- Loses insulating ability when wet
- Burns—insulates against heat as well as cold so fire may not be noticed immediately.

Hollofil II was developed by DuPont specifically for insulated apparel end use. It is a large diameter, hollow



Down is one of the oldest insulating fibers and currently the most expensive.



Compare the thickness of the new, thin insulation polyolefin microfiber (shown on the left) with the more common polyester fiberfill.

fiber which provides better loft per pound, thus more warmth per unit weight. A special finish gives Hollofil II a down-like feel. Like other fiberfills, 15-20 percent more synthetic fiber is needed to match the warmth of down. Because Hollofil II has short fiber lengths it must be quilted to prevent fiber shifting.

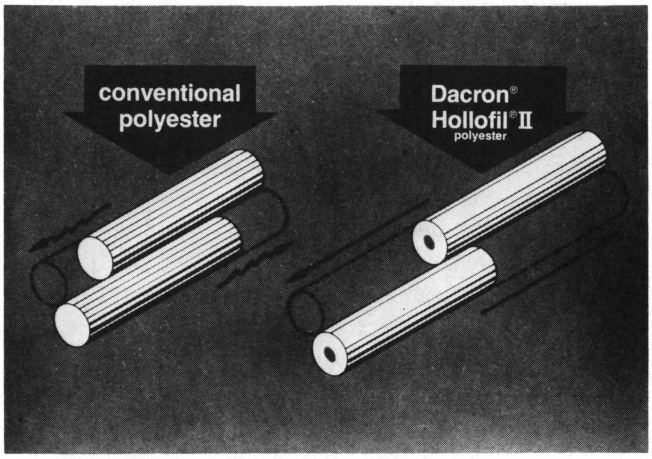
PolarGuard is a continuous solid fiber bound into a batting sheet. This construction does not form cold spots nor shift, therefore a minimum of quilting is needed. Like Hollofil II it is nonallergenic, washable and fast drying. Both are appropriate for wet weather campers and back packers.

Polyslim, a polyester insulator, is different from either Hollofil II or PolarGuard as it is needlepunched into a thin, base fabric and requires minimum quilting. It is used for insulation, interfacing and padding. Polyslim is also available in a stretch form primarily for ski-wear.

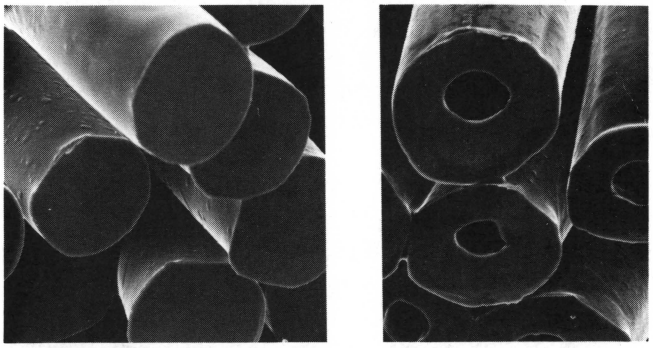
Polyolefin microfiber is the most recent development in the apparel insulation market. Thinsulate is the trademarked polyolefin microfiber of the 3M Corporation. The key to its insulation value is the fineness of the fiber and the air which surrounds the fibers. Thinsulate provides more warmth (insulation value) per inch of thickness than any other insulator including down. However, Thinsulate is heavier than down, so on a weight

basis Thinsulate is not as efficient as down. Since the microfiber is produced in a relatively thin sheet of batting it does not develop cold spots, mat nor shift. With this insulation product it is not necessary to have a bulky nor quilted look.

The chart will provide a basis for comparison of the characteristics of the current insulation products.



The hollow form has a larger diameter and provides more warmth per unit weight than the conventional polyester fiber.



Photograph of magnified conventional and hollow polyester fibers.

Fabrics

Several factors determine whether a fabric is suitable for outerwear use—weight, strength, abrasion resistance and porosity. Garments worn for active use need to provide some porosity so that perspiration can evaporate, however for insulation purposes not too much air should pass through.

The type of outer fabric for a jacket depends essentially on how the jacket will be used. For rugged versatile use, a tightly woven blend of cotton/polyester will be durable enough to withstand rips, tears and normal abrasion. However, in wet conditions the cotton/polyester blend will take longer to dry outdoors than 100 percent nylon. For backpacking, where the weight of the jacket becomes a key factor, nylon taffeta or ripstop nylon is frequently used. Tightly woven fabrics are essential coverings for down and other insulated fibers so the insulation does not work its way through the fabric.

Ripstop and taffeta nylon are both tightly woven, lightweight, strong, durable fabrics. Ripstop nylon has a grid-like appearance with a heavier yarn lengthwise and crosswise every 1/8 inch or 3/16 inch. Taffeta has heavier crosswise yarns. Both fabrics are water repellent and wind resistant. Nylon has a low melting point so placing the fabric in contact with hot iron, bulb or flame should be avoided. Nylon taffeta has better resistance to tearing and snagging than ripstop nylon.

Fabric finishes affect garment performance and personal comfort. Water-repellent and waterproof finishes are the two most frequently used for insulated outerwear. In general, waterproof finishes seal a fabric so that water and air do not pass through. When body moisture cannot evaporate, it condenses inside the garment creating a cooling effect or making the wearer feel chilly. Water-repellent finishes result in fabrics that resist wetting, are comfortable and do not alter appearance. A recent innovation in this area has been the use of Gore-Tex

Characteristics	Down	Hollofil II	PolarGuard	Thinsulate
Cost per lb.	$35-40	$1.35-1.55	$1.60	$3.00
Relative warmth of 1 cm thickness.	1.0	0.9	0.9	1.8
Weight per Volume	Excellent	Moderate	Moderate	Good
Compressibility	Excellent	Good	Good	Good
Allergenic	Yes	No	No	No
Mildew	Yes	No	No	No
Recomended Care:*				
Hand Wash	Yes	Yes	—	—
Machine Wash	—	—	Yes	Yes
Machine Dry	Yes	Yes	Yes	Yes
Dry Clean	No	No	No	No

*Varies according to garment manufacturer, follow permanent care label instructions.

Laminate which claims to be waterproof and breathable. To improve performance, the thin Gore-Tex is laminated between layers of durable nylon creating a lightweight, tough, windproof, soft and breathable fabric.

Storage

Most insulated garments except down items do not require special care before and during storage. A bonus for down items is that they can be rolled or packed int a very small space, which is convenient for backpacking and traveling. When unrolled and briskly shaken, down will spring back to its original loft. However, for regular storage purposes, down garments should not be stored like that. Hang garments on broad wooden hangers and protect them with dust covers. At least once a year, hang down garments outside to air and restore its loft. Other down items should be loosely folded and completely dry then placed in a covered container and stored in a dry place.

Care

Permanent care labels should be in all insulated garments. Frequently, care labels in down items state dry clean or hand wash. Actually, if proper procedures are followed washing will produce excellent results. But, a down garment can be satisfactorily dry cleaned. It is essential that a dry-cleaned down jacket be properly aired because dry-cleaning solvent fumes have caused serious illnesses and deaths. It is strongly recommended *not* to dry-clean down items at home.

A down jacket represents a fairly large investment and if properly cared for should last a number of years. Periodically these garments need to be cleaned because heavily soiled garments tend to become compact and are not as warm as clean garments. Frequently, consumers complain that once a garment is cleaned it is not as warm as it was originally. The following procedures should produce a clean jacket which retains its loft and provides maximum warmth.

1. Close all fasteners particularly Velcro tape before washing to prevent snagging the jacket fabric.
2. Pretreat any heavily soiled areas or spots with a mild, liquid hand dishwashing detergent (Ivory, Joy).
3. Soak garment in a solution of warm soft water and mild detergent such as Ivory Snow, Woolite or other products designed for down in a large tub. Regular phosphate detergents have a tendency to dry the natural oils in down; avoid products containing enzymes or bleaches.
4. Sponge the shell of the garment, rubbing stubborn spots with detergent. As the garment shell is very tightly woven and possibly water repellent, sufficient time is necessary for the detergent solution to penetrate and clean the down. Let the garment soak for an hour or two depending upon the amount of soil.
5. Press the soapy water out of the garment by gently pressing with both hands. Avoid wringing or lifting the garment when it is full of water. Wet down is extremely heavy; if unsupported the weight of the water may rip the quilting or stitches.
6. Rinse garment by pressing water through the fabric with fingers spread apart—until the rinse water is perfectly clean. Traces of soap left in the jacket will cause the down to mat.
7. Pick up the article and gently transfer it to the washing machine. Thoroughly balance the garment in the machine and put through the spin dry cycle or allow to drip dry by draping it over two lines.
8. Place the garment in a clothes dryer, add a pair of clean, rubber-soled tennis shoes with laces removed and a few towels. Set the dryer on the lowest heat possible. The shoes will help break up the down clumps, and help regain the loft.
9. Tumble dry for about 15 minutes, check to note the drying progress. Nylon jackets will dry more rapidly than cotton/polyester fabrics. Return jacket to dryer until it feels dry. If it is not as fluffy as preferred, tumble it on air-fluff for a short period of time. Be sure there is no moisture left, because down can mildew.
10. Or dry the garment outside, spreading it across two lines to avoid a stress point. If possible dry in warm, dry weather. It may take several days to dry depending upon the weather.

References

Born, Pete. "Processors Expect to Feather Their Nests Even When Down is up." *Women's Wear* Daily, March 13, 1978.

Coats & Clark Inc., *Nylon Ripstop and Taffeta.* Stamford, Connecticut, 1978.

Cunningham, Gerry, "How to Keep Warm." Denver, Colorado, 1972.

"Dry Clean Only". Taum Sauk, Wilderness Outfitters, Columbia, Missouri.

Federal Trade Commission, "Guides for the Feather and Down Products Industry," October 29, 1971.

"FTC Taking A Cold Look at Down-Filled Products," *FTC News Summary,* No. 29, 1978.

"Fine Feathered Friends," *Clothes,* June 1976.

Fourt, Lyman and Norman R. S. Hollies, *Clothing: Comfort and Function,* New York, Marcel Dekker, Inc., 1970.

Hollies, Norman R. S. and Ralph F. Goldman (ed.) *Clothing Comfort.* The Fiber Society, Inc. Comfort Symposium Proceedings. Ann Arbor, Michigan, Ann Arbor Science Publisher, Inc., 1977.

Horn, Marilyn. *The Second Skin.* Boston, Houghton Mifflin Company, 1975.

McKeown, Bill. "New Fiber That's Better Than The Birds." *Popular Mechanics,* December 1978.

Miller, Bill D. "Better Than a Goose Can Produce." *Mechanix Illustrated,* October 1978.

Warner, Gret. "Selecting a Down Parka Or Jacket." New York State College of Human Ecology, Cornell, 1977.

Outdoor Catalogs:

Altra
Eddie Bauer
Frostline
Holubar
Sierra Designs

To simplify information, trade names and illustrations of products have been used. No endorsement of these products is intended, nor is criticism implied of similar products which are not mentioned.

■ Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914 in cooperation with the United States Department of Agriculture. Leonard C. Douglas, Acting Director, Cooperative Extension Service, University of Missouri and Lincoln University, Columbia, Missouri 65211. ■ An equal opportunity institution.

File: Clothing & Textiles 11/79/8M