To insulate or encapsulate? Is that the question?

Foreheads glow, bodies perspire and feet sweat; up to half a pint a day according to Dr. Bill Rossi, the world's most prominent pedorthist. The feet are the furthest distance from the body's main heat engine. Therefore they are the most difficult part of the body, not only to heat, but also to apply temperature and moisture controls. Wearing too thick or too many layers on the feet can affect the fit of the boot and restrict circulation. Wear too little and numb, cold feet are the least of the problems you will encounter.

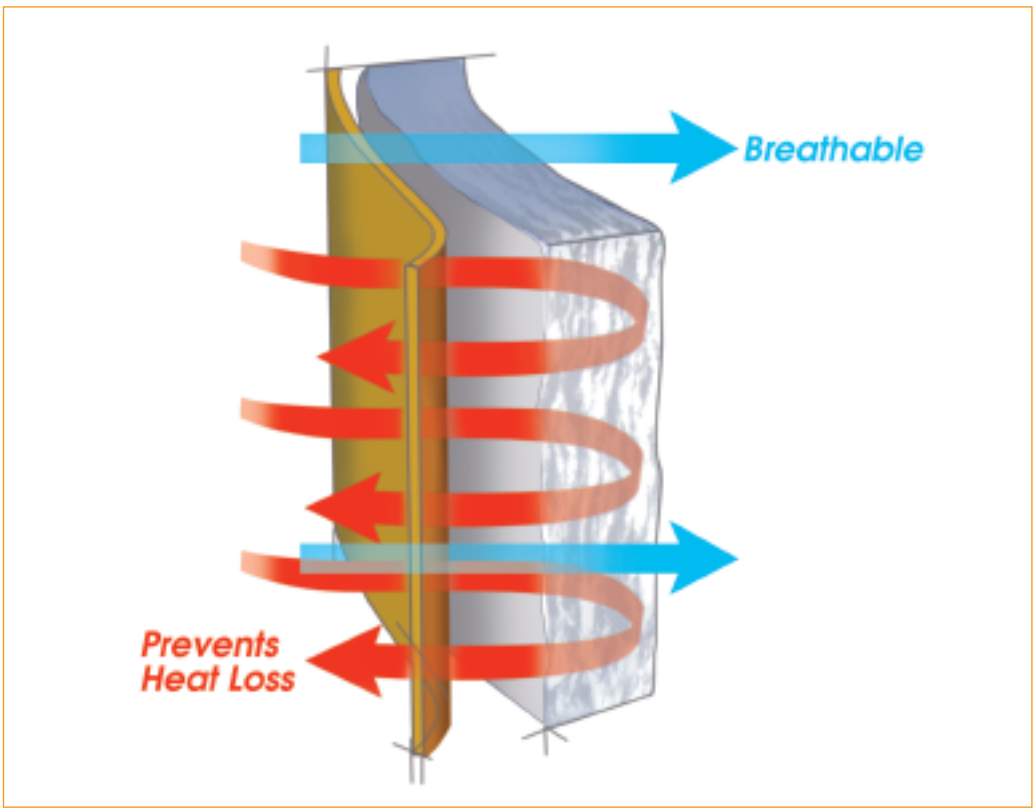
Tecnica's T-Rock thermal boot. The first to use Primaloft insulation.

When a person gets cold the capillaries that carry blood to the skin constrict to limit the amount flowing through them, which in turn regulates the loss of valuable body heat. When we overheat the capillaries expand to increase the blood flow and thus purge the extra heat from the body. When the body is operating within a normal temperature range some areas vary quite markedly from the norm. The average skin temperature at the head and abdominal area, the body core areas, is approximately 95°F (35°C). As you move away from the heat engines of the body the average skin temperature drops. Naturally, the feet, being the most distant part, experience an average skin temperature drop of about 7°F (2°C). Left to our own devices, we can only sweat or shiver. Sweating is the body's natural homeostatic system of evaporating moisture in order to cool the skin. Confined in a boot for hours on end, excessive sweating and moisture evaporation (hyperidrosis) can cause problems for feet in cold weather.

Thanks to moisture management materials in foot coverings, such as DuPont CoolMax in socks, sweat can be wicked away from the skin and quickly evaporated through perforated or hollow-spun fibre linings into the warm, dry air of summer. But what if it's winter and you're half-way up an icy mountain on a windy day?

Cold weather presents an interesting challenge in terms of heat loss and moisture evaporation for those who produce materials for hiking, trekking or mountain climbing boots. Thermal resistance is measured in 'CLO', which is the operator in the thermal weight efficiency (ratio of CLO to weight), but not all forms of insulation work well in winter footwear. Traditional insulators such as down and Syriaca, that have a high 'CLO' rating, are not suitable for use in footwear. Primaloft, Permaloft, Quallofil and Hollofil are great modern insulators in active apparel but they are usually considered to be too bulky to be effective in winter boots.

Minimal amounts of moisture evaporate from winter footwear during use. However, even a low sweat rate (3g/h) can considerably reduce insulation in footwear (9-19%). At higher sweat rates (10 g/h) the reduction can be up to 36%. Combined effects of sweating, walking and wind can reduce insulation by up to 45%. Luckily, we have technology on our side. Sock brands such as Thorlo, Smartwool and Seirus already produce specific winter socks offering acrylic and polyester fibre blends to wick moisture away from the skin with added wool areas for warmth. Seirus also makes a neoprene liner for winter boot insulation. Now significant advances in



Cambrelle Extreme footwear lining and insulation system provides excellent breathability and moisture management.

winter boot insulating materials are just the other side of the mountain.

In order to meet the comfort and warmth criteria of the active outdoorsman, insulation in winter boots must be thin, warm and light. Thin, or more precisely, the correct loft, is crucial in footwear simply because there is little room between the lining and the materials of the upper. Compressibility, which is the compatibility of the insulation under pressure, is also an important factor. Unlike other insulated outerwear garments, each step exerts tremendous pressure on every boot component. This pressure is especially hard on insulation, which can become compacted. Insulation materials work best by trapping microscopic pockets of air in their fibres. Compacted insulation loses its effectiveness. Polypropylene, continuous filament and thermally bonded fibres all tend to permanently lose loft under pressure.

Thinsulate, introduced over twenty years ago by 3M, has come a long way in solving many of the problems presented in insulating winter footwear effectively. Its unique blend of polyester and polyolefin fine denier fibres springs back to its original loft therefore taking less of a compression set than foam, pile or felt and retaining those air pockets that are so important for keeping feet warm. Thinsulate insulation absorbs less than 1% of its weight in water, so it keeps warm even in damp conditions inside the boot. Cambrelle, well known for its durability and wicking properties as a shoe lining, has been combined with DuPont's insulation material Thermolite to produce a proven performer, Cambrelle Extreme with Thermolite. This product is said to have excellent breathability and moisture management qualities to keep feet dry and comfortable, even when sweating. The blend of soft, durable microfibre is exceptionally flexible and effectively blocks the escape of radiant body heat to retain maximum warmth at minimal loft. Engineered to inhibit growth of bacteria and most molds and fungi, Cambrelle Extreme is also said to help keep footwear hygienic and fresh even when worn for days on end.

Recommended insulation standards are measured in grams per square metre (gsm) for footwear. Insulation at 200gsm is considered minimal for cool conditions, or for high activity levels where the wearer generates a lot of body heat through activities such as alpine skiing or snowboarding. A 400gsm level is recommended for rubber bottomed boots in cold conditions or where only moderate levels of body heat are generated.

For extreme winter conditions, where the retention of body heat can be a matter of survival, 3M has developed Thinsulate Ultra insulation for extreme performance footwear. Both Cambrelle Extreme and Thinsulate Ultra set minimum testing and manufacturing standards at 400gsm. In order to use the Thinsulate Ultra label 3M insist on at least 400gsm of insulation and manufacturers must insulate the boots to strict specifications - through the toe, vamp, heel and all the way over the ankle. At 600 and 800gsm Thinsulate is recommended for use in hiking, work, hunting and PAC boots under extreme cold conditions where there is a minimal build up of body heat through activity. For unique applications such as Arctic and

Stuco by Schoeller.

It's an insulating life

Insulation products are enjoying a modest but welcome expansion, and the fact is highlighted by the interest shown by companies other than the major brands.

The Tergal Fibres group, based in Gauchy, France, produces Filifine micro fibre and claims to be the only producer of polyester staple micro fibre in Europe. Its products are to be found in a wide variety of market sectors – from underwear to household textiles and appearing in sportswear and lace on the way.

Since early in 2002, however, Filifine has another role as an insulating wadding that is said to have an exceptional performance factor. Which is quite a claim to make in a market where performance is the be all and end all.

Under the PEG brand, the new insulator is apparently capturing interest among the existing users of Tergal's products – particularly those who use Filifine in denim and see advantages in retaining one base product as the source for a number of applications. Technical data is not yet to hand from Tergal, but watch this space.

The Korean company Khalke International manufactures Charcoalon – from charcoal. To be absolutely accurate it's a combination of powdered charcoal (about 85%), polyester and an unnamed product that is melted together and extruded as a fibre.

The resulting lofted wadding is pollution-free, low absorption and has a high UV resistance. It is said to resist degradation during washing and is not affected by household detergents. Khalke makes a particular point that Charcoalon is an excellent deodoriser and has an anti-bacterial capability.

Back to France for an insulation product that offers a return to nature. It's down, but not as we know it.

Napturel is produced in Saint-Hermine with the promise that manufacturers can now treat down fillings just as they would any synthetic fill and sew it into a garment or sleeping bag. Down has three main factors in its favour: it's light, retains its loft and is undoubtedly the warmest insulator known. On the minus side: it has a tendency to migrate leaving cold spots, has the insulating power of cold crème anglaise when it's wet and takes forever to dry.

With Napturel the down is spread into a mat formation and quilted according to specification by density and depth. It can then be trimmed and sewn as any synthetic wadding, but with the benefits of the natural product. Add a high DWR coating to the shell fabric and that should remove any of the minuses. *DD*

Himalayan expedition footwear, 1,000gsm Thinsulate is the recommended specification by 3M. Despite being more difficult to meet, these requirements have been embraced by boot manufacturers and have set a new consumer confidence standard in insulation in the marketplace.

The Thermal Shock Absorber

At present 'PCM' to the outdoor footwear industry probably means "Permanently Cold Metatarsals", but that's about to change. Now two companies, Frisby Technologies in Winston-Salem, North Carolina, and Outlast Technologies in Boulder, Colorado, will attempt to raise the heat bar one notch higher with their introduction of "Phase Change Materials". It is claimed in MIT's Technology Review that "just about every major brand of outdoor apparel will offer phase change materials by 2003". What is this new technology they are calling the "Thermal Shock Absorber" and can it be applied to outdoor and winter footwear? PCM's are non-toxic paraffin wax-based chemicals that change their physical characteristics from liquid to solid and back again as they release or absorb body heat within the temperature range established by the properties of the given material being used. They can be held inside individual synthetic fibre strands, coated topically to knit, woven or non-woven fabrics, or applied to foams either directly or bonded to a PCM coated fabric. As temperature increases, the solid component or gel absorbs excess heat generated by the body. This holds the skin temperature at a bearable level and slows down the time before the body's own cooling system (perspiration) kicks in. As the body begins to cool down, the PCM components change back from a liquid to a more solid state thus releasing the absorbed energy and returning it to the wearer. Through this process, PCM's help the body to maintain a thermal equilibrium in conjunction with other materials that cause overheating or heat loss. By adjusting the melting range of the PCM this new technology, which has progressed rapidly since it was initially introduced in an end-use application in 1997, can be incorporated into an existing variety of protective temperature controlled materials, including existing insulation materials.

Chilkat

Frisby's thermal management products consist of a series of PCM thermal additives, which it sells under the brand name of Thermasorb, and host materials containing Thermasorb, which are sold under the brand name of ComforTemp. ComforTemp materials come in a variety of forms, such as foams, fabrics, gels, plastics and rubber. Most recently Frisby has developed the technology to incorporate Thermasorb into non-woven fabrics. Outlast technology is based on patented microencapsulated phase change materials called Thermocules. These Thermocules interact with the body and the microclimate around the body to smooth fluctuations in temperature caused by changes in activity levels and the external environment. Outlast products can store up to six times as much energy as a conventional synthetic fabric, providing a 25-50% improvement in thermal stability when tested against conventional fabrics. Outlast PCM treated foam at a maximum loading of 40% by weight has been shown to absorb five to six times its weight in water.

Are winter boot manufacturers paying attention? Whereas the shoe industry is notoriously slow to adopt new technologies, the apparel and ski industries tend to be more aggressive to drive broad new markets with top line technical products. Major brands in the winter shoe industry like Kamik and Sorel still use a high percentage of traditional insulating fibres such as wool and Thermoplus felt in their boots. Tecnica, a leading Italian boot company is the first high-performance footwear company to use Albany International's PrimaLoft in its T-Rock model. PrimaLoft, not to be confused with Permaloft (a 100% polyester product), is a lightweight, soft and warm microfibre known primarily as a down alternative insulator used in comforters and duvets. With great heat retention and allegedly superior water-repellency properties, PrimaLoft is said to speed up drying but allow the boot to remain light in weight.

Brands that already use significant amounts of Thinsulate and Thermolite insulation product, such as Chippewa, Lacrosse, Vasque, Columbia and Rocky Boots, are now testing the new PCM foams and fabrics with the view to adding the envisaged benefits of thermal additives. Outlast recommends that the PCM treated fabric or foam should fully envelop the foot for optimal temperature regulation. The Outlast layer should be directly behind the shoe lining, next to the foot with the coated side toward the foot. Adaptive linings that buffer against overheating, reduce sweat, and work within a boot's microclimate to control temperature and humidity are sure to impress performance minded shoe makers and consumers. By reducing sweat, PCM's enable fabrics and foams to work better, existing insulation materials to perform better and waterproof breathables to work up to 33% more effectively. Now that's worth wearing on your feet next winter.

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