(LEFT) Performance sports demand performance clothing. Credit: Mountain Equipment/ John Norris. (RIGHT) Clothing must be able to keep you warm, whatever. Credit: Arrans. (SMALL) Winter hill walking places great demands on your clothing system.

COMFORT ZONE

Chris Smith from Mountain Equipment takes a look at the layering concept. How it began, how it's changing, and what we can look forward to in the future.

The majority of outdoor clothing systems worn by today's climbers, mountaineers, and fell walkers, are loosely based upon the well-established principle of layering. The fundamentals of this idea have been well documented over the years, and you can be certain that when reading any kind of mountaineering literature, there'll be a reference to the type of clothing systems that existed at that time.

The principles of layering will probably never change, as they are fundamentally based on scientific laws. However, the items of clothing that constitute a layering system have changed dramatically over the years, in terms of their technical function, comfort, and features - and are still radically changing today. Within the last 25 years, a myriad of new clothing systems and garment technologies have been launched, some of which have challenged the traditional concepts of layering and have stood the test of time, whilst others have burnt out. However, the most recent, more radical developments in outdoor clothing technology may permanently change the way we 'get layered'.

First Principles...

The purpose of any outdoor clothing system is to keep you and your body comfortable whilst you are outside. The layering system consists of several different layers of clothing, each layer fulfilling a different role. A correct combination of layers ensures that your body temperature remains constant and safe in all weather conditions. The system remains flexible, as it allows the wearer to take off, or put on layers, depending on the weather conditions and the level of activity. The system is versatile, as many different types, makes and models of outdoor clothing can be combined to create an effective system. Any layer used as part of an outdoor clothing system will typically fall into one of three categories; a Base Layer; a Mid Layer and an Outer Layer (or Shell).

The Base Layer

This is the layer of clothing that is worn closest to the skin. Modern base layers are usually made of 100% polyester or polypropylene, usually incorporate some form of stretch, and come in different weights. Lighter weight garments suit high-energy activities in warmer conditions. Mid-weight garments are slightly warmer, suiting cooler conditions. Finally, heavier weight base layers possess more thermal qualities, will usually have a half zip and/or roll-neck and are designed for use in very cold conditions.

The fibres that make up the fabric of a base layer are inherently hydrophobic (water-hating). A combination of your body's natural energy forces and these treated fibres creates a push/pull situation, whereby moisture is pushed out of the body's pores onto the inner surface of the base layer. The fibres of the base layer then rapidly transport (pull) the moisture from the inner to the outer surface (a process known as 'wicking') where the moisture will naturally disperse and evaporate. The moisture vapour is now ready to be transported through the next layer within the system.

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Harsh Scottish conditions. Credit: Mountain Equipment / Parnell

Micro-climates

The complex activity that exists on the surface of the skin, and also between each layer within a clothing system, is sometimes referred to as a 'micro-climate', where varying amounts of perspiration (moisture and moisture vapour), accumulate and diffuse, depending upon levels of activity and the 'temperature differential' (delta T or ΔT) between the layers. The primary aim of any layering system is to manage these individual micro-climates, and to quickly move or transfer perspiration through the system.

The Mid Layer

Mid layer garments are worn to provide thermal insulation by trapping warm air around the body and are designed to allow moisture to pass quickly and efficiently from the base layer to the outer layer. Fabrics with a non-absorbent open weave are best suited to this – the best example of this is fleece. A standard fleece jacket, however, will not prevent wind from penetrating the system. Therefore, if worn on a windy day without an outer layer, the warm air trapped within the system, insulating the body, will be replaced with cold air and the wearer will immediately begin to feel cold. Typical examples of mid-layers would include all types of fleece and fibre-pile, down, and synthetic hollow-fibre clothing.

Outer Layer

The main purpose of the outer layer is to protect the mid and base layers from wind, rain and snow, thus allowing them to function efficiently. Outer layer garments will typically fall into one of four categories:

1. Windproof (breathable)
2. Breathable and Water-Resistant
3. Waterproof
4. Breathable and Waterproof

Windproof (breathable) garments are usually made from tightly woven, lightweight nylon with a high fibre density (such as Pertex). This outer layer will protect the insulating mid-layer from wind-chill and because fabrics of this type have inherently low RET values (Resistance to Evaporative Transfer), the system will retain high levels of breathability, ensuring the wearer remains comfortable.

Breathable and Water-Resistant outer layers are usually treated with a DWR (Durable Water Repellency) coating to give extra protection in light rain or snow. Garments of this type offer an excellent compromise between protection, weight and performance. However, in more severe weather a fully waterproof, breathable outer layer would be required.

Waterproof garments that are not breathable will offer excellent protection from the wind, rain and snow in static conditions. However, due to the high RET values, even during low energy activities, the moisture vapour will be unable to escape from the system and will condense on the inside of the garment. Moisture ingress to the base and mid layers would ensue, compromising the whole system. For the majority of serious mountain users, a non-breathable waterproof garment is simply no longer an option worth considering since the development of waterproof, breathable fabrics.

This type of outer layer garments offer the best protection against wind, rain and snow. They also enable the base and mid layers to function efficiently. The majority of garments that combine waterproof and breathable qualities fall into two categories:

1. Waterproof Breathable Membranes (e.g. Gore-Tex, Drilite Extreme)
2. Waterproof Breathable Coatings (e.g. Triple Point, Ceramic, Drilite Plus)

Membranes

A typical waterproof and breathable membrane consists of a wafer thin, man-made membrane containing millions of microscopic pores, each large enough to enable moisture vapour (sweat) to pass through, but small enough to prevent the passage of water droplets (rain). Temperature and pressure differentials over the membrane (i.e. it is warm and dry inside the system, cold and/or wet outside) drive moisture vapour outwards, providing the breathability.

Coatings

A breathable coating is created by spreading a thin layer of resin directly onto the face of a given fabric. Two different types of coating exist; microporous and hydrophilic. A micro-porous coating works on the same principle as a microporous membrane.

A hydrophilic (water-liking) coating is reliant on the chemical and molecular properties of water molecules. When the body generates heat inside the garment, this forces moisture vapour down polymer chains found within the coating to the external face of the garment. The moisture vapour moves through the system from molecule to molecule, rather than freely through a physical microscopic pore. As the body produces more moisture and the fabric gets wetter, the polymer chains naturally increase in size allowing more moisture vapour to be transferred through the system.

Old vs New

When George Mallory's body was found on Mount Everest in May 1999, the remains of his layering system, (which in 1924 was state of the art), consisted of a couple of tattered woollen sweaters and the frayed threads of a cotton wind-jacket. By today's standards, a climber wearing Mallory's clothing system, even on a 3000ft mountain in the UK, would be ridiculed, never mind on the highest mountain in the world.

When Don Whillans and Dougal Haston conquered the South Face of Annapurna in May 1970, their layering system consisted of poly-cotton base layers, over which two mid-layers were worn - a 'Borg' fur jacket and trousers, and a Mountain Equipment down-filled jacket and breeches. The base and mid layers were then protected by an outer shell of Ventile Cotton, which was at the time, a relatively light, windproof and exceptionally breathable fabric when dry. Although Ventile was 'state of the art' and was suited to extremely cold, dry climates, when it got wet, it stayed wet, became very heavy and lost nearly all its breathability. Ventile Cotton is still favoured today over modern outer shell fabrics such as Gore-Tex for expeditions to arid regions such as the Arctic.

A modern winter clothing system would probably still incorporate several layers, and most definitely would include fleece, and down-filled garments for climbs in cold extreme conditions. Today however, an increasing number of modern garments exist that essentially 'break the mould' of the conventional layering system, whereby a combination of high wicking, thermal/insulating, wind-proof, water-resistant and

breathable layers are consolidated in a single garment. Furthermore, many of these modern systems are light, quick drying and have a small pack size when carried, and greatly reduce the need to take off or put on more layers.

Alternatives:

Pile/Pertex

In 1986, the first single layer clothing system was born, comprising a polyester fibre-pile that was bonded to a shell of Pertex. Pile/Pertex (Double P or P2 for short) clothing was designed to be worn next to the skin without the need for numerous additional layers. The system relied on body heat to drive moisture vapour from the skin through the fibre pile to the outer pertex shell, where moisture then spread out across the surface of the fabric and evaporated. Although such garments were not waterproof, any rain that did penetrate the system would be warmed by the body and driven rapidly back out through the fibre-pile and Pertex.

Pertex/pile garments have many advantages; quick drying, very warm during high activity making them useful for winter climbers, relatively low price (also making them useful for winter climbers!!), easy to repair and low in weight and bulk. However, when used during relatively low activity or static conditions, moisture can be retained within the system and the wearer may start to feel damp, cold and clammy.

Wind Resistant and Windproof Fleece

The introduction of fleece clothing with wind protection caused a revolution within the outdoor clothing market as it enabled the most popular form of insulating layer to double-up and be used as an outer layer in blustery conditions. Early innovations of wind-resistant fleece consisted of very tightly woven close-knit fibres that resisted wind, repelled light rain and trapped warm air generated by the body. For climbers and mountaineers this meant that an outer shell layer would only be required in the worst conditions and sometimes not at all.

The development of the fleece continued and it soon became the most versatile piece of outdoor clothing available. Advances in technology meant that manufacturers could develop totally windproof fleece garments that consisted of a windproof and breathable membrane that was sandwiched between two layers of micro-fleece. Gore-Windstopper and Malden Mills' 'Windbloc' technology was now being used in the large majority of branded wind-proof fleece.

Early wind-proof garments were, however, quite heavy, bulky and not very breathable, due to laminating techniques and the limited amount of face and liner fabrics available. However, they did offer excellent protection against the elements because they utilised a membrane, and so remained highly water-resistant and could almost be deemed as waterproof. Today, more modern wind-proof fleeces incorporate much lighter face and liner fabrics, and improvements in membrane and laminating technology have increased levels of breathability, suppleness, and lightness. The new buzz-word describing this type of garment is 'Soft-Shell'.

Soft-Shell Clothing

The modern concept of soft-shell clothing is being taken to new levels and will, arguably, replace the good old-fashioned fleece. More products are being developed that incorporate ultra-lightweight, open-woven, micro-fibre linings that are then bonded (laminated) or stitched to a soft lightweight wind-proof and water-repellent outer. These garments have a tiny pack size (a third of the size of a standard fleece), and can be worn as a shell in milder conditions, or under a more durable outer shell in extreme, colder or wetter conditions.

1922 - Geoffrey Bruce being helped down by Sherpas. Credit: Fell & Rock / Audrey Salkeld collections. Mountain clothing has evolved incredibly since these early days - what's in store for the future? Visit the new Helly Hansen National Mountaineering Exhibition to experience what is was really like in the early days.

Layering in the 21st Century

The second generation of outdoor clothing systems is now being introduced to the outdoor clothing market. These new, radical garments aim to further shift the parameters of traditional layering concepts by offering higher levels of performance and comfort in a single layer, thus enabling the user to wear less, pack less and simplify their existing clothing systems.

The inside of the garment draws moisture away from the skin and allows it to evaporate. Moisture vapour is pushed very quickly through a unidirectional membrane (windproof and highly water-resistant), which prevents it from returning. After being transported to the outer layer, the moisture can then evaporate.

Because there is only one layer, these new products have a much lower RET than a traditional base layer plus wind-protection, so they retain exceptional levels of breathability. Additionally, because the membrane of the garment is situated much closer to the skin, moisture vapour is naturally forced through the system at a faster rate due to a higher ΔT. This ensures that a dry and warm micro-climate exists between garment and skin, and the potential build-up of moisture that would occur in a traditional system is for the most part negated.

The Future...

More and more products of this type will be introduced to the outdoor clothing market, and, although the technology used in these garments is radical, the perfect balance of fabrics, treatments and features that will eventually create the ultimate outdoor clothing system - has not been found...yet!