Taking functionality to the extreme

Whilst for many people 'travelling' conjures up the idea of hopping on an aeroplane to a beach resort or travelling on business, where their main worries are whether they packed that extra bikini or if their suit will crease, there are groups of 'travellers' that have far more serious concerns. Soldiers entering remote areas in unknown (and often unfriendly) areas, or mountaineers heading off, literally, to the top of the world cannot afford to forget a vital item of clothing, and the odd crease here and there is the least of their worries.

There is what seems to be an infinite choice of functional fabrics and garments on the sports and outdoor market nowadays. But talking to experts in the industry, there is often a big difference between what it says on the label and the level of functionality these garments actually offer. Everyone 'in the know' has their own personal favourites, but how is the average consumer, or even the professional sports person, meant to judge whether they should believe the 'hype' on the labels of performance apparel or whether they should take it all with a large pinch of salt? Most people make up their own minds through trying different brands and garments until they find the one that suits them. But in certain situations the wearer cannot afford to take a risk with their clothing as it could lead to serious illness or even death rather than a slight inconvenience. In extreme climates, whether it be hot or cold, the correct clothing really can mean the difference between life and death.

The Pentland team with Sir Chris Bonnington at the summit of Kilimanjaro.

Pentland

Getting to the core of it

Consumers wish to have the optimum level of comfort and protection possible, and in extreme climatic conditions, the efficacy of clothing is vital.

Humans are homeotherms, which means that they try, and need to, maintain a constant body temperature regardless of the surrounding temperature. If the core body temperature rises above or falls below 37°C, the major organs can be damaged. If the core temperature drops too low, hypothermia can occur which can lead to respiratory problems, cardiac arrest and possibly death.

Conversely, a rise in the core body temperature can lead to heat exhaustion which can also be fatal in inhospitable surroundings such as a desert where there is no protection from the extreme temperature and humidity. Whilst animals such as polar bears and lizards have evolved with 'built-in' protection to survive, clothing is the only means by which humans can maintain their core temperature in such extreme conditions, therefore functions such as moisture management, thermoregulation and waterproofness are vital for the protection of the wearer.

Back to the future

Researchers are constantly trying to come up with the next innovation in fabric and yarn technology, to improve and add to the functionality of garments. As one of the most competitive sectors, brands are constantly battling to maintain and increase market share. This means constantly addressing the needs of the consumer and developing more and more advanced fabrics. But a recent conference held in Cumbria, UK, proved that developers should maybe look backwards rather than forwards in order to shape the future of apparel for extreme climates.

One of the key features at the recent Pertex Clothing for Extremes Conference was the unveiling of testable replicas of George Mallory's clothing that he wore on his ill-fated expedition to Mount Everest in 1924. Until now many believed that Mallory's clothing had been inadequate for the challenge of scaling Everest where temperatures can drop as low as -60°C. But recent research, led by Mary Rose and Mike Parsons of the Institute for Entrepreneurship and Enterprise Development (IEED), seems to have proved otherwise.

The results of a three-year project involving the universities of Lancaster, Southampton, Derby and Leeds show that Mallory was in fact equipped with lighter, freer moving clothing and footwear than current day climbers.

From artefacts collected from around Mallory's body (discovered in 1999), the project team has succeeded in producing testable replicas of his clothing in order to bridge the gap between innovation in performance clothing in 1924 and the 21st century.

"Mallory was wearing clothing that was some 20% lighter than modern mountaineering gear," says Prof. Mary B. Rose. Mallory's total clothing weighed a mere 4,160g compared with the 4,825g worn by Al Hinkes who scaled Everest in 2005 as part of a challenge to become the first Briton to scale the world's 14 highest peaks (which he achieved). "He was wearing a very effective layering system that allowed for very free movement. Our research has shown that the 1924 expedition's equipment was very much part of the evolutionary path from the polar exploration years to the successful 1953 Everest expedition," adds Rose.

"There is nothing about Mallory's clothing or footwear that would have, in itself, prevented a successful ascent of Everest – indeed the lightweight clothing he was wearing was an advantage, just as it is today," says Mike Parsons, innovation director at OMM Ltd - which organises the KIMM Original Mountain Marathon -

Thermal mannequins

Thermal mannequins have become the standard means for test clothing in extreme climates where it is not feasible to expose humans, especially in the military. These have existed in various levels of sophistication for decades.

According to USARIEM, legend has it that Dr. Harwood Belding, a researcher conducting studies on heated flight suits for the Army at the Harvard Fatigue Laboratory in the early 1940s, saw a window manikin in a Boston department store and was inspired to build his own. Belding's first heated manikin was constructed out of stovepipe and sheet metal by a Boston tinsmith.

"It looked like the Michelin Man, but it was theoretically similar to the thermal manikins used worldwide today," says Tom Endrusick. In 1941, the actual scientific study of military clothing started because the War Department was concerned about the inadequacies of military clothing at the beginning of World War II, according to Endrusick.

The urgency to develop better clothing hit home in May 1943 when 2,100 of the 15,000 US troops who were sent to retake the Japanese-occupied Aleutian Island of Attu suffered from trench foot and cold exposure. They were wearing wool and cotton clothing along with uninsulated leather boots that were developed during World War I.

Belding's stovepipe manikin provided the first useful biophysical data related to a military clothing ensemble and brought him in contact with researchers at General Electric in Bridgeport, Conn.

He asked GE to build him a manikin made of copper like the one that the company was using to develop the first heated blankets for consumers. GE eventually delivered a series of four copper manikins as well as the first copper hand and foot to the Army.

As World War II continued, the Army and the other services intensified their efforts to develop better military clothing. In 1943, the US Army Quartermaster Corps formed the Climatic Research Laboratory (CRL) and moved it into the Pacific Woollen Mills facility in Lawrence, Mass.

In 1945, Belding brought his manikin and expertise with him when he became the first civilian director of the CRL. That lab was reorganised as the Environmental Protection Research Division (EPRD), which became part of the new Quartermaster Research and Development Command at Natick in 1954.

Endrusick says many of the first generation metallic models still exist but are in storage. Models still in service are upgraded, rebuilt and refurbished about every 10-15 years as technology advances. He said the basic clothing research conducted during the early 1940's eventually formed the foundation for much of the work that is now conducted at the US Army Soldier Systems Centre (Natick).

"Soldiers were fighting in environments never encountered before World War II," Endrusick said. "They were required to operate in severe climatic extremes. Today's soldiers are facing the same extremes, and that's why we continue to provide the support for this research that started over a half century ago."

and former managing director of Karrimor. So, if Mallory was so well-equipped in 1924, how do modern garments differ and do adventurers need so much technically advanced clothing? Do these garments really perform well enough in such extreme conditions to really make a significant difference to the protection and even health of climbers?

Extreme testing

Whilst it is now fairly simple to test how clothing for running, cycling, swimming, etc., perform in a laboratory, how do manufacturers reconstruct extreme conditions such as a desert or the Arctic in order to ensure that functional clothing does improve the comfort and safety of the wearer?

In an attempt to ascertain whether extreme temperature variations affect the performance of functional garments, Germany's Hohenstein Institutes' Department of Clothing Physiology has carried out extensive and varied tests, looking at the physiological function of breathable materials in a climatic chamber with mannequins and in wearer trials at sub zero temperatures. Previous research, carried out by Osczevski and Dolham in their study, "Anomalous Diffusion in a Water Vapour Permeable, Waterproof Coating", had concluded that water vapour resistance was diminished at low temperatures, and that the difference between shell layers and standard clothing was significantly smaller in sub-zero temperatures. However, in more recent tests, performed by Hohenstein on breathable waterproof apparel, the results showed no indication that water vapour resistance of hydrophyllic membrane laminates decreases with extreme temperature variations and the study concluded that foul weather textiles still offer a great benefit to wearers. So, whether this is attributable to advances or more relevant testing, it seems that functional garments do offer extra protection in cold climates.

Primary factors of protection

Japan's Toray has also performed in-depth research into the performance of functional garments in extreme temperature conditions at its Technorama weather room. This facility, which was built in 1983, can simulate any weather conditions that exist in the real world and scientifically analyse the relationship between the garment/fabric and the environment in dynamic conditions.

In the real world it is almost impossible to stabilise the environment in order to evaluate a product, but with its 4x6x5m main room, Technorama can easily stabilise extreme conditions and provide reliable results.

To test products, Toray addresses six primary factors essential for providing the wearer with comfort while exerting energy in both extreme conditions, and more casual outdoor activities, in various tests to ascertain the true functionality of such fabrics. These factors are: waterproofness, moisture permeability, water repellency, heat management, fabrication, and windproofness. Tests are performed in an attempt to establish Toray's own standards for the comfort characteristics of activesport fabrics to provide manufacturers and consumers with the sound data on the actual functionality of these textiles.

In addition to specification superiority, Toray believes it is also important to combine different functional qualities in an optimal manner to specifically meet the individual requirements of each application. To facilitate customer choice of the fabric depending on application, a guide includes application-specific requirements of comfort characteristics.

Toray's Technorama
Weather control ranges

Temperature	-50 ~ +60°C
Humiditiy	20 ~ 80 RH
Wind velocity	0~30m/sec
Rainfall	0~2000mm/hr
Snowfall	1m/day
Illumination	0~100,000lux
Solar radiation	0~1,000kcol/m nr

The human touch

But whilst there is no doubt that climatic simulation provides invaluable data in testing clothing and improving functionality in the future, the clothing is only really put to the test in real-life extreme situations. The Mallory project has uncovered the fact that he wore a Burberry cotton gabardine jacket and a wool-silk vest, so what do modern day mountaineers wear and how do they perform in the field?

World famous mountaineer, and chairman of Berghaus, Sir Chris Bonnington, led an expedition up Kilimanjaro with Pentland CEO Andy Rubin and other members of the company's senior management in September.

The team of eight came together in a personal challenge that would take them to the highest point on the African continent (5,895m).

Before this trip the team, except for Sir Chris, had never experienced serious mountaineering first-hand, so it was a matter of really placing their trust in their companies' brands (Berghaus and Brasher) to ensure they were protected from the elements for the six days that the trek lasted.

The team used a range of Berghaus products during their trip including the PacLite Alpine Pro jacket, Tech T base layers, the Freeflow 25+6 daysac and Berghaus' latest underwear range, Tech Base.

It seems that the clothing certainly passed the test as far as the team were concerned as Berghaus managing director, Lewis Grundy, is already preparing for his next trip, a Himalayan adventure with Sir Chris Bonnington.

According to Sir Chris, "On the legs, the Extrem tights under the Coronna pants with the PacLite trousers for total windproofness kept my lower part warm. On my upper body, the Extatic T provided good wicking and has the charm of not getting too smelly after several days use, while the Stretch light top, Rage jacket and Infinity light over the lot, gave sufficient layering to keep me warm without sweating. The Infinity Light in this respect is a really good insulation layer. I didn't feel the need to wear my PacLite Pro jacket but if the wind had got up I'd most certainly have put it on. The Freeflow 25+6 was a winner since the good air gap at the back means you don't get that wet sweaty patch that so many rucksacks create by fitting too closely to the back."

Keeping your cool when the temperature drops

Clothing for cold climates must protect the wearer from the cold, however, as mountaineers and soldiers are also performing strenuous tasks, it is equally important to ensure that they do not overheat due to wearing bulky, heavy

apparel. With this in mind French company PEG - that specialises in wadding - has introduced Thermolite Micro with a Coolmax lining, which provides exceptional warmth without excess bulk or weight and provides a high level of moisture management. It is warmer per inch than 550 fill power down and twice as warm per dollar. This is due to a patented blend of fine microfibres that create tiny air pockets for better insulation, and block radiant heat loss. However with the addition of Coolmax, PEG has ensured the wearer is kept at an optimum temperature as they are protected from the cold, but the Coolmax also wicks moisture away from the body, to keep the wearer comfortable.

Heated debate

Cold climatic conditions are only one side of the extreme climatic spectrum, excessive heat can be equally as dangerous as the low temperatures. The military are arguably the most expert at dealing with the whole spectrum of temperature extremes as soldiers have to perform in many different climatic conditions, but require protection from the elements and the enemy. The US Army Research Institute of Environmental Medicine (USARIEM) is responsible for testing clothing that allows soldiers to function in harsh environments.

USARIEM, an installation partner of the US Army Soldier Systems Centre (Natick), assists Natick's project officers by measuring the thermal and water vapour resistance properties of textiles, boots, gloves, clothing ensembles and sleeping bags using sophisticated metallic models.

The division uses a variety of equipment designed specifically to set apart the good from the bad when testing items to be adopted as part of the army's Extreme Cold Weather Clothing System, the Modular Sleeping Bag System, etc., beginning with basic textile evaluations using the Hohenstein Thermoregulatory Model of the Human Skin.

Whilst according to USARIEM, high-technology textile materials, such as Thinsulate, Polartec fleece and Gore-Tex, have proven their effectiveness under scientific scrutiny, Tom Endrusick, research physical scientist at the Biophysics and Biomedical Division adds, "From a biophysical standpoint, you can quickly tell whether it's simply advertising hype or truly worth further Army interest." He added that many items on the commercial market have vague or misleading protective and temperature comfort claims, mainly because the human testing required for scientifically accurate labelling is difficult and expensive. It is only through science and its own test programmes that USARIEM helps ensure that products used by the Army will protect the soldier as intended.

It seems then that consumers should not always believe the hype, but thanks not only to the army, but also to private companies and organisations such as Toray, Pentland, and the Hohenstein Institute - who are continuing to develop and carry out tests on clothing for extreme climatic conditions - people will and can be equipped to face the hottest desert or the coldest mountain top.

Sir Chris Bonnington wore:

Explorer IV GTX boots

Upper:	Suede/Ardura
Lining:	Gore-Tex
Sole unit:	Adventure (PU midsole)
Weight:	615g

Brasher 4 season socks

Tech base boxer shorts

Fabric:	Tech Base - (polyester) with anti-microbial finish
Weight:	65g

Extrem Light tight

Fabric:	Fast wicking, brushed back stretch nylon
Weight:	230g

Corona pant

Fabric:	Toray nylon/polyester double weave stretch with DWR
Weight:	524g

PacLite Alpine Pro pant

Fabric:	Gore-Tex paclite cassis (Cordura)
Reinforcements:	3 Layer Gore-Tex XCR Lofoten
Weight:	495g

Short-sleeved X-Static T

Fabric:	Polartec Power Dry with X-Static
Weight:	160g

Stretch Light top

Fabric:	Fast wicking brushed back stretch nylon
Weight:	335g

Rage jacket

Fabric:	Airfoil
Lining:	Brushed warp knit lining
Weight:	365g

Infinity Light

Fabric:	Pertex Quantum nylon Ripstop
Insulation:	Primaloft PL1 60gm fill
Weight:	275g

PacLite Alpine Pro jacket (unused)

Fabric:	Gore-Tex Paclite Cassis (Cordura)
Weight:	495g

Icefall XCR glove

Fabric:	Schoeller Stretch with Cordura, Pittards Leather
Fill:	60gm Primaloft
Liner:	Gore-Tex XCR
Weight:	140g

Mountain hat

Fabric:	Gore Windstopper Glacier
Lining:	Polartec Classic 200 fleece
Weight:	60g

Freeflow zipped 25+6

Fabric:	Ardura 420rs & Esdura 600
Back System:	Freeflow III
Weight:	1.22kg
Capacity:	25+6 litres

Except where specified, all items were Berghaus.