

The heat is on... (or off)

Many people get involved in extreme activities these days, pushing their bodies to the limit whether it be as part of their professional life or just for the pure thrill of it. But although these activities all involve sweat and tears, straining muscle and sinew, it is often temperature rather than tiredness that forces people to call it a day. But this could all be about to change thanks to the latest innovation from Scottish inventor, Robin Caird. The new EXO² Thermoflex heating pad, integrated into clothing, allows the wearer to turn the heat on, and off, as and when they choose.

You can bend it, stretch it, sew it, punch holes in it, wash it endless times and yet the EXO² heater will still warm up on demand and keep you warm... at the touch of a switch.

In technical terms what Caird has produced is a heat-treated conductive polymer (Fabroc), based on a carbon-loaded silicon. Naturally flexible, even with a protective backing, it will stretch by over 40%. Non-toxic, inert, waterproof, windproof, crushproof, with nothing to leak, and a slightly rubbery feel, the EXO² Thermoflex is a self-regulating heater. This means that it has the unusual property of having positive temperature coefficient and, once set to the wearer's specification, it will never go above the maximum, ensuring that the product cannot burn the wearer. It is powered by a small rechargeable battery, which weighs about the same as two small mobile phones (which is not a great deal when you consider that many of us carry both work and personal mobiles around without even noticing).

Fabroc is a constituent of PTC thermo electrical devices which enables the wearer to harness the power of the sun, combined with Li-Ion (Lithium-Ion) battery technology (already used in mobile phones), to operate information systems; from vital sign sensors, to MP3 and phone operations, to heat generation at the touch of a fabric switch located on the arm or collar of the garment.

The 'extreme' in extreme sports often refers to the climate as well as the activity.

 Sportful



EXO² technology has been incorporated into EXPO and ProSport motorcycle wear.

 EXO²

Following the development of this new 'smart textile' EXO² decided a few years ago to offer the invention to the sports market and has been using DesignIQ to assist it in finding suitable partners and end uses. According to James Laing of EXO² and Guy Mathiot of DesignIQ, this has been a journey of discovery in itself, where success and learning have gone hand in hand.

Few innovations end up being used where and how they were expected to be, and EXO² is no exception. The initial concept was that the heater would be used by walkers and hikers to keep them warm in adverse conditions. While this application is as relevant as ever, the actual possible uses are far more wide-reaching.

Why get hot under the collar?

But, while heat retaining, insulating clothing is nothing new, why should EXO² be considered better than any standard insulating garment?

According to Mathiot, it is important to accept that heating is what the body does, and the clothing we wear is designed to retain the heat that the body generates. The real benefit lies in offering intermittent heat supply to allow the wearer to regulate heat as and when required.

One obvious advantage of the EXO² heater is that it allows the wearer to reduce the amount of bulky clothing, safe in the knowledge that heat can be produced as required, especially during activities where there are periods of inactivity that can cause a drop in body temperature. For example, skiers are often too warm on the downhill, but quickly lose heat when at the bottom of the run and whilst waiting for the ski lift. This is the moment when a heated jacket can be a real benefit.

Underwater adventure

Based on this approach, many uses become apparent from sports training where problems arise between bouts of activity through to the Tour de France, where riders are often seen stuffing old newspapers down their jerseys as they start long mountain descents in an attempt to retain some of their body heat. One surprise application was the heater's use in deep sea diving, but this has



The innovative Typhoon Icebreaker bodywarmer can be used in conjunction with any drysuit or undersuit to help the wearer stay warmer for longer in extreme underwater conditions.

 Typhoon

proved very successful, with Typhoon International having now integrated EXO² into its Icebreaker suit.

Typhoon was seeking a new partner to develop a system for keeping divers warm at depths of up to 150 feet. This was due to periods of inactivity in the cold when ambient temperatures can fall as low as 2°C whilst divers are waiting to adjust to atmospheric pressures so that they are able to resurface safely.

However, having carried out earlier trials with other heat generating products, Typhoon had several specific demands of the product. It had to be lighter and less unwieldy than previous products and also more reliable, as the earlier products that



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they had trialed before EXO² had proved to be unreliable in relation to temperature fluctuation and overall functionality. EXO² worked with Typhoon during 2003, taking these aspects into account in addition to pressure, safety, and waterproofness. The result was the Icebreaker, that went on to win the Diving Innovation Award at Oceanology International in 2004.

The final product is a 3mm neoprene under-suit vest, containing EXO²'s Fabroc combined with a conductive tinned copper braid in a nylon envelope connected to a waterproof canister housing a Li-Ion battery, which has been designed to maintain an optimum temperature of 42°C. With two pads positioned at the front and two at the back, the vest allows divers to remain underwater for longer periods of time, as it is designed to provide up to 70 minutes of constant heat.

Having proved popular with both male and female divers around the world, work is now in progress to develop diving socks, glove liners and dry suit products.

Again the fact that divers do not need the heat on all the time, but use it to keep warm between periods of activity at depth, or while waiting to resurface proved to be successful for EXO². The heating can work at the moments when most needed, essentially during the inactive moments.

The collaboration with Typhoon led Mathiot to consider the true spectrum of outdoor activities in which the EXO² technology could be applied. Bird watching and fishing are two areas where there is an obvious potential, but, as with cycling, the advantages of EXO² could also benefit horse riders.

Berghaus wraps it up

Berghaus introduced a Heatcell Gilet at ispo in February 2004 in order to gauge the market's reaction to the technology and were so pleased with the results that at the most recent ispo, it introduced a full jacket with a heater option that offers a half and full power setting. Heating from one 61gm battery will last for six hours in continuous use. Berghaus has also introduced a mitt, in order to retain heat in the hands, which are well-known as a trouble area concerning heat loss when taking part in outdoor activities. The mitt has a battery fitted discreetly into an interior pocket, providing heat whilst not impeding dexterity.

Taking heat to the extreme

The fact that the extremities of the body are often the first areas to suffer from the effects of the cold, the potential for heated gloves and footwear is significant.

One challenge that has been addressed in this area is ski boots. EXO² was approached with two requests:

- Relieve the discomfort and reduced performance caused by wearing ill-fitting boots.
- Reduce the dampness of early morning starts and from wearing ski boots that have not had time to dry out from the previous day.

The ski boot manufacturer already had an idea of producing a malleable foam insert with form memory and wanted EXO² to design a heated insert that could work with this. EXO² designed a Fabroc pad that provided heat which could mould or 'thermoform' the foam into a shape to provide a snug fit around the ankle and heel, that would then provide support and comfort. This would mean that the boot would be 'personalised' in order to offer each individual wearer the highest level of comfort and fit. This technology allows gaps around the ankle to be filled as required whilst still allowing for the natural expansion of the foot during periods of exertion. With the addition of a 12v transformer, skiers are able to dry the boots more effectively overnight.

What's in a name?

Working with brands has proved very successful for EXO², but according to Laing it takes time. In an attempt to accelerate the uptake and awareness of the product EXO² is currently building a small range of items themselves. A selection of belts, gloves, and jackets, called Heatwave, is being developed which will be sold in a select market in an attempt to gain

exposure and experience. One new development that has resulted from this work is the ability to use the same battery to heat pockets as well as the kidney area in jackets, so that when inactive, the wearer can place his or her hands into the jacket pockets to warm them up.

Another market seen as having a great deal of potential is the over-50s age group. As we grow older, circulation decreases and we begin to lose the ability to retain heat as efficiently. However, as older people are remaining active longer in life, EXO² and its brand partners believe that this technology could find a large market in this age group that wants to stay active, but also wants to remain comfortable.

All charged up

If one were looking for a drawback to the EXO² product, the fact that it needs recharging seems to be the only negative aspect, an aspect that is integral to any electrical equipment including mobile phones and notebooks. This has no detrimental effect to the general consumer. Skiers can recharge their garments in the chalet at night, hikers can plug it in at home, even mountain rescue teams have a base camp normally equipped with mains electricity, but what about in more remote locations? Does the fact that it needs recharging reduce the suitability or usability of the product? It's true that in situations such as at sea, items requiring



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recharging are always a concern as power supply is limited. However, even in these situations it seems that the benefits of the product outweigh any extra usage of the precious, limited power supply. As one sailor was quoted as saying, "At 2am when you are not quite certain where you are in the Bay of Biscay, keeping the captain warm at the wheel is a very sensible trade off when rationing power."

The future's bright

The potential applications for this technology seem almost endless, and it is already being tested and used in motorcycle fleeces (with heating controlled from the handlebars), car seat warmers, heated joint supports and belts in medical applications, sleeping bags, heated boots and insoles, wetsuit warmers, domestic radiators, and horse blankets, saddle and leg warmers.

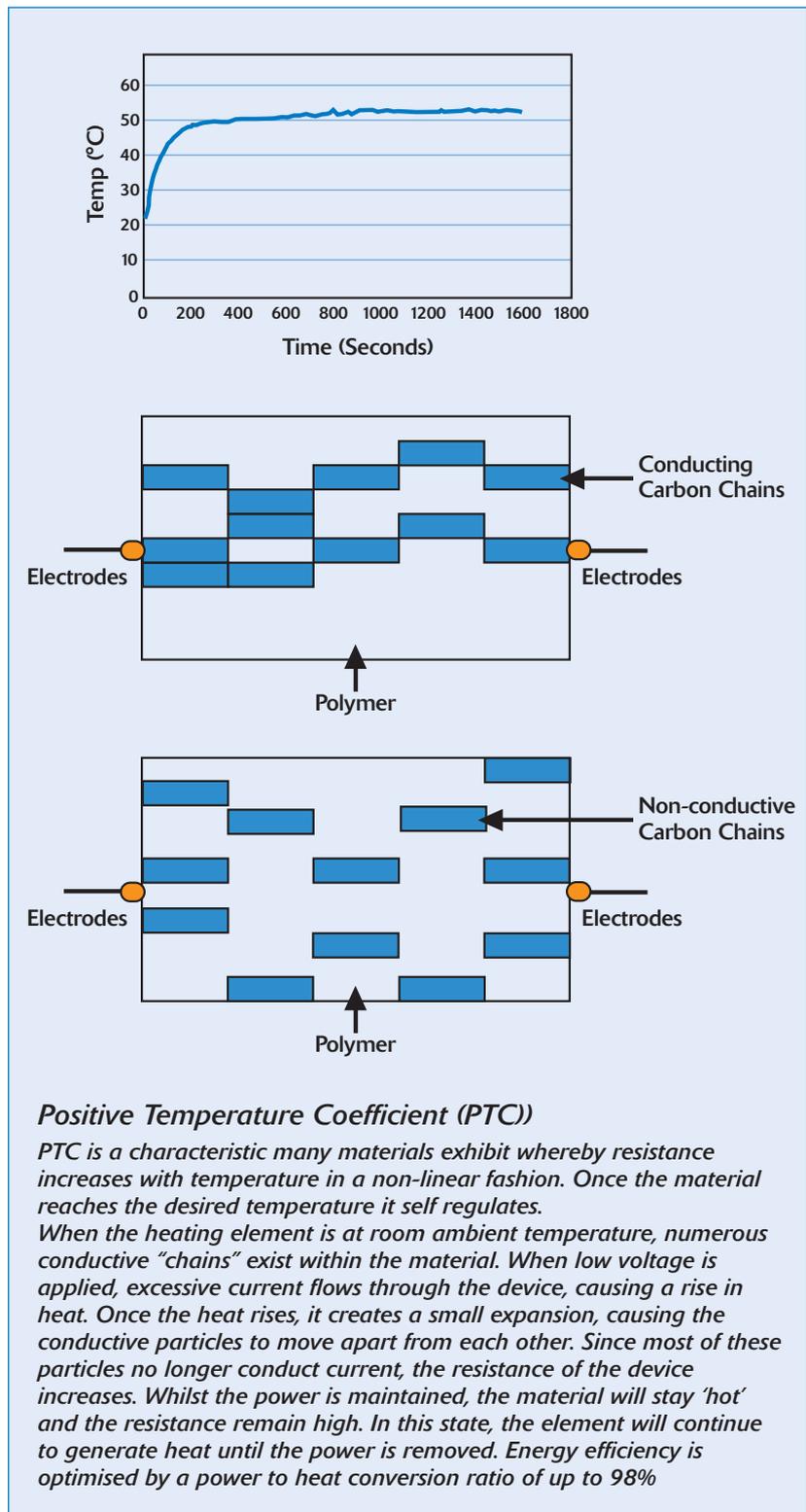
Laing is clearly excited about the future potential of the product and the company is now in the process of developing products for skiing, golf, and with the military. Previous developments in this area have normally required bulky wiring that often breaks after a short time, and systems that have proved to be unreliable in terms of overheating and general unreliability. However, at a time when consumers are becoming more and more accustomed to wearable technology such as GPS and RFID being attached to their equipment, it seems that EXO² has managed to produce a patented product that offers efficient reliability in a compact form. It seems that the timing and the technology is right.

EXO²: How does it work?

Designed using patented self-regulating heating pads, EXO² products all have a positive temperature coefficient (PTC) which means that they will not burn the wearer by overheating, and so they are safe and reliable.

PTC is a characteristic exhibited by several materials whereby resistance increases with temperature in a non-linear way. This means that once the material reaches the desired temperature, it self-regulates maintaining a constant, safe level.

When the heating element is at room temperature, conductive chains exist within the material. These chains are broken when a low voltage is applied. An excessive current flows through the device causing a rise in heat. This leads to a small expansion causing the conductive particles to move apart from one another, so breaking the chain. As the particles move apart, they no longer conduct current and the resistance of the device increases. Whilst the power supply is maintained, the material remains hot and the resistance remains high as the element continues to generate heat. Energy efficiency has also been optimised in the thermomesh, producing a power to heat conversion rate of 98%.



The pad can be placed throughout the garment, but at present the majority of pads are positioned in the kidney area or near the extremities where the benefit is greatest. Some customers have also opted to have the pad in close to the chest for instant gratification. Mathiot argues that in order to change the positioning of the pads requires a change of mindset in the consumer and the brands. As we get more used to electronics in garments we can use EXO² to imagine different ways to manage insulation and heating. 🌐