Keep Cool!

Perfectly illustrating the need for body cooling, this soldier's body is trying to regulate his temperature

Ambient heat, humidity and physical exercise tend to increase human body temperature; this degrades the efficiency of the body, which best operates at an average temperature of 37° C. About 70% of metabolism is expressed as heat, while only 30% is transformed into mechanical work. Considering these parameters, and with a typical military mission on foot in mind, it is easy to understand how quickly overheating can become a problem in a standard situation, not to mention a hot climate, with heavy loads and covered with equipment that inherently is not breathable – typically body armour.

Paolo Valpolini

Body heat is lost by radiation, conduction, convection and evaporation. Since all four need air to move them away from the body, it is easy to see how soldier equipment can obstruct the circulation of air around the body, particularly around the torso and the head. Overheating causes sweat, which can lead to a relative state of dehydration if fluid loss exceeds replacement.

Beyond a certain stage physical performance is reduced, the sweating mechanism compromised and body temperature is on the up. Oddly enough, humidity worsens things, as it prevents sweat from evaporating. According to medical literature, a fluid loss of 3% causes a reduction in aerobic work capacity of between 6 and 15%, but frighteningly, at 5% loss working capacity is slashed by 30%.

Solutions aimed at controlling body temperature are thus becoming an increasingly common sight at military exhibitions. Many of these were developed for sports, some appeared in the industry and emergency rescue world and others have been purposely developed for the military.

Various systems are used to keep body temperature under control:

► water evaporation is probably the simplest and cheapest method and results from garments with an embedded polymer fabric that is immersed in water for a few minutes prior to use to absorb many times its weight in water; after a light squeeze the garment is donned as close as possible to the body and it keeps cool for many hours

► while the previous system does not work well in humid areas, cold pack body cooling is effective in most climates, but the garment must be cooled in a freezer for up to four hours before use

► change cold pack cooling systems require ice water but no freezer, have a higher weight and are more expensive

► active cooling water circulating systems are made of a lightweight vest and a water reservoir, the liquid being circulated in the vest. Very expensive, they also require power to keep the water cool, and are suited for vehicles crewmembers or for soldiers who dismount from their vehicles for short periods of time

► the newest systems are based on air circulation in the garment, thanks to microblowers that provide endurance and low weight.

The Entrak cooling vest is equipped with two blowers that have three different working modes and are able to blow up to 200 litre/min each, providing very good cooling power. (Armada/PV)

The latter solution is particularly suited for infantrymen having to carry out operations over an extended period of time. The garment itself is normally made of a porous material, or porous structure, with blowers circulating air inside that structure to soak in the heat before expelling it, the resultant heat exchange drops the body temperature with the added boon of tossing out perspiration. Various systems of this type are appearing on the market, with a number of them associated with some of the major soldier modernisation programmes.

W.L. Gore has developed two types of systems, one dedicated to infantrymen and the other to crewmembers. Leveraging its experience in the fabrics field, the company has developed a special three-dimensional material that is very lightweight and that neither burns nor melts. The Active Cooling solution can be worn under body armour but also under normal battle dress uniforms. The material is

The infantry version of the Gore Active Cooling (the black element) is worn under a body armour. Following trials in operational theatres the company is discussing honing the latest details before starting production. The fan (inset) is in the lower pocket of the garment. (Armada/PV)

contained between two layers of fabric, through which air is circulated.

In the vehicle version the Active Cooling can exploit the fresh air blown by the climate control system, which is connected to the vest via a hose. This version is deployed in Afghanistan on British Army Titans and Trojans; lessons learned show that the system can also be used to warm up during wintertime, and that it allows to reduce the energy used by the vehicle climate control system, with positive effects to the overall energetic balance.

As for the infantry version, Gore provided some prototypes to the British Ministry of Defence and discussions are now underway on lessons learnt before deciding on a final configuration. The current blower circulates 150 litre/min and, at full cooling power, the rechargeable battery lasts 8.5 hours, which can double if the system is used at reduced power. The battery can be recharged in 3.5 hours from flat. Initially the blower was quite bulky and heavy, but the latest versions are compact and lightweight enough to fit in a pocket on the left side of the vest.

These blowers are manufactured by German electronic company Entrak which, for more than three years, has been active in the industrial safety sector addressing, among others, cooling-related issues. It eventually stepped into the military market a year and a half ago, developing a cooling system that has been evaluated by three top German Army units, the Long Range Surveillance Training Centre in Munster, the Airborne Reconnaissance Company 260 and the Sniper's Instruction Centre at the Infantry School in Hammelburg. Feedback from those units was used to improve the product to its current configuration.

While Gore went to Entrak for the blowers, Entrak has a partner company that provides the garment that is based on a mesh system taken from sportswear; the current problem is that this material is not flame resistant. However Entrak has already enquired about the feasibility of making a similar vest with flame-resistant characteristics and received a positive answer.

The Entrak vest has two blowers, contained in two side pockets. Each blower has three different operating modes, position 1 providing 100 litre/min and 20 hours endurance, position 2 at 160 litre/min and ten hours, and position 3 200 litre/min and six hours, power provided by a three-cell Lithium-Ion battery.

The Gathergy by Active Space Technologies is a liquid circulated vest that exploits solar cells for powering the system in daylight. (Armada/PV)

Entrak blowers are pretty silent, noise has been rated at approximately 30 dB(A) in position 1, 36 dB(A) in position 2 and 40 dB(A) in position 3, shifting from one speed to another is done simply by pressing a button, even through the fabric, while prolonged pressure will shut down the system. Each blower weighs 265 grams for a garment weight of some 500 grams, resulting in an overall weight of slightly more than 1.1 kg.

Another German company involved in cooling vests is Blücher, which in April 2010 took over Texplorer. The latter was responsible for the development of the protection and clothing system of the German enhanced future soldier system,

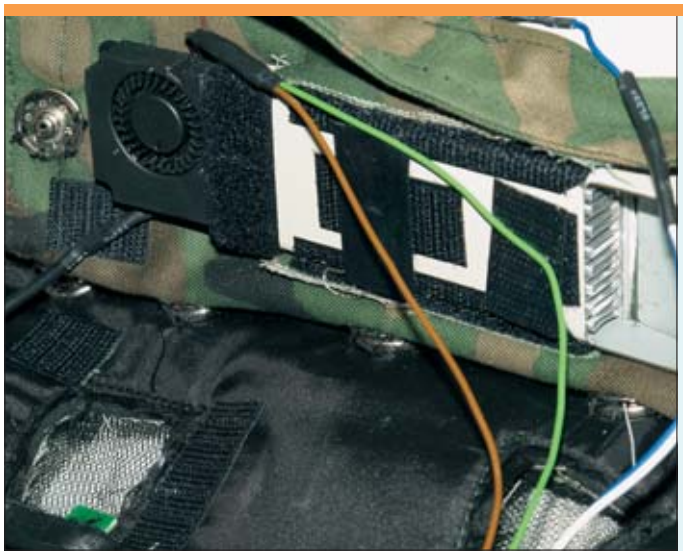
A detailed view of the inside of BCB International cooling body armour. Clearly visible in this picture are the vents that allow the air to circulate. (Armada/PV)

originally known as IdZ-ES and now renamed IdZ II.

For this programme the choice went for an integrated system in which the trauma liner of the IdZ II body armour is made of a three-dimensional shape with air blown through its channels; the material is completely flame retardant.

Known as the Swout, the Blücher system circulates air from top to bottom by two blowers (front and back) powered by 14-hour-endurance batteries recharge-

Allen Vanguard liquid circulating garments are standard issue in many US Army vehicles. The vest weighs only 700 grams and is connected to the liquid chiller units installed in the vehicles. (Allen Vanguard)



The Pelletier cell and the blower of the Gathergy liquid circulated cooling system are more complex than air blown cooling vests; the advantage of such a system is that it is possible to set the desired temperature. (Armada/PV)

able in 1.5 hours. The overall weight of the Swout is less than 500 grams and includes a three-minute turbo mode.

It is interesting to note that during the IdZ-ES initial trials mountain troops operated in mid-December at -9°C. During that exercise they used the Swout system to reduce perspiration during heavy physical activity, which allowed them to avoid getting their underwear completely drenched by the end of the action, thence freeze as they stopped.

Following these trials the German Army required slight modifications to reduce the surface of the cooling system. In the meantime, Blücher developed a standalone version of the Swout. This comes in two parts, front and rear, which can be fixed inside body armour, as the Swout is to be worn directly on top of the underwear. Among recent upgrades is a charging adapter to connect the Swout to a vehicle for charging while on the move. Another improvement is the ability to connect an air filter for very dusty conditions.

Another specialist is BCB International, with a body cooling system that can be integrated into a protective vest. Known as the Mistral Body Cooler, it has been integrated into the Osprey body armour, which, in turn, resulted in the Cool Osprey.

In the Mistral, ambient air is directed through vents located along the length of the sternum and spine, from bottom upwards. Three separate cooling circuits operate sequentially, shifting from one cooling zone to another every 20 seconds. The fan can operate continuously for ten hours on a single power pack, the latter containing eight AA batteries or equivalent rechargeable cells. The plug-in fan can be quickly disconnected and the Mistral connected to a vehicle climate control system.

Vehicle Feed

Excessive heat built up inside vehicles can lead to serious injury from heat stress. Today, vehicle-mounted Liquid Circulating Garments (LCG) are standard issue in many vehicles. One supplier, Allen Vanguard, has fielded over 10,000 cooling systems to coalition forces in Iraq and Afghanistan since 2004 to provide personnel and electronics cooling in combat vehicles.

Each of its two families of chiller systems is customised and scaled to specific operational requirements in terms of power source, cooling output, space claim and installation.

The Alcu chiller series works with and enhances the vehicle's existing environmental control unit to provide focused cooling. Alcu systems are currently deployed on Humvees, Bradleys, M113s and Mraps. For vehicles that don't have such amenities, the PLCU series of completely self-contained chillers provide a battle-proven cooling capability in Humvees, M113s, tanks and so forth. These extremely rugged thermal management systems have been mounted internally and externally as required.

Equally important to crew cooling is keeping critical electronic and mechanical systems within acceptable operating temperatures. The Epic (Environmental Protection with Integrated Cooling) solutions for electronics and the new Pacs (Positional Air Conditioning System) increase the capabilities of the chillers described above to focus cooling to where it is most needed.

The Epic case encloses and protects the equipment from the harshest of environments. The Pacs provides conditioned air to electronics or crew, without the ducting or infrastructure of a conventional environmental control unit. The versatility and customised nature of these chiller systems allows vehicle designers with highly effective thermal management solutions.

Chopper Chill

Numerous systems are available for airborne use onboard many helicopters, but liquid circulating garments are seldom used by infantrymen. However, at the Future Soldiers conference held in Prague in October 2010, Active Space Technologies – a Portugal-based company – unveiled its Gathergy (Garment with Active THermal control and powered by solar enERGY).

Based on a Pelletier cell with liquid circulated by a pump through the heat exchanger, its blower forces the air through the heat sink to dissipate calories from the heat pump. Although integral solar cells charge the batteries (these power the system when sun is down), the major drawback of the system remains its weight and complexity. On the other hand, it offers the advantage of temperature controllability through a small man-machine interface worn on the garment.

Another company active in personal liquid cooling systems is DSKool from China, whose systems have also been tested in the United States. ◘

Chilly Water

Cool water is often a soldier's dream in hot climate areas. BCB International's Chilly Water Cooler, here photographed by the author, works by evaporation alone (and thus does not require power) and can easily be clipped to most inline hydration systems. The only consumable is water: the drinking water passes through the succession of cooling elements and its temperature can be reduced to 25°C. A small amount of water is transferred to the outer covering fabric through a wick, both made with an anti-microbial and anti-fungal fabric. Weighing 410 grams, the device is 220 mm long, 120 mm high and 70 mm deep.

Besides keeping the body cool through cooling garments, the ingestion of cool water consistently helps to reduce heat stress and dehydration. To this end Allen Vanguard offers the HCS1 (Hydration Cooling System), which works with a heat exchanger sleeve and a pump powered by four c-cell type batteries providing three hours of service. The modified Camelbak is loaded with water and frozen; the heat exchanger is wrapped around the frozen Camelbak bladder, the chilled liquid circulates in a closed loop through the sleeve into the pump unit and into the LCG vest worn by the soldier. The water warms up with the heat 'stolen' from the soldier's body, which in turn melts the ice in the bladder to be supplied as chilly drinking water to the soldier.