Matters of fire retardancy and safety capture the headlines every time there is a disaster involving uncontrollable bush fires. They are also key requirements in military protective wear where multiple properties, including comfort, need to be incorporated in a single fabric.

Burning issues

An almost unprecedented heatwave struck Arizona at the end of June, with temperatures in the high 40°C range (115°F). The tinderbox conditions it created burst into flames that continued to burn into July. Devastatingly it also claimed the lives of 19 elite firefighters, the worst fatalities in US wildfire history since 29 firefighters died in 1933 tackling a blaze in Los Angeles. On June 30 this year, the temperature in California's Death Valley hit 51.6°C (125°F).

The disaster caused many to consider issues of flame retardancy and protection, although in this instance it appears that nothing could have protected the men.

The team that lost their lives were known as the 'Granite Mountain Hotshots', formed in 2008. The concept of hotshot firefighters dates back to the late 1940s, when specialist crews were formed in southern California to patrol local national forests. To join a crew, a new recruit has to be in peak physical condition, be able to run a mile-and-a-half in about 10 minutes, and do 40 sit-ups in a minute.

They are also expected to be able to cope with carrying bulky apparatus as well as a supply of food and water. They even carry fire retardant shelters for extra protection. According to the Arizona State Forestry Division, it appears that 19 shelters were deployed on this occasion but even these were overwhelmed by the ferocity of the fire.

According to the US NFPA, the national fire protection agency, founded in 1896, the deadliest incident was the 9/11 attack on the Twin Towers in New York but, in terms of wildfires, the latest incident is the third highest death toll – in 1910, the Devil's Broom fire killed 86 men.

It is clearly a high risk occupation: in 2012 64 firefighters lost their lives on duty, the second lowest total in 35 years across the US; the annual US average for the past decade dropped to 88 as a result.

It is no wonder that issues of fire retardancy (FR) continue to demand research and development, especially in the world of textiles. It's also clearly an area that is of major importance to the military world. Alexium International, an Australian company founded to commercialise a reactive surface treatment process originally developed by the US Air Force and is actively developing new FR solutions. It estimates that the US military has a market potential of 27 million yards, while other global markets, including industrial workwear and first responders' protective clothing, could require in excess of a further 50 million yards (46 million metres) of FR fabric to meet demand.

Fresh developments

Alexium holds the proprietary patent applications for a process developed initially by the US Department of Defense which allows for the surface modification and attachment of nanoparticles or multiple chemical functional groups to surfaces or substrates to provide



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functions such as water proofing, oil proofing, antimicrobial, nonstick and UV protection. In September 2012, Alexium had secured a $200,000 contract with the US Air Force Research Laboratory to demonstrate its Cleanshell CB treatments for chemical and biological protection applications and clearly hopes to build on its relationship with the US Department of Defense. It is the FR sector, however, that is seen as a key market for its expansion while the company seeks financial backing from stock markets in a number of countries including the US and Germany.

The company's fire retardant treatment for 95% nylon-based products is already marketed under the Ascalon trademark but it is now focusing on nylon blends, such as nylon/cotton, under the Nycolon trade mark. The treatment is seen as a unique combination of physical and chemical flame retardancy. Bob Brookins, Alexium's chief technical officer, says: "Traditional flame retardant chemistries such as halogen- or phosphorous-based compounds decompose when heated, producing active species that retard and extinguish the flame. The Ascalon technology can couple such traditional chemistries with a unique flame retardant mechanism that rapidly forms an external barrier to effectively smother the flame. A simple, but apt analogy is that it is like throwing a blanket over a flame to extinguish it."

He believes that the difficult balance of inhibiting melting and combustion has been resolved with their technology, which is bromine-and halogen-free. Duro Textiles LLC is Alexium's licensee partner for North America, but the company also expects to create licensing agreements with partners in other markets too.

If Ascalon was targeted at 95% nylon fabrics, Alexium now appears to have developed a wash durable, topical, self-extinguishing FR treatment on printed 50/50 nylon/cotton fabric that does not melt or drip when exposed to flame tests — and at a lower cost than current systems. [Cost is said to have limited the number of FR-ACUs or fire resistant active combat uniforms that the US military is able to provide to each soldier]. The treated fabric also maintains its breathability. Its chemistry provides comparable performance attributes to the FR-ACU but enables the use of traditional heat curing methods; it can be applied to the fabric with a standard 'oven' as well as the company's microwave technology.

The company believes the use of traditional curing methods significantly lowers entry barriers to key markets and could lead to the establishment of new categories of FR and technical fabrics, allowing the textile industry to use much higher percentages of nylon in FR fabric blends, increasing strength and fabric performance.





(Left) 50/50 nylon-cotton (after vertical flame testing) with Nycolon treatment. The Nycolon treatment is wash durable.

(Right) Before the material was treated with Nycolon.

Alexium International

Not the only player with fire

The FR sector as a whole continues to see innovation, with fibre and fabric producers aiming to achieve the right level of protection with the demands of comfort. Protective wear can often be considered cumbersome so current thinking targets comfort with lighter weight fabrics and garments. The FR requirements vary across different industries and the hazards encountered by those working in specialist fields. For instance, Drifire, part of Optimer Brands, targets a range of industries.

Drifire fabrics and clothing are engineered to be inherently fire resistant but do not rely on topical treatments. The fibres are flame resistant, which ensures that the safety features will not wash or wear out. The fabrics are no-melt, no-drip so its apparel will not melt or fuse to the skin when exposed to flame or fire. Drifire claims that its fibre blend optimises the ratio of hydrophobic and hydrophilic fibres to ensure that its garments offer optimal wicking of moisture from the skin, and fast drying times.

Its product range now includes what is said to be the first dual hazard fabric designed specifically for the oil and gas market. The fabric, named DualCool, features arc-rated thermal protection from flash fire and is in the process of UL (Underwriters Laboratories) Certification. In testing, DualCool was found to be twice as durable as other fabrics, and provided excellent protection in instrumented mannequin flash fire exposure, with less than 10% predicted second degree burns under garment and no third degree burns.

South Carolina-based textile manufacturer Mount Vernon Mills unveiled its latest flame-resistant fabrics and finishes at the American Society of Safety Engineers' Safety 2013 show in

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Las Vegas in July. Its FlexTex fabrics have been developed for increased comfort and mobility, with an elastomeric fibre that allows the fabric to flex up to 14% with a 97% recovery. The fabrics have a bilateral flex that allows them to elongate sideways and diagonally, eliminating bagging. The company also launched amDry, a durable water repellent finish that can be applied to FR fabrics to deliver protection to workers in water-intensive jobs and industries. Fabrics finished with amDry have a spray rating of 90/100, the ability to repel water where a rating of 100 indicates maximum water repellency.

"As industries requiring FR garments continue to grow, fibres, fabrics and finishes will help meet the evolving needs of workers who rely on FR protective garments for their safety on the job," says Mike Woods, vice-president of FR fabrics for Mount Vernon FR. "FlexTex and amDry represent the first of several new innovations that we will be introducing over the next few months as we focus on FR fabrics." Its six FR fabric collections cover various blends including cotton, nylon and Nomex.

Dutch textile chemicals manufacturer Tanatex used TechTextil in June this year to promote its series of products especially designed for coating synthetic fabrics for outdoor apparel. These include Tanacoat OMP, a soft basecoat, and Tanacoat MTO, a medium hard topcoat. The end products show high light-fastness and UV-resistance, and it quoted Tanacoat SFT as a good example of how some of these products can work together in textile applications. Tanacoat SFT is a compounded coating for polyester fabrics with flame-retardant properties, without halogen-containing components. Tanatex also confirms the point that safety product manufacturers want flame-retardant solutions that are free of halogen because many halogenated flame-retardant chemicals are persistent, bio-accumulative and toxic.

Schoeller Textil has also been working on FR fabric collections. It has recently launched its pyroshell technology that it describes as a modular overall concept that makes reliable protection from heat and flames possible on synthetic fabrics as it combines permanent flame protection with polyamide and polyester fabrics. It also provides high levels of safety and visibility in all EN 471 colours (neon yellow, orange and red). Applications on elastic fabrics are also possible, offering freedom of movement and comfort to wearers without any compromise on breathability, tear-strength, abrasion resistance or weight. Three-layer protective fabrics that no longer need to be lined are available in two-way and four-way stretch versions or as a non-elastic. The fabrics are manufactured in keeping with bluesign standards.

Invista also sees potential in the FR segment.



Schoeller-Works says reliable protection from heat and flames is now possible in synthetic fabrics that comply with EN directives.

Schoeller

The polymers and fibre producer has acquired Ashburn Hill, a flame-resistant products producer based in Texas, to expand its performance fabrics offerings and "add a new skillset" to the company. "Invista has an aggressive growth strategy that includes identifying new business opportunities to allow us to continue building a product portfolio that delivers value to customers," says Jeff Brown, executive vice-president of Invista Performance Materials. "The Tecgen flame resistant brands have quickly gained trust in the marketplace, and by coupling that expertise with Invista's workwear capabilities, we have high expectations for the specialised garment segment."

The acquisition includes two flame resistant brands: Tecgen Select, flame and flash fire-resistant clothing developed for manufacturing, mining and oil and gas operations; and Tecgen Xtreme, lightweight apparel that repels moisture and is designed for firefighters for wildland and technical rescue applications. Invista claims that it has made Tecgen fibre far more protective than it needed to be. The patented fibre with its high-density carbonaceous shell absorbs extreme heat, yet allows the comfortable inside fibre to remain untouched, adding 'cool comfort'. The fibre has a visco-elastic core and a carbon shell.

WL Gore has also been active in the sector, teaming up with US-based military wear company Massif in the softshell segment to produce two new nylon-faced, FR and water-resistant laminates for the military and tactical markets. The Massif Battleshield and Battleshield X fabrics provide durability, water resistance, breathability, flame protection, stretch and a high warmth-to-weight ratio. The Gore FR technology is used to increase breathability while improving water repellency and water entry pressure.

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In terms of protective wear it is worth noting that US-based Radiation Shield Technologies (RST) has been awarded patent protection in South Korea for its anti-nuclear protective garment which the company claims offers chemical, biological, radiological as well as heat stress protection. The suits are made of Demron, a polymeric nano metal fabric that is lightweight and flexible. RST says it "combines the metallic properties of gamma radiation reduction, trauma reduction and thermal conductivity with advanced nano polymer technology". The company's product line includes body suits, blankets and tents which have been used by military in the US, China, Iraq, Kuwait, Vietnam and Singapore.

Another US-based workwear company, UniFirst, has also expanded its line of FR workwear, choosing a Tencate fabric for its new Armorex Cool range.

The safety garments are made of an innovative, lighter weight, tri-blended FR fabric that helps keep workers who are exposed to flame risks safe and more comfortable on the job.

Ideally suited for such workers in the oil and gas industries, as well in environments that produce combustible dust, the shirts and coveralls are made from a new Tecasafe Plus 580 fabric.

The cellulosic tri-blend FR fabrics have moisture wicking and air permeability characteristics and are compliant for protection against flash fires and electric arcs, and the protective qualities can never wash out.

While much of the activity in the market has focused on nylon and polyester, Kelheim Fibres, based in Bavaria, now includes Danufil CS, a flame-retardant viscose speciality, in its range of fibres, having acquired the intellectual property and technology from Finnish fibre company Avilon, which has gone out of business.

A wearer trial to beat most

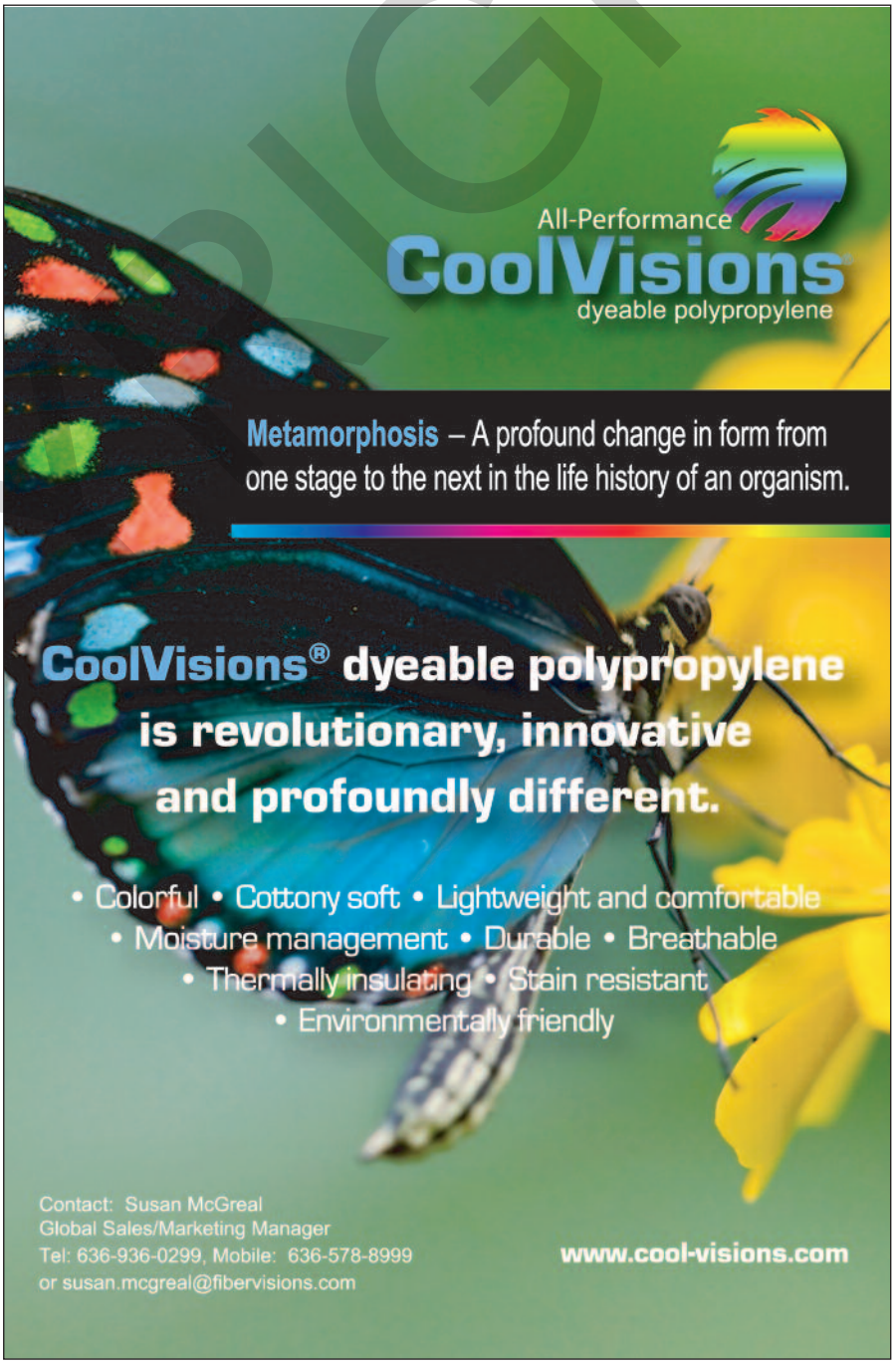
Comfort combined with safety remains the target and if you believe in your product then the best way of proving your claims is to personally test them. The president and chief operating officer of US-based military clothing company Secure Planet put the comfort of its shrapnel shorts to the test by running a marathon in them.

The protective undergarments withstood 26.2 miles of running without irritating the skin, due to the flexible, moisture-wicking, antimicrobial ballistic and mesh fabrics.

"We knew that the level of safety provided by our shrapnel shorts exceeded the US government's ballistic and flame resistant requirements but we wanted to assess the comfort level of the shorts first hand in order to equip soldiers with the best product possible," says Bob Kocher, president of Secure Planet.

The shorts provide protection to the pelvis, femoral artery and lower abdominal organs of soldiers against fragmentation, shrapnel, dirt and debris. Shrapnel shorts are made of knit ballistic fabrics and contain pockets along the front inner leg that allow for optional flexible ballistic pads to shield the femoral artery. Secure Planet won a contract to provide 75,000 pairs of the shorts to the US army. In terms of the number of companies eyeing government contracts, no doubt Mr Kocher felt that it was a marathon worth running.

Returning to the start of this article, no matter what technology is built into FR wearable protective wear, the viciousness of an Arizona type fire-storm will, in all likelihood, sadly still prevail.



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