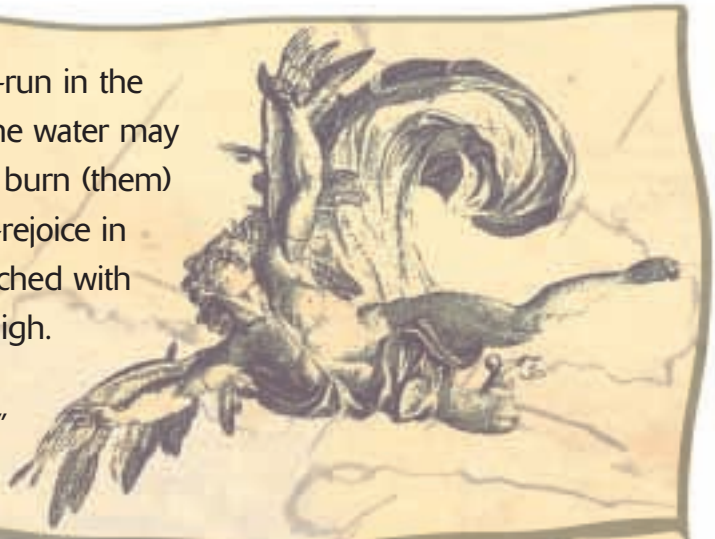
"Oh Icarus, I advise (thee) that thou mayest-run in the middle path, lest, if thou shalt go too low, the water may burthen the wings; if too high, the fire may burn (them) fly between each…when the boy began to-rejoice in bold flight and forsook (his) leader, and touched with desire of heaven he acted (his) course too-high. The nearness of the rapid (hot) sun softens the fragrant waxes, the bonds of the wings."
Ovid's Daedalus and Icarus



PPE and flying arcs

Many of us are familiar with at least the basics of the ancient Greek myth of Icarus, the boy who, against his father's advice, flew too close to the sun and whose wings (held together with wax) melted, leading to his death in the ocean below. As a salutary tale it has inspired ancient, medieval and modern poets and artists as diverse as W.H. Auden and Henri Matisse.

Of the many interpretations of the story two have relevance to current working practices. First - take heed of the dangers in going beyond safe limits and second - always take account of good sound advice. They, in turn, could be said to be the basis of the foundations of good Health & Safety practice at work. In the latest instalment of WSA's exploration of innovative developments in the protective wear market, a link to the Icarus myth could not be more appropriate.

Arc resistance

Having explored the understandable need for flame retardant fabrics (WSA March/April 2004) and high visibility clothing (WSA May/June 2004), we turn our attention to the relatively recent and slightly more complicated requirements for arc resistant clothing. The dangers facing the emergency services and the military are often there for all to see, yet the dangers facing many skilled workers every day should not be under-estimated.

"In March 1997 two industrial electricians anxious to begin a job in Norton's Hospital in Louisville, Kentucky, USA, entered the basement electrical room. They knew the parts they were near were energised but wanted to begin the measurements. They didn't know the full danger that lay behind the 'Danger High Voltage' signs. The workers were attempting to make measurements to the buss when the metal tip of their wooden ruler caused a massive electric arc in this hazardous area. The fire balloon lasted only a fraction of a second and, although, no one was electrocuted, one man died instantly and another ended up in a severe burns unit. It didn't take long for substantial damage to occur, instantly igniting the poly/cotton uniform shirts the men were wearing. Another worker 10ft away was also burned when his shirt ignited." reported Electrical Contract & Engineering News in July 1998.

The heat of the sun

An 'electric arc' is simply a continuous discharge of high current between two electrodes, giving out a brilliant light and generating heat. An 'arc flash' is the extremely high temperature discharge in the air produced by an electrical fault.

How serious a problem can this be? The temperature of an arc flash can reach upwards of 20,000 degrees Kelvin - roughly four times the heat of the surface of the sun.



British Telecom jacket made by Monarch Textiles using Tilsatec fabric innovation.

Monarch Textiles

✔ DD ✔ DB

Hazard Risk Category	Workwear Description (1/2/3/4) refers to the number of clothing layers	Minimum ATPV Ebt Rating For Workwear cal/cm^2
0	Untreated Cotton (1)	n/a
1	FR Shirt and FR Pant (1)	5
2	Cotton Undergarments + FR Shirt/Pant (2)	8
3	Cotton Undergarments + FR Shirt/Pant + FR Coveralls (3)	25
4	Cotton Undergarments + FR Shirt/Pant + Double Layer Switching Coat and Pant (4)	40

The Standard for Electrical Safety Requirements for Employee Workplace Protective Clothing Characteristics.
Source: NFPA

In fact, it is difficult to imagine any known materials that are able to withstand such extreme temperature without becoming vaporised. It, therefore, takes little imagination to realise what an arc flash can do to human skin. The key to the problem then is not electrocution but burns injuries caused by such an incredibly intense burst of heat.

Electric arcs are a real and present danger for anyone repairing electrical equipment or working in areas of high electric tension. Since the mid-1990s extensive research and investigative work have taken place in this area in both the development of test methods and the introduction of standards for arc resistant clothing, although as yet, there is no global agreement on the latter.

In America, which does seem to be more advanced in this field, the National Fire Protection Association's (NFPA) 70E standard does require workers to wear flame retardant work wear that meets the requirements of ASTM F1506 (American Society for Testing and Materials) and also sets out the safe distance a person can be from an arc flash hazard.

ASTM F1959 is a standard test method for determining the arc thermal performance value (ATPV) of clothing materials. ATPV measures the energy of the arc flash in calories. The higher the value the more insulated a person is from second-degree burns. ATPV is the minimum energy causing the predicted onset of second-degree burns.

Standard practice is to undertake a thorough risk assessment before determining what level of protection is required. ASTM F1506 sets standard performance specifications for flame resistant textile materials in apparel worn by electrical workers exposed to momentary electric arc and related thermal hazards. It also specifies the work wear which suits each category of risk, having an ATPV rating at least equal to those listed in NFPA 70E as set out below.

What not to wear

As many are aware, everyday work clothing made from synthetic fabrics that are not flame resistant, such as polyester and poly/cotton blends, are not appropriate for electrical workers. They melt and drip when exposed to an arc flash and can cause severe contact burns to the skin. There are also many misconceptions about the protective abilities of 100% cotton and other flammable fibres.

The growth in flame resistant clothing over the past decade has been well documented and includes a variety of options such as natural fabrics engineered to be flame resistant like Indura by Westex, synthetic fabrics such as Nomex IIIA by DuPont and chemical finishes such as Proban from Rhodia. When maintained properly, each should retain their FR characteristics throughout the life of a garment. The relational key in offering resistance to electric arc flashes is, however, in understanding the flash protection offered by each, measured as the arc rating or ATPV as above.

The primary aim of electric arc protective clothing is to minimise heat transfer through the garment before it gets to the skin.

The ARC-MAN

DuPont, producer of the one of the best known FR products – Nomex has developed a unique test facility known as ARC-MAN which also allows end-users to test and evaluate the performance of different garment systems. It measures the ability of a fabric to resist ignition and break-open, and to provide a thermal barrier between the arc flash and the skin. Available to view on DuPont's Nomex website, it is quite frightening to see the impact an electric arc flash can have on basic non-FR fabrics and the difference when wearing a garment made from Nomex. (Nomex is DuPont's registered trademark for its nylon aramid fibre with inherent flame resistance.)

Furthermore, DuPont has found that measuring the ATPV of Nomex fabric systems illustrates a very important phenomenon. Double layers of lightweight fabric provide much more than double the protection of a single layer of equivalent total weight. It is believed that having two fabric layers creates an additional layer of air which helps to dissipate the intense burst of heat, allowing the outer layer to act 'sacrificially.' In order to achieve an ATPV rating of >40 cal/m^2 DuPont would recommend for example: a jacket made of three layers of Nomex IIIA consisting of two each of 6oz/sq.yd or greater and one 4.5oz/sq.yd or greater fabric over 100% cotton knit, with insulated bib overalls.

European Classes 1 and 2

In Europe the proposed ENV50354 standard for electrical arc test methods for material and garments is set at two levels. Class 1 is tested at a current setting of 4 kA while Class 2 is tested to 7 kA. As with most proposed standards emanating from the European Union, ENV50354 is causing some anxious debate.

In 2001 a study was undertaken by the Central Institute for Labour Protection in Poland in order to compare the flammability of fabrics in accordance with the proposed ENV 50354 and the more usual flame-spread test method, EN 532. Interestingly, in the arc test at the lower testing level of 4 kA, the requirement was met by materials which did not pass the flame spread test. These materials contained a large amount of melting fibres and, therefore, tended to shrink or melt rather than char. However, in order to meet the 7 kA standard, a rather thick and heavy flame-retardant fabric was required because lighter fabrics tended to break open in the tests. One of the conclusions was that "the flame retardancy of the under layer fabric is therefore important to ensure the needed protection".

In summary, it would appear that almost nothing will pass the higher class 2 standard on its own which is why most companies offering arc resistant fabrics to ENV 50354 Class 2 will always qualify them with statements such as "When worn in conjunction with a lightweight FR under layer'."

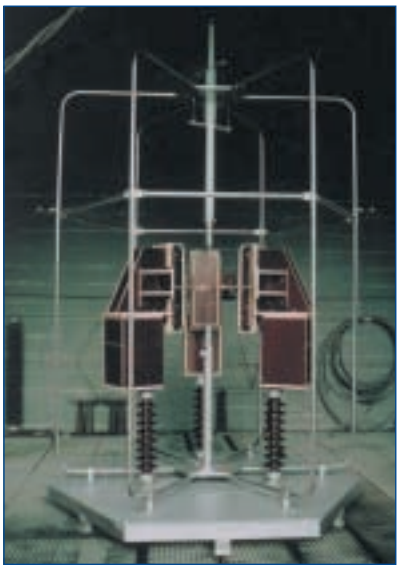
Tilsatec Marlin

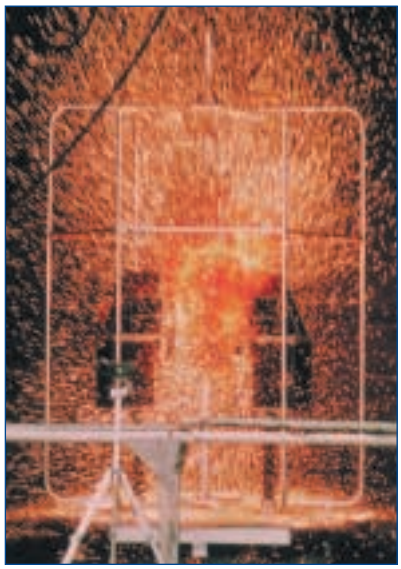
Part of the long established Sirdar Spinning Group (founded in 1880) - Tilsa Technical - is a UK manufacturer which specialises in the development and production of solutions to problems involving hazardous and extreme applications. Utilising its expertise in different fabric technologies it has already developed Marlin, an engineered fabric composite which is aimed at providing high levels of personal protection including electric arc resistance. Marlin fabrics are also waterproof and breathable.

Whilst the importance of technical performance in the personal protection sector of the work wear market is paramount and unquestioned, comfort is increasingly being seen as extremely important in ensuring that the products are actually worn by the employees who need them. Motivating electricians to wear the correct clothing in uncomfortable conditions (too cold, too wet or too hot) can be difficult.

One innovation recently launched by Tilsa is the textile for the new protective clothing for British Telecom's aerial riggers – technicians who work with high levels of electricity in all kinds of weather. Simon Havis, technical product manager at Tilsa, says: "We used our experience in technical textiles to produce a fabric that is all-purpose. It is the blend of fibres that gives it a wide range of properties."

The fabric is yet to be named but it is already said to be a market first and the process is so secret that it is not even patented. "Patenting it would reveal its make up," explains Sheila Cheetham, a PPE work wear consultant.





The DuPont ARC-MAN testing system.
DuPont

It is water repellent, highly impermeable to water penetration and breathable. It has a permanent anti-static performance and arc resistance (ENV50354 Class 2 when worn in conjunction with a lightweight FR under layer). A fire-resistant PU membrane is used for added security, even though it is unlikely to ever be in contact with a flame. Another key aspect is the bonded fleece top (knitted fleece and the new fabric) designed to be worn on its own or in combination with the trousers to give the same level of FR and arc protection, whereas in the past, fleece was only there for warmth and nothing else - a significant move in the search for a combination of working comfort and ultimate protection.

With all of the work the company has been doing recently, Simon Havis believes that the next goal, specifically in relation to the development of electric arc flash resistant clothing, is to be able to create a fabric that succeeds in passing ENV50354 Class 2 whilst remaining as light as possible and being suitable for use as a single layer.

Split-second fatality

Whilst demonstrations of electric arc flashes are spectacular to behold, they last only momentarily and can be fatal. The fact, unfortunately, is that there is no such thing as perfect protection. However, since legislation was introduced in the mid-1990s in the USA, the whole industry has moved forward to contribute to significant reductions in fatalities and injuries.

Whilst development continues, maybe the difference between the electrical industry's plight and that of the legendary Icarus is not so much a worker's 'desire' to get too close to the hazard but his desire and willingness to wear the clothes that will protect him when he gets there. Once again in the technical textile industry, the advances of performance and comfort go hand in hand.