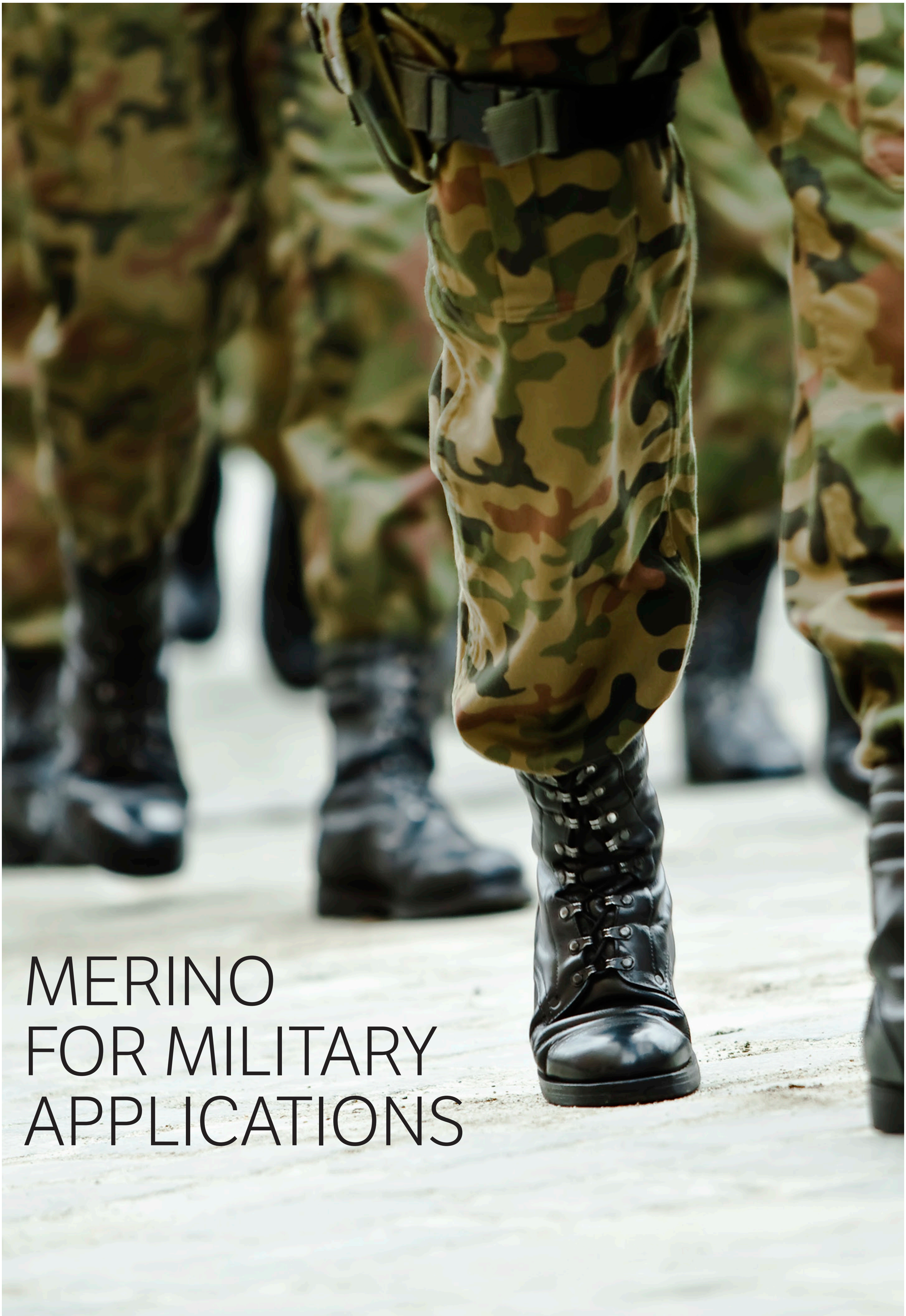
MERINO FOR MILITARY APPLICATIONS



MERINO FOR MILITARY APPLICATIONS

The use of Merino apparel in the active outdoor sector is growing, supported by strong consumer endorsement and objective evidence of performance. Merino is equally well suited for use in protective clothing for military and emergency services personnel. These, and other groups of professional risk takers, often have specialised performance requirements (e.g around flammability etc), which are regularly achieved at the expense of wearer comfort. Merino apparel and hosiery offer a means of overcoming such challenges.

Benefits that Merino offers include:

- Exceptional wearer comfort (through active control of temperature and moisture)
- Excellent flame resistance
- Improved wearer stamina
- Ease of laundering
- Low penetration by aerosols
- Low penetration by ultraviolet radiation
- The ability to tailor performance by blending with other fibres
- Excellent odour suppression

HOW DOES MERINO APPAREL HELP MANAGE HEAT AND MOISTURE FLOWS FOR THE WEARER?

The ability of a fabric to manage heat and moisture flows has a major influence on the thermal state of the body, on the wearer's perceptions of their physical condition, and on physical performance of the wearer.

An excellent example of this, applicable to the military/emergency/first response industries, is the application of wool in hosiery. With technical footwear that is largely impermeable to moisture (eg leather military boots) wool's hygroscopic properties are valued. Wool is able to absorb a significant quantity of moisture, thus minimising/delaying any increase in the skin coefficient of friction that might result in user discomfort, blisters, etc (Collie 2002).

Wool has an additional differentiator in that an appreciable quantity of heat is generated as water is absorbed into the fibre; and then lost again as it dries (Leeder 1984) – effectively warming and cooling the wearer when needed the most, thus assisting in the maintenance of overall user comfort. This heat release is referred to as 'heat of sorption', and is significantly greater for wool than synthetic fibres or cotton (Figure 1).

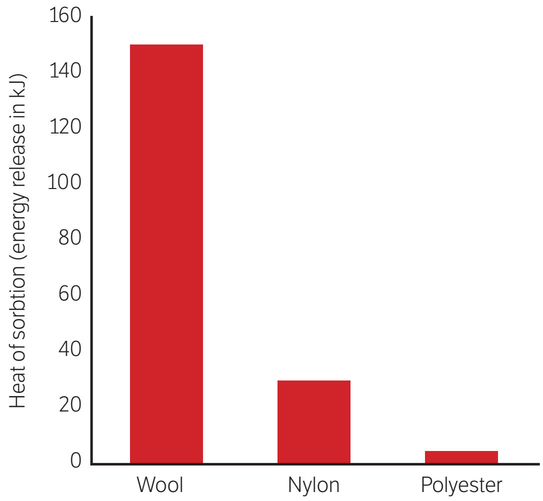


Figure 1. Heat of sorption of wool and synthetic fibres (Collie and Johnson, 1998).

The skin has nerve endings that will detect even minute or brief temperature changes, and the degree of coolness or warmth felt by the wearer will depend on how well the fabric conducts heat away from the skin. Heat has a natural tendency to move from warmer to cooler regions, and losses by the human body occur in a number of different ways:

- Radiation
- Conduction
- Convection
- Evaporative cooling.

The thermal resistivity (R) of a fabric is a measure of its insulating properties – and hence of its relative warmth. Thermal resistivity is influenced by a range of factors, but the key ones are:

- The fabric surface
- The fibres contained in the fabric
- The air trapped in the fabric, yarn or in the fibres themselves.

The key parameter determining the thermal resistance of a fabric is the amount of air trapped in its structure. This is closely correlated with fabric thickness (Figure 2). Fibre type has a much lesser influence on thermal resistivity, although wool has some distinct advantages in this respect also. Thermal resistance of the R-value is measured as tog values where 1 tog = 0.1 K.m^2/W (Pierce and Rees 1946, Holcombe and Hoschke 1983).

Due to the natural crimp of the fibres, Merino fabrics and hosiery have an inherent bulkiness or loft, with the fibres being unable to pack together too closely in the yarn structure. The resilience or elastic recovery of the Merino fibre allows this bulkiness to be maintained over time (Leeder 1984).

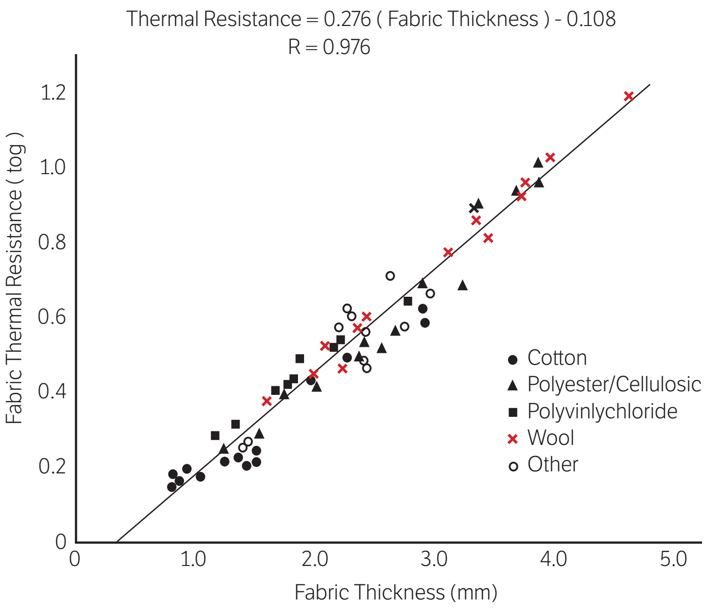


Figure 2. Influence of fibre type and fabric thickness on thermal resistance of underwear.

Pessenhofer et al. (1991) showed that fabric surface temperatures were higher for wool, indicating improved heat dispersal characteristics, while measures of retained heat were significantly lower for wool than for polypropylene. When assessed subjectively, subjects involved in the investigation gave more positive responses to garment comfort questions with respect to wool than they did for polypropylene.

WHY IS THE FLAME RESISTANCE OF MERINO SO EXCEPTIONAL?

Merino fibre is naturally flame resistant, with its performance exceeding that of all other commonly encountered textile fibres. This makes it ideal for usage in outer and base layer military clothing. This flame retardancy arises from the unique chemical structure of Merino (for example, its high nitrogen content (14%) and high relative moisture content), which confers the following beneficial properties and behaviours:

- A very high ignition temperature (570-600˚C).
- A high Limiting Oxygen Index (20- 25%) – with the LOI being a measure of the minimum % of oxygen required to sustain combustion.
- A low heat of combustion.
- A low rate of heat release.
- No propensity to melt or stick upon burning.
- A tendency to self extinguish.
- Formation of an insulating char when it burns.
- Evolution of less smoke and toxic gases than formed during combustion of most synthetic fibres.

Table 1 and Figure 3 afford a comparison of Merino fibre with other important textile fibres, demonstrating superior performance across virtually all parameters measured.

Table 1. Key measures of flammability for common textile fibres.

FIBRE:	Limiting Oxygen Index (%)	Heat of Combustion (Kcal/g)	Ignition temp (°C)	Melting temp (°C)
Wool	25.2	4.9	570-600	Does not melt
Cotton	18.4	3.9	255	Does not melt
Nylon	20.1	7.9	485-575	160-260
Polyester	20.6	5.7	485-560	252-292
Rayon	19.7	3.9	420	Does not melt

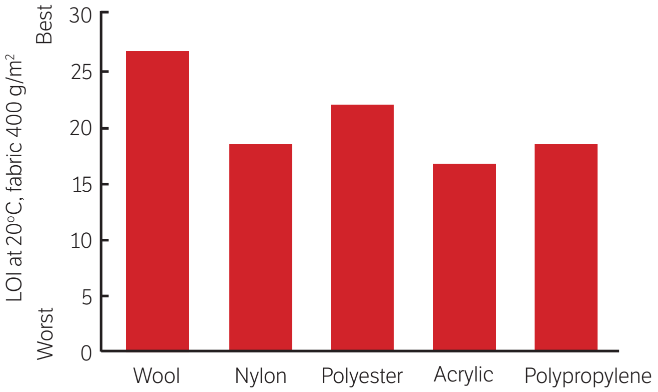


Figure 3. Limiting Oxygen Index (LOI) of common textile fibres (Collie and Johnson, 1998)

WHAT OTHER SIGNIFICANT BENEFITS DOES MERINO OFFER FOR MILITARY APPLICATIONS?

Socks/Foot Health

Socks are a key component of clothing ensembles and a number of significant technical advances in hosiery materials and design have occurred over the last decade. 100% wool socks are not common, however wool is widely used as a component of most high performance socks, usually being incorporated as a plating yarn, or similar, rather than as an intimate blend. The primary reason for incorporating synthetic fibre is to improve the longevity and abrasion resistance of such hosiery. 100% synthetic socks (eg. acrylic, polyester, or blends thereof) are also common, however, inclusion of Merino fibre (typically as 60-80% of mass) offers significant benefits in terms of comfort, cushioning and blister suppression.

Friction blisters are one of the most common foot-related health complaints and are experienced by hikers, runners, and other groups involved in active pursuits. They are of particular interest in military circles as they can have a marked effect upon the performance of individual soldiers, and/or the ability of a team to function as an effective combat unit.

Blisters form on the feet when the outer stratum corneum, stratum lucidum and stratum granulosum of the skin soften and move relative to the stratum spinosum (Herring, 1990).

The hydroscopic properties of wool can help to prevent this occuring by delaying any increase in the skin coefficient of friction that occurs with sweat accumulation (Brooks et al 1990).

In a study of military personnel (http://www.current-reports.com/article.cfm?KeyWords=&PubID=SR01-6-1-01&type=article) 69% of soldiers were found to have blisters after a 20km road march, with 10% of these requiring medical attention.

Odour Suppression/Ease of care

Body odour arises as the result of the build up of bacteria and micro organisms on the skin and/or in worn appareland hosiery. One of the key contributing factors to the build-up of bacteria and body odour is sweat on the skin surface. Sweating is the tool the body uses to regulate its temperature as the process of evaporation of sweat from the skin cools the skin surface. The human body has more than 3,000,000 sweat glands, which continuously secrete moisture. Sweat by itself does not have any odour. However, if sweat remains on the skin for a period of time, bacteria are likely to proliferate, creating the body odour that many find offensive. Such body odour is due largely to volatile fatty acids produced by these bacteria as a waste product.

When apparel fabrics were examined by researchers at the University of Otago they found fabrics constructed from Merino fibre exhibited a significantly lower propensity for odour emission after wear than polyester fabrics of a similar weight and construction (Figure 4) (McQueen et al 2007a,b).

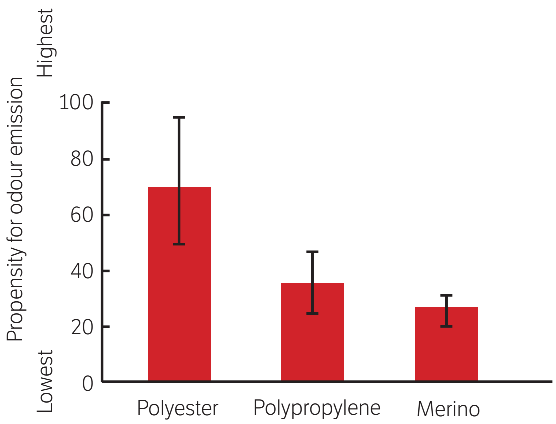


Figure 4. Propensity for odour emission by fabrics of similar construction (SEM indicated).

Similarly, a study carried out by researchers at the Wool Research Organisation of New Zealand (WRONZ), (Burling-Claridge 1998), found that the odour generated on wool socks in active use was significantly less objectionable than that of other fibres (Figure 5).

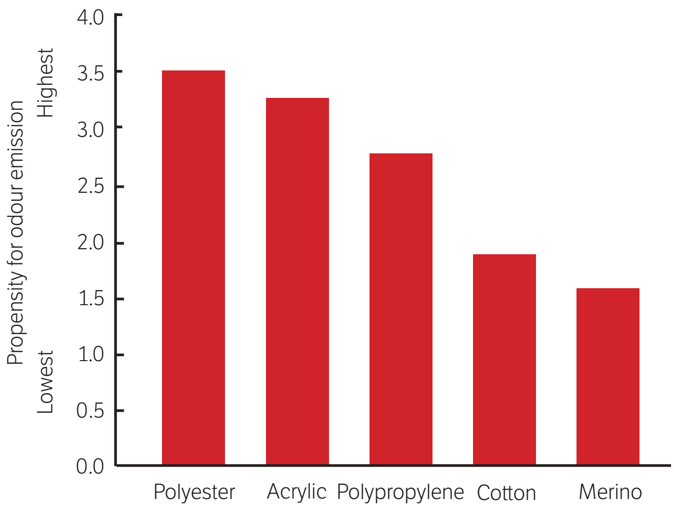


Figure 5. Propensity for odour emission from socks constructed of differing fibres (Burling-Claridge 1998).

Ultraviolet Protection Factor (UPF)

Ultraviolet (UV) radiation is a component of the solar radiation that comes from our sun. The potential for a fabric to protect its wearer from ultraviolet radiation is described as its Solar Protection Factor (SPF) or, more commonly, its Ultraviolet Protection Factor (UPF). UPF relates to the time taken before human skin begins to redden after exposure to ultraviolet light – and is usually measured on a scale of 0-50. Until recently there was a widespread perception that clothing afforded complete protection against such radiation, however, there is an increasing understanding that this may not necessarily be the case. Some fabric constructions perform much better than others, as do some fibre types.

Many factors influence the level of ultraviolet protection a garment provides. When radiation strikes a textile surface some components are reflected, some are absorbed, and some pass through it. The greater the amount of radiation able to pass through the textile, the lower the UPF. The most important of the factors influencingUPF are summarised below:

Fibre type (with the UPF being dictated by such things as chemical composition, ecru colour, fibre cross sectional shape, presence of delustrants, etc). Wool typically has a much higher UPF than synthetic fibres such as polyester.

- Fabric density (with denser knit/weave structures conferring a higher UPF).
- Degree of stretch (with the UPF being lowered in a stretched state).
- Fabric colour (with the UPF factor conferred being dependent upon the amount of dyestuff present and the chemistry of the dye itself – noting that darker colours usually, but by no means always, result in a higher level of protection being conferred).
- Whether the fabric is wet or dry (with the UPF decreasing markedly when wet).
- Presence of UV absorbing finishes and/or optical brightening agents (with a range of proprietary finishes able to be applied to fabrics in order to increase the UPF).
- Garment construction and design.

Merino wool affords excellent UV protection. Research by Hilfiker (1996), Reinert (1997) and Haerri (2000) has shown that wool absorbs radiation throughout the entire UV spectrum, whereas untreated cotton, nylon, acrylic, and silk are poor absorbers of UV. Polyester absorbs UV predominantly at low wavelengths – but with little benefit as these are the same wavelengths that the earth's atmosphere is also efficient at screening out.

In a study by Gamblicher et al (2001) more than half of 236 fabrics surveyed fell below the European standard for ultraviolet protection of UPF >30.

All 100 of the Merino fabrics passed the test, with even the worst performing fabric still having a UPF greater than 40 (Table 2). In contrast, all of the linen samples, and 89% of the viscose samples tested fell below the standard of UPF 30 – while the other fabrics tested (nylon, polyester, cotton and blends there of fared equally badly. For example 79% of the cotton fabrics had a UPF ≤20.

Table 2. UPF Factor for 236 Summer fabrics (mean weight 158 g/m^2)

UPF Rating						
FIBRE:	0-10	10-20	20-30	30-40	40-50	50+
Wool	-	-	-	-	27	73
Cotton	28	28	21	-	7	14
Linen	31	52	20	-	-	-
Viscose	52	29	9	6	2	1
Polyester	2	4	2	2	11	22
Nylon	44	19	-	-	-	38
Blends	-	10	12	14	19	46

Chemical residues and aerosol penetration

Because of its unique internal and surface chemistry (in particular, its hydrophobic cuticular scale structure) wool fabrics have been shown to be more resistant to penetration of aerosols (such as insecticides, etc) than those made from synthetic fibres such as nylon, acrylic and rayon (Salehet al 1998).

KEY POINTS

Heat and Moisture Management

- Merino fibre has a hydrophobic (water repelling) exterior and hydrophilic (water loving) interior that confer its unique moisture management properties resulting in enhanced wearer comfort and performance.
- In contrast to most synthetic fibres, wool has the capacity to remove large amounts (up to 35% of its own weight) of moisture from the skin surface, before the fibre even begins to feel wet.
- A fabric's ability to allow the transmission of water vapour through its structure will significantly affect the comfort of the wearer. The ability of Merino fabrics to do this surpasses that of synthetics.
- The chemical structure of Merino fibre means that it has the ability to absorb and desorb moisture and to gain and release heat depending on the external and internal environment - thus buffering wearers against environmental changes.
- As it absorbs moisture, Merino fibre releases a small but perceptible amount of heat. In an apparel or hosiery application this prevents the wearer from chilling in wet, cool conditions. In hot conditions the reverse effect occurs, affording a natural means of buffering the body's microclimate.

Flammability

- Merino fibre is naturally flame resistant, and its performance exceeds that of all other commonly encountered textile fibres, making it ideal for usage in military and protective services applications.
- In the unlikely event it does ignite, Merino has a low heat of combustion and a low rate of heat release compared with other textile materials.
- If Merino comes into direct contact with a burning substance, it won't melt or stick, and will self extinguish once the ignition source is removed.
- Wool forms an insulating char when it burns and evolves less smoke and toxic gases than formed during combustion of most synthetic fibres.

Foot Health and Comfort

- Managing relative humidity and temperature within footwear and providing cushioning to the feet are key to maintaining foot health and comfort.
- Wool socks provide a means of managing the foot micro environment, effectively reducing relative humidity and the propensity for blister formation.
- The natural resilience and bulk of wool means wool socks provide a mechanism for cushioning the jarring impact of the foot during strenuous walking/running activity.
- Wool socks have been shown to have odour suppression properties far superior to socks made from synthetic fibres or cotton.

Odour Suppression/Ease of care

- Body odour arises as a by-product of bacteria, which proliferate in warm moist environments (e.g when sweat is allowed to remain on the skin for a period of time).
- Merino fibre, through its complex chemical and physical structure, resists the development and proliferation of odour to a much greater extent than synthetic materials or cotton.
- Merino apparel and hosiery is readily laundered to remove soil or other contaminants of potential relevance to health - and efficient shrink resist processes are employed to enable full machine washability.

UV Protection

- UV radiation reaching earth from the sun can have deleterious effects on human health when overexposure occurs.
- Merino fibre is a very efficient absorber of potentially harmful UV-A and UV-B radiation.
- Fabric construction is also a key determinant of the extent to which textiles will protect a wearer from UV radiation.
- Summer-weight Merino garments have been consistently shown to offer a higher degree of UV protection than similar fabrics constructed of competing materials.

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