Evaluating Functional Properties of Performance Apparel

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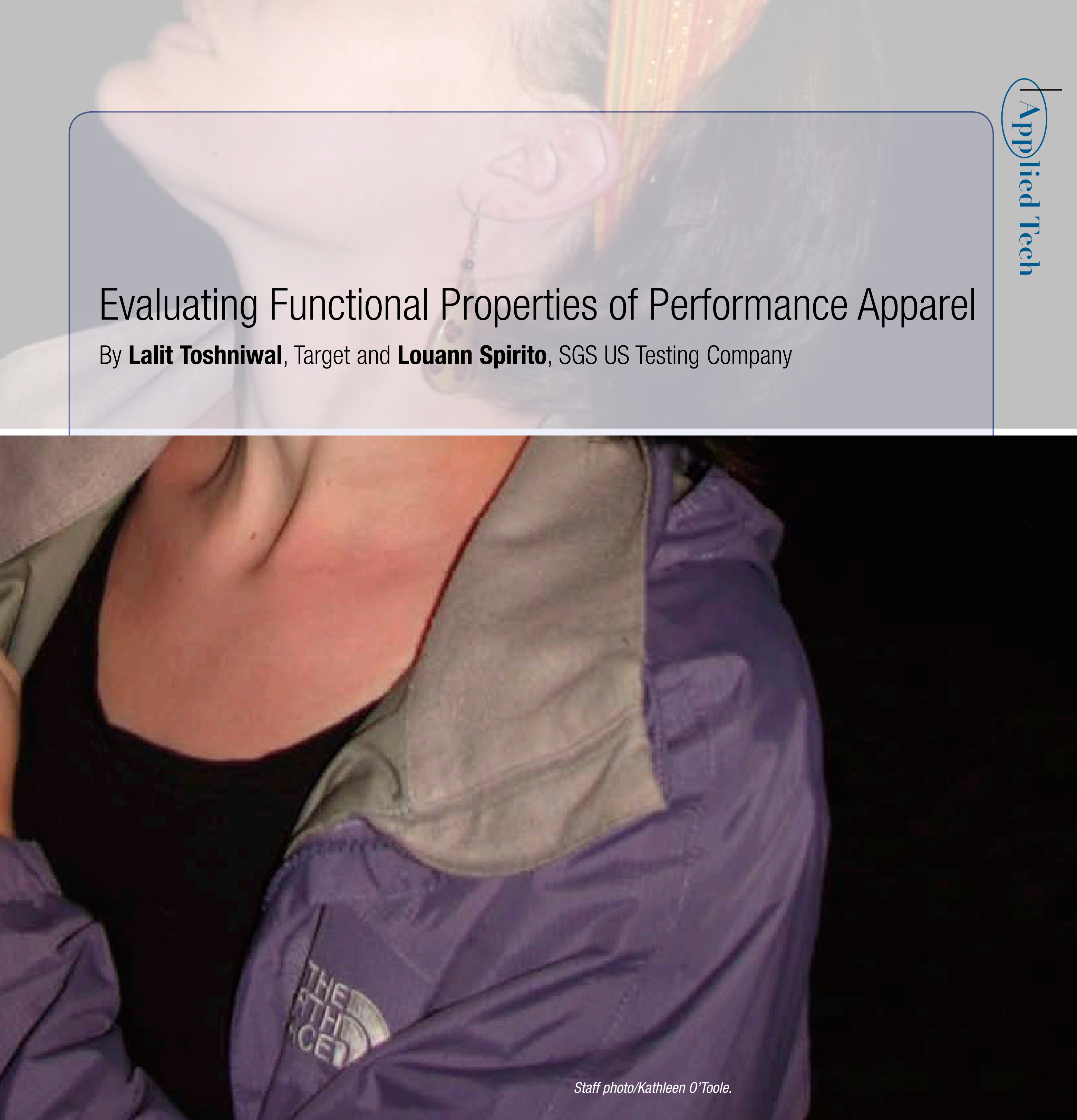


Staff photo/Kathleen O'Toole.

Introduction

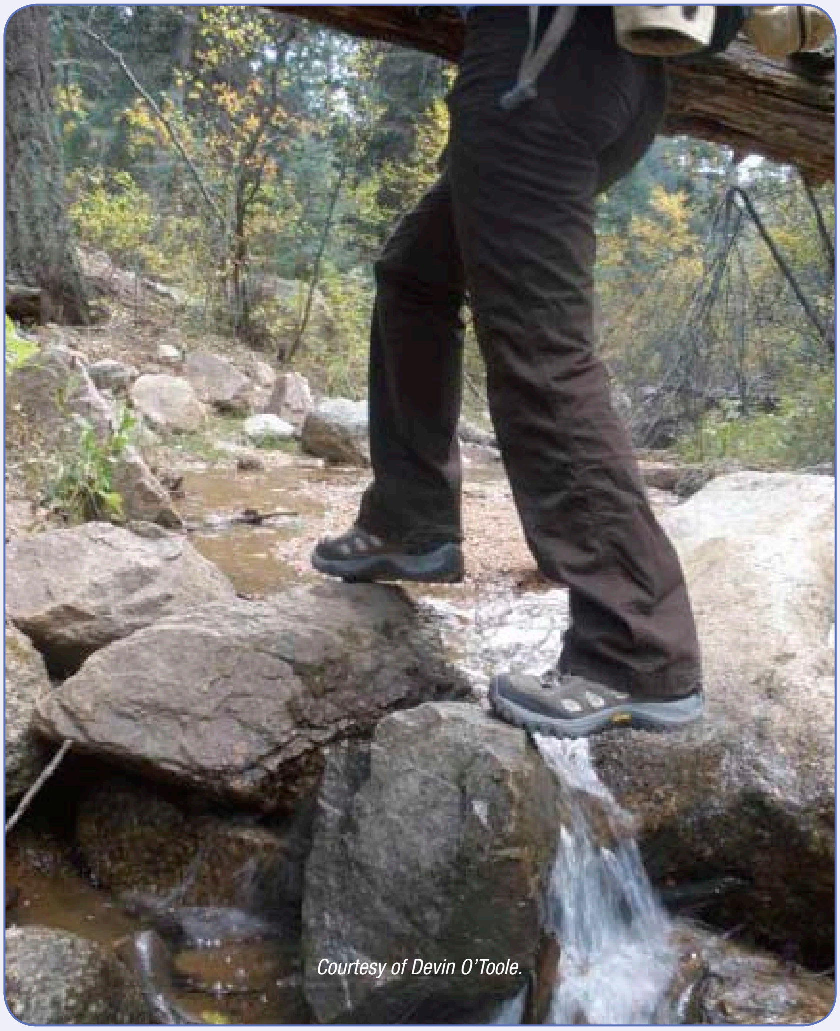
With the increasing popularity of outdoor recreational activities, the market for performance apparel continues to expand. Buyers are willing to pay higher prices for sportswear, high-tech activewear, casualwear, swimwear, and outerwear with advanced features and functional properties. These properties include moisture management, UV protection, antimicrobial, thermoregulation, and wind and water resistance. Properties come from garment construction, fabric and trim specifications, novel fibers, and chemical treatments. Performance is truly as much about the materials in the garment as the garment itself. To ensure quality levels are maintained at every stage of production, it is necessary to evaluate the performance of outdoor clothing and sportswear for functional properties. This paper will describe some of the basic principles, methods, and terminology used to evaluate the functional properties of performance apparel sold as sportswear.

Moisture Management

Moisture management is defined as the ability of a garment to transport moisture away from the skin to the garment's outer surface, where it evaporates. This action prevents perspiration from remaining next to the skin. Moisture management is one of the most desired properties in performance apparel worn next to skin or during exercise. In hot weather, moisture trapped next to the skin may contribute to fatigue or diminished performance. In cold conditions, trapped moisture can drop in temperature and contribute to chilling and hypothermia. Excess moisture may also cause the garment to become heavy, or skin to become chafed.

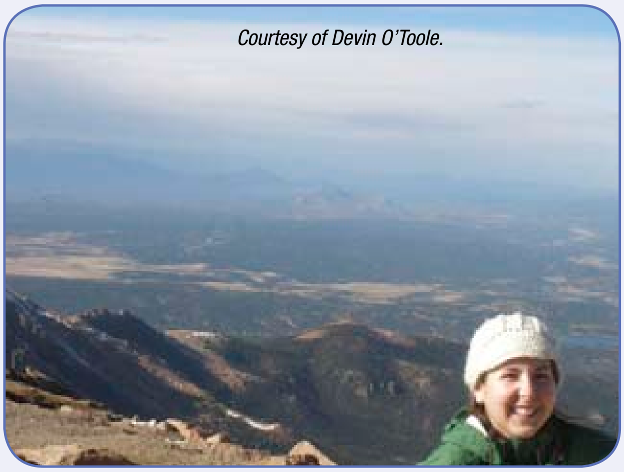
Moisture travels in textiles via wicking. Wicking is the spontaneous flow of a liquid in a porous substrate, driven by capillary forces. The spaces between the fibers and fiber bundles effectively form narrow tubes, which act as capillaries and transport the liquid away from the surface. Another factor that affects moisture management in textiles is absorbency. The ability of textiles to draw the moisture through the fabric improves with enhanced absorbency properties. However, due to the tendency of absorbent fibers to retain moisture, the garment becomes saturated, affecting comfort levels. Fabrics that wick moisture rapidly through the fabric, while absorbing little water, help to better regulate body temperature, improve muscle performance, and delay exhaustion. Horizontal transmission rate of moisture through the fabric thickness is determined by placing a specimen on a horizontal test plate, such that specimen's bottom surface rests on the plate and its upper surface is covered by a test weight. The test plate is connected to a liquid reservoir by means of a siphon tube. The spatial relationship between the bottom surface of the test specimen and the effluent of the siphon tube is constantly maintained by continuously adjusting the top surface of the liquid in the liquid reservoir. During the test, liquid absorption into the specimen causes a reduction in the reservoir liquid, which is measured by a weighing device. The weight decrease in the liquid reservoir with respect to time is a measure of the liquid absorbency rate of the test specimen.

Another important moisture management property is breathability. A garment is classified as breathable when it allows perspiration to escape. Breathability is measured by calculating the amount of moisture vapor escaped per square meter of fabric in one hour. This could be determined in two ways. In the desiccant method, the mouth of a test dish containing a desiccant is sealed with a test specimen, and the entire assembly is placed in a controlled atmosphere. Periodically-measured weight change of the assembly determines the rate of water vapor movement through the specimen into the desiccant. In the water method, the test dish containing distilled water is sealed with a test specimen. The weight change of the assembly determines the rate of vapor movement through the specimen from the water into the controlled atmosphere. The vapor pressure difference is the same in both methods, with extremes of humidity on opposite sides. The water method can be modified for coated fabrics (i.e., the dish containing distilled water can be inverted such that, during the test, one surface of fabric stays in contact with the water).



Courtesy of Devin O'Toole.

Thermoregulation


Courtesy of Devin O'Toole.

Thermoregulation is the body's ability to balance heat production from metabolic sources and heat loss from perspiration, radiation, convection, and conduction. Even in cold conditions, excess heat generation resulting from physical activities can result in sweating that could lead to rapid evaporative cooling and eventual breakdown of the body's thermoregulatory capacity. Thus, in addition to moisture management properties, thermal insulation is extremely desirable for certain performance apparel, e.g., ski jackets. Insulation of clothing is often measured with the unit "Clo." Clo is the amount of insulation that maintains normal human skin temperature when heat production is 50 kilogram-calories per square meter per hour, the air temperature is 70F (21C), and the air is still. Fabric intrinsic thermal resistance is measured as the rate of heat transfer over time from a warm, dry, constant-temperature, horizontal plate, up through a layer of test material, to a relatively calm, cool atmosphere. It is determined by measuring the energy required to maintain the test plate, covered with a test specimen, at a constant temperature.

Wind and Water Resistance

Once wind penetrates a garment, it alters the thin layer of air close to the skin, known as the micro climate. This provokes a sensation of cold and discomfort commonly known as the shiver effect. Water conducts heat 23 times faster than air. This means that a wet body looses heat 23 times faster than a dry one. Thus windproof and waterproof properties are extremely desirable to stop wind and water penetration and thus loss of warmth.

To determine fabric air permeability, a steady flow of air is drawn through the test specimen. The rate of air passing perpendicularly through a known area of fabric is adjusted to obtain a prescribed air pressure difference between the face and back fabric surfaces. From this air flow rate, the air permeability of the fabric is calculated.

Fabric water resistance is determined by subjecting one surface of the fabric to hydrostatic pressure, increasing at a constant rate, until leakage appears on the other surface. In a less severe test, the specimen is backed by a weighted blotter and is sprayed with water for certain period of time under controlled conditions. The blotter is then reweighed to determine the amount of water that has leaked through the specimen.

UV Protection

The use of UV blocking apparel can provide excellent protection against the hazards of sunlight. Various textile qualities affect a finished garment's UV protection factor (UPF); fabric construction, type, color, weight, thickness, and porosity are important. UV protection can be incorporated into the yarn, or it can be applied to the surface of the fabric as a finish. UPF indicates the garment's ability to provide sun protection by blocking UV rays from reaching the skin. Spectrophotometry is the preferred method for determining the UPF of textile materials. UPF is computed as the ratio of the ultraviolet radiation (UV-R) irradiance detected with no specimen in the path of the rays to the UV-R irradiance detected with a specimen present in the path of the rays.


Staff photo/Kathleen O'Toole.

Antimicrobial Properties

The intrinsic properties of textile substrates make them good media for microorganism growth. Microbial replication also causes cross infection by pathogens and odor development where the fabric is worn next to skin. It may also result in staining and loss of textile performance properties. Therefore, biocidal properties are desired for textile substrates to protect both the wearer and the textile substrate itself.

Various test procedures have been used to demonstrate the effectiveness of antibacterial finishes. Two tests that can be used are the agar diffusion test and the challenge test (quantitative).

The agar diffusion test is a preliminary test to detect a diffusive antimicrobial finish. Diffusive antimicrobial agents are released from the textile, whereas non-diffusive antimicrobial agents form a chemical bond with the textile substrate. In the Agar diffusion test, a specimen is placed in intimate contact with nutrient agar streaked with an inoculum of test bacterium. After incubation, the agar surface is observed for a clear area of interrupted bacterial growth underneath and along the sides of the test material. This test is not suitable for textiles treated with non-diffusive finishes.

Quantitative evaluation of antimicrobial activity is performed using the challenge test where treated and untreated specimens are inoculated with test bacteria. After incubation, the difference between the actual bacterial count of the treated and untreated material is accounted for and the percentage reduction is calculated. Immobilized antimicrobial agents are not free to diffuse into their environment under normal conditions of use. Several techniques are used to ensure intimate contact between the bacteria and treated substrate. In one method, contact between bacteria and treated substrate is ensured by constant agitation of the test specimen in a bacterial suspension during the test period.

Conclusion

Performance apparel represents one of the fastest growing sectors of the textile and clothing industry. Market growth is being fueled by an increasing desire for healthy lifestyles. This growth is supported by the advent of new fibers, finishes, and innovative process technologies. Today's technology encourages breathability, thermal insulation, moisture management, and odor neutralization. High-tech fabrics and apparel designed for high-performance wear are increasingly crossing over into everyday fashion, making these properties even more important.

For Further Reading

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Author

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