PROTECTION - SCIENCE AND TECHNOLOGY ADVANCES FOR CHEMICAL AND BIOLOGICAL PROTECTION

The Influence Of Textile Properties On Chemical-biological Protective Garment Design And Thermal Burden

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Chemical-Biological (CB) protective garments are designed to protect against liquid, vapor, and aerosol threats. Many CB protective garments are bulky and cumbersome, and traditional materials are stiff, thick, and noisy, which are less suitable for tactical missions. Users accept risk of heat exhaustion injuries due to the increased thermal burden associated with many CB protective garments. Reducing the thermal burden and increasing tactility is key when designing cutting-edge CB protective garments. The material development trade-space means finding the ideal balance between protection, thermal burden, and tactical mobility.

Material choice is a key influence on final garment design. On the textile level, material configurations for CB protective garments generally fall under two categories: laminated and hung liner. Laminated materials consist of two or more textile material layers adhered together to reduce overall bulk and thermal burden. By contrast, a hung liner utilizes two component layers that are sewn together at strategic points, producing insulating air gaps and thicker seams from multiple layers of material.

While laminated materials generally decrease thermal burden by reducing materials and removing air gaps, the lamination process uses adhesives that can sometimes produce stiffer materials, pushing the garment patterning toward a bulkier silhouette with no thermal difference compared to a hung liner design. Adhesive choice is important, as amount and application can affect breathability and stiffness that will impact the final CB protective garment.

Patterning and grading a garment to achieve optimal fit is another important aspect of garment design. To avoid mobility restrictions, ease is needed to allow the material to move with the body. The more ease added, the more air pockets are created between the skin and the garment, which increase thermal burden. Restrictions in the garment can also increase thermal burden. The more the body is fighting against the garment, the more heat will be produced. Desirable materials, like laminated stretch materials, allow for a more conformal fit and require less ease.

System level testing conducted with a thermal manikin highlighted how materials used in a garment directly influence thermal burden. Stiff laminated textiles resulted in loose-fitting garments with excess ease, which negated the thermal advantage typically given by a laminated material. Laminated configurations using flexible knit textiles resulted in lower thermal burden compared to hung liner configurations, as the textiles were less stiff, offered more stretch, and could be brought closer to the body, but they often feature lower durability and abrasion resistance.

Laminated textiles offer an advantage over hung liners to reduce thermal burden in CB protective garments, but there cannot be a “plug-and-play" methodology as material optimization and pattern refinement impact one another. Strategies to decrease thermal burden are highly dependent upon the influence of the textile’s material properties on garment design.