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NATIONAL URBAN SECURITY TECHNOLOGY LABORATORY

U.S. Department of Homeland Security
SAVER
System Assessment and Validation for Emergency Responders ®

TechNote

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The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER®) program to inform emergency responder equipment selection and procurement decisions.

Under the Science and Technology Directorate, the National Urban Security Technology Laboratory (NUSTL) manages the SAVER program, which – with the participation of emergency responders – performs objective operational assessments of commercially available equipment.

SAVER publications provide information about equipment that falls under the DHS Authorized Equipment List (AEL) categories and focus on two questions for the responder community: "What equipment is available?" and "How does it perform?"

To explore SAVER online visit www.dhs.gov/science-and-technology/saver.

For additional information on the SAVER program, email NUSTL at NUSTL@hq.dhs.gov.

Science and Technology

PERSONAL COOLING GARMENTS

Law enforcement, firefighters, and hazardous material response teams are vulnerable to heat-related illnesses as they frequently perform physically demanding work in high temperature environments. Maintaining a safe core body temperature is critical to working safely in these conditions. The body's primary cooling mechanism, evaporation of sweat from the skin, is greatly diminished under the layers of personal protective equipment (PPE) responders wear. The materials, weight, and stiffness of protective clothing and operational gear also increase the energy responders expend as they work, further increasing their need to cool down. Personal cooling garments assist responders in maintaining a safe core body temperature, thereby reducing the possibility of heat-related illnesses. This equipment falls under the AEL reference number 02PE-02-COOL titled "Garment/Vest/Device, Cooling."

Overview

Personal cooling garments may use either passive or active systems to affect body temperature. Passive cooling garments have no mechanical or electrical components; instead, they provide enhanced evaporative cooling or heat removal using cool water, cooled gel or ice packs, or phase change material (PCM) to help regulate core body temperature. Passive cooling garments have limited cooling capacity but are more portable and less expensive than active cooling systems.

Figure 1. PCM Vest
Image credit: Glacier Tek

Active cooling systems typically use a cooled liquid or air circulation system to help regulate body temperature. Active systems provide constant cooling to the wearer but require external components and power. These systems have greater cooling capacity but are less portable and more expensive.

Passive Cooling

Phase change material cooling systems rely on PCM packs made of paraffins, salts, or other solid composite materials that melt above an engineered temperature (58–82° F). The cooling effect is provided by their phase change from solid to liquid, which acts as a heat sink for the wearer. PCM packs do not produce condensation and do not get cold enough to injure the skin, so they can be worn close to the body. PCM cooling vests can maintain a constant temperature for two to four hours depending on operating conditions.

After PCM packs turn into liquid, they can be solidified again by either putting them in an ice bath, freezer, or refrigerator for twenty minutes to two hours. The time needed for solidification is much shorter than for ice packs due to the higher phase change temperature. They can then be stored at below their melting temperature for reuse.

Gel or ice pack cooling systems can be a reusable garment with sewn in in packs or reusable inserted packs placed in pockets around the body core. They require freezing down to 32° F to activate. The gel used is a nontoxic mixture of starch, water, and other ingredients that when frozen has a cooling capacity similar to ice. These products are slightly heavier than PCM but have a higher cooling capacity. Since they operate below typical dew point temperatures, water vapor from the environment may condense on the packs, causing discomfort to the wearer.

Evaporative cooling systems use water to mimic and enhance the body's natural cooling ability. These garments consist of highly absorbent fabrics that are either soaked in water prior to use or have a built-in water bladder. While relatively inexpensive, lightweight, and easy to use, these systems are inefficient in high humidity environments. Also, evaporative cooling systems require sufficient ventilation for evaporation, so they are not effective when covered by PPE.

Active Cooling

Circulation cooling systems typically use water or air that continuously circulates from a cooling source to the wearer. These systems can be powered by batteries, compressed air or standard alternating current outlets. Circulation systems have the highest cooling capacity but require wearing or otherwise using external components that reduce mobility and add weight for the wearer in addition to adding power and mechanical requirements.

Ambient air cooling systems move air between the outer and inner layers of a garment, increasing the convective and evaporative heat loss for the wearer. These systems consist of a powered blower unit that is worn. Cooling power of these units depends on the ambient air temperature and the air conditioner's cooling capacity.

Figure 2. Backpack ice water cooling system
Image credit: COMPCOOLER

Considerations

When selecting a cooling garment, responders should consider several characteristics to assess the product's ability to remove heat or provide cooling. Factors such as the heat generated by the user's workload, personal risk factors, temperature acclimation, mobility requirements, PPE, and environmental conditions need to be accounted for.

Relevant Standards

To evaluate the relative effectiveness of various cooling systems, tests are performed on thermal manikins in climatic chambers. Using thermal manikins removes the variability that results from using human subjects. ASTM International Standard F2300-10 (2022), *Standard Test Method for Measuring the Performance of Personal Cooling Systems Using Physiological Testing* [1] outlines the protocols and types of performance tests suited to when human subjects are involved. This test method can be used to quantify and compare the cooling provided by different personal cooling systems worn with a standard outer garment or with a specified protective outer garment.

References

[1] ASTM International, "ASTM F2300-10 (2022) Standard Test Method for Measuring the Performance of Personal Cooling Systems Using Physiological Testing," ASTM Compass, Feb. 25, 2022.