

ANALYSIS: The following types of cooling equipment were evaluated.

Evaporative Cooling: The evaporative cooling (EC) equipment used two different techniques to hold water in the equipment. One group used polyacrylamide crystals (PA) (the same material used in diapers) to hold the water. This group of equipment generally held more water, but had a drawback from the inability to wash the equipment. The equipment tended to work well, and was inexpensive. This type of cooling works well only in low humidity environments.

The PA equipment tested included hats, hard hat liners, bandannas, vests and wristbands. This equipment was procured from the Kool-N-Safe Company. The hats were issued to promote the technology, but were not usable as PPE. Two items from this group that gained widespread acceptance were wristbands and hard hat liners. The wristbands were popular only on some sites, but were very popular at those sites.

The hard hat liner was the single most popular cooling equipment at BHI. The hard hat liner fit under the hard hat and included a flap to shade the neck. This flap also kept insects off of the worker's neck. As the hard hat liner offered both cooling and shade, it was a desirable item for the workers. The bandannas met with success, but not as much as the hard hat liner.

The PA vests met with mixed success. This equipment demonstrated the absolute necessity of clearly communicating proper use of PPE and the effect of safety leadership. At one site, the vest was used improperly under impermeable PPE that did not allow the water vapor to escape. In this circumstance, the vest added to the heat load instead of improving it. As a result of this event, none of the EC equipment of any type gained acceptance at that site. At other sites, the PA vests met with mixed success. The success appeared to be tied to acceptance instead of performance.

A separate group of EC equipment procured from Silver Eagle Outfitters tested. This equipment held the water in fibers that were in the middle of two other layers of cloth. The fiber EC material held less water. This equipment offered the advantage of being washable, and being more durable than the PA equipment. The fiber EC equipment was popular because of its durability, but it did not appear to provide the same perceptible level of cooling as the PA equipment.

Phase Change: The evaluation tested vests using phase-change (PC) materials. These phase change vests were similar to ice vests, but used various materials that changed phase at higher temperatures and were easier to 'recharge' than ice packets. These vests were procured from Kool-n-Safe.

Phase change (PC) vests met with mixed acceptance. While several testers at BHI were very positive on the PC vests, other testers were not. Some evidence supported that the workers associated the PC vests with ice vests and would not voluntarily use the vests. The PC vests did not get a widespread test at BHI.

A similar phase-change test with the same equipment in 2005 at BJC in Oak Ridge Tennessee met with good worker acceptance and multiple follow-on PC vests were procured. Increased use is anticipated for 2006.

Active Cooling: These vests, originally designed for military use, combined several features from older cooling systems very successfully. The "Kool Suit" sold by Aegis Sales, circulated chilled water continuously around the torso, using a heat exchanger contained in an ice reservoir in a backpack. The device was significantly lighter than full-body suits and was also less cumbersome. The Kool-Suit won worker acceptance.

Breathable PPE: This evaluation explored the concept of improving the natural cooling abilities of the workers. The evaluation procured lightweight, disposable PPE from the OREX Company. This PPE has a tight weave pattern and a smaller pore-size than the washable cotton PPE typically used. However, the OREX PPE was thin enough to allow breezes to pass through the material. The OREX coveralls were popular at every site that allowed their use. The OREX coveralls were not used at sites where the contamination could be transported in water and waterproof PPE were required. The OREX material allowed and promoted natural evaporative cooling and allowed the other EC materials to work though at diminished efficiency. While other breathable PPE were reviewed, OREX seemed to offer the best balance of breathability and splash resistance.

RECOMMENDED ACTIONS: The evaluation demonstrated that cooling PPE that gained worker acceptance, most notably active cooling, evaporative hard hat coolers and breathable PPE demonstrated a net benefit to the workers. PPE that did not gain worker acceptance did not get used despite a demonstrable benefit. While this evaluation would benefit from a scientific analysis of the core body temperature of the workers, it is unlikely that the data would change the conclusion regarding worker acceptance.

Several types of this equipment will be made more available for widespread use in the future and the breathable PPE will be provided wherever possible.

Name	Pro	Con	Notes
PA EC	Very low cost; (\$30) safety vest versions available	Not cleanable; low worker acceptance	Low-humidity climates only
Fiber EC	Low cost; (\$65-\$100); safety vest versions available; cleanable	Perceived as less effective; low worker acceptance	Low-humidity climates only
Phase Change	Replaceable cooling packets; perceptibly cool; safety vest versions available	Higher cost; (\$125-\$350)	Any humidity, works well under multiple layers of PPE; PC packets can be 'frozen' in approximately 10 minutes; mixed moderate-to-positive worker acceptance
Active cooling	Long duration, perceptibly cool; rechargeable ice reservoir	Highest cost (~\$500)	Any humidity, works well under multiple layers of PPE; good worker acceptance.
Breathable PPE	Breathable; splash-resistant models available	Not waterproof	Immediate worker acceptance at both sites. Cost comparable to common disposable PPE

PRIORITY DESCRIPTOR: Green/Good Work Practice

FUNCTIONAL CATEGORY (S) (DOE): Radiological Protection

BJC TREND CODE (S) (USER-DEFINED): RP – Radiological Protection

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KEYWORDS: Cooling Equipment; PPE; Heat Stress

REFERENCES: Kool-N-Safe Company; Silver Eagle Outfitters; OREX Company, Aegis Sales

HAZARDS: Temperature Extremes; Weather Related

WORK ACTIVITY: Radiological

ISMS CODE: Develop & Implement Hazard Controls; Hazard Controls Tailored to Work Being Performed