Homeland Security
Science and Technology

Summary

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

The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders making procurement decisions.

Located within the Science and Technology Directorate (S&T) of DHS, the SAVER Program conducts objective operational tests on commercial equipment and systems and provides those results along with other relevant equipment information to the emergency response community in an operationally useful form. SAVER provides information on equipment that falls within the categories listed in the DHS Authorized Equipment List (AEL).

The SAVER Program is supported by a network of technical agents who perform assessment and validation activities. Further, SAVER focuses primarily on two main questions for the emergency responder community: "What equipment is available?" and "How does it perform?"

To contact the SAVER Program Support Office
Telephone: 877-336-2752
E-mail: saver@dhs.gov
Visit the SAVER Web site:
https://www.rkb.us/saver

Personal Cooling Systems Analysis Report

The comparative analysis project was conducted by the Center for Domestic Preparedness. This summary is a brief excerpt of the Personal Cooling Systems Analysis Report*, available by request at* https://www.rkb.us/saver.

Background

Personal cooling systems have been identified by emergency responders from federal, state, local, and tribal agencies as a critical tool to emergency response operations. Personal cooling systems are health and safety items, not comfort items, as they improve responder stamina and thus improve readiness (Figure 1). By using preventative measures to sustain responders when they are physically stressed, they are less likely to incur a heat stress injury and require less back-up personnel. Therefore, emergency responders can remediate the situation more safely and more rapidly. With the responders needs in mind, the Center for Domestic Preparedness (CDP), a SAVER partner, conducted a comparative field assessment on personal cooling systems.

The assessment was conducted to provide impartial and relevant responder evaluations of personal cooling system performance in realistic weapons of mass destruction (WMD) scenarios. The scenarios were derived from the Office of State and Local Government Coordination and Preparedness (SLGCP) Universal Task List (UTL), and the CDP worked with the U.S. Army Natick Soldier Center (NSC) in planning the assessment. The scenarios were carried out with evaluators wearing both Level A and Level C personal protective equipment (PPE) ensembles. The assessment provides information that enables decision makers and responders to better select, procure, use, and maintain emergency response equipment.

Evaluation Criteria Focus Group

The CDP convened a Responder Cooling System Evaluation Criteria Focus Group on October 16, 2004. The purpose of the focus group was to recommend assessment criteria to be used for validating the effectiveness of equipment being tested by the Microclimate Cooling Team at the NSC. The focus group consisted of ten HazMat technicians who volunteered to stay an additional day after completing a HazMat course at the CDP. An assessment plan was developed to support the evaluation criteria, and

following the cooling system equipment procurement, the assessment took place on December 12 – 18, 2004, at the CDP main complex at Anniston, Alabama.

Methodology for Equipment Procurement

In January 2004, the NSC conducted a research market survey regarding an evaluation of microclimate cooling systems for the SLGCP. The NSC objective for this evaluation was to identify, obtain, and evaluate available microclimate cooling systems. This market survey of personal cooling systems created a cooling system database that categorized over 250 commercially available cooling system products into six categories: evaporative cooling, phase change material, ice-based/liquid circulating, compressed air, thermoelectric (Peltier), and vapor compression.

Upon conferring with project leaders at the NSC, the CDP recommended that three technologies—including phase change devices, circulating systems, and tethered devices—be proposed for focus group consideration; however, after presenting criteria on October 16, 2004, the focus group recommended a comparative assessment of the phase change and circulating systems under realistic operational conditions.

Types of Cooling Systems Assessed

Phase-Change Systems – These systems are made up of paraffin or ice-based materials that absorb body heat in the vest/hat/neck wrap configurations. They require the use of a refrigerator, freezer, or ice chests to recharge the phase change material. Additionally, phase-change systems require a cooler to transport the phase change packets.

Circulating Systems – The selected circulating system incorporates chilled water that is pumped from an ice reservoir to a tube-lined cooling garment. Requirements for systems of this type include freezers to provide ice and coolers to transport additional ice.

Based upon the recommendation of the focus group, the CDP proposed and the NSC provided

Figure 1. First Responder Wearing Personal Cooling System

representative products for assessments that met the following parameters:

- Three phase change systems –one using frozen water/ice; one with phase change at approximately 50°F; and one with phase change at approximately 65°F.
- One circulating system – system must be portable and worn by the responders.

Items to be Assessed

The NSC nominated the following devices as representative of the technologies and the capabilities listed above. Additionally, these systems were identified as possessing the performance criteria recommended by the focus group.

- OccuNomix Phase 2B Vest (Fig.2)
- Isotherm Cooling Vest (Fig.3)
- Steele Vest (4 Pocket) (Fig. 4)
- CardioCOOL Vest with PortaCOOL Chiller (Fig. 5)

Figure 2. OccuNomix Phase 2B Vest

Figure 3. Isotherm Cooling Vest by Bullard

Figure 4. Steele Vest (4 Pocket)

Figure 5. CardioCOOL Vest with PortaCOOL Chiller

Evaluation Criteria

The focus group agreed that a viable personal cooling system should possess the following attributes as priority features:

- Operable or provide cooling for a minimum of 45 minutes.
- Capable of being used by several responder disciplines.
- Rechargeable or re-supplied at the incident site.
- Wearable under the duty uniform including body armor.
- Comfortable.
- Temperature adjustable.

In addition, the focus group identified the criteria and assigned each to the appropriate SAVER category. The criteria within each category were assigned weighting factors based on the focus group's evaluation of their significance within that category. Finally, the focus group assigned an overall weighting factor for each category to prioritize the significance each of the SAVER categories should have on the cooling system's overall score.

Assessment Equipment Training

Day one of the assessment was used to orient and introduce the evaluators to the different cooling systems as well as the variety of assessment activities that were used on days two and three. In preparing for the assessment, the evaluators were familiarized with each of the equipment items prior to the first assessment day. For example, they were provided instructional materials on each cooling system and were allowed the time to open, configure, and practice using the equipment.

During this hands-on session, the evaluators had access to the literature previously provided in the classroom, as well as materials that were contained in the original shipping boxes. This familiarization opportunity ensured that the time during days two and three was not hampered by lack of knowledge of the cooling systems and the environments in which they were assessed. To avoid biasing the evaluators, the CDP instructors did not provide training, coaching, or comments on the cooling devices. They did, however, answer questions the evaluators may have had regarding the PPE, detection devices, and scenarios to be used in the assessment.

Assessment Activities

During the assessment, two-man evaluator teams performed four separate activities consistent with operational objectives that would exist in the event that a nerve agent attack occurred.

Triage

Evaluators wearing Level C PPE conducted a systematic search for victims throughout a series of rooms in the CDP HazMat smoke area. The evaluators identified, prioritized, and tagged viable victims for further triage. The evaluators then passed victims along to the medical personnel for treatment.

Extrication

Evaluators wearing Level A PPE extricated non-ambulatory victims from the second floor using a Sked extrication device. The victims were transported to the warm zone approximately 70 yards from the building and transferred to the decon team at a mock decontamination site.

Detection and Monitoring

Evaluators wearing Level A PPE worked in pairs to perform sampling and monitoring tasks using Chemical Agent Monitors (CAM) and M8 paper to perform this task.

Cut-Out and Decontamination

Evaluators wearing Level C PPE extricated victims using a Sked extrication device and dragged the victims to a previously set-up decon line. The team cut the victims out of clothing, dipped gloved hands into decontamination solution, and placed the victim upon the rollers. The team then performed decon and moved the victim to the stretcher. The victim was taken from that point by simulated medical personnel.

The cooling systems were rotated from activity to activity to vary the environments in which they were used. The assessment flow was conducted in a "round-robin" format, with a total of 16 individual assessments conducted. Each group assessed each piece of equipment once, each piece of equipment was used in every activity, and all pieces of equipment were assessed four times.

Assessment Results

Overall, the evaluators were able to successfully accomplish the mission in each scenario with each cooling system. The scores from the data collection questions posed to the evaluators show that all of the phase change vests ranked virtually the same in the scenarios used. It should be noted that the evaluators were placed in PPE while wearing the cooling device and then performed various tasks for 45 minutes, simulating activities they might perform at a WMD incident. The numerical results are presented in table 1, with higher scores indicating a better cooling system ranking from the evaluators.

The *Personal Cooling Systems Analysis Report* contains detailed assessment results including evaluator comments; however, all of the systems used in this assessment provided sufficient responder cooling within the assessment scenarios. Nonetheless, upon doffing the vests, several evaluators commented that the cooling effects of the ice and paraffin vests had been lost. However, upon later checking the inserts, they noted that the inserts were still "cool" to the touch. According to the evaluators, the CardioCOOL remained noticeably cool throughout the assessment. Thus, the conclusion is that all of the cooling systems assessed would aid in responder "sustainment" during a WMD incident.

Cooling System	Capability Score	Usability Score	Affordability Score	Deployability Score	Maintainability Score	Overall Score
CardioCOOL	22	24	6	13	7	71
Isotherm® Cooling Vest (Bullard)	25	28	6	16	7	82
Occunomix Phase 2B Vest	24	27	8	16	8	84
Steele Vest®, 4 Pocket	25	27	8	14	8	82

Table 1. Assessment Results

Note: Numerical results have been rounded to the nearest whole number.

Capability Category Conclusions

All of the cooling systems were capable of being used in conjunction with the PPE. However, the carrying harness provided created difficulty in positioning the circulating system, which made the circulating system more difficult to wear.

In order to replace the phase change cooling packs, the self contained breathing apparatus (SCBA) must be removed. Normally this activity would take place in the team rehabilitation area within the cold zone. Unlike the vest cooling inserts, the circulatory system can be recharged by replacing the Chiller bottle and does not require removal of the SCBA or the vest. However, the responder would still have to undergo technical decontamination in order to safely unzip the PPE for the Chiller bottle swap.

Affordability Category Conclusions

In scoring the systems, evaluators were asked to assess cooling system cost versus "value added" in the assessment scenario. The CardioCOOL circulating system was higher in cost than the other pieces of equipment involved in the test. At a little over $900, this system is priced three to four times higher than the phase change systems, which fall within the $200 to $300 price range. See exhibit 1 for a break down of equipment cost.

While the CardioCOOL performed its cooling function consistently throughout the 45 minutes of use, the evaluators scored the CardioCOOL value added versus cost as negligible when compared to the other systems.

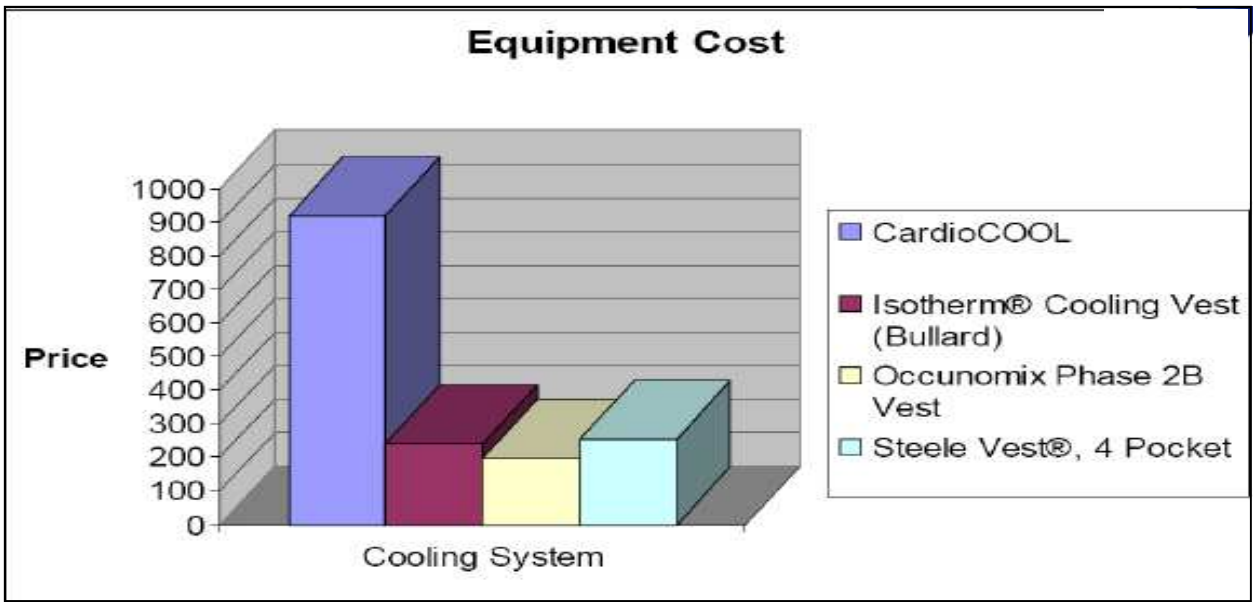

Exhibit 1. Equipment Cost

Deployability and Usability Category Conclusions

Three of the systems can be charged either by soaking the paraffin cooling inserts in ice water for 20 minutes or by filling the Chiller bottle with crushed ice and water. The Steele Vest requires that the gel ice packs be frozen in a freezer for five hours in order to use. Thus several evaluators scored the Steele Vest Lower than the other devices for deployability.

Many evaluators experienced difficulty comfortably wearing the CardioCOOL Chiller unit inside of Level A PPE due to the carrying harness configuration and placement around the waist. Attempting to improvise a more comfortable location while still maintaining an upright Chiller position proved difficult. In each of the configurations, evaluators commented on the bulkiness of the unit and difficulty in bending with the lunch box-sized unit strapped to their waist.

In each of the phase change vests, evaluators found it necessary to pre-adjust the straps before putting on the vest. Evaluators also experienced added difficulty in adjusting the straps on the Steele Vest, especially while wearing the SCBA.

Because of the shape of the cooling inserts in the Bullard vest, the top of the vest puckered causing a 1 to 1½ inch gap between the vest and the chest when evaluators cinched down the SCBA shoulder straps. The effects of this gap would seem to reduce cooling to the upper torso.

One of the principle improvements recommended for each of the devices concerned the durability and usability of the belts, straps, and/or buckles. The three phase change vests were slightly awkward to don or doff because of excessive strap elasticity (OccuNomix andBullard) or difficult to adjust due to the metal sizing buckles (Steele Vest). As noted above, the CardioCOOL carrying harness was very awkward to wear in Level A PPE. Additionally, one of the waist strap buckles broke under modest strain while being adjusted. Unfortunately, due to the carrying harness construction, there is no way to replace the buckle in the field.

Maintainability Category Conclusions

Based on the focus group criteria, the scoring order for maintainability was as follows:

- Steele Vest (4 Pocket)
- OccuNomix Phase 2B Vest
- Isotherm Cooling Vest by Bullard
- CardioCOOL Vest with PortaCOOL Chiller

Discussion of the evaluation criteria not able to be evaluated or cooling system anomalies are listed below.

Re-supply requirements

Most opinions were that once the required refrigeration/freezer/cooler equipment is in place, other re-supply issues could easily be attained.

Maintenance

The issue of the systems not easily being "wash and wear" was addressed with each system. One evaluator commented that information regarding the cleaning of the chiller, tubing, and bags was not given with the CardioCool system.

Availability of repair parts

The general answers were that the instructions stated to return the system to the manufacturer rather than order repair parts. However, replacement gel and ice packs could be ordered individually.

Ease of decontamination

Because the personal cooling systems were worn underneath the PPE ensembles, decontamination from a chemical or biological WMD event would not be necessary.

Post-Test Observations

Several of the cooling system manufacturers claim that their vests will maintain a "constant temperature" for two to three hours. However, they do not specify what that temperature might be. As a result, several evaluators requested information on the temperature change in the phase change cooling packs during the

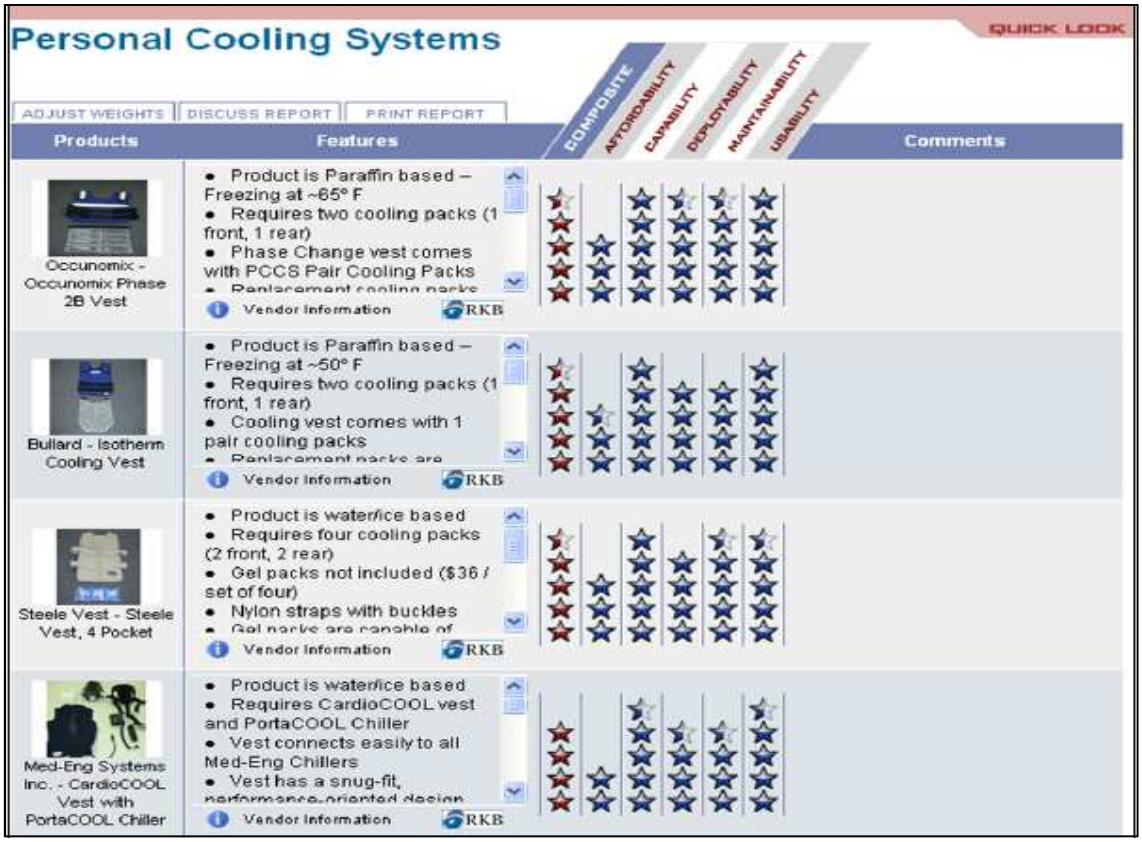

Exhibit 2. SAVER Web site: Personal Cooling Systems Assessment QuickLook

45 minute assessment. This was not measured during the field assessment, but to accommodate the evaluators' request, a follow-up 'experiment' was conducted to gain insights on phase change temperature degradation overtime.

As part of routine CDP HazMat training, two responder teams (three responders per team) were equipped with the OccuNomix Phase 2B Vest (the highest rated vest) under their Level A PPE. While undergoing training, the responder teams performed tasks similar to those conducted in the personal cooling systems assessment. However, these training tasks were only for the duration of 21 and 22 minutes versus the 45 minutes in the assessment.

The OccuNomix paraffin packs were cooled to a temperature of 48ºF when received in the PPE dress-out area. In this experiment students donned their PPE including the vest (approximately ten minutes), performed their training mission (21 to 22 minutes), and doffed their PPE and vest (approximately six minutes). Immediately upon removing the vests, the six ice vests were measured and found to have an average temperature of 58ºF. This was an increase of 10ºF over 22 minutes of strenuous activity. It is not known if this temperature would have remained constant or if further degradation would have occurred before attaining a near constant temperature, but the NSC testing indicates that significant cooling degradation occurs over the first two hours of operation. Thus, if cooling for more that one hour is a critical operational requirement, one might ask prospective vendors for details on cooling effectiveness over time before making procurement decisions.

Conclusion

Of the four types of cooling system technologies identified for the personal cooling systems assessment, all proved capable of being used in a HazMat scenario with responders wearing PPE. However, the less expensive and easier to use phase change vests were better rated in a short duration scenario.

All four assessed technologies require some type of refrigerator, freezer, or ice cooler to charge the cooling mechanism. The responder focus group felt that such freezer/charging capabilities already exist in most HazMat organizations or are readily available to emergency responders. Therefore, none of the assessed products had an advantage or disadvantage in the level of support logistics required to charge the cooling mechanism at the scene.