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The *Personal Cooling Systems Market Survey Report* was prepared by the National Urban Security Technology Laboratory for the U.S. Department of Homeland Security, Science and Technology Directorate.

Cover photographs courtesy of First Line Technology, LLC; Glacier Tek; Kappler, Inc.; Steele, Inc.; Summitstone Corporation; and TechNiche International.

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## FOREWORD

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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 assessments and validations on commercial equipment and systems, and provides those results along with other relevant equipment information to the emergency responder 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 mission includes:

- Conducting impartial, practitioner-relevant, operationally oriented assessments and validations of emergency response equipment; and
- Providing information, in the form of knowledge products, that enables decision-makers and responders to better select, procure, use, and maintain emergency response equipment.

Information provided by the SAVER Program will be shared nationally with the responder community, providing a life- and cost-saving asset to DHS, as well as to Federal, state, and local responders.

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?”

As a SAVER Program Technical Agent, the National Urban Security Technology Laboratory has been tasked to provide expertise and analysis on key subject areas, including chemical, biological, radiological, nuclear, and explosive weapons detection; emergency response and recovery; and related equipment, instrumentation, and technologies. In support of this tasking, NUSTL conducted a market survey of commercially available personal cooling systems (PCS) that use phase change material and gel/ice technology. PCS fall under AEL reference number 01ZA-06-COOL titled Personal Cooling Systems.

Visit the SAVER website at <http://firstresponder.gov/SAVER> for more information on the SAVER Program or to view additional reports on PCS and other technologies.

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## 1. INTRODUCTION

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Personal cooling systems (PCS) are used by first responders to maintain normal body temperature when working in high-temperature environments. To provide emergency responder and law enforcement organizations with information on PCS, the System Assessment and Validation for Emergency Responders (SAVER) Program conducted a market survey on commercially available PCS that use either phase change material (PCM) or gel/ice as the cooling technology.

This market survey report is based on information gathered between June 2013 and September 2013 from vendor websites, industry publications, and a government-issued Request for Information (RFI) posted on the Federal Business Opportunities (FedBizOpps) website (<https://www.fbo.gov>).

For inclusion in this report, PCS had to meet the following criteria:

- Is a commercial off-the-shelf (COTS) product;
- Uses a PCM or gel/ice pack to provide cooling;
- Provides at least 1 hour of cooling in a warm environment;
- Allows the user to be mobile, i.e., not attached to an umbilical device;
- Can be recharged at the incident site; and
- Can be worn under protective clothing.

Due diligence was performed to develop a report that is representative of products in the marketplace.

## 2. PERSONAL COOLING SYSTEMS OVERVIEW

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In order to work safely, rapidly, and efficiently, first responders must maintain a normal body temperature. The body functions most efficiently within a limited temperature range, usually within a few degrees of 98.6°F. Working at high temperatures can lead to fatigue, impaired concentration, heat exhaustion, and heat stroke. In addition, first responders often wear layers of personal protective equipment, which diminishes the body's normal ability to cool by evaporation of sweat from the skin. The weight, stiffness, and design of protective clothing may also raise the amount of energy responders expend, further increasing the need for cooling. PCS maintain a microclimate around the responder, reducing the possibility of heat stress-related illnesses.

PCS can be active or passive and are comprised of a cooling technology and a garment, usually a vest, or occasionally a bandana. Active devices usually involve a circulating fluid, e.g., air or chilled water, and require a power source. They provide consistent, high-level cooling for the duration of use and are fairly expensive. In the past, they were frequently not usable by first responders since they required the user to be tethered to a stationary source of either chilled liquid or forced air. Technological advances have allowed these systems to become portable and light enough for a first responder to use. Passive systems have no moving parts and do not

require a power source. They include evaporative, gel/ice, and PCM garments, all of which provide cooling for a limited amount of time and are relatively inexpensive.

## **2.1 Current Technologies**

Brief descriptions of passive and active cooling technologies follow. This market survey focuses specifically on two types of passive systems: gel/ice and PCM.

### **2.1.1 Evaporative Cooling**

Evaporative cooling systems use water's ability to absorb heat as it evaporates. These systems consist of a garment and water absorption crystals, which are soaked in water before use. They are readily available, inexpensive, portable, and do not require external power. However, they are not effective at high relative humidity or when there is little air movement. They also tend to remain damp, which can cause skin irritation and bacterial growth. Evaporative cooling systems are not frequently used by first responders because they are not effective if worn inside of nonventilated outer garments, such as personal protective equipment.

### **2.1.2 Gel/Ice Pack**

Gel/ice pack vests consist of a garment containing pockets that hold the gel/ice packs. Body heat, carried to the surface of the skin by the blood, is absorbed by the packs. Gel is a mixture of starch, water, and other ingredients that, when frozen, has a cooling capacity similar to ice. These passive products are relatively inexpensive, portable, have high cooling power, and provide body core temperature reduction when used for short periods. The packs can be reused many times. They are nontoxic but require approximately 5 hours of cooling time in a freezer to activate. Since they operate below typical dew-point temperatures, water vapor from the environment can condense on the packs, which may cause skin irritation. The extreme cold may also cause vasoconstriction, the reduction in peripheral blood flow when the skin is exposed to cold temperatures, which may eventually cause the body to retain heat and the core temperature to rise.

### **2.1.3 PCM**

PCM garments, frequently vests, are usually made of a wicking material that draws perspiration from the wearer. There are pockets on the inside of the garment, next to the body, that hold the PCM packs. For cooling, PCM depends on the latent heat absorbed in the phase change of a substance, frequently paraffin, from solid to liquid. The PCM packs act as heat sinks and are activated when the temperature rises above a certain level (from 55°F to 90°F for commonly used PCM). They work most effectively when worn close to the body. PCM vests are considered passive because they do not have any moving parts or an external power supply. They remain cold only for a limited time and may be recharged in ice water, a refrigerator, or a freezer. An advantage of PCM packs is that the time to recharge in ice water is frequently only 20 minutes. The temperatures of PCM packs are not cold enough to freeze the skin or cause condensation, and they may be worn without an undershirt. Vasoconstriction is unlikely to be a significant issue because most PCMs operate at temperatures above 55°F.

Typical cooling duration is up to 3 hours depending on ambient conditions and the responder's workload. PCM packs do not provide as much cooling as gel/ice packs, but lose less cooling potential to the ambient air since the temperature difference between the PCM (at 55°F to 65°F)

and ambient air is less than that between gel/ice (at 32°F) and ambient air. Paraffin-based materials are flammable and may be irritating if they come into contact with the skin. Newer PCMs are claimed to be nontoxic and nonirritating.

#### **2.1.4 Liquid Circulating Systems**

Liquid circulating products work by pumping a chilled fluid through a heat-transfer garment lined with a network of tubing. Metabolic heat is transferred to the circulating fluid, which is pumped back to a cooling unit where the heat is rejected. The coolant fluid is chilled in the cooling unit, using either a vapor compression system or thermoelectric cooling, and re-circulated back to the heat-transfer garment to continuously cool the user. The cooling unit, regardless of the cooling method used, must be located external to the user's uniform since heat must be released to the ambient environment. Both methods also require power from batteries or an electrical outlet. Advances in vapor compression technology have reduced the size, weight, and power needs of these systems, greatly enhancing their portability. Ice can also be used as the cooling source in a liquid circulation system. A battery-powered pump draws chilled ice water from a reservoir and circulates it through the garment. The ice water is usually carried in a backpack for portable units. The system requires periodic replenishment of the ice and batteries. The temperature of the fluid in the garment can be controlled somewhat by varying the speed of the pump motor that regulates the amount of fluid circulating. These garments can be worn directly against the skin without danger of freezing. They are relatively expensive and heavy, but are very effective.

#### **2.1.5 Ambient Air Systems**

Ambient air systems work by blowing air between the protective outer garments and the inner layers of clothing, increasing both convective and evaporative cooling. They typically use a battery-powered blower to circulate air through an air-distribution garment. Systems are available that weigh less than 5 pounds. Air cooling is not as efficient as water cooling because the air heat-transfer coefficient is only 1/25 that of water. However, ambient air systems are fairly effective at low relative humidity. Compressed air products, which use the expansion of compressed air as the cooling source, are not useful for first responders since they require the user to be tethered to the source of the air.

### **2.2 Applications**

PCS are used by first responders, including firefighters, police officers, and hazardous-material workers, when they are exposed to elevated temperatures. Performing strenuous activities in high-temperature environments while wearing heavy equipment has been linked to cardiac events, the leading cause of death for firefighters.<sup>1</sup> They are also used by soldiers deployed in hot environments to lessen the likelihood of heat stress-related illnesses. Interestingly, people suffering from multiple sclerosis, whose symptoms are aggravated by increased body temperature, use PCS to help keep cool, allowing them to live more normally even during the hot summer months or when exercising.

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<sup>1</sup> Fahy, Rita F., LeBlanc Paul R., Molis, Joseph L., *Firefighter Fatalities in the United States, 2012*, NFPA Journal, July August 2013.

## 2.3 Standards/Regulations

ASTM International F2371-10, *Standard Test Method for Measuring the Heat Removal Rate of Personal Cooling Systems Using a Sweating Heated Manikin*, can be used to objectively quantify and compare the cooling provided by different PCS. A sweating thermal manikin system accurately simulates evaporative cooling, which is the only active means of heat transfer used by humans. The manikin has 20 computer controlled, independently heated thermal zones, containing embedded heaters and thermistors. A baseline test is first run to establish the heat loss from the manikin without a PCS. The computer collects temperature data from each zone and adjusts the power to the heaters to maintain the desired manikin temperatures. The power provided to the heaters is equivalent to the heat loss from the manikin. The test is repeated with a manikin that has been fitted with a PCS, and the manikin's surface temperature is kept at 95°F. The cooling rate of the PCS is quantified by subtracting the average power during the baseline test from the power used during the test with the PCS. The test method calls for the test to end when the heat gained by the cooling source, i.e., the PCS, drops to less than 50 watts above the baseline.

ASTM International Standard F2300-10, *Standard Test Method for Measuring the Performance of Personal Cooling Systems Using Physiological Testing*, provides guidance on protocols and the types of tests to use when human volunteers with the necessary fitness levels are available. The method assesses the performance of the PCS based on the physiological measurements of core temperature, mean skin temperature, heart rate, oxygen consumption, and whole body sweat rate.

## 2.4 Emerging Technologies

Advances in miniature vapor compression technology have allowed for the manufacture of PCS that meet the size and weight requirements for a man-portable system. Digital control systems maintain the circulating liquids at the desired temperature by varying the speed of the compressor. Some of these systems weigh as little as 6 pounds and provide a substantial amount of cooling capacity for a sustained period of time.

Research is being done on the effectiveness and portability of PCS using high-efficiency thermoelectric cooling. Thermoelectric coolers use electrical voltages to create temperature gradients across the thermoelectric device, a phenomenon known as the Peltier effect. Research indicates that these systems may provide effective heat removal.

## 3. PRODUCT DATA

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The products in Table 3-1, PCM Product Comparison Matrix, and Table 3-2, Gel/Ice Product Comparison Matrix, are mainly vests. This market survey report includes 13 PCM vests, 1 PCM under armor holder, 1 PCM neck cooler and 5 gel/ice vests, which range in price from \$35 to \$475.

Products are listed in alphabetical order by company. Product data was obtained directly from the manufacturer or distributor or their websites. The information obtained has not been independently validated by the SAVER program.

Features in Table 3-1 are defined as follows:

**Company** indicates the manufacturer or distributor of the PCS.

**Product** indicates the product name of the PCS.

**Cost** indicates the price of the PCS rounded to the nearest dollar as quoted by the vendor in U.S. dollars. If a cost range is given, this indicates that the price of the system varies according to options that the buyer may choose.

**Phase change material type** gives information about the type of material that provides cooling.

**Weight fully loaded** indicates the weight of the equipment in pounds, including all necessary inserts.

**Temperature when charged** indicates the temperature in °F of the PCM or gel/ice when fully solidified.

**Recharging method** lists the equipment or materials needed to activate the PCM or gel/ice to make it ready for use.

**Hours before recharging required** indicates how long the PCS will stay in a solid state and be able to provide sufficient cooling. The environmental temperature at which this cooling time was measured is indicated if it was provided by the vendor.

**Time needed for recharging** indicates the time in minutes needed to recharge using the indicated equipment or material.

**Cost of one set of replacement packs** indicates the cost in U.S. dollars to fully fill a garment with new PCM inserts or gel/ice packs.

**50 watts of cooling for 2 hours** indicates whether the PCS is able to provide 50 watts of cooling for 2 hours, the quantity used in ASTM International F2371-10, *Standard Test Method for Measuring the Heat Removal Rate of Personal Cooling Systems Using a Sweating Manikin*.

**GSA schedule** indicates if the PCS is available for purchase through the General Services Administration.

Table 3-2 has the same features, except the column titled “Phase Change Material Type” is replaced by “Composition of Gel/Ice,” and the column titled “Time Needed for Recharging” is eliminated since all of the gel/ice packs need approximately 5 hours in a freezer for recharging.

**Composition of gel/ice** lists the substances making up the cooling material.

Table 3-1. PCM Product Comparison Matrix

Company	Product	Cost (\$)	Phase change material type	Weight fully loaded (pounds)	Temperature when charged (°F)	Recharging method	Hours before recharging required	Time needed for recharging (min)	Cost of one set replacement packs (\$)	50 watts of cooling for 2 hours	GSA schedule
Barbosa Cool Products*	Personal Cool Vest	135	Semi-solid thermal energy storage material	4.0	65	Refrigerator, freezer, ice water	2	20, ice water 35, refrigerator	110	NA	NA
Black Ice, LLC	Cool Collar CCX PCS	35	Hexadecane/tetradecane	0.5	57	Refrigerator, freezer, ice water	1-1.5	20, ice water	25	No	No
First Line Technology, LLC	PhaseCore® Heat Activated Cooling Vest, Type 28 and Type 32	SWEDE Model 350-475 Standard Model 340-450	PhaseCore nontoxic, nonflammable salt mixture sealed in thermal wrapper	3.6-4.8 depending on model	Type 28: 82.4 Type 32: 89.6	Room temp. air, refrigerator, freezer, ice water, ice	Type 28 2-3, Type 32 5-7	95, 75°F office 25, refrigerator 20, freezer 8, ice water 5, ice	SWEDE (22 elements) 240 Standard (16 elements) 180	Yes	Yes
Glacier Tek	Renewable Phase Change Material (RPCM®) Cool Vest	179-199	RPCM	4.4	59	Refrigerator, freezer, ice water, anything below 59°F	2.5	20, ice water	129	Yes	No
Glacier Tek	RPCM Cool Armor	99	RPCM	Less than 2	59	Refrigerator, freezer, ice water, anything below 59°F	2-2.5	20, ice water	79	Yes	No
Kappler, Inc.	Cool Vest with 600-gram PCM packs	368	Hexadecane	8	60-65	Refrigerator, freezer, ice water	1.5-2 at 110°F	90, refrigerator 20, ice water	285	No	No
Polar Products, Inc.	Cool58™ Phase Change Vest	101-153	Hexadecane and tetradecane	4-7.5	58	Refrigerator, freezer, ice water	2-3	20, ice water	54-106	Yes	Yes

**Table 3-1. PCM Product Comparison Matrix (continued)**

Company	Product	Cost (\$)	Phase change material type	Weight fully loaded (pounds)	Temperature when charged (°F)	Recharging method	Hours before recharging required	Time needed for recharging (min)	Cost of one set replacement packs (\$)	50 watts of cooling for 2 hours	GSA schedule
Steele, Inc.	Steele Cool UnderVest with PCM packs, SA500	Vest 75, 4 10oz PCM cooling strips 70, 4 18 oz PCM cooling strips 80	Hexadecane	3 with 10 oz strips 5 with 18 oz strips	58	Refrigerator, ice water	1.7	NA	4 10 oz PCM cooling strips 70, 4 18 oz PCM cooling strips 80	Yes	No
Summitstone Corporation	HeatShield II / CM2000	180 includes one layer of panels	Nontoxic, nonflammatory proprietary material	5.6 with one layer of panels	72	Freezer	4 at 120°F with 2 layers	210, freezer	35 for one set of panels	Yes	No
Techniche International	TechKewl™ Phase Change Cooling Vest and Kool Pax™	170	C16 alkane	6	58	Refrigerator, freezer, ice water	1-3	45, ice water	130	Yes	Yes
Texas Cool Vest	Standard Cool Vest	121	Proprietary material	4.8	65	Refrigerator, freezer, ice water	2-2.5	20, ice water 60, refrigerator	100	Yes	Yes
Western Fire Supply	Phase Change Cool Vest®	139	Alkane blend	5	58	Refrigerator, freezer, ice water	2-3	30, ice water 30, refrigerator	110	Yes	No

\* Information for this product is from the vendor website.

NA: Information not available.

### 3.1 PCS Using PCM Technology

#### 3.1.1 Barbosa Cool Products, Personal Cool Vest

The Personal Cool Vest is constructed of a heavy duty nylon mesh outer shell and uses Cool Packs that maintain a 65°F temperature. The vest is available in a variety of colors: safety orange, yellow, blue, green, and black. It has adjustable straps on each side of the garment for a comfortable fit and can be worn directly against the skin without danger of frostbite. Cool Packs are nontoxic and can be used indefinitely.

#### 3.1.2 Black Ice, LLC, Cool Collar CCX PCS

The Cool Collar CCX PCS is a lightweight, ergonomically designed neoprene neck wrap which holds a 57°F rechargeable pack that lasts for up to 1.5 hours. A rapid replacement design allows pack replacement (removal of the collar, removal of the pack, attachment of a new pack, and placement on neck) in 7 seconds or less. This product does not provide 50 watts of cooling for 2 hours but can be worn under a helmet or protective clothing.

There is a 6-month replacement warranty. The Cool Collar is not currently available on the GSA schedule but may be in the future. If purchased together, one neck wrap and two cooling packs can be purchased for \$44.95. One neck wrap, two cooling packs, and a portable soft-sided cooler can be purchased for \$74.95. There is a volume-purchase discount available.



**Cool Collar CCX PCS**  
Courtesy of Black Ice, LLC

#### 3.1.3 First Line Technology, LLC, PhaseCore® Heat Activated Cooling Vest

PhaseCore Cooling Vests are carriers for PhaseCore elements and are available in two styles (Standard or SWEDE) and three materials (Mesh, Basic, and CarbonX®). The Standard vest has a two-piece, over-the-shoulder design and contains 16 PhaseCore Type 28 or Type 32 elements. The SWEDE vest features a front closure and contains 22 PhaseCore Type 28 or Type 32 elements. PhaseCore 28 activates at 82.4°F and PhaseCore 32 activates at 89.6°F. Since PhaseCore 28 has a lower activation temperature than PhaseCore 32, PhaseCore 28 provides a stronger cooling effect, but for a shorter time. The manufacturer recommends that workers use PhaseCore 28 elements in temperatures less than 110°F and PhaseCore 32 elements in environments greater than 110°F. These elements are made of a nontoxic, nonflammable salt mixture and sealed inside a thermal wrapper. First Line Technology is an ISO 9001:2008-certified manufacturer. PhaseCore 28 elements can last up to 4 hours and PhaseCore 32 elements up to 7 hours, with actual time depending on physical activity, body type, and



**Standard CarbonX PhaseCore®  
Cooling Vest**  
Courtesy of First Line Technology, LLC

environmental conditions. PhaseCore elements are designed to self-recharge at room temperature and begin recharging at any temperature below their activation point: Type 28 below 82°F with 75°F or less recommended, and Type 32 under 92°F with 85°F or less recommended. They will be recharged more quickly in a colder environment: 95 minutes in an office environment, 25 minutes in a refrigerator, 22 minutes in a freezer, 8 minutes in ice water, and 5 minutes on ice. If ice water is used, the elements must be removed from the vest. The vests are machine washable after removing the elements. The elements can be taken through 7,000-10,000 charge-discharge cycles before they need to be replaced. If an element is damaged in the field, the remaining elements will continue to operate normally, but the reduction in performance will be less than would be the case with a smaller number of larger gel/ice packs.

A cooling hat liner, offered with either type of cooling element, is available for \$50.00. Volume purchase discounts are offered on quantities of 100-249, 250-299, and more than 1,000 PhaseCore Cooling Vests. There is a 1-year warranty for materials and workmanship under normal use.

### 3.1.4 Glacier Tek, Renewable Phase Change Material (RPCM®) Cool Vest

RPCM Cooling Vests feature side elastic straps and adjust over the shoulder to fit a wide range of body sizes. The vests maintain a constant 59°F temperature for up to 4 hours, depending on the model. They weigh from 4.4 pounds for the standard model to 8.8 pounds for the extended-duration model. They can be washed in a regular laundry. Glacier Tek's RPCM is officially certified “biopreferred” by the U.S. Department of Agriculture and meets the criteria of a “green” chemical as defined by the U.S. Government. It is a nontoxic, bio-based product that is an alternative to petroleum-based phase change materials. RPCM Cool Packs recharge in 20 minutes in ice water or a freezer. They may also be recharged in a refrigerator or any environment cooler than 59°F. The packs can be charged and discharged indefinitely. Packs have been cycled 60,000 times with no change in performance.



**RPCM® Cooling Vest**  
Courtesy of Glacier Tek

Substantial discounts are available for government, military, and large-volume purchases. Glacier Tek offers a 1-year warranty against manufacturer defects. For military working dogs, Glacier Tek also offers a RPCM Chilly Dog Cooling Vest, which weighs 3 pounds, at a price of \$129.00. They have adjustable straps allowing them to fit a wide range of dog sizes.

### 3.1.5 Glacier Tek, RPCM Cool Armor

RPCM Cool Armor reduces the heat stress created by wearing body armor. This product maintains 59°F for 2 hours and recharges in minutes using the same RPCM Cool Packs as the Cool Vest. It is designed to fit comfortably under all major brands of body armor without modification and can be worn directly against the skin. It is not a vest, but a Cool Pack with a holder that is to be worn under body armor. This item does not



**RPCM® Cool Armor**  
Courtesy of Glacier Tek

attach to the body, but attaches to the armor instead. The pack can be replaced without removing the body armor or uniform shirt. Cool Armor weighs less than 2 pounds and is ¾ inch thick. It contains no hazardous ingredients, which means that the cooling formula is harmless if accidentally ingested or enters the blood stream. The RPCM Cool Pack inside the Cool Armor can be replaced with a recharged pack in under 1 minute.

Substantial discounts are available for government, military, and large-volume purchases. Glacier Tek offers a 1-year warranty against manufacturer defects.

### **3.1.6 Kappler, Inc., Cool Vest with 600-gram PCM Packs**

The Cool Vest is a Banox Certified™ vest with 600-gram PCM packs that fit into internal pockets. Banox Certified fabrics are 100 percent cotton fabrics treated with a flame retardant finish. The vest cools to 60°F to 65°F for up to 2 hours at 110°F. It weighs 8 pounds when fully loaded with packs. An 800-gram PCM pack version is available, which provides a longer cooling duration. The vest can be worn with or without a shirt underneath. The vests are washable and reusable. They are available in one size fits all and have adjustable hook and loop closures. The packs can be reused hundreds of times.

A 90-day warranty for manufacturer defects is offered. There is no volume-purchase discount available.



**Cool Vest with 600-gram PCM Packs**  
*Courtesy of Kappler, Inc.*

### **3.1.7 Polar Products, Inc., Cool58™ Phase Change Cooling Vest**

The Cool58 is available as a poncho vest and a zipper vest. It can be recharged in a freezer, refrigerator, or ice water. The poncho vest is one size fits most, while the zipper vest comes in four sizes. Both vests are 100 percent cotton and do not require the user to wear an undergarment. The vests use four packs, and these packs are available in three different sizes (0.88, 1.1, and 1.76 pounds each) in order to match the size of the wearer. Loaded with four packs, the total vest weights are 4, 5, and 7.5 pounds, respectively. Prices are as follows: Cool58 poncho or zipper vest with 0.88 pound packs, \$100.50; with 1.1 pound packs, \$112.56; with 1.76 pound packs, \$152.76. The packs can be reused for years with the proper care.

A 6-month warranty against defects in materials and workmanship is provided. Neck bands, crown coolers, and torso vests are also available.



**Cool58™ Phase Change Cooling Zipper Vest**  
*Courtesy of Polar Products, Inc.*

### 3.1.8 Steele, Inc., Steele Cool UnderVest with PCM Packs, SA500

The SA500 UnderVest's shell fabric is available in 100 percent polyester microsuede or 100 percent Banox Certified flame retardant cotton. It has four insulated pockets which accept 10- or 18-ounce PCM cooling strips. Four heavy-duty elastic strips allow for size adjustment of the one size fits all vest. The user is not required to wear an undergarment under the vest. The strips can be used indefinitely.

There is a volume-purchase discount available. A 1-year warranty on defects in material and workmanship is offered.



**Steele Cool UnderVest  
with PCM Packs, SA500**  
*Courtesy of Steele, Inc.*

### 3.1.9 Summitstone Corporation, Heatshield II / CM2000

Summitstone Corporation's PCS includes a vest with available leggings. The Heatshield II can be adjusted using VELCRO® fasteners. The CM2000 has a zippered front and features vented mesh construction and tight lacing to provide back support for heavy work. It is available in one size with side adjustments allowing for variations in chest size. The vests use a layered system of cooling panels, which permits additional panels to be added to increase cooling time, e.g., three layers of cooling panels will last 8 hours at 100°F temperature. Cooling panels can also be removed to reduce weight. The vest weighs 5.6 pounds with one layer of panels. The vest should be worn with an undergarment, preferably a tee shirt. The PCM used is a nontoxic, nonflammable proprietary material. The panels are shipped DryPack and must be hydrated for at least 30 minutes and frozen before initial use. They can be purchased hydrated for an extra \$10.00 per set.



**CM2000 Vest**  
*Courtesy of Summitstone  
Corporation*

There is a volume-purchase discount available. Leggings are available for \$129.95. A freezer that can cool 24 panels and operates at -30°F is available for \$699.00.

### 3.1.10 Techniche International, TechKewl™ Phase Change Cooling Vest and Cool Pax™

These cooling vests are available in a variety of styles, sizes, and fabrics, and can also be custom made. High-visibility and fire-resistant vests are available. They cool to 58°F and can be reused thousands of times. Cool Pax are activated at any temperature below 58°F and will solidify completely after 45 minutes in ice water. They are sealed inside high-strength polyurethane to ensure they do not leak. It is recommended that the user wear an undergarment under the vest.



**TechKewl™ Phase Change  
Cooling Vest**  
*Courtesy of Techniche International*

A volume-purchase discount is available. Vests have a 30-day warranty, while the Cool Pax has a 1-year warranty. An insulated cooler bag is included in the purchase price of \$169.99 for the vest.

### 3.1.11 Texas Cool Vest, Standard Cool Vest

This vest has adjustable shoulders, easy on and off zipper front, six adjustable side straps, and fits up to a 49-inch waist. The Standard cool packs contain PCM that operates at 65°F and lasts between 2 and 2.5 hours (depending on body type, ambient temperature, and the amount of physical exertion performed). Cool packs charge in ice water in 20 minutes. Recharging takes longer in a refrigerator or freezer. The vest weighs about 4.8 pounds with standard cool packs in place and is available in Supplex, Polly Cotton Twill, or Banox Certified fabric. The user should wear an undergarment under the vest. The packs can be used indefinitely if not punctured or damaged.



**Standard Cool Vest**  
*Courtesy of Texas Cool Vest*

There is a volume-purchase discount available, with a larger discount for any purchase above \$3,000. The vests come with a 30-day money-back guarantee, and the packs are guaranteed for 1 year against manufacturing defects. Heavy-duty and light-weight packs are available. The manufacturer also makes cooling neck bands and medical modular cooling units.

### 3.1.12 Western Fire Supply, a Blue Mountain Ltd dba, Phase Change Cool Vest®

This vest, manufactured by Lakeland Industries in Dallas, Texas, uses a cooling material that is a proprietary blend of alkanes. The inserts are nontoxic and nonflammable and can be used many times. The vest provides a 58°F temperature for 2 to 3 hours. It comes in four sizes and has an adjustable shoulder and waist. The vest is available in Banox Certified flame-retardant cotton, Nomex® material, and polycotton. The manufacturer recommends that the user wear a tee shirt or other light shirt under the vest.



**Phase Change Cool Vest®**  
*Courtesy of Western Fire Supply*

There is a volume-purchase discount available.

Table 3-2. Gel/Ice Product Comparison Matrix

Company	Product	Cost (\$)	Composition of gel	Weight fully loaded (pounds)	Temperature when charged (°F)	Recharging method	Hours before recharging required	Cost of one set of replacement packs (\$)	50 watts of cooling for 2 hours	GSA schedule
Polar Products, Inc.	Kool Max Poncho/ Zipper Front Vest	95	Water, pulverized cellulose, sodium benzoate	Poncho 4.5, Vest 3.5-5.5 depending on size of user	32	Freezer	2-4	S/M: 8 cold packs: 20 M/L: 9 cold packs: 20 Poncho: 10 cold packs: 21 L/XL: 11 cold packs: 21 XXL: 12 cold packs: 22	Yes	Yes
StaCool Industries, Inc.	StaCool Industrial Vest	250 (comes with 2 sets of packs)	Polymer material	7	32	Freezer dry ice	2.5-3	45	Yes, up to 3 hours	No
Steele, Inc.	Six Pocket SteeleVest SA1140	198 with 15 ounce packs, 204 with 27 ounce packs	85% water, 15% food-grade cornstarch	8 for 15-ounce packs, 12 for 27-ounce packs	21-32	Freezer	2-3	48 for 15 ounce packs, 54 for 27 ounce packs	Yes, 270 watts for 2 hours	No
Steele, Inc.	Trimlite Four Pocket SteeleVest SA440	182 with 15 ounce packs, 186 with 27 ounce packs	85% water, 15% food-grade cornstarch	5 for 15-ounce packs, 8 for 27-ounce packs	21-32	Freezer	2-3	32 for 15 ounce packs, 36 for 27 ounce packs	Yes, 113 watts for 2+ hours	No
Steele, Inc.	Zip Cool-UnderVest SA880	182 with 15 ounce packs, 186 with 27 ounce packs	85% water, 15% food-grade cornstarch	5 for 15-ounce packs, 8 for 27-ounce packs	21-32	Freezer	2-3	32 for 15 ounce packs, 36 for 27 ounce	Yes, 113 watts for 2 hours	No

S/M small/medium  
 M/L medium/large  
 L/XL large/extra large  
 XXL extra extra large

## 3.2 PCS Using Gel/Ice Technology

### 3.2.1 Polar Products, Inc., Kool Max® Vest

The Kool Max vest is available either as a poncho or a zipper-front vest. These vests use frozen water-based Kool Max cooling packs that are inserted into insulated pockets. The gel material is nontoxic and not irritating to the skin. The vests provide between 2 and 4 hours of cooling, depending on the user's metabolism, level of activity, and ambient temperature. The poncho vest is one size fits most, while the zipper vest comes in four sizes. The poncho vest includes the vest and 10 cold packs; the small/medium, medium/large, large/extra large and extra extra large zipper front vests include 8, 9, 11, and 12 cold packs, respectively. Even though the pockets are cotton and insulated, it is recommended that a light tee shirt be worn under the vest to protect the skin. The vest is available in fire-resistant material. The vest adjusts at the chest, waist, and shoulders using straps with hook and loop attachments. The vest can be cleaned using a mild soap, washed on a gentle cycle, and hang dried. The packs can be hand washed in soap and water. This vest has been tested by Kansas State University and was found to significantly lower heart rate and final body core temperature.<sup>2</sup>

Polar Products also makes wrist wraps, neck wraps, and torso vests. There is a 6-month warranty against defects in materials and workmanship.



**Kool Max Poncho Vest**  
Courtesy of Polar Products, Inc.

### 3.2.2 StaCool Industries, Inc., StaCool Industrial Vest

The StaCool Industrial Vest uses 3M Thinsulate™ insulation to protect users from excessive cooling, allowing the vest to be worn directly against the skin. The outer shell is made of Dupont® Cordura® nylon and holds three ThermoPaks in front and three in the back. The vest comes with two sets of ThermoPaks, which allows the user to switch sets when needed. The vests come in one size fits all and are fully adjustable at the shoulders, chest, and stomach area. The cooling gel is a polymer material that is safe, nontoxic, nonflammable, and will not cause skin irritation. This vest was developed 15 years ago and was made to withstand the heat and high humidity of Florida. It will provide 2.5 to 3 hours of cooling in a 90°F, high-humidity environment.

StaCool also makes an UnderVest. A warranty against manufacturer defects is offered. Bulk-order and military discounts are available.

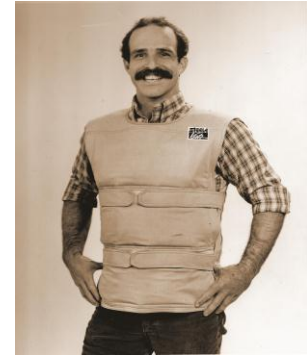


**StaCool Industrial Vest**  
Courtesy of StaCool Industries, Inc.

<sup>2</sup> Elson, John C., McCullough, Elizabeth A., Eckels, Steve, *Evaluation of Personal Cooling Systems for Military Use*, Kansas State University, Proceedings of the 15<sup>th</sup> International Conference of Environmental Ergonomics, Queenstown, NZ February, 2013.

### 3.2.3 Steele, Inc., Six Pocket SteeleVest SA1140

The Six Pocket SteeleVest is an over the head cooling vest with an optional split shoulder for easy donning and removing. It has a durable 9-ounce, Banox Certified flame-retardant cotton shell with six insulated pockets—three on the front and three on the back of vest. While there is an inner layer of tricot to protect the user from excessive cooling, it is recommended that the user wear one to two layers between the vest and skin. The vest accepts six 27-ounce or six 15-ounce frozen gel Thermo-strips™. Four adjustable side straps and a hook and loop on the front of the vest allow for universal sizing. The vest can be dry cleaned or washed on a gentle cycle using mild detergent. The vest provides 2 to 3 hours of cooling.



**Six Pocket  
SteeleVest SA1140**  
*Courtesy of Steele, Inc.*

### 3.2.4 Steele, Inc., TrimLite Four Pocket SteeleVest SA440

The TrimLite Four Pocket SteeleVest is a zip-front vest with a split shoulder closure for easy donning and removing. It has four insulated pockets and four adjustable side straps with a hook and loop on the front of the vest for universal sizing. It accepts both 15- and 27-ounce Thermo-strips. The strips are sectioned and flex easily to fit the torso without impeding movement. Multiple layers of micro-thin, highly breathable insulation reflect heat away from the body. The vest can be dry cleaned or washed on a gentle cycle using mild detergent.



**TrimLite Four Pocket  
SteeleVest SA440**  
*Courtesy of Steele, Inc.*

### 3.2.5 Steele Inc., Zip Cool-UnderVest with Thermo-strips, SA880

The Zip Cool-UnderVest's shell fabric is either polyester microsuede or Banox Certified flame-retardant cotton. The vest has four vertical insulated pockets—two in front and two in back. Zippers on the top and bottom of the pockets allow for the easy removal and replacement of Thermo-strips when wearing body armor or protective clothing. Four heavy duty elastic straps allow for size adjustment and freedom of movement. This vest has been tested by Kansas State University and was found to significantly lower heart rate and final body core temperature.<sup>3</sup>

Steele also manufactures neck coolers, wrist coolers, and hat and bra coolers. A 1-year warranty against defects in materials or workmanship is offered. There is a volume-purchase discount available.



**Zip Cool UnderVest  
with Thermo-strips  
SA880**  
*Courtesy of Steele, Inc.*

<sup>3</sup> McCullough, Elizabeth A., Eckels, Steve, Elson, John, *Evaluation of Personal Cooling Systems for Military Use*, Kansas State University, Proceedings of the 15<sup>th</sup> International Conference on Environmental Ergonomics, Queenstown, NZ, February 2013.

## 4. VENDOR CONTACT INFORMATION

Additional information on the products included in this market survey report can be obtained from the following vendors.

**Table 4-1. Vendor Contact Information**

Company	Product	Address/Phone Number	E Mail/Website
Barbosa Cool Products	Personal Cool Vest	9810 Abernathy Avenue Dallas, TX 75220 (214) 358-6857	<a href="mailto:barbosacoolproducts@gmail.com">barbosacoolproducts@gmail.com</a> <a href="http://www.barboscacoolproducts.com">www.barboscacoolproducts.com</a>
Black Ice, LLC	Cool Collar CCX PCS	9160 Highway 64 Suite 12, Number 301 Lakeland, TN 38002 (901)-937-8129	<a href="mailto:mike@blackicecooling.com">mike@blackicecooling.com</a> <a href="http://www.blackicecooling.com">www.blackicecooling.com</a>
First Line Technology, LLC	PhaseCore® HeatActivated Cooling Vest	3656 Centerview Drive Suite 4 Chantilly, VA 20151 (703) 955-7510	<a href="mailto:sales@firstlinetech.com">sales@firstlinetech.com</a> <a href="http://www.firstlinetech.com">www.firstlinetech.com</a>
Glacier Tek	RPCM® Cool Vest RPCM Cool Armor	P. O. Box 120642 West Melbourne, FL 32912 (321) 752-4130	<a href="mailto:info@coolvest.com">info@coolvest.com</a> <a href="http://www.coolvest.com">www.coolvest.com</a>
Kappler, Inc.	Cool Vest with 600-gram PCM packs	115 Grimes Drive Guntersville, AL 35976 (256) 505-4005	<a href="mailto:usa@kappler.com">usa@kappler.com</a> <a href="http://www.kappler.com">www.kappler.com</a>
Polar Products, Inc.	Cool58™ Phase Change Vest Kool Max® Vest	3380 Cavalier Trail Stow, OH 44224 (800) 763-8423	<a href="mailto:polar@polarproducts.com">polar@polarproducts.com</a> <a href="http://www.polarproducts.com">www.polarproducts.com</a>
StaCool Industries, Inc.	StaCool Industrial Vest	4287 NW 76 <sup>th</sup> Court Ocala, FL 34482-6713 (866) 782-2665	<a href="mailto:sylvia@stacoolvest.com">sylvia@stacoolvest.com</a> <a href="http://www.stacoolvest.com">www.stacoolvest.com</a>
Steele, Inc.	Steele Cooling Undervest with PCM packs Six Pocket SteeleVest TrimLite Four Pocket SteeleVest Zip Cool Undervest with Thermo-strips by Steele	P.O. Box 7304 Kingston, WA 98346 (360) 297-4555	<a href="mailto:steeleinc@silverlink.net">steeleinc@silverlink.net</a> <a href="http://www.steelevest.com">www.steelevest.com</a>
Summitstone Corporation	HeatShield II CM2000	1661 James Wharf Road White Stone, VA 22578 (804) 435-0074	<a href="mailto:coolingvest@gmail.com">coolingvest@gmail.com</a> <a href="http://www.summitstone.com">www.summitstone.com</a>
TechNiche International	TechKewl™ Phase Change Cooling Vest	1261 Liberty Way Suite A Vista, CA 92081 (888) 823-2665	<a href="mailto:sales@techniche-intl.com">sales@techniche-intl.com</a> <a href="http://www.techniche-intl.com">www.techniche-intl.com</a>
Texas Cool Vest	Standard Cool Vest	7211 Regency Square Boulevard Suite 201 Houston, TX 77036 (713) 952-1983	<a href="mailto:sales@texascoolvest.com">sales@texascoolvest.com</a> <a href="http://www.texascoolvest.com">www.texascoolvest.com</a>
Western Fire Supply, A Blue Mountain Ltd dba	Phase Change Cool Vest®	11476 Sunrise Gold Circle Suite 1 Granite Bay, CA 95742 (916)-851-9004	<a href="mailto:steve@westernfiresupply.net">steve@westernfiresupply.net</a> <a href="http://www.westernfiresupply.net">www.westernfiresupply.net</a>

## 5. SUMMARY

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Personal Cooling Systems allow first responders to work safely and efficiently in high-temperature environments. Included in this market survey report are 15 PCM and 5 gel/ice systems ranging in price from \$35 to \$475 for the PCM systems and \$95 to \$250 for the gel/ice systems. Thirteen of the PCM systems are vests, one is a cooling neck collar, and one attaches directly to body armor. They are available in different colors, fabrics, and styles, including reflective, camouflage, and fire resistant. The user must determine if the style of vest can be worn comfortably under protective equipment or body armor and how much weight is acceptable. The vests work most effectively if worn close to the body. Cooling neck kerchiefs, head coolers, and leggings are also available. Some vendors make cooling vests for the dogs that may accompany first responders.

This market survey report focused on systems that use two cooling technologies, PCM and gel/ice. Systems that use PCM technology are frequently lighter in weight, provide a limited amount of cooling, and are effective for a few hours. PCM systems do not shock the wearer with excessive cold, do not cause condensation, and are unlikely to cause vasoconstriction. They can be recharged in 20 minutes in ice water. Gel/ice systems may provide more cooling for a longer period of time. They usually require the user to wear an undergarment since they cool to 32°F. Condensation and vasoconstriction are potential problems if used for extended periods of time. Their main disadvantage is that they require a freezer and up to 5 hours to recharge. PCMs can range from potentially skin irritating, flammable paraffins to nontoxic renewable substances. Gel/ice materials are usually nontoxic and nonirritating to the skin if the packs were to break. Cooling duration of any PCS is affected by the ambient environment, an individual's physiology, workload, and the amount of protective clothing worn.