



System Assessment and Validation for Emergency Responders (SAVER)

Chemical, Biological, Radiological, and Nuclear Air-Purifying Escape Respirators Market Survey Report

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System Assessment and Validation for Emergency Responders

Prepared by the National Urban Security Technology Laboratory

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FOREWORD

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 assessments and validations on commercially available equipment and systems, and develops knowledge products that provide relevant equipment information to the emergency responder community. 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.

SAVER Program knowledge products provide information on equipment that falls under the categories listed in the DHS Authorized Equipment List (AEL), focusing primarily on two main questions for the responder community: “What equipment is available?” and “How does it perform?” These knowledge products are 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. As a SAVER Program Technical Agent, the National Urban Security Technology Laboratory (NUSTL) 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 chemical, biological, radiological, and nuclear (CBRN) air-purifying escape respirators (APERs). CBRN APERs fall under the AEL reference number 01AR-04-APER titled Respirator, Escape, Air-Purifying, Single-Use, CBRN.

Visit the SAVER website on First Responder.gov (www.firstresponder.gov/SAVER) for more information on the SAVER Program or to view additional reports on CBRN APERs or other technologies.

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TABLE OF CONTENTS

| | |
|---|----|
| Foreword..... | i |
| Points of Contact..... | ii |
| 1. Introduction..... | 1 |
| 2. CBRN APER Overview..... | 1 |
| 2.1 Current Technologies..... | 1 |
| 2.2 Standards/Regulations..... | 2 |
| 2.3 Features of CBRN APERs..... | 3 |
| 2.4 Applications and Limitations of CBRN APERs..... | 4 |
| 3. Product Information..... | 5 |
| 3.1 Avon Protection Systems NH15™ Escape Hood..... | 7 |
| 3.2 Honeywell Safety Products USA, Inc., ER2000CBRN..... | 8 |
| 3.3 ILC Dover, Inc. SCape® CBRN ³⁰ and CO/CBRN ³⁰ | 9 |
| 3.4 Mine Safety Appliances CBRN Safe Escape™ Respirator..... | 10 |
| 4. Manufacturer Contact Information..... | 11 |
| 5. Summary..... | 11 |

LIST OF TABLES

| | |
|--|----|
| Table 3-1. CBRN APER Specifications..... | 6 |
| Table 4-1. Manufacturer Contact Information..... | 11 |

1. INTRODUCTION

Air-purifying escape respirators (APERs) are worn for protection from breathing harmful gases during an emergency evacuation to fresh air. Chemical, biological, radiological, and nuclear (CBRN) APERs are a special class of APER designed to block certain chemical and biological agents and radioactive dust particles. To provide emergency responders with information on commercially available CBRN APERs, the System Assessment and Validation for Emergency Responders (SAVER) Program conducted a market survey.

This market survey report is based on information gathered between October and November 2014 from manufacturers, Internet research, and a government-issued Request for Information (RFI) that was posted on the Federal Business Opportunities website. For inclusion in this report, the CBRN APERs had to meet the following criteria:

- Quick-donning, short-duration respiratory protection
- Designed for escape purposes only
- Commercially available
- Certified by the National Institute for Occupational Safety and Health (NIOSH) as compliant with CBRN requirements.

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

2. CBRN APER OVERVIEW

Respirators generally work by either cleaning the ambient air before inhalation or by supplying fresh air. Different types of respirators offer varying levels of protection. The simplest type is a particulate respirator, such as a mask worn in hospitals to mechanically block infectious particles. A particulate respirator does not protect against hazardous gases. In contrast, a gas-mask respirator contains a special filter that chemically reacts with specific gaseous hazards, and it seals onto the face or head so that air does not bypass the filter. A gas mask is effective only for the specific hazard(s) for which its filter is designed. Respirators that offer the greatest level of protection are self-contained breathing apparatuses (SCBAs)—they include an air tank to supply clean air and do not need a filter. SCBAs can weigh more than 30 pounds and require special training to use safely. The CBRN APER is a type of gas mask. It does not use a fresh air supply; instead, it filters contaminants from the ambient air.

2.1 Current Technologies

A CBRN APER consists of a hood, which fits over the entire head and seals around the base of the neck, and an attached filter that captures airborne contaminants. The hood is made from synthetic rubber and protects the head and eyes. The filter is designed to block particles, such as dust and infectious spores, and includes materials that chemically react with specific gaseous chemicals or aerosolized toxic liquids to neutralize the hazard in order to provide purified air for breathing. The filter is housed in a cartridge, also called a canister, which is attached to the hood.

By industry standard¹, cartridges are color coded to indicate the specific hazard for which they are designed, either by an attached label or the color of the cartridge itself. CBRN protection is indicated by an olive color.

CBRN APERs are available in two different types. Negative-pressure models have a cup that fits over the mouth and nose. The wearer draws in filtered air through the cup and exhaled air exits through an exhalation valve. Positive-pressure APERs have an integrated fan that draws air through the filter and fills the hood. The wearer breathes the filtered air circulating around his or her head. An exhaust valve maintains the interior of the hood at a higher pressure than the outside air. There are advantages and disadvantages for each type. For example, positive-pressure devices may be easier to use and have the advantage that small breaches in the neck seal would not allow contaminated air to enter the hood. However, they require batteries for operation. Negative-pressure APERs do not require batteries and usually cost less, but breathing may be more difficult, especially for someone with a respiratory illness.

2.2 Standards/Regulations

The U.S. Centers for Disease Control and Prevention (CDC), National Institute for Occupational Safety and Health (NIOSH) has published a performance test standard for CBRN APERs². Products submitted voluntarily by manufacturers are tested by the NIOSH National Personal Protective Technology Laboratory (NPPTL) to ensure that they meet acceptable levels for protection against CBRN agents.

The performance tests involve 10 chemical contaminants such as organic vapors, acid gases, ammonia, sarin, sulfur mustard, and a range of particulates. Environmental and durability tests evaluate the product's storage packaging. Other tests cover breathing resistance, field of view, fogging, and donning time. In a category called practical performance, trained users evaluate human interface components such as the use of breathing interfaces, the hood seal around the neck, and the strength required to don. APERs submitted for approval for carbon monoxide protection are also tested for flammability and heat resistance.

Products that meet the standard requirements receive an alphanumeric Testing and Certification (TC) approval number of the form TC-14G-0000, where 14G designates the applicable set of standards, and the last four digits after the dash are a unique identification number assigned by NIOSH. In addition, the NIOSH approval indicates a capacity level of protection rating of 15, 30, 45, or 60 minutes, which is the amount of time that the product would provide protection. For example, respirators receiving approval for a 30-minute duration rating are marked:

“ESCAPE ONLY NIOSH CBRN 30.”

Respirators receiving approval for a 30-minute duration rating with carbon monoxide protection are marked:

“ESCAPE ONLY NIOSH CBRN 30 with Carbon Monoxide.”

¹ American National Standards Institute, ANSI Z88.7-2010 *Color Coding of Air-Purifying Respirator Canisters, Cartridges, and Filters*

² *Statement of Standard for Chemical, Biological, Radiological and Nuclear (CBRN) Air-Purifying Escape Respirator* is found at www.cdc.gov/niosh/npptl/standardsdev/cbrn/escape/standard/aperstd-a.html (accessed Dec 10, 2014)

A list of certified CBRN APER equipment is posted at the NPPTL Certified Equipment List (CEL) website, www.cdc.gov/niosh/npptl/topics/respirators/CEL/default.html.

2.3 Features of CBRN APERs

While all NIOSH-certified CBRN APERs have demonstrated compliance with NIOSH standards, their designs vary. Performance requirements may be achieved with different hood and cartridge designs, and additional features and details can vary among products. These variations are additional factors to consider in product selection.

For example, the NIOSH certification process tests a device’s anthropomorphic features using neck circumferences ranging between 12 and 18 inches. Most products come in one “universal” size that spans this range. Additionally, some products are offered in sizes beyond the NIOSH certification range, i.e., neck sizes less than 12 inches or more than 18 inches. Selecting a product with appropriate sizing options involves consideration of both user fit and storage approach. For example, at some workplaces, APERs may be stored at a central location and nested together in a cache, while in others they may be assigned to individuals and kept at their workstations.

NIOSH certification requires that, when fully donned, the respirator should function properly without the wearer having to use his or her hands to maintain the correct respirator position. Head straps of varying design may be used. Some products have elastic, harness-style straps inside the hood, and others have adjustable straps on the outside of the hood. There are advantages and disadvantages of each strap style. For example, external straps may have the potential to catch on objects during the user’s escape, while internal straps could be harder to position under the hood.

NIOSH certification testing verifies that the product’s filters are effective against CBRN contaminants for specified concentrations and time periods, but the filter/cartridge design is left up to the manufacturer and varies among products. The cartridge shape may be cylindrical or rectangular, and its location on the hood varies. In some negative-pressure products, a single cartridge protrudes from the center in front of the mouth, while in others dual cartridges are positioned at angles on either side of the mouth; how far they protrude also varies. In positive-pressure designs, the filter rests on the upper part of the chest, along with a fan.

An important component of CBRN APERs is the hood design. The hood seals out contaminated air and provides dermal protection for the head. Typically, a neck seal is built-in at the base of the neck, and the user stretches the neck seal to fit over the head. Users who wear glasses must use care to stretch the seal over their glasses. Long hair that extends onto the neck may interfere with the seal; one solution is to use an elastic band to tie back long hair before donning. Hoods include a clear window for vision, and some are treated to reduce fogging. In addition to product design details that affect donning and vision, some products also include reflective markings on the outside of the hood that could serve as a rescue aid by making the hood more visible to others.

Product differences may also be found in the respirators’ storage package configuration. NIOSH certification verifies that a CBRN APER’s “ready-to-use” configuration can pass various environmental, vibrational, and drop tests. The ready-to-use configuration refers to the manufacturer-provided sealed package that would be opened to allow the user to immediately don the respirator. This is typically a hermetically sealed Mylar foil packet. It is tested by

NIOSH at 24°F for 3 days and at 160°F for 5 weeks. The manufacturers' recommended long-term storage temperature range (e.g., for a 5-year shelf life) varies and may be different from the NIOSH test conditions. Package design details may also vary: the inner package may include a notch for ease of opening, and it may also include graphical instructions to remind the user how to don the hood. The sealed packet typically comes with a hard-sided or soft-sided storage case that also varies among brands. For example, external cases vary in size and shape, and some may have straps for carrying or wearing the respirator on the leg or shoulder. Thus, temperature storage requirements, and the weight, shape, and dimensions of the outer package may be considerations for product stockpiling and use.

NIOSH certification requires that APERs have associated product-specific training requirements, including training systems and an instruction manual that explains donning procedures, use, and limitations. Manufacturers may also offer posters and instructional videos. Since the CBRN APER is a single-use device, units intended for use in an emergency must remain unopened and cannot be used for practice. A practice model of the respirator is required to allow the user to experience the product's donning procedure and breathing resistance.

2.4 Applications and Limitations of CBRN APERs

Escape respirators are designed for a single, emergency use, to be quickly donned and worn for a short time, 15 minutes to 1 hour. As their name implies, CBRN APERs are used to escape from, not to enter, a dangerous atmosphere. They are not adequate for responder operational use involving entry into dangerous atmospheres—SCBAs would be used in these missions. CBRN APERs could be prepositioned in high-risk locations for self-rescue during emergency situations, issued in workplaces for emergency preparedness, or used in high-rise or safe-haven rescues where shelter-in-place is not an option. Current users of CBRN APERs include public safety, emergency management, law enforcement, emergency medical service, government administrative, military contractor, hazardous material, transportation, chemical processing, and oil and gas extraction and refining personnel.

Several limitations are important to consider before purchasing or using CBRN APERs. Since they do not include an air supply, CBRN APERs are not designed for use in an oxygen-deficient environment. In an atmosphere without sufficient oxygen, someone wearing a CBRN APER could suffocate. Also, unless specified for dual use, CBRN APERs are not for use in escaping a fire. The CBRN filters are not effective against carbon monoxide and could become clogged by smoke particles, and the hood may not be heat resistant. (Carbon monoxide protection requires a separate certification: some CBRN APERs may have this additional certification.)

Another limitation is that the filter capacity depends on the contaminant concentration and how hard the wearer is breathing. Filters may become overloaded in atmospheres with high CBRN contaminant concentrations. Also, while an APER can protect from inhalation hazards, some chemicals may be absorbed through the skin. Additional protective clothing may be needed for safe escape. After use, special handling and disposal procedures must be followed to avoid contact with CBRN agents deposited on the APER.

Storage conditions are another important consideration. CBRN APERs must be stored in the manufacturer-specified minimum packaging configuration, which typically includes an airtight filter package that must remain intact until the filter is needed for use. Even if sealed, the filters have a finite shelf life, typically 5 years.

Because of individual human variations, performance can vary among users. Small or large necks may be difficult to fit. Breathing through a respirator is more difficult than normal breathing in open air, so some people, such as those with respiratory ailments (e.g., asthma or emphysema), the elderly, and people with claustrophobia may have trouble using a CBRN APER. Also, vision may be affected since the hoods can be difficult to don and wear with glasses and may become fogged due to perspiration or condensation. The hood may also impede verbal communication during an emergency.

Due to these limitations, the improper use of CBRN APER could result in injury or death from the respirator itself; proper use requires product-specific training and practice.

3. PRODUCT INFORMATION

This section provides information on five CBRN APERs that range in price between \$205 and \$357. Table 3-1 compares key features, and the following sections provide more information about each product. Product information is based on information gathered between October and November 2014 from manufacturers, Internet research, and a government-issued Request for Information (RFI) that was posted on the Federal Business Opportunities website. The information has not been independently verified by the SAVER Program. Clarifications of certain specifications in Table 3-1 are provided below, listed in column order.

Pressure may be negative or positive and distinguishes the two different designs of APERs. In negative-pressure APERs, the wearer draws in filtered air through a cup that fits over the mouth and nose. In positive-pressure APERs, the wearer breathes air that fills the hood via an integrated fan which draws air through the filter.

Capacity is the time duration of protection, in minutes, for which the product received NIOSH certification.

Weight refers to the weight of the product in pounds as worn by the user, i.e., not in its storage package.

Storage Temperature Range is that recommended by the manufacturer for a 5-year shelf life.

Extra Sizes indicates if additional sizes are offered beyond the standard 12- to 18-inch neck circumference. Where available, the neck sizes are shown in parentheses.

Straps are used in some products to hold the respirator on the wearer's head. They may be internal or external to the hood, and "none" indicates that straps are not used.

Reflective Markings are designed to make the hood easier to be seen by others to aid in rescues. "Yes" means that the product has this feature, "no" means that it does not.

Table 3-1. CBRN APER Specifications

| Manufacturer | Product | Price (\$) | Pressure | Capacity (min) | Weight (lbs) | Storage Temperature Range (°F) | Extra Sizes (inches) | Straps | Reflective Markings |
|--|-----------------------------|------------|----------|----------------|--------------|--------------------------------|------------------------|----------|---------------------|
| Avon Protection Systems | NH15 Escape Hood | 205 | negative | 15 | 1.0 | 5 – 105 | XS (12–13) XL (>18) | internal | yes |
| Honeywell Safety Products USA, Inc. | ER2000CBRN | 267 | negative | 30 | 1.3 | 0 – 120 | none | external | yes |
| ILC Dover, Inc. | SCape CBRN ³⁰ | 249 | positive | 30 | 1.9 | 0 – 130 | none | none | no |
| | SCape CO/CBRN ³⁰ | 299 | positive | 30 | 1.9 | 0 – 130 | child/infant | none | no |
| Mine Safety Appliances | CBRN Safe Escape Resiprator | 357 | negative | 15 | 2.8 | 0 – 120 | none | internal | no |

3.1 Avon Protection Systems NH15™ Escape Hood

The NH15 Escape Hood is priced at \$205. This is the smallest and lightest NIOSH approved escape hood, weighing 1 pound when worn. It is a negative-pressure system that provides 15 minutes of protection. The filter components are activated charcoal and a high-efficiency particulate air (HEPA) filter. Low-profile filters protrude only 2 inches from the face and are balanced on the user's head. The design is intended to reduce snagging and delay in donning.



NH15 Escape Hood
Image courtesy of Avon Protection Systems

The close-fit filters combined with self-adjusting internal harness straps are intended to enhance comfort and security by offering a correctly fitted hood. The NH15 provides a clear range of vision and includes an anti-fog coating on the visor. A reflective label on the hood allows users to be easily seen by rescue teams with emergency lighting. The NH15 is wearable with long hair and with glasses. Regular size models (number 70527-100) fit neck circumference sizes between 13 and 18 inches. Hard-to-fit sizes are also available: an extra small (model number 70527-104) is for neck sizes between 12 and 13 inches, and an extra-large (70527-107) is for necks greater than 18 inches.

The storage package contains a quick-don label to guide users in an emergency situation. In storage, the hood is vacuum packed in a four-layer foil bag surrounded by a reinforced nylon carrier with dimensions of 6 x 4 x 3.4 inches and weight of 1 pound 7 ounces. The product shelf

life is 5 years with a recommended storage temperature range between 5°F and 105°F. No maintenance or annual checks are required. A comprehensive training package is available, which includes digital video discs (DVDs), posters, PowerPoint slides, and training hoods. Volume purchase discounts are available.



NH15 foil package and nylon carrying case
Images courtesy of Avon Protection Systems

3.2 Honeywell Safety Products USA, Inc., ER2000CBRN

The ER2000CBRN is priced at \$267. It is a negative-pressure system that is NIOSH approved to provide 30 minutes of protection. It weighs 1.3 pounds as worn and uses activated charcoal and HEPA filters. The dual-cartridge design is ergonomically balanced for comfort, and the cartridge



ER2000CBRN

Image courtesy of Honeywell Safety Products

position is intended to avoid interference with vision. This product has a clear polyurethane hood, which is non-claustrophobic, and allows emergency personnel to identify the wearer. The large lens has a wide field of view and is non-fogging and scratch resistant without coatings. The head strap is located on the outside of the hood and is adjustable to provide secure fit during strenuous activities. A reflective stripe on the head strap helps guide rescue workers to victims. The flexible, contoured neck dam with beveled edge is pulled over the head to seal without constriction. The ER2000CBRN comes in one size that fits neck circumferences between 12 and 18 inches.

The storage package consists of an inner Mylar bag and an external carry bag made of insulated nylon with dimensions of 10 x 6 x 4.5 inches. The total weight is 1.7 pounds and includes an instruction sheet. The inner bag is pre-notched and laser-scored for ease in

opening, and the external bag includes belt loops that can be worn vertically or horizontally. No batteries or mechanical parts are used. The ER2000CBRN has a 5-year shelf life when stored between 0°F and 120°F. Training hoods and labels, manuals, a training DVD, posters, and on-site training are available.

The ER2000CBRN is on the General Services Administration pricing schedule GS-07F-0283W, and volume purchase discounts are available.



**ER2000CBRN inner mylar package
and outer nylon carry bag**

Image courtesy of Honeywell Safety Products

3.3 ILC Dover, Inc. SCape® CBRN³⁰ and CO/CBRN³⁰

The SCape CBRN³⁰ is priced at \$249. It weighs 1.9 pounds as worn and uses activated charcoal and HEPA filters. Its positive-pressure ventilation system is NIOSH certified for 30 minutes of protection. This product uses a powered air system—when it is removed from its storage container, a blower starts automatically and delivers 64 liters per minute of purified air to the



SCape CBRN³⁰

Image courtesy of ILC Dover, Inc.

user. This product does not require adjusting straps to stay in place. An integral exhaust valve regulates and maintains positive pressure within the hood. Since no nose cup is required, the wearer can readily communicate and use phones and other devices. A blower indicator-light shows that the product is operational. The SCape is intended to reduce claustrophobic feelings associated with hoods, and it aids breathing for those with respiratory issues. The clear hood and large visor allows the user to perform a wide range of tasks, including reading and driving, and allows total facial recognition. The SCape comes in one size. The positive-pressure design accommodates beards, glasses, and long hair.

The storage package includes visual donning instructions. It consists of a foil bag surrounded by a fabric pouch wrapped in a plastic tub container. The SCape CBRN³⁰ has a 5-year shelf life with a storage temperature range between 0 and 130°F.

Another model, the SCape CO/CBRN³⁰ provides the same CBRN protection as the SCape CBRN³⁰, while offering additional protection against carbon monoxide. It is priced at \$299. This product also comes in children and infant sizes, where the infant version is for children younger than 3 years of age.

Both products are made in the United States and are on the General Services Administration pricing schedule GS-07F-342AA. Volume purchase discounts are available.



SCape CBRN³⁰ in storage container

Image courtesy of ILC Dover, Inc.



SCape CO/CBRN³⁰

Image courtesy of ILC Dover, Inc.

3.4 Mine Safety Appliances CBRN Safe Escape™ Respirator

The CBRN Safe Escape respirator is priced at \$357. It is a negative-pressure system that is NIOSH certified for 15 minutes of protection. It weighs 2.8 pounds as worn and uses activated charcoal and HEPA filters in a cylindrical canister. Inhaled air flows through the canister directly into the nose cup. Inlet check-valves maximize filter performance, and exhaled air exits through



an exhalation valve. The canister is permanently bonded to the respirator coupling in a secure connection. The translucent hood has a one-piece, large, bonded lens that offers a wide field of view and is intended to reduce claustrophobia. It includes inside-the-hood, self-adjusting, cradle-type head straps. The hood has a soft, high-stretch rubber neck seal that conforms to neck contours. An elastic hair tie is included on the package to secure long hair before donning the respirator.

The respirator is stored in a foil bag inside a black polyethylene case with a distinctive hexagonal shape. The hexagonal shape allows the cases to nest together for easy group caching and provides strong but lightweight storage. A multipurpose carrying strap can be used for the leg or shoulder. The storage container is 6.75 x 6 x 12.5 inches in size and weighs 3.3 pounds. The shelf life is 5 years with a storage

CBRN Safe Escape Respirator
Image courtesy of Mine Safety Appliances

temperature range between 0 and 120°F. Available training options include onsite training, practice hoods, instruction manuals, and online training.

Volume purchase discounts are available. The CBRN Safe Escape respirator is available on the GSA pricing schedule GS-07F-5530P.



**CBRN Safe Escape Respirator in hexagonal storage case (left)
 and shown worn on the leg (right)**

Images courtesy of Mine Safety Appliances

4. MANUFACTURER CONTACT INFORMATION

Additional information on the CBRN APERs included in this market survey report can be obtained from the manufacturers listed in Table 4-1.

Table 4-1. Manufacturer Contact Information

| Manufacturer | Address Phone Number | Website |
|-------------------------------------|--|--|
| Avon Protection Systems | Hampton Park West Melksham, Wiltshire SN12 6NB United Kingdom +44 1225 896000 | www.avon-protection.com |
| Honeywell Safety Products USA, Inc. | 900 Douglas Pike Smithfield, RI 02917 (614) 554-3218 | www.honeywellsafetyproducts.com |
| ILC Dover, Inc. | One Moonwalker Road Frederica, DE 19946 (302) 355-3911 x 506 | www.ilcdover.com |
| Mine Safety Appliances | 1000 Cranberry Woods Dr. Cranberry Township, PA 16066 (540) 383-6689 | www.minesafety.com |

5. SUMMARY

This market survey report provides information on five NIOSH-certified CBRN APERs ranging in price between \$205 and \$357 and offering 15 or 30 minutes of protection. They differ in design, have various filter and hood configurations, and weigh between 1 and 2.8 pounds. Three are negative-pressure and two are positive-pressure designs. All are available in a universally sized model to fit adults with neck circumference sizes between 12 and 18 inches, while two are also offered in additional sizes. All have a 5-year shelf life, although the upper end of the temperature storage range varies among the products and is between 105°F and 130°F.

Agencies that consider purchasing CBRN APERs should carefully research each product’s overall capabilities and limitations in relation to their agency’s escape and preparedness plans.