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PPE Update

How good are firefighter SCBAs at keeping chemicals out?

SCBA's ability to ward off external chemicals was greatly enhanced in 2007; now they'll be tested to find out just how good they are

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Since its full introduction into mainstream firefighting, SCBA have protected firefighters and have led to sustained aggressive, interior-attack fireground tactics under ever-changing and extreme circumstances.

SCBA are further used in a variety of operations potentially involving IDLH conditions such as hazardous-materials response. SCBA must therefore provide resist not only the effects of high heat and physical abuse, but retain their integrity and prevent any hazardous substances from leaking inward and contaminating the breathing air.

It was not long after 9/11 that research was stepped up to examine just how well SCBA prevented the inward leakage of chemicals through the various components, namely the facepiece seal and lens, regulator materials, exhalation valves, high-pressure hoses, and connectors. The research conducted by the National Institute for Occupational Safety and Health and the Edgewood Chemical Biological Center resulted in new standards for defining CBRN (chemical, biological, radiological and nuclear) protective respiratory devices.

This protection focuses on the more insidious threat of exposure to chemical warfare agents. The NIOSH standards created sophisticated test methods using a vapor and liquid involving live chemical warfare agent exposures on sample SCBA mounted on a breathing manikin where the breathing air is monitored for permeation of the chemicals.

In the 2007 revision of the NFPA 1981 standard on SCBA, the CBRN criteria were made permanent for all fire service SCBA. Although the committee responsible for the standard recommended that such

requirements be optional, an overwhelming number of firefighters and fire service organizations supported mandatory requirements.

The reasoning was that firefighters were truly the first responders to any terrorism incident and that their equipment should provide a level of protection for the likely hazards they may face in these situations.

CHEMICAL AGENT TESTING

The tests results showed that chemical warfare agents could get into SCBA at dangerous levels. The industry had to change its materials and designs for fire service SCBA to conform to the new requirements.

The NIOSH-specified testing that is currently performed at ECBC entails separate evaluations with two chemicals: sarin and distilled mustard. Both are classical chemical warfare agents.

Sarin, a nerve agent, is tested as a vapor at a concentration of 2,000 milligrams per cubic meter (350 parts per million). In contrast since it is a lower volatile blister agent, distilled mustard is tested both as a vapor at a concentration of 300 milligrams per cubic meter (46 parts per million) and as a liquid with the placement of 43 20-microliter liquid droplets distributed over the principal components of the SCBA protecting the breathing air.

These chemicals are the two more common warfare agents; the exposure levels are also set based on research for what would be anticipated during a terrorism event. Testing SCBA in this fashion gives rise to the expectation that the SCBA is adequately designed to protect against exterior environment chemicals permeating through its key materials.

Historically, only limited chemical testing has been carried out on SCBA against more conventional hazardous such as toxic industrial chemicals. These chemicals, such as ammonia, chlorine and hydrogen sulfide, tend to be smaller molecules and thus should more easily permeate as compared to the larger chemical warfare agents.

DIFFICULT TESTING

Yet, this testing is difficult to perform because most material tests — such as those applied for chemical protective clothing — require small flat samples that can be placed in a test cell for measuring permeation. Most SCBA components are either curved or have varying thicknesses that make testing in this way impractical.

Moreover, one consideration for the effectiveness of SCBA in providing the permeation resistance against exterior chemical exposures is that air passing through the system and being continually replenished and exhausted reduces any risk of exposure.

In testing performed by the IAFF in early 2015 evaluating the entire structural firefighting ensemble involving SCBA against a particle-laden environment intended to represent a heavy smoke exposure showed that the SCBA facepiece adequately prevented any particle infiltration. This evidence suggests

that the SCBA functions extremely well to prevent most contaminants from getting into the breathing air supply.

Still, there is an increasing use of SCBA on the exterior of protective ensembles for chemical protection. In hazardous materials response, many choose between Level A vapor-protective suits and Level B liquid splash-protective suits, which both use SCBA.

The principal difference is that most Level A ensembles are fully encapsulating, enclosing both the wearer and the SCBA. On the other hand, Level B ensembles have the SCBA on the outside of the clothing system.

The vast majority of hazardous material exposures involve Level B exposures and there are several types of ensembles that meet the NFPA 1994 standard for CBRN that are now popular for hazardous materials responses. Many of these use clothing configurations where the SCBA is worn on the outside of the ensemble primarily to provide a more form fitting and functional design of the clothing.

NEW TESTING

As the materials used in the clothing are rigorously tested for chemical compatibility and permeation resistance, the same cannot be said for SCBA. Therefore, there are questions concerning how well SCBA hold out chemicals under both these circumstances and other IDLH environments.

These questions are about to be answered in new government-sponsored research. Like the NIOSH/ECBC testing, the plan is to evaluate full SCBA for effectiveness against selected chemical exposures.

These exposures could involve a myriad of different hazardous chemicals, yet it is impractical to evaluate a large number of chemicals given the expense of not only the equipment that the testing itself. Therefore, there is interest in determining which chemicals should be the priorities for any form of respiratory system testing.

The research project extends into the evaluation of other types of respirators that are sometimes used in hazardous materials response such as powered air-purifying respirators and ordinary air-purifying respirators. Thus, the research team is interested in getting any end user feedback through this short on-line survey.

This survey is mainly intended for SCBA end users that have worn hazardous materials protective ensembles, where the SCBA has been positioned on the outside of the ensemble.

It is believed the most fire service SCBA will perform well against the industrial chemicals given the hardening that resulted after CBRN chemical agent testing was added to NFPA 1981 in 2007. Nevertheless, the testing is intended to prove or disprove that SCBA are as good as we believe they are.

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About the author

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Jeffrey and Grace Stull are president and vice president, respectively, of International Personnel Protection, Inc. They are members of several NFPA committees on PPE as well as the ASTM International committee on protective clothing. Mr. Stull was formerly the convener for international work groups on heat/thermal protection and hazardous materials PPE as well as the lead U.S. delegate for International Standards Organization Technical Committee 94/Subcommittees on Protective Clothing and Firefighter PPE. They participate in the Interagency Board for Equipment Standardization and Interoperability and have authored the book, "PPE Made Easy." Send questions or feedback to the Stulls via email.

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