Homeland Security
Science and Technology

TechNote

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 assessments and validations 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?"

For more information on this and other technologies, contact the SAVER Program by e-mail or visit the SAVER website.

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NUSTL

Self-Contained Breathing Apparatus, Full Facepiece, Closed Circuit

The full-facepiece, closed-circuit (CC) self-contained breathing apparatus (SCBA) is designed to protect personnel in hazardous, toxic, or oxygen-deficient environments. The CC-SCBA recirculates breathing air and purifies it, removing carbon dioxide and adding fresh oxygen. CC-SCBAs are mostly utilized by emergency responders operating in hazardous materials remediation, mine and tunnel rescue, and special missions.

Background

SCBA systems are used when emergency responders need to have a supply of breathable air to work in fouled atmospheres that may pose an imminent danger to health and life. SCBA systems fall into two general categories: open-circuit (OC) and closed-circuit. Open-circuit SCBA systems provide air via a high-pressure tank and exhaust exhaled air to the atmosphere. CC-SCBA systems (Figure 1) recirculate and recycle exhaled gas and are sometimes referred to as rebreathers. CC-SCBAs are used when a longer-duration supply of breathing gas is needed or when responders require a system with a smaller footprint than the OC-SCBA, which has a large air cylinder. CC-SCBAs also weigh less than OC-SCBAs because they use a smaller cylinder that contains pure oxygen. The full-facepiece mask of a CC-SCBA holds in the breathing air and is designed to provide some protection from the operational environment.

Figure 1. Biomarine Biopack 240 Revolution

Figure courtesy of Fire Rescue Safety Australia (FRSA)

Technology Overview

CC-SCBAs allow users to recycle their exhaled breath by absorbing the carbon dioxide produced and adding oxygen to replace that which has been metabolized. The addition of oxygen is necessary since continued rebreathing of the recycled gas depletes oxygen; therefore, the gas must be replenished with oxygen to maintain the required concentration.

Addition of oxygen to the recycled gas must be done in conjunction with the removal of carbon dioxide. Buildup of carbon dioxide in the recycled gas could initially result in mild respiratory distress and rapidly develop into carbon dioxide toxicity. CC-SCBAs use carbon dioxide scrubbers to chemically remove the carbon dioxide from the recycled air.

CC-SCBAs have two basic gas-passage configurations: the pendulum and the loop. The pendulum configuration is used mainly for underwater diving and will not be discussed here. The loop configuration is used for

emergency responder applications and consists of a gas-tight loop for the responder's inhalation and exhalation. The loop comprises a mouthpiece and full-facepiece mask connected to one or more tubes that duct inhaled and exhaled gas between the user and a counterlung, or breathing bag. The breathing bag holds gas when it is not in the user's lungs. Air passes through a scrubber containing carbon dioxide absorbent to remove the carbon dioxide exhaled by the user. Attached to the loop is a valve to allow for the addition of oxygen from the storage tank. The loop may also contain valves that allow the venting of gas.

The loop configuration has one-directional circulation of the breathing gas (Figure 2). On exhalation, the gas leaves the mouthpiece, passes through a nonreturn valve into the exhalation hose, and then through the carbon dioxide scrubber and counterlung, to return to the mouthpiece through the inhalation hose, where oxygen is added, and then through another nonreturn valve when the user inhales. The Dräger PSS® BG 4 CC-SCBA is an example of this type of loop configuration.

The breathing circuit operates at slight positive pressure, which protects the wearer by preventing hazardous substances from entering the breathing system. The CC-SCBA system can be used from 30 minutes to 4 hours, depending on the application. In contrast, OC-SCBAs can only be used for a maximum of 75 minutes.

Many CC-SCBAs have coolers for the gas in the breathing loop. The absorbent produces heat when it reacts with carbon dioxide, and the resulting warm gas may be uncomfortable to emergency responders in hot operational environments. Cooling is usually done with air coolers that can be filled with ice, or with electronic coolers.

Figure 2. Loop Configuration on Dräger PSS® BG 4

Figure adapted courtesy of Dräger

Considerations

Depending on the operational needs, emergency teams may want CC-SCBAs equipped with special features. For example, systems used in fire scenarios need to be reasonably heat and fire resistant. Special coatings may be applied to CC-SCBA systems that may be used in corrosive environments. Systems may need to be reinforced against other elements that might be encountered in operational situations, such as falling debris.

CC-SCBAs are more expensive than OC-SCBAs, in general. Additionally, the maintenance of CC-SCBAs, including the need to periodically replace components, can also add to the overall cost of the system. They require thorough inspection before each use. For safety, responders must be trained before using CC-SCBAs to ensure they are operating the systems correctly.

Facepieces are usually equipped with harnesses to adjust to various face shapes and have a dual-sealing line to ensure a tight fit. Other features of facepieces include optimized viewports for an improved field of vision and, sometimes, a wiper. Some masks provide a drinking system that allows the wearer to drink through a straw. The system is activated when a biting valve is pressed together by the teeth.

Newer models of CC-SCBAs feature electronic monitoring, notification, and warning systems that will alert if any vital breathing apparatus functions start to fail. These systems may automatically record mission data, and indicate cylinder pressure, temperature, and remaining duration of use.

Standards and Requirements

The U.S. Centers for Disease Control and Prevention's National Institute for Occupational Safety and Health (NIOSH) has a program to approve CC-SCBAs for use by emergency responders. Since CC-SCBAs use pure oxygen and positive pressure, they are required to show resistance to high radiant heat and open flames to be exempted from NIOSH's prohibition of operating CC-SCBAs in firefighting applications.

There is currently no Chemical, Biological, Radiological, and Nuclear (CBRN) standard for CC-SCBAs; however, NIOSH is working to produce a CBRN standard. Until such a standard becomes available, purchasers are urged to carefully review test data provided by manufacturers.