Two New Pieces of Emergency Response Equipment for Use in Confined Space Environments

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The needs of emergency response equipment for use in a confined space environment (like a space craft or a submarine) are different from the needs of traditional first responders. Traditional first responders generally come from an environment outside the affected area, respond to the emergency for a limited duration, and then retreat to a safe and habitable environment. In a confined environment, like a mine or a submarine, or a spacecraft, the first responders to an emergency are likely in the affected environment, and likely have no safe and habitable environment to retreat to.

NASA is developing two new pieces of emergency response equipment that recognize and address the constraints of a confined space environment. One piece of equipment is a respirator designed for use in a post fire environment. Traditional first responders generally use supplied air respirators – they provide cool, dry, safe breathing air to the first responder, and because they are supplied at above ambient pressure, the system is tolerant to a loose-fitting mask. Supplied air respirators have a limited supply of air, but because the traditional first responder intends to address the emergency from outside and then retreat, this limited air supply does not pose a serious problem. NASA uses a supplied oxygen respirator for first response to an emergency affecting air quality on the International Space Station. The air supply is rated for 15 minutes – ISS program managers sponsored a hardware development activity to provide the astronauts up to 8 hours of breathing protection after the supplied air system is exhausted. Size and weight limitations prevent the use of a supplied air system for 8 hours for six crew members. A trade study resulted in the selection of a filtering respirator system over a re-breather system; due to design simplicity, operational simplicity, and likely threats to air quality on ISS. The respirator cartridge that filters smoke particles, adsorbs organics and acid gases, and catalytically converts carbon monoxide to carbon dioxide has been qualified for use on ISS, and was delivered on STS-135, the final mission of the Space Shuttle Program.

The ISS presently uses a carbon dioxide based fire extinguisher. Each fire extinguisher contains 6 lbs of CO_2 product. The filtering respirator does not remove carbon dioxide, so a crew member wearing a filtering respirator, or a crew member who discharges a CO_2 extinguisher before donning a supplied oxygen respirator risks exposure to extremely high levels of CO_2. To address the disconnect between PPE and fire extinguisher, ISS program managers sponsored an effort to develop a fire extinguisher that uses fine water mist technology to extinguish the fire. Tests have shown that fine water mist can penetrate into sequestered places, and can extinguish a fire (by quickly removing heat from the fire environment) without creating a large plume that is not safe to breathe. The design philosophy behind fine water mist is that a fire extinguisher should be; “safe for the crew, safe for the vehicle, and effective at putting out fires.”

This paper describes the design, and reports the performance of the fire response respirator, and the fine water mist fire extinguisher. This hardware may be useful in a submarine environment.