1000 FREDERICK LANE, MORGANTOWN, WV 26508 · 304.285.5916

Career Probationary Firefighter Dies During SCBA Confidence Training at Fire Academy – New York

Executive Summary

Tunnel Prop (Photo by NIOSH)

On March 12, 2021, a 21-year-old career probationary firefighter (PF) died nine days after a medical event during a training exercise. The PF was maneuvering through a self-contained breathing apparatus (SCBA) course training prop when he experienced a medical emergency and lost consciousness. The incident occurred while attending an eleven-week firefighter training academy. Week three of the curriculum is focused on firefighter survival and SCBA confidence training. At the end of the week, confidence in these skills is evaluated by completing a maze containing various obstacles while wearing firefighter personal protective equipment (PPE), and SCBA with a blackout cover over the facepiece. The blackout cover simulates zero visibility conditions that may be present during live fire encounters. On March 3, 2021, after two days of physically strenuous training, the PF spent the morning shift practicing individual obstacles to prepare for the maze. These obstacles included two window bail-out props, two stud-wall props to simulate stud channel escapes, and a 24-inch by 20-foot smooth bore plastic culvert tube with an 18-inch tube of the same material inserted. The 18-inch tube simulates a diminishing clearance profile within the 24-inch space. The PF reportedly struggled maneuvering through this prop during his morning practice when he had to doff and then don his SCBA pack while moving through the culvert tubes and the diminishing clearance profile. Once completed, the PF went for lunch. Recruit interviews reveal varying reports of the PF appearing nervous, pale, sweaty and cramping at different times during the late morning and while at lunch. Some reported that the PF had vomited during the lunch period. The afternoon training session continued with negotiation of the escape and confidence props practiced during the morning. In addition to the props from the morning session, a 21-feet-long wooden entanglement and obstacle confined space tunnel prop (tunnel prop) was added (see photo). While in the tunnel prop, the PF stopped moving. The instructors provided coaching to encourage the PF to continue moving through the prop, and assistance with displacing equipment interfering with forward movement. When forward movement did not continue by the PF, the instructors pulled him partially from the tunnel prop to ensure no gear or equipment were obstacles, leaving his lower extremities within the tunnel prop, and continued to coach him through. When the PF continued to not move, the instructors pulled him completely from the prop, removed his facepiece, and provided a rapid

assessment. The PF was identified as not breathing and having no pulse. The instructors began cardiopulmonary resuscitation (CPR). The PF was transported to a local hospital (Hospital A) where return of spontaneous circulation (ROSC) was achieved. The PF was transported by medical helicopter to a trauma center (Hospital B). The PF was diagnosed with anoxic brain injury and remained on a ventilator in the intensive care unit. After nine days, based on physical examination findings and brain imaging studies, the PF was declared brain dead and pronounced deceased at 1319 hours on March 12, 2021.

The death certificate issued by the county's chief deputy coroner stated that death "…is ascribed to anoxic brain injury from a cardiac arrest that occurred as a consequence of physical exertion during SCBA training. The autopsy examination did not reveal an anatomic cause for the cardiac arrest and genetic testing did not show mutations known to be associated with arrythmia."

Contributing Factors

- *A patent airway was not maintained from the period of the PF's initial collapse in the tunnel prop until a definitive airway was established via endotracheal intubation on arrival at Hospital A*
- *Ineffective rehabilitation and medical monitoring were conducted and not in accordance with written policy*
- *Lack of a designated safety officer placed safety responsibilities on the instructors at the respiratory protection training evolutions*
- *Lack of standard operating procedures (SOPs) and instructional objectives that specify actions to be taken by instructors and recruits when personal alert safety system (PASS) and End-of-Service-Time-Indicator (EOSTI) devices are engaged and alarming during training evolutions*
- *Lack of a written risk management plan to address administrative controls that includes manufacturer recommended training on limitations of structural gear and SCBA and heat-related illness recognition and reporting*
- *Lack of instructional objectives developed and communicated for each activity of the evolution based on the institution's written Job Performance Requirement (JPR)*
- *Lack of comprehensive SOPs for each training prop and associated drill.*

Recommendations

Adhere to certification requirements for Basic Life Support (BLS) for Healthcare Providers, either through American Heart Association or American Red Cross, which require a clear and open airway and assisted ventilations with an oxygen source to prevent anoxic brain injury in a person in respiratory arrest

Fire training facilities should ensure use of a comprehensive rehabilitation program complying with National Fire Protection Association (NFPA) 1584, Standard on the Rehabilitation Process for Members During Training Exercises [NFPA2015]

Fire training facilities should appoint a safety officer to review the planned training exercises and actively observe all training activities

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PASS and the EOSTI activations during training should be addressed in training SOPs and instructional objectives should be outlined in training SOPs and repeated during pre-training safety briefings

Fire training facilities should implement a systematic risk management process in all activities, and ensure that it includes training on structural gear and SCBA limitations and heat-related illness recognition and reporting

Fire training facilities should ensure instructional objectives are developed and communicated for training evolutions intended to satisfy a job performance requirement and ensure instructors follow compliance with instructional objectives and reasons associated with deviation from the objective(s)

Fire training facilities should ensure that SOPs for each skill/drill are developed and implemented.

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Introduction

On March 12, 2021, a 21-year-old male career probationary firefighter (PF) died nine days after losing consciousness while maneuvering through a 21-feet-long wooden confined space entanglement and restricting profiles tunnel prop (tunnel prop) during an 11-week firefighter training academy. On March 12, 2021, the U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. On April 13-21, 2021, a general engineer, a safety and occupational health specialist, and a technical information specialist from the NIOSH Fire Fighter Fatality Investigation and Prevention Program traveled to New York to investigate this incident. The NIOSH investigators met with fire academy officials, including two deputy state fire administrators, the deputy chief of fire training, and members of the fire academy's staff. The NIOSH investigators visited the incident site and conducted interviews with the fire academy's state fire instructors and the recruit firefighters that were present when the incident occurred. The NIOSH investigators also met with two New York Department of Labor, Public Employee Health and Safety Bureau investigators and the lead New York State Police Investigator. The NIOSH investigators travelled to meet with the PF's fire chief, his staff, the International Association of Fire Fighters local president, SCBA manufacturer representatives, and the parents and fiancé of the deceased. The NIOSH investigators inspected and photographed the PF's PPE and SCBA. They also reviewed department training records and SOPs. NIOSH investigators continued the interview process at a county fire academy where numerous recruits from the PF's class had transferred. There they also met with one state fire instructor from the fire academy. On April 21-23, 2021, the NIOSH technical information specialist travelled to the Albany, NY area to interview other key state fire instructors that were at the academy on the day of the incident. Judith Eisenberg, MD, MS, Medical Officer Board Certified in Emergency Medicine, with the Fire Fighter Fatality Investigation and Prevention Program, Hazard Evaluations and Technical Assistance Branch, Division of Field Studies and Engineering, NIOSH located in Cincinnati, OH, provided medical consultation in preparing this report.

State Fire Academy

The fire academy offers firefighter and emergency services training through on-site programs and outreach programs and offers national certification testing for Firefighter I and II, Fire Instructor I and II, and Fire Officer I and II. Annually, the fire academy trains approximately 30,000 firefighters, related governmental officers, and other emergency response personnel. The fire academy initiates certified training and instructor development to minimum standards, develops and revises training courses, develops and delivers programs to combat arson, and provides support to firefighting and code enforcement personnel standards and education commission. Approximately 4,500 of these firefighters participate in training held at the fire academy. Attendance at state sponsored training is restricted to personnel within the following categories:

- Career firefighters assigned by their fire department
- Other career emergency service personnel assigned by their agencies
- Active volunteer firefighters covered under the New York Volunteer Firefighters Benefit Law
- Employees of related private and commercial organizations who have optional third-party workers' compensation coverage.

The academy's recruit firefighter training course is a residential program conducted over an 11-week period, totaling approximately 500 hours of instruction. The PF was assigned to the course by his career fire department, where he joined 39 other recruit firefighters in the course. One recruit left the program after the first day. The class was divided into two battalions. There were 6 companies in each battalion. The PF was designated Battalion B, Company 7, Officer. There were 20 state fire instructors assigned to the recruit training course. An example of the course curriculum for battalion B is listed below. Each week begins with testing on topics from the previous week.

- Week 1 - Firefighter Training Series; Live Demo
- Week 2 - Candidate Physical Ability Test (CPAT) Simulation #1; Firefighter Training Series (continued); Skills testing
- Week 3 - SCBA Confidence; Firefighter Survival; Firefighter Advanced Survival Techniques (FAST); Skills evaluation
- Week 4 - Flammable Gas Emergency Response Workshop; Flammable Gas Practical; Emergency Vehicle Operations Course (EVOC) lecture; EVOC Driving Course and Skills; Wildland Firefighting
- Week 5 – Accident Victim Extrication Training; Vehicle Fires; CPAT Simulation #2; Skills Evaluations; National Fire Incident Reporting System and preplanning lecture
- Week 6 – Apparatus Operator/Pump; Live Fire/Fire Attack
- Week 7 – Hazardous Materials First Responder Operations; Confined Space Awareness; Electrical Safety; Skills evaluation and Firefighter I National Certification Exam
- Week 8 – Truck Company Operations; Live Fire/Standpipe Operations; Skills evaluation
- Week 9 – Rescue Technician Basic; CPAT Simulation #3; Hazardous Materials First Responder Operations National Certification Exam
- Week 10 – Fire Prevention; Elevator Rescue; Firefighter's Guide to Lightweight Wood Construction; Firefighter II National Certification Exam
- Week 11 – Skills evaluation; Advanced Fire Control/Live Fire; CPAT and NYS Final Exam

State Firefighter Training Requirements

The State of New York Codes, Rules and Regulations 426: *Minimum Standards for Firefighting Personnel* [NYSDHSES 2008] requires the basic training of firefighters and temporary, probationary, and nonpermanent firefighters that are scheduled to be on duty an average of more than 20 hours per week to successfully complete a certified basic training program within 18-months of initial appointment. Temporary, probationary, and nonpermanent firefighters scheduled to be on duty an average between 10 and 20 hours per week are required to successfully complete a certified basic training program within 24-months of their initial appointment. Temporary, probationary, and nonpermanent firefighters scheduled to be on duty less than 10-hours per week are required to successfully complete a certified basic training program within 36-months of their initial appointment. Training may be suspended during periods of non-service, but all periods of service shall be counted toward the fulfillment of the applicable requirement.

NYSDHSES 2008 426.6 lists the overall minimum basic firefighter training as follows:
(a) Minimum basic fire training for probationary and nonpermanent firefighters shall consist of a minimum of 229-hours in approved courses
(b) Satisfactory completion of a basic training shall include a "candidate physical ability test" as specified in this Part.
(c) The courses shall be as set forth herein, with content at least the equivalent to that found in appropriate sections of the New York State fire training courses and shall be conducted for the minimum times specified herein, section, or until the indicated performance objective has been accomplished and measured by the chief of the fire department or his or her designee.

> (1) Local fire department rules, regulations, standard operating policies or procedures, communications systems, policies for receiving both personal and official phone calls, procedures to initiate an emergency response, general duties other than those covered in training for emergency operations and response. There are no hours established for this training, compliance is required.
> (2) Firefighting Skills. The firefighter shall demonstrate appropriate knowledge, skills, or abilities. (75 hours)
> (3) Fire Prevention. (24 hours)
> (4) Ladder Operations. (18 hours)
> (5) Pump Operations. (18 hours)
> (6) Basic Wildland Fire Suppression. (9 hours)
> (7) Rescue Operations. (21 hours)
> (8) Hazardous Materials First Responder Awareness and Operations. (16 hours)
> (9) Auto Accident Victim Extrication. (16 hours)
> (10) First Aid and Cardiovascular Pulmonary Resuscitation. (17 hours)
> (11) Incident Command System. (12 hours)
> (12) Candidate Physical Ability Test. There are no hours established for this element, compliance is required.
> (13) Health and Wellness (1 hour)

SCBA Confidence Week

Recruits are provided PPE, which includes all structural turnout gear and SCBA, by their sponsoring fire department. The third week of the recruit training is conducted in gymnasium area in a re-purposed barn which includes various skills/drills training stations. Drills are initially done on individual props and then put together into a circuit exercise. The end of the week's training culminates with a requirement that recruits successfully navigate a maze. There is an associated formal practical skills test matrix listing the conditions for successful completion of the SCBA Confidence maze requirement. The props used by the fire academy were constructed at the academy. As the recruit program developed, the design and number of the props and the length of SCBA confidence course increased. The tunnel prop was built from a ladder shipping box and was added to the training in 2018 (see Photo 1). The recruits do not have the opportunity to see or practice maneuvering through the tunnel prop. The first experience is while using an SCBA with a black-out cover over the facepiece.

Photo 1: Tunnel Prop made from a ladder shipping box
(*Photo by NIOSH)*

Training and Experience

The PF was a firefighter and currently served as an assistant chief for a local volunteer fire department. There he completed training in Fire Police in 2017, Truck Company Operations in 2019, and blended training in Basic Exterior Firefighting, Interior Firefighting Operations, SCBA, and Firefighter I over a 2-month period in 2019. He also was an associate member and firefighter with another local volunteer fire department while he attended college. The PF was offered a position as a career firefighter with a local career fire department on December 23, 2020. His first day on duty was February 1, 2021. He received fit testing for his SCBA facepiece, and completed training for the SCBA, first aid, cardiopulmonary resuscitation, and station procedures before being assigned to a line company. The PF's training records reflect he met the respirator medical evaluation requirements of 29 C.F.R. 1910.134, Respiratory Protection.

Personal Protective Equipment

At the time of the incident, the recruit was wearing his station uniform, and his fire department provided the PF with an SCBA, three 45-minute SCBA cylinders, structural coat, and pants (NFPA 1971, edition 2007) rubber boots, a fire apparel hood, gloves, and knee pads. The issue of older used gear for academy training was due to expected wear and tear, and new gear would be provided by the fire department following the PF's completion of the recruit training. The NIOSH Investigators inspected and photographed the PPE and equipment while at the fire department.

The National Personal Protective Technology Laboratory, Morgantown, WV, evaluated the PF's SCBA unit. Results of the evaluation are in Appendix 3.

Weather and Road Conditions

At the time of the incident, the weather was clear with an approximate outdoor temperature of 43 degrees (F) with 56 percent humidity. The training was held inside a converted large two-story hill barn, which provided protection from the outside elements. Space heaters were in use to ensure temperatures did not go below freezing.

Explanation of SCBA Data Time

After examining various time stamped sources, NIOSH investigators found evidence that the SCBA's internal clock had drifted from actual time. The SCBA service provider identified the last calibration of the PF's SCBA was completed on November 5, 2020. A technical examination was not completed by NIOSH investigators or SCBA representatives to determine a specific length of the time drift. To develop a timeline of events and the activities for each event, the time reflected on the SCBA data logs provided by the SCBA manufacturer are used as a time counter to identify the length of time spent on the corresponding cylinder and to identify the approximate number of minutes spent on the described drills. All times in this report will refer to the 24-hour time standard.

A timeline of the events on March 3, 2021, is in Appendix 1.

Investigation

On March 12, 2021, a 21-year-old career PF died in a hospital from an incident that occurred nine days prior during SCBA confidence training at a fire academy. The incident occurred during the PF's third week of an 11-week training course and the third day involving firefighter survival skills, which included SCBA confidence building for recruits. The recruit training class was made up of two battalions with six companies in each battalion. Battalion A was formed with companies 1 through 6 and Battalion B was formed with companies 7 through 12. The PF was designated company 7 officer under battalion B, overseeing four recruits.

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During interviews, recruits reported the deceased as coughing and stumbling up a staircase while going to clean the 5th floor bathrooms the evening of March 2, 2021, one day prior to the fatal incident.

The day started at 0530 hours with morning wake up and mild physical training followed by showers and breakfast before onset of the day's training. Physical training was scheduled to be mild training due to planned training activities that day. It was reported that the PF had a light meal at breakfast. After breakfast, the companies reported to their assigned areas for training drills. Each training drill had either one or two instructors assigned. Battalion B was scheduled for firefighter survival, which began with a filter breathing drill, commonly referred to as "chinning" in this academy.

"Chinning" is the act of breathing through the Nomex hood material after lifting the lower seal of the mask. It was trained to be used as a last resort during an out-of-air emergency during firefighter survival training. Familiarization training initially consisted of the recruit in a classroom setting donning a full SCBA pack and 'breathing down' the cylinder. Once at zero air pressure, the cylinder was shut down and residual air is breathed out. The recruit then practiced the "chinning" technique (See Appendix 2, Graph A).

The "chinning" training process continued with the recruits donning a full cylinder SCBA with a blackout cover over the facepiece and going on air. The recruits were instructed to walk around the gymnasium until an instructor turned off the air cylinder. At that time, the recruit was expected to crawl and lift the lower seal of the facepiece enough to breathe air filtered through the hood. While the recruit was crawling and "chinning", the recruit's partner was instructed to grab the recruit by the coat and drag the recruit approximately 50-feet across the gymnasium floor (See Appendix 2, Graph B).

The next drill for battalion B was the culvert tubes. The objective was to enter the culvert tube, travel approximately 10-feet, doff the SCBA, crawl an additional distance, and then don the SCBA prior to exiting the culvert tube. The initial evolution was done with a clear facepiece (See Appendix 2, Graph C).

The recruits then completed the culvert tube drill with a blackout cover over the facepiece. It was consistently reported during interviews that if a recruit depleted the SCBA cylinder during this drill, the recruit was expected to use the "chinning" technique to complete the evolution.

At approximately 1100 hours, the PF's fire chief, two captains, and a firefighter arrived to observe training and check on the department's two recruits. The two recruits were in different training battalions and conducting different drills. The fire chief learned that the PF was having difficulty with doffing and re-donning his SCBA in the culvert tubes during the drill with the facepiece covered. One of the captains arrived with the fire chief at the culvert tubes to observe the drill and witnessed the instructor coaching the PF through the drill. The captain spoke with the PF about his experience and learned that the PF had run out of air during the last 5-feet of the drill and had to use "chinning" for approximately 5 minutes to exit the tube (See Appendix 2, Graph D).

After observing drills and briefly talking with both recruits, the fire chief, two captains, and firefighter departed the academy. The PF's next drill was ladder bailouts. The SCBA was not required for this drill. One of the recruits recalled that the PF's eyes were red in color and his hands were cramping during the ladder bailouts and needed to be "peeled off the rung" of the ladder.

After completing the scheduled morning training, the recruits had a scheduled 30-minute lunch break and were to report back to the gymnasium at 1305 hours. Through witness interviews it was reported that the PF was in the cafeteria for approximately 20-minutes. The recruit then went to his quarters. The PF's recruit battalion leader and several others in his battalion reported that the PF had vomited and continued to dry heave from persistent nausea. Several recruits, including the recruit battalion leader, reported during interviews that they had spoken with the PF, and that the PF had indicated he was tired and nervous but was able to continue the training program.

Recruits reported to the gymnasium to start the afternoon training session of SCBA confidence drills (see Diagram 1). The afternoon training activities consisted of a circuit of the culvert tubes with a diminishing profile, two single obstacle boxes, two window bailouts, two stud-wall channel escapes and the tunnel prop. These activities were conducted with a blackout cover over the facepiece. This is the first experience with the tunnel prop for the recruits.

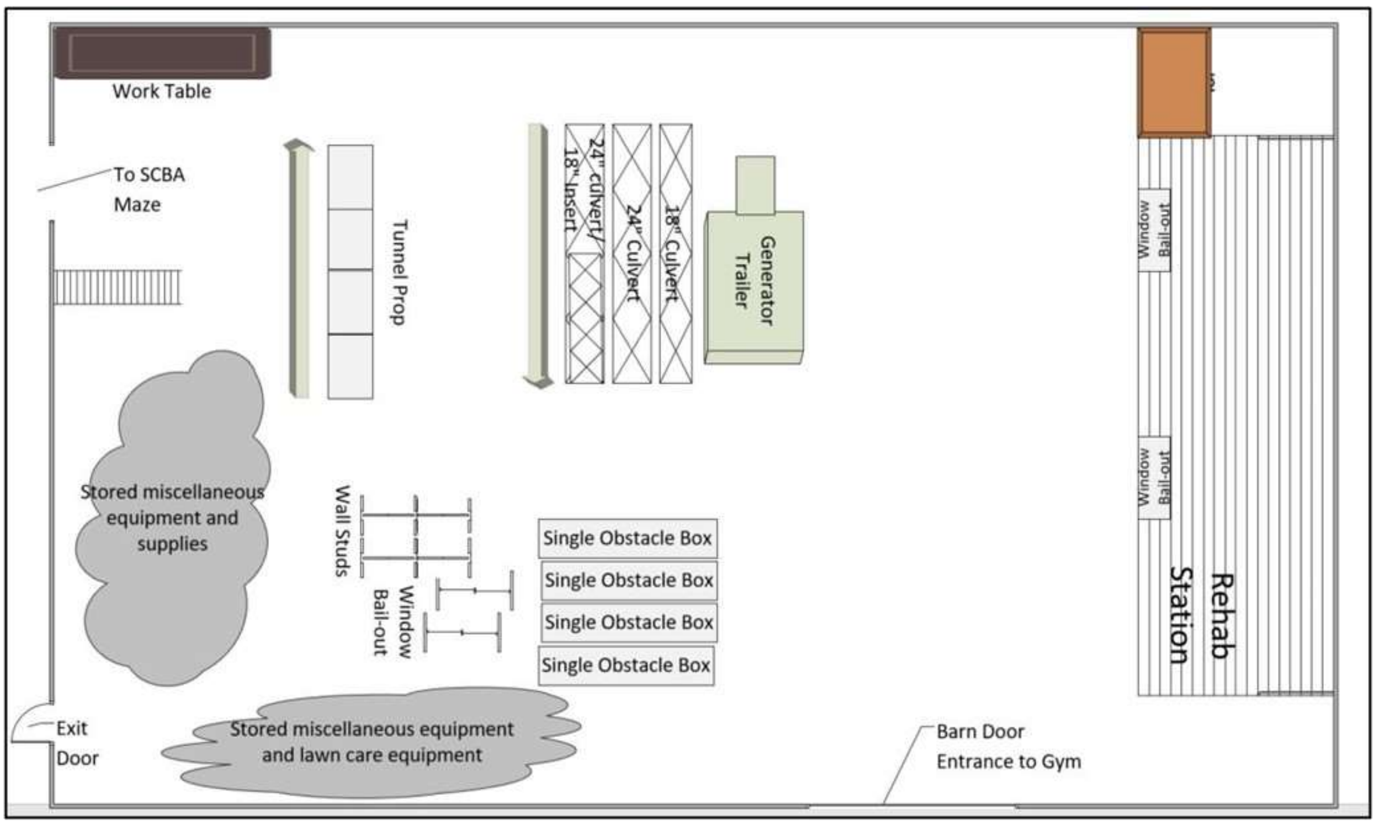

Diagram 1: SCBA Confidence Drills training layout in the gymnasium

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SCBA Drills began approximately 30-minutes after the lunch break. The PF began with the culvert tubes drill. The PF completed this exercise while depleting his air cylinder in approximately 15-minutes. He went to rehab to change cylinders. He reportedly expressed to recruits in his company that he was pleased that drill was over.

Table 1 shows the SCBA activity of the PF's evolution through the culvert tubes. The graph's cylinder pressure is color-coded green, yellow and red. Green indicates pressure at or above 75% of the cylinder's volume. The graph transitions to a lighter green once below 75%. The lighter green is hard to depict in the available graph. Once the cylinder's volume is less than 50% volume, the graph color transitions to yellow. When less than 35% of cylinder air volume is available, the graph color turns to red.

Table 1: Fifth air cylinder for the day's training activities, the first after lunch, used to complete the culvert tube evolution.
(Graph provided by SCBA manufacturer)

Interpreting SCBA Data from Table 1

The Estimated Liter per Minute (LPM) portion of the supplied graph references the air flow used by the PF. For the first three to four minutes, the cylinder is engaged but not being used as reflected by the low LPM and no decrease in pressure. The gray bar with in the LPM indicate either 0-LPM or a LPM of greater than 250, according to the manufacturer. With a reflected drop in pressure during times a gray bar is present, it is assumed that the air flow was greater than 250-LPM. Flow rates exceeding 250-LPM can occur when the facepiece is lifted away from the face, or the mask mounted regulator (MMR) is removed from the facepiece and not disengaged. The blue bars reflect the flow rates of air the PF consumed during the drill. Higher flows of air would be attributable to increased workload.

The bottom portion of the graph provides a comparative view of pressure levels to time. It also includes the Motion Pre-Alarm and Motion Alarm indicators. Motion Pre-Alarms occur when the SCBA pack identifies 15-seconds of non-movement. This is indicated by yellow dots for each event. This Pre-Alarm can easily be reset with movement. When the motion pre-alarm is not reset, the Motion Alarm activates. The Motion Alarm can also be reset, depending on the manufacturer, either through shaking the whole SCBA cylinder pack or depressing a chest console button twice. A period of motion alarm activation is displayed by the two orange dots connected with an orange line, indicating the length of time the alarm was activated.

The PF spent nine minutes in between cylinder use while at rehab to hydrate and change cylinders before he began the next evolution of drills. This evolution involved two individual obstacle prop boxes, two window bailouts, two sections of wall stud channel escapes and the tunnel prop. Witnesses reported that the PF completed the first three without difficulty and moved on to the tunnel prop.

The tunnel prop was built by the academy utilizing a wooden ladder shipping box that was 21-feet long, 29-inches wide and 21-inches high, separated into four sections. The top of each section of the tunnel prop was designed with a lid that could be opened by the instructor to observe and coach recruits (see Photo 2). The inside was fitted with entanglements that included electrical wires, ropes, and chains. It was also configured to have three differing shaped diminishing profiles for the recruit to crawl through. There was one instructor assigned to the tunnel prop.

Note: The following account of the PF's tunnel prop evolution results from NIOSH investigators interviews, the SCBA data log, and review of written accounts by instructors, academy staff, and recruits. In developing an objective and educated account of this evolution where subjectivity or disagreement arose, investigators attempted to find corroborating and common accounts between at least two of the three personnel classifications interviewed. NIOSH investigators classified instructors as those working directly with the recruit class that day on all training evolutions. Academy staff were any personnel that worked for, or were affiliated with, the academy but were not working directly with the recruit class that day or assigned to a prop training evolution. Recruits were members of the PF's recruit class. Lastly, direct observations supported by the SCBA data log were also considered.

The PF began maneuvering through the tunnel prop and, reportedly, made his way through the first two restricted openings and associated entanglements. At some point between the second and third restricted openings, the third lid was opened, and the PF was seen talking to the instructor. Witness

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Photo 2: Third restricted opening in the tunnel prop
(Photo by NIOSH)

interviews reported hearing the PF stating he could not breathe, and the instructor replied that he could breathe if he was talking. The instructor closed the lid for the PF to continue. The third restricted opening was an angled trapezoid-shape opening requiring a recruit to feel the opening and make the decision on how to proceed through. The angles serve as catch points on structural gear, tools, and SCBA packs. Based on interviews, the PF proceeded through the third restricted opening head-first which caused his shoulders to be stuck in the opening. The instructor opened the third lid and continued to coach the PF in pushing through the opening. As the PF attempted to push, his gear and pack became stuck on obstacles. During this time the PF was reportedly “yelling” and “screaming”, which ultimately had caused other instructors to assist at the tunnel prop. The fourth lid was opened as the instructors continued coaching the PF. Coaching was conducted verbally, asking multiple times if the PF was going to quit or give up, and by telling him to keep pushing through. The PF also made at least one attempt to remove his mask and was told not to remove his mask. At this point, there were four instructors at the tunnel prop that witnesses described as "yelling". The instructors continued to verbally assist the PF in navigating the restricted opening. The PF reportedly could not get into a position to fully clear the SCBA through the third restricted opening due to ancillary attachments getting caught on the obstacles. The instructors began to manually assist the PF by manipulating the ancillary attachments to free the obstacles. An instructor reported that he noticed that the PF's mask mounted regulator (MMR) was disengaged and there was no free flow of air. It was reported that during this time the PF shouted that he had trouble breathing.

After verbally coaching and reportedly noticing the PF not moving forward, an instructor grabbed the PF's SCBA straps and pulled him through the last restricted opening. The PF was reportedly facedown with his legs still within the tunnel prop. There are witness reports that the PF attempted to push himself out using his legs but was not successful in clearing the tunnel prop. Instructors continued to loudly encourage the PF to remove his entire body out of the tunnel prop, which was approximately 3 feet. The instructors did not receive a reply and observed no movement from the PF. An instructor rolled the PF onto his back and removed the PF's helmet and mask. The color of the PF's face was reported during interviews as having been gray, flushed, and blue. An initial assessment by an instructor revealed that the PF was not breathing and had no pulse. Instructors performed a "CPR Firefighter Down" maneuver, which provides for removal of the SCBA cylinder, pack, and structural coat so that CPR can be initiated. CPR was initiated by the instructors while the EMT stationed at the rehab area was summoned to assist. An oropharyngeal airway (OPA) was placed, and ventilations provided using a two-person technique via a bag-valve-mask (BVM) with 15-liters of supplemental oxygen. An automated external defibrillator (AED) was retrieved. All recruits were then directed outside.

The AED was applied after approximately one-minute of CPR. The AED analysis advised "No Shock Advised", and CPR continued. Phone records show that at approximately 1417 hours, a fire protection specialist contacted the PF's fire department and advised them of the incident. This message was relayed by phone to the fire chief, who was approximately 45 minutes away from the academy. The fire chief, two captains, and firefighter diverted and began travel to Hospital A. While enroute to Hospital A, the fire chief contacted the PF's family and advised them of the incident.

The local ambulance service consisted of one advanced life support (ALS) ambulance. At the time of the ALS request by the academy EMT, the ambulance was returning from a previous emergency and announced a 20-minute estimated time of arrival to the fire academy. State fire instructors at the academy then chose to utilize the academy's transport van, with county sheriff escort, to transport the PF to Hospital A approximately 1.5 miles away so that earlier advanced cardiac life support care could be initiated.

The PF was loaded onto the floor of the academy's transport van and basic life support was continued by academy staff while enroute to the hospital. During CPR at the academy and while enroute to Hospital A, it is reported that the PF had multiple vomiting episodes, requiring staff to use suction and finger-sweep methods to clear the PF's airway of vomitus. Upon arrival at Hospital A, advanced cardiac life support was provided, including endotracheal intubation, and the PF regained a pulse. The PF was airlifted to a trauma hospital (Hospital B) approximately 40-miles away, where the PF was diagnosed with anoxic brain injury. The PF remained on ventilator support in the intensive care unit.

On the ninth day after the incident, based on physical examination findings and brain imaging studies, the PF was declared brain dead. The PF was pronounced deceased on March 12, 2021, at 1319 hours.

Table 2 presents the data log for the sixth air cylinder used by the PF on March 3, 2021, which was the second cylinder after lunch. This cylinder was used by the PF for the last evolution of the SCBA Confidence drill. This evolution included two window bailouts, two individual obstacle boxes, two stud-wall channel escapes and the tunnel prop. Interviews indicated that the PF spent approximately 12-14 minutes working through the tunnel prop. When comparing this time reference with the SCBA graph (Table 2), it can be determined that the tunnel prop drill began around the same time as the motion pre-alarm activity is reflected on the graph.

Interpreting of SCBA data from Table 2

A review of Table 2 supports the following:

1. The overall time of the cylinder use is 21-minutes. The cylinder was engaged nine minutes after the end of the fifth cylinder. The first two to three minutes of SCBA use are reflected as idle time with no air flow that would contribute to a decrease in available pressure.
2. The overall available pressure reached less than 50% psi after approximately 9-minutes and less than 35% psi after approximately 12-minutes. The SCBA pack is set to activate a low air alarm once pressure decreased to 35%.
3. Air flow ceases after approximately 18-minutes of cylinder use. This is reflected when the pressure reaches approximately 700-psi and remains at this pressure for the duration of the cylinder use. This is supportive of the MMR being disengaged.
4. Multiple motion pre-alarms begin after approximately seven minutes of cylinder use. According to witness statements, this is about the same time that the PF began the tunnel prop drill. Motion pre-alarm events would be anticipated in the tunnel prop due to reacting to entanglements.
5. The motion alarm is activated twice. Motion alarm activation is accompanied by an alarm. The first event occurred at approximately 10-minutes into the cylinder usage and approximately 1-minute after the cylinder pressure is indicated below 50%-psi. This event lasted less than one minute. The motion alarm needed to be purposefully reset to end the alarm. This occurred prior to the low-air alarm activation.
6. The second event of motion alarm activation begins at approximately 12-minutes into the cylinder usage and within two minutes of the cylinder pressure reaching 35% psi available. The alarm is not purposefully reset until the cylinder is shut down after 21-minutes of usage.

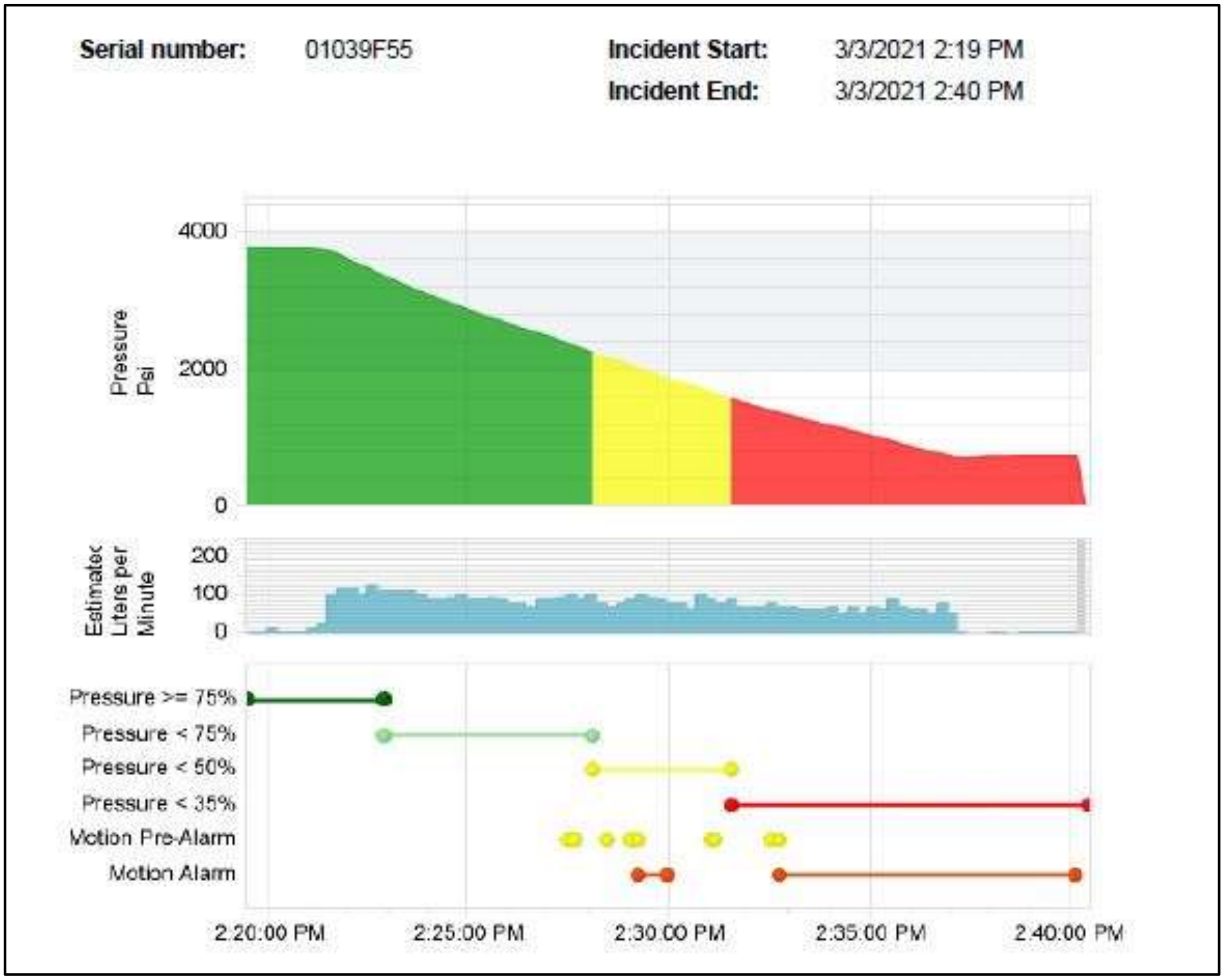

Table 2: The sixth cylinder used on March 3, 2021, which was the second cylinder after lunch. The cylinder was used for two window bailouts, two individual obstacle boxes, two stud-wall channel escapes and the tunnel prop
(Photo by SCBA manufacturer)

Medical Investigation Findings

Preplacement Medical Evaluation

The PF's pre-placement medical evaluation occurred on December 28, 2020. It was noted that his past medical history was non-contributory (i.e., no past medical conditions reported) and he was cleared for respirator/SCBA use with no limitations per OSHA 29 CFR 1910.134.

Pre-Event/Peri-Event Medical Course

The coroner's notes from interviews with the family, fellow recruits, and the State's police investigator reveal that a fellow recruit reported that the PF had been coughing in bed the night before the exercise. It was also reported that the PF had abruptly left the cafeteria during lunch to vomit in the bathroom just prior to starting the afternoon exercise. When fellow recruits questioned the PF, the PF stated that he was feeling stressed and may have eaten too much for lunch. It was noted that a fellow recruit who was also scheduled for the tunnel prop that afternoon reported hearing the PF shout: "My air is running out" and "I can't breathe" while in the tunnel prop. However, the PF was directed by the instructor to continue trying to navigate through the tunnel prop at that time.

Post-Event Medical Course

Records from Hospital A, Hospital B, and the coroner's interviews note that CPR was started immediately after the PF was noted to be in cardiac arrest after his removal from the tunnel prop. The AED applied on scene reported "No Shock Advised" and continued reporting the same as the PF was transported in a state fire academy vehicle with CPR in progress and ventilation provided with a BVM and supplemental oxygen. Medical records report that large amounts of vomitus occurred enroute to Hospital A and maintaining a patent airway was difficult. Cardiac monitoring by Hospital A showed asystole upon arrival at 1431 hours, and an endotracheal intubation was performed for airway control at 1435 hours, following suctioning of significant amount of vomitus from the mouth. Endotracheal tube placement was confirmed by chest x-ray and the PF was started on treatment for suspected aspiration pneumonitis. The PF received two 1-milligram (mg) doses of epinephrine. The PF had a return of spontaneous circulation at 1439 hours. An electrocardiogram (EKG) obtained at this time did not show an injury pattern consistent with a myocardial infarction or abnormal heart rhythm. There was evidence in the EKG of hyperkalemia (elevated potassium levels) which was confirmed by a laboratory blood test, but this is often seen with prolonged resuscitation. Post-mortem evaluation of the heart also did not show any evidence of myocardial infarction.

While at Hospital A, the PF was placed on hypothermic protocol (also known as targeted temperature management protocol) and sedated prior to transfer to Hospital B's intensive care unit (ICU) later the same day.

According to Hospital B's records, on March 4, 2021, the PF's creatine kinase (CK) level (also known as creatine phosphokinase or CPK), a blood test for rhabdomyolysis (breakdown of muscle tissue), was >20,000 international units per liter (IU/L). The upper limit of normal for the CK assay used at Hospital B was 190 IU/L. According to physician's notes this was attributed to immobility and prolonged shivering due to the hypothermic protocol. There was no documented evidence of acute kidney injury due to rhabdomyolysis. Rhabdomyolysis can occur due to many different reasons, including muscle overuse from shivering, seizures, and intense physical exertion; muscle damage from immobility due to pressure on the muscle from lying in one position for a prolonged period, and increased core body temperature resulting in heat damage. By March 5, 2021, the CK had dropped to 3,321 IU/L and by March 12, 2021, it was below the upper limit for males. Since hypothermic protocol was immediately initiated on arrival to Hospital A prior to a core body temperature being obtained, it is impossible to determine if heat stroke played a role in the initial cardiac arrest.

Despite these interventions, the PF's clinical condition continued to deteriorate over the next several days and subsequent brain magnetic resonance imaging (MRI) studies and electroencephalogram (EEG) studies showed worsening of anoxic brain injury. Palliative care services were engaged at this time to assist the family. On day 9, the PF was declared brain dead based on physical examination and vascular imaging study of his brain that showed "no flow to the brain with flow to the scalp and nasal area" and life support efforts were discontinued.

Cause of Death

According to the death certificate, the medical examiner listed the victim's causes of death as "anoxic brain injury from cardiac arrest that occurred during the physical exertion of SCBA training". The coroner's report confirmed that the PF had no past medical history other than seasonal allergies. The postmortem findings are limited as blood samples taken on arrival at Hospital A were not available for toxicological testing and all organs, except the heart and lungs, were harvested for donation. According to the pathologist "The autopsy did not reveal an anatomic cause for the [cardiac] arrest and genetic testing did not show mutations known to be associated with arrythmia". The PF had a body mass index (BMI) of 35.7 kg/m^2 and his heart weighed 390 grams. This is within the 273-575-gram range of heart weights for males 18-34 years of age with a BMI $\geq$ 30 kg/m^2 [Molina and DiMaio 2012]. The coronary arteries were generally clear with only two atherosclerotic plaques in the left anterior descending coronary artery, with neither blocking more than 20% of the vessel interior. There was no evidence of thrombosis (clotting) within the coronary arteries nor any evidence of dissection. There were no focal areas of pallor, hyperemia, or fibrosis (evidence of recent or past heart attack). There was no dilation of either atria or ventricles and all cardiac valves were "in their usual anatomic position and are without gross abnormalities." The thoracic aorta appeared normal without any dissection, was not dilated, and did not have any gross atherosclerotic plaques.

Discussion of Medical Findings

Anoxic brain injury, irreversible neurological damage due to inadequate oxygenated blood flow to the brain, is a common consequence of prolonged cardiac arrest. Although resuscitation was reported to have started promptly, including assisting ventilation via a BVM, the delivery of oxygen into the bloodstream during this time may have been compromised by the vomit in the airway creating a physical blockage. The staff in Hospital A documented that his airway had to be suctioned to clear the vomit prior to the placement of the endotracheal tube. It is unclear when the PF vomited between his arrest and arrival to hospital A. However, hospital A noted that on arrival, the PF was in asystole and his skin was cyanotic indicating he had experienced a period of inadequate oxygenation. Coroner's interview notes state that the instructor who pulled the PF out of the maze reported that he did not see any vomit in the mask when he first removed the SCBA facepiece from the PF.

The survival rate for out-of-hospital cardiac arrest is approximately 10% even with quick initiation of CPR [Ramiro and Kumar 2015]. Males ages 20–25 years had a predicted survival rate of <10% even when adjusted for witnessed arrest, initial rhythm, initiation of bystander CPR, and time for EMS arrival [Safdar et al 2014].

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Anoxic brain injury is one of the most common causes of death in out of hospital cardiac arrest cases as the brain is highly sensitive to oxygen depletion. Loss of blood flow to the brain for 20 seconds depletes the brain's oxygen supply resulting in loss of consciousness. Once anoxic brain injury occurs, the prognosis is generally poor [Elmer and Callaway 2017; Ramiro and Kumar 2015].

At Hospital A, the PF was noted to have hypoxic myoclonus (muscle spasticity which is consistent with an anoxic brain injury). Imaging studies done the following day at Hospital B, in addition to several EEG studies over the next several days, confirmed the diagnosis of "diffuse/global cerebral anoxia" despite the implementation of a hypothermic protocol. Hypothermic protocols following cardiac arrest may prevent or reduce the severity of anoxic brain damage, but the benefit of these protocols is questionable once anoxic brain injury has occurred [Chan et al 2016; Girotra et al 2015].

Imaging studies of the brain at both hospitals did not reveal an acute primary central nervous system event (i.e., hemorrhage, aneurysm, stroke, etc.) that could have precipitated the cardiac arrest. Serial EKGs and cardiac enzymes also quickly ruled out a heart attack, and there were no autopsy findings consistent with a heart attack. The PF's complaint of "not feeling well", along with the nausea and vomiting immediately following a physically demanding training exercise conducted in full structural gear that preceded his cardiac arrest could be consistent with heat stroke. In addition, the complaint of him not feeling well the evening before, as reported by another recruit, could indicate some manifestation of heat-related illness and/or dehydration present during and/or following day 2 training. Heat stroke is the most severe form of heat-related illness and may result in seizures or fatal arrythmias. Heat-related illness may have resolved overnight if the PF sufficiently lowered his core body temperature before rejoining training the next morning. Similarly, if the PF was dehydrated following day 2 and did not adequately replace the lost fluid volume, he may have started day 3 training already at a fluid volume deficit. Sweating is one of the body's main heat-loss mechanisms via evaporative cooling and it may be impaired if there is not adequate fluid volume from which to create sweat. It is unknown if this situation was present at the start of day 3 training and if so, to what extent.

The PF had elevated CK levels suggestive of rhabdomyolysis, the breakdown of skeletal muscle. Rhabdomyolysis can be caused by many different conditions including heat exposure and prolonged, intense exertion. However, in this case any consideration regarding the role of heat-related illness is speculative as the lack of a core body temperature taken on arrival to the emergency department at Hospital A and the implementation of the hypothermic protocol made future assessments of hyperthermia (elevated core body temperature) impossible. More information on rhabdomyolysis can be found on the NIOSH topic page: What is Rhabdo? Factsheets on rhabdomyolysis in structural firefighters can be found here: Resources: Rhabdomyolysis

Contributing Factors

- A patent airway was not maintained from the period of the PF's initial collapse in the tunnel prop until a definitive airway was established via endotracheal intubation upon arrival at Hospital A

- Ineffective rehabilitation and medical monitoring were conducted, and not in accordance with written policy
- Lack of a designated safety officer presence placed safety responsibilities on the instructors at respiratory protection training evolutions
- Lack of standard operating procedures (SOPs) and instructional objectives that specify actions to be taken by instructors and recruits when personal alert safety system (PASS) and End-of-Service-Time-Indicator (EOSTI) devices are engaged and alarming during training evolutions
- Lack of a written risk management plan to address administrative controls that includes manufacturer recommended training on limitations of structural gear and SCBA and heat-related illness/injury recognition and reporting
- Lack of instructional objectives developed and communicated for each activity of the evolution based on the training facility's written Job Performance Requirement (JPR)
- Lack of comprehensive SOPs for each training prop and associated drill.

Recommendations

Recommendation #1: Adhere to certification requirements for BLS for Healthcare Providers, either through American Heart Association or American Red Cross, which require a clear and open airway and assisted ventilations with an oxygen source during cardiac arrest resuscitation efforts to prevent anoxic brain injury in a person in respiratory arrest

Discussion: During cardiac resuscitation, the primary goal is to re-establish enough circulation to provide adequate oxygenation to the brain, heart, and other tissues. Maintaining a clear airway during resuscitation is a vital step in this process. Current resuscitation guidelines prioritize recognition of cardiac arrest, initiation of effective CPR, and application and use of an AED [Panchel, et al., 2019]. Opening and maintaining a patent airway remains an integral part of CPR. A patent airway is essential to facilitate proper ventilation and oxygenation [Panchel, et al., 2019].

The American Heart Association recognizes supraglottic airway devices (SADs), also referred to as non-visualized airways, as advanced airways along with endotracheal tubes (ETTs). The advantage of SADs is that unlike ETTs, which can only be placed by ALS certified providers, SADs can be placed by both ALS and BLS providers depending on local regulations. With SADs, serious complications such as aspiration and loss of a patent airway, are rare and largely preventable as their structure and placement effectively compresses the esophagus while simultaneously covering the trachea, thereby resulting in mechanical blocks to vomitus exiting the esophagus and reaching the trachea to cause aspiration. The American Heart Association updated its guidance in 2019 regarding prehospital airway management to remind providers that, while use of the BVM for airway management was still valid in certain situations, it is vital to have a backup plan in case that approach fails, as stated, "the choice of the BVM instead of advanced airway insertion will be determined by the skill and experience of the provider and the patient needs. An important aspect of all these airway management decisions must be a clear and distinct plan for situations in which the initial airway device fails" [Panchal et al. 2019]. Ideally, if only basic life support (BLS) providers are available for resuscitation efforts, use of SADs would be preferable to oropharyngeal airway (OPA), as the SADs design incorporates extra airway safety measures by their design, which could have prevented the airway blockage due to emesis and the resulting loss of oxygenation that occurred until a definitive airway was placed at Hospital A. In a systematic review completed that compared effectiveness of initial airway interventions in improving a return of spontaneous circulation, it was demonstrated that SADs is better than ETTs and BVM ventilations, and ETTs were better than BVM ventilations [Chi-Hung Wang, et al., 2019]. OPA are effective in ensuring the tongue does not block the trachea, and their use should be advised only when suction devices are on hand, especially if one considers that OPA are only used in patients that lack a gag reflex and cannot protect their own airway. Adequate operator experience, familiarity with the selected device, attention to details and careful patient selection are fundamental to safety and proficiency [Gordon, et al. 2018].

In this incident, the PF was reportedly cyanotic when the facepiece was removed. Cyanosis occurs due to a poor or lack of oxygenation. The PF was immediately determined to be not breathing and having no pulse. CPR was initiated by instructors, while the EMT was summoned from across the gym. An OPA was placed in position and ventilations provided through a BVM with supplemental oxygen. Once applied, the initial AED analysis provided was "No Shock Advised". NIOSH investigators identified an episode of vomiting during pre-hospital care while at the training facility. This occurred several minutes after the start of CPR, according to the training facility's written patient care report (PCR). During this episode, the OPA was removed to enable airway suctioning and finger-sweep removal of pieces of vomitus. Ventilations resumed, but it is unknown if the OPA was placed back in position. Later, while transporting the PF to Hospital A in a training facility vehicle, the PCR describes that compressions, ventilations and suctioning continued, evidencing that additional vomiting episodes occurred. Based on the medical examiner's report, ultimately, the PF's death was due to anoxic brain injury, an irreversible state due to period(s) of inadequate oxygenation. Though providers made every attempt to maintain a patent airway through the use of appropriate BLS equipment and airway techniques, the PF did not receive a definitive airway that allowed for him to be properly oxygenated/ventilated until his arrival at Hospital A.

Recommendation #2: Fire training facilities should ensure use of a comprehensive rehabilitation program complying with NFPA 1584, Standard on the Rehabilitation Process for Members During Training Exercises [NFPA 2015]

Discussion: A properly implemented rehabilitation station can identify illness/injury of a firefighter engaging in physical exertion activities on the fireground or in training. In accordance with NFPA 1584, Chapter 6, *Incident Scene and Training* Rehabilitation, rehabilitation operations should be provided in accordance with fire department SOPs, NFPA 1500, *Standard on Fire Department Occupational Safety and Health* Program, and NFPA 1561, *Standard on Emergency Services Incident Management* System. [NFPA 2021; NFPA 2020a] Rehabilitation efforts shall include the following:

1. Relief from climatic conditions

2. Rest and recovery
3. Active and/or passive cooling or warming as needed for incident type and climatic conditions
4. Rehydration (fluid replacement)
5. Calorie and electrolyte replacement as appropriate for longer duration incidents
6. Medical monitoring
7. Member accountability
8. Release. [NFPA 2015]

In addition, other areas that apply and are in accordance with NFPA 1584, Chapter 6:

6.2.2.2 – Members shall rest for a minimum of 20-minutes following the use of a second 30-minute or 45-minute SCBA cylinder, a single 60-minute cylinder, or 40 minutes of intense work without SCBA

6.2.6.3.1 – The following vital signs shall be obtained for all members entering rehabilitation:

1. Temperature
2. Heart rate
3. Respiratory rate
4. Blood pressure
5. Pulse oximetry

6.2.6.4 – EMS personnel shall be alert for the following:

1. Personnel complaining of chest pain, dizziness, shortness of breath, weakness, nausea, or headache
2. General complaints such as cramps, aches, and pains
3. Symptoms of heat- or cold-related stress (see Annex B)
4. Changes in Gait, speech, or behavior
5. Alertness and orientation to person, place, and time
6. Vital signs considered to be abnormal as established by protocol. [NFPA 2015]

Research studies have documented significant physiological strain from the physical and environmental stress of firefighting activities, such as near-maximal heart rates, elevated core body temperature, and fluid losses [Horne et al. 2013, 2018]. Heart rate is particularly affected and often surpasses maximum heart rates caused by similar levels of heavy exertion, such as exercise treadmills, without concurrent fire exposure or encapsulating gear [Horn et al. 2013]. Studies have revealed that after approximately 20 minutes of firefighting, vital signs (particularly core body temperature) and cardiac perfusion may not return to pre-firefighting baseline levels for approximately one hour [Horn et al 2013, 2018]. Research by Smith et al. [2016] identified numerous factors associated with heart rates that were higher upon entry to incident rehab and/or took longer to normalize, including heavier workload, being more active during rehab (less time spent sitting), warmer weather (>86°F/30°C), and obesity (BMI >30kg/m^2). The majority (88%) of firefighters in the study still had heart rates in the tachycardia range (>100bpm) after 15 minutes of rehab [Smith, et al. 2016].

Even young firefighters in peak physical condition need rehab, and firefighters who are less fit may need to access rehab sooner and take more time to recuperate. In departments that do not currently require annual medical examinations, as recommended by NFPA 1582 (NFPA 2018a), greater scrutiny of rehab procedures may be warranted. Firefighters may have developed medical conditions or began taking new medications since their entrance physical that could compromise their physical or mental endurance for firefighting. Enhanced incident rehab could be a temporary measure until annual medical exams can be implemented for all firefighters participating in emergency response and training. Enhanced rehab can include earlier entry of firefighters to rehab, more in-depth medical monitoring, longer recovery time, more frequent rotation, and rotation of firefighters released from rehab to less demanding tasks. These enhancements can reduce the physiological strain and the likelihood of injuries or sudden cardiac events in individuals with underlying, silent cardiovascular disease [Hostler, et al. 2016].

In this incident, recruits were expected to use their own judgement on when to go to and from rehab, with no time requirement based on the number of SCBA cylinders used. Medical monitoring was recorded only if the recruit had a complaint. There were no available baseline vital sign assessments for the PF that day, and witness interviews report that the PF did not voice any concerns when he was in rehab that would have resulted in any medical monitoring assessment.

The training facility provided a policy document referencing firefighter care and rehab during training evolutions. The document specifically states its application to SCBA confidence training. The document references vital signs, physical assessments, and medical staff's visual impression of recruit well-being, as well as rest periods related to the time spent in training evolutions. These action items occur upon the recruit reporting to or entering rehab. According to the training facility document, baseline vital signs are to be taken before starting a training evolution.

The training facility had a rehab area set up for recruits, which was staffed with an EMT. NIOSH investigators found that although the facility policy referenced rest periods, those specific rest periods were not clearly communicated to all involved in training - instructors, recruits, and medical personnel, nor executed and recorded. There is no evidence of any baseline vitals sign assessments taken or records for any recruits that day. A specified period of time was not defined for rehab staff to form an overall impression of the recruit's well-being. Though the facility's policy document does not match NFPA exactly, several foundational subjects are present.

Recommendation #3: Fire training facilities should appoint a safety officer to review the planned exercises and actively observe all training activities.

NFPA 1404, *Standard for Fire Service Respiratory Protection Training*, Chapter 6.1 states that a safety officer shall be appointed for all respiratory protection evolutions. [NFPA 2018] The safety officer must have the authority to intervene and control all aspects of the operations. Responsibilities of the safety officer includes the safety of all persons on the scene to include students, instructors, and visitors, as well as prevention of unsafe acts and elimination of unsafe conditions. A safety officer should be part of the development of each drill and SOP to ensure that the risk management process is reinforced during all training drills. The safety officer should be familiar with each drill and know the risks identified, as well as the mitigation for those risks. Additionally, all personnel participating in training drills should have the ability to stop an activity if a safety hazard is observed.

Respiratory protection training standards also provide for an instructor-in-charge. The instructor-in-charge shall. at a minimum, be a certified Fire Instructor I, and maintain responsibility of the overall respiratory protection training activities and assign instructors to achieve an instructor to student ratio of 1:5. In addition, the instructor-in-charge shall provide appropriate rest and rehabilitation for participants. Rest and rehabilitation shall include medical evaluation and treatment, fluid replenishment, and relief from climatic conditions [NFPA 2018].

In addition to the safety officer and instructor-in-charge requirements at respiratory protection training, the fire department should appoint an overall health and safety officer and an incident safety officer for emergencies and planned events. NFPA 1521, Chapter 5, *Standard for Fire Department Safety Officer*, defines the role of the health and safety officer (HSO) and incident safety officer (ISO), as well as assistants for each role [NFPA 2020b].

The HSO is assigned by the fire chief and manages the health and safety program for the whole department. Areas of responsibilities of the HSO include risk management; laws, codes, and standards; training and education; accident prevention; accident investigation, records management, and data analysis; apparatus and equipment; facility inspection; health maintenance; health and safety liaison; and infection control.

Incident safety officers (ISO) shall be a certified Fire Officer I and perform duties within an incident command system. An incident safety officer has similar responsibilities as the HSO, however, at a specific event or planned activity. The ISO monitors and assesses and event or planned activity for safety hazards and unsafe conditions to develop measures for ensuring personnel safety [NFPA 2020b]. Safety officers and instructors-in-charge should work with the HSO to provide effective oversight for training events.

Recommendation #4: The PASS and the EOSTI activations during training should be addressed in training SOPs, and the instructional objectives should be outlined in training SOPs and repeated during pre-training safety briefings

Discussion: The PASS and EOSTI are unique pieces of personal safety equipment to a working firefighter. These devices alert the wearer and everyone else around them that an unsafe situation is evolving. Activation of these devices should trigger a response that is clearly described in SOPs and instructional objectives. How to handle a situation when a firefighter has stopped moving or is breathing reserve air supply should be addressed specifically in SOPs and instructional objectives. NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services* (NFPA 2019a), and NFPA 1582, *Standard on Personal Alert Safety Systems (PASS) (NFPA 2018a)*, meticulously specify the design and performance of these devices. These devices need to be used as designed in the training environment to help ensure they will be used correctly in the operational environment.

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The PASS and EOSTI device activations should serve as check points during SCBA training. Instructors should use these check points as opportunities for wellness/status checks of a student. These check points should evolve to stop points when the recruit isn't clear in their responses or demonstrates degradation in motor skills, such as an inability to reset their own PASS device that is in full alarm [NIOSH 2018-16 PA; NIOSH 2022].

Table 3 illustrates multiple motion pre-alarm and two full alarm activations; each representing the opportunity for check point and stop point considerations. An activated PASS device, motion pre-alarm, or motion alarm should trigger a check point intervention by the instructor. Instructors should be prepared to assess the recruit's actions and verbal responses, such as:

- Ability to silence the alarm
- Ability to effectively execute the current training task
- Breathing patterns and ability to effectively communicate

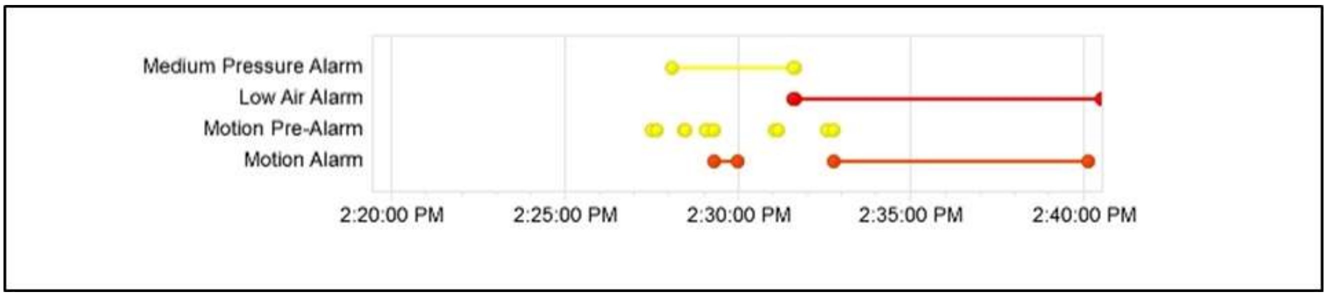

Table 3: Excerpt from Table 2 to highlight Low Air Alarm, Motion Pre-Alarm, and Motion Alarm activity (Photo provided by SCBA manufacturer)

The alarming EOSTI should trigger much the same check point intervention from instructors to assess:

- A student's ability to communicate air status at EOSTI milestones
- What is to be learned by working through the alarm?
- How much physical work has been done to this point?
- Can the student accurately communicate the work they have accomplished?
- Can the recruit articulate an exit or emergency strategy given the circumstances?

Once an instructor actively intervenes and assesses a recruit, an objective decision should be made to terminate the evolution creating a stop point. This action should be tied closely to written standard operating procedures and clearly communicated training objectives.

Recommendation #5: Fire training facilities should implement a systematic risk management process in all activities, and ensure that it includes training on structural gear and SCBA limitations and heat-related illness recognition and reporting

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Discussion: Risk assessment and risk mitigation is crucial, especially in a controlled environment for training. Fire academy safety officers should be familiar with the overall training program and each fire training activity. The safety officer should work with instructors when developing training objectives to identify hazards, apply risk reduction through engineering and substitution approaches where possible, as well as implement administrative controls and identify the need for PPE. There should be continuous supervision and evaluation of the training during all activities. This will aid in identification of any new or recurring hazards so that the activity can be stopped, risk assessments conducted, and appropriate controls implemented.

A risk assessment should be conducted by training and safety officers to identify the highest level of risks involved in each training drill. NFPA 1521, Chapter 5.2 recommends a risk assessment of the activities involved in each activity, a description of any applied mitigations for the identified risks, and assignment of the appropriate level of medical personnel for residual risks [NFPA 2020b]. The level of residual risk, with all factors considered (including past/recent history of incidents and near-misses), will support the level of care needed for each activity.

When PPE is used in training, whether PPE-specific training or training requiring the use of PPE, training on use, maintenance, and limitations of the PPE selected should be provided to the wearer prior to the onset of training. At a minimum, it should be expected that SCBA and firefighter structural gear will be involved in recruit training. Limitations involved in the use of SCBA and protective gear, and how anyone involved in an activity are to identify and report hazards, illness, and injury, should be a standard part of the training curriculum and communicated to all involved in the activity.

Respiratory training implements risk controls for the specific PPE being used. NFPA 1404, Chapter 6, establishes requirements for SCBA training to include the selection, use and care of equipment and identified minimum performance standards in accordance with NFPA 1001, *Standard for Fire Fighter Professional Qualifications, [NFPA 2019],* and the authority having jurisdiction. [NFPA 2018a] Training requirements also include training on the limitations of the selected respiratory protection and medical signs and symptoms that impact use of a respirator.

Structural firefighting gear imposes its own limitations on use. Multiple studies have shown that fatigue, dehydration, mental and physical performance are impacted by even mild periods of PPE use. [Hur, et al. 2016] Manufacturers of structural gear identify the dangers of heat-related illnesses and recommend training in the identification of the signs and symptoms of heat-related illnesses. Appendix 2, Figure B.1(a) in NFPA 1584 lists each heat-related illness with the corresponding cause, signs and symptoms, treatment, and prevention [NFPA 2015]. Including this information in administrative controls and communicating to all involved in the training activity will provide early identification of heat-related illnesses, and early intervention of medical care. It is common for recruits to use older structural gear for training as a cost-effective way to mitigate training damage on new gear. Older gear is compromised from dirt, oils, heat damage and other exposures from the fireground that compromises the ability for the protective gear to dissipate heat as it is intended. This compromise can be expected to increase the risks of heat-related illnesses and injuries, fatigue, and impaired performance during training.

Screening strategies from other groups may be helpful to develop a risk assessment checklist or other screening tool specific to identifying medical emergencies among firefighter trainees. For example, the U. S. Army created a "Risk Assessment Worksheet" to assess soldiers prior to missions or tasks that require physical exertion in hot conditions. [TRADOC 2016] The risk assessment accounts for risk considerations, such as projected workload, the workload completed on the previous two days, the number of days acclimated to the heat, hours slept during the past 24-hours, and other risk profiles. For athletes wanting to play competitive sports, an expert panel developed a "Heat-Illness Screening Instrument" for athletic trainers to use when conducting pre-participation sports physicals. The instrument includes a brief questionnaire, several baseline health measures, and a scoring system to estimate each athlete's level of risk. [Eberman and Cleary 2011] NIOSH also created a heat-illness screening tool to protect cleanup workers during the Deepwater Horizon Oil Spill response in 2010, Oil Spill Response Resources: Medical Pre-Placement Evaluation Indicators | NIOSH | CDC.

Firefighter Advanced Survival Skills (FAST) and SCBA Confidence trainings are physically demanding trainings required of all firefighters. These trainings simulate worst-case scenarios of interior structural firefighting. As described by many recruits as "Hell Week", the training is planned to push the recruits physically and mentally. Drills involving visual disruption, instructors creating an environment similar to real-world firefighting, and a recruits' own fear of failing to complete an activity, could impose physical and mental stress on recruits, and each recruit will react differently to these stressors. Once stressors exceed the individual recruit's ability to compensate, physical and emotional distress signs and symptoms can manifest. When coupled with the limitations of SCBA and fire protective gear, and recruit-specific experience, the development of physical and mental stress can be further enhanced.

Risk management for FAST and SCBA Confidence training should anticipate mental, as well as physical stressors. Risk assessments should include a review of past trainings and patient care reports for the same, or similar, training. Available controls should be implemented to minimize incidences of stress exceeding any recruit's ability to compensate. The residual risks communicated should include anticipated mental and physical stress symptoms that can manifest within a recruit, as well as the signs that instructors and recruits should look for in others.

In this incident, NIOSH investigators identified times where potential signs and symptoms of heat-related illness or physically impacting signs of distress may have occurred. However, each of these instances alone may not have triggered a warning to the PF or observers that would have elicited medical intervention. This is indicative of the need for implementing risk management and ensuring all involved in the training understand the potential for illness and injury and know how to report anything that may seem incidental by itself, yet when combined with other signs and symptoms, could indicate a true emergency.

As part of risk management, the process for identifying and reporting new and recurring safety hazards and individual signs or symptoms of physical or mental distress should be clearly communicated to all involved during the review of residual risks prior to initiation of training. During planned physically demanding training, continued reinforcement of recognition and reporting of any signs or symptoms should be encouraged by safety officers, medical staff, and instructors through-out training. Avoiding stigma related to reporting any observed signs or symptoms should be maintained as a priority. A process should be in place that all illness or injury reports reach the safety officer, so that an appropriate response on continuation of training can be determined.

Review of the documents provided by the training facility did not identify clear procedures in reporting illness or injury concerns or safety hazards identified during training activities. Higher-level reporting of recruit injury or illness events is described within the document; however, this level of reporting would be initiated after a recruit is treated by medical staff and is dependent on the disposition of the involved recruit.

Recommendation #6: Fire training facilities should ensure that instructional objectives are developed and communicated for training evolutions intended to satisfy a job performance requirement (JPR) and ensure instructors follow compliance with instructional objectives and reasons associated with deviation from the objective(s).

Discussion: NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, provides professional qualification standards that are written as JPRs. JPRs describe the performance required for a specific job and grouped according to the duties of the job. [NFPA 2019b] NFPA 1001 and NFPA 1041, *Standard for Fire and Emergency Services Instructor Professional Qualifications*, [NFPA 2019c], Annex B, addresses how JPRs are to be used for instructional purposes:

JPRs state behaviors required to perform specific skills on the job, as opposed to a learning situation. These statements should be converted into instructional objectives with behaviors, conditions, and degree to be measured within the educational environment. Instructional objectives are used to identify what recruits must do at the end of the training session and are stated in behavioral terms that are measurable in the training environment. By converting JPRs into instructional objectives, instructors would be able to clarify performance expectations and avoid confusion caused by the use of statements designed for purposes other than teaching. [NFPA 2109a, 2019b]

Training institutions, fire departments, and individual fire service instructors can use NFPA JPRs in their instruction and evaluation development. Many of these same organizations develop their JPRs using NFPA and jurisdictional resources. By their definition, JPRs become the desired outcome of any training. Instructional objectives related to the JPR define the performance expectations for each training session. No matter the length of the session, every training task leading up to evaluation of a JPR should be clearly understood by instructors and recruits. Instructional objectives are an effective tool to define those tasks.

The training institution in this incident had developed an SCBA confidence JPR, a practical skills evaluation form designed for successfully completing an SCBA at the end of the training week. The form listed 14 evaluation criteria and cited NFPA 1001 and NFPA 1041. This format is commonly used throughout fire service training. What is often not clearly developed in writing are the training tasks leading up to a JPR evaluation, and the length of time for each task. Instructional objectives define these tasks and the time required for each one.

The tunnel prop provides a good example of these types of tasks. Training institutions and fire departments across the country use varying types of these props. The most important question to be answered for any of these props is “What is the recruit to learn from the time of entry to the time of exit from the tunnel prop?”. A follow-up question is “How will they learn from this?”. If these questions are not answered in the form of instructional objectives, performance expectations will be difficult to objectively observe and measure. Maneuvering through entanglement hazards and traversing restricted openings are common components of tunnel props. Instructional objectives will assist the instructor in discerning if learning to handle entanglement hazards and restricted openings is occurring. If learning by the recruit is no longer occurring, as with any training evolution, the training is of little to no value and should be stopped.

Recommendation #7: Fire training facilities should ensure that SOPs for each skill/drill are developed and implemented.

Discussion: Written policies and SOPs for each training structure and prop shall be established by the authority having jurisdiction (AHJ). [NFPA 2019c] SOPs play an integral role in establishing order and consistency in operations at any training facility, fire department, or emergency scene. They are especially important in training because of the inherent complexities of firefighting that need to be taught. SOPs improve safety by establishing consistency and enhancing muscle memory to the essential skills/drills that a firefighter performs. SOPs should be written to achieve these purposed:

- Establish roles, responsibilities, and conduct of each instructor
- Establish skills/drills that meet a standard or serve an essential need
- Establish levels of acceptable outcomes for the recruits
- Establish safeguards to prevent and recognize potential medical emergencies. [NFPA 2020a]

Chapter 4 of NFPA 1402, *Guide to Building Fire Service Training Centers*, [NFPA 2019d], requires SOPs for each training prop.

During interviews of recruits and instructors, NIOSH investigators asked questions about the SCBA confidence tunnel related to procedural elements. Answers varied among both groups. For example, when asked if the tunnel prop was a stand-alone prop to be completed with only one SCBA cylinder or if it was part of a circuit of props to be completed on one or more cylinders, the answers provided were not consistent. When asked “What is the expectation if a recruit depletes the cylinder while in the tunnel prop?”, most answers were a variation of disengaging the MMR and continue to the end of the tunnel (filter breathing was included in some of the responses, but not all of them) and the evolution would be terminated.

These examples highlight the procedural elements that should be included in an SOP. Key procedural definitions need to be clearly understood by instructors and recruits for every training session and prop.

Additionally, an SOP serves as a means of communication for all levels of the organization. An SOP may also identify known hazards, the risks of those hazards and identify hazard controls to be implemented. The SOP should be reviewed by all involved in the activity prior to the activity and updated as additional hazards are identified.

Basic topics to cover in a SOP include:

- Object/Purpose
- Scope
- Accountability
- Task/Procedures
- Documentation
- References

The SOP task/procedure section should include criteria to halt the skill/drill by anyone present that identifies a new hazard or danger.

The following recommendations were not considered contributing factors in this incident but are being provided as accepted standard operating guidelines and best practices.

Recommendation #8: During advanced SCBA skills and confidence building training programs, recruits should be cautioned against "filter breathing".

Discussion: During advanced SCBA skills training class, there may be occasions when, due to the complexity and length of the skills and confidence class, a recruit depletes the air in their cylinder in training scenarios that are not immediately dangerous to health (IDLH). There are training facilities that instruct recruits, as a last resort, to disconnect the MMR and cover the opening with the lower portion of their PPE hood or lift the lower portion of the face mask and breath through the PPE hood, a maneuver sometimes called "filter breathing" or "chinning". NIOSH has cautioned against using this method in training and during actual fire suppression activities for the following reasons:

First, fire smoke is composed of toxic gases, vapors, and particulates. [Fabian, et al. 2010] Using a hood as a filtering material might provide protection against larger particles, but it will not protect against chemicals, gases, or vapors. [NIOSH 2020] Fire smoke contains dangerous levels of several gases that cause asphyxiation, for example, carbon monoxide and hydrogen cyanide. [Fabian, et al. 2010] Teaching recruits filter breathing during training increases the risk of filter breathing during an actual fire, putting the firefighter at risk for asphyxiation.

Second, many modern hoods have vapor ad moisture barriers to prevent skin burns. Like surgical masks and N-95 respirators, using hood material as a respiratory filter may increase the amount of carbon dioxide on the inside of the mask or nose cup. [Sinkule, et al. 2013] While it is debatable whether this increase in carbon dioxide is clinically significant [Rhee, et al. 2021], it could lead to an increase in the firefighter's respiratory rate leading to the potential for increased inhalation of carbon dioxide.

Finally, filter breathing has not been shown or tested in laboratory studies to reduce the inhalation of fire smoke particulates. It is known that the meta-aramid materials of Nomex hoods are not rated for filtering ambient air of gases, vapors, or other fine particulates.

Instead, air management guidance should be incorporated into SCBA confidence training to train recruits to exit IDLH environments before incurring an out of air event. This type of training should eliminate the need to entertain filter breathing, or "chinning", as part of any training.

Recommendation #9: Fire training facilities should ensure that training props and confined spaces used in SCBA confidence training have adequate safety features, such as, emergency egress panels, emergency lighting, ventilation, and a temperature monitoring system to measure the ambient temperature inside.

Discussion: In this incident, the tunnel prop was well constructed with access lids on the top of the prop to observe and assist if a recruit was having difficulty. The size and environment associated with this tunnel prop did not require emergency lighting, ventilation, or temperature monitoring and these elements were not considered to be a factor in this incident.

The PF was being coached with the last two lids opened when he was stuck in the last restricted opening. This restricted opening was a trapezoid-shaped opening. Eventually, the instructors pulled the PF through the opening and out of the tunnel prop.

Since this incident, the academy has since ceased to use this specific tunnel prop. The academy staff reviewed the incident and identified ways to improve the safety of the tunnel prop. The academy built a new tunnel prop to include additional safety features that would enable a person to more easily be removed in the event of any emergency. These features include five-foot sections that can be pinned together to form a 22-foot tunnel prop, sides that can be collapsed for more expedient removal, and wire cutters attached to the tunnel prop for rapid disentanglement. (See Photos 3 and 4)

NIOSH investigators recommend that all training facilities review NFPA 1402, *Guide to Building Fire Service Training Centers,* for general guidance on training structures and props, and technical rescue training props.

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Photo 3: New tunnel prop with added safety features
(Photo by NIOSH)

Photo 4: New tunnel prop with side collapsed
(Photo by NIOSH)

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Investigator Information

This incident was investigated by Matt Bowyer, General Engineer, and Tammy Schaeffer, Safety and Occupational Health Specialist, with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH located in Morgantown, WV, and Robert Saunders, Technical Information Specialist. Judith Eisenberg, MD, MS, Medical Officer Board Certified in Emergency Medicine, with the Fire Fighter Fatality Investigation and Prevention Program, Hazard Evaluations and Technical Assistance Branch, Division of Field Studies and Engineering, NIOSH located in Cincinnati, OH, provided medical consultation in preparing this report. An expert technical review was provided by Mike Barakey, Chief of Suffolk Fire and Rescue located in Suffolk, Virginia. A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division.

Disclaimer

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Appendix 1
Incident Timeline

The following timeline is a summary of key events that occurred as the incident evolved on March 3, 2021. Not all incident events are included in this timeline. The timeline exists to provide readers with a general chronology of events. Times are approximate and should not be considered exact. The timeline is a combination of a summary of the PF's SCBA data log information and witness statements.

SCBA Confidence Day Drill Indicators & Conditions	Time
Recruits participated in mild physical training followed by showers.	0600
Recruits had breakfast then prepared for drills. Recruits reported during interviews that the PF had a light breakfast.	0700
The PF, as designated Company 7 Officer of Battalion B, informed recruits to report for flag detail.	0750
Battalion B reported to gym for firefighter survival training. Recruits performed drills that involved chinning (breathing through hood), stud-wall channel escapes, window bailouts, ladder bailouts, and crawling through culvert tubes.	0800
The PF's fire chief, two captains and a firefighter arrived to watch their department's two recruits train. They observed the PF finishing the culvert tube evolution. He was on his 4th air cylinder of the morning.	1100 (Estimated time)
Recruits broke for lunch. Recruits described that the PF ate lunch, vomited, and then reported to recruits that he was "fine" indicating it was "mainly nerves" causing him to vomit. As the recruits walked back to the gym after lunch, it was reported that the PF continued to have "dry heaves."	1230 (Estimated time)
Battalion B reported to the gym to conduct the SCBA confidence evolution. The PF started his evolution in the culvert tubes where he struggled to doff and re-don his SCBA, but he completed it and told several recruits he was relieved because he thought the worst was over.	1305 (Scheduled time)

SCBA Confidence Day Drill Indicators & Conditions	Time
After a short break and fresh cylinder, he continued to the window bailouts and stud-wall channel escapes, and then moved to the entanglement tunnel prop. Many recruits estimated he was in the tunnel prop for 10 to 12 minutes.	1352
The PF was motionless and stuck in the last obstacle (right triangular shaped hole). An instructor noticed that the PF's mask mounted regulator (MMR) was disengaged from the facepiece. State fire instructors pulled the PF through the obstacle and were yelling at the PF to get him to continue.	1410
The PF was motionless and on his right side. A state fire instructor from another prop area realized something may be wrong and removed the PF's mask and checked his pulse. The PF was blue and had no pulse. State fire instructors initiated the "firefighter down" maneuver, removing his SCBA and turn-out gear, and initiated CPR. The staff EMT was summoned.	1413
The two battalions were in various stages of drilling. All recruits were cleared from the gymnasium. Multiple state fire instructors rotated in performing CPR.	1414
An automated external defibrillator (AED) was brought to the scene and applied to the PF. The AED indicated "No Shock Advised". The staff EMT contacted the local emergency medical service ambulance by cell phone. The ambulance staff reported a 20-minute response time to the academy	1415
An academy fire protection specialist contacted the recruit's fire department to inform them of the incident. They, in turn, contacted the PF's chief, who was on his way home after visiting the recruits during the morning training exercises.	1417
Since ambulance service was not immediately available, the state fire instructors decided to utilize the state fire academy's transport van to transport the PF to the hospital.	1423

SCBA Confidence Day Drill Indicators & Conditions	Time
The PF arrived at the emergency department (ED) with no pulse.	1429
The PF's pulse returned during treatment, and he was flown by medical helicopter to the closest trauma center.	1439
The PF was flown by medical helicopter to Hospital B	1535
Nine days later, life support was disconnected, and the firefighter was pronounced deceased.	March 12, 2021

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Appendix 2

The following graphs represent SCBA air cylinders used by the PF during the morning session of the day's SCBA Confidence Course.

Graph A: First cylinder on March 3, 2021. Used for "chinning" drill.
(Graph by SCBA manufacturer)

Graph B: Second cylinder on March 3, 2021. Used for "chinning" drill while being dragged across gymnasium. *(Graph by SCBA manufacturer)*

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Graph C: Third cylinder on March 3, 2021. Used for culvert tube drill.
(Graph by SCBA manufacturer)

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Graph D: Fourth cylinder on March 3, 2021. Used for second opportunity for culvert tube drill.
(Graph by SCBA manufacturer)

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Appendix 3

Evaluation of The Self-Contained Breathing Apparatus for Potential Contribution to a Fatal Event in the Fire Service

As part of the National Institute for Occupational Safety and Health (NIOSH) Fire Fighter Fatality Investigation and Prevention Program (FFFIPP), investigation F2021-08 NY, the National Personal Protective Technology Laboratory (NPPTL) agreed to examine and evaluate the SCBA unit identified as a MSA Model G1, 45-minute, 4500 psi unit with NIOSH Approval Numbers TC-13F-0787CBRN. The firefighter was wearing the unit when the event occurred. The corresponding facepiece and cylinder were provided with the unit. The testing team determined a replacement facepiece was needed because they were unable to achieve a passing static pressure test with the facepiece provided after the Gas Flow Test. Therefore, the remainder of the testing was conducted utilizing an NPPTL facepiece. Overall, the SCBA was in good condition. The NFPA approval label was present and readable. The PASS, HUD, and alarm systems functioned as designed during the inspection and during the remaining service life indicator testing completed on 5/26/2021. However, it seems as though the battery is no longer charged. The unit passed all the NIOSH tests as well as meeting the requirements for the NFPA "Airflow Performance" test.

The information obtained during this investigation does not suggest that the components tested contributed to the fatality. The SCBA was shipped back to the Fire Department.

Summary

No evidence was identified to suggest that the SCBA unit inspected and evaluated contributed to the fatality. NIOSH determined that there was no need for corrective action with regards to the approval holder or end user of SCBA manufactured under the approval numbers granted to this product.