



Death in the line of duty...



A summary of a NIOSH fire fighter fatality investigation

August 20, 2013

Volunteer Captain Dies While Participating in Advanced Dive Training at Quarry—Ohio

Executive Summary

On August 10, 2012, a 46-year-old male volunteer captain drowned while attempting to complete an advanced underwater diving course at a county park (formally a stone quarry). The course was to consist of two dives and focus on underwater navigation using a compass. The victim experienced buoyancy problems during both dives. The victim started with a reported 28 pounds of weight in his buoyancy control vest. He borrowed two 2-pound weights from his partner on the first dive. While on shore between dives, the instructor gave him what is believed to be two more 2-pound weights, making a total of 36 pounds. During the next dive, the victim and his partner attempted to surface because the victim was low on air. When the victim surfaced, the victim's buoyancy compensator was not inflated, he was out of air, and he appeared to be in a panic. His partner got him under control and began to drag him to the dock. The victim became unconscious, and due to being overweighted, his partner was not able to hold onto the victim and the victim sank to the bottom at a depth of 60 feet where he drowned.



**Dock where victim was pulled from quarry.
(NIOSH Photo)**

Contributing Factors

- Insufficient dive training/experience
- Over-weighted dive belt
- Lack of medical screening

Recommendations

- Fire departments should consider performing a preplacement and an annual physical performance (physical ability) evaluation for all fire fighters to ensure they are physically

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capable of performing the essential job tasks of fire fighting and technical rescues such as SCUBA diving.

- The authority having jurisdiction should ensure that members who are assigned to public safety dive teams receive sufficient training.

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH “Fire Fighter Fatality Investigation and Prevention Program” which examines line-of-duty-deaths or on duty deaths of fire fighters to assist fire departments, fire fighters, the fire service and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with State or Federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the victim, the fire department or those interviewed. The NIOSH report's summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency's recommendations and is not intended to be definitive for purposes of determining any claim or benefit.

For further information, visit the program website at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).

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Introduction

On August 10, 2012, a 46-year-old male volunteer captain drowned while attempting to complete an advanced underwater diving course in a lake at a county park (formally a stone quarry). On August 13, 2012, the U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. On August 14, 2012, a safety and occupational health specialist and a general engineer from the NIOSH Fire Fighter Fatality Investigation and Prevention Program traveled to Ohio to investigate this incident. The NIOSH investigators conducted meetings and/or interviews with representatives of the fire department, emergency medical services, county park representatives, and the county dive team director. The incident site was visited and photographed.

Fire Department

This volunteer department consists of 22 uniformed fire fighters. The department has 1 station and serves a population of about 6,000 people covering an area of approximately 80 square miles.

Training and Experience

The state of Ohio requires 36 hours of training to be a fire fighter and 18 hours of annual refresher training to maintain state fire fighter certification. The fire department requires 36 hours of basic fire fighter training for an individual to be an active fire department member. Fire department records showed that the victim was certified as an NFPA Firefighter II and had over 240 hours of training on topics such as ANDI (American Nitrox Divers, Inc.) Open Water Sport Diver, Emergency Medical Technician, Cardiopulmonary Resuscitation, Water Rescue, and the National Incident Management System (courses 100, 200, 300 and 700).

The victim held a basic open water sport diver certification for recreational SCUBA diving, which consisted of four dives that he completed in August 2004. In July 2011, the victim completed two additional dives, logged in his log book as Dive No. 5 and Dive No. 6. Both dives were actual calls to respond with a regional dive team. Dive No. 5 lasted 17 minutes at a depth of approximately 8 feet. Dive No. 6 lasted 30 minutes at a depth of approximately 10 feet.

NIOSH investigators contacted the dive instructor to review his training and experience, but he refused to participate in the NIOSH investigation.

Medical History

During the interviews of family and department members, it was discovered that the victim had a history of high blood pressure and, at the time of the incident, was taking medication to control his condition.

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SCUBA Equipment

The SCUBA equipment used by the victim in this incident was personally owned by the victim. After the incident, the equipment was taken into custody by the county park authorities at the former stone quarry and stored pending investigation. NIOSH investigators examined the equipment and the department sent the gear through NIOSH to the Navy Experimental Dive Unit (NEDU) for evaluation. The NEDU found the equipment to be in proper working condition.

The following equipment was present and examined and photographed by NIOSH investigators at the local police department evidence room:

- 1 open-circuit SCUBA demand regulator,^a having a single intermediate pressure hose with first-stage pressure reduction at the yoke^b (cylinder attachment) and second-stage regulator at the mouthpiece
- 1 octopus rig^c
- 1 depth and pressure gauge pack (depth gauge had a maximum-depth indicator indicating 60 feet on last dive)
- 1 buoyancy compensator device (air bladders empty)
- 2 80-cubic feet, 3000-psi aluminum dive cylinders (empty). The cylinders each had a mark indicating when the last hydrostatic test was performed. One was on July 2009 and the other cylinder was June 2012.
- Dive fins
- Wrist-mounted dive computer
- 6.5-mm neoprene two-piece wet suit
- 1 SCUBA mask

^a A demand regulator is an apparatus in which the gas supply is activated by the negative pressure associated with inhalation.

^b A yoke is a device for attaching the regulators to the cylinder(s) in order to make a leak-proof seal.

^c An octopus rig is a single-hose regulator with an extra low-pressure port where an additional second-stage regulator has been provided for emergency buddy-breathing air supply or in case of primary second-stage regulator failure.

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The victim's weight belt was not recovered from the lake after being jettisoned by the dive instructor during the rescue attempt. The dive instructor was at the dive site the day following the incident looking for the weight belt. He reported to park authorities that he could not find it. The victim's dive computer showed the victim's deepest location, which was 62 feet. This depth is only possible in this lake at the spot where he was found and recovered. The park authorities called in a chief from a neighboring department, who was also a member of the regional dive team, to search for the weight belt in the 20-foot diameter circle around the location indicated by the victim's computer. After several searches it could not be found. Investigators could not verify how much weight the victim was wearing, but the victim's dive partner reported what he had started with and what the dive instructor had added to that weight. NIOSH investigators recommended that the department ship the victim's SCUBA gear to a qualified independent test facility to examine and provide an evaluation report. The department sent the gear through NIOSH to the Navy Experimental Dive Unit (NEDU) and an equipment evaluation was performed. The evaluation report noted that all of the dive gear functioned as designed. The report identified that the buoyancy compensator was designed for a positive buoyancy capacity of approximately 40 pounds in fresh water. The victim had at least 36 pounds of weight added to his vest. This amount of weight would offset the buoyancy of the vest and not allow it to provide enough positive buoyancy to raise its wearer to the surface if inflated. The vest was not designed to store that much weight and it is unsure how the weight was configured and secured inside the vest. NIOSH investigators believe, it is likely that during the time of duress it was unfamiliar and difficult for the victim to jettison these additional weights.

Dive Site Conditions

The dive site is a county park in Ohio. The park encompasses nearly 800 acres and has a 15 acre lake on the property with an average depth of 40 feet. Primitive camping and swimming are also available and there is a full time manned EMS Squad on the park property. In the event of an emergency, response time is usually less than 3 minutes.

Stone quarry operations, which had once been located at the site, resulted in two deep sections of the lake. One section was 60 feet deep and the other was 80 feet deep. The shoreline was composed of a beach and swimming area, a walk-in area for dive operations, and multiple fishing docks. The bottom was covered with rock and silt. Surface water temperature at the time of the incident was not reported, but divers experienced a 50-degree Fahrenheit thermocline at a depth of 22 feet. Visibility was reported to be 10–15 feet.

Weather conditions on the day of the event were reported as an average air temperature of 64°F. Winds were from the northwest at an average of 10 mph.

Investigation

On August 10, 2012, a 46-year-old male volunteer captain drowned while attempting to complete an advanced underwater diving course in a lake at a county park (formally a stone quarry). The fire department authorized the class consisting of two dives focused on underwater navigation using a

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compass. The instructor had four students in his class. He conducted a short briefing that covered the dive plan for both dives and had paired the students into two dive teams. The first dive was a shore entry and the dive teams were to navigate to a sunken boat in approximately 35 feet of water. The instructor walked the teams into the water to start the first dive. Immediately upon descent, the victim had trouble maintaining negative buoyancy. After obtaining negative buoyancy, the victim and his partner went underwater for 12 minutes and 40 seconds at an average depth of 20 feet. During that time, the victim's ascent warning on his wrist-mounted dive computer activated three separate times. The victim and his partner surfaced without direction from the instructor to attempt to fix the problem. The victim had started the dive with a reported 28 pounds of weight in his vest. After they returned to shore, he borrowed two 2-pound weights from his partner and took off his 6.5-mm neoprene jacket to attempt to compensate for his buoyancy problems. This took approximately 15 minutes while the instructor and the other dive team were still in the water conducting their first dive.

The victim, now with 32 pounds of weight, and his partner returned to the water to finish the first dive. He continued to struggle to maintain negative buoyancy. The divers reached a depth of approximately 30 feet. They descended through the thermocline at 22 feet where the water temperature changed to 50 degrees Fahrenheit. This second leg of the first dive lasted for 7 minutes and 40 seconds. During the first dive, the victim consumed over double the amount of air as his partner did, likely due to his filling and deflating his buoyancy compensator. The victim started with 2,900 psi of air and surfaced with less than 1,000 psi of air. His partner started with 2,800 psi of air and surfaced with over 2,000 psi of air. The victim and his partner were in the water on that first dive for a total of 20 minutes and 20 seconds.

The dive class members and instructor took a break on shore between the two dives for approximately 40 minutes. During this time the victim discussed his buoyancy problems on the first dive with the instructor. The instructor advised him to wear his neoprene jacket and remove his neoprene bottoms to assist with his buoyancy issue and to accommodate for the temperature of the cold water. He also gave the victim two additional weights. *Note: The instructor refused to meet with the NIOSH investigators.* The victim's partner witnessed the instructor giving him the weights, but could not confirm their size. They are believed to have been two additional 2-pound weights. That would make the victim's total weight in his vest 36 pounds.

The second dive was to consist of the dive teams descending to a depth of approximately 45 feet and navigating to a submerged point of land approximately 40 yards from where they entered the water. The victim and his partner entered the water from the dock. The victim's partner descended to approximately 45 feet where visibility was around 10 feet. He waited approximately 5 minutes for the victim to descend to him. Once the victim united with his partner, the two swam underwater to the submerged point of land. The victim struggled maintaining buoyancy on the 40-yard underwater navigation. The victim and his partner made it to descent point and waited approximately 3 minutes for the instructor to arrive. During this time, the victim's partner noticed that the seal on the victim's mask had been compromised due to it being over a portion of his neoprene hood. The victim had water in his mask up to his nose. The partner slid the victim's mask off of his hood, but the victim did not attempt to clear his mask. At this time the instructor arrived at their location. The instructor asked the

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victim about his air quantity and the victim reported 500 psi. The instructor signaled for the victim and his partner to swim underwater back to the dock.

The victim and his partner swam approximately half way back to the dock platform when the victim signaled low on air and the need to surface. They stopped at a depth of 15 feet for approximately 3 minutes for a safety stop, during which the victim drifted up and down between 15 and 25 feet. His partner repeatedly descended to assist him but struggled with water pressure differences. The victim and his partner eventually surfaced. The victim surfaced with his mask on and was in extreme panic. His regulator was out of his mouth and he removed his mask and threw it yelling that he was drowning. His dive partner immediately swam to him to provide assistance. The victim was attempting to inflate his buoyancy compensator orally. The partner gave the victim his primary regulator and used his secondary. The victim was flailing and ripped the regulator from his mouth and the secondary from his dive partner's mouth. He then continued to flail and strike his dive partner and pushed his partner under the water as he tried to climb on top of him. *Note: The victim outweighed his partner by approximately 100 pounds, not including the addition of all his dive weights.*

The victim's partner resurfaced, struggling from ingesting water and wrestling with the victim. The victim appeared to start to lose consciousness. The partner yelled out to a fisherman to jump in and assist him with swimming the victim back to the dock. They made it back to the dock when the victim lost consciousness. The partner, totally exhausted from wrestling and dragging the victim through the water for over 30 yards, held on to the victim and attempted to get himself and the victim onto the dock. The victim lost consciousness. His weight was too much for the partner to hold. The victim's partner held on to the victim as he sank down pulling the partner under the water through several attempts to make it on the dock. The partner lost his grip on the victim and the victim immediately sank. The instructor arrived at the dock at this time and dove to locate the victim. He located the victim in approximately 60 feet of water. He attempted to inflate the victim's buoyancy compensator, but it did not work. He then inflated his own buoyancy compensator with very little progress. He released both of the victim's releasable weights and was able to bring him to the surface. People on shore assisted getting the victim onto the dock where CPR was initiated. The victim was pronounced dead at the scene by the attending physician assigned to the life flight helicopter.

Contributing Factors

Occupational injuries and fatalities are often the result of one or more contributing factors or key events in a larger sequence of events that ultimately result in the injury or fatality. NIOSH investigators identified the following items as key contributing factors in this incident:

- *Insufficient dive training/experience*
- *Over-weighted dive belt*
- *Lack of medical screening*

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Cause of Death

According to the death certificate, the medical examiner listed the victim's cause of death as drowning.

Recommendations

Recommendation #1: Fire departments should consider performing a preplacement and an annual physical performance (physical ability) evaluation for all fire fighters to ensure they are physically capable of performing the essential job tasks of fire fighting and technical rescues such as SCUBA diving.

NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*¹ requires fire department members who engage in emergency operations to be annually evaluated and certified by the fire department as meeting the physical performance requirements identified in paragraph 8-2.1. Frequently, private physicians are not familiar with a fire fighter's job duties or with guidance documents such as NFPA 1582 *Standard on Comprehensive Occupational Medical Program for Fire Departments*.² To ensure physicians are aware of these guidelines, NIOSH recommends that fire departments provide contract and private physicians with a copy of NFPA 1582² and a SCUBA diving medical clearance form. Lastly, NIOSH recommends that all return-to-work clearances be reviewed by a fire department-contracted physician. The final decision regarding medical clearance for returning to work lies with the fire department. The fire department can receive input from many sources, including the fire fighter's private physician.

The purpose of periodic medical evaluations is to ensure that fire fighters have the ability to perform duties without presenting a significant risk to the safety and health of themselves or others. Guidance regarding the content and scheduling of periodic medical examinations for fire fighters can be found in NFPA 1582 *Standard on Comprehensive Occupational Medical Program for Fire Departments*.² In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire-fighting tasks. Applying NFPA 1582 involves legal and economic issues, so it should be carried out in a confidential, nondiscriminatory manner. Appendix D of NFPA 1582 provides guidance for fire department administrators regarding legal considerations in applying the standard. Technical rescue SCUBA diving candidates should be required to pass a more comprehensive medical evaluation that is administered by a physician familiar with diving medicine. A physician with a strong background in diving medicine and familiar with NFPA 1582 can help provide the technical rescue SCUBA dive team a more comprehensive evaluation of members and candidates.³ The Divers Alert Network⁴ is one resource technical rescue SCUBA diving teams can use to locate physicians familiar with diving medicine. The regional dive team did not require any medical screenings to become a member of their dive team. Family and department members informed the NIOSH investigators that the victim suffered from high blood pressure and was taking medication. A regional dive team appointed physician would have been able to evaluate the victim's condition to determine if he was able to perform duties without presenting a significant risk to the safety and health of him or others.

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Recommendation #2: The authority having jurisdiction should ensure that members who are assigned to public safety dive teams receive sufficient training.

Public safety SCUBA diving is a technical skill that greatly exceeds recreational SCUBA certification levels. Annual confirmation of these skills should be performed to ensure continued competency. The level of knowledge, skills, ability, equipment, and support required for a public safety SCUBA diver are outlined in NFPA 1006 *Standard for Technical Rescuer Professional Qualifications*⁵ and NFPA 1670 *Standard on Operations and Training for Technical Search and Rescue Incident*.⁶ Public safety diving requires emergency response teams with specific knowledge, skills, ability, equipment, and continued support beyond basic fire fighter or emergency responder requirements to resolve unique or complex rescue situations. The dive team needs to stay current on training and annual skills evaluation.

The environment does not change between training and actual rescue operations. They are both potentially dangerous and training evolutions should be performed with the same standard operating procedures to ensure the levels of operational capability, equipment, and apparatus are identical to real technical rescue incidents. At a minimum, medical personnel that meet the qualifications for basic life support should be provided on site.^{5,6}

Technical rescue SCUBA dive teams need to stay current on new equipment available, such as in-mask communications and protective gear, such as dry suits and redundant air supply options. Continued support for the team is an important function of the leadership of technical rescue teams. Once a team is properly trained and equipped, the organization must continue to provide support to maintain the technical rescue team's operational readiness through continued training and review of program goals and needs. Inadequately trained divers should not be allowed to participate in technical rescue SCUBA diving incidents beyond their level of training.

In his book *Dive Rescue Specialist, Operational Training for Public Safety Divers*,³ author Steve Orusa notes the following: "Inadequate SCUBA skills may be the leading cause of public safety diver accidents. In many cases, a problem developed that the diver was unable to solve due to a basic skill level. In most cases, divers had received either insufficient or nonexistent SCUBA skills refresher training after initial certification." Public safety divers should have training and experience in a variety of environments likely to be encountered in rescue operations, such as, ice, swift currents, hazardous materials, dry suit, and lifting operations.

In this incident, the victim was attempting to receive his advanced open water certification. The authority having jurisdiction over the regional dive team should have been in charge of ensuring that all of their members were trained sufficiently in all required prerequisite courses and make the determination if the victim was adequately trained and equipped to attempt an advanced course. The victim held a basic open water sport diver certification, which he received in August 2004. The victim was using his personal dive equipment, which was the same equipment used in 2004. The same instructor who trained the victim in 2004, was conducting the advanced open water course. This level

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of training is for recreational SCUBA diving, and the training is limited to the level of training received at the time of the certification, which in this case was more than 8 years ago. Since his initial certification training course, which consisted of four dives in 2004, the victim had completed two additional dives. These dives were logged in the victim's log book as Dive No. 5 and Dive No. 6. Both dives were in July 2011 and they were actual calls to respond with the regional dive team. Dive No. 5 lasted 17 minutes at a depth of approximately 8 feet. Dive No. 6 lasted 30 minutes at a depth of approximately 10 feet.

Despite the certified recreational training, the victim was not properly experienced or equipped to safely perform an advanced underwater operation. The victim's personally owned SCUBA equipment was over eight years old and had not been inspected. At a minimum, the equipment, such as the buoyancy compensator vest and regulators, should be inspected annually by a certified dive shop. For this incident, the instructor was the only person involved in providing and overseeing the training. There were not any additional dive personnel to provide emergency rescue support, safety officers, or other equipment or apparatus that would be required for an actual dive rescue event, and no medical care providers present on site during the training activity. The authority having jurisdiction over the regional dive team should oversee and approve all training evolutions to ensure the safety of its members. The authority having jurisdiction of the regional dive teams must ensure the safety of its members and follow the guidelines set forth in NFPA 1006 *Standard for Technical Rescuer Professional Qualifications*⁵ and NFPA 1670 *Standard on Operations and Training for Technical Search and Rescue Incidents*.⁶ which will ensure that the training requirements are identical to the levels of operational capability, equipment, and apparatus used during actual technical rescue incidents.

References

1. NFPA [2007]. NFPA 1500 Standard on fire department occupational safety and health program. Quincy, MA: National Fire Protection Association.
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5. NFPA [2008]. NFPA 1006 Standard for technical rescuer professional qualifications. Quincy, MA: National Fire Protection Association.

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6. NFPA [2009]. NFPA 1670 Standard on operations and training for technical search and rescue incidents. Quincy, MA: National Fire Protection Association.

Investigator Information

This incident was investigated by Jay L. Tarley, safety and occupational health specialist, and Matt Bowyer, general engineer, with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH, located in Morgantown, West Virginia.

An expert technical review was provided by Chief Steve Orusa of the Town of Fishers Fire Department. Chief Orusa is also the author of *Dive Rescue Specialist, Operational Training for Public Safety Divers*. A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division.

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