



## **Fire Fighter / Paramedic Drowns During an Underwater Scuba Training Drill - Missouri**

### **SUMMARY**

On July 15, 1999, one male fire fighter / paramedic / rescue diver (the victim) drowned while taking part in a drill. The victim, one of four rescue divers and a boat driver participating in a training drill, was assigned the "Pivot Diver" position. During the drill, a Safety Diver was to remain at the surface. The Pivot Diver (the victim), was to enter the water, follow the anchor line to the bottom, set up with a 50-foot length of rope, then signal the Pattern Diver (whose duty is to swim in a circular pattern searching for a rescue/recovery target) to descend and proceed with the drill. The crew on the surface observed air bubbles as the victim descended. Approximately 2 minutes later the rope bag surfaced while the bubbles continued. It appeared to the crew on the surface that the victim was searching for the rope bag because the air bubbles appeared to be moving back and forth. The Lead Diver instructed the Pattern Diver to descend and retrieve the victim. The Lead Diver also started to knock on the bottom of the rescue boat with a dive knife in hopes of signaling the victim to return to the surface. When the Pattern Diver surfaced, he reported the victim could not be found. The Lead Diver then instructed the Boat Driver to radio for emergency assistance and implement the department's Incident Command System (ICS). The Lead Diver also directed the Safety Diver to initiate rescue of the victim. When the Safety Diver surfaced without the victim, the Lead Diver instructed the Safety Diver to assume the role of Pivot Diver. The Lead Diver assumed the role of Pattern Diver. Both the Safety Diver and Lead Diver dove below the surface to initiate a rescue of the victim. The victim was found during the search and brought to the surface approximately 11 minutes after the Boat Driver initially requested emergency assistance. When the victim was brought to the surface, the air

regulator was not in his mouth and he was noticeably cyanotic and unresponsive. The victim received immediate medical attention on the Rescue Boat and while en route to a regional trauma center, where he was pronounced dead upon arrival.

NIOSH investigators concluded that, to reduce the risk of similar incidents, fire departments that provide Public Safety Diving (PSD) rescue services should

- *review and update fire department policies and Standard Operating Procedures to incorporate information contained within NFPA 1670-1999, Standard on Operations and Training for Technical Rescue deemed as appropriate*
- *consider that whenever water-based training sessions are conducted, all participants have practiced the specific evolution in a controlled environment such as a swimming pool before attempting the evolution in open water*

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at:

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- *ensure that positive communication is established between all divers and those personnel who remain on the surface*

Additionally, the membership of the National Fire Protection Association (NFPA) should consider

- *adding relevant sections that establish minimum job performance requirements for Rescue Technicians engaging in Public Safety Diving activities during the next adoption cycle of NFPA 1006, Standard for Rescue Technician Professional Qualifications*

#### **INTRODUCTION**

On July 15, 1999, a 25-year-old male fire fighter / paramedic / rescue diver (the victim) drowned while taking part in a “Boat-Based Circular-Pattern Search” training drill. The victim entered the water with a rope bag containing a 50-foot length of ½-inch rope and descended. About 2 minutes later the rope bag surfaced and the Lead Diver instructed the Pattern Diver to descend and retrieve the victim. After an unsuccessful attempt to retrieve the victim, the Lead Diver then instructed the Boat Driver to radio for emergency assistance and implement the department’s ICS. A rescue search was initiated, and about 11 minutes later the victim was found and brought to the surface. The victim received immediate medical attention on the rescue boat, and Advanced Life Support (ALS) was provided during transport to an area hospital. The victim was then transferred by helicopter to a regional trauma center, where he was pronounced dead.

On July 19, 1999 the United States Fire Administration notified NIOSH of this incident and on July 22, 1999, a Safety Engineer and a Safety and Occupational Health Specialist traveled to Missouri to conduct an investigation. Meetings were

conducted with the Fire Chief, the Assistant Fire Chief in charge of training, and the President and Vice-President of the International Association of Fire Fighters local union. NIOSH investigators also met individually with members of the dive team and relevant fire department staff on duty at the time of the incident. Subsequently, NIOSH investigators conducted telephone interviews with the Medical Examiner and the leading Missouri State Water Patrol Officer investigating this incident. Equipment worn by the victim was secured by the local police department and made available for NIOSH investigators. The equipment consisted of

- a face mask
- a wet suit composed of two pieces, an upper body suit commonly called a “shorty” and a lower body suit commonly called “farmer john pants”
- a pair of gloves
- a pair of booties
- a strobe light
- a flashlight
- a buoyancy compensator (BC) vest with integrated weight system, which held 24 pounds of lead shot
- an air tank (The air tank, at the time it was recovered, had 2,600 psi remaining as reported by the Missouri State Water Patrol. When NIOSH investigators inspected the tank on July 22, 1999, the reading was below 500 psi.)
- first- and second-stage regulators and alternate second-stage regulator

NIOSH investigators reviewed relevant fire department policies, SOPs, incident reports, and they listened to audio taped radio transmissions that had been made during the incident. The victim’s personnel/medical and training records and the autopsy report were assessed as well. The fire department involved in the incident serves a suburban population of 72,200 people in a geographical area



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of 70 square miles. The fire department is comprised of 112 employees, of whom 99 are uniformed fire fighters. At the time of the incident, 25 fire fighters assigned to 3 squads were designated as Rescue Divers. The fire department established a policy in August 1991 covering Water Rescue Certifications. Three levels of certification outlined in the policy are First-Responder, Technician, and Specialist. All uniformed members of the department are provided training to the First-Responder level. Upon obtaining an Open Water card from the Professional Association of Diving Instructors (PADI) and passing a fire department skill evaluation process, the diver is considered to be operating at the Technician level. Technician-level divers can participate in emergency, "non-hazardous" dives such as dives not greater than 60 feet, non-ice dives, and non-confined space dives. Divers operating at the Specialist level are those divers who have ". . . more detailed or specific knowledge of water rescue." This policy requires Technician-level divers to demonstrate a swimming proficiency and specific dive skills such as clearing water out of a dive mask, entering water with full equipment, and buddy breathing (both as donor and recipient), with and without facemask. Divers also have to demonstrate these proficiencies: understanding underwater signs and signals, emergency ascent techniques, competency in use of a buoyancy system, ability to achieve and maintain neutral buoyancy while submerged, self rescue, buddy rescue, and the ability to navigate under water. The department's Water and Ice Rescue Operations SOP was most recently revised in May 1997. The department's SOP addressed topics such as incident management, search and rescue procedures, rope signals, and safety considerations. The department's Water and Ice Rescue Operations SOP also outlined required diver's equipment. The victim initially received a PADI "Open Water Diver" card in July 1997. The victim successfully passed the fire department's required annual certification 11 months

before the incident. One month before July 15, 1999, the victim completed specialized Public Safety Dive training; however, the training session did not include a practical "Boat-Based Circular-Pattern Search" evolution. At the time of the incident, the victim was considered a Technician according to the fire departments' policy governing Water Rescue Certifications. The victim's last medical evaluation did not identify any information that would preclude the victim's participation in fire fighting or underwater SCUBA activities.

#### **INVESTIGATION**

The morning of July 15, 1999, was the first day back to duty after a scheduled shift relief period for the victim and other divers participating in this drill. The victim was one of four divers and one boat driver participating in the drill that morning, which was held on an inland lake. The lake had been formed about 25 years ago when a river was dammed, creating a smooth and muddy bottom, as classified by the Missouri Water Patrol (MWP). Over the years a coating of silt built up over the muddy layer, and this silt was described by the MWP as having the consistency of baby powder. When the silt coating was disturbed, it clouded the water and severely obstructed visibility. The weather conditions on the morning of July 15 were clear with moderate winds (7 - 14 MPH) and the air temperature was recorded at 88° F. The lake was calm (waves less than 6 inches) and the initial surface water visibility of the lake was moderate. The goal of the drill was to use the Boat-Based Circular-Pattern Search technique and locate a simulated rescue target on the lake bottom in limited visibility. The fire department's Water and Ice Rescue Operations SOPs were reviewed at the fire station and again just before launching the rescue boat from shore. During the boat ride to the dive site, pre-dive equipment checks were performed. The Lead Diver, as part of the customary buddy-check, inspected all the



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participants' gear, including ensuring the valves on the air tanks were fully open. The Lead Diver opened a partially opened air valve and replaced a malfunctioning tracking light. The Lead Diver noted the victim's air pressure gauge read 3,000 psi of air pressure. The Lead Diver asked the Boat Driver to find a shallow location, about 20 feet deep; however, due to the contour of the lake bed, diving a circular search pattern would not be possible at that depth. The Boat Driver relocated in water that was about 30 feet deep. Once the location for the drill was suitable, the victim swam out about 40 feet from the boat, put out a dive flag to warn others that a dive operation was in progress, and returned to the rescue boat. The drill assignments were again reviewed and the drill began. The victim was assigned the position of Pivot Diver, and others were assigned positions of "Pattern Diver," "Safety Diver," "Lead Diver," and "Boat Driver." The Pivot Diver's role is to descend and maintain a fixed location while a Pattern Diver swims increasingly larger circles, thus ensuring an area has been systematically searched. The search pattern equipment used to ensure a systematic search during this drill was a 50-foot length of ½-inch rope in a bag. The rope bag, fabricated of nylon material, measured 5 inches in diameter and 13 inches in length and had a small grommet hole in the bottom. The victim placed the rope bag under his buoyancy compensator vest. While the victim descended with the rope bag, the Pattern Diver was on the surface holding onto (tending) the other end of the rope. During the victim's descent the crew on the surface observed his air bubbles about 8 to 10 feet away from the Rescue Boat. The Pattern Diver did not feel any tugging on the rope during the descent. (A preestablished signal for distress per the department's SOP is four pulls when sent from the diver to the surface.) Approximately 2 minutes later the rope bag surfaced. Because the air bubbles appeared to be moving back and forth, it appeared to the crew on the surface the victim was searching for the rope

bag. The Lead Diver instructed the Pattern Diver to descend and retrieve the victim so the drill could be restarted. The Lead Diver also started knocking on the bottom of the rescue boat with a dive knife in the hopes of signaling the victim to return to the surface. The Pattern Diver descended down the anchor line to the lake bottom but could not find the victim. When the Pattern Diver returned to the surface without the victim, he described a near-zero visibility on the bottom due to "black water." The Lead Diver requested the Boat Driver call for emergency assistance and implement the department's ICS. The Safety Diver, who was in the water standing by on the surface, was instructed by the Lead Diver to initiate rescue of the victim. Realizing that his assistance may be needed, the Lead Diver prepared to enter the water. When the Safety Diver returned to the Rescue Boat without the victim, the Lead Diver assigned the pivot position to the Safety Diver, the Lead Diver assumed the duties of the Pattern Diver, and they both descended to initiate rescue of the victim. While filling the duties of the pivot position during the circular search, the Safety Diver found the victim near the boat's anchor. The victim's immediate rescue was hampered by his prone position, a ½-inch rope, underwater debris, and muck on the lake bottom. The Safety Diver surfaced, identified the victim's location as being near the center of the search pattern, and requested assistance. The diver originally designated as the Pattern Diver, dove to the victim's location and found the victim again. In the meantime the Lead Diver ceased executing the circular search pattern and moved toward the center point. Due to the near-zero visibility, the Pattern Diver took the Lead Diver's hand and placed it on the victim. Both the Lead and Pattern divers worked to free the victim before they could ascend to the surface. To ease the victim's transfer into the Rescue Boat, his dive gear was released into the water. Mud covered the victim's face and was also in his mouth and nose. The victim was unconscious



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and cyanotic. On board the Rescue Boat, after an initial patient assessment, Cardio-Pulmonary Resuscitation (CPR) was initiated, an airway was established by suctioning the mud from the victim's airway, and an Esophageal Airway (EOA) tube was inserted into victim's esophagus. In accordance with the department's Water and Ice Rescue Operations SOP, an Advanced Life Support team was available on shore and provided medical assistance when the victim was brought to shore. The victim was transported to an area hospital and later transferred by helicopter to a regional trauma center, where he was pronounced dead upon arrival. As part of the fire department's investigation into this incident, air samples from SCUBA and SCBA tanks in use throughout the department were tested by an independent testing laboratory. The test results confirmed that the air sampled was within industry and regulatory standards. When the victim's first- and second-stage regulators were evaluated by NIOSH investigators, they were found to be operating normally. The loss of the regulator from the victim's mouth appears to be the primary event causing this fatality. The contributing factors that culminated in the loss of the regulator are not known and may never be definitively established. However, the following possibilities have been raised:

1. The rope bag [due to a positive buoyancy] knocked the regulator from the victim's mouth when he removed the rope bag from beneath his Buoyancy Compensator.
2. The victim may have experienced a temporary ascent and developed an embolism, thus causing him to expel the regulator due to pain or loss of consciousness. Autopsy findings do not support, nor could they definitively rule out this scenario.
3. The victim's regulator may have been knocked out of his mouth by the anchor line.

#### **CAUSE OF DEATH**

Based on the findings of an autopsy performed by the Medical Examiner, the cause of death was listed as an accidental drowning. The medical examiner also noted the presence of small amounts of "muddy material" in the upper airway of the victim.

#### **RECOMMENDATIONS/DISCUSSION**

***Recommendation #1: Fire Departments should review and update departmental policies and Standard Operating Procedures to incorporate the information contained within NFPA 1670-1999, Standard on Operations and Training for Technical Rescue deemed as appropriate.<sup>1</sup>***

Discussion: Departments that provide Public Safety Diving services should take advantage of the information contained in NFPA 1670-1999 and referenced material. This document represents the collective body of information that has passed a consensus review based on NFPA's Regulations Governing Committee Projects. Specifically, NFPA 1670-1999 outlines technician-level functions as, but not limited to, procedures for dealing with the various underwater environments with which the rescue diver could come into contact and procedures for effective underwater communication. Departmental SOPs should outline duties for all Public Safety Divers while performing various search patterns; items to be addressed should include consideration of tie (or tender) lines that have the capability to be released by the diver, if necessary, in low/zero visibility environments. In some high-entanglement situations, tender lines may not provide the desired level of operational safety that a partner diver would allow. It should be noted that NFPA 1670-1999 was accepted as an American National Standard on February 4, 1999, as a new standard. Commonly, the process to disseminate, review and incorporate relevant portions of a new document such as NFPA 1670-1999 into departmental SOPs by an authority



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having jurisdiction can require several months after a document is adopted as a national standard. In this incident, the fire department developed policies and SOPs based on its experience in the absence of a document similar to NFPA 1670-1999.

***Recommendation #2: Fire Departments should consider that whenever water-based training evolutions are conducted, all participants have practiced the specific evolution in a controlled environment such as a swimming pool before attempting the evolution in open water.***<sup>2</sup>

Discussion: The complexity of Public Safety Diving cannot be underestimated. Whenever new skills and/or equipment are introduced, it is important to gradually increase the level of complexity the diver is expected to master. For example, performing a task underwater without a wet suit would be less complex than performing the same task with a wet suit. Pool sessions that gradually increase the level of complexity would allow the diver to master the tasks and skills expected in a controlled situation, thus improving the chance of a positive outcome when the evolution is replicated in an open-water environment. A diver's skills should be evaluated with the diver wearing the full complement of equipment that would be worn while performing in actual rescue situations. This skill evaluation should include underwater emergency procedures as well as the other skills needed to deliver Public Safety Diving services. It cannot be established if the victim practiced this particular evolution in a controlled environment before this attempt. This recommendation also would be relevant to any rescue diver, regardless of the experience level, whenever a new piece of equipment is being introduced. For example, a new piece of equipment may perform differently than expected under water due to buoyance characteristics and limitations on manual dexterity when the diver is wearing a full wet suit or dry suit.

***Recommendation #3: Fire Departments should ensure that positive communication is established between all divers and those personnel who remain on the surface.***<sup>3</sup>

Discussion: Effective underwater communication is imperative. Specifically, diver-to-diver and diver-to-surface communications should be established and maintained during the dive. Effective communication can be achieved through the use of rope signals or through hard-wired or wireless underwater communication systems. This department placed an order for an underwater communication system prior to this incident; however, the equipment was not yet delivered. The department is currently taking steps to develop procedures and train divers in the use of this communication system, prior to deployment.

***Recommendation #4: Membership of the National Fire Protection Association should consider adding relevant sections that establish minimum job performance requirements for Rescue Technicians engaging in Public Safety Diving activities during the next adoption cycle of NFPA 1006, Standard for Rescue Technician Professional Qualifications.***<sup>4,5</sup>

Discussion: Because many of the skill and performance requirements found in recreational dive programs are also found in Public Safety Diving, it has been a common judgment within the fire service that recreational divers can function as rescue divers on organized dive rescue teams. National standards need to delineate the functional differences between fire department personnel who are certified to a recreational standard and those divers who are trained and possess the skills needed to operate at a level necessary to deliver Public Safety Diving services. At the time this incident occurred and subsequent to the investigation, *NFPA 1006-2000, Standard for Rescue Technician Professional*



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*Qualifications* was proceeding through the NFPA process for ultimate consideration by the NFPA membership at the 1999 Fall Conference. The submission of NFPA 1006-2000 to the NFPA membership for consideration represents the first document cycle for this new professional standard. All aspects of technical rescue operations could not be considered by the committee within the time frame necessary to meet the document cycle schedule. The version for consideration by the NFPA membership at the 1999 Fall Conference did not address the necessary minimum job performance skills for Rescue Technicians engaged in Public Safety Diving. As the number of fire departments that provide Public Safety Diving services increases across the country, the need to provide clear guidance increases in relative importance. In the absence of any guidance, departments attempt to develop policies and procedures that might not take full advantage of the collective knowledge and experience base that can be provided by including relevant job performance skills in a document such as NFPA 1006. It is urged that the members of the NFPA 1006 Technical Committee consider adding relevant job performance skills for Rescue Technicians engaged in Public Safety Diving to the standard at the earliest opportunity.

#### REFERENCES

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3. National Fire Protection Association [1999]. NFPA 1670, Standard on operations and training for technical rescue, Section A-7-4.7.3(j). Quincy, MA: NFPA.
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5. Kinsella J [1999]. Letter of December 15, 1999, from J. Kinsella, Training and Quality Management, Professional Association of Diving Instructors, to Eric R. Schmidt, Division of Safety Research, National Institute for Occupational Safety and Health, Centers for Disease Control, Public Health Service, U. S. Department of Health and Human Service.

#### INVESTIGATOR INFORMATION

This investigation was conducted by Eric R. Schmidt, Safety Engineer, and Frank C. Washenitz, Safety and Occupational Health Specialist, NIOSH, Division of Safety Research.