

FATALITY ASSESSMENT AND CONTROL EVALUATION

**A Department of Public Works Worker and a Volunteer Firefighter Died
in a Sewer Manhole Case Report
10NY060****CASE SUMMARY**

In September 2010, a 48 year-old male worker (Victim I) employed by a village Department of Public Works (DPW) and a 51 year-old male volunteer firefighter (Victim II) of the village Fire Department (FD) died after entering a sewer manhole. The manhole was located behind the fire house. The Fire Chief and a firefighter were called in by the DPW general foreman (GF) to unlock the firehouse and move the fire truck so it would not be blocked by the DPW utility truck while working at the manhole. Victim II also arrived to offer assistance. The manhole was five feet in diameter and 18 feet deep with an opening 24 inches in diameter (see photo). Victim I started climbing down the metal rungs on the manhole wall wearing a Tyvek suit and work boots in an attempt to clear a sewer blockage. The DPW GF, the firefighter and Victim II walked over to observe. They saw Victim I lying on the manhole floor motionless. They speculated that he had slipped and fallen off the rungs and injured himself. The Fire Chief immediately called for an ambulance. Meanwhile, Victim II entered the manhole to rescue Victim I without wearing any respiratory protection. The firefighter saw that Victim II fell off the rungs backwards while he was half way down and informed the Fire Chief. The Fire Chief immediately called for a second ambulance and summoned the village FD to respond. The FD responders arrived within minutes. The Assistant Fire Chief (AFC) donned a self-contained breathing apparatus. He could not go through the manhole opening with the air cylinder on his back. The cylinder was tied to a rope that was held by the assisting firefighters at the ground level. The AFC entered the manhole with the cylinder suspended above his head. He did not wear a lifeline although there was a tripod retrieval system. He secured Victim II with a rope that was attached to the tripod. Victim II was successfully lifted out of the manhole. The AFC exited the manhole before a second rescuer entered the manhole and extricated Victim I in the same manner. Both victims were transported to an emergency medical center where they were pronounced dead an hour later. The cause of death for both victims was asphyxia due to low oxygen and exposure to sewer gases.

CONTRIBUTING FACTORS**Contributors to the DPW worker's death:**

- *DPW no-entry policy for permit-required confined spaces was not enforced*
- *DPW permit-required confined space program was not implemented*
- *Employees were not trained on confined space hazards, and proper entry and rescue procedures*

Contributors to the firefighter's death:

- *Firefighters were not trained in confined space rescue procedure*
- *FD confined space rescue protocol was not followed*
- *Standard operating procedure (SOP) was not established for confined space rescue*

KEY RECOMMENDATIONS

For employers with permit-required confined spaces:

- *Implement a permit-required confined space entry program*
- *Provide worker training on confined space hazards, and safe entry and rescue procedures*
- *Prohibit any worker from entering a permit-required confined space without following safe entry procedures*
- *Evaluate all tasks to be performed within confined spaces and make feasible modifications to reduce worker entries*

For fire departments:

- *Develop and implement an SOP for confined space rescue operations*
- *Provide all firefighters with training on assigned duties during confined space rescue operations according to the SOP*
- *Ensure that all firefighters strictly follow the SOP during confined space rescue operations*
- *Survey and evaluate the representative confined spaces within the fire district and provide appropriate rescue equipment*

For municipalities:

- *Ensure newly constructed manholes have large enough openings for rescuers to enter with all necessary personal protective and rescue equipment*



The incident sewer manhole was five feet in diameter and 18 feet deep with an opening 24 inches in diameter; the access rungs were sturdy and intact (Photo courtesy of NYSDOL-PESH).

INTRODUCTION

In September 2010, a 48 year-old male worker (Victim I) employed by a village Department of Public Works (DPW) and a 51 year-old male volunteer firefighter (Victim II) of the village Fire Department (FD) died after entering a sewer manhole. New York State Fatality Assessment and Control Evaluation (NY FACE) staff learned of the incident from newspaper articles the next day. A NY FACE investigator conducted an on-site investigation on October 28, 2010. During the site visit, the NY FACE investigator interviewed the Village Administrator, the Village Engineer and the DPW general foreman (GF). Both the New York State Public Employee Safety and Health Bureau (PESH) and the National Institute for Occupational Safety and Health (NIOSH) Firefighter Fatality Investigation and Prevention Program (FFIPP) investigated the case. The NY FACE investigator met and discussed the case with both the PESH and NIOSH investigators. The police report, the Technical Rescue Team Report (TRT) and death certificates were reviewed while developing this report. NY FACE did not conduct a complete investigation of the firefighter death; the recommendations for the FD were developed based on the NIOSH investigation results. The NIOSH investigation report is available at www.cdc.gov/niosh/fire/reports/face201031.html.

Victim I started working for the village DPW as a highway/road maintenance worker in 1980. He was promoted to a road maintenance foreman in 2005 supervising approximately 20 workers with another foreman. The DPW maintains highway and village roads, catch basins and sanitary and storm water sewer systems, including approximately 500 manholes.

The DPW has two high water pressure jet trucks for clearing sewer blockages. The smaller jet truck was purchased in 1993; it has a 500 foot long hose and 400 gallon water tank. The bigger jet truck that was purchased in 2005 has a 1,000 gallon water tank and 350 foot long hose as well as a vacuum with a 12 inch diameter vacuum hose. These jet trucks deliver a high pressure water jet up to 1,500 pounds per square inch through a steel nozzle (jet head). The jet head can be lowered and guided into the sewer pipe with a rope and a tool with a long handle at the ground level (no worker has to enter a manhole to place the jet head). Once inside a sewer pipe, the jet head and jet stream pound, loosen and clear the sewer line. The DPW purchased both trucks with the intention of preventing workers from entering manholes.

The DPW developed a permit-required confined space program in the 1990's but stopped implementing it in 2004 when the last trained employee retired. On April 26, 2007, the DPW provided an 8-hour permit-required confined space training that was conducted by a safety consulting firm. Seventeen highway workers including Victim I attended the training. The DPW purchased a four-gas (oxygen, hydrogen sulfide, carbon monoxide and combustible gases) monitor and a retrieval tripod to be used during the training. According to the village and DPW management, a permit-required confined space program was never developed because the DPW policy prohibited workers from entering a manhole. However, the no-entry policy was not enforced. Numerous incidents of workers entering manholes were confirmed by employee interviews conducted by the PESH investigation.

Victim II joined the village FD as a volunteer firefighter in 1977. The FD is comprised of all volunteer firefighters; it has six fire companies and responds to fire and carbon monoxide alarms, vehicle fires, as well as extrication and rescue calls. The firefighters received training on first aid and cardiopulmonary resuscitation (CPR), Hazardous Waste Operations and Emergency Response and Essentials of Fire Fighting.

The FD did not have a permit-required confined space rescue program and the firefighters did not receive training on permit-required confined space rescue procedures. The neighboring town has a TRT that was specialized in high risk rescue operations including confined space rescues. According to the agreement between the village and the town, in case of an emergency rescue beyond the FD trained capability, the FD would summon the TRT to conduct the rescue.

INVESTIGATION

At approximately 4 p.m. on a holiday afternoon, the DPW highway crew was dispatched to respond to a homeowner's call reporting a sewer backup in his basement. The DPW GF called Victim I and another worker to assist. The GF met up with Victim I and the worker who drove the bigger jet truck to the site. They were to trace the sewer line downstream from the homeowner's basement and run the high pressure water jet to clear the blockage.

The first manhole downstream was full to the top. They proceeded to the next two manholes and jetted the sewer line, but could not clear the blockage. They then drove to the firehouse where the next three manholes were located: one was in the front, one was inside and the other was in the back of the firehouse. The DPW crew first worked on the manhole in front of the firehouse using the jet truck. Meanwhile the GF, who was also a volunteer firefighter, called the Fire Chief to unlock the firehouse so that they could work on the manhole inside the building.

The jet truck ran out of water while the DPW crew was jetting the first manhole. Victim I and the DPW worker drove the jet truck to a nearby fire hydrant to fill its water tank. At this point, the Fire Chief and a firefighter arrived; they unlocked the firehouse and drove the fire truck out so that it would not be blocked. Victim II, who was not officially dispatched, also arrived at the firehouse to offer assistance.

The GF inspected the manhole inside the firehouse; it was still clogged. He then proceeded to the manhole that was behind the firehouse (the incident manhole) accompanied by the firefighter and Victim II. The incident manhole was built two years ago. It was located on a hill approximately five feet from the firehouse and fifty feet from the street. The manhole cover was covered with brush which the firefighter cleared with a shovel. The GF considered calling for the small jet truck with a longer hose for a better access to the manhole. The GF, firefighter and Victim II were sitting at a picnic table that was approximately fifteen feet from the manhole when Victim I came back from filling the jet truck. The GF was calling for the small jet truck on his cell phone. Victim I walked to the manhole and opened the cover with the shovel.

The manhole was five feet in diameter and 18 feet deep with an opening of 24 inches in diameter. Two sewer pipes were connected at opposite sides of the vertical manhole wall in 180 degrees near the bottom. An 8 inch diameter half pipe that was cemented into the manhole floor connects the two sewer pipes. There were metal access rungs mounted on the manhole wall; all rungs were sturdy and intact. Victim I examined the manhole and commented to the others that it was clogged and he did not smell any odor. He was wearing a Tyvek suit and work boots; he was not wearing any respiratory protection. With a shovel in his hand, he started climbing down the metal rungs. The men who sat at the picnic table including the GF all saw that Victim I was entering the manhole. They all got up and walked over to the manhole to observe. As soon as they got to the manhole, they saw victim lying on the manhole floor motionless. At this point, they speculated that Victim I had slipped and fallen off the rungs and injured

himself. The firefighter immediately suggested to the GF that he would go down the manhole to rescue Victim I; the GF answered "no". The GF asked the Fire Chief to call for an ambulance. At 6:36 p.m., the Fire Chief called 911 and requested an ambulance and summoned the firefighters to respond.

The firefighter brought boots, ropes and a four-gas monitor from the fire truck to the GF who started tying the gas monitor with a rope. Meanwhile, Victim II retrieved his fire boots from his pickup, put them on, went to the manhole and started climbing down the rungs while the GF and the Fire Chief were looking on. The firefighter who was standing next to the manhole saw Victim II looking up with his eyes rolled back and falling off the rungs backwards while he was half way down. The firefighter immediately notified the Fire Chief and the GF. At 6:41 p.m. the Fire Chief placed another 911 call to request a second ambulance and summoned a full FD and TRT response. He also gave the order that no one was to enter the manhole.

The GF lowered the four-gas monitor to the bottom of the manhole and the alarm went off. The GF said that the monitor was reading 14% oxygen, while the firefighter thought the reading was 11.4%. Normal atmospheric oxygen content is 20.9%. The concentrations of hydrogen sulfide, carbon monoxide and combustible gases were not measured.

The village FD responders arrived at the scene approximately five minutes following the alarm. An exhaust fan was placed on the manhole opening facing down to ventilate the manhole while the firefighters were setting up for the rescue operation. A retrieval tripod was set up. The Assistant Fire Chief (AFC) donned a self-contained breathing apparatus (SCBA) mask. The manhole opening was too small for him to enter carrying the air cylinder on his back. A 30-minute air cylinder was tied to a rope and the rope was held by the assisting firefighters at the ground level. The fan was removed from the manhole opening to make room for the AFC to enter the manhole and the manhole air was not monitored before the entry. The AFC entered the manhole with the air cylinder suspended above his head. He did not wear a lifeline that was secured to the tripod.

The firefighters attached an oxygen bottle with a face mask to a rope and lowered it into the manhole. A third rope for lifting the victims was secured to the tripod. Upon descending to the bottom of the manhole, the AFC first put the oxygen mask on Victim II, secured him with the rope that was attached to the tripod and then signaled for lifting. Victim II was successfully lifted out of the manhole. The AFC exited the manhole before the second rescuer, the Fire Captain entered the manhole and extricated Victim I in the same manner. Both victims were in traumatic cardiac arrest. When the TRT arrived at the site at 7:18 p.m., both victims were en route to an emergency medical center where they were pronounced dead an hour later. The cause of death for both victims was asphyxia due to low oxygen and exposure to sewer gases.

Upon arrival, the TRT immediately established a unified command with the representatives of all responders on-site: the village police department (PD) and FD, the neighboring town PD and the county HAZMAT team. It was noted by the TRT that several firefighters were in dangerous proximity to the incident manhole with numerous fire ignition sources including cigarettes and non-intrinsically safe lighting sources. The TRT quickly cordoned off a safe zone and secured the site.

Three four-gas monitors were used to monitor the exterior atmosphere and the air inside the manhole. The TRT noted that they took extreme caution to prevent fire and explosion when removing the incident

manhole cover that had been replaced prior to the TRT's arrival. Urethane tubes were attached to all three monitors that were lowered into the manholes. The readings were taken from top to bottom incrementally. All three monitors recorded nearly identical safe readings of oxygen, carbon monoxide, hydrogen sulfide and combustible gases both inside and outside the incident manhole according to the TRT report.

The village administrator contacted the neighboring town DPW to provide assistance in clearing the sewer blockage. The town DPW was advised to use extreme caution and conduct all work at the ground level. The town DPW worked on an adjacent manhole north of the incident manhole and unplugged the sewer line hours later.

The TRT continued monitoring the air inside the incident manhole while the town DPW was clearing the blockage. Two elevated hydrogen sulfide readings were recorded: 18 parts per million (ppm) taken approximately $\frac{3}{4}$ down the shaft and 25 ppm taken at the bottom of the manhole. The OSHA acceptable ceiling concentration (ACC) limit for hydrogen sulfide is 20 ppm.¹ According to OSHA, an employee's exposure to hydrogen sulfide should not exceed 20 ppm at any time during an 8-hour shift (with an exception of 10 minute maximum peak exposure of 50 ppm). The concentration that is immediately dangerous to life and health (IDLH) is 100 ppm.² The incident manhole was continuously ventilated and monitored until the sewer obstruction was cleared and all four-gas monitors showed safe readings. The TRT response ended at 10:45 p.m.

After the fatal incident, the village administration contracted an occupational safety and health consulting firm to conduct a complete hazard assessment of the job duties assigned to the DPW workers and develop a permit-required confined space program. All DPW employees received permit required confined space entry training. A contractor was hired to conduct all confined space work until the training was completed. The DPW will perform annual program review and provide refresher training following the initial training. While all members of the village FD received confined space awareness training, a select group of firefighters received training in confined space rescue. This group of firefighters will assist the TRT in conducting a confined space rescue. The confined space awareness training was also provided to both the Police Department and the Parks and Recreation Department.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: *Employers should recognize the dynamic and unpredictable nature of confined space atmospheres and prohibit all workers from entering a permit-required confined space without following safe entry procedures.*

Discussion: A confined space is a space that is large enough for a worker to enter, is not designed for continuous worker occupancy, and has a limited or restricted entry or exit. A permit-required confined space potentially contains serious hazards including engulfment, entrapment, explosion and life threatening atmospheric hazards. A sewer manhole is a typical example of a permit-required confined space.

The air inside a confined space can be very different from the outside atmosphere since air may not circulate freely in and out of the space. A confined space environment can range from benign (presenting no detectable atmospheric hazards) to lethal (overcoming entrants within seconds). One

important characteristic of a confined space environment is that it can change rapidly and these changes can be drastic and unpredictable. A NIOSH investigation had documented over 200 incident-free entries into a water valve vault prior to a fatality caused by asphyxiation.³

The makeup of the sewer manhole air can change due to atmospheric temperature and humidity, precipitation, ground water level, microbial activities, blockage in the sewer line and contaminants entering the sewer line. Toxic gases can be generated by chemical and microbial activities; oxygen can be consumed by bacteria as they decompose organic substances or displaced by inert or toxic gases. Fire or explosion can occur due to an oxygen-rich atmosphere and the presence of explosive gases such as methane inside a manhole.

The employer and workers in this case failed to recognize the dynamic and unpredictable nature of the sewer manhole environment. The DPW had a no-entry policy but did not enforce it. According to employee interviews conducted by PESH, the incidents of these workers entering manholes occurred on a monthly basis. Management knew about these but took no action to stop them. The frequent incident-free manhole entries over the years in turn induced a false sense of security among both management and workers and led them to ignore confined space hazard warnings and continue the high risk entries. Employers should recognize the rapidly changing nature of confined space atmospheres and educate workers about the possible life-threatening consequences of entering a permit-required confined space without following proper entry procedures. Workers should strictly follow safe entry procedures and not take any short cuts. Employers should vigorously enforce the safe entry program, and reduce and eliminate risk-taking behaviors through training, supervision and enforcement.

Recommendation #2: *Employers should develop and implement a comprehensive permit-required confined space entry program for all workers who are exposed to confined space hazards.*

Discussion: Municipal workers can be exposed to confined space hazards when performing tasks such as sewer system maintenance. The life-threatening nature of confined space hazards is well known, yet many municipal employers do not have a permit-required confined space program. The village DPW in this case developed the program but failed to implement it. The DPW had a no-entry policy but tolerated frequent breaches of the policy.

Affected by the current economic downturn, municipal governments across the country are facing budget shortages. Municipal employers should make sure that essential safety programs, such as permit-required confined space entry and rescue are developed and implemented.

A permit-required confined space program should be developed in accordance with the OSHA standard (29CFR1910.146) and the NIOSH guidelines (A Guide to Safety in Confined Spaces).^{4,5} Confined space entry procedures should be specific to each type of confined space that may present different physical and atmospheric hazards. The program should at minimum contain the following components:

- A complete evaluation of all confined space tasks to determine whether entry is necessary or the task can be performed from the outside;
- The standard procedure for issuing a confined space safe entry permit before each entry;
- Requirement for posting of warning signs and entry procedures;
- Standard atmospheric testing procedure for before and during entry to ensure that:
 - oxygen concentration is within the range of 19.5% and 23.5%

- flammable gas, vapor, or mist is at or below 10% of its lower explosive limit (LEL or LFL-lower flammable limit) and airborne combustible dust is below its LEL
- Air contaminant concentrations remain below the levels that could be immediately dangerous to life or health
- Precautions against fire and explosion hazards when breaking the plane of a confined space (e.g. opening a sewer manhole cover) and working inside a confined space;
- Standard procedures for ventilating the confined space before and during entry;
- Worker training in safe work procedures in and around confined spaces;
- A confined space rescue plan;
- Worker training in confined space rescue procedures;
- Worker and supervisor training in the selection and use of personal protective equipment:
 - respiratory equipment
 - environmental test equipment
 - lifelines
 - rescue equipment

Employers should perform program review, and update and revise the program as necessary at least annually or whenever the following deficiencies or conditions are identified:

- unauthorized entries
- a hazard not covered by the permit
- an injury or near-miss incident during entry
- a change in the use or configuration of a space
- employee complaints about the effectiveness of the program

Recommendation #3: *Employers should identify the workers who are exposed to confined space hazards through a job hazard analysis and provide appropriate and adequate employee training.*

Discussion: The employer should identify the workers who are potentially exposed to confined space hazards through a job hazard analysis and provide immediate training. Although not all workers are assigned to perform confined space entry during the course of their normal duties, they may encounter a situation where having knowledge of confined space safety would prevent serious injuries or death caused by hazards associated with a confined space. Employers should provide these workers with confined space awareness training to ensure they understand the nature of the confined space hazards and will not attempt to enter a confined space under any circumstance.⁶

Complete permit-required confined space training should be provided to the workers who are assigned to confined space duties. The training should include the confined space hazards and the standard safe entry and rescue procedures. Employers should ensure that workers achieve proficiency in conducting entry and rescue procedures. The training should be provided before an employee is assigned to the specific confined space work. Refresher training should be provided at least annually or whenever there is a change in the assigned duties or in confined space operations, or a change or update in the confined space entry procedures.

Recommendation #4: *Employers should ensure that pre-entry air monitoring is conducted strictly in accordance with the OSHA permit-required confined space standard and NIOSH guidelines.*

Discussion: Before Victim I entered the manhole, he commented that he did not smell any odor. One important reason not to rely on entrants' senses to detect hazards in confined spaces is that many of these hazards are not detectable by human senses. Carbon monoxide, methane and some oxygen deficiency environment are all odorless. Hydrogen sulfide exhibits a "rotten egg" odor at low concentrations. However an entrant cannot detect high concentrations of hydrogen sulfide (150 ppm) since it paralyzes the entrant's olfactory nerve.⁷ The wide range of variations in odor detection adds another reason not to rely on human senses but to use appropriate scientific instruments to detect the confined space atmospheric hazards.

Before a worker enters a permit-required confined space, the internal atmosphere should be tested with a calibrated direct reading instrument in the following order required by OSHA: 1) oxygen content; 2) flammable gases and vapors; and 3) toxic air contaminants. The oxygen concentration should be within the range of 19.5% - 23.5%.

Oxygen is essential for an entrant's survival. It is also needed for proper detection of combustible gases. The sensors (catalytic diffusion type) used by many gas monitors detect combustible gases by oxidizing small amounts of the gas in oxygen.⁸ If oxygen content in a confined space is below 10%, the gas monitor will not be able to detect any amount of combustible gas. Hydrogen sulfide and carbon monoxide are two of the most common toxic gases in confined spaces. Both should be monitored before a worker enters the space.

The confined space atmosphere may be stratified: heavier gases or vapors such as hydrogen sulfide will settle to the bottom while lighter ones such as methane stay on the top of a confined space.⁸ It is important to conduct representative sampling by testing all areas (top, middle and bottom) of a confined space to determine what gases are present and their concentrations.

In order for a gas monitor to accurately respond to the presence of atmospheric hazards and warn workers of the danger, regular instrument calibration should be conducted following the procedure and frequency specified by the instrument manufacturers. Employers should provide necessary air monitoring equipment and ensure that the equipment is inspected, calibrated, tested and maintained according to manufacturers' specifications.

The only reading that was taken before the rescue in this case was the oxygen content. Flammable gases and vapors were not monitored, nor were carbon monoxide and hydrogen sulfide. Employers should ensure that all workers conduct continuous air monitoring before entry as well as during entry in strict accordance with the OSHA permit-required confined space standard.⁹ All monitoring results should be clearly documented on the confined space entry permits. Employers should periodically review the permit records to identify deficiencies and address them during worker training.

Recommendation #5: *Employers should ensure that a designated attendant is posted and no-entry-rescue equipment is set up for each confined space entry.*

Discussion: Employers should provide an attendant for each authorized entry operation and no-entry-rescue equipment such as chest or full-body harness, life line, and retrieval system including mechanical winches and tripods. Winches should be equipped with a braking system that prevents free falls and holds a person in place when raising and lowering has stopped. Tripods should have two winches; one

for an entrant and a second for lifting a victim. By having two winches, the entrant would not be tempted to disconnect himself/herself from the lifeline.

The designated attendant should receive training on the specific confined space hazards that an entrant may encounter as well as the signs and consequences of exposure, and procedures for communicating with entrants, monitoring entrants' activities, conducting no-entry-rescue and summoning emergency services.

The DPW worker in this case entered the manhole without a designated observer and did not use any no-entry-rescue equipment. An attendant outside of the manhole with appropriate rescue equipment could have lifted the victim out of the manhole when he first showed signs of distress.

Recommendation #6: *Employers should educate workers about the fire and explosion hazards inside a manhole and make sure precautions are taken when conducting air monitoring, opening manhole covers, entering and working inside the manhole, and rescuing trapped workers.*

Discussion: The DPW workers in this case did not test flammable gases and vapors before opening the manhole cover using a shovel that was not spark proof. Some village emergency responders were smoking and using lighting sources that were not intrinsically safe (spark-proof) within the immediate vicinity of the incident manhole in this case.

Employers should educate workers about the flammable and explosion hazards in a permit-required confined space and implement prevention measures. A flammable atmosphere is created by the proper mixture of oxygen and a fuel such as a flammable gas, vapor or dust. Some flammable gases such as methane are lighter than air and they stay on top of a manhole. If the flammable gas content exceeds 10% of its Lower Explosive Limit (LEL), sparks or static charge could ignite the pockets of flammable gas resulting in fire or explosion.

Workers should strictly follow the safe entry procedures from the moment the plane of the confined space is penetrated. Before removing a manhole cover, a remote sampling probe should be inserted into a vent hole to measure the oxygen content and the presence and concentrations of flammable and toxic gases and vapors. If the LEL is above 10%, workers should not open the cover. Spark-proof or intrinsically safe tools should be used when inserting a monitoring device through a manhole cover, opening a manhole cover as well as working inside the manhole and conducting a rescue operation.

Recommendation #7: *Employers should evaluate all tasks that are conducted inside a permit-required confined space and make feasible modifications so that workers can perform as many of those tasks from outside as possible.*

Discussion: The DPW workers in this case had entered manholes on a monthly basis to clear sewer blockages or perform manhole maintenance. Employers should evaluate all the tasks that are currently conducted inside manholes and find out whether workers can perform these tasks from outside. Possible solutions include combining tasks to reduce the number of entries, or purchasing additional jet trucks if necessary.

Recommendation #8: *Fire departments should ensure that the firefighters strictly follow the protocol for confined space rescue operations.*

Discussion: The FD did not have a permit-required confined space rescue program in this case and the firefighters were not trained on confined space entry and rescue. The FD had an agreement with the neighboring town that in the event of a confined space rescue, the FD would summon the town TRT to conduct the rescue. The role of the FD was not to conduct but to assist the rescue operation. Instead of following the protocol, the FD decided to conduct the rescue operation and subjected additional firefighters to life-threatening risks:

- the manhole atmosphere was not tested before the two firefighters entered the manhole to rescue the two victims;
- the manhole was not ventilated during the rescue;
- firefighters entered the manhole without wearing lifelines and harnesses that were secured to the retrieval tripod;
- appropriate respirators (supplied air breathing apparatus aka airline respirators) were not available: the firefighters could not enter the 24 inch diameter manhole opening carrying a SCBA air tank and the tank had to be held by the assisting firefighters with a rope (see more discussion in Recommendation #11)

Recommendation #9: *Fire departments should develop, enforce, and train on standard operation procedures (SOPs) for confined space rescue if the firefighters perform entry rescue.*

Discussion: Fire departments should develop written SOPs specifying safe, standard and effective approach during a confined space rescue emergency if they are to conduct entry rescue. The nature of confined space hazards dictates the specific rescue plan and staff training as well as rescue equipment. Fire departments should survey the confined spaces within their fire districts and conduct a thorough hazard analysis and risk assessment when developing the SOP. The SOP should be based on applicable OSHA regulations (e.g. 29CFR1910.146) and NFPA standards of recommended practices (e.g. NFPA 1670 *Standard on Operations and Training for Technical Search and Rescue Incidents* and NFPA 1006 *Standard for Technical Rescuer Professional Qualifications*).^{10,11}

Recommendation #10: *Fire departments should ensure that all firefighters receive adequate training on their assigned roles and responsibilities for a confined space rescue operation.*

Discussion: Whether their role is assisting or conducting rescue during a confined space rescue operation, fire departments should ensure that the firefighters receive adequate training and achieve proficiency on the level of assigned duties. Fire departments should conduct simulated rescue drills in which the rescue personnel conduct entry rescue from representative confined spaces. The rescue procedures should be practiced frequently enough so that the rescuers can achieve a level of proficiency that eliminates life-threatening rescue attempts and ensure a safe, efficient and calm response to every emergency.

Recommendation #11: *Fire departments should survey and assess the specific confined space hazards in their fire district and provide the necessary and appropriate types of respiratory protection equipment.*

Discussion: The specific hazards and unique configurations of the confined spaces determine the types of respiratory protection equipment needed for the confined space entry and rescue operations. Fire departments should select and provide proper respiratory protection equipment based on the results of a complete confined space hazard survey and assessment.

SCBAs were used by the two firefighters to rescue the victims. Because the manhole opening was too small for the firefighter to enter with the air cylinder on his back, the air cylinder had to be lowered into the manhole with a rope by assisting firefighters. The air hose connecting the air cylinder and the face piece was only three-feet long and the visibility inside the manhole was poor. The margin of error was slim. If the rescuer slipped or tripped, or the air hose got caught, the face piece could be dislodged from the wearer and the rescuer could be exposed to a life threatening atmosphere.

Supplied-air breathing apparatus (SABA aka airline respirator) supplies air to a wearer through a hose connected to an air source (e.g., breathable air compressor or pressurized oxygen tanks) placed outside of the confined space. For rescues involving restricted entrance or complicated retrieval that cannot be safely completed within a short time (15 to 20 minutes), employers may consider providing the rescuer with a SABA along with an emergency escape air cylinder. However, the 24-inch manhole opening in this case may still be too small for a rescuer wearing a SABA with an escape air cylinder. Employers should be aware of this issue and work with municipalities to ensure that manhole access entrance meet requirement for a safe rescue (see Recommendation #12).

Recommendation #12: *Municipalities should take confined space rescue safety into consideration when designing and constructing manholes for wastewater systems.*

Discussion: According to "Recommended Standards for Wastewater Facilities", a guide that is widely used by municipalities for designing and preparation of wastewater plans, the minimum manhole access diameter should be 24" (610 millimeter).¹² A 24" diameter opening is too small for a rescuer to enter since he most likely has to wear a lifeline, a SCBA and a harness carrying an air cylinder on his back. Because of the restricted entrance, a rescuer has to enter the manhole with the air cylinder removed from his harness and the cylinder has to be either held by assisting firefighters as in this case or lowered into the manhole for the rescuer to place it back on his harness. Either way, the extra handling increases the chance for errors that can cause dislodgement of the SCBA face piece. A Naval Base fire officer attempted to pass his SCBA ahead of himself into a ship's tank compartment attempting to rescue a worker in 1988 at Little Creek Naval Base.¹³ The officer lost his grip on the SCBA which fell and pulled his face piece from his face. He was overcome before he could re-don the face piece. The extra time on handling the air cylinder also diminishes the chance for the victim's survival.

While it is not feasible to change the existing manhole structure, it is very important that newly constructed wastewater systems have manholes with large enough access openings that allow rescuers to enter with all required personal protective and rescue equipment. During the design stage, municipalities should consult with the fire departments and technical rescue teams to ensure that the manhole access entrance meet requirement for a safe rescue, and when possible, design sewage systems requiring minimum worker entry for maintenance.

Keywords: *permit-required confined space, sewage manhole, DPW, firefighter, rescue, self-contained breathing apparatus.*

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ADDITIONAL INFORMATION

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The New York State Fatality Assessment and Control Evaluation (NY FACE) program is one of many workplace health and safety programs administered by the New York State Department of Health (NYSDOH). It is a research program designed to identify and study fatal occupational injuries. Under a cooperative agreement with the National Institute for Occupational Safety and Health (NIOSH), the NY FACE program collects information on occupational fatalities in New York State (excluding New York City) and targets specific types of fatalities for evaluation. NY FACE investigators evaluate information from multiple sources and summarize findings in narrative reports that include recommendations for preventing similar events in the future. These recommendations are distributed to employers, workers, and other organizations interested in promoting workplace safety. The NY FACE does not determine fault or legal liability associated with a fatal incident. Names of employers, victims and/or witnesses are not included in written investigative reports or other databases to protect the confidentiality of those who voluntarily participate in the program. Additional information regarding the NY FACE program can be obtained from:

New York State Department of Health FACE Program
Bureau of Occupational Health and Injury Prevention
Corning Tower, Room 1325
Empire State Plaza
Albany, NY 12237
1-518-402-7900

www.health.ny.gov/nysdoh/face/face.htm