



The National Institute for Occupational Safety and Health (NIOSH)

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through safety and health research



Two Confined Space Fatalities During Construction of a Sewer Line




Death in the Line of Duty...A summary of a NIOSH fire fighter fatality investigation

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Introduction

At approximately 3:26 p.m. on March 8, 1984, a city fire department received a report that a man was down at a sewer construction site. When the firemen arrived on the scene, they learned that two workers were down in the newly constructed sewer. One worker was an employee of the company contracted to construct the sewer. The other worker was a state inspector with the State Department of Transportation. The two workers were removed from the sewer and pronounced dead at the scene. Subsequent autopsy indicated cause of death to be carbon monoxide (CO) poisoning. As a result of the rescue effort, 30 firemen and 8 construction workers were treated for CO intoxication and/or exhaustion.

Synopsis of Events

In the process of constructing the interstate highway, the contractor had to construct several thousand feet of sanitary sewer line composed of 66 inch ID by 16 feet long sections of concrete pipe. This new line had to tie into an existing line. The upstream portion of the existing line would be abandoned after completion of the new line. (Figure) 

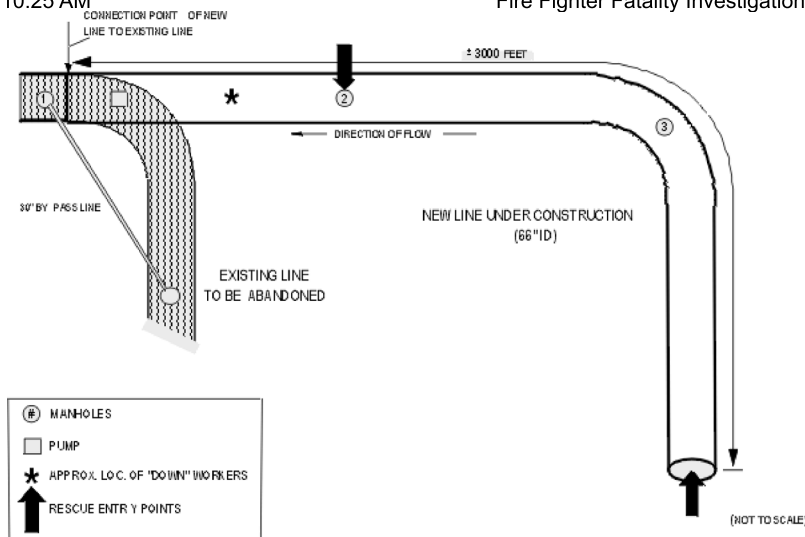


Figure.

The existing line had to be kept in service during construction. A by-pass line had to be built around the connection point of the new and existing lines. This was done by tapping a 30 inch by-pass line into the existing line, upstream of the connection point, and tying the by-pass line into a newly constructed manhole (No. 1) at the connection point. In order to keep sewage from entering the construction area of the connection point, the pipe was diked by sand bags several feet upstream of Manhole No. 1. The dike was left in place for approximately 1 month while the contractor continued to lay pipe.

During this time, sewage seeped/flowed past the dike and extended approximately 480 feet (30 sections) into the newly constructed line. This sewage had to be removed before the contractor could proceed with grouting the pipe joints.

The contractor replaced the sand bag dike with a steel plug to eliminate further seepage. A gasoline engine driven pump was placed upstream of the plug so that the existing sewage could be removed from the pipe. The pumping procedure required a laborer to enter the new line at Manhole No. 2, walk downstream approximately 1,200 feet to the pump, fuel the gasoline engine, start it and exit back through Manhole No. 2. This procedure was performed on a 3-day cycle. At no time was the atmosphere in the pipe tested prior to entry, nor was there mechanical ventilation to remove air contaminants.

This procedure was not removing the sewage quickly enough and it was decided to increase this cycle to three times per day. On March 8, 1984, at 8:30 a.m., the labor foreman and one worker (his son) followed the procedure of starting the pump.

Around 3 p.m. on the same day, the same two workers returned to Manhole No. 2 to repeat the procedure of refueling the pump. However, Manhole No. 2 had been covered with plywood and framed over in order to have concrete poured the following day. So the two had to enter the pipe from the point of construction. Each carried a flashlight and the worker carried a can of gasoline. They began walking the 3,000-foot distance to the pump. After passing Manhole No. 3, they took a short break and proceeded past Manhole No. 2 toward the pump. Approximately 750 feet past Manhole No. 2, the two came to the board used to mark the water line. While the foreman was moving the board and counting the pipe length to determine how far the water had receded, the worker went on ahead to fuel the pump and start it. After noticing haze in the sewer, the foreman told the worker to keep talking so he could tell if anything was wrong. Shortly the foreman heard the worker attempt to start the pump four times and then say "I feel dizzy." The foreman ordered the worker out of the pipe. The worker started to leave, dropping his flashlight and stumbling in his unsuccessful attempt. By the time the foreman reached the worker, the worker was down and unresponsive. After failing to carry the worker out, he propped him up out of the water and told him he was going for help. The foreman walked, crawled, and stumbled 3,000 feet to the outside to report the worker was down near the pump. The only ill effect experienced by the foreman was a severe headache.

Seven workers went into the pipe in an attempt to remove the downed worker. At the same time the state inspector got into his truck and drove to Manhole No. 2, where he removed the plywood cover and entered the sewer. The state inspector proceeded towards the area where the worker had been reported down. The underground superintendent also entered the sewer at Manhole No. 2 but exited after 2 or 3 minutes. Six of the seven workers who entered the pipe at the portal exited

at Manhole No. 2. The seventh man reached the worker but was unable to remove him. The company safety director entered the sewer at Manhole No. 2 and reported passing the seventh worker and reaching the deceased. Shortly after 3:30 p.m., the seventh worker and the safety director exited the sewer Manhole No. 2.

At this time three firemen arrived at the scene and entered Manhole No. 2. The firemen were equipped with 30-minute self-contained breathing apparatus (SCBA). In addition to the bulkiness of the SCBA, they were hampered by the curved and slick inner surface of the sewer. Initially, the firemen were told the victims were down approximately 150 feet into the sewer. However, they had to travel 500 to 600 feet to reach the victims. As their air supply decreased, the firemen placed one SCBA on the victim (the state inspector) who was still breathing, and resorted to buddy breathing to exit. The state inspector was removed through Manhole No. 2 at approximately 4 p.m. He was pronounced dead at the scene. Subsequent autopsy indicated his carboxyhemoglobin level was 50 percent and his pO₂ was 0 percent. The laborer was removed through Manhole No. 2 at 5 p.m. He was also pronounced dead at the scene. His carboxyhemoglobin level was 56 percent and pO₂ level was not available.

Conclusions /Recommendations

Combustible gas measurements, oxygen and carbon monoxide levels were taken 22 hours later at the incident site by an industrial hygienist. Oxygen level was 19 percent and concentrations of CO were 600 ppm. The industrial hygienist estimated that concentration of CO next to the pump on the day of the incident was 2000 ppm. An air sample taken the following day revealed readings of 19 to 20 percent oxygen. Trace amounts of H₂S were also recorded.

Given the industrial hygiene survey results and the toxicologic findings, the cause of death was determined to be exposure to high concentrations of CO, a by-product of the gasoline-powered pump, in an area with no natural ventilation, i.e., a confined space.

While the following list of recommendations is not exhaustive, it does cover some of the salient points which, if implemented, could have prevented this fatal incident:

1. When the existing sewer was activated (passing through Manhole No. 1), no plans were made to prevent the sewage from flowing into the newly constructed sewer.

Recommendation: An analysis of the conditions surrounding the connection at Manhole No. 1 should have generated several safe alternatives for an effective temporary barrier in the new sewer which also considered safe atmospheric conditions.

2. A gasoline-powered pump was installed inside the sewer (a confined space) which was known to have almost no ventilation. Neither workers nor pump could have operated efficiently in the sewer. The rich mixture created by depletion of O₂ increased the levels of CO.

Recommendation: The pump should have been located on the outside of the sewer with a hose running to the sewage via an access hole or an electric motor driven pump should have been considered.

3. A static ventilating condition was created when the plug was installed in the new sewer next to Manhole No. 1.

Recommendation: Since it was necessary for workmen (either those servicing the pump or those planning to do the grouting) to enter the sewer, adequate ventilation should have been provided. If ventilation could not create a safe atmosphere, the use of SCBA should have been mandatory.

4. Workers were permitted to enter an untested atmosphere of a confined space.

Recommendation: The atmosphere should have been tested by a qualified person prior to entry by workers.

5. Both fatal victims lacked experience in working in confined spaces.

Recommendation: If workers are expected, as part of their job, to work in confined spaces, they should be given appropriate training.

6. The established corporate safety procedures for work in confined spaces was not implemented.

Recommendation: Management, including local supervisors, should comply with approved corporate policy and procedures for confined space entry as well as other rules and regulations approved by the corporate president. The policy and procedure should include entry into confined spaces for rescue efforts.

7. Workers were not able to adequately assess their risk of personal injury of the tasks they were required to perform, much less the additional hazards associated with rescue efforts.

Recommendations: Management should develop a safe job procedure for all routine tasks starting with high risk tasks and specifically establish a policy and procedure regarding rescue efforts.

Emergency Response Recommendations

As a result of evaluation of the rescue events at the scene and the actual response by the fire personnel in this emergency, five recommendations have been made. These recommendations are meant to help improve overall response and practices in terms of buddy breathing, training, optimal selection and deployment of long duration SCBA, and use of short duration ESCBA during rescue efforts.

1. The fire department should reassess the issue of buddy breathing in regard to the specific confined space pipe incident.

In view of the actual field actions of fire personnel and the performance of the SCBA under these conditions, the following questions are appropriate:

Was previous training provided the firemen adequate or should training be modified to cope in a more efficient manner in a future incident?

Should buddy breathing be used at all?

All the information gained from this incident should be explored and used in arriving at and setting a policy for the use of buddy breathing.

2. The fire personnel who used buddy breathing during this incident should share their personal experience with all other fire personnel in the Department.

These firemen should relate their experiences with training academy practices. This should be related to the rescue of civilians as well as other fire personnel and all problems encountered. This experience sharing will result in increased awareness of the dangers involved, the appropriate methods or technique to use in a confined space entry situation, and recommendations to other fire personnel based on actual field exposure. Education of fire personnel in the use of buddy breathing under emergency situations based on actual field experience gained in this specific incident, should be a beneficial mode of training.

3. Fire department officials should consider the variety and types of long duration SCBA available for emergency response requiring extended rescue time and efforts.

Although one-hour closed-circuit compressed oxygen SCBAs are available, it may be desirable to use newly approved one-hour open-circuit, compressed-air SCBAs if the oxygen units are to be used in a potential fire/flame exposure situation. Also, the breathing air temperature would be cooler utilizing open-circuit units vs. the closed-circuit units. The low profile and fit of the closed-circuit SCBA are advantageous over the large profile type open-circuit where confined space entry is necessary. Such consideration of available, alternative units can optimize selection and availability of specific long duration SCBA, which can contribute to the efficient and safe use of various types of respiratory support on a specific application basis.

4. The deployment of long duration SCBA at specific fire fighting companies in relation to their location within the city is important.

Consideration should be given to those exposures (confined spaces, shopping centers, high rises and others) where emergency response could be required at any time. Identification of such exposures should assist the department in the strategic deployment of long duration SCBA in relation to the risks involved.

5. Consideration should be given to the potential use of short term ESCBA for rescue purposes.

Use of the various types of ESCBA should be based on expected emergency situations and conditions found in confined spaces, structural fires and others. The choice of oxygen vs. air units should be based on specific rationale to optimize their safe use. This effort would accomplish refined rescue techniques and minimize the need for use of buddy breathing in certain dangerous circumstances, potentially increasing the chance of victim survival as a result.

NOTE: The fire department that responded to this emergency is one of the best equipped and trained in the country. As a result of this preparedness, potential injury and fatalities to their personnel were avoided.

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Was this page helpful?

Yes

Partly

No

FACE: 84-13

DATE: none

CAUSE: Confined Space (Poisoning)

SUBJECT: Two Confined Space Fatalities During Construction of a Sewer Line

On March 8, 1984, a male worker entered an enclosed sewer that was under construction, to fill a pump with gasoline. He was killed by carbon monoxide (CO) poisoning, and a male Arizona Department of Transportation inspector was also killed by CO while attempting a rescue. Following rescue attempts, 30 firefighters and 8 construction workers were treated for CO intoxication and/or exhaustion.

In the course of constructing an Interstate Highway, the contractor had to construct several thousand feet of new sanitary sewer line, 66 inches in diameter, connected to an existing line. The existing line was to remain in operation, and a 30-inch bypass line was installed to pass sewage around the point where the new line was attached. Sandbags to keep sewage out of the new line were not effective, so the contractor substituted a steel plug and placed a gasoline-driven pump in the new line to remove sewage that had seeped past the sandbags. The pump was located 3,000 feet from the entrance of the new line and 1,200 feet from the nearest manhole on the new line -- an enclosed area. Fueling the pump every three days was not sufficient to drain the sewage, and on the 8th a procedure of refueling the pump three times a day was initiated. At 3:00 P.M. a foreman and worker (the foreman's son) entered the new line through the entrance to refuel the pump for the second time that day. About 450 feet from the pump, the foreman halted. The worker went forward, and was instructed to keep talking so that the foreman would be aware of problems. The foreman heard the worker try to start the pump four times and complain of dizziness. The foreman ordered the worker back, but by the time the foreman reached the worker, he was down and unresponsive. The foreman was unable to carry him out, and left for help. Seven construction workers and the state inspector entered the line. Six of the workers left before they could reach the victim; the worker who reached the victim could not move the victim and had to exit as well. At 3:26 P.M. the fire department received a call, and firefighters were at the scene shortly after 3:30. The fighters were equipped with 30-minute SCBAs, a short time given the long distances the fighters had to travel in the sewer. On finding the inspector, who was still breathing, fighters placed a SCBA on him and resorted to "buddy breathing" to exit. The inspector was retrieved at 4:00 and the laborer at 5:00 P.M. Both were dead at the scene with carboxyhemoglobin levels over 50%. Recommendations:

- o Effective plans for keeping sewage out of the new line should have been made ahead of time. The pump should either have been located outside the sewer with a hose running down, or an electric pump should have been used.
- o Workers entering enclosed spaces should be trained on the dangers of enclosed spaces, air in enclosed spaces should be tested before entry, and ventilation or SCBA should be available.
- o Management should establish safe policies and procedures on rescue efforts.
- o The fire department should examine its policies on "buddy breathing," and consider obtaining more powerful SCBA gear.