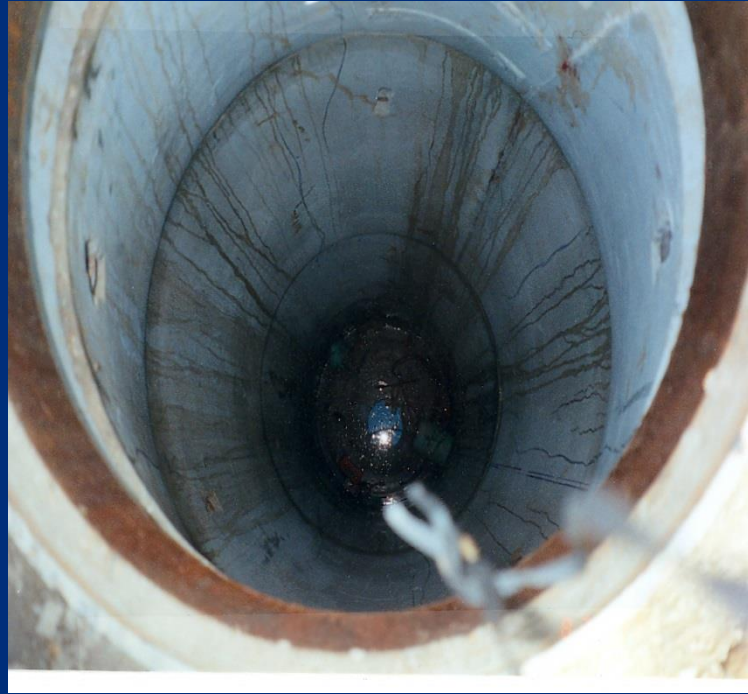


Silent Killer in a Newly Constructed Manhole



Occupational
Safety and Health
Administration

Reason For the Intervention

- OSHA received notification of a construction site fatality on August 5, 2004 – day following the incident
- Reported that the employee was found at the bottom of a manhole
- New sewer system under construction - SIC Code 1623



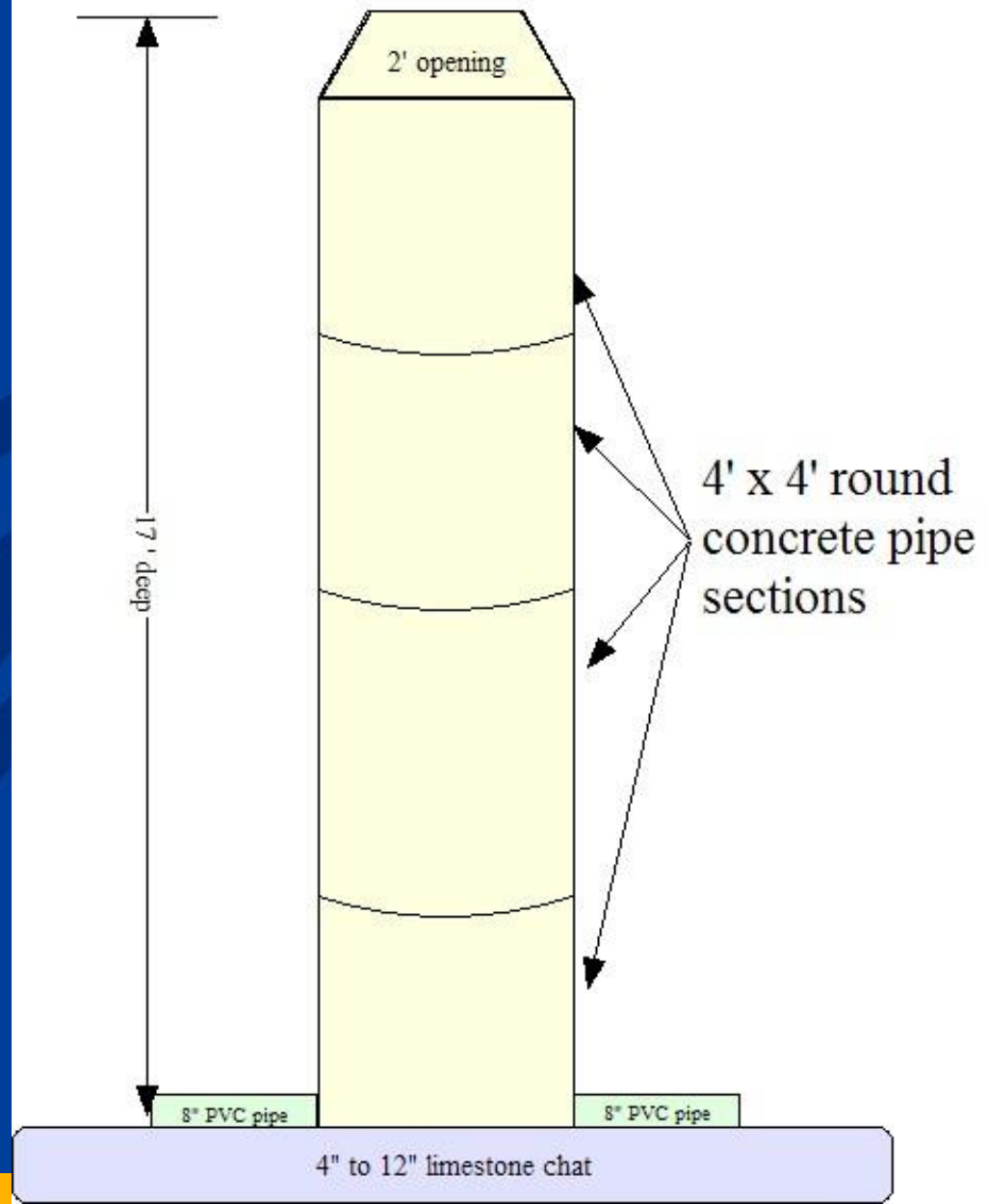
The Site

- Company laying sewer pipe & manholes for a new housing development
- 6 employees onsite
- Farm land; slightly hilly; slope of ground ~ 1 to 4
- Manhole was adjacent to an entrance ramp to a highway



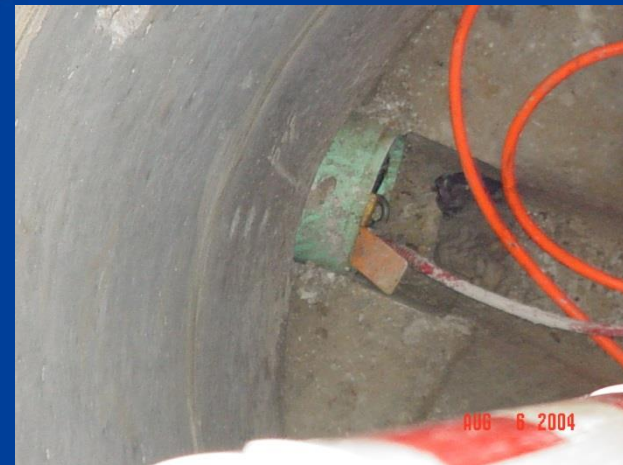
The Confined Space

- 2 foot opening
- 4 foot wide internal diameter
- Riser was constructed of 4' X 4' concrete pipe sections
- 17 feet deep outside 16 1/2 feet inside
- Two 8" PVC Pipes in the bottom
- Built on a 4" to 12" bed of limestone chat



Code Requirements

- City codes require a vacuum test – must maintain 10 inches of mercury for a specific time based on depth of manhole
- If vacuum test fails, then sections of the manhole must be grouted to get a better seal



The Incident

- After vacuum test failure, employee reportedly was assigned the grouting task
- Grouting is done by hand and takes about 1 hour
- The employee was working alone
- The employee was found at the bottom of the manhole unconscious



Manhole Conditions

- After recovery, the medical examiner requested sampling of manhole
- Fire Department – Haz Mat Division took some multi-gas readings about 3 hours after recovery
- Results were 16.3 to 17% for oxygen and 0.0 to 4.5 % LEL
- Zero readings for carbon monoxide and hydrogen sulfide
- No readings taken for carbon dioxide

Inspection Activity

- The employer did not have a confined space entry program
- OSHA's Salt Lake City Technical Center Health Response Team assisted with site analysis
- Direct Reading Instruments results 9 days later revealed:
 - Oxygen – 16.0 to 18.2 %
 - CO2 – 1.8 to 3.5 % or 18,000 to 35,000 PPM
 - LEL – 5 to 8 %



Inspection Activities (cont.)

- Grab or bulk air samples taken with a medium flow pump at 3 L/Min.
- Collected in aluminum bags
- Lab results as follows:
 - Oxygen – 12.5 to 14.1 %
 - CO₂ – 16,845 to 23,968 PPM
 - Methane – 776 to 1372 PPM



Carbon Dioxide

- Colorless odorless gas
 - Displaces oxygen leading to oxygen deficiency
- Special problem in Midwest area
 - Limestone Rock
 - Calcium Carbonate
 - Acidic topsoil
 - Acid leaches from soil, which then contacts the limestone producing Carbon Dioxide
- Numerous fatalities
 - Especially in new sewer/vault leak testing using a vacuum
 - Pulls carbon dioxide into the space
 - Oxygen measured at less than 3% on other similar fatalities
 - **5 similar cases known Nation-wide since 2000; 2 cases with 4 fatalities in the Kansas City area**

Oxygen Deficient Atmospheres

19.5 %	Minimum acceptable oxygen level.
15 - 19%	Decreased ability to work strenuously. Impair coordination. Early symptoms.
12-14%	Respiration increases. Poor judgment.
10-12%	Respiration labored. Lips blue.
8-10%	Mental failure. Fainting, Nausea, Unconsciousness, Vomiting.
6-8%	4-5 minutes - possible recovery, 6 minutes - 50% fatal, & 8 minutes - fatal.
4-6%	Coma almost instantaneously. Death

Asphyxiation in Sewer Line Manhole

U.S. Department of Labor

Occupational Safety and Health Administration

www.osha.gov (800) 321-OSHA (6742)

INCIDENT SUMMARY

Incident type: Confined space asphyxiation
 Weather conditions: Sunny, 61-67°F
 Type of operation: Sanitary sewer system installation
 Size of work crew: 4
 Worksite inspection conducted: Unknown
 Competent safety monitoring on site: No
 Safety and health program in effect: No
 Training and education for workers: No
 Occupation of deceased worker: Foreman/Operating Engineer
 Age/Sex of deceased worker: 46/M
 Time on job: 15 years
 Time at task: Less than 1 hour
 Employment classification (FT/PT/Temporary): Full time
 Language spoken: English
 Union/Non-Union: Union



Figure 1: Photo of manhole

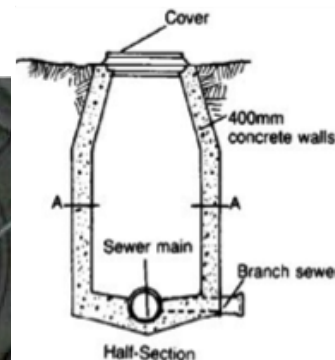


Figure 2: Diagram of manhole

BRIEF DESCRIPTION OF INCIDENT

A construction foreman died from asphyxiation after entering a manhole with an uncontrolled hazardous atmosphere. Four construction workers were working in an inactive sewer system on a jobsite that was unoccupied for over a week. A few minutes after they started working, the crew noticed that the foreman was missing and a manhole cover was removed. While one worker called emergency services, a second worker entered the manhole to assist the foreman and found him unresponsive at the bottom of the 20²/₃ ft. manhole (see Figures 1 and 2). When the second worker became disoriented inside the manhole, another worker used a fan to blow fresh air into the manhole and the worker was able to climb out. The foreman was retrieved by fire department personnel and was later pronounced dead due to asphyxiation.

Likely Causes of Incident

Although the manhole was newly constructed and not yet connected to an active sewer system at the time of this incident it contained a hazardous atmosphere that resulted in asphyxiation. The employer did not ensure that atmospheric hazards were identified and precautions for safe operations implemented before starting work at the site.

- Workers were not trained to recognize confined space hazards and to take appropriate protective measures.
- The atmosphere in the manhole was not assessed to determine if conditions were acceptable before or during entry.
- Proper ventilation was not used to control atmospheric hazards in the manhole.
- Protective and emergency equipment was not provided at the worksite.
- An attendant was not stationed outside the manhole to monitor the situation and call for emergency services.

You Have a Voice in the Workplace

The *Occupational Safety and Health Act of 1970* affords workers the right to a safe workplace (see OSHA's **Worker Rights** page, www.osha.gov/workers). Workers also have the right to file a complaint with OSHA if they believe that there are either violations of OSHA standards or serious workplace hazards.

How OSHA Can Help

For questions or to get information or advice, to report an emergency, fatality, hospitalization, amputation or loss of an eye, or to file a confidential complaint, contact your nearest OSHA office, visit www.osha.gov or call our toll-free number at 1-800-321-OSHA (6742), TTY 1-877-889-5627. It's confidential.

More Information

OSHA standards and regulations:
www.osha.gov/law-regs.html

OSHA publications:
www.osha.gov/publications

OSHA-approved state plans:
www.osha.gov/dcsp/osp

OSHA's free On-site Consultation services:
www.osha.gov/consultation

Training resources:
www.osha.gov/dte

Help for Employers:
www.osha.gov/employers

Asphyxia occurred when the foreman did not get enough oxygen to sustain life, either because the amount of oxygen in the atmosphere was too low (i.e., oxygen deficiency) and/or a hazardous chemical concentration was too high (e.g., high carbon dioxide level). Although the exact atmospheric conditions in the manhole at the time of the incident are unknown, measurements taken after the incident indicate it was possible the oxygen levels were low enough and/or carbon dioxide levels were high enough to cause asphyxiation.

When rescuers arrived the atmosphere contained 19.1% oxygen, however this measurement was taken after construction workers had used a fan to provide fresh air to the disoriented worker. One day after the incident, the atmosphere contained 16.5% oxygen and four days after the incident the oxygen concentration dropped to 7.7%. Hazardous atmospheres in [OSHA's Confined Spaces in Construction standard](#) include atmospheres with less than 19.5% oxygen (29 CFR 1926.1202). Normal atmospheric oxygen level is between 20.8% and 21%. Four days after the incident, the carbon dioxide concentration was 6.5%. An atmosphere with 4% or more carbon dioxide is considered Immediately Dangerous to Life or Health according to the National Institute for Occupational Safety and Health.

Changes in atmospheric conditions over time might be due to several causes, for example, organic matter (e.g., dead plants, animals or animal waste products) decay in soil that uses up oxygen and produces hazardous gases (e.g., carbon dioxide, hydrogen sulfide). Although conditions within these spaces could seem acceptable during initial entry, atmospheric changes could occur over time and result in fatalities.

INCIDENT PREVENTION

Employers must ensure each confined space in which workers may be assigned duties and each space that is a permit-required confined space (PRCS) is identified before starting work at a construction site (29 CFR 1926.1203(a))¹.

¹ 29 CFR 1926 Subpart AA was published on May 4, 2015 with an effective date of August 3, 2015.

A PRCS is a confined space with one or more of the following characteristics (29 CFR 1926.1202):

- contains or has a potential to contain a hazardous atmosphere,
- contains a material with potential for engulfment,
- has an internal layout that could trap or asphyxiate an entrant, or
- contains any other serious physical or health hazard.

Employers with workers who will enter one or more PRCS must implement a PRCS program for safe permit space entry operations (29 CFR 1926.1203(d), 29 CFR 1926.1204) including the following requirements:

1. Provide training to workers at no cost to them in a language and vocabulary they understand, as required in 29 CFR 1926.1207, on how to safely perform permit space duties before their first assignment and as necessary.
2. Prohibit entry into permit spaces until hazardous conditions (atmospheric and physical) present are identified, evaluated, and addressed (29 CFR 1926.1204(b)&(c)).
3. Eliminate or control atmospheric hazards by ventilating, purging, inerting or flushing the permit space as necessary (29 CFR 1926.1204(c)(4)).
4. Perform pre-entry testing for oxygen content, flammable gases and vapors, and potential toxic air contaminants (29 CFR 1926.1204(e)(3)).
5. Continuously monitor the permit space to verify that atmospheric conditions remain acceptable during entry (29 CFR 1926.1204(e)(1)(ii)).
6. Provide essential equipment to workers with training on proper use, including:
 - a. Personal protective equipment when necessary (29 CFR 1926.1204(d)(4)).
 - b. Rescue and emergency equipment to authorized workers, or implement procedures for rescue and emergency services (29 CFR 1926.1204(d)(8)&(i), 29 CFR 1926.1211).
 - c. Station at least one trained attendant outside a permit space to perform all attendant's duties (29 CFR 1926.1204(f); 29 CFR 1926.1209).

Note: The described case was selected as being representative of improper work practices which likely contributed to a fatality from an incident. The incident prevention recommendations do not necessarily reflect the outcome of any legal aspects of this case. OSHA encourages your company or organization to duplicate and share this information.

This Fatal Facts is not an OSHA standard or regulation and it creates no new legal obligations. The recommendations contained herein are advisory in nature and are intended to assist employers in providing safe and healthful workplaces. The Occupational Safety and Health Act of 1970 (OSH Act) requires employers to comply with safety and health standards promulgated by OSHA or by an OSHA-approved state plan. The requirements of OSHA-approved state plans can be reviewed by selecting the state's website at: www.osha.gov/dcsp/osp. The OSH Act's General Duty Clause, Section 5(a)(1), requires employers to provide employees with a workplace free from recognized hazards likely to cause death or serious physical harm.

For assistance, contact us. We can help. It's confidential.



www.osha.gov (800) 321-OSHA (6742)



U.S. Department of Labor