THE UNIVERSITY OF IOWA

COLLEGE OF PUBLIC HEALTH
Department of Occupational and Environmental Health

TO: **Director, National Institute for Occupational Safety and Health**

FROM: **IA FACE** **Case ID: 2002IA031** **Report Date: 01 May 2007**

SUBJECT: Two Sewer Pipe Relining Workers Killed by Toxic Sewer Gas

SUMMARY

Midsummer 2002, two male workers age 25 and 19 were overcome by toxic sewer gas – probably hydrogen sulfide – while walking through a 600 ft (183 m) length of underground sewer pipe. The men were clearing debris from the pipe in preparation for installing a Cured-In-Place-Pipe (CIPP) liner. The sewer pipe was 15 ft (4.5 m) under ground, measured 2 ft (0.6 m) wide by 5 ft (1.5 m) high, and had 1 to 2 ft (0.3 to 0.6 m) of untreated sewage standing in it. The worksite had been inactive for about 10 days prior to the two workers entering the pipe through a manhole at the downstream end of the section. They walked toward an access pit (Photo 1) at the upstream end of the section. There other workers were preparing for installation of the liner when the workers walking through the duct called for help. Five co-workers attempted to rescue them and were also overcome. Emergency personnel from the local fire department responded and entered the access pit after donning air-supplied respirators. They lifted the seven workers out of the pit with the aid of a nearby mobile crane. The two workers walking in the pipe were found face down in the sewage and had drowned. Neither of them was wearing a respirator nor were several key permit-required confined space precautions followed, such as monitoring before and during the workers' entry. The other five men recovered after several days in the hospital.

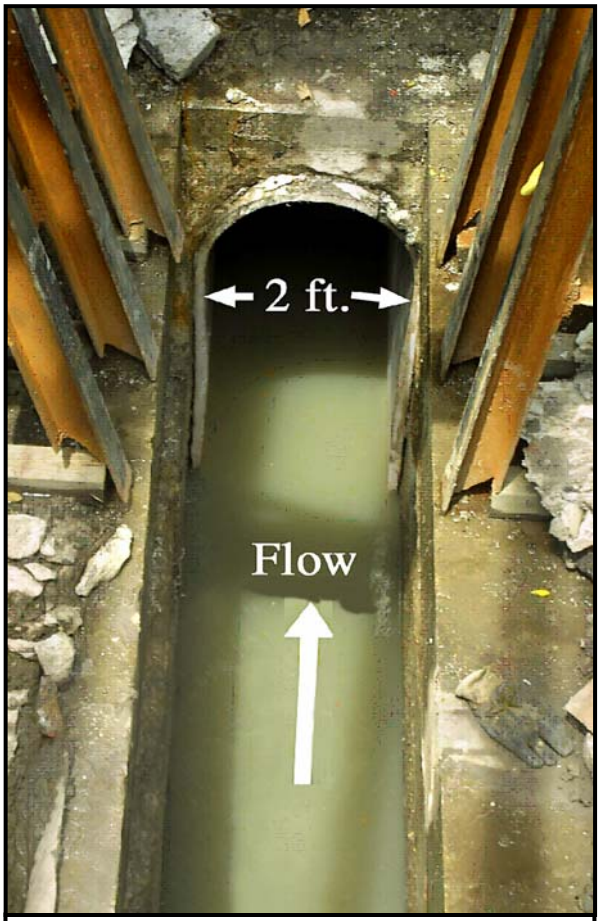

Photo 1 – Bottom of access pit, showing end of liner in narrow duct, direction of sewage flow, and steel legs of overhead tower.

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RECOMMENDATIONS based on our investigation are as follows:

- *Formal communication between the hosts of a construction or maintenance site and contractors or employers regarding hazardous conditions and comprehensive safety procedures must be established before any work is to begin.*

- *Employers must ensure that all components of a comprehensive confined space entry program are communicated to all workers and enforced.*

- *Employers must ensure that worksite-specific written standard operating procedures governing the selection and use of respirators are followed.*

- *Like emergency responders, coworkers and others should never enter a pit to attempt a rescue without proper respiratory protection.*

INTRODUCTION

Midsummer of 2002, two male workers, ages 25 and 19, were overcome by toxic sewer gas – probably hydrogen sulfide – and drowned while walking through an approximately 600 ft (183 m) section of underground sewer duct. The Iowa FACE program became aware of the incident the same day through local news reports and immediately began an investigation. An Iowa FACE investigator and a Deputy Medical Examiner visited the worksite and interviewed investigators and employees involved in the incident. Among other sources of information were reports from the Iowa State Medical Examiner's Office, the Iowa Division of Labor Services Occupational Safety and Health Bureau, and courts of appeal. In addition, information associated with the incident was obtained from local news reports, interviews by local police, eyewitness accounts, and photographs of the scene.

INVESTIGATION

The employer specialized in lining sewer and water mains and had been in business for over 25 years, employing 1500 workers on multiple work crews. The company had been hired to reline a 5 mile (8 km) section of municipal sewer pipe which was leaking into a storm sewer that ran alongside it. The sewer pipe was buried 15 ft (4.6 m) below ground level and measured roughly 2 ft (0.6 m) wide by 5 ft (1.5 m) high with a flat bottom and a rounded top. The company's specialty was installing Cured-In-Place-Pipe (CIPP) linings. The installation process involved application of flexible fiberglass (Photo 2) sections to the inside of existing underground pipes. The fiberglass sections are held in place by fillets – materials anchored to the walls of the sewer duct – and resins with the sections are cured in place when hot water is pumped through

Photo 2 – Section of uncured fiberglass liner.

the CIPP lining. Once the process is completed, the resin-fiberglass matrix forms a hard, durable liner on the inside of the pipe. Major advantages of this approach are that above ground structures are not disturbed and most of the work can be done through existing manholes and other access points.

The company dug 15 ft (4.5 m) deep access pits periodically along the length of sewer line to be relined. A temporary steel tower was erected at each pit to assist with insertion of lining and curing materials (Photo 3). The crew had been working on relining the five mile run for approximately a year. However, work on this section had been suspended for 10 days before the two victims entered the pipe through a manhole approximately 600 ft (183 m) down-stream from an access pit and proceeded to walk upstream removing debris and old resin in preparation for installing the liner.

Photo 3 –Temporary steel tower to handle liner and curing materials for the cured-in-place sewer duct relining project. The crane was used to lift fallen workers from the pit.

The flow of sewage had been blocked upstream from the access pit and a 12 in (300 mm) diameter sewage bypass pipe had been installed on top of the ground. However, the underground sewer duct still had 1 to 2 ft (0.3 to 0.6 m) of stagnant, untreated sewage in it.

One of the workers was nearing the access pit where other workers were preparing for installation of the liner when he called for help. Five co-workers attempted to rescue the workers from the pipe but were subsequently overcome. Emergency personnel were summoned and the local fire department crew responded. They entered the access pit after donning supplied-air respirators and extricated all seven workers with the help of a nearby mobile crane (Photo 3). The two workers walking through the pipe were found face down in sewer water, had drowned, and were pronounced dead at the scene. Their five co-workers were taken to local hospitals: three in critical condition. After several days of treatment in hyperbaric conditions they all recovered. Five of the responders were also taken to local hospitals and treated for symptoms of heat exhaustion.

The workers were wearing hardhats and were equipped with flashlights, but they did not have respirators or two-way radios for communication with other workers. The workers had also not employed confined space entry protocols or procedures. Toxic gas levels were not monitored before the workers entered the manhole or as they walked through the sewer pipe.

The probable cause of the incident was the release of dangerous levels of hydrogen sulfide gas from the sewer water which had been stagnant for several days before the workers entered the sewer pipe. Hydrogen sulfide is formed by microbes in the anaerobic breakdown of organic

wastes. It is heavier than air, only slightly soluble in water, and is readily released when waste water containing it is disturbed. As the two victims walked through the sewer pipe, hydrogen sulfide gas was probably released increasing its concentration in the duct.

It is not known if either of the victims noticed the odor associated with low concentrations of hydrogen sulfide gas as they walked through the sewer pipe. Hydrogen sulfide has a “rotten egg” odor at low concentrations. However, odor perception is unreliable as a forewarning because rapid olfactory fatigue may develop when concentrations are high, above 100 ppm (parts per million). Concentrations above 1000 ppm may cause rapid unconsciousness and death. Consequently, both men could have unknowingly been breathing increasing concentrations of hydrogen sulfide as they approached the pit area.

CAUSE OF DEATH

The official cause of death from the autopsy report was drowning. Acute hydrogen sulfide intoxication was a probable contributing factor.

RECOMMENDATIONS / DISCUSSION

Recommendation #1 – *Formal communication between the hosts of a construction or maintenance site and contractors or employers regarding hazardous conditions and comprehensive safety procedures must be established before any work is to begin.*

Discussion: The hosts (owners or operators of premises, city, county, state, or federal agencies) of construction or maintenance sites must inform contractors of hazardous conditions which may exist in their facilities as well as any procedures they must have in place to protect their employees from hazards that might exist in their facilities.

Consequently, all contractors and employers must obtain available information regarding hazards in permit-required confined spaces from the host before entry processes begin. All employers must inform the host of any permit-required confined space entry process in use and the hazards which may be confronted or created in the permit-required confined space (OSHA 29 CFR 1910.146 (c) (8-9)). The presence of toxic gases is a well-known hazard in sewer work and comprehensive safety procedures, which had been established by the primary contractor, should have been strictly followed.

Recommendation #2 – *Employers must ensure that all components of a comprehensive confined space entry program are communicated to all workers and enforced.*

Discussion: The company employees had received safety training on confined space entry procedures and the company had developed a comprehensive safety manual. However, employees may have practiced a routine in which they did not follow proper safety precautions before entering the sewer pipe. Measurements for toxic gas levels were not taken before the workers entered the manhole, they did not carry gas monitors with them as they walked through the pipe, and the workers were not provided with two-way radios in order to maintain communication with other workers. This incident demonstrates the value of safety protocols and why workers and supervisors must be diligent in their implementation. This was the last section of pipe to be repaired and it appears the workers were accustomed to a routine that did not require conformance to strict confined space entry procedures.

Confined space entry procedures should be specific to each type of confined space (i.e. tanks, vessels, silos, pits, etc.). Employers should develop and enforce a confined space entry program as outlined in NIOSH publications 80-106 (*Working in Confined Spaces*) and 87-113 (*A Guide to Safety in Confined Spaces*), and they must comply with OSHA Standard 1910-146 (General Industry) or 1926-21b (Construction).

The company was responsible for ensuring that the air quality was properly tested before the workers entered the manhole and during the entire entry period. Continuous air monitoring in both the sewer pipe and pit area would have alerted (visual and audible alarms) workers to the hazardous situation. Continuous air monitoring would also have triggered co-workers to use engineering control equipment, such as powered air movers available at the site, to remove contaminants and provide fresh air into the sewer pipe as the workers exited.

Recommendation #3 – *Employers must ensure that worksite-specific written standard operating procedures governing the selection and use of respirators are followed.* (See OSHA requirement 29 CFR 1910.134 (c)(1)).

Discussion: Employers must ensure that respirators used by employees are provided based upon the hazards that could be encountered. In this case, supplied air or self-contained breathing apparatus is required. In addition, employers must ensure that respirators used by employees are properly fit-tested before use. The workers may have survived if at a minimum they had been provided emergency escape respirators.

Recommendation #4 – *Like emergency responders, coworkers and others should never enter a pit to attempt a rescue without proper respiratory protection.*

Emergency rescue teams must be aware of all hazards associated with confined spaces and wear proper personal protection and devices for emergency entry. Similarly, respiratory protection must be used by all co-workers and other personnel before attempting rescue or entering any confined space, or where a contaminated or oxygen deficient atmosphere could exist, until it can be established by monitoring and continuous sampling that the atmosphere is not contaminated or oxygen deficient.

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Fatality Assessment and Control Evaluation

FACE

Fatality Assessment and Control Evaluation, FACE, is a program of the *National Institute for Occupational Safety and Health* (NIOSH), which is part of the *Centers for Disease Control and Prevention* of the *U.S. Department of Health and Human Services*. Nationally, the FACE program identifies traumatic deaths at work, conducts in-depth studies of select work deaths, makes recommendations for prevention, and publishes reports and alerts. The goal is to prevent occupational fatalities across the nation.

The NIOSH head office in Morgantown, West Virginia, carries out an intramural FACE case surveillance and evaluation program and also funds state-based programs in several cooperating states. In Iowa, *The University of Iowa* through its *Injury Prevention Research Center* works in conjunction with the *Iowa Department of Public Health* and its *Office of the State Medical Examiner* to conduct the Iowa FACE program.

Nationally, NIOSH combines its internal information with that from cooperating states to provide information in a variety of forms which is disseminated widely among the industries involved. NIOSH publications are available on the web at http://www.cdc.gov/NIOSH/FACE/ and from the NIOSH Distribution Center (1-800-35NIOSH).

Iowa FACE also publishes its case studies, issues precautionary messages, and prepares articles for trade and professional publication. In addition to postings on the national NIOSH website, this information is posted on the Iowa FACE site, http://www.public-health.uiowa.edu/FACE/. Copies of FACE case studies and other publications are available by contacting Iowa FACE, too.

The Iowa FACE team consists of the following specialists from the University of Iowa: Craig Zwerling, MD, PhD, MPH, Principal Investigator; John Lundell, MA, Co-Investigator; Murray Madsen, MBA, Chief Trauma Investigator; and Co-Investigator/specialists Risto Rautiainen, PhD, and Wayne Sanderson, PhD, CIH. Additional expertise from the Iowa Department of Public Health includes Rita Gergely, Principal Investigator, and John Kraemer, PA, from the Office of the State Medical Examiner.

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