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Occupational Confined Space-Related Fatalities: Surveillance and Prevention

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The National Institute for Occupational Safety and Health (NIOSH) investigates selected workplace fatalities through the Fatal Accident Circumstances and Epidemiology (FACE) project. This surveillance project is designed to collect descriptive data on selected fatalities using an epidemiologic approach, to identify potential risk factors for work-related death, to develop recommended intervention strategies, to disseminate findings that increase employer and employee hazard awareness and to reduce the risk of fatal injury in the workplace. From December 1983 through December 1989, 55 confined-space events, resulting in 88 deaths, were investigated through the FACE project. In these events only three of the workers who died had received any training in confined space safety. Additionally, only 27% of the employers had any type of written confined space entry procedures. Where written procedures did exist they were either not implemented, inadequate, or both. Because many employers and workers were not aware of the hazards associated with confined spaces, basic NIOSH recommendations published in 1979 that would have prevented the fatalities were not followed. These data underscore the importance of developing and implementing comprehensive confined-space entry procedures and educating workers and supervisors on following safe work procedures to reduce the number of occupational confined space-related fatalities.

Occupational fatalities associated with confined spaces are not a new problem. The Occupational Safety and Health Administration (OSHA) addresses safety applicable to confined spaces in many different sections of the General Industry and Construction Safety and Health Standards (29 CFR 1910 and 1926, respectively). Additionally, OSHA is planning to promulgate a confined-space standard as a General Industry Standard (Docket No. S-019, Permit Required Confined Spaces). However, these standards do not apply to small businesses (10 or fewer employees) and municipalities. Yet these employers continue to suffer a large number of confined space fatalities. The American National Standards Institute (ANSI) also addresses the hazards associated with confined spaces in the recently revised ANSI Standard, Z117.1-1989 (American National Standards Institute [ANSI], 1989). However, not all risk factors are addressed; some (such as the use of rescue equipment, tools, and personal protective equipment) are only con-

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tained in broad ANSI standards not specific to work in confined spaces.

NIOSH has developed several publications pertaining to confined-space safety. In 1979, NIOSH published a Criteria Document providing recommendations for working in confined spaces (National Institute for Occupational Safety and Health [NIOSH], 1979). In 1986, an Alert was published by NIOSH (Request for Assistance in Preventing Occupational Fatalities in Confined Spaces) on this same topic (NIOSH, 1986). More recently, NIOSH published a worker's guide to safety in confined spaces (Pettit & Linn, 1987) and an article discussing confined-space safety (Pettit, Sanderson, & Linn, 1987). NIOSH (1979) defines a confined space as a space which by design has limited openings for entry or exit; unfavorable natural ventilation which could contain or produce dangerous air contaminants; and which are not intended for continuous employee occupancy. Tunnels, manholes, utility vaults, storage tanks, and silos are all examples of confined spaces.

Confined space-related fatalities present a unique occupational safety problem: Death may result from many different causes, such as asphyxiation, inhalation of toxic gases or vapors, drowning, falling, explosions, or contact with electrical or mechanical energy. Workers from many different occupations and industries are at risk because they may enter confined spaces to perform work-related tasks, unaware that they are entering a potentially hazardous work environment. This paper describes confined space-related fatalities investigated by NIOSH, identifies potential risk factors, and evaluates whether NIOSH recommendations (published in NIOSH, 1979) for confined space entry were followed.

METHODS

NIOSH investigates selected workplace fatalities (such as confined space fatalities) through the Fatal Accident Circumstances and Epidemiology (FACE) project. The FACE project is designed to collect descriptive data on selected work-related deaths by studying and evaluating the working environment, the worker, the task the worker was performing, the tools the worker was using, the energy exchange resulting in fatal injury, and the role of management in controlling how these factors interact. The on-site investigations conducted by NIOSH are for research purposes only, and are not intended to determine culpability or compliance with OSHA standards. Rather, the goal of the FACE project is to prevent worker fatalities in the future by identifying potential risk factors, developing recommended intervention strategies, and disseminating findings to reduce the risk of fatal injuries in the workplace.

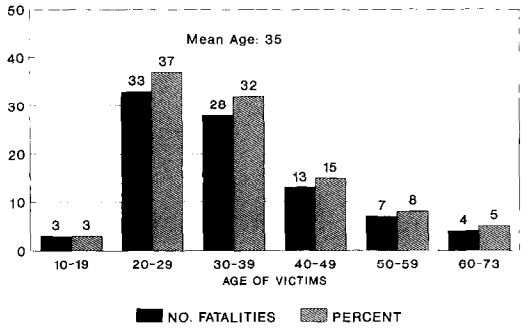
The FACE project serves as a passive surveillance system, which relies on a cooperative notification procedure to identify workplace deaths for conducting on-site fatality investigations. There is no method for monitoring notification — it is voluntary and some notification agencies are more responsive than others. Also, the agencies responsible for notifying NIOSH receive information from different sources that is reflected in the reliability and comprehensiveness of their reporting. For example, some agencies use newspaper clipping services as a source for reporting deaths. Others rely on employers complying with legal requirements to report worker deaths. Notification is usually via telephone; however, some notification agencies send reports of deaths through the mail.

Confined space-related fatalities are included in the FACE project for two reasons. First, many confined space fatality events involve the death of more than one worker; second, confined space-related fatalities often involve employers with 10 or fewer employees, or municipality employers who do not fall under Federal OSHA or most state OSHA plans.

Cooperating agencies and organizations who voluntarily report confined space fatalities to the Division of Safety Research (DSR) are the Water Pollution Control Federation, eight state occupational safety and health administrations, the National Association of Waste Transporters, medical examiner offices from two states, and one state health department. Reporting is nationwide, although not all states report, and not all confined space-related deaths are reported.

NIOSH investigators conduct on-site investigations, (i.e., visit the site of the event with field survey instruments that are used to collect data) depending on the circumstances of

FIGURE 1
AGE DISTRIBUTION
(NIOSH, 1983-1989)

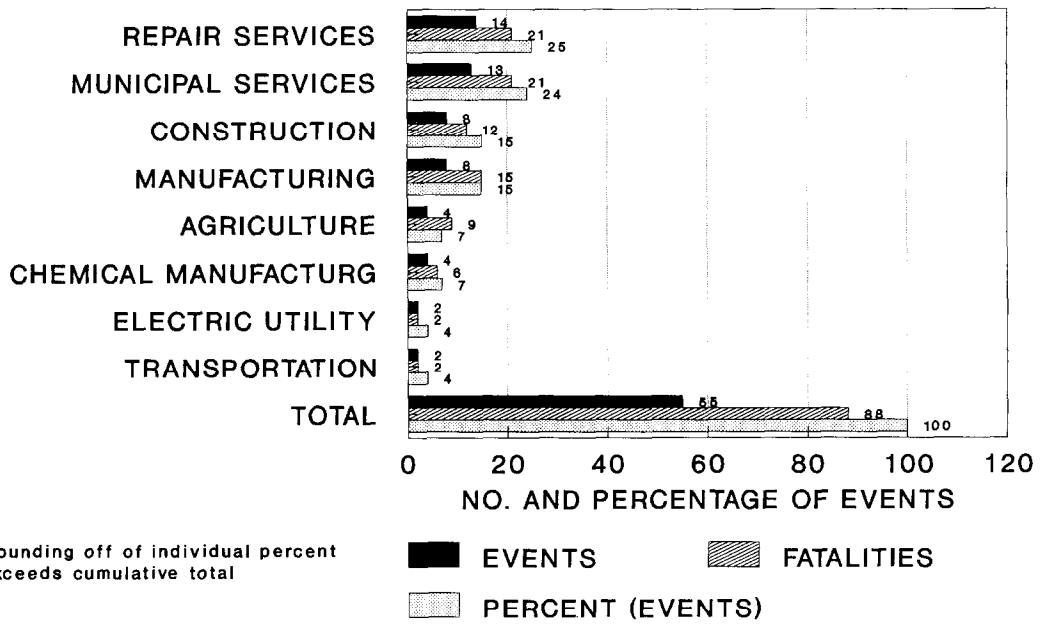


each event, including the agent, host, and environment characteristics. Interviews are conducted in person with company officials and co-workers to obtain environmental and personal characteristics data. Environmental data includes information on the workplace conditions, company safety policy, and employee training, which has been noted to be important in preventing fatalities (Fine, 1980). Other sources of information such as reports from medical examiners, OSHA compliance officers, police and fire departments, and emergency medical services (EMS) are also obtained for use in NIOSH investigations.

From December 1983 through December 1989, 55 events with one or more confined space-related fatalities were investigated by DSR under the FACE project. A confined space-related occupational fatality event is defined as one or more deaths resulting from or associated with work being performed in a confined space (rescuer fatalities are included in this definition). The official cause of death is not incorporated into the definition; however, the death must have been associated with working in the confined space.

Data were abstracted from the FACE field survey instruments, medical examiner reports, and FACE investigative reports. These data were then entered into a computer data base, edited, and analyzed using the Epi Info software program (Centers for Disease Control [CDC], 1988). Univariate and bivariate frequencies were used to describe the fatalities. Because of the small number of deaths, tests were not performed to assess statistical significance. However, the results identify potential risk factors common to most of the fatalities. This information was also used to evaluate whether NIOSH confined space entry recommendations (published in NIOSH, 1979) were being followed.

FIGURE 2
INDUSTRY DISTRIBUTION (NIOSH, 1983-1989)



* Rounding off of individual percent exceeds cumulative total

FIGURE 3
CS ENTRY TASK DISTRIBUTION OF 88 FATALITIES
(NIOSH, 1983-1989) *

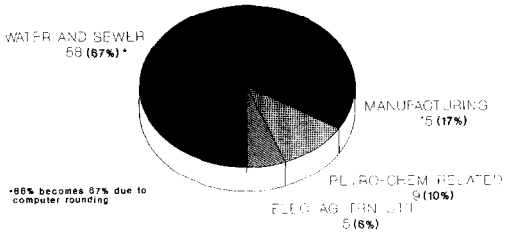
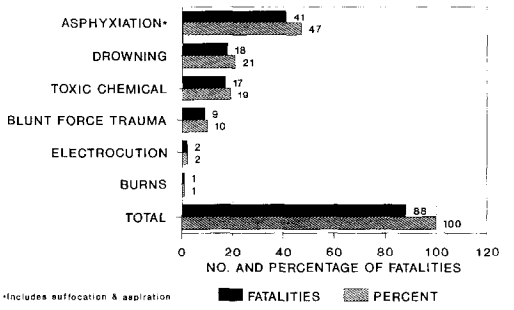


FIGURE 4
CAUSE OF DEATH DISTRIBUTION
(NIOSH, 1983-1989)



RESULTS

NIOSH investigated 55 confined-space events resulting in 88 worker deaths. The victims (all men) ranged in age from 15 to 73 years (Figure 1) and the mean age was 35 years.

Figure 2 shows the industries (according to the Standard Industrial Classification Manual, 1987) that experienced one or more of the confined-space fatalities. These industries were municipal water and sanitary services, repair services (mostly tank, septic tank/sewer cleaning and repair), construction (mostly water system and sewerage construction, including special trade contractors), manufacturing (nonchemical), agriculture (mostly family owned farms), electric utility, and transportation (trucking). Figure 3 shows that out of 88 fatalities, 66% were workers who were engaged in activities relating to water system, wastewater system, and sewerage construction (repair, cleaning, inspection, etc.). Thirty-five percent were workers with supervisory responsibilities. In four events two supervisors died, and in one event three supervisors died.

FIGURE 5
TYPE OF CONFINED SPACE (NIOSH, 1983-1989)

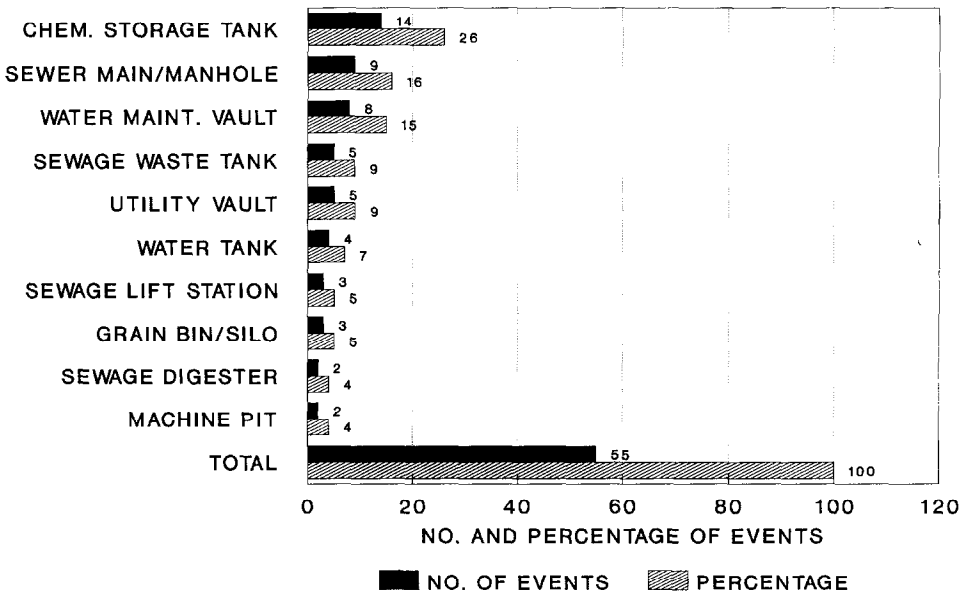
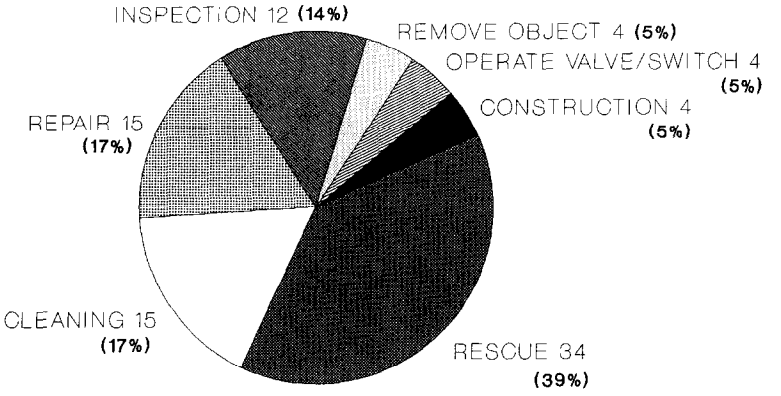


FIGURE 6
REASONS FOR CS ENTRY OF 88 FATALITIES * (NIOSH, 1983-1989)



* Rounding off of individual percent exceeds cumulative total

** Applies to task, not industry

Figure 4 shows the cause of death (as determined by medical examiners). Forty-seven percent of deaths were due to asphyxiation (including suffocation and aspiration), 21% were due to drowning, 19% from the toxic effects of chemical exposure, 10% due to blunt force trauma, 2% due to electrocution, and 1% due to burns.

Characteristics of the confined spaces were evaluated to see if any pattern existed. However, it should be noted that the type of confined space also reflects reporting sources. Figure 5 shows the different types of confined spaces involved in these events. The type of confined space, its size, shape, and access opening, may have an effect on entry, emergency exit, and rescue potential. In one study a minimum manway opening of 23 inches in diameter was necessary for fire fighters (with chest sizes from 36 to 45 inches) to successfully complete trial rescues while wearing a typical self-contained breathing apparatus (SCBA) (Silk, 1971). In the 55 events investigated in the FACE project, confined space openings were either round (55%) or rectangular (45%). Thirty-eight percent of the confined spaces had openings with dimensions (either square or round) of less than 23 inches. EMS rescue efforts were hampered because of this small opening size in 16% of the events.

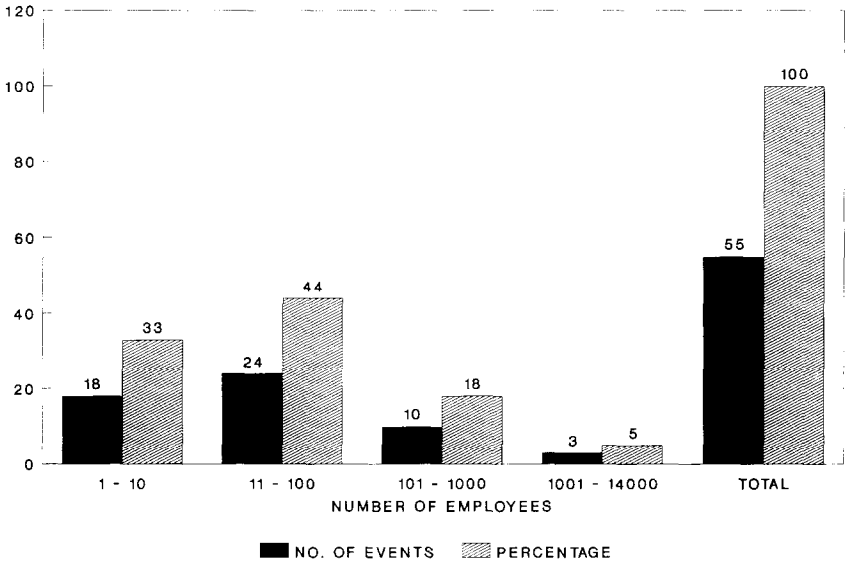
The material inside a confined space can often be associated with the potential hazards of the confined space environment. The confined spaces investigated contained the following materials: Sewage — 40%, water — 22%, chemicals (other than petroleum products) — 16%, petroleum products — 9%, unstable solid materials — 5%, and release of mechanical or electrical energy — 7%.

Figure 6 shows the reasons for confined-space entry in the 88 fatalities. Thirty-nine percent were workers who were attempting to rescue another worker. Cleaning, repair, and inspection accounted for 17%, 17%, and 14% of the fatalities, respectively. Other entry reasons were to remove an object (5%), to operate a valve or switch (5%), and to accomplish a construction-related task (5%). Organization and safety policies of the companies with fatalities were also considered. Company size varied from one employee to 14,000 employees (Figure 7). Seventy-seven percent of the companies had fewer than 100 employees. Thirty-three percent of the companies had 10 or fewer employees.

Eighty percent of the companies indicated that this same type of entry had been performed in the past under similar circumstances without adverse effects (Figure 8). These data indicate previous inadequate confined space work practices resulting in unnecessary exposure of workers to confined space hazards.

More than half of all companies (51%) had some type of written safety program.

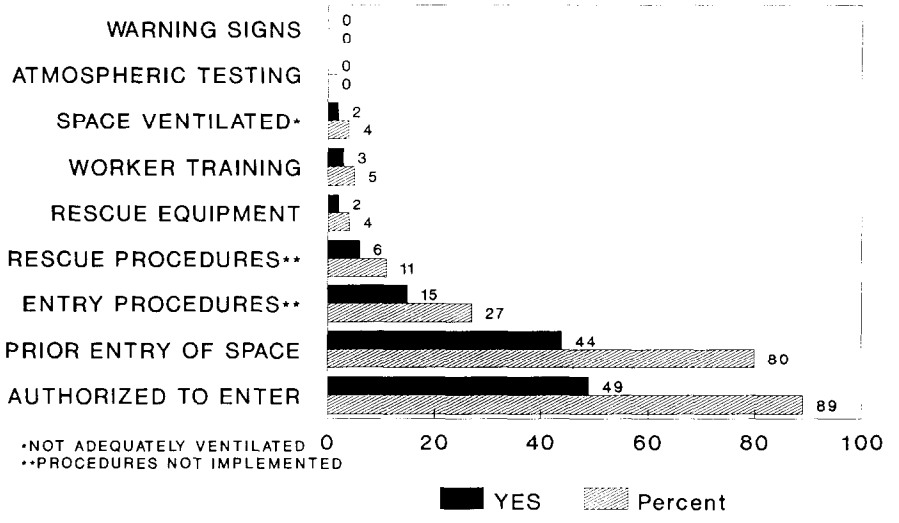
FIGURE 7
SIZE OF COMPANY (NIOSH, 1983-1989)



However, as shown in Figure 8, only 27% of companies had a written policy for confined space entry, and only six companies (11%) had written confined space rescue procedures. Of these written confined space policies or procedures, none were implemented at the time of the event. In only three events had workers received any confined-space safety training; in these events two supervisors and two workers died, three of whom had received the training.

According to information collected during the FACE investigations, none of the NIOSH recommendations for confined-space entry

FIGURE 8
CONFINED SPACE FATALITY FACTORS
TOTAL INCIDENTS = 55



(NIOSH, 1979) were completely and accurately followed. Testing the atmosphere inside the confined space prior to entry was not performed in any of the events, none of the confined spaces were labeled or posted with confined space warning signs, and in only two of the events was the confined space ventilated prior to entry. However, in both of these events the ventilation was inadequate. In 51% of the events, a supervisor was present when the worker entered the confined space, and entry was authorized in 89% (49) of the events. However, none of the 49 authorizations followed any type of written confined space entry procedure.

The proper selection and use of respirators is necessary for safe entry into confined spaces. Seventy-eight percent of the fatalities were directly or indirectly due to oxygen deficient or toxic atmospheres (immediately dangerous to life or health [IDLH]). In some fatalities drowning was preceded by the victim being overcome by an oxygen deficient or toxic atmosphere. In 16% of the events, either the wrong type of respirator was being used (air-purifying instead of air-supplying) or an air-supplying respirator was being used improperly in an IDLH atmosphere.

DISCUSSION

The FACE surveillance system is passive and limited to fatalities reported to NIOSH. If unreported deaths differ from reported deaths, this may limit generalization of results. However, the FACE project can still provide useful information on these deaths and clues towards further studies needed to evaluate prevention strategies.

Confined space fatalities occurring prior to 1988 were searched for in the National Traumatic Occupational Fatality (NTOF) database (NIOSH, 1990). The NTOF database, maintained by the Division of Safety Research at NIOSH, contains death certificate data on work-related deaths occurring within the United States. As expected, this death certificate data base contained all of the deaths, but none were identified as confined space-related. Although the deaths were a result of confined space work-related activities, only the immediate causes of death (asphyxiation, drowning, toxic chemical exposures, etc.) are given on the death certificates. Because of this, surveillance of confined space-related fatalities using death certificates is difficult, at best.

Also, since there is no specific Standard Industrial Classification (SIC) code for deaths within confined spaces, an accurate estimation of the number of workers potentially exposed to confined spaces would likewise be difficult using the NTOF system. Additionally, there is no current surveillance mechanism available to identify injuries resulting from nonfatal exposures in confined spaces. However, based on the total working population of selected specific SIC codes, and a rough estimate of the percentage of each category that may work in confined spaces at some time, NIOSH estimates that millions of workers may be exposed to hazards in confined spaces each year (NIOSH, 1979).

Confined space fatality events investigated by NIOSH suggest three underlying factors common to most of these deaths:

1. Failure to recognize the hazards associated with confined spaces.
2. Failure to follow existing, known procedures for safe confined space entry.
3. Incorrect emergency response.

These data substantiate the NIOSH Criteria Document.(NIOSH, 1979) and other NIOSH confined space safety publications that indicate that occupational confined space-related fatalities are occurring because confined space entry procedures are either not developed, inadequate, and/or not being implemented. The following is a summary of safe work procedures for confined space entry presented in the NIOSH Criteria Document (NIOSH, 1979) and other NIOSH publications on confined space safety:

1. Determine whether confined space entry is necessary to complete the assigned task.
2. Confined spaces should be entered only with an approved permit.
3. The confined space atmosphere should be tested and monitored for oxygen level and the presence of toxic and flammable gases/vapors prior to entry and during work.
4. The confined space should be ventilated prior to entry and during work.
5. Protective clothing, body harness, hoisting apparatus, NIOSH/MSHA approved respi-

rators, and other appropriate safety equipment should be used as needed.

6. The confined space should be isolated from electrical or mechanical hazards where possible by lockout/tagout.

7. Workers should be trained to identify confined spaces and their hazards, and also trained on the proper use of personal protective equipment (i.e., respirators).

8. Warning signs should be posted near confined space entrances.

9. Medical surveillance of workers exposed to confined-space hazards should be increased.

10. Standby/rescue procedures should be established.

11. A comprehensive written policy should be developed for all aspects of confined space safety including entry, monitoring, emergency rescue procedures, and management commitment to the established policy.

CONCLUSION

During the six years between December 1983 to December 1989, DSR investigated 55 confined-space fatality events resulting in 88 fatalities. These 55 events have been analyzed and show that NIOSH recommendations for working in confined spaces were not adequately followed. These data indicate that many companies either had no confined space entry procedures, or they were inadequate, or they were not implemented. Thus, many workers and supervisors may not have recognized the hazards associated with confined space entry. This underscores the need for companies to increase worker understanding and awareness through developing and implementing comprehensive confined space entry procedures and worker training in accordance with NIOSH recommendations. In some instances, a lockout entry system that would prevent the worker from entering until all appropriate confined space entry procedures are followed is one preventive method of ensuring that workers follow safe procedures for working in confined spaces.

DSR is continuing investigations of selected occupational confined space-related fatalities. However, as this research exemplifies, there are existing countermeasures to prevent these deaths that are not being implemented. It is the responsibility of management to develop and implement comprehensive confined space entry procedures, provide adequate training to all workers and enforce adherence to established policies. NIOSH encourages companies, trade associations, and unions to work together to recognize the dangers associated with confined spaces, and to work toward preventing these deaths by implementing appropriate engineering controls (i.e., different ways of accomplishing confined space-related tasks without having to enter confined spaces) and by following NIOSH recommendations for confined-space entry.

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