

# Preventing Deaths of Farm Workers in Manure Pits

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This Alert describes seven deaths from asphyxiation (suffocation) that occurred during two incidents involving entry into manure pits. The recommendations included in this Alert should be followed by all farm owners and operators who have manure pits on their property. Editors of appropriate trade journals, agriculture extension agents, farm owners and operators, and those in the agricultural trades are requested to bring the recommendations in this Alert to the attention of all workers who are at risk.



**WARNING!** Many farm workers have died after entering manure pits.

The National Institute for Occupational Safety and Health (NIOSH) requests assistance in preventing deaths of farm workers in manure pits. An urgent need exists to inform farm owners and workers about the dangers of enter such pits, where oxygen-deficient, toxic and/or explosive atmospheres often result from fermentation of the wastes in confined areas. These hazards have been known for several years. However, recent NIOSH investigations conducted under the NIOSH Fatal Accident Circumstances and Epidemiology (FACE) Program suggest that farm workers are unaware of the danger, and many deaths continue to occur as a result of entry into manure pits.

This Alert describes seven deaths from asphyxiation (suffocation) that occurred during two incidents involving entry into manure pits. The recommendations included in this Alert should be followed by all farm owners and operators who have manure pits on their property. Editors of appropriate trade journals, agriculture extension agents, farm owners and operators, and those in the agricultural trades are requested to bring the recommendations in this Alert to the attention of all workers who are at risk.

## Background

Of the approximately 2.3 million farms in the United States [USDA 1985], an unknown number contain manure pits or tanks. Manure pit systems are used primarily on livestock farms (including dairy operations) to allow for the easy cleaning of animal confinement buildings and the efficient underground storage of large amounts of raw manure. Because large areas of the confinement building can be cleaned with a water hose or other similar methods, such handling of manure is more efficient than the historical method of shoveling solid animal waste.

Inside the pit, the manure undergoes anaerobic digestive fermentation to form fertilizer. The digestive process can generate four potentially dangerous gases:

- Methane
- Hydrogen sulfide
- Carbon dioxide
- Ammonia

The accumulation of these gases within the confined space of the manure pit can produce an oxygen-deficient, toxic, and/or explosive environment.

The National Traumatic Occupational Fatality (NTOF) Data Base indicates that from 1980 through 1985, 16 deaths resulted from the asphyxiation (suffocation) of workers in manure pits or similar waste tanks [NIOSH 1989a]. These deaths resulted from nine separate incidents, but five of them involved multiple fatalities. Because the NTOF Data Base includes only work-related deaths of U.S. workers aged 16 or older, it may underestimate the number of deaths resulting from entry into manure pits during 1980-85.

Under the Fatal Accident Circumstances and Epidemiology (FACE) Program, NIOSH investigated two 1989 incidents described in this Alert. These two incidents resulted in seven fatalities and suggest that many farm workers are unaware of the hazards of entering manure pits. These pits are designed as confined spaces with limited means of entry and unfavorable ventilation. The gases generated by the bacterial decay of the manure may accumulate sufficiently to create deadly oxygen-deficient (less than 19.5% oxygen), toxic, and/or explosive atmospheres [NIOSH 1987].

In these two incidents and in those reported earlier, the fatalities often involved more than one victim. Two or more workers often died when rescue was attempted without appropriate safety equipment and procedures. Such a chain of events is consistent with the findings of other FACE investigations, which show that 39% of the victims in confined-space incidents were coworkers or others who attempted to rescue the initial victim [Manwaring and Conroy (in press)].

## Regulations

No Occupational Safety and Health Administration (OSHA) standard exists for work in and around manure pits. OSHA is reviewing a proposed rule on confined-space procedures that would address safety in confined spaces such as manure pits [54 Fed. Reg. 24080 (1989)], but even this standard would not be enforced by OSHA on farms with 10 or fewer workers (calculated as an annual average). The absence of a standard and the lack of knowledge about the dangers of these pits increase the potential for deaths such as those described in this Alert.

NIOSH has published criteria for a recommended standard for working in confined spaces [NIOSH 1979], an Alert on confined-space hazards [NIOSH 1986], and a guide for working in confined spaces [NIOSH 1987].

## Health Effects

The following is a brief summary of the physiological effects of gases commonly encountered in manure pits. Because all of the gases generated in these pits can displace oxygen (O<sub>2</sub>), atmospheric conditions inside the pit can become oxygen-deficient. Table 1 lists the health effects associated with various percentages of oxygen in the atmosphere [NIOSH 1987].

Table 1. Health effects associated with various percentages of oxygen in the atmosphere

% oxygen in atmosphere	Health effects
21 (normal oxygen content in air)	None
19.5 (minimum oxygen level for safe entry)	None
16	mpaired judgment and breathing
14	Faulty judgment, rapid fatigue
6	Difficult breathing, death in minutes

Source: NIOSH [1987].

## Methane

Methane (CH<sub>4</sub>), is an odorless gas that is flammable or explosive at concentrations of 5% to 15% by volume of air [NIOSH 1985b]. At high concentrations, methane can displace enough oxygen to cause death by suffocation. Because this gas is lighter than air, it occurs near the top of the pit. Methane should be expected to be present in manure pits.

## Hydrogen Sulfide

Hydrogen sulfide (H<sub>2</sub>S) is a highly toxic gas with a “rotten egg” odor at low concentrations [NIOSH/OSHA 1981]. At high concentrations, hydrogen sulfide can paralyze the olfactory senses [NIOSH 1979]. Because this gas is heavier than air, it can settle near the bottom of the manure pit. Hydrogen sulfide is a severe eye irritant and may cause tissue damage [NIOSH/OSHA 1981]. At low concentrations, gas can cause dizziness, headache, nausea, and irritation of the respiratory tract. At high concentrations, hydrogen sulfide can cause unconsciousness, respiratory failure, and death within minutes. In addition, hydrogen sulfide may be explosive at a wide range of concentrations in air—4.3% to 46% by volume [NIOSH 1985a].

## Carbon Dioxide

Carbon dioxide (CO<sub>2</sub>) is an odorless that is normally in the atmosphere [NIOSH/OSHA 1981]. Because this gas is heavier than air, it can settle near the bottom of the manure pit. At low concentrations, carbon dioxide can result in labored breathing, drowsiness, and headache. At high concentrations, carbon dioxide can displace enough oxygen to cause death by suffocation.

## Ammonia

Ammonia (NH<sub>3</sub>) has the sharp odor characteristic of household ammonia [NIOSH/OSHA 1981]. This gas can severely irritate the eyes, nose, throat, and lungs. Exposure to high concentrations can be fatal.

## Case Reports

The two incidents described below were investigated by NIOSH as part of its FACE Program. These incidents suggest that many farm workers may be unaware of the hazards of entering manure pits. Furthermore, both incidents involved the deaths of would-be rescuers who were members of the same family. Family members may be more apt than others to attempt a rescue.

### Case No. 1—Two Fatalities

On June 26, 1989, a 31-year-old male dairy farmer and his 33-year-old brother died after entering a 25-foot-square, 4-1/2-foot-deep manure pit inside a building on their farm. A pump intake pipe in the pit had clogged, and the farmer descended into the pit to clear the obstruction. While in the pit, he was overcome and collapsed. The victim's brother was standing at the entrance of the pit and apparently saw the victim collapse. He entered the pit an attempt to rescue him. The brother was overcome and collapsed inside the pit. Four hours later, another family member discovered the two victims inside the pit and called the local fire department to rescue them. The victims were pronounced dead at the scene by the coroner. The coroner's report attributed the cause of death in both cases to methane asphyxiation [NIOSH 1989b].

### Case No. 2—Five Fatalities

On July 26, 1989, five farm workers died after consecutively entering a manure pit on their farm. The pit measured 20 by 24 feet and was 10 feet deep. The victims were a 65-year-old dairy farmer, his two sons aged 37 and 28, a 15-year-old grandson, and a 63-year-old nephew. The younger son initially entered the pit to replace a shear pin on an agitator shaft. (NOTE: Agitation of the manure, which is required to facilitate transfer, causes a rapid release of the gases formed during decomposition.) While attempting to climb out of the pit, the initial victim was overcome and fell to the bottom. The grandson then entered the pit to attempt a rescue. He too was overcome and collapsed. The nephew, the older son, and the dairy farmer then entered the pit one at a time, attempting to rescue those already overcome. Each was overcome and collapsed in turn. A carpet installer working at the farm house then entered the pit to attempt a rescue. He too was overcome but was rescued by his assistant and subsequently recovered. Finally, the owner of a local farm implement business arrived on the scene with two of his workers and, using a rope, extricated the five victims from the pit. When the local emergency rescue squad arrived on the scene approximately 20 minutes after the incident, they immediately began cardiopulmonary resuscitation. The nephew was pronounced dead at the scene. The remaining four victims were transported to the local hospital. The farmer and his younger son were pronounced dead on arrival, and the older son died an hour after reaching the emergency room. The grandson was transferred to a major trauma center by helicopter but he died approximately 6 hours after his removal from the pit. Reports of the medical examiner cite methane asphyxiation as the cause of these five deaths [NIOSH 1989c].

# Conclusions

Many farm workers appear to be unaware of the immediate danger posed by entry into manure pits. Like other types of confined spaces, manure pits present special problems regarding worker awareness of hazards. The dangerous atmospheric conditions may exist intermittently. In both of the incidents described in this Alert, the pits had been entered on numerous occasions without problems. Previous uneventful entries may lead farm workers to feel safe about entering these pits.

The decomposition of waste that occurs in manure pits can create oxygen-deficient, toxic, and/or explosive atmospheres. The anaerobic bacterial action that breaks down the manure can generate methane, hydrogen sulfide, carbon dioxide, and ammonia. These gases may produce toxic effects, but more important, they can displace oxygen in a confined space. Deaths can occur from lack of oxygen or from the toxic effects of these gases [Donham 1983; CES 1980]. In addition, methane and hydrogen sulfide may present an explosion hazard.

The two incidents reviewed in this Alert occurred during hot weather, which may result in increased gas accumulation in manure pits. All 16 deaths identified in the NTOF Data Base occurred from April through September, with the highest number occurring in August. Although this information indicates that summer is the most dangerous period, the potential for an oxygen-deficient, toxic, and/or explosive atmosphere is always present in a manure pit.

# Recommendations

Manure pits on farms should be treated like any other type of confined space. As such,

- all manure pits should be ventilated,
- the atmosphere within the pit should be tested before entry,
- a standby person should be in constant contact and ready to lift the worker to safety with mechanical lifting equipment (winch, hoist, or pulley), and
- anyone entering a manure pit should wear a safety belt or harness with a lifeline tied to the mechanical lifting device.

In addition, a positive-pressure, self-contained breathing apparatus (SCBA) should be used by individuals entering the pit if an oxygen-deficient or toxic atmosphere is detected. However, because the required training and specialized equipment may not be readily available to farm workers, NIOSH recommends that they take the following MINIMUM precautions wherever manure pits are in use:

- NEVER enter a manure pit unless absolutely necessary and only when proper safeguards have been taken!
- Post hazard signs on all manure pits. The signs should be understandable to workers who cannot speak English or read. Signs in more than one language may be necessary in some areas.
- Provide a powered, continuous fresh air ventilation system for each manure pit. Ventilation is especially important when agitation of waste is initiated after it has been fermenting for some time. Because this system should consist of both supply and exhaust ventilation, two openings are required in the waste pit. Portable fans can be used if they have an explosion-proof design and are sufficiently large enough to provide a continuous change of air within the pit. An alternative is a ventilation system that uses a large, high-velocity, high-volume fan of explosion-proof design to force fresh air into a manure pit that has an exhaust vent located as far from the supply fan as possible. All exhaust from the pit should be directed outside and away from workers and livestock.
- Explosion-proof ventilation equipment must be used because methane and hydrogen sulfide gas can be explosive. The pit should be ventilated continuously. Contact local agriculture extension agents for additional information on ventilating manure pits.
- NEVER enter a manure pit unless someone is standing by and maintaining constant visual or auditory contact. This standby person must
- remain at the opening of the pit during the entire time the pit is occupied,
- have a mechanical device (winch, hoist, or pulley) in place to help remove the person from the pit,
- be physically capable of using the mechanical device to lift an unconscious victim from the pit without entering it,
- resolve all details of the rescue plan, including availability of rescue equipment, before anyone enters the pit, and
- remember that a delay of even a few minutes could be fatal in an emergency.

- ALWAYS wear a harness or safety belt with a lifeline when entering a manure pit. Secure the end of this lifeline to the mechanical lifting equipment outside the pit. The use of a harness or safety belt with a lifeline is critical because it is the only safe means for a standby person to rescue a worker from the pit without proper respiratory protection (i.e., positive-pressure, self-contained breathing apparatus).
- NEVER enter a manure pit to attempt a rescue without proper respiratory protection (i.e., positive-pressure, self-contained breathing apparatus). Rescuers who enter the pit without such equipment will almost certainly become victims. Instead, call the local fire department or rescue squad immediately. They have the training and equipment needed to accomplish such a rescue without endangering other lives.

NIOSH further recommends that the following actions be taken by farm owners and operators as well as manufacturers and providers of equipment for animal waste pit systems:

- Provide the information in this Alert to all farm workers.
- Fit all openings to manure pits with substantial metal grill covers to provide some natural ventilation and to prevent accidental falls or entries into the pits. Remember, however, that natural ventilation alone cannot maintain a safe atmosphere within the pit. Powered ventilation must be used before anyone enters the manure pit.
- Eliminate the need for entry into the pit by providing access to all serviceable parts (shears, pins, cleanouts, etc.) from the outside:
  - Modify existing systems to relocate serviceable parts to the outside.
  - Engineer new manure pit systems to provide access to all serviceable parts from the outside.
- Provide all purchasers of equipment designed for manure pit systems with the following:
  - Information on the hazards of these pits
  - Information (diagrams, etc.) on installing the equipment to permit servicing without entry into the pit.

## Acknowledgments

Comments or questions concerning this Alert should be directed to Dr. Thomas R. Bender, Director, Division of Safety Research, 944 Chestnut Ridge Road, Morgantown, West Virginia 26505-2888; telephone (304) 291-4595.

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