THE UNIVERSITY OF IOWA

COLLEGE OF PUBLIC HEALTH
Department of Occupational and Environmental Health

TO: Director, National Institute for Occupational Safety and Health

FROM: Iowa FACE Program **Case No. 03IA58** **Report Date: 24 June 2005**

SUBJECT: Hog Farmer Dies from Asphyxiation after Manure Pit Agitation

SUMMARY

In the fall of 2003, a 42-year-old farmer was killed in a hog confinement building after he was overcome by toxic gases arising from agitation of the manure pit beneath the facility. Working alone very early in the morning, the farmer prepared the manure for removal by agitating the pit with a manure pump attached to a tractor power take off (PTO). After starting the agitation process, the farmer entered the building to retrieve a dead hog that he had noticed inside of the building (Photo 1). The mechanical ventilation system in the building was not in use and the building was totally enclosed at the time of his entrance. Later in the afternoon the farmer was found lying face down in the center of the building by his fiancé, who immediately called 911 for help. Upon arrival, emergency rescue personnel donned appropriate personal protective equipment and removed the farmer from the confinement building. Examination of the farmer revealed that he had been deceased for several hours prior to the discovery of his body.

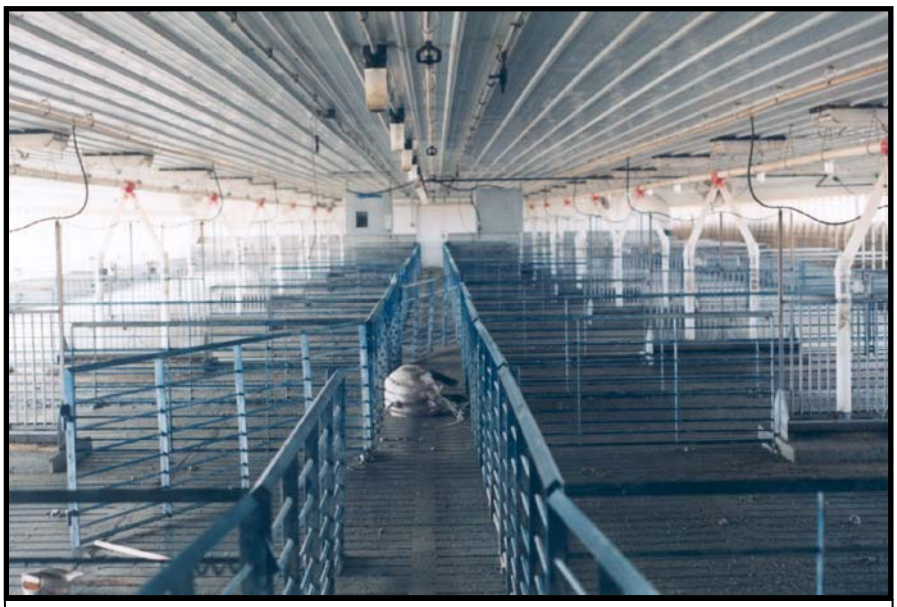

Photo 1 – Dead hog in the aisle of the confinement building. The farmer's cap is in the lower left corner, which is where he was found.

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RECOMMENDATIONS based on our investigation are as follows:

- *Hazards of working in and around manure pits should be regularly and effectively communicated to farmers.*
- *Pits and confinement areas should be ventilated before, during and after the agitation of manure.*
- *No workers should be inside animal confinement buildings during agitation of manure pits beneath the buildings.*
- *Farmers should have proper respiratory protection and a rescue capability in place when entering a manure pit.*

INTRODUCTION

In the Fall of 2003, a 42-year-old male farmer was killed in an animal confinement building in northwest Iowa after agitation of the manure pit beneath the building resulted in the release of toxic gases. The Iowa FACE program was alerted to this incident by a local newspaper article and began an investigation. Information for this report was derived from a Sheriff's Office report, Medical Examiner's report, newspaper articles, and interviews with family members.

The farmer was a co-owner with his brother in this swine production operation. After loading hogs at one of their hog confinement sites for transport to a processing plant, the farmer drove seven miles to the incident site. He began to agitate the manure pit beneath the floor of one of the buildings in preparation for taking a sample to analyze for nutrient levels. The hogs from this building had been removed two days earlier, and at that time, a dead hog had been seen inside the building. The farmer appeared to have entered the building to remove the hog while the pit was being agitated. With no added mechanical ventilation inside the enclosed building, the farmer was overcome by suffocating gases coming from the pit during agitation. The farmer was found dead several hours later.

Through manure management courses provided by the Iowa Extension Service, both the victim and his brother were aware that toxic gases are produced by decomposing manure, and that it was dangerous to enter unventilated manure pits. However, both farmers casually enter and exit these confinement buildings every day, and a strong ammonia smell inside of the buildings was considered normal.

The farm produced approximately 12,000 hogs per year. The farmer and his brother had been in partnership since 1995 and also produced cattle and grew corn and soybeans. The farmer had grown up on the farm where he died and had been involved in farming operations since he was a small boy.

INVESTIGATION

In the fall of 2003, sometime between 3:45 AM and 1:00 PM, a 42-year-old male farmer died in a hog confinement building after he was apparently overcome by toxic gases. During the night the farmer and his brother, who was his business partner, had finished loading hogs at one of their production sites for shipment to a processing plant. His brother believed that immediately after

loading the hogs, the farmer drove seven miles to the confinement building located at another site. All hogs had been removed from that confinement building two days before the incident, with the exception of one dead hog noticed during the loading process.

The farmer planned to collect a manure sample from the pit beneath the confinement building to have its nutrient level analyzed by the Iowa Department of Natural Resources. Prior to collecting this sample, it was necessary to agitate the pit, and the brothers had positioned a large row-crop tractor with a waste removal system attached to its power take off, and inserted this into the pit to stir the manure (Photo 2).

Photo 2 – Tractor in position with attached pump to agitate manure slurry.

The victim's fiancé had driven to the confinement building searching for the farmer, because she was concerned that no one had seen him all morning. Upon arriving at the confinement building at 1:00 PM,, she saw the man lying face down in the center aisle with a small puddle of blood on the floor beneath his face. The tractor was out of fuel and the manure pump no longer agitating the pit. The dead hog with a six-foot (1.8 m) piece of rope tied around its right hind leg, was approximately 10 feet (3.0 m) from where the farmer was lying. His fiancé immediately called 911 for help.

Upon arrival at the scene, the emergency rescue personnel donned air packs and entered the confinement building to remove the farmer. Examination of the farmer in the ambulance revealed that his body showed signs of stiffness and lividity, with a body temperature less than 80^{o} F (27^{o} C), indicating that he had died several hours earlier. He had pulled the hog approximately 60 feet (18 m) from where it had been seen lying the previous day, and he was only 20 feet (6 m) from the door of the building.

The building in which the farmer died was 50 ft. wide by 160 ft. long and 7.5 ft. high [approximately 60,000 ft.^{3} (1700 m^{3})]. The building was used for raising 1000 hogs. Six ventilation fans were in one end of the building—two 20" (500 mm) fans and four 24" (610 mm) fans. These fans were capable of moving approximately 30,000 cubic feet per minute (850 m^{3}/min.) of air through the building. Curtains, which could be lowered during warm weather, lined both sides of the building. These curtains on the side of the confinement building were closed, and the ventilation fans were not operating. An electronic control system automatically raised the side curtains and started the ventilation fans when the temperature in the building reached 58^{o} F (14.5^{o} C). Inspection of the control system revealed that it was operating properly, but because of the cool temperatures (minimum 24, maximum 52, average 38^{o} F; -4.5, 11.1, and 3.3^{o} C respectively, according to the nearest weather reporting station) on this particular day, the curtains and fans had not been engaged. The fiancé and the emergency crew noted a very strong ammonia odor when they entered the building, but did not notice the "rotten-egg" odor associated with hydrogen sulfide.

Manure pit systems are commonly used on livestock farms to allow for easy cleaning of animal confinement buildings and storage of large amounts of raw manure. The manure pit on this farm was 8 ft. (2.4 m) deep beneath a slatted floor running the entire width and length of the confinement building. Large areas of the confinement building could be efficiently cleaned by washing manure and debris through the slats and into the pit. At the time of the incident, the pit was approximately 75% full. Inside pits such as this, manure undergoes anaerobic digestive fermentation. This process can generate four potentially dangerous gases: methane, hydrogen sulfide, carbon dioxide, and ammonia (Table 1). Accumulation of these gases within the confined space of the manure pit can produce an oxygen-deficient, toxic environment.

Oxygen levels below 16% lead to impaired judgment and breathing; levels below 6% lead to death within minutes. Methane is a colorless odorless gas which is explosive at concentrations between 5% and 15%, and at high concentrations can displace oxygen causing suffocation. The atmospheric concentration of carbon dioxide is generally 0.035%; higher concentrations may displace oxygen causing labored breathing, drowsiness, headache, and suffocation. Ammonia has a sharp, pungent odor, and can irritate the eyes and respiratory membranes. High concentrations may cause pulmonary edema and suffocation. Hydrogen sulfide has a "rotten egg" odor at concentrations between 0.02 to 0.13 ppm, but odor perception is unreliable as a warning because rapid olfactory fatigue may develop at concentrations above 100 ppm. Hydrogen sulfide is a metabolic toxin, blocking the cellular respiration in the mitochondria (cytochrome electron transport chain). Hydrogen sulfide concentrations above 1000 ppm may cause rapid unconsciousness and death. With hydrogen sulfide being heavier than air, the oxygen is displaced just above the emitting manure surface. With agitation, a large amount of hydrogen sulfide is emitted, replacing the oxygen at the level of a pig before affecting an adult in the upright, standing position.

Table 1: NIOSH Recommended Exposure Limits (RELs)

Gas	Odor	Exposure Limits	Effects
Ammonia (NH_3)	Pungent	25 ppm* 35 ppm (ST)	Eye and respiratory irritation, asphyxiation at high levels
Carbon dioxide (CO_2)	None	5,000 ppm*	Drowsiness, headache, asphyxiation
Hydrogen sulfide (H_2S)	Rotten egg smell	10 ppm (C)	CNS depression, respiratory irritation, chemical asphyxiation
Methane (CH_4)	None	1,000 ppm*	CNS depression, cardiac sensitization, asphyxiation, explosive

* REL for a time-weighted average10-hour workday during a 40-hour workweek.
ST REL for a 15-minute time-weighted average exposure that should not be exceeded at any time during a workday.
C REL Ceiling value which should not be exceeded at any time.

The gas concentrations to which this farmer was exposed are unknown, nor is it known which gas was most responsible for his death. Hydrogen sulfide, which is readily released from water and liquid manure slurries when agitated, has been responsible for numerous fatalities among workers who entered manure pits. Hydrogen sulfide has also killed confined animals when manure pits beneath the floors were agitated. Hydrogen sulfide is the most likely cause of this farmer's death; however, fatalities occurring when agitating manure may be caused by the compound toxic effect of H_2S with

the asphyxiating effects of NH_3, CO_2, and CH_4. If the ventilation fans had been turned on, five air changes could have been made in the building within 10 minutes, significantly reducing toxic gas levels.

CAUSE OF DEATH

The official cause of death from the Medical Examiner's report was, "asphyxiation, due to suffocating gases". Autopsy revealed marked pulmonary congestion and edema, and the larynx showed areas of mucosal hemorrhage, both findings consistent with prior exposure to toxic gases. There was no evidence of heart disease or other natural causes identified that may have contributed to the man's death.

RECOMMENDATIONS / DISCUSSION

Recommendation #1 *Hazards of working in and around manure pits should be regularly and effectively communicated to farmers.*

Discussion: The anaerobic digestion of manure below animal confinement facilities causes the generation of four potentially dangerous gases—methane, hydrogen sulfide, carbon dioxide and ammonia. In particular, agitation of the manure pit may produce hydrogen sulfide in the atmosphere above the pit. The accumulation of these gases within the confined space of the manure pit can produce an oxygen-deficient, toxic environment. Entering such an environment can be lethal and death can occur from the lack of oxygen or from the toxic effects of these gases. Livestock producers and other agricultural workers should be made aware of these hazards through training via extension service programs, trade journal announcements, producer meetings, and other communication campaigns. These education, outreach, training, and communication efforts should be continued and repeated periodically to inform new workers and remind experienced workers. While the number of manure pit asphyxiation fatalities may be on the decline, the potential for fatal injury still exists whenever agitating and handling liquid manure.

Many hog farmers are aware of the dangers associated with manure pits, and take appropriate precautions when working in or around the pits. However, farmers are naturally more casual with the confinement building interior space, since they enter and exit these buildings several times every day. Farmers must remember that these two areas share a common exchange of air through slats on the floor, and that agitation of the manure pit will cause gas levels to rise in the entire building. Farmers may assume they will notice something unusual if high concentrations of toxic, suffocating gases are present in their hog buildings, but this is not the case, and farmers must always be disciplined to take necessary precautions whenever they agitate a manure pit.

Recommendation #2 *Pits and confinement areas should be ventilated before, during, and after agitation of manure.*

Discussion: It is very important to adequately ventilate animal confinement buildings while a manure pit is being agitated to prevent the build up of toxic gases. The building may be supplied with an exhaust ventilation system to provide removal of heat and moisture from the building. This system should be engaged to thoroughly remove toxic gases during pit agitation. It should be started and adjusted before agitation begins to avoid entering the building during agitation.

The concentration of toxic gases is reduced by approximately one-third with each air exchange. After agitation is complete and gases cease to be emitted, the ventilation system should be allowed to provide at least five air exchanges before entering the building. However, because it is not a straight-line formula, with no additional generation of toxic gases and thorough air mixing, five air exchanges will reduce toxic gas concentrations by about 99%.

Manure pits may also be equipped with ventilation fans. These fans should be engaged during pit agitation. Many hog confinements have curtains or windows which should be fully open during pit agitation. Workers should not enter the building for at least one hour after agitation has stopped and effective ventilation with curtains, windows, and doors open and fans on has cleared the building. Diffusion of gases will gradually reduce toxic gas concentrations.

Recommendation #3 *No workers should be inside animal confinement buildings during agitation of manure pits beneath the buildings.*

Discussion: In addition to the human fatalities, there have been many reports of animals being killed while residing in buildings during pit agitation. When manure pits are being agitated, toxic gas concentrations may build up quickly within enclosed buildings. It is possible that pockets of high gas concentrations could develop, even in ventilated buildings during pit agitation. Manure storage systems and handling processes vary. In many systems it is not possible to empty manure storage pits only when the building is empty. It is important to realize hazardous gases can be emitted when liquid manure is agitated and handled, and that precautions are necessary.

Recommendation #4 *Farmers should have proper respiratory protection and a rescue capability in place when entering a manure pit.*

Discussion: Prior to anyone entering a manure pit, thorough ventilation should take place such that at least five air exchanges have occurred and the pit should continue to be ventilated. In addition, all details of a rescue effort should be resolved prior to anyone entering the pit. A safety belt/harness, lifeline, and a mechanical device to help a person out of the pit should be in place, as well as the availability of other rescue equipment. If no mechanical lifting device is available, then at least two people must be ready to help retrieve someone from a pit. This second person is also a good idea since they can call for emergency assistance.

The standby person(s) should remain at the opening of the pit and maintain constant visual contact during the entire time the pit is being occupied. This person should be capable of operating the mechanical device to assist the person out of the pit without having to enter the pit themselves. Entering a manure pit or other confined space to attempt a rescue without proper respiratory protection (i.e., positive-pressure, self-contained breathing apparatus) has in many cases been lethal.

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With special acknowledgement of contributions to this report by Dr. Patrick O'Shaughnessey, University of Iowa, Dr. Dick Nicolai, South Dakota State University, and Dr. William E. Field, Purdue University..

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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