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Beware of Manure Pit Hazards[1]

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Since the increased use of manure pits by Michigan livestock producers, there have been several instances where a farmer, family member, or employee has asphyxiated or succumbed to toxic gases from the pit. Cases have been reported where several individuals have died while attempting to rescue a coworker or family member from a pit.

Nationwide data shows that most deaths occur during the summer months, a time when many producers are emptying pits. Regardless of the season, it is always best to presume that the pit contains hazardous gases or lacks oxygen. Producers need to take protective measures to protect themselves and others working in or around the pit.

The four main gases produced from decomposing manure are hydrogen sulfide, methane, ammonia, and carbon dioxide. In high concentrations, each of these gases may pose a health threat to humans and livestock (see Table 1). In swine housing facilities, where the manure pit is often located below the facility floor, these gases are generally detectable in low concentrations throughout the year. When pits are agitated for pumping, some or all of these gases are rapidly released from the manure and may reach toxic levels or displace oxygen, increasing the risk to humans and livestock.

HYDROGEN SULFIDE

Hydrogen sulfide is considered the most dangerous gas in manure pits because it is highly toxic and is rapidly released from decomposing manure during agitation and pumping. Concentrations of hydrogen sulfide can soar from 5 parts per million (ppm) to more than 500 ppm in seconds after agitation begins.

Concentrations of hydrogen sulfide above 600 ppm can kill an individual after taking only one or two breaths. The person falls immediately, apparently unconscious and dies without moving again. A safe evacuation of the individual can be made only if the rescuer is wearing a self-contained breathing apparatus (SCBA). Generally, a rescuer has about six minutes to begin cardiopulmonary resuscitation (CPR) before brain damage/death occurs. Unless the rescuer is wearing SCBA protective equipment (see section on personal protective equipment), there is a strong likelihood that the rescuer will also succumb to the toxic gases or lack of oxygen. There have been numerous instances where several farmers have been killed while attempting to remove someone from a pit or facility.

At lower concentrations, hydrogen sulfide can cause severe illness and irritate the entire respiratory track and eyes. Symptoms may include nausea, stomach distress, belching, coughing, headache, dizziness, irritation of the eyes and blistering of the lips.

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Table 1. Acute Effects of Swine Confinement Air Contaminants on Humans*

Gas	Exposure level	Effect or symptom
Hydrogen Sulfide	5 ppm	**RECOMMENDED MAXIMUM FOR HUMAN HEALTH**
	10 ppm	Eye irritation
	20 ppm for >20 minutes	Irritation to the eyes, nose and throat
	50 to 100 ppm	Vomiting, nausea, diarrhea
	200 ppm	Dizziness, nervous system depression, increased susceptibility to pneumonia, fluid in the lungs with prolonged exposure
	500 ppm for 30 minutes	Nausea, excitement, unconsciousness
	600 ppm and above	Rapid death
Ammonia	5 ppm	Lowest concentration detectable by smell.
	7 ppm	**RECOMMENDED MAXIMUM FOR HUMAN HEALTH**
	6 - 20 ppm and above	Eye irritation and respiratory problems
	40 - 200 ppm	Headache, nausea, reduced appetite, irritation to airways, nose and throat
Carbon Monoxide	50 ppm	**RECOMMENDED MAXIMUM FOR HUMAN HEALTH**
	50 ppm for 8 hours	Fatigue, headaches
	500 ppm for 3 hours	Chronic headaches, nausea and impaired mental ability
	1,000 ppm for 1 hour	Convulsions, coma after prolonged exposure
	4,000 ppm and over	Rapid death
Methane	50,000 to 150,000 ppm	Potentially explosive
	500,000 ppm	Asphyxiation
Carbon Dioxide	1,500 ppm	**RECOMMENDED MAXIMUM FOR HUMAN HEALTH**
	20,000 ppm	Deep, rapid breathing
	40,000 to 60,000 ppm	Heavy breathing, drowsiness, for 30 minutes and headaches
	100,000 ppm and above	Narcotic effect, dizziness, unconsciousness
	250,000 ppm and above	Death
Dust	2.4 mg/cubic meter	**RECOMMENDED MAXIMUM FOR HUMAN HEALTH** Cough and increased phlegm (bronchitis), fewer episodes, chest tightness.
Endotoxin	0.08 micrograms/cubic meter	**RECOMMENDED MAXIMUM FOR HUMAN HEALTH** Decreased lung efficiency
	0.1 micrograms/cubic meter	Organic Dust Toxic Syndrome

* Adapted from Baker J., Curtis S., Hogsett, O., et al ; Safety in swine production systems, Pork Industry Handbook, publication PIH-104, Cooperative Extension Service, Purdue University, West Lafayette, Indiana, 1986. Tables 1,2 and 3.

It is a common belief among farmers that it is safe to enter a facility or pit if they cannot smell the putrid, rotten egg odor associated with hydrogen sulfide. This is not necessarily true because high concentrations of hydrogen sulfide paralyzes the nerve cells of the nose to the point where the person can no longer smell the gas.

Hydrogen sulfide, because it is heavier than air, accumulates above the liquid level of the pit. Individuals may be quickly overcome with hydrogen sulfide when working around a pit, whether it be climbing down a ladder to make repairs or when leaning down to take a manure sample.

AMMONIA

Ammonia is easily recognized because of its pungent odor that is characteristic of drying urine. This gas is released throughout the year from urine and feces on the facility floor, or from a pit beneath the floor. Ammonia is lighter than air and generally dissipates from a well-ventilated facility.

Concentrations ranging from 6 to 20 ppm and above will irritate the eyes and throat. At higher concentrations, ammonia can irritate the respiratory system and cause wheezing and shortness of breath. Concentrations above 2500 ppm are considered to be dangerous to human life, but individuals are not likely to

enter a facility with a concentration this high because of the extremely strong odor.

METHANE

Methane is continuously produced in manure pits and released into the air at a steady rate. A colorless, odorless, non-toxic gas that is lighter than air, methane generally dissipates from a confinement building. The primary danger of methane accumulation in a facility is the risk of a fiery explosion from a spark if the methane/oxygen mix is in proper proportions. The risk of fire is greater in a poorly-ventilated structure.

Although non-toxic to humans and livestock, methane can cause asphyxiation if it displaces the oxygen in a closed facility.

CARBON DIOXIDE

Carbon dioxide is produced by decomposing manure, animal respiration and heating fuels. An odorless, colorless, non-toxic gas, carbon dioxide is normally present at 300 ppm in the air. Concentrations rise when ventilation systems are inadequate or functioning improperly, This may result in oxygen being displaced in the facility with carbon dioxide. Carbon dioxide, in combination with rising temperatures and humidity, can kill hogs through asphyxiation and heat stress if ventilation failures last for several hours.

PROTECTION DURING PIT ENTRY

Pits are unpredictable, they may have been safe to work around for years, but suddenly, factors such as the stage of manure decomposition, wind conditions, or other components are just right (or in this case, wrong) for the pit to release deadly concentrations of toxic gases. Always treat a pit as if it is a death trap and take necessary precautions to protect yourself and others if entry is necessary.

SCBA

If you must enter a manure pit where gases are suspected, a self-contained breathing apparatus (SCBA) must be worn along with a safety harness and preferable two persons available to assist in a rescue.

A self-contained breathing apparatus supplies the wearer with 15 to 30 minutes of safe air to breath. A SCBA system, similar to those worn by firefighters, has a small air tank and facemask that allows the person to move about freely in an area where toxic gases or insufficient oxygen is suspected.

There are restrictions to wearing a SCBA that should be considered before purchasing the equipment. Training on the use of a SCBA is essential to ensure proper use. The facemask must fit properly or toxic gases may enter the mask. The wearer cannot have a beard because the facemask will not seal properly around the face. Your local fire department is the best source

Table 2. Gas Measuring Devices Useful in Confinement Buildings

Gas	Situations*	Detector Tubes	Dosimeter Tubes	Solid state Detectors
Ammonia	routine measurements	satisfactory	preferred	Not reliable
Hydrogen Sulfide	routine measurements	preferred	satisfactory	satisfactory
	emergency situations	satisfactory	too slow	preferred**
Carbon Monoxide	routine measurements	preferred	satisfactory	satisfactory
	emergency situations	preferred	too slow	preferred
Carbon Dioxide	routine measurements	satisfactory	satisfactory	satisfactory
	emergency situations	preferred	too slow	satisfactory
Methane	flammable levels	preferred	not available	satisfactory

* Routine is defined as typical daily average concentrations. Emergency is defined as any non-routine situations such as pit pump-out, ventilation or electrical failure, observation of abnormal swine behavior, or unusual respiratory symptoms in persons entering buildings which may indicate gas concentrations immediately hazardous to human health.

** Solid state detectors are preferred here because of the speed or response and because they provide continuous information on hydrogen sulfide concentrations.

Table 3. How to Measure Hydrogen Sulfide*, Carbon Monoxide, and Carbon Dioxide During Emergency Situations**

1.	Do not enter the building. Open widows and doors from the outside, turn on ventilators, and use any fans available to blow air into the facility.
2.	Use a detector tube with an extension hose to avoid the possibility of breathing highly toxic air. The detector tube must be specific for the gas to be measured (carbon monoxide, carbon dioxide, or hydrogen sulfide). While reaching through a window or other opening, place the detector tube near floor level and use the vacuum pump to draw air into the tube. Remove the detector tube and read the gas concentration.
3.	If measurement is low, borderline, or hard to read, take additional measurements in different areas of the building. One measurement may be inadequate to detect high gas concentrations.
*	Note that monitoring hydrogen sulfide concentrations is recommended whenever a deep pit underneath a building is being pumped, even if there are no indications of toxic gases.
**	Emergency is defined as any non-routine situation such as pit pump-out, ventilation or electrical failure, malfunction of fossil fuel-burning heaters, observation of abnormal swine behavior or death, or unusual respiratory symptoms of persons entering the buildings. These symptoms may indicate gas concentrations immediately hazardous to human health.

for information and training on its use. The cost of a SCBA is about $1,700.

Due to the equipment requirements and inherent risks associated with entering an area where there may be toxic gases or insufficient oxygen, you should consider hiring a professional trained in working in these areas to perform maintenance tasks. If hiring a professional or using a SCBA is not possible, the best advice is to stay out of the pit.

Meters and Ventilation

An alternative to wearing a SCBA is to check gas and oxygen levels of a facility or manure pit with a gas and oxygen testing meter before entering (see Table 2 for types of meters and gases that they can detect).

Metering can also present problems if not done properly. Toxic gas concentrations may vary throughout the area; higher levels may be detected in dead air spaces where ventilation is inadequate; lower levels are likely in areas near open windows and mechanically ventilated areas. It should also be noted that gas levels can rapidly escalate during agitation and pumping; meter readings that were at safe levels before these activities may reach hazardous levels in a few minutes. Continue to ventilate the area throughout the entire process. Table 3 gives instructions on how to measure some gases in emergency situations.

The three basic types of meters are detector tube, dosimeter tube and solid state detectors. Detector and dosimeter tubes use inexpensive gas sampling devices that give reliable readings for ammonia, hydrogen sulfide, carbon monoxide, carbon dioxide, or other gases found on the farm. Dosimeters are best for measuring average concentrations; detector tubes do the best job of measuring instantaneous concentrations during emergency situations. Solid state detectors give continuous readings and have audible alarm systems, but are more expensive than tube type detectors and must be calibrated frequently.

Additional Equipment

Anyone entering a pit should be equipped with an approved harness and a rescue rope attached to a tripod and pulley system. Two people can remove an unconscious individual from a pit in a few seconds with this type of a emergency lift. Remember, you have only six minutes to begin cardiopulmonary resuscitation (CPR) before brain damage/death occurs.

Unsafe Alternatives

The cost of a self-contained breathing apparatus, metering, and approved equipment to lift an unconscious individual from a pit may lead you to consider less costly alternatives. Unfortunately, all these alternatives have substantial safety risks.

- Lowering an open flame into a pit to check oxygen levels may result in an explosion from accumulation of methane gas. Also, this only tells you that there is at least 16 percent oxygen in the pit, but research shows that most individuals need 19.5 percent

oxygen concentrations to live. Normal air contains about 21 percent oxygen.

- An alternative to an approved harness and safety lift may be to tie a rope around the individual entering the pit. This may work, but there is a substantial risk of breaking a rib and puncturing a lung while making a rescue.

Do not Enter any Confined Manure Pits Without Either:

A self-contained air supply like those fire fighters use. (Dust masks or other cartridge respirators will not filter out the toxic gases nor will they provide the oxygen requirement to work in confined spaces such as manure pits.)

OR

1. Testing the air for hydrogen sulfide, combustible gases or methane, and oxygen with dependable and reliable equipment, AND

2. Constant and adequate ventilation of fresh air, AND

3. An approved harness/lifeline on the person entering the pit with at least two people outside the pit who are capable of pulling the person out of the pit if necessary, AND

4. An approved pulley and tripod or other suitably strong lifting system that will make it possible to remove a limp body from the pit.

Remember, you have only six minutes after a person stops breathing to begin mouth-to-mouth resuscitation before brain damage/death occurs. Being prepared will greatly reduce the risk of panic, ill adverse action, and needless death or injury.

Reducing Hazards from Manure Gases

Fence around pits to keep children and other nonworkers away from the pit. Keep gates locked to prevent anyone else from entering the area.

- Provide mechanical ventilation in closed buildings to provide as much ventilation as possible during pit agitation. Turn all fans on during agitation and throughout the entire pump-out period. This is the time of greatest danger and when most deaths and injuries occur.

- Keep workers away from the pit and out of the building during and immediately after agitation. Move animals out of the building if possible.

- Post warning signs at common potential entry points of confined spaces where hazardous gas concentrations could occur.

- Warning decals are available from the Michigan Department of Labor-S.E.T. Division, P.O. Box 30015, 7150 Harris Dr., Lansing, MI 48909. (Ask for SET #2054 confined space decal sign.)

- Thoroughly ventilate and continue ventilation while working around a pit. Have a second person standing by before attempting to enter a building to rescue an animal or coworker. If thorough ventilation is not immediately possible, a self-contained breathing apparatus should be worn. Failure to use this equipment could result in death or serious health impairment of the rescuer.

- Consider installing railings on all walkways and permanent ladders on the inside wall of the tank. Construct lids or tops on all ground level pits, or fence around them where possible.

- If possible, remove clogged or damaged pumps from the tank to make repairs instead of entering the pit. Remind children, visitors and any non-essential workers to stay away from manure pits and transfer/holding tanks, especially during agitation and pumping. Do not allow people to enter livestock buildings during agitation and pumping of manure pits under the building floor.

WHEN TO CONSULT A PHYSICIAN

Livestock confinement operators should consult a physician whenever they experience one or more of the following symptoms:

- Persistent cough, especially a cough accompanied by large amounts of phlegm, shortness of breath, or a feeling of chest tightness.

- Wheezing, chest tightness, or shortness of breath which develops while working in a confinement building.

- Episodes of flu-like illness with fever, headache, muscle aches, cough, chest tightness, and shortness of breath that develops several hours after entering the confinement building.

- Excessive and persistent shortness of breath at any time.

- Excessive fatigue or intolerance to exercise.

- Any respiratory symptoms following a known exposure to high concentrations of gas associated with pit agitation.

- Livestock confinement operators should also consider having a yearly physical examination which will enable the physician to examine the patient's respiratory condition and compare any changes in lung function from year to year.

REFERENCES

Swine Confinement and Respiratory Health, University of Iowa, Institute of Agricultural Health and Occupational Medicine, 1989.

Hazardous Gases in Manure Tanks in Livestock Operations, 1989, Michigan State University, Agricultural Engineering Information Series, AEIS #573.