Safety in Swine Production Systems – Pork Industry Handbook
Michigan State University Extension Service
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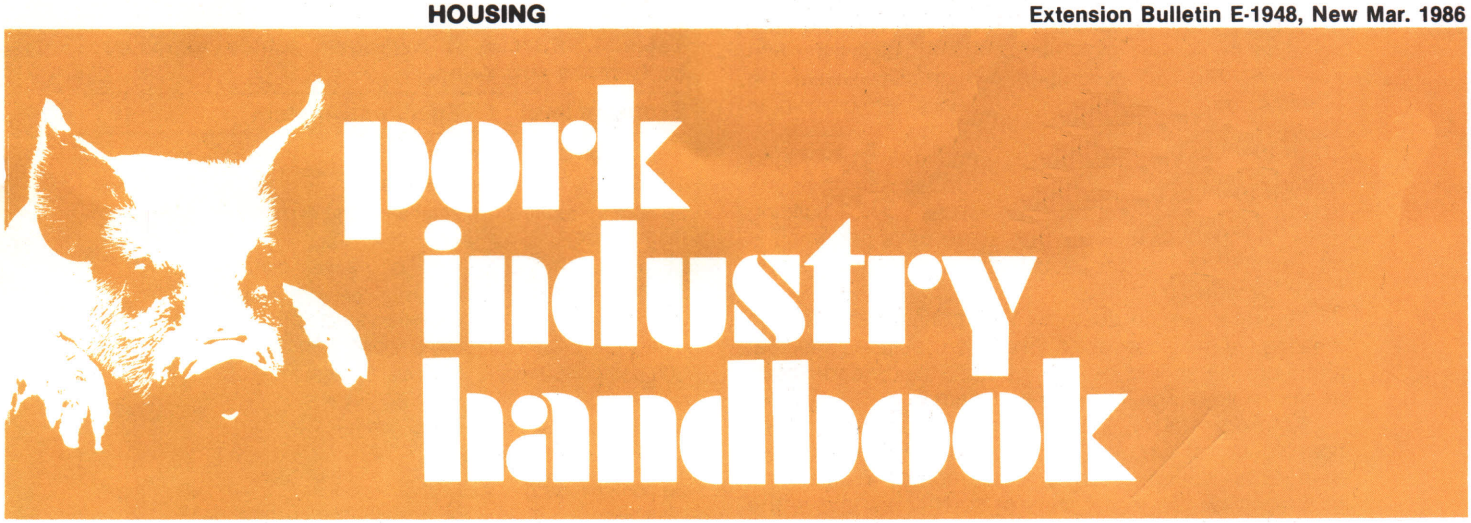

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Safety in Swine Production Systems

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Introduction

The swine industry has increasingly moved toward specialization and mechanization for high density rearing of livestock. One aspect of this specialization can be seen in housing systems that assist managers in raising animals with less labor in a more controlled environment, one that incorporates mechanized ventilation, supplemental heating, liquid or slurry manure handling, and automated dry-feed handling. These systems introduce new management factors related to both people and livestock. It is significant that animal health and performance advantages of housing systems when compared to pasture or dirt lot systems are reflected in lower mortality, better feed conversion, and increased growth rates.

However, manure accumulations within enclosed buildings generate gases which can be both toxic and asphyxiating when improperly managed. Another problem is unvented heaters in poorly ventilated buildings that lack enough oxygen for complete fuel combustion. This situation can increase carbon monoxide levels. Dust resulting from automated feeding systems, animal hair and dander, and dried manure on floors and animals can irritate respiratory systems. The severity of these problems is seasonal in that the atmosphere within enclosed buildings is often much better during the summer than the winter because ventilation rates are not reduced for heat energy conservation.

The potential danger of stored manure gases must be respected. Livestock have died as a result of ventilation failures or stored manure agitation. Human fatalities have occurred from entering a manure collection or storage pit without insuring adequate ventilation or without being equipped with proper breathing apparatus. In addition, manure storage pits or tanks and lagoons, like any water impoundment, should be respected for the drowning potential.

Toxic and Asphyxiating Gases

When manure and urine are stored and undergo anaerobic digestion, dangerous gases are produced. The ones of primary concern are: hydrogen sulfide, ammonia, carbon dioxide, and methane. But more than 40 different gases are produced; and some, such as volatile acids, amines, and mercaptans are highly odorous in very small quantities. In addition, carbon monoxide can rise to toxic levels when heating units malfunction or inadequate oxygen is present.

Hydrogen Sulfide (H_2S). Hydrogen sulfide is the most toxic gas associated with the decomposition of swine manure. It is believed to have been responsible for most of the deaths of livestock and humans that have occurred around liquid manure storage pits. It is colorless, heavier than air, and highly soluble in water; it has the characteristic odor of rotten eggs. However, the odor of hydrogen sulfide can be deceiving. It is first detected, by most people, at concentrations below one part per million (ppm) by volume. (One ppm is the equivalent of one volume of gas mixed in one million volumes of air.) Above 6 ppm, the odor will only increase slightly even though the concentration of hydrogen sulfide increases significantly. The gas at 150 ppm can have a deadening effect on the sense of smell making detection extremely difficult.

A common level of hydrogen sulfide gas in environmentally controlled swine units is around 5 ppm. But during the first stages of stored manure agitation and pumping liquid manure, hydrogen sulfide can reach dangerous concentrations. Levels of 200 to 300 ppm

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have been reported to exist within a few minutes after agitation begins, and levels can go as high as 1,500 ppm. The effects hydrogen sulfide can have on humans and swine, at different levels, are shown in Table 1.

The National Institute of Occupational Safety and Health (NIOSH) maximum recommended safe concentration of hydrogen sulfide for workers in a building during an eight-hour work period five days per week is 10 ppm. Human evacuation is recommended when levels exceed 50 ppm.

Even if a person does not lose consciousness after inhaling heavy doses of hydrogen sulfide, medical attention still should be sought since fluids can accumulate in the lungs following exposure.

Ammonia (NH_3). During storage and decomposition, significant amounts of ammonia are released from manure and urine. Sources of ammonia include urine and feces on the top of slats or solid floors and in the pit. Ammonia gas is an irritant which is colorless, lighter than air, and highly water soluble. It has a sharp pungent odor that becomes detectable at levels as low as 5 ppm.

Typical ammonia levels in well-ventilated environmentally regulated buildings are 10-20 ppm with liquid manure systems and 50 ppm where manure and urine are deposited on solid floors. Levels can exceed 50 ppm with lower winter ventilation rates and reach 100-200 ppm in poorly ventilated buildings. The effects of exposure to ammonia gas are presented in Table 2. The NIOSH maximum recommended safe ammonia concentration for workers in a building for an eight-hour work period is 25 ppm.

Carbon Dioxide (CO_2). The earth's atmosphere normally contains 300 ppm of carbon dioxide. At considerably higher concentrations, it can asphyxiate people by reducing the amount of oxygen present.

Manure decomposition and the normal breathing process of animals can increase the level of carbon dioxide in confined spaces. Typical concentrations inside ventilated buildings range from 1,000 ppm during well-ventilated periods to 10,000 ppm during winter. The effects of excessive concentrations of carbon dioxide are presented in Table 3. The NIOSH maximum recommended safe carbon dioxide concentration for workers is 5,000 ppm.

Methane (CH_4). Methane is produced during natural decomposition of manure and is nontoxic. It is rarely a problem in swine buildings. However, high concentrations can cause headaches and even asphyxiation. The major safety concern about methane is that it is highly flammable and can be explosive at levels ranging from 50,000 to 150,000 ppm (5 to 15 percent). Because methane is lighter than air, it tends to rise and accumulate near the higher stagnant parts of enclosed buildings and tightly closed manure storage pits. This colorless, odorless gas is only slightly soluble in water. But if a unit is well-ventilated, concentrations should be well below the minimum explosive point.

The NIOSH maximum recommended safe methane concentration for workers during an eight-hour period is 1,000 ppm. Its effects on humans and swine are presented in Table 4.

Carbon monoxide (CO). When fuels burn incompletely, as all fuels do to some extent, carbon monoxide is produced. This is a gas which is most notorious for killing people who operate their car engines inside closed garages.

Inside a building, carbon monoxide can build up in poorly ventilated areas where heating units malfunction,

Table 1. Effects of hydrogen sulfide exposure on humans and swine.

Exposure level	Effect or symptom
On humans	
10 ppm	Eye irritation
20 ppm for more than 20 min.	Irritation to the eyes, nose, and throat
50 to 100 ppm	Vomiting, nausea, diarrhea
200 ppm for 1 hr.	Dizziness, nervous system depression, increased susceptibility to pneumonia
500 ppm for 30 min.	Nausea, excitement, unconsciousness
600 ppm and above	Rapid death
On swine	
20 ppm, exposed continually	Fear of light, loss of appetite, nervousness
200 ppm	Possible pulmonary edema (water in the lungs) with breathing difficulties and possible loss of consciousness and death

Table 2. Effects of ammonia gas exposure on humans and swine.

Exposure level	Effect or symptom
On humans	
6 to 20 ppm and above	Eye irritant, respiratory problems
100 ppm for 1 hr.	Irritation to mucous surfaces
400 ppm for 1 hr.	Irritation to eyes, nose, and throat
700 ppm	Immediate irritation to eyes, nose, and throat
5,000 ppm	Respiratory spasms, rapid suffocation
10,000 ppm and above	Death
On swine	
50 ppm	Reductions in performance and health. Long-term exposure increases the possibility of pneumonia and other respiratory diseases.
100 ppm	Sneezing, salivation, and loss of appetite thereby reducing animal performance.
300 ppm and above	Immediate irritation of nose and mouth. Prolonged exposure causes extremely shallow and irregular breathing followed by convulsions.

Table 3. Effects of excessive carbon dioxide exposure on humans and swine.

Exposure level	Effect or symptom
On humans	
60,000 ppm for 30 minutes	Heavy breathing, drowsiness, and headaches
100,000 ppm (10%) and above	Narcotic effect, dizziness, unconsciousness
250,000 ppm (25%) and above	Death
On swine	
40,000 ppm	Increased rate of breathing
90,000 ppm	Discomfort
200,000 ppm (20%)	Cannot be tolerated by market hogs for more than one hour

where there are unvented heaters, or where there are gas catalytic heaters. Winter is the most dangerous period because buildings are usually closed and ventilation rates are lowest. A victim can be unaware of the presence of carbon monoxide because it is colorless and odorless. The NIOSH maximum recommended safe working carbon monoxide concentration for adults during an eight-hour period is 50 ppm. Pregnant female workers should be aware that an unborn fetus is more susceptible to carbon monoxide than adults. Carbon monoxide has the same density as air and is insoluble in water. Table 5 presents the effects of carbon monoxide exposure.

Dust and Particulate Matter

High levels of dust particles resulting from automated dry-feed handling systems, dander and hair from animals, and dried manure particles from animals on slotted and solid floors can occur inside swine units. Manure gases can cling to these dust particles in such a way that inhaling these gas-laden particles is like taking a breath of smog. Particulate matter also includes viral, bacterial, and fungal agents from the building environment and carries them into a person's respiratory system.

Another potential problem is inhalation of animal feed dust containing antibiotics. These inhaled particles could cause a person to become sensitive to certain antibiotics. It is possible for some workers to contract infections that are resistant to antibiotics. When a person breathes dusty air for an extended time there may be several consequences:

- Chronic bronchitis (frequent cough bringing up phlegm) may result.
- The respiratory system's capacity to take in and exhale oxygen may be reduced.
- There may be an increased susceptibility to respiratory diseases such as colds and pneumonia.
- Episodes of flu-like illness with fever might develop.
- Adverse allergic reactions may result.

Although NIOSH standards allow for exposure to 5 mg/m^3 respirable and 10 mg/m^3 total dust exposure, excess human and animal health problems are seen in buildings having greater than 2.5 mg/m^3. Dust levels in some swine housing units during the winter have been reported to be two to three times higher than the recommended working levels.

Potentially Hazardous Situations

Ventilation breakdown. *A ventilation malfunction can result in severe animal stress or death, particularly on hot, still days when no natural drafts occur to replace the air in animal areas. Animals may die from heat prostration, lack of oxygen, or a combination of these hazards.*

Manure agitation. *When liquid manure that has been stored for a prolonged period is agitated, toxic levels of hydrogen sulfide gas will be released. This situation can create lethal conditions, even when there is full ventilation. The greatest hazard exists almost immediately after vigorous agitation of stored manure begins. When this occurs, high concentrations of gases are released near the building's exhaust fans as well as at the area around the point of agitation.*

Entering a manure storage. *A manure storage pit should never be entered without full respiratory protection. Even if it has been ventilated or recently emptied, a person could be killed by hydrogen sulfide gas or by the lack of oxygen. Moreover, the methane gas that accumulates in the upper stagnant-air areas of enclosed tanks can create an explosive condition.*

Open manure storage pits, tanks, or lagoons. *When an opening into a deep manure storage pit or tank is unguarded, it invites an accident. Workers and animals could fall into the pit and drown. Surface scums and crusts can be deceiving since they may appear capable of supporting a person's weight, especially a child's, when in fact, they cannot..*

Heaters and engines. *Unless there is adequate ventilation where unit heaters, catalytic heaters, and radiant heaters are used, carbon monoxide can reach deadly concentrations. Another hazard is the use of auxiliary generators that are not vented to the outside.*

Table 4. Effects of methane exposure or presence on humans and swine.

Exposure level	Effect or symptom
50,000 to 150,000 ppm	Potentially explosive
500,000 ppm	Asphyxiation

How to Control Toxic and Asphyxiating Gases

Insure adequate ventilation. Adequate ventilation systems should be designed to provide the recommended air exchange rates within animal and worker zones. When conserving heat during the winter, be sure to not reduce ventilation rates below the minimum recommended. Consider using air circulation fans or distribution ducts to improve the mix of indoor air during the winter.

In addition to maintaining adequate ventilation, observe these management tips:

- Maintain the ventilation systems by frequently removing dust accumulations from exhaust fans, fan shutters, and air inlet screens.
- Place ducts to be used for underfloor exhaust fans below the slats and above the highest level the manure will reach. Use them to exhaust air outside.
- Provide the maximum amount of mechanical ventilation possible whenever stored manure is agitated.

Table 5. Effects of carbon monoxide exposure on humans and swine.

Exposure level	Effect or symptom
On humans	
50 ppm for 8 hr.	Fatigue, headaches
500 ppm for 3 hr.	Chronic headaches, nausea, and impaired mental ability
1,000 ppm for 1 hr.	Convulsions; coma after prolonged exposure
4,000 ppm and over	Death
On swine	
200-250 ppm	Baby pigs are less vigorous
150 ppm and over	Causes abortions in late-term sows, and an increased incidence of stillborn pigs. Reduces growth rate of young pigs.

In a naturally ventilated building; agitate only when there is a brisk breeze; and even then, consider removing livestock from the building before agitating the manure.

- Install an alarm system to warn of power failures that would affect the mechanical ventilation system. Check and maintain the alarm system and power unit on a weekly basis. If power fails, an emergency power generating unit should start immediately. If an auxiliary unit is not available, open all windows and doors and consider removing livestock from the building where manure is stored.

- Use proper manure storage management. Do not overfill underfloor manure storage pits. These pits should be pumped or drained when the liquid level rises to within 1 foot of the slats or to within 4 inches of the bottom of slat support beams. Clean the manure pits regularly. After emptying the pit, add enough liquid to cover the remaining residue and manure solids. Hydrated agricultural lime can be added to manure storage contents at the rate of 1 pound per 1,000 cubic feet of stored manure to maintain the pH near 7. Alkaline conditions suppress the release of hydrogen sulfide but increase ammonia emissions.

- Placement of gas traps in drain lines connecting outside manure storage structures with enclosed buildings is recommended.

- Unvented heaters should never be installed unless continuous ventilation is provided; in other words, vent all engine and heater exhausts to the outside to minimize carbon monoxide levels.

Precautionary Measures

- If possible, evacuate all animals and workers from buildings before stored manure is agitated. If animal evacuation is not possible, observe from a distance, start agitation slowly and be ready to turn off the pump at the first sign of trouble or discomfort. See Tables 1-5 for effects of exposure to gases. Do not agitate vigorously at the start. Instead, begin agitating at near tractor idle speed and slowly build up the pump speed.

- Never look into a manure storage when agitating. Never try to rescue a distressed animal or person without being equipped with self-contained breathing apparatus that has its own oxygen supply.

- *Enter a manure storage pit or tank only when it is absolutely necessary. Even then, only do so if it is well-ventilated and if you are wearing a self-contained breathing apparatus with a lifeline attached. Make certain a similarly equipped person who is capable of retrieval is ready and strategically located for rescue.*

- Be aware of the signs which indicate gas has reached toxic levels. These signs include rapid blackening of copper pipes, electrical wiring, or lead-pigmented paint—or white deposits of zinc sulfate on galvanized steel. Approved commercial gas monitors, measuring devices, or kits can be used to check gas levels.

- To help prevent the risk of drowning, construct covers for ground-level and below-ground manure collection and storage tanks. Once installed, keep these access covers in place. Covers should be round or chained to the floor to prevent them from falling into the pit. Install railings around all manure storage pit or tank openings, walkways alongside the structures, and piers or catwalks over the open storage areas. Attach permanent ladders made of noncorrosive material to the inside wall of all deep manure storage structures.

Other Safety Precautions

- Fence in earthen manure storage basins and lagoons to keep out animals and people. Remind people, by posting warning signs, to exercise utmost caution.

- Prohibit smoking, welding, or the use of open flames in poorly ventilated buildings or enclosed manure storage areas until the areas have been thoroughly ventilated.

- Use explosion-proof electric motors. Keep light fixtures and electric wiring around storage structures in good condition. All electrical wiring should meet the National Electric Code.

- Place flame arrestors on the gas lines that lead to heating units or generator engines.

- The area around the anaerobic digester systems for methane production should have "Caution-Flammable" signs posted in plain view.

- Keep all guards and safety shields in place on equipment such as pumps, manure spreaders, and power units.

- Stand clear of "tipping bucket" flush tanks when they rotate.

- When working in enclosed buildings for a prolonged period, reduce inhalation of dusty air by wearing a disposable dust mask which has been approved by the American National Standard Practices for Respiratory Protection, or NIOSH.

First-Aid Procedures

- Be able to recognize symptoms of gas poisoning and the physical effects that occur as a result of exposure to manure decomposition and/or heating units.

- Rescue equipment and first-aid supplies that meet the approved standards of a consulting physician should be located near the manure storage area.

- Post the phone number of the local fire department or rescue squad near rescue equipment and beside all telephones.

- Do not attempt to rescue a victim from a storage pit unless you are equipped with a self-contained breathing apparatus.

- When phoning for emergency medical help, make sure rescuers know what the situation involves so they can determine the need for special equipment.

- If the victim can be safely moved, get him or her to fresh air.

- If the gases have simply irritated a part of the body, flush the affected areas with fresh water.

- If the victim is not breathing, start cardiopulmonary resuscitation (CPR, if properly trained) immediately and continue until medical help arrives.