

Safety and Emergency Response for Manure Management Systems

This Fact Sheet is an NRCS update to the Safety Section of the Manure Management for Environmental Protection, Document MM2, dated 11/2001.

Storing animal manure on farms is very common in Pennsylvania. Many dairy, beef, veal, swine, and poultry operations are installing manure storage systems with the potential, under certain circumstances, for safety risks. Experience indicates that when an accident does occur, it sometimes involves two or three fatalities. Large numbers of livestock may also perish.

Some manure storage systems are more hazardous than others. Below-ground storages, or pits, are more hazardous than above-ground storages. Systems that are covered by lids, caps, or slotted floors are more hazardous than uncovered systems. The most dangerous storages are pits within buildings or directly beneath livestock. Pump-out access pits with lids or caps can also be very hazardous.

Safety Hazards

Under certain circumstances, manure storage hazards include gases that are toxic (hydrogen sulfide), asphyxiant (carbon dioxide), corrosive (ammonia), and explosive (methane), and may include an atmosphere that contains insufficient oxygen to sustain life. Drowning is also a possibility. With solid covered or slatted covered pit storages, the danger from gases is most severe when manure is being agitated or pumped out. At other times, little gas is produced, and natural air movements or ventilation from fans can at times prevent hazardous gas buildup and oxygen levels from becoming dangerously low. With open storages and above-ground tanks, oxygen depletion and toxic and explosive gas buildup are less likely (with the exception of sulfur-containing additives such as gypsum), so the major potential hazard normally associated with such systems is drowning. The use of gypsum as an animal bedding or for non-slip alley footing dramatically increases the amount of hydrogen sulfide produced by the manure. In some cases the presence of gypsum has increased the hydrogen sulfide gas content by a factor of 100 fold (this applies to both covered storages and open-top storages).

Maximum safe gas concentrations, or threshold limit values (TLV), have been established for an 8-hour exposure for humans by the American Conference of Government Industrial Hygienists. TLVs are expressed in parts per million (ppm). Safe gas levels for animals have not been established, but animal responses to gases are known to be similar to human responses. Animals, however, suffer more continuous exposure and may be adversely affected over time by a lower level of gas than affects humans. This is of particular concern with small or lightweight animals, such as newborn pigs.

The concentrations of gases in manure storages can be measured with special instruments, but such instruments are reliable only if they are carefully maintained, stored, calibrated, and operated by trained personnel. Some instruments cost only a few hundred dollars. Using gas detection instruments is the best way to monitor a hazardous environment. Never enter a confined space without proper testing and safety equipment. Emergency procedures are outlined at the end of this document.

Hydrogen sulfide (H₂S), the most hazardous manure gas, is associated with most fatalities in manure storages. H₂S can cause death within seconds at high concentrations. The TLV is 10 ppm. It is colorless and heavier than air, accumulating near the bottom of the storage (this gas can flow out of a storage and continue to hug the ground and adjacent low areas). Though some concentrations (100 to 150 ppm) can be identified by a rotten-egg odor, hydrogen sulfide deadens one's sense of smell and its odor is often masked by other smells common to livestock facilities. Lethal concentrations of 500 to 600 ppm are thus difficult to detect. Gas amounts can increase a thousand fold during agitation and emptying of a manure facility. The presence of gypsum additives increases H₂S production to extremely high levels.

Carbon Dioxide (CO₂), while a nontoxic gas itself, displaces oxygen and therefore can asphyxiate humans and animals. The TLV is 25 ppm. Being both colorless and odorless, carbon dioxide is impossible to detect without gas detection equipment.

Ammonia (NH₃) can severely damage the eyes, throat, and lungs. It combines with moisture in the eyes and respiratory tract to form an alkaline solution that causes severe burns. Its TLV is 25 ppm. NH₃ is lighter than air and has a strong bleach-like odor. Because of its irritating nature, people usually leave a contaminated area. Therefore, it is not suspected to have caused any human deaths. Constant, low-level exposure to ammonia has a discomforting effect on humans and livestock.

Methane (CH₄) is a highly-flammable and explosive gas. The TLV for methane is 1000 ppm. Like carbon dioxide, it is odorless, colorless, asphyxiating, and impossible to detect without gas detection instruments. Methane is lighter than air and rises out of storage areas to collect under hoods, roof ridges, and corners. It is most likely to accumulate during hot weather, especially if ventilation is poor. Methane explosions have resulted from someone lighting a torch or from short circuits in electrical system.

Oxygen (O₂) deficient atmosphere occurs when oxygen is displaced by another gas to less than 19.5% by volume of the total air. Normally, oxygen in air is 20.8% by volume. When oxygen is at 16% by volume of the air, a person becomes disorientated and has impaired judgement. At 14% by volume of the air, a person has rapid fatigue and faulty judgement. At 6% by volume of air, a person can have difficulty in breathing and death will occur within minutes. The oxygen percent should be measured at all levels of a manure storage to ensure that there is no oxygen deficiency.

Design and Construction Recommendations

Many safety hazards can be minimized by properly designing and constructing a manure storage facility. Several recommendations to consider when building a storage are listed below. Many of the recommendations should also be incorporated into existing storages.

- Keep in-barn pits for liquid manure to a minimum.
- Install fences to restrict access for people and animals. Keep fence gates and access locations locked.
- Gypsum for bedding or creating non-slip surfaces should never be loaded into storages located within buildings (and covered storages). Extreme caution and continuous use of gas monitoring equipment shall be used when agitating open, outdoor storages with gypsum.
- Locate pump-out openings for manure pits outside of buildings. Use heavy covers or grates for pit access points and keep them in place.
- Equip ventilation systems with an alarm to indicate power failure, and provide a backup ventilation system.
- Walls of open storages adjacent to barnyards should extend two feet above barnyard elevation.
- If the manure storage is outdoors, provide a gas trap or other device in pipes running to the storage to prevent gases in the storage structure from reentering the building, especially during pit agitation.
- Install a fence around open storages, ponds, treatment basins, and lagoons. The fence should be tight enough to keep out small children.
- Warning signs should be placed near storages and above-ground tanks, and a rescue pole and rope should be located conspicuously in the area.

Operating Recommendations

Manure storage hazards can be further reduced by consistently following recommended operating procedures. You should adopt all of the following practices that apply to your operation.

- Test the pit atmosphere for toxic gases and oxygen levels.
- Never enter a pit without proper ventilation. When going in, wear an air-supplied respirator or a self-contained breathing apparatus (SCBA), as well as a safety harness attached to a rope attended by at least two people at the entrance to the pit. Any person utilizing this equipment must be trained in advance. Attaching the safety rope to a winch or hoist is also recommended. Cartridge-type masks are not safe.
- Keep people and animals out of any building where manure is being agitated or emptied. Provide strong mechanical ventilation during agitation and pumping, and for a few hours after pumping has stopped. If an animal collapses during pit agitation, do not try to rescue it immediately. Turn the pump off and ventilate the building until the gases have had a chance to escape.

- Never fill a manure pit completely, but allow 1- to 2-feet of air space to accommodate concentrations of gas. Lower the level of liquid manure in a storage facility before starting agitation to reduce the possibility of gas being forced above floor level.
- Keep the agitator below the liquid surface because gas is released in greater volumes with vigorous surface agitation.
- Forbid smoking, open flames, or spark-producing operations in the immediate vicinity of the storage area. Keep all guards and safety shields in place on pumps, pump hoppers, tank wagons, and power units, and maintain electrical motors, fixtures, and wiring in good condition.
- Do not leave temporary access ladders leaning against above-ground tanks. Permanent ladders on the outside of above-ground tanks should terminate above the reach of people or should have locked entry guards.
- Do not walk, ride, or allow animals on the crust surface of open-air storages. Like ice, the crust is not uniformly solid and can break through suddenly.
- Warn visitors and guests of manure storage hazards. Owners are legally responsible for their safety while they are on their property.
- Only dump or scrape manure into storages at locations designed for that purpose. Install safe access locations for lifting manure over tank walls, or install safety guard push-in structures for safely loading manure into storages.
- Never dump manure over the top of chain link or other fences.
- Become familiar with and follow the Occupational Safety and Health Administration (OSHA) regulations and recommended practices for confined spaces (OSHA 1910.146). While production agriculture was excluded from these regulations, any farmer with an employee could be cited for a violation under the General Duty Clause of the OSHA Act, Public Law 91-596. The General Duty Clause requires employers to provide their employees with a workplace free from recognized hazards likely to cause death or serious physical harm. A confined space, such as a manure storage, may fit this clause. A confined space is defined by OSHA as a space that (1) is large enough for an employee to enter fully and perform assigned work; (2) is not designed for continuous occupancy by the employee; and (3) has a limited or restricted means of entry or exit.

Emergency Procedure

Emergencies result from ignoring or not knowing the hazards of manure storages and the recommended safety practices. Generally, someone enters a pit without a self-contained breathing apparatus (or is not properly trained in its use) and passes out almost immediately from toxic gases or oxygen deficiency. The tragedy can be compounded when would-be rescuers, family, coworkers, emergency personnel, panic and follow the first victim into the pit.

When someone collapses in a pit, gases are so concentrated that it is extremely dangerous for anyone else to enter without a self-contained breathing apparatus and proper training. The only reasonable immediate action is to ventilate the storage area and notify rescue personnel who can bring the proper equipment. Barn fans and silo blowers may be activated to provide ventilation, but do not lower fans into the pit because of the possibility of a methane explosion.

Before entering a confined space manure storage, gas detection equipment must be used to determine hazardous gas concentrations and oxygen levels. This should be done prior to and during entry because extremely toxic gases often accumulate from decomposing manure and safe oxygen levels are often depleted. A gas monitor with remote sampling enables measurements to be taken by workers located safely outside the storage facility. These measurements can also be used to establish ventilation times and rates before workers enter the manure storage. The gas and oxygen measurement results would be used with ANSI/ASABE S607, Ventilating Manure Storages to Reduce Entry Risk, to establish ventilation times before entry for a specific manure storage facility. Once a worker has entered the facility, gas sensors allow for constant monitoring of the atmosphere while the person is in the storage. Additional information is presented in Fact Sheet E 52 titled "Confined Space Manure Gas Monitoring" written by Penn State Cooperative Extension.

In any rescue attempt, the rescuer should have a self-contained breathing apparatus, proper training, and a safety harness with a lifeline. The lifeline should be attended by at least two people outside the storage unit. Rescuers should never place their own masks on a victim or remove their own lifelines. Ropes, carriers, and oxygen for victims can be lowered into the pit if necessary. Victims should be brought out as quickly as possible, administered to by emergency services personnel, and transported to an emergency room.

