

## Safety around manure gases and confined spaces



The decomposition of manure in storage or handling systems generates gases, some of which are toxic, explosive, and oxygen displacing. The most hazardous gases are hydrogen sulfide ( $H_2S$ ), ammonia ( $NH_3$ ), methane ( $CH_4$ ), and carbon dioxide ( $CO_2$ ). Dangerous levels of these gases can accumulate in and around manure management systems, particularly when manure is being agitated or otherwise disturbed.

### Four major gases to be concerned about

#### Ammonia ( $NH_3$ )

Ammonia has a sharp pungent odor and is generally higher in poultry manure. It is lighter than air and most likely the gas you will feel the effects of first as it causes irritation of the eyes and respiratory tract. At higher concentrations, this gas may cause permanent lung damage. Ammonia concentrations are generally higher in warm buildings than cold buildings. Enclosed buildings with scrapers or with bedded packs can have ammonia levels as high as those found in shallow and deep pit buildings. The minimum perceptible level of ammonia for people is variable.  $NH_3$  is detectable in concentrations from 1 to 5 ppm, however, concentrations higher than this can begin to result in irritation to the eyes. As concentrations increase, irritation will be noticed in the respiratory tract. The minimum perceptible level for ammonia is 0.5 to 54 ppm.

#### Methane ( $CH_4$ )

Methane is highly flammable. It is odorless, colorless, and lighter than air. Since it is lighter than air, methane can make its way through other parts of the storage and handling facilities and cause explosions away from the structures. A spark from equipment, open flames, smoking materials, faulty wiring, or welding could provide an ignition source for an explosion or fire. Methane is generated from the anaerobic decomposition of manure. All manure storages release  $CH_4$ , but the rate of production varies with temperature. Although temperatures of approximately 95°F are considered ideal for  $CH_4$  production from manure, a small amount of  $CH_4$  is produced from manure at lower temperatures found in under-floor manure storages. Explosive concentrations of methane may be released during liquid manure agitation and remain for several weeks after emptying the storages. Air mixtures containing from 50,000–150,000 ppm or 5–15%  $CH_4$  are explosive. Methane is not toxic and is unlikely to

adversely affect animal and human health and performance in normally ventilated buildings. Methane is an asphyxiant and can cause suffocation by displacement of oxygen from the lungs and will cause rapid breathing, dizziness, and fatigue.

#### Hydrogen sulfide ( $H_2S$ )

Hydrogen sulfide is the most dangerous of manure gases. This extremely toxic gas may cause death in seconds at high concentrations. It is colorless and smells like rotten eggs, although at low concentrations this odor is easily masked by other odors and the odor isn't detectable by the human sense of smell at higher concentrations. It is heavier than air and looks to be released especially during the agitation of the storage structure. Reception pits and barns with below-floor storage and transfer areas or other confined spaces are locations where  $H_2S$  concentrations can increase rapidly upon agitation.

$H_2S$  affects eyes, respiratory system, and the central nervous system. In acute poisoning,  $H_2S$  acts so rapidly that there are few symptoms of imminent danger. Sudden nausea and unconsciousness are followed by death at concentrations of 800 ppm or greater.

Hydrogen sulfide is normally released from all stored manure, but it is most dangerous with agitated liquid manure. Hydrogen sulfide levels may increase a thousand-fold during agitation. Concentrations reaching 200–300 ppm have been reported within a few minutes after the start of manure agitation and have been as high as 1000 ppm during vigorous agitation. The release is generally very slow in undisturbed manure and at low temperatures.

#### Carbon dioxide ( $CO_2$ )

Carbon dioxide is not highly toxic to humans or animals. Its main danger is that of contributing to an oxygen deficiency which can result in asphyxiation or suffocation. Carbon dioxide is heavier than air and will displace the oxygen especially within a confined space. Carbon dioxide exposure may result in headaches and dizziness. Death by asphyxiation is possible at high concentrations. The normal atmosphere contains about 300 ppm of  $CO_2$ . Within an animal housing facility, more  $CO_2$  is released through respiration of the animals than by manure decomposition. Typical concentrations of  $CO_2$  in well-ventilated buildings are in the 500–5000 ppm

range for livestock, depending on season of the year. Levels for people in an office building run about 700 ppm or less for good air quality. Higher CO<sub>2</sub> levels can also slows animal growth and performance because it inhibits their appetite.

Air containing 40,000 ppm causes deeper and faster breathing. More than 100,000 ppm may produce dizziness and unconsciousness. Death will occur after a few hours at concentrations of 450,000 250,000 ppm or more.

### Safety around confined spaces

A confined space is any space with one or limited number of entry and exit points. When working with manure handling systems, two items are important to know before entering a confined space such as a reception pit or manure tanker. These two items are the air quality and how to protect ourselves.



**Photo: Reception pits are an example of a confined space. Notice limited entry and exit point.**

### Air quality

Since any or all of the four manure gases can be present in a confined space around manure handling equipment, it is essential to know if the gases are present and in what concentration. The best way to determine if manure gases are present at dangerous levels is to use a gas monitor. A gas monitor can be lowered into confined spaces to measure current gas levels and if conditions are safe for entry. A monitor such as this measures H<sub>2</sub>S, methane, CO<sub>2</sub>, and oxygen deficiency levels. Be sure to use a gas monitor that fits the needs for your operation.

**Photo: Example of four-gas monitor**



Ventilation is another component of managing air quality and gases around manure storage and confined spaces. Portable fans and tubing are an

excellent way to displace and exchange manure gases in confined spaces with good quality air. An industry standard is to make an equivalent of seven air exchanges on a volume basis before a worker can enter the confined space. The amount of time for the exchange depends on the amount of air that can be moved and size of the confined space. When using portable fans, make sure the fan moves enough cubic feet of air to adequately ventilate the confined space. Also, be sure to use spark-proof or explosion-proof fans so the fan does not ignite flammable gases such as methane.

### Protection in a confined space

If a gas monitor or ventilation is not available, then the best approach to entering a confined space is use of a self-contained breathing apparatus (SCBA). It is important individuals using SCBA are trained properly and the equipment fits properly.

Use of lifeline and harness is also a critical part of confined space entry. Having a lifeline and harness will provide a way of retrieving a person if overcome by gases. Of course, never enter a confined space alone. A attendant should always be monitoring the person who entered the confined space and be tending to the lifeline and harness.

### To reduce the danger of manure gases in and around confined spaces, take the following precautions:

- Never enter a pit, especially during or just after agitation. Without testing for toxic gases, there is no way to know if it is safe.
- If absolutely necessary to enter a pit, always wear a self-contained breathing equipment with oxygen supplying tanks. Cartridge respirators are not sufficient.
- Always wear a safety line and work with at least two other people outside the pit.
- Remove all people and all animals from buildings over pits before pit agitation.
- Provide maximum ventilation when agitating or pumping manure.
- Do not smoke or have any other fire or ignition source around manure pits.

### Sources:

Manure Gas Safety: Review of Practices and Recommendations for Wisconsin Livestock Farms , November, 2008  
<http://datcp.wi.gov/uploads/Environment/pdf/ManureGasSafetyReport.pdf>  
<http://fyi.uwex.edu/agsafety/confined-spaces/>