Foaming Manure Pit Dangers

In the Midwest, an estimated 24% of swine barn manure pits have experienced “foaming”. This foam traps a high concentration of methane gas (50 – 70%) that is rapidly released into the environment when the foam is disturbed, resulting in a hazardous environment. These high concentrations can cause flash fires or explosions if there is an ignition source in the room. Since 2009, at least 11 explosions have occurred in upper Midwest barns from methane releases in foaming manure. These explosions have destroyed barns and injured workers.

Do not disturb the foam without taking precautions.

What are the hazards?

Methane and hydrogen sulfide gases are generated naturally in all anaerobic manure pits. When foaming occurs, these gases become trapped in the foam’s bubbles, which may be comprised of 50 to 70% methane. The foam can be broken when agitating the manure, pressure-washing, or dropping feed through the floor slats. When this happens, these gases are rapidly released into the air, resulting in potential explosive concentrations of methane. Hydrogen sulfide is released from the foam and is hazardous to breathe above 10 ppm. Methane gases are explosive when concentrations are between 50,000 to 150,000 parts per million (ppm). Within the foam, the methane concentrations are above the explosive limit, meaning there is not sufficient oxygen to be flammable. However, when the foam is broken and the gas is released, the gas dilutes in the air and quickly becomes explosive.

What else is needed for an explosion?

High concentration of methane gas is flammable: if there is any ignition source in the room when high concentrations of methane are released, an explosion could occur. Many Midwestern barns, both empty barns and barns with workers and hogs inside, have exploded when the surface of the foam has been disturbed. Sources sufficient to ignite methane include: cigarettes, electric motors (such as those for pressure washers and feed system), pilot lights, welding, metal cutting, or faulty or damaged wiring that can produce sparks. It is critical to eliminate all sources of heat or sparks before conducting tasks inside a barn with foaming manure when these activities can break the foam.

How do we work with the foam?

Many producers want to spray the foam with water will break it up: this is dangerous because it will release the methane into the room, increasing the risk of explosion. Before doing any activities that will disturb the foam, including wetting down the foam, washing the barn, or pumping a manure pit, follow the Steps in the inset box to prepare for high methane release from the foam. It is extremely important to shut off all possible ignition sources prior to doing any activity that will quickly break down the foam.
Can I pressure wash inside my barn with foaming in the manure pit?

Pressure washing inside the barn will usually result in water entering the manure pit through the floor slats. This water is sufficient to break the foam, which can release dangerous methane concentrations. Follow procedures to eliminate ignition sources prior to pressure washing. It is safest to pressure wash with a very low volume of manure in the pit, when foam is minimal and pit fans are capable of venting manure pit gases.

What equipment is available to measure methane?

Direct reading monitors, specific for combustible gases, are available to measure whether methane gases are released in the air. These devices can be expensive ($600-1200 each), and units require calibration to ensure accurate readings. You should select a meter that is “intrinsically safe” so that it does not introduce a spark that might ignite the methane in the room. Rental companies can provide calibrated monitors, but plan ahead to make sure you have monitors when you plan on activities that may release methane. These meters provide readouts that will indicate the presence of methane to let you know if the indoor environment has a problem. Evacuate the building if you see %LEL increase when wearing / using these monitors.

How do we know if we have released methane?

Obtain a combustion meter or LEL monitor to measure methane concentrations in the air. Methane, once released, disperses throughout a building, and, since it is lighter than air, it may accumulate near the ceiling or in the attic if there is little air movement. You should measure first in the area where foam is disturbed, and then measure throughout the barn, including near the ceiling, before restoring electricity to the barn. Use the combustion meter to measure explosive risk, continuously before, during and after the activity that might break the foam.

Steps to take prior to disturbing foam:

1. Prevent entry into the barn; prohibit agitating the pit.
2. Shut off gas (propane) to the building to prevent additional fuels from feeding a fire.
3. Turn off electrical sources in the building, except for ventilation systems. This includes lights, heaters and feeders. Extinguish any pilot lights. Put breakers into the “off” position to prevent automated systems, including feed and heaters, from energizing.
4. Ventilate the building – Keep the pit fans exhausting and ventilate the room with 10 air exchanges per hour. Additional ventilation may require portable fans: use explosion-proof fans only.
5. If you are going to pump the pit: Agitate only when there is 2 feet of air space between the top of the foam and the floor slats, when the pit fans are able to evacuate air from the pit.
6. Continue ventilating the barn after the foam-breaking activities have been completed. Wait at least 30 minutes with full ventilation.
7. Monitor air quality in the barn to ensure methane is fully ventilated before turning systems back on.

Using Gas Monitors – LEL

1. There must be sufficient oxygen in the environment for an LEL monitor to read correctly, so a multi-gas monitor that also reads oxygen is recommended.
2. Gas monitors should be calibrated, at least as frequently as is specified by the manufacturer’s directions. Follow calibration procedures in a safe area, where concentrations are anticipated to represent clean air.
3. To make sure the sensors are working before needing to rely on them to protect you, bump test the monitor with gas to make sure the sensors can “see” the gas and the monitor alarms to give you warning. You can use the calibration gas to do this check (without putting the monitor in calibration mode).
4. If oxygen content decreases when using an LEL meter, the %LEL reading will be wrong: Respond to a LOW Oxygen reading as an indication of dangerous LEL and evacuate.
To minimize risk to the worker when monitoring, mounting the monitor on a pole or using monitors with extension wands and internal pumps can allow the user to be at a safer distance from pockets of methane. These also allow easier measurement near the ceiling, where methane can pool near electrical sources.

What does %LEL mean?

The reading on most combustion meters indicate the gas concentration relative to its ability to combust or explode. Meters indicate the gas concentration in percent of the lower explosive limit (%LEL). Normal air should read 0% LEL. When the meter indicates 10% LEL, the air in the room has a significant concentration of combustible gas. This concentration can rise quickly with broken foam. Near the release, concentrations will quickly reach 100% LEL, where the gas can be ignited by any spark, resulting in an explosion. We recommend setting alarms to sound when the concentration reaches 10% LEL to quickly alert workers of a hazardous methane concentration. (Note: For methane, 100% LEL is 50,000 ppm. Hence, an alarm at 10% LEL would indicate methane concentrations of 5000 ppm, which indicates a risk of asphyxiation is starting to be a concern.)

How do I respond to a reading of %LEL?

Leave the area once the combustion meter reaches 10% LEL. Continue to ventilate the room when you are outside of it. Return, only with the combustion meter, checking to ensure that concentrations are again safe. Note that the meter only reads the concentration in the immediate vicinity of the monitor: if there is little air movement in the room, you may have pockets of concentration that are above safe levels. Hence, it is critical to have turned off electrical sources for the entire room and to check areas above you for methane if there is little air motion.

What can I do to reduce methane in the barn?

Ventilating the barn to bring in fresh air is needed whenever actions might result in breaking the foam layer of a manure pit. Running the manure pit fans is not sufficient to remove methane from a room, particularly if the foam layer is deep and prevents air from being drawn across the manure pit. The room should be ventilated at a rate of 10 air exchanges per hour, which may be more than the typical ventilation capacity of a barn. Compute the total needed flow rate, in cfm, using the following: (1) determine the room volume (length x width x height, in feet), (2) multiply that by 10 and (3) divide that by 60 to get the total cubic feet per minute (cfm) flow rate needed for the room. Wall fans may not be sufficient to provide this level of air exchange, so portable fans might be needed. Use an intrinsically safe (or “explosion proof”) fan (that will not spark), and set it up to push fresh air into the room.
What causes the foam?

Currently, the answer is we don’t know. Some barns may have one foaming pit in it while the other pit is not foaming. Researchers are examining sources, including microbial imbalance in these manure pits as a function of feed, water, and climate. While methane is always generated from anaerobic breakdown of manure in a pit, the foam traps the methane, preventing it from being exhausted by the pit fans. The foam traps methane over time, releasing large amounts of methane in a short period of time when the foam breaks. Feed with higher dietary fiber have been implicated in foam stabilization. See references for current research updates.

Is there any treatment available to reduce foaming in a pit?

Research is underway. Applying 5 pounds of Rumenin-90 per 100,000 gallons of pit volume, dosed over 6 weeks, has moderately reduced foaming, but is not always successful (MN, 2012). Continue to follow updates from your state Ag Extension or the National Pork Council for updates foam prevention and guidance on application of foam suppressants.

More Information

General Information on Foaming Manure Pits

Iowa Pork Producers Association publication for Understanding Foam & Pump-out safety:  
http://www.iowapork.org/FileLibrary/States/IA/Headlines%20Fall%202010.pdf

Iowa State University Extension and Outreach – Manure Management Action Group:  
http://www.agronext.iastate.edu/immag/manurevideos.html

University of Minnesota Extension Office information on foaming manure:  

Pit Pumping safety - http://vimeo.com/15463270

Potential Causes of Manure Pit Foaming in Pig Finishing Barns  

University of Minnesota Extension Fact Sheet (Sept 5, 2012), Monensin addition to swine manure deep pits for foaming control - http://pioconnect.uwex.edu/files/2013/01/Adding-Rumenin-to-swine-deep-pit-foaming.pdf

Gas-Vapor Monitoring References

NIOSH Technical Report: Components for Evaluating Direct-Reading Monitors for Gases and Vapors  
http://www.agronext.iastate.edu/immag/manurevideos.html

OSHA Safety and Health Information Bulletin (SHIB 09-30-2013): Calibrating and Testing Direct-Reading Portable Gas  
Monitors https://www.osha.gov/dts/shib/shib093013.html

Process to prepare and perform high-risk activities with a foaming manure pit

Is an indoor manure pit foaming?  

Yes: Identify high-risk activities

- Washing barn
  - Water that falls onto foam will release methane: Explosion Risk

- Changing feed system
  - Feed that falls onto foam will release methane: Explosion Risk

- Pumping manure pit
  - Agglomeration breaks foam that will release methane: Explosion Risk

- Hot work (welding, grinding)
  - Prohibit ignition sources when pit is foaming

No: No action needed

Prepare for high-risk activities

- Determine ventilation needs:
  1. Compute room volume (ft³).
  3. Divide number in step 2 by 60 to get total cfm needed to dilute the barn.
  4. Purchase or negotiate rental for explosion-proof fans that meet the total cfm calculated in step 1.

- Obtain a gas monitor:
  1. Select and purchase/rent a monitor that measures NEEL.
  2. Obtain calibration gas to use for making sure the monitor works (developer calibration schedule per manufacturer's instructions).
  3. Set the monitor alarms to 10 ppm and 50 ppm if there is a second alarm.
  4. Write procedure and train on how to use the monitor to take measurements at all levels of the barn (floor to ceiling - this may be mounted on a pole or on a man with an extension wand).

- Prepare for shut-down prior to high-risk activities:
  1. Identify any electrical sources that might cycle on (feeders, heaters) and learn how to shut them off and the automated controller off.
  2. Determine what equipment is essential to be on during the activity; identify how to shut off and lock out all other electrical sources.
  3. The sparking risk is maximum when items turn on/off, if something MUST be on, have it on prior to the start of the activity. It is ideal to have every power source off for high-risk activity.
  4. Identify how to stop the flow of propane/natural gas that flows into the room.

Formalize procedures to implement ventilation, monitoring, and shut-down activities prior to starting high-risk activities

- Communicate the procedures and risk of explosion to workers.

- Implement procedures prior to and during high-risk activities

- Washing barn
  - Main Procedure:
    1. Prohibit entry into the barn.
    2. Prepare ventilation/override equipment and gas monitor.
    3. Implement shutdown procedure for electricity and gas.
    4. Put monitor on area during activity: EVACUATE IF ALARMS CHANGE.
    5. If evacuates:
       a. Continue ventilating the room (wait 15 minutes if operating at recommended cfm)
       b. Return with a monitor, testing as approach area where foam broke, testing every 4 feet, including floor and ceiling levels, backout if concentrations are high and wait another 15 minutes
       c. Return to task only if NEEL is at background
    6. When work is completed, and foam is no longer at risk of breaking, continue ventilating the barn until monitoring indicates no methane in the room.

- Changing feed system
  - Hot Work:
    1. Prohibit hot work inside the barn if the manure pit is foaming.
    2. If work must be done, prevent any activities that might result in broken foam (no water spraying, no feeding)
    3. Follow steps 1-6 in the Main Procedure (to the left).

- Pumping manure pit
  - Pumping Foaming manure:
    1. Prohibit agglomeration when there is less than 2 feet between the top of the foam and the floor slots.
    2. Ensure pit fans are operating.
    3. Follow steps 1-3 in Main Procedure (to the left) and manure gas protection procedures for unfoaming pit.
    4. If anyone enters the barn, both H2S and NEEL monitors must be worn.
    5. Continue ventilating the barn until H2S and NEEL are at background concentrations.