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Progress of Pit Foaming

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Progress of Pit Foaming

Disciplines
Agriculture | Bioresource and Agricultural Engineering

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Progress on Pit Foaming
(what we know, what we don’t know, what we’re doing)

2013 Iowa Pork Congress

Steven Hoff, Ph.D., P.E.
Professor of Ag & Biosystems Engineering
Iowa State University

January 24, 2013
Objectives for Today

General Background on Foaming
Theories Regarding Pit Foaming
Discuss Current IPPA Funded Project
Precautionary Measures
Overall Foaming Requirements

Three-phase Process:

1. Gas generation (i.e. methane, hydrogen sulfide),

2. Surface tension reduction (surfactants; bio- or otherwise),

3. Bubble support structure (clustering bacteria or small fibers).

A surfactant causes surface to “elasticize”

Gases otherwise naturally escaping at very low concentrations are trapped
More on Surfactants

Surfactants allow stretching of the liquid interface. Surfactants can be:

- via detergents, oils, grease, or,
- via Biosurfactants produced by growing microbes

*Surfactants reduce the surface tension of the liquid allowing gas bubbles to form.*
More on Foam Support

For foam to persist, it must be supported somehow. This support can come from:

*Special “filamentous” bacteria cluster together forming long strands (these bacteria also produce a bio-surfactant)*

*OR*

*Fine fibers present provide the required bubble support structure*
Example Filamentous Bacteria Found in *Some* Foam

*Microthrix parvicella*

*Gordonia spp. (i.e. Nocardia)*

www.epa.state.oh.us/portals/35/compl_assist/TGlymphe_Filament.ppt
In-field Foaming

Foam Creeping Through Slats (4 ft of foam case)

Photo courtesy of Dr. Larry Jacobson, UMN

Foam Into Animal Occupied Zone

Photo courtesy of Dave Preisler, MPB; Dr. Larry Jacobson, UMN
Foaming at Pump-out Location

Photo courtesy of Dr. Larry Jacobson, UMN
Barn Explosion

Potential Consequences of Foaming

Photos courtesy of Dr. Larry Jacobson, UMN

Barn Explosion (Fall 2011)
Curious Nature of Foaming

- Has occurred in one pit of side-by-side rooms with equalizing channel.
- Commonly found in one barn of multi-barn sites with common genetics, feed, management, etc.
- Attempts at correlating foaming vs non-foaming barns with multiple factors has been elusive.

Photo courtesy of Dr. Larry Jacobson, UMN
General Avenues Being Pursued

- Microbial versus Chemical Causes
  - Is it Bacteria Population imbalances caused by ??, OR,
  - Is it a Chemical Imbalance caused by ??

- Current Research Suggests Some of Both

- Role of DDGS being investigated but far from conclusive

 Recall: We experienced foaming pits long before DDGS arrived on the scene.....just not at this rate.
IPPA Funded Research Project

GOAL: Finding and Correcting Root-cause of Foaming

Photo courtesy of Dr. Larry Jacobson, UMN
IPPA Funded Research Effort

- Multi-state effort (ISU, UMN, UILL) involving 20+ academic professionals with expertise in manure management, chemistry, microbiology, feed rations, and digestibility

- $1M investment over three years (we are currently 6 months into this research)

- Project managed by Iowa State University

- Our team is working diligently to solve this problem; and we will
# Project Advisory Panel

<table>
<thead>
<tr>
<th>Member</th>
<th>Affiliation</th>
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<tr>
<td>Rich Degner</td>
<td>Executive Director, IPPA</td>
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<tr>
<td>Jay Harmon</td>
<td>Professor, ISU ABE</td>
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<tr>
<td>Howard Hill</td>
<td>Director of External Affairs, Iowa Select Farms</td>
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<tr>
<td>Maynard Hogberg</td>
<td>Chair, ISU Animal Science</td>
</tr>
<tr>
<td>Chet Hollingshead</td>
<td>Producer, Ogden IA</td>
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<tr>
<td>Brian Kerr</td>
<td>USDA- ARS</td>
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<tr>
<td>John Mabry</td>
<td>Former Director, Iowa Pork Industry Center</td>
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<tr>
<td>Steve Mickelson</td>
<td>Chair, ISU ABE</td>
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<tr>
<td>Allan Stokes</td>
<td>Director of Environmental Programs, NPB</td>
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<tr>
<td>Paul Sundberg</td>
<td>VP Science and Technology, NPB</td>
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<tr>
<td>Wendy Wintersteen</td>
<td>Dean, ISU CALS</td>
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Project Status

- Site visits made to Midwest research community (Spring 2012)
- Request for Proposals released (Spring 2012)
- Ames meeting with potential researchers and the Project Advisory Panel (May 2012)
- Proposals received June 2012
- Funding decisions made in late July 2012
- Projects started Fall 2012
- Three year effort...we will keep you posted
Multi-state Research Collaboration

ISU
- Feed trials
- Chemical composition analysis
- Methane production
- Foaming potential testing

UMN
- Extensive producer survey
- Microbial analysis
- Foaming potential testing

UILL
- Organize all manure sampling and distribution
- Microbial analysis
**Iowa State University**

(Kurt Rosentrator (PI), Dan Andersen, Brian Kerr, Steve Trabue)

- **Graph 1**: Methane Production Rate (L CH₄/L-day) vs. Temperature (°C)
  - Equation: $y = 0.0169e^{0.082x}$
  - $R^2 = 0.9895$

- **Graph 2**: Biogas Production Rate (L/L-day) vs. Volatile Solids Content (%)
  - No Foam
  - Foam
University of Minnesota
(Chuck Clanton (PI), Larry Jacobson, Bo Hu, David Schmidt, Neslihan Akdeniz, Brian Hetchler)

- Developed and is managing extensive producer survey. Please participate!
  On-line version at: www.surveymonkey.com/s/foamsurvey2012

- Participating universities will be distributing survey this winter/spring.
Manure sampling protocol developed for all university researchers on project.
Manure samples have been collected from 58 deep-pit swine finishing operations comprising a total of 76 barns.
Sampling will continue for one year to investigate microbial population shifts and overall development.
In the first two months of project, 250 samples collected for each collaborating institution.

Layer C Sample Collection Depth = \[\text{Total Pit Depth} - (\text{Foam Depth} + 12")/2 + \text{Foam Depth}\]

Layer D Sample Collection Depth 6" from bottom of pit
Precautionary Measures

- Any attempt to break-up foam WILL release explosive levels of methane. Therefore....

1. All ignition sources OFF (i.e. pilot lights, welding),
2. Set ventilation at 30 cfm/space minimum,
   - Use open curtains if ≥ 5 mph wind, OR,
   - Use fans* + ceiling inlets if calm
3. Make sure ceiling inlets operational,
4. Vacate barn, then finally,
5. Foam/pit can be disturbed.

* In a 1000-hd barn, equates to 2-48” or 3-36” or 6-24” fans
Ventilation Strategies
(1000-hd Finisher)

6-24” fans or 3-36” fans or 2-48” fans
+ operational ceiling inlet system +
curtains closed

OR

Curtains Open with Wind of ≥ 5 mph

But NOT

Curtains Open, Calm Conditions
Reliance on Fans
Ventilation Dilution Time

1,000-hd finisher

Trapped methane in foam measured at 70% or more

LEL_{CH4} = 5.1% (51,000 ppm)
Precautionary Measures (NPB)

Stay Safe When Pumping Pits

Recent news reports of flash fires and explosions in livestock buildings while a liquid pit manure was being agitated and pumped reinforce the need for safety at all times when working on a swine farm.

Liquid manure in pits undergoes slow decomposition, which creates several gases including methane and hydrogen sulfide, both of which are flammable. The rate of gas release from manure can be drastically increased when the manure is stirred during pumping. This increase is especially true for hydrogen sulfide, which can have a lethal paralyzing effect in addition to being flammable, noted Shawn Shouse, an Iowa State University (ISU) Extension area agricultural engineer.

Strict safety protocols, along with proper ventilation and agitation practices, can minimize the risk of flash fires and explosions during manure pumping. On the right are tips from ISU and the Pork Checkoff.

What If You Can’t Pump Pits Because of Rain?

In many parts of the country, wet, rainy conditions have saturated fields, delayed harvest and put farmers behind schedule this fall for pumping out swine manure pits. Producers have to do their best they can, but if muscles are too wet to pump, then you should tag all doors, and lock doors. Remember to tag all doors during pit agitation and pumping.

- Review your emergency action plan with all workers and have emergency contact numbers available at the site. The Pork Checkoff’s Pork Production System, available at www.pork.org/workersafety offers tips on developing and implementing an emergency action plan. It also includes sections on hazardous gases and fires.
- Prior to agitation or pumping, turn off electrical power to any non-ventilation equipment and extinguish any pilot lights or other ignition sources in the building.
- Fully open all ventilation curtains or ventilation pivot doors but leave walk-in doors locked to prevent human entry.
- Run ventilation fans at maximum speed.
- Ensure that all people are out of the building.
- Clearly tag all doors, noting that the building is unsafe for entry during agitation and pumping.
- Agitate the manure keeping the jet of pressurized manure below the liquid surface. Don’t let the jet of manure strike walls or columns in the pit.
- Stop agitation when the manure level does not allow agitation below the liquid surface.
- Continue maximum ventilation for 30 minutes after pumping has ended before re-entering the building.
- Never enter a building or manure storage structure when liquid manure is being agitated or pumped.
Precautionary Measures (ISU)

IMMAG Home Page

Winter manure application rules go into effect on December 21.

Water Quality Initiatives
Water Quality Initiatives for Small Iowa Beef and Dairy Feedlot Operations

IMMAG Monthly News Updates
Read IMMAG’s latest news update by Angie Rieck-Hinz

http://www.agronext.iastate.edu/immag/
Foam Forms, now What?

Foaming Requires: Gas, Surfactant, Support Structure
Reduce one aspect= Foam reduction (this is the good news...we have options)

Example....Research has shown that foam will form if the surface tension reduces to 60 mN/m (plain water has a surface tension of 72 mN/m)

However, once foam forms, a good remedy to break-up foam slowly is a product with a significantly lower surface tension compared to what caused foam to form in the first place. Comparison of products....

<table>
<thead>
<tr>
<th>Component</th>
<th>Surface Tension (mN/m)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>72</td>
<td>at 68°F</td>
</tr>
<tr>
<td>Foam forms</td>
<td>60</td>
<td>on-set of foaming</td>
</tr>
<tr>
<td>Soybean, corn, canola oils</td>
<td>29-32</td>
<td>at room temperature</td>
</tr>
<tr>
<td>WD-40/Liquid Wrench</td>
<td>25</td>
<td>very low viscosity resulting in high flowability</td>
</tr>
<tr>
<td>Diesel fuel</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Silicon oil</td>
<td>15-20</td>
<td>wide range of viscosities (low viscosity needed)</td>
</tr>
<tr>
<td>Defoamers</td>
<td>15-20</td>
<td>Silicon-based products (low viscosity)</td>
</tr>
</tbody>
</table>

- Decrease the effects of foam causing surfactants --- Product with an even lower surface tension compared to 60 mN/m AND low viscosity allowing free-flowing over the foam surface.

Still: Root Cause Needs to be Found!