Engineering Design and Installation of Air Filtration Systems in Swine Barns

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Who’s considering filtration?

- **Boar studs**
  - Most are filtered in the Midwest

- **Grandparent breeding stock**
  - A few have done it – PRRS risk is great

- **General production sow units**
  - Will look at data from one

- **Wean-finish tunnel barns for winter**
Evaluating a Facility for Filtration

- Does the present ventilation system meet industry standards?

- What make, types and sizes of filters are needed?

- What will happen to overall ventilation system performance when filters are put in place?

- How much will it cost to install a complete filtration system?

- What is the longevity of the filters under these conditions?
Who makes filters?

- **Camfill-Farr**
  - Licensing and marketing agreement with Automated Production Systems (AP)
  - L9 and L6 filters

- **Clarcor** (MERV-15)

- **Noveko**
  - Licensing and marketing agreement with Monitrol (Varifan controls and Multifan)
  - Installed in Quebec
  - Flat panel and bag
Typical Camfil Filter Installations
Noveko Filters @ 0.1 s.p.

2-Filter Duct Box
2200 cfm

3-Filter Duct Box
3300 cfm

6-Filter Duct Box
6600 cfm

Cool Cell wall sample
A filtration system will not make your present ventilation system better. It will make it worse.
Design Considerations

- What types of ventilation system facilitates filtration
- Static pressure effects on the ventilation system
- MERV-16 filters vs. MERV-14 filters
Main Types of Systems

**Negative Pressure**
- ‘Exhaust’
- Slight vacuum
- Most common for livestock buildings

**Positive Pressure**
- ‘Pushed Air’
- Rise in pressure
- Think grain drier

**Neutral Pressure**
- ‘Push-Pull’
- Balanced pressure
## Recommended Ventilation Rates
cfm/crate/animal

<table>
<thead>
<tr>
<th></th>
<th>Cold</th>
<th>Mild</th>
<th>Hot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farrowing</td>
<td>20</td>
<td>80</td>
<td>500</td>
</tr>
<tr>
<td>Gestation</td>
<td>13</td>
<td>40</td>
<td>250</td>
</tr>
</tbody>
</table>
Static Pressure and Airflow Resistance

- **Airflow resistance**
  - Restricts airflow
  - Increases static pressure
  - Makes fans
    - Work harder
    - Less efficient

- ** Desired static pressure**
  - 0.05” H₂O
  - No more than 0.12” H₂O

Filtration increases static pressure.
Static Pressure Points

• **Air intake to attic**
  - less than 0.04 inches

• **Air inlet**
  - Ceiling (0.04 to 0.10 inches)
  - Cool Cells (0.05 inches)
  = 0.05 design

• **Fan pit transitions**
  - less than 0.05

• **Filters (without push fans)**
  = 0.15 design
  - Pre-filter (from 0.03 inches to 0.08 inches) – 0.05
  - MERV 16 or 14 filters (less than 0.15 inches) – 0.10

Static pressures are additive
Design for 0.20 inches
Manometer
(measures static pressure)
# Fan Test Data (52-inch Fan)

<table>
<thead>
<tr>
<th>Static pressure</th>
<th>Speed</th>
<th>Airflow</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>in. H₂O</td>
<td>rpm</td>
<td>cfm</td>
<td>cfm/W</td>
</tr>
<tr>
<td>0.00</td>
<td>649</td>
<td>29,500</td>
<td>23.8</td>
</tr>
<tr>
<td>0.05</td>
<td>647</td>
<td>28,100</td>
<td>21.5</td>
</tr>
<tr>
<td>0.10</td>
<td>646</td>
<td>26,600</td>
<td>19.5</td>
</tr>
<tr>
<td>0.15</td>
<td>645</td>
<td>25,000</td>
<td>17.7</td>
</tr>
<tr>
<td>0.20</td>
<td>643</td>
<td>23,200</td>
<td>15.7</td>
</tr>
</tbody>
</table>
Airflow Ratios

Airflow ratio = \[
\text{airflow at 0.20” s.p. divided by airflow at 0.05” s.p.}
\]

Example: 51-inch fan
Ratio = 21,100 cfm/28,300 cfm
Ratio = 0.75
## Fan Test Data (52-inch Fan)

<table>
<thead>
<tr>
<th>Static pressure (in. H₂O)</th>
<th>Speed (rpm)</th>
<th>Airflow (cfm)</th>
<th>Efficiency (cfm/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>448</td>
<td>25,500</td>
<td>29.5</td>
</tr>
<tr>
<td>0.05</td>
<td>446</td>
<td>23,200</td>
<td>25.6</td>
</tr>
<tr>
<td>0.10</td>
<td>445</td>
<td>20,600</td>
<td>22.2</td>
</tr>
<tr>
<td>0.15</td>
<td>445</td>
<td>16,800</td>
<td>18.1</td>
</tr>
<tr>
<td>0.20</td>
<td>447</td>
<td>9,900</td>
<td>11.5</td>
</tr>
</tbody>
</table>

Airflow ratio = 9,900 cfm/ 23,200 cfm = 0.43

“Not very good”
Fan Performance Data

To order book:
www.mwps.org
www.bess.uiuc.edu
### Stages of Fan Operation: 2600 sow Facility

<table>
<thead>
<tr>
<th>Stage</th>
<th>Fan Staging</th>
<th>Static Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.10 in.</td>
<td>0.15 in.</td>
</tr>
<tr>
<td>Stage 1</td>
<td>24” Fans</td>
<td>67,200 cfm</td>
</tr>
<tr>
<td></td>
<td>+12 Fans</td>
<td>62,400 cfm</td>
</tr>
<tr>
<td>Stage 2</td>
<td>26” Fans</td>
<td>+28,000</td>
</tr>
<tr>
<td>Stage 3</td>
<td>51” Fans</td>
<td>+49,800</td>
</tr>
<tr>
<td>Stage 4</td>
<td>51” Fans</td>
<td>+99,600</td>
</tr>
<tr>
<td>Stage 5</td>
<td>51” Fans</td>
<td>+149,400</td>
</tr>
<tr>
<td>Stage 6</td>
<td>6-51” Fans</td>
<td>+149,400</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>543,400 (209 cfm/sow)</td>
</tr>
</tbody>
</table>

- **0.10 inches**: 543,200 cfm/2600 sows = 209 cfm/sow
- **0.15 inches**: 488,680 cfm/2600 sows = 188 cfm/sow
- **0.20 inches**: 425,480 cfm/2600 sows = 164 cfm/sow
Uses for the fully sealed Merv 14 for Finishing

In high flow filter bank mainly used in warm season

All locations for lower value production units

In high value production units in bail-out doors
Two Inch Pre-Filter
Filtered Ceiling Inlet Issues

- Must have attic access from dirty side
- Must have walkways
- Height above inlet box to roof line
Filter Ratings

MERV (minimum efficiency reporting value)
- Based on the efficiency at various particle sizes and airflow rates
- ASHRAE 52.2

Currently using:
- MERV 8 as a pre-filter (2” depth)
- MERV 16 (boar studs) or MERV 14 (sow units) as the ceiling inlet PRRS capturing filter
- MERV 14 or 16 as the Koolcell filter
MERV 16 Filter

- 24” X 24” Filters
- 2000 cfm (500 cfm/ft²) at 0.8 inches static pressure
- Typically 400 to 500 cfm per 24” x 24” filter
  - 100-125 cfm/ft²
  - @ 0.1 static pressure
- L9 (Camfil-Farr)
MERV 14 Filter

- L6 (Camfil-Farr) 24” X 24” Filters

- 2000 cfm at 0.37 inches static pressure

- Typically 600 to 800 cfm per 24” x 24” filter
  - 150-200 cfm/ft²
## Airflow with Pre-filter

<table>
<thead>
<tr>
<th>Pathogen Barrier</th>
<th>Airflow with pre-filter installed at pressure in inches of water column.</th>
</tr>
</thead>
<tbody>
<tr>
<td>L6 Pathogen Barrier</td>
<td>0.10</td>
</tr>
<tr>
<td>20” X 24” w/ Pre-Filter</td>
<td>410</td>
</tr>
<tr>
<td>24” X 24” w/ Pre-Filter</td>
<td>550</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>L9 Pathogen Barrier</th>
<th>Airflow with pre-filter installed at pressure in inches of water column.</th>
</tr>
</thead>
<tbody>
<tr>
<td>L9 Pathogen Barrier</td>
<td>0.10</td>
</tr>
<tr>
<td>20” X 24” w/ Pre-Filter</td>
<td>210</td>
</tr>
<tr>
<td>24” X 24” w/ Pre-Filter</td>
<td>290</td>
</tr>
</tbody>
</table>

**L6 = 175 cfm/ft\(^2\)**  
**L9 = 112 cfm/ft\(^2\)**  

@ 250 cfm/crate gestation  
L9 = 1.8 crates/filter  
L6 = 2.8 crates/filter
Other Filter Efficiencies @ 0.1

Clarcor

Merv15 = 150 cfm/ft²

Noveko

90 cfm/ft²

125 cfm/ft²
A 1200 cfm ceiling inlet would require a 2’ x 4’ filter box
A 3000 cfm ceiling inlet will require a 44” wide by 8’ filter box.
Selecting filters

- Work with factory representatives to obtain documentation showing the new MERV ratings for their products.
- Not all filters are alike.
- MERV ratings encourage filter selection based on particle size requirements.
- Inspect filter installations for good sealing and damage. No filter can stop particles that bypass the media.
- What is filter effectiveness at low airflow rates
- Confirm that filters have manometers to indicate the time for change-out, and monitor filters regularly.
Filter Longevity

Pre-filter:
Approximately 6 months or greater
Change out in the spring

MERV 16 or 14
Filters:
Unknown ????
3+ yr
2600 Sow Gestation Facility with Cool Cells
Sidewall Cool Cells

- Three rows
- 24”x24” Filter
- DOP 95 MERV 16

Existing Evap Cooler
Existing Inlets

3’ Min

4’ Min

Curtain (bottom up)

Air Filtration Systems
Problem Areas

- Entry doors
- Dead stock removal doors
- Load out Areas

Backdraft shutters sealing?
Problem Areas
Problem Areas

Backdraft shutters sealing?
Pit Lids sealing?
Pit Pumping?
3000 Sow Operation

- 12 year old facility
- Mechanically ventilated with no tunnel
- PRRS outbreaks
H2 Filter Project 2008

- 3250 sow farm built in 1995
- On site gilt developer GDU – 1200 gilts
- Farrow to wean at 20 days of age
- History of new PRRS every 10 months in the past 5 years
- 1-18-2 in 2007
- June, 2008 – start of filter construction project
- Sept 13, 2008 – filter construction completed
Sites Surrounding 3000 Sow Facility

Martin Co, MN
960 pigs/sq mi
Dec 1, 2008
Problems to overcome

- Existing fans not providing enough airflow with the higher static pressures
- Sealing all unplanned openings including non-operating fans and pit covers
- Filtration box construction and installation
- Hot weather cooling
- Dead pig removal points and worker entry points
1st Things 1st, sealing the leaks

- $18,000.00 on caulk
- New filtered furnace, all new appliances, etc.
- Replaced all outside and inside doors with air tight doors
- Installed double door dead chambers
- Foamed around all non used doors
- Replaced and/or fixed all shutters
- Screwed shutters
6-inch slot air Inlet to Gestation
40 to 44-inch wide full length box for MERV16
Do not forget the details;

- Employee entryway
- Supply room
- Dead animal removal
- Backdrafting through fans
- Weaned pig load out area
- Any crack or leak
LEAVE FAN ON AT ALL TIMES
Operating Expenses

- Higher fan maintenance expense
  - Burning out fan motors faster

- Higher electric bills
  - More fans run to get same cfm

- 6 month cycle for replacement of pre-filters

- 2(?) yr cycle for filter replacement
Conversion Costs - $721,000
$240/sow

- 3746 pre-filters and MERV-16 filters
  - Filters (10 semi loads) - $460,000
  - Labor and Materials - $173,000

- New shutters, fence, 21 doors with magnetic sensors, 16 video cameras
  - $88,000

- 100 cases of caulk (4 men and 2 weeks)

- Unexpected cost (the plywood ceiling started to come down)
# Production H2- 2008

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total services</td>
<td>8475</td>
<td>8506</td>
<td>8492</td>
</tr>
<tr>
<td>% repeats</td>
<td>13.3</td>
<td>15.8</td>
<td>5.9</td>
</tr>
<tr>
<td>TB/LB</td>
<td>12.8/11.3</td>
<td>13.4/11.8</td>
<td>13.3/12.1</td>
</tr>
<tr>
<td>FR %</td>
<td>76.0</td>
<td>77.1</td>
<td>85.2</td>
</tr>
<tr>
<td>Lit weaned</td>
<td>6673</td>
<td>6544</td>
<td>7376</td>
</tr>
<tr>
<td>Wean/sow</td>
<td>9.5</td>
<td>10.0</td>
<td>10.5</td>
</tr>
<tr>
<td>Total pigs</td>
<td>60,978</td>
<td>65,345</td>
<td>77,493</td>
</tr>
<tr>
<td>PSY</td>
<td>21.6</td>
<td>21.7</td>
<td>24.9</td>
</tr>
<tr>
<td>Death rate</td>
<td>15.2</td>
<td>15.5</td>
<td>8.0</td>
</tr>
</tbody>
</table>
Partial Filtration vs. Year-Round Filtration

“We all have plenty to do without trying to be weather-men too.”

“Filtering air is like being pregnant, you either are or you aren’t.”

Dr. Kennedy
Summary

- Apply good design practices
- Understand the effects of static pressure on the ventilation system
- Use high quality filters
- Work in progress
- Facility are being built with MERV-14 filters?
Conclusions

- It is feasible from a ventilation standpoint to install a filtration system.

- Cost of filtration is influencing decision makers.

- Filters are only a part of site biosecurity.
Thank You

Questions???