Minimization of the Risk of Contamination in Canadian Swine Barns with Air Filtration Systems

Jacquelin Labrecque, Jr Eng. ¹

Authors

• Geneviève Berthiaume¹
• Dr. François Cardinal²
• Caroline Duchaine³
• Marie-Claude Gariépy¹
• Jacquelin Labrecque¹
• Valérie Létourneau³
• Dr. Sylvain Messier⁴
• Michel Morin¹
• François Pouliot¹
• Marie-Aude Ricard¹
• Lilly Urizar¹

¹ Centre de développement du porc du Québec inc.
² Les Consultants Avi-Porc SENC, Member groupe Maelström
³ Centre de recherche de l’Institut universitaire de cardiologie et de pneumologie de Québec
⁴ Demeter Services Vétérinaires inc.
Plan of Presentation

• Project Background
• Objectives
• How does Filtration Work?
• Filtered Farms in Canada and USA
• Contamination in Canadian and American Filtered Farms
• Cost Analysis
• Investigation of Outbreaks in Filtered Farms
• Audits
• Development of a Test Bench for Filter Efficiency Assessment
• Developed Tools
• Future of Filtration
Project Background

- This project is an integral part of four projects involving the CDPQ, the Prairie Swine Centre Inc. and the collaborators of the Canadian swine industry
- In connection with the strategy of the Canadian Swine Health Board (CSHB) to improve the protection of the swine from airborne pathogens
- Potential tools for CLÉ-SRRP projects
Objectives

• The aim of this project is to conduct multidisciplinary activities to help us take stock of the situation of Canadian swine barns equipped with air filtration systems.

• In addition, it will help to determine key factors and technical, technological and biosafety improvements within the industry in further minimizing the risks of contamination by the PRRSV and other airborne pathogens.
How does Filtration Work?

- **Mechanical Filters**
  - Clarcor AirGuard®
  - Camfil Farr

- **Characteristics**
  - V-Box pleated filters
  - MERV 14 to MERV 16
  - Tested and found effective for swine applications
  - Used with MERV 8 prefilter to block larger particles
Antimicrobial Filters

- Noveko Filtration

Characteristics

- Polypropylene fibers with embedded antimicrobial agents
- 10 to 20 layers of membrane
- 15 layers recommended based on lab tests
- Installation of prefILTER recommended
- Washable
How does Filtration Work?

- Lateral Air Inlet Installation of V-Box Type Filters

1. Air entering through a curtain
2. Air moving through the prefilters and filters
3. Air entering the room
4. Stale air expelled by exhaust fans
How does Filtration Work?

- Lateral Air Inlet Installation of Antimicrobial Curtain Filters (Now similar way to install Clarcor’s V-Box filters)

1. Air moving through the prefilters and filters
2. Air entering the room
3. Stale air expelled by exhaust fans
How does Filtration Work?
How does Filtration Work?

- Modular Ceiling Air Inlet (in attic)

1. Air entering through the eaves
2. Air moving through the prefilters and filters
3. Air entering the room through the modular diffusers
4. Stale air expelled by the exhaust fans
How does Filtration Work?
How does Filtration Work?

- Continuous Linear Air Inlet (in attic)

1. Air entering through the eaves
2. Air moving through the prefilters and filters
3. Air entering the room through ceiling air inlet
4. Stale air expelled by exhaust fans
How does Filtration Work?
How does Filtration Work?

Factors to Consider when Selecting a Filtration System

1. Filtration efficiency
2. Ease of installation of the filter model on the air inlets
3. Pressure drop (resistance to air flow) caused by the filter
   • Influences design
   • Balance between cost and efficiency of ventilation system
4. Cost of filtration over a determined period of time
   (maintenance, replacement and initial capital)
Filtered Farms in Canada

- Approximately 30 filtered barns in Canada in 2013 (mainly in Quebec)
- First installation in 2003 (boar stud)
- 9 x sow farms = 12,000 sows (first one in 2008)
- 3 x farrow-to-finish sites = 1,000 sows (first one in 2004)
- 3 x gilt development units
- 2 x quarantine barns
- 13 x boar studs
Filtered Farms in the USA

• Approx. 98 filtered barns in US, including among others:
  • 62 x sow farms
  • 26 x Boar Studs
  • 10 others (quarantine barns, gilt development units, etc.)

(Reicks, 2012, personal communication)
Annual rate of contamination in Canada:

- Data from February 2013
- Before filtration: 50-100%
- 37% for 14 farms investigated (using filtration from 5 to 50 months)
- Excluding the contamination from known sources (other than aerosols), the annual contamination rate is 28%
- Excluding the contamination from known sources (other than aerosols) and cases of contamination by aerosols related to an avoidable error, the annual rate of contamination goes to 12%
- Annualized rate of contamination (last 6 months): 29%
Contamination in the USA

Annual rate of contamination in the USA

• Data for August 2012 from three veterinary clinics
• 25% for 62 farms investigated
• Annualized rate of contamination (last 6 months): 21% for 48 farms

Source: Reicks, 2012, personal communication
7 swine farms have recently installed an air filtration system

3 types of farms participating:
- 4 farrowing facilities (1,400 to 2,600 sows)
- 2 gilt development units (560 to 1,200 places)
- 1 farrow-to-finish site
**Cost Analysis - Canada**

Estimate of Costs for an Air Filtration System

<table>
<thead>
<tr>
<th></th>
<th>Gilt Development Unit</th>
<th>Farrowing Facility</th>
<th>Farrow-to-Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital outlay costs per place $^1$</td>
<td>$12–78</td>
<td>$46–98</td>
<td>$217</td>
</tr>
<tr>
<td>Annuities per place $^2$</td>
<td>$2–11</td>
<td>$6–13</td>
<td>$30</td>
</tr>
<tr>
<td>Frequency of filter changes</td>
<td>3 years 5 years</td>
<td>3 years 5 years</td>
<td>3 years 5 years</td>
</tr>
<tr>
<td>Maintenance costs per place per year</td>
<td>$13–15  $9</td>
<td>$18–31  $12–21</td>
<td>$63  $41</td>
</tr>
<tr>
<td>Total annual operating costs</td>
<td>$15–25  $10–20</td>
<td>$25–45  $18–35</td>
<td>$93  $72</td>
</tr>
</tbody>
</table>

$^1$ Does not include initial and replacement filters and prefilters. These are included in maintenance costs.

$^2$ For a 10-year loan with an annual interest rate of 6.5%
• Profitable if it prevents 1.5 to 4 outbreaks on a 10-year period (depends on frequency of filter change)
• Payback (excluding funding) of 9 to 10.5 months
Information was collected regarding incidents of PRRS infections in hog barns using air filtration in Canada and the United States to avoid further contamination.

- 14 farms investigated for the project.
Probable Causes of Contamination

- Spreading of manure
- Entry of contaminated gilts (restocking)
- Sealing of the building and/or the air filtration system
- Absence of sufficiently airtight backdraft dampers on fans
Probable Causes of Contamination

• Failure to comply with the biosecurity protocol in place
• A chronic PRRS strain in the barn and genetic evolution of the strain
• Failure to comply with recommendations for the required modifications to the building
• Aerosols
Main Recommendations

- Budget the necessary modifications to the building with specialists
- Reduce the risk during the introduction of gilts
  - Filter the gilt development unit and use a filtered trailer
  - Set up a quarantine section in the farrowing facility
- Perform an eradication procedure (eliminate wild strains)
- Improve the air tightness of buildings
Main Recommendations

- Improve application of minimum biosecurity measures
- Improve monitoring of differential pressure between the building and the exterior
- Improve the airtightness of the filter brackets during installation
- Use filters with an adequate level of filtration (depending on the risk)
- Replace filters at the end of their active life expectancy (see manufacturer recommendations)
- Install an efficient backdraft damper
Audits
• 16 Canadian buildings with air filtration were audited (including 4 with Dr. Darwin Reicks) and a PADRAP evaluation was conducted (n = 13)
  • 11 in Quebec
  • 4 in Ontario
  • 1 in Manitoba
• Solutions suggested for each farm
Main Findings from the Visits

- Major and minor breaches of biosecurity
- Improper installation of filters (leaks)
- Back drafting through fans
- Access doors not correctly sealed
- Significant leakage in the building that could have been sealed
- Inadequate loading bay
Main Findings from the Visits

- Owner and staff
  - Improve their training and especially their thoroughness
- Several of the recommendations remain to be applied to the majority of farms
  - Considering the important amount invested, the cost of PRRS and the difficult economic conditions, we must limit the risks as much as possible!
Evaluation of the Performance of Prefilter and Filters Using a Test Bench

Performance Assessment of Prefilters and Filters Using a Test Bench

June 2013

Test Report

Valérie Létourneau¹, Ph. D.
Jacquelin Labrecque²

¹ Centre de recherche de l’Institut universitaire de cardiology et de pneumologie de Québec (CRIUCPQ)
² Centre de développement du porc du Québec Inc. (CDPQ)
Design of a Test Bench to Measure Filter Effectiveness
Generation and Sampling of Test Bench Viral Aerosols

- Experimental device for nebulizing viral aerosols
- Experimental device for sampling viral aerosols
Conclusions

• The basis and foundations necessary for the development of a test bench have been established
• We could not reproduce what the filters are really challenged with in swine buildings
• Improvements to the method must be made
  • Representativeness of the cloud of nebulized particles
Tools Developed in the Project

- Establish standards adapted to the filtered buildings:
  - Design, biosecurity, operation, maintenance and post-installation follow-up
- Make a checklist of items to verify for engineering and biosafety audits of air filtered buildings during start-up and post-installation follow-up
Minimum Standards for Swine Buildings with an Air Filtration System – Engineering and Biosecurity

May 2013

Fact Sheet

Marie-Aude Ricard, Eng.
François Cardinal, DVM, M. Sc.
Francis Pouliot, Eng., MBA
The purpose of this document is to list the biosecurity and engineering elements that must be applied to a filtered air site to maximize the result obtained by an air filtration system (access zones, animal transportation, staff, equipment, sealing of the building, etc.)
Checklist for Swine Barns with Air Filtration Systems

May 2013

Audit of Engineering and Biosecurity Elements

Marie-Aude Ricard¹, Eng.
François Cardinal², DVM, M. Sc.
Francis Pouliot¹, Eng., MBA.

¹ Centre de développement du porc du Québec inc.
² Les Consultants Avi-Porc SENC, Membre du groupe Maelström
Checklist for Swine Barns with Air Filtration Systems

• This checklist is meant to help you optimize the performance of your swine building under filtered air by inspecting various components regularly. The key issues addressed in the checklist concern the building, equipment and biosecurity.

• Audit of engineering and biosecurity elements

• Reveals several points to be checked

• The objective of this list is simple: you have to evaluate whether the items are being complied with or if corrective action needs to be taken to follow up on your observations.
Conclusion

• Air filtration is an important tool to reduce the risk of contamination by the PRRSV and other airborne viruses

• However, be aware that it is impossible to eliminate the risk of contamination

• It is therefore essential to tightly control different risk factors regarding biosecurity

• Improvements remain to be made (buildings and biosecurity) in order to reduce the overall risk of contamination by PRRSV
Future of Air Filtration

- **Goal:** To work at the regional scale rather than at individual scale to lower viral density in pig-dense regions (partnership with regional control groups)

- In order to achieve that, we need to lower filtration costs and/or find new ways to reduce viral density

- Need to better characterize the aerosols and virus
  - Projects going on at CDPQ to characterize virus and aerosols (Collaboration with aerovirologists from the Quebec Heart And Lung Institute Research Centre (CRIUCPQ))

- Results will allow to:
  - Better assess filtration needs
  - Develop new means of controlling virus density in air
  - Test efficiency of new and used filters by reproduction on a test bench of what they are really challenged with in pig buildings
For more information, do not hesitate to contact us or visit:

- Canadian Swine Health Board (www.swinehealth.ca/)
- Centre de développement du porc du Québec inc. (www.cdpq.ca)
- Prairie Swine Centre Inc. (www.prairieswine.ca)
Collaborators

- Dr. Brent Jones, South West Ontario Veterinary Services
- Ron MacDonald, AGVIRO
- Dr. Julie Ménard, F. Ménard
- Dr. Jacques Miclette, Agri-Marché
- Bernardo Predicala, Prairie Swine Centre Inc.
- Dr. Darwin Reicks, Swine Vet Center
- Lee Whittington, Prairie Swine Centre Inc.
- Participating producers
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Funding Partners

ONTARIO PORK

Manitoba Pork

Sask PORK

ALBERTA PORK

CDPO

Centre de développement du porc du Québec inc.
Funding Partners
Innovative Biocontainment Concept with Air Filtration at the Exhaust Fans in a Quarantine Facility

Jacquelin Labrecque, Jr Eng. ¹

Francis Pouliot¹, Valérie Dufour¹, Caroline Duchaine², Valérie Létourneau², Christopher Robitaille³, Michel Morin¹, Marie-Aude Ricard¹

¹ Centre de développement du porc du Québec inc.
² Centre de recherche de l’Institut universitaire de cardiologie et pneumologie de Québec
³ R. Robitaille et fils
Plan of Presentation

• Objectives
• Challenges
• Concept and Methodology
• Results
• Economic Analysis
• Conclusions and Recommendations
General Objectives

• To test an innovative biocontainment system adapted to a swine quarantine barn to prevent airborne pathogen spread in case of contamination
• To test technologies that may reduce to an acceptable level the clogging rate of the filters installed at the exhaust fans.
Challenges

• Make sure that the pathogens remain inside quarantine during a contamination
  – Biosecurity protocol
  – Level of air filtration

• Find one or several affordable solution(s) to reduce the clogging rate and the frequency of maintenance of filters

• The air must be filtered at the exhaust fans about 50% of the time (time required to confirm that animals are naive following their entry into the building)
1. An Electrostatic Particulate Ionization (EPI) system
   • To decrease dust build-up on the filters

2. A prefiltration system
   • To maximize the efficiency and life cycle of the antimicrobial filters

3. Antimicrobial filters at the exhaust fans
   • 10 antimicrobial membrane layers and pre-filter
   • To block and inactivate any virus possibly coming out through the fans

4. Antimicrobial filters at the air inlet
   • 15 antimicrobial membrane layers and pre-filter
   • To avoid a contaminated air backdraft from the air inlet during an outbreak
Methodology

- Quarantine of 108 gilts attached to the farrowing barn
- Exhaust fans and filtration system in an air treatment room
**Air Treatment Room**

- Exhaust fans and backdraft dampers
- Antimicrobial filters (10 membrane layers) and prefilter
- Prefilter
Prefilters

StuffNix (Big Dutchman)
Trials 1 and 2
Summer

MERV 13 Filters (DP-Green®)
Trials 3 and 4
Fall
Filters at the Air Inlets

• Air inlets
  • Cubic antimicrobial filters
  • 15 antimicrobial membrane layers
  • Pre-filter
Ionization System (EPI)

- Under high voltage, a power block generates negative ions in the air through 6 stainless steel spiked discharge lines.
- A winch system allowed moving the discharge lines further away from or closer to the ceiling in order to optimize the production of ions.
Ionization System (EPI)
Results
**Ionization System Performance**

<table>
<thead>
<tr>
<th>Season</th>
<th>Reduction in Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>45%</td>
</tr>
<tr>
<td>Fall</td>
<td>73%</td>
</tr>
<tr>
<td>Total Dust</td>
<td>36%</td>
</tr>
<tr>
<td>Total Bacteria</td>
<td>91%</td>
</tr>
</tbody>
</table>

- A reduction of at least 45% of dust so nearly half the maintenance is required — Meets the expectations
- The number of discharge lines of the ionization system was doubled as compared with the manufacturer’s recommendation
- The air flow has an impact on the effectiveness of dust and bacteria removal
Dust Concentration (Trials 1 to 4)

- **MERV 13 + ionization**
  - Total Dust (mg/m³)
  - In building
  - After pre-filter
  - After filter

- **MERV 13**
  - Total Dust (mg/m³)
  - In building
  - After pre-filter
  - After filter

(slightly more efficient because of clogging)
Total Bacteria Concentration (Trials 1 to 4)

- **0.1 M/m³ Outdoors**

- **Building**
  - MERV 13 + ionization: 10 times less in building
  - MERV 13: 7.6 M/m³ (5 times less)
  - After filters: (42 M/m³)

- **Bacteria (bacteria/m³)**
  - Millions
  - **Building**
    - MERV 13 + ionization: 10 times less in building
    - MERV 13: 7.6 M/m³ (5 times less)
    - After filters: (42 M/m³)
## Economic Analysis

### Additional Costs

<table>
<thead>
<tr>
<th>Type of Expense</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filters</td>
<td>$10,050</td>
</tr>
<tr>
<td>Prefilters (MERV 13)</td>
<td>$1,250</td>
</tr>
<tr>
<td>Ionization System</td>
<td>$18,700</td>
</tr>
<tr>
<td>Labour Cost</td>
<td>$5,775</td>
</tr>
<tr>
<td>Hardware</td>
<td>$625</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$36,400</strong></td>
</tr>
</tbody>
</table>

### Construction Savings

<table>
<thead>
<tr>
<th>Type of Expense</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access Path ($107/m², 100 m passage)</td>
<td>$15,000</td>
</tr>
<tr>
<td>Electrical Line ($56/m, along 100 m)</td>
<td>$5,600</td>
</tr>
<tr>
<td>Service Box</td>
<td>$2,500</td>
</tr>
<tr>
<td>Shaft ($20/ft at 500 ft depth + infrastructure)</td>
<td>$10,000</td>
</tr>
<tr>
<td>Temporary Manure Storage</td>
<td>$4,000</td>
</tr>
<tr>
<td>Pump</td>
<td>$2,500</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$39,600</strong></td>
</tr>
</tbody>
</table>

Sources: Francis Pouliot, Eng. CDPQ and Christopher Robitaille, Jr. Eng., personal communications

However, the air filtration system coupled to an ionizer made it possible to attach the quarantine facility to the farrowing barn.
Economic Analysis (Cont’d)

- Annual cost for prefilters and filters
  - Prefilters (24 units every 56 days) :
    $2,400/year = $22 /place/year
  - Filters (3 years) : 2 500 $/year =  23 $/place/year
    – For air inlets and exhaust fans

- Other savings might be considered :
  - Cost of the concrete for the foundation if constructed simultaneously with the farrowing barn
  - Transportation cost (no transport trailer, no fuel)
  - Work time (transportation, trailer cleaning)
Conclusion and Recommendations

• The ionization system allows to reduce the maintenance frequency of prefilters and filters at exhaust fans by nearly half
  • Stay prudent and install twice the recommended number of discharge lines
  • New version of EPI is supposed to be even more efficient according to manufacturer (still need to double lines?)
Conclusion and Recommendations

- Prefiltration wall
  - MERV-13 filters:
    - 25 days without cleaning during fall
      - Beyond our expectations
        (we expected to change prefilters every 5 to 10 days)
    - Pressure drop < 0.25 in wg
    - System designed for a pressure of 0.50 in wg
    - Summer validation should be done in the future
Conclusion and Recommendations

• It is recommended to choose fans that can support the added pressure drops from both your ventilation system and your filtration system (when dirty)
  • Install gauges and regularly check static pressure gradients (filters and fans) and replace filters when you hit the pre-determined limit
• MERV 13 filters are easy to change (45 minutes)
  • Anticipate 1 replacement per batch
  • Other tests should be done to validate the feasibility of further reducing the frequency of replacement
• Antimicrobial filters stay relatively clean
  • Anticipate 2 cleanings / year
Conclusion and Recommendations

- Little or no savings at the building construction, but better protection of the breeding herd
  - You should ask your veterinarian about the need to filter the air at the exhaust of a quarantine facility built close to the farrowing barn
    - If yes, quarantine facility annexed to farrowing barn offers an interesting economic advantage
- Case by case analysis
- Important to establish a biosecurity protocol for the quarantine period and one in case of riddance of infected animals (Prepared by Dr François Cardinal in this project)
Conclusion and Recommendations

• Considering this was a pilot project and that each case is different, it is important to consult your veterinarian and your engineer specialized in ventilation and air filtration prior to engage in such a project.
Acknowledgement

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Acknowledgement
Questions?

Thank you!