Porcine reproductive and respiratory syndrome virus (PRRSv): Update on Noveko’s Air Filtration System

Francis Pouliot, Eng., M.B.A.
Objectives of the presentation

• Review the research and development carried out with Noveko’s antimicrobial air filters
• Explain how Noveko’s antimicrobial filters work
• Discuss engineering aspects with respect to the installation of air filtration systems in swine buildings
• The costs are not discussed in this presentation. These may be discussed during another presentation
Ventilation concept

Negative pressure:

- Air is expelled from the building using fans. The indoor air pressure is inferior to the external air pressure.
- Standard in conventional buildings.
- Air pressure is usually below 25 Pa when all fans are in use.
- The building must be airtight and the pressure not too high so as to avoid infiltration of parasitic air.
Airborne transport of PRRSV and *M. Hyo* is possible.

It has now been scientifically proven:
University of Minnesota

DR. SCOTT DEE’S WORK
Trials with different biosecurity levels

- In 2008, Dee *and al.* confirmed aerosol transmission of PRRSv.
- Dr. Dee confirmed that air filtration is necessary to avoid PRRSv introduction in swine buildings via aerosol transmission, in high density swine production zones.
# Dee and al. (2008) results

<table>
<thead>
<tr>
<th>Description</th>
<th>Infected Rooms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without biosecurity (n=21)</td>
<td>14</td>
</tr>
<tr>
<td>Medium biosecurity level (n=26)</td>
<td>8</td>
</tr>
<tr>
<td>Medium biosecurity level + air filtration (n=26)</td>
<td>0</td>
</tr>
</tbody>
</table>
Assessment of long distance airborne transport of PRRSv and *Mycoplasma hypneumoniae*

- In 2010, Dr. Dee confirmed that airborne transport of PRRSv and *M. hyo* was possible up to 9.2 km.
GLOBAL APPROACH TO BIOSECURITY !!!
Biosecurity chain: as strong as the weakest link
Noveko’s antimicrobial air filter
Noveko’s antimicrobial air filter

• Made by Noveko (Canada)
• ABS and aluminum case with airtight cover measuring approximately 74 cm x 123 cm
• Polypropylene media
• Case available in vertical or horizontal format
Noveko’s antimicrobial air filter

- Patented virucidal/bactericidal/fungicidal filter
- Innovative aspects:
  - Virucidal/bactericidal/fungicidal agents integrated in the fiber’s molecules which increases the filter’s porosity and decreases energy losses in the ventilation system
  - 1870 m\(^3\)/h/filter @ 25 Pa
  - 2 year life cycle
  - Developed for the agricultural industry
  - Designed for use in operations with both negative and positive pressure ventilation environments
  - No structural changes to the building
  - Noveko is currently working on developing concepts that will lower installation costs
Noveko’s antimicrobial air filter

- 3 separate filtration levels which are removable, washable and replaceable
  - Adjustable filtration levels,
  - Optimizes filtration performance,
  - Makes cleaning easy,
  - Allows for single level filtration so that the air is continuously filtered, even during cleanings.
Noveko’s filters features

• 1st filtration level
  – Removable pre-filter screen for easy cleaning
    • Filters out dust and coarse particles
Noveko’s filters features

• 2\textsuperscript{nd} filtration level
  – 1\textsuperscript{st} filter media with virucidal/bactericidal agents
    • Composed of 5 layers of filter media (quantity can be changed according to needs)
    • Filters out dust particles
    • Filters out and neutralizes bacteria and viruses
    • Reduces cleaning frequency of the 3\textsuperscript{rd} filter
Noveko’s filters features

- **3rd filtration level**
  - Filters out and neutralizes bacteria and PRRS virus
  - A 5 layer filter is also available (quantity can be changed according to needs)
  - This filters stay clean, maximizing the performance of Noveko’s virucidal and bactericidal agents
Here is how it works:

• **Straining**: Large diameter particles are captured between 2 filter fibers.
Here is how it works:

- **Inertial impaction**: Contaminated particles come into contact with the fiber causing them to bond with it. The bacteria and viruses on the bonded particle are neutralized by the antimicrobial compound.
Here is how it works:

- **Interception**: Smaller particles are forced into contact with the fiber due to air turbulence. The bacteria and viruses on the bonded particle are neutralized by the antimicrobial compound.
Here is how it works:

- **Diffusion**: Small particles travel in random patterns due to molecular interactions, and are forced into contact with the antimicrobial fiber, neutralizing particle contamination.
NOVEKO'S FILTER EFFICIENCY EVALUATION PROGRAM

By Dr. Laura Batista
Objective:

• Evaluate the efficiency of Noveko’s filters in blocking the transmission of PRRSv by bioaerosol
Experimental Device
- PRRS vaccine atomization at 5 minute intervals (Total dose 300 x 10^7 TCID50)
- 20 naïve piglets exposed for 6 hrs in the reception chamber after atomization
- Piglets are isolated during 14 days
- Blood sampling at days -1, 0, 1, 7 and 14
Dr. Laura Batista’s Evaluation Project
Results
<table>
<thead>
<tr>
<th></th>
<th>Surfaces of clean room PRRSv+</th>
<th>Success rates*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noveko’s filters (n=20)</td>
<td>0/20</td>
<td>95% (19/20)</td>
</tr>
<tr>
<td>Negative control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(saline solution atomizing only; n=4)</td>
<td>0/4</td>
<td>100%</td>
</tr>
<tr>
<td>Positive control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(no filter and virus atomizing; n=4)</td>
<td>4/4</td>
<td>0%</td>
</tr>
</tbody>
</table>

*Confirmation with PCR and ELISA
Objective:

• Evaluate the efficiency of Noveko’s filters in blocking the transmission of PRRSv by bioaerosol AFTER 16 MONTHS of utilization in a commercial swine barn
Experimental Device
- Noveko’s commercial filter with 10 layers (16 months of utilization in commercial swine barn)
- PRRS vaccine atomization at 5 minute intervals (Total dose $300 \times 10^7$ TCID$_{50}$)
- 9 naïve piglets exposed for 6 hrs in the reception chamber after atomization
- Piglets are isolated during 14 days
- Blood sampling at days -1, 0, 1, 7 and 14
Results
### Success rates in avoiding PRRSv transmission after 16 months of use

<table>
<thead>
<tr>
<th></th>
<th>Surfaces of clean room PRRSv +</th>
<th>Success rates*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noveko’s filters (n=9)</td>
<td>0/9</td>
<td>100% (9/9)</td>
</tr>
<tr>
<td>Negative control</td>
<td>0/4</td>
<td>100%</td>
</tr>
<tr>
<td>(saline solution atomizing only; n=4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive control</td>
<td>4/4</td>
<td>0%</td>
</tr>
<tr>
<td>(no filter and virus atomizing; n=4)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Confirmation with PCR and ELISA
Dr. Laura Batista’s Evaluation Project

• Confirmed the efficiency of Noveko’s 10 layer filters:
  – PRRSv filtration and antimicrobial efficiency
    • 100% efficiency after 16 months of use
By
Dr. Scott Dee from the
University of Minnesota

NOVEKO’S FILTER EFFICIENCY EVALUATION PROGRAM
Dr. Scott Dee’s Evaluation Project

- Laboratory tests using a cyclonic collector
Air sampling with cyclonic collectors: Performance of Noveko’s filters against PRRSv

<table>
<thead>
<tr>
<th>PRRSv (TCID&lt;sub&gt;50&lt;/sub&gt;/L)</th>
<th>20 layers</th>
<th>15 layers</th>
<th>10 layers</th>
<th>Swine Bioassay</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^7$</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
<td>4/10 (+)</td>
<td>NEG</td>
</tr>
<tr>
<td>$10^6$</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
<td>neg</td>
</tr>
<tr>
<td>$10^5$</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
<td>neg</td>
</tr>
<tr>
<td>$10^4$</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
<td>neg</td>
</tr>
<tr>
<td>$10^1$-$10^3$</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
<td>neg</td>
</tr>
</tbody>
</table>

Source: Dee (2008)
Air sampling with cyclonic collectors: Performance of other filters against PRRSv

<table>
<thead>
<tr>
<th>PRRSv (TCID50/L)</th>
<th>MERV-16 Sweden</th>
<th>MERV-16 United States</th>
<th>MERV-14 Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>10^7</td>
<td>0/10 (+)</td>
<td>10/10 (+)</td>
<td>10/10 (+)</td>
</tr>
<tr>
<td>10^6</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
</tr>
<tr>
<td>10^5</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
</tr>
<tr>
<td>10^4</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
</tr>
<tr>
<td>10^1-10^3</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
<td>0/10 (+)</td>
</tr>
</tbody>
</table>

Source: Dee (2008)
Dr. Scott Dee’s Evaluation Project

• Confirmed the efficiency of Noveko’s filters:
  – PRRSv filtration efficiency
    • 100% efficiency for 15 and 20 layers up to log 7
    • 100% efficiency for 10 layers up to log 6
  – Antimicrobial efficiency in deactivating the PRRSv
    • At log 7 with 10 layers, the PRRSv that passed through the filter media were found to have been deactivated through the action of Noveko’s antimicrobial cocktail.
Dee and al. (2009): SIV

<table>
<thead>
<tr>
<th>Type of filter</th>
<th># PCR + (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEPA</td>
<td>0</td>
</tr>
<tr>
<td>Camfill MERV-16</td>
<td>0</td>
</tr>
<tr>
<td>Noveko 15 layers</td>
<td>0</td>
</tr>
<tr>
<td>Noveko 20 layers</td>
<td>0</td>
</tr>
<tr>
<td>Noveko 10 layers*</td>
<td>2</td>
</tr>
<tr>
<td>Camfill MERV-14</td>
<td>6</td>
</tr>
<tr>
<td>Camfill MERV-11</td>
<td>8</td>
</tr>
<tr>
<td>Positive control</td>
<td>10</td>
</tr>
</tbody>
</table>

* Bioassay: not done as virus was killed
Since Dr. Dee used a killed preparation of SIV, he was not able to use a swine bioassay as a means to assess viability of samples collected from the antimicrobial filters. However, based on the similarities between PRRSv and SIV, he would expect that the antimicrobial compounds would be effective on SIV just as they have been on PRRSv.

Source: Dee (2009)
Project at SDEC in Minnesota with Dr. Scott Dee

- Production of a regional model under heavy challenge:
  - Assess Noveko’s antimicrobial filters efficiency against:
    - PRRS
    - Mycoplasma hyopneumoniae
### Dee and al. (2009): PRRS + M. hyo

<table>
<thead>
<tr>
<th>Type of filter</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noveko antimicrobial 10 layers</td>
<td># replicates with piglets PCR +</td>
</tr>
<tr>
<td></td>
<td>0/13 (PRSS)</td>
</tr>
<tr>
<td></td>
<td>0/13 (M. hyo)</td>
</tr>
<tr>
<td>No filter</td>
<td>8/13 (PRSS)</td>
</tr>
<tr>
<td></td>
<td>5/13 (M. hyo)</td>
</tr>
</tbody>
</table>
Dee and al. (2009): PRRS + M. hyo

- 10 layer antimicrobial Noveko filter
  - Over 13 months: the piglets were never contaminated despite being within 120 m of a heavily contaminated feeder barn
Current project at SDEC in Minnesota with Dr. Scott Dee

- Assays from December 2009 to November 2010
- Tested filters
  - 10 layers antimicrobial Noveko filter, with an initial age of 23 months
  - In August 2010, following 9 repetitions, the piglets remained free of PRRS and M. hyo with filters having 32 months of age
Results of Dr. Scott Dee’s assays

- Summary: 10 layer antimicrobial Noveko filter
  - In the lab, the PRRS virus passed through 4 out of 10 times at log 7 but bioassays were negative
  - In the lab, the influenza virus passed through 2 out of 10 times which makes Noveko’s technology one of the most efficient against this virus
  - The pigs were never contaminated in the chamber of the regional model
  - Only one pig was contaminated during all the assays (n= 46; success rate of 98 %) (suspect cross contamination)
  - Since the beginning of the undertaking of the assays, the filter’s performance has been constant
Results of Dr. Scott Dee’s assays

- 15 and 20 layer antimicrobial Noveko filters
  - During Dr. Dee’s assays in the lab, neither the influenza virus nor the PRRSv passed through
In all R&D cases, Noveko’s filters were exposed to extreme contamination conditions!!!
Results in France

- Commercial farrow-to-finish farm with 450 sows
- Depopulation-repopulation in June 2008 with the installation of Noveko filters and overall improvement of biosecurity
- From June 2008 to April 2010: the animals remain disease-free
Results in France (May 2008 to June 2009)

- Costs (CAP-50, 2009):
  - Depopulation-repopulation: 400 Euros/sow
  - Cost of filters and installation: 168 Euros/sow
  - Total cost: 570 Euros/sow

- Cost savings generated:
  - Gap in the margin: 365 Euros/sow/year

- Return on investment: less than 2 years

- IMPORTANT REMARK:
  - Standard ventilation flow in France is 2.25 times lower than North American standards, which has a major impact on the cost of the air filtration system
Field application of biosecurity protocol including air filtration technology

- **Project participants:**
  - 8 producers located in swine dense regions in Canada (Quebec) (total of 10,000 sows)
  - CDPQ, Clinique Demeter, Laura Batista, F. Ménard, Noveko, Monitrol
  - 3 producers are currently under an eradication process.

- **Objective:**
  - Optimize biosecurity protocol by including air filtration technology in order to eradicate PRRSv and/or *M. hyo* from swine herds in a sustainable way
Field application of biosecurity protocol including air filtration technology

• Timeline of the project:
  – Beginning: June 2009
  – End: May 2012
• **Before installing the filters:**
  - Check the total air flow during the summer
    - If there is insufficient flow initially, the producer could blame the filters for this
    - Adding filters will slightly increase the static pressure if well designed
  - Opening air inlets
    - Static pressure add up from the outside to the inside of the building and are added to filters
    - Air velocity of 2.5 m/s = 6 Pa
    - 5 m/s = 25 Pa
Before installing filters, ensure all ventilation standards are respected:

- Total air flow for summer
- Air inlet opening
- Air inlet calibration
- Electronic controller settings

Design filtration system according to the SP desired (less than 25 Pa ideally)
Conceptual stages

• Determine the filtration level according to the risks
• 4 season filtration
• Determine the total static pressure wanted and calculate the number of filters required
  – Ideally < 40 Pa: including filters + air inlets
  – Generally, filter = 25 Pa and air inlets = 12.5 Pa (may vary for air inlets)
  – If the pressure is too high:
    • Increased risk of parasitic infiltration
    • Decreased ventilator performance
    • Ex: 610 mm fan = 20% decrease in flow, going from 12.5 Pa to 50 Pa
Conceptual stages

• **Controlling parasitic air infiltrations**
  – Single airlock for entrances and loading docks
  – Positive pressure fans for shipping areas
  – Cover summer ventilators during the winter
  – Make sure cases containing filters are installed correctly
  – Block windows
  – Etc.
To date, risks linked to non-filtered air intake (windows, loading docks, infiltrations, out of use ventilators) remain unknown.

- Decrease them as much as possible as a precautionary measure.
- Tests carried out to date seem to indicate that these risks are limited.
- More information will come to light in the future, whereas the importance of monitoring the performance of different farms equipped with filters.
- To decrease risks, avoid an overall negative static pressure over 25 Pa.
Novekos’s Filters Maintenance

- Washable
- Frequency of cleanings:
  - Estimated at twice a year depending on location
- Estimated life cycle
  - Case: 10 years
  - Filter: 2 years
Noveko’s static pressure target

- Designed to meet less than 25 Pa of static pressure
- In order to achieve such a goal, Noveko’s concept design was submitted to several performance tests in a wind tunnel.
Bench test
Noveko’s filter calibration

Airflow vs static pressure for Noveko’s filters 27”x47”

Airflow (cf3/min)

Static pressure (in W.G.)
NOVEKO FILTER INSTALLATIONS
J. P. Dion Farm (Québec)

340 sows – Farrow-to-finish
GAEC François (France)

450 sows – Farrow-to-finish
Pigalys: France

120 sows - Farrow-to-finish
France

250 sows - Farrow-to-finish
Boar studs #1 (Canada)

400 boars
Boar stud #2 (Canada)

400 boars
Nursery barn in China

400 places
AGR Labrecque (Québec)

1,400 sows
F. Ménard (Québec)

1,100 sows
Porc S.B. (Québec)

1,600 sows
R.M. Côté (Québec)

900 sows
Poultry barn in China

Cooling pad installation
The risk of airborne spread is real. Air filtration is an essential tool for control of area spread of airborne disease for farms in swine dense regions.

Source: Dee, 2009
Thank you!