

# Application of Air Filtration Systems in Swine Operations

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## ■ Introduction

There is a significant economic advantage to maintaining a PRRS negative herd, whether it is a boar stud, sow farm, or nursery-grow-finish. As the reality of aerosol transmission of PRRS, Swine Influenza, and Mycoplasma are being more accepted, any means to prevent aerosol transmission of these agents is of great interest. Our practice has taken an aggressive approach with our producers on air filtration systems. Six farms implemented filtration in 2005, five in 2006, eleven in 2007, and eleven in 2008. Application of filtration systems in our practice has been previously described (Brumm 2008; Feder 2008; Reicks 2006, 2007, 2008). I will review what has been learned from these experiences.

## ■ Filtration System Options

There is no one size fits all to air filtration. We have found it necessary to work up each farm on a situation by situation basis. All of the farms have utilized Merv 16 Camfil Farr filters<sup>1</sup> to date. We have also utilized some of the new filters from Camfil Farr, called the PB L6 filter. There are 21 boar studs, eight sow farms, three research barns, and a finishing site. We have done small and large farms. Five of the sow farms are over 2500 sows. The other three are 700 – 1200 sows. Five of the boar studs are air conditioned.

In the field, air filtration has been adopted by a number of farms. Dr. Scott Dee and Andrea Pitkin have shown us that aerosol transmission of PRRS virus can be repeated experimentally and it is becoming widely accepted to be

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<sup>1</sup> Camfilfarr; 1 North Coporate Drive; Riverdale, NJ 07457; camfilfarr.com

a common way that negative farms become re-infected (Dee 2007; Pitkin et al., 2007). One challenge for implementation of air filtration is the number of filters needed to get adequate air flow through a barn for summer ventilation.

## ■ How does it work?

The true HEPA filters are normally rated at 99.99% efficient down to 0.3 micron particle size (Camfil Farr 2000). This means that when they are new, they will filter 99.99% of particulates that are 0.3 micron in diameter. The efficiency percentage increases for larger particles and decreases for smaller particles, but as the particle size becomes extremely small, the efficiency actually increases again. As the filter becomes “used” it actually becomes more efficient, as trapped particles help to filter an even higher percentage of small particles.

There are three basic ways filtration works to stop particulates (including viruses and bacteria):

- **Impaction:** larger particles are unable to avoid the filter fibers and imbed in them directly. This is how larger particles (>0.4 um) are caught up in the filter
- **Interception:** smaller particles (<0.4 um) come within 1 radius of a fiber and adhere to it. The particles are held there with van der Waals forces.
- **Diffusion:** Brownian motion (turbulence) increases the likelihood that small particles will be stopped by Interception or Impaction

For the primary agents of concern with aerosol spread in swine, the diameter of each is as follows:

- Swine Influenza Virus – 80-120 nm (.080 - .120 micron) (Olsen et al., 2006)
- PRRSV – 50-65 nm (.050 - .065 micron) (Zimmerman et al., 2006)
- PCV2 – 17-22 nm (.0017 - .0022 micron) (Quinn et al., 2002)
- Mycoplasma – 0.3 – 0.9 micron (Quinn et al., 2002)

As you can see, SIV, PRRSV, and PCV2 should be able to get through the HEPA filters. However, it is the particulates that they are carried on which is important, as bioaerosols are generally 0.4 – 0.7 micron. Also, tiny particulates can stick to the filter fibers due to interception and diffusion processes.

## ■ Filter Options

There have been many inquiries from producers about cheaper filters. I have found that not all filters are equal, and that the current rating systems are not necessarily applicable to the applications we are doing. For example, we are running the barns typically at .05-.20 (inches water gauge) for static pressure. When these types of filters are tested, they are done so at much higher pressures. As a result, quality of materials, frame integrity, etc. become much more important to make sure no air can bypass the filter material itself.

There has been some redesign of the frame and also a new filter which has better air flow, but may have a breaking point and allow virus to pass through at very high concentrations. Our strategy right now is that we will use the same filter as in the past (now called L9 filter since the new frame design) for farms that have a poor history with PRRS, have farms within about two miles, or have a large number of pigs within three or four miles. We will use the higher air flow filter for lower risk farms.

Partial filtration continues to be utilized due to cost. The problem is with just putting filters on the ceiling inlets and having no filtration for cool cell pads, most of those farms are unfiltered for about 4 months of the year. We've had one farm switch from partial filtration to 100% filtration just by switching the filter bank to the new higher airflow L6 filter.

For the Camfil Farr Merv 16 filter, now revamped to the PB L9 filter, we are figuring 600 cfm of air will go through the filter at 0.2 inches W.G. For the PB L6 filter, we are figuring 1000 cfm of air go through the filter at 0.2 inches W.G (Camfil Farr 2000). Most of the sites have been able to run the static pressure to 0.2 without any trouble, although it is important to know what fans you have and how they perform at these higher loads.

## Partial Filtration

Many of these sites simply put a filter above each of the ceiling inlets. If one filter was placed above the inlet, the air flow is adequate until the outside temperatures generally reach 65°-70° F. After that point, there is too much restriction and they must either remove the filters or utilize air coming through a cool cell in tunnel mode ventilation. In tunnel mode, all air comes in a through an opening at one of the building and exits at the other end. One of the challenges with this system is that during the late spring and early fall in the Midwest, the temperature often gets hot enough during the day where tunnel mode is necessary. Then at night the temperature drops down into the 50's or 60's F when survivability of the PRRS virus is favorable (Hermann et al., 2007).

## Dealing with High Temperatures

Utilizing the survivability curve of the PRRS virus, it may be possible to remove the filtration system at a certain summer temperature while only taking on minimal risk of aerosol introduction of PRRS virus. In order to handle the large volume of air needed through a cool cell during summertime ventilation, a filter bank needs to be about three times the size of the cool cell pad or utilize squirrel cage type fans to pressurize the air going through the filter bank. Both of these can be quite costly options. An alternative to either of these systems is to stop filtering once the outside temperature gets hot, above 27°C (80°F) for example. With this system, a filter bank can still be utilized to allow air to go through the evaporative cool cell pad but the high end ventilation needs can still be met without the additional cost of fans or large building structures containing the larger filter banks.

Another application of this option is in farms where all of the air comes through ceiling inlets year-round. An extra row of inlets can be put in at a fairly minimal cost. If these inlets are actuated, they can also be tied to the ventilation system to provide an option during the higher temperatures. These unfiltered inlets would open up when the outside temperature rises above 27°C (80°F) for example, and then are pulled shut as the temperature decreases.

This option can be a feasible low cost way to handle the majority of the risk throughout the year. It probably is not going to be a good application in high risk areas.

## 100% Filtration

100% filtration for a barn that goes to tunnel mode in the summer basically involves the construction of a filter bank in front of the cool cell. This does add construction cost. In addition, these facilities normally pull air through ceiling inlets in the winter so filters need to be mounted on top of each inlet box. The cost of implementation of a filtration system for these facilities, including cost of construction for the filter banks, has been \$180-\$200 per animal.

Some facilities pull air through inlets year round so just need filters mounted in front of each inlet. The cost of implementing filtration with this type of building design has generally cost \$80-90 per boar.

## ■ Air Conditioning Systems

Air conditioning systems greatly reduce the number of filters needed (because extra summer time ventilation needs don't exist anymore). Because the air

comes in cool year round, the ventilation needs are more similar to winter time.

## **Types of Air Conditioning Systems**

We have implemented air conditioning in five boar studs and 100% filtration using the MERV 16, 95% DOP filters over the last three years. In all cases, we use ceiling inlets and negative pressure ventilation for the cooler weather seasons, the same as a normal swine facility. All of these have filters above each inlet. As we transition into late spring, when ventilation rates become inadequate to meet the moisture and heat removal needs of the barn, the air conditioning system starts to operate. There is some variation in systems on how this transition happens.

### ***Recirculated Air System***

We have one farm that recirculates the air in the room through the air conditioners. When the outside temperature rises into the 20°C to 25°C range (upper 60's to low 70's °F), the air conditioner turns on and recirculates and cools the air that is in the room. Fresh air continues to come in through the ceiling inlets and filters.

### ***Fresh air systems***

The other sites all use fresh air rather than recirculated air. There are three slight variations on how this is accomplished:

- One of the sites has air handlers in the attic and the air conditioned air comes in through the same ceiling inlets as before. In this site, the air is pulled through the air conditioning duct work year round. As the temperature warms up, first the blowers come on to push outside air through the ceiling inlets. As the temperature in the barn continues to rise, the condensing units come on and air condition the air. The air handlers are in the attic but the condensing units sit outside so that the heat is released into the outdoors.
- Two of the sites have a similar system to above, except that the air conditioning unit and air handlers all sit outside and push the air in through the side wall rather than through ceiling inlets. This seems to be a simpler system because it avoids having all the air handling equipment and duct work in the attic. However, getting the air evenly distributed within the room is more of a challenge.
- Another system also has air coming in through the side walls, but inserts an evaporative cooling pad in front of the air conditioner and air handler. With this system, as the temperature rises, the blower comes on to help

push air through the filters as above. However, as the temperature rises, water circulates through the evaporative cooling pad to cool the air prior to the condensing units of the air conditioner coming on. The purpose of this is to delay the condensing units coming on until the mid 20s C (upper 70s F) rather than coming on with temperatures in the low 20s C (upper 60s F). This should save considerably on electrical costs.

## ■ Filter and Air Conditioning Needs

Because the air conditioned facilities have control of the temperature of the incoming air, the ventilation rates can be similar to winter time rates year round. All of the facilities operate in the range of 6 to 20 cfm per animal year round. This means a minimal number of filters are needed and greatly reduces the cost of filters. Normally a 24" x 24" filter would supply only two adult swine under maximum summer ventilation. With air conditioning operating under 20 cfm/animal year round, the same filter can supply 30 adult swine.

A rule of thumb is - air conditioning needs are 5.5-7.0 animals per ton of air conditioning. The number of animals that can be supplied per ton of air conditioning is higher for a unit that recirculates the air. This barn air can be hard on equipment however. Farms using fresh air are in the 5.5 – 6.25 animals per ton range.

## ■ Costs

The costs of implementing an air conditioning system with filtration have varied widely. We have seen a range of \$300-\$600 per animal (Reicks 2008). The reasons for this wide range have primarily depended on:

- Whether 3-phase electricity is already on the site or needs to be either brought in or a converter installed.
- The existing capability of the generator on site.
- Whether using recirculated air or fresh air. The recirculated air system is cheaper but will have more maintenance.
- New construction or retrofit. New construction will be cheaper because one can avoid the cost of installing all the fans, cool cells, inlets, etc. that would normally be needed for summer ventilation.
- The type of air conditioning system. We've seen a range from using household type systems to large commercial systems.

Operating costs have run around \$20-30 per animal more for the warm weather season.

## ■ Challenges with Air Filtration

Some of the challenges with air filtration have been as follows:

- How can you get everything sealed up? Because the system relies on negative pressure, there is always the challenge of minimizing air entry into the building other than through the filter. Positive pressure systems address this but there has been concern about driving warm, moist barn air into cracks and rotting out the barn due to this air condensing in the walls in the winter time.
- Summer filtration. To cover the ventilation needs of a non-air conditioned barn, you need about three times the number of filters in the summer as in the winter. Current research is suggesting that night time in the summer is still a significant risk, especially with gentle winds coming from an infected facility. Cooler night temperatures also are favorable for virus survival. 100% filtration or making sure the facility drives all the air through the filters at night are ways to control this risk.
- All doors have to be secured. We have implemented a rule that no external doors can be opened. Deads are taken out through isolation or a hallway where doors to the barn can be closed. Culls are taken out in a similar fashion. Entering animals also go through a double door system to minimize any air re-routing around the cool cell.
- Back-drafting through inactive fans is a challenge as fan louvers can stick open and don't provide a great seal when closed. We have put fan covers inside and outside during the winter and try to delay opening up fans as long as possible. Also, it is important that fans are working and should be checked at least once per week.
- Installing filters without damaging them. It is important that filters are not damaged during installation. Often, those installing filters only have experience with changing their furnace filter at home. It is important that those installing the filters understand that the filter material cannot be torn or damaged in any way during installation.

## ■ Results

A total of 33 farms have installed filters in our practice since 2005. Eighteen of these farms have 100% filtration; the rest have partial filtration. Since implementation of air filtration, we have had three PRRS breaks on farms using partial filtration. All three were infected when the air was not being filtered. We have had one PRRS break on a farm with 100% filtration, although we believe that was the result of a transportation biosecurity breach or the result of having a number of heavily damaged filters in use. We have had two Swine Influenza breaks on 100% filtered farms. We have not had any *Mycoplasma hyopneumoniae* breaks on any of the filtered farms, although most are vaccinated.

An important consideration for us from the start has been that we shouldn't expect to never have a PRRS break just because we installed air filtration. However, if we can reduce the incidence of PRRS breaks significantly, it would be good return on the investment. This has proven to be the case, in our experience. Most of the farms that have filtration had a previous history of multiple PRRS breaks.

## ■ Summary

Air filtration systems have been in place in our practice for three years, in a wide variety of farms and in large and small farms. For boar studs, filtration has become the standard, except for studs with no history of PRRS and located five miles or more from other pigs.

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