Facility Maintenance and Modernization

Joseph M. Zulovich, Ph.D., P.E.
Commercial Agricultural Engineer
Animal Structures Specialist

Biological and Agricultural Engineering Dept.
University of Missouri-Columbia

Commercial Agriculture Program
University Outreach and Extension

Abstract

A general understanding of the operation of swine facilities is required in order to develop a maintenance program. The objective of this paper is to provide an understanding of swine facility operation and to indicate key areas necessary for an effective maintenance program. Any implemented maintenance program may or may not require all key areas presented because of the various types and designs of facilities. Implementing a maintenance program will almost always improve pig performance and increase the longevity of the facility. Hints for modernization are also included.

Introduction

Maintenance programs are recommended and many times are required for numerous things comprised of, at least in part, mechanical components. Adhering to maintenance and service schedules is often required to insure warranties and guarantees remain valid. In general, maintenance programs help a device or system operate effectively and hopefully with only few, if any, problems.

Swine facilities are not exempt from needing a maintenance program. A well-designed maintenance program will often help improve pig performance. The maintenance program will generally increase the life expectancy of the components within the facility as well as the life of the structure itself. However, in order for someone to develop a maintenance program, one must understand the operation and impacts of the various components within the facility.

This paper discusses various components within a swine facility and identifies maintenance areas or issues for the various components. An effective maintenance program for a given swine facility is developed by combining the maintenance areas and issues that relate to the specific facility into a maintenance and service schedule. Maintenance recommendations and service intervals for various components are presented where appropriate.

Building Structure

Maintenance is required to protect the building structure itself. The building structure provides the foundation for the swine facility system. Rodent control is the important maintenance issue for the building structure.

Rats and mice can literally destroy the insulation within the walls and ceiling of a swine facility. Inside temperature control is difficult to manage without the insulation being intact and may be difficult to be kept at desirable levels. Inadequate temperature control is known to reduce pig performance. Walls and ceilings without intact and adequate insulation levels tend to sweat and even form frost on the inside surfaces. Wet surface conditions within a facility can reduce the health status of the pigs within the facility. Rodent damage can cause moisture to collect within the wall cavities. This moisture will damage and reduce the life of various structural components and limit the longevity of the building itself. Finally the rodents themselves can be spreading diseases in a swine operation.

Effective rodent control will not only help preserve the building structure but also allow for improved pig performance while allowing a high health status to exist within a well maintained building structure.

Manure Handling System

The manure handling system has a significant impact on the indoor air quality of a swine facility. Good indoor air quality will tend to allow for good pig performance as well as for a favorable working environment. Removing the manure from the pig space on a regular and frequent basis improves indoor air quality by reducing the amount and concentration of odors and manure gases. The ventilation system can reduce the impact of manure gases and odors on indoor air quality but usually not as well as by an effective manure removal system. So, maintaining a clean building with respect to manure removal helps allow for good pig performance.

The manure handling system needs to be maintained to remove the manure produced by the pigs from the building in an environmentally acceptable manner. Depending upon the specific system, different maintenance procedures and schedules may be required. In general, gravity drain lines need to be monitored to insure that they remain open and intact. Any recycle pumps and lines will require cleaning to remove any struvite build-up with a muratic acid or other solution on some regular basis.

If deep pits under buildings are utilized, close monitoring of the inside building environment during the pumping process should be done. Manure gases can be released from the slurry into the animal space. These gases can cause death of both pigs and people. Operating an effective pit ventilation system and providing high ventilation rates in the animal space during pumping periods can help reduce the possible deadly impact of manure gases on pigs within a facility. Having all pigs removed from the facility is the safest practice but may not be practical.

Fresh Water Systems

Several components within a swine facility use or distribute fresh water. These components include the drinking water system, any supplemental cooling system, and any pre-soak system. The quality of the fresh water source will directly affect the maintenance requirements of the various components. Maintenance and operation of these components will directly affect the efficiency of water use.

The drinking water system is the primary user of fresh water. The system provides the growing pigs with fresh drinking water. It is well know that water must be provided for the pigs and what the problems are if water is not available. So, insuring that the water system is delivering water is known. However, if the drinking water system is not properly maintained, excess water can be wasted and potentially increase manure handling costs. For example, if nipple waterers are used and one is leaking at the rate of a drop every second, about 6 gallons of water can leak from one leaky waterer per day. For example, if an 800 head grow-finish facility had 25% of the waterers leaking at the above rate, about 120 gallons of water will be added each day to the manure handling system. Extra water added to a manure handling system may or may not be a significant problem. But, even slow leaks that are continuous can add up to a significant amount of water over time. So, monitoring drinking water systems for leaks can be very important depending upon the manure handling system utilized.

If water leakage seems to be a continuing problem and the manure is handled as slurry, replacing the drinker system to cups or wet-dry feeders should be considered. The replacement cost of the drinker system can usually be offset from the decreased cost of manure hauling. Replacing a nipple drinker system to a cup system or wet-dry feeder system will generally reduce manure volume by 25% to 33%.

Sprinklers and/or misters used for supplemental cooling will use fresh water. The objective of sprinkler cooling is to wet the pigs, allow them to dry, and then wet them again. The real cooling potential comes from the drying of the water from the skin of the pigs and not really from the water flow itself. A typical management scheme for sprinkler cooling is to run the sprinklers for one minute out of every 5 to 15 minutes. The off time will depend on facility location, design and weather conditions. If sprinkler system is operated continuously instead of intermittently and has a flow rate requirement of 12 gpm, for each hour of continuous instead of intermittent operation, between 576 and 672 gallons of extra water will be added to the manure handling system. So, maintaining the sprinkler system controls to cycle the sprinklers on and off can significantly reduce the water added to a manure handling system during a summer season.

A pre-soak system can use a lot of water during its operation periods. Cycling the pre-soak system in a similar manner as for sprinklers does not appear to reduce the pre-soak function because it takes time for water to soak into caked, organic materials. So, cycling the pre-soak system will reduce the extra water that will collect in the manure handling system.

Water quality can have impacts on maintenance requirements of equipment. An evaporative cooling pad system will have significantly different maintenance requirements as well as life expectancy due to water quality. An evaporative cooling pad evaporates water into the air to reduce the temperature of the inlet air. Since the water evaporates off the pad, all salts and minerals will be deposited on and in the evaporative cooling pad. These salts and mineral build-ups need to be removed to maintain the pad itself. Evaporative pads using water with lower hardness levels will have less maintenance requirements and a long life expectancy than pads using harder water. A water softener will change the kind of salts that are in the water to ones that should be easier to clean from the cooling pads. However, if a water source without the initial hardness, such as a surface water source, is used, cleaning requirements for evaporative cooling pads will be reduced.

Feeders

Feed wastage is known to reduce profitability of an operation. Wasted feed costs money and directly reduces profits. Additional impacts exist from wasted feed above the initial cost of the feed. These additional impacts relate to the manure handling system and the manure spreading areas required.

Wasted feed in the manure handling system quickly increases the total solids of the resulting manure slurry. If the manure handling system relies on the slurry to flow during the handling process, wasted feed will thicken the slurry and reduce its ability to flow. Shallow gravity drain gutter systems that use little dilution water are most affected by feed wastage. Deep pits will probably develop significant pump out challenges due to feed wastage. Removing the thicker and probably increased volume of sludge will require significant agitation and pumping efforts. So, depending upon the manure handling system, feed wastage can be or not be a significant problem.

The other important impact of feed wastage relates to land available to spread manure. The nitrogen in any wasted feed will increase the amount of land required to spread the nitrogen in the manure. Vegetable protein in typical feed is about 16% nitrogen. A pig will utilize about 35% of the protein that a pig consumes and excrete about 65% of the protein. If the pigs ate 1000 lbs of a 14% ration, about 14.56 lbs of nitrogen will be excreted into the manure system (1000 lbs x 0.14 x 0.16 x 0.65). If the same 1000 lbs of feed was wasted into the manure system, about 22.4 lbs of nitrogen will be added to the manure system (1000 lbs x 0.14 x 0.16). This increase in the nitrogen quantity in the manure directly causes the spreadable acres to increase. An increase in the protein level of the feed will cause a larger increase in the additional nitrogen added to the manure system. So minimizing feed wastage will help reduce manure spreading costs.

Two sources of feed wastage exist in a swine facility. The first relates to the feeder itself. A properly adjusted feeder will minimize feed wastage without reducing pig performance. Because feed characteristics will change how feed flows though any given feeder, the feeders need to be checked daily to insure sufficient feed flow to the pigs while minimizing any feed wastage. The second source exists during clean-up times. Are feeders emptied prior to washing the facility in preparation for the next batch of pigs? Any residual feed should be removed prior to beginning the washing effort. Any feed left in the feeders is essentially wasted and will negatively impact the manure disposal system at some point.

If feeders are difficult to maintain adjustment and/or appear to be a main source of feed wastage, the existing feeders should probably be replaced. Feed savings and reduced costs for handling manure nutrients can quickly offset the cost of replacing feeders. The type of feeder to select for replacement in grow-finish or wean-finish should have a flat bottom, a front lip no more than 4” to 5” off floor, solid dividers, and a feed access space about 8” deep and 12” to 14” wide. If the water drinker system is fairly leaky, installing new wet-dry feeders will improve both feed efficiency and drinking water utilization.

Ventilation Operation and Management Issues

Various building systems will influence different building issues that affect pig performance. The ventilation system used in the facility influences five different issues. Basic information about ventilation systems and operation will be presented below. Impact on pig performance from other building systems will be presented later.

A) Ventilation System Basics
Mechanical and natural categorize the ventilation systems available for swine facilities. The building site and the desired structure impact the feasible methods available for ventilation. Both ventilation categories have some common basic functional components. Heating and cooling systems are often required to provide additional thermal comfort for swine. Both heating and cooling systems can be incorporated into both mechanical and natural ventilation systems.

1) Why Ventilate
The ventilation system is the primary system that regulates the thermal and gaseous environment of the pig. The failure of a ventilation system to provide the necessary conditions for swine production can and often does result in numerous swine health problems and lead to significant decreases in production performance and efficiency.

2) How Much
A required minimum ventilation rate is needed to provide for adequate indoor air quality removing moisture and other contaminants as well as maintaining life. The required minimum ventilation rate for pigs at various sizes is provided in Table 1 below.

Table 1. Target Minimum Ventilation Rates for Pigs at Various Sizes

Weight	Rate
Sow & Litter	20 cfm/crate
10-30 lbs	1 to 2 cfm/pig
30-50 lbs	3 to 4 cfm/pig
50-75 lbs	5 to 7 cfm/pig
75-180 lbs	7 to 9 cfm/pig
180 lbs – Adult (Mkt.)	10 to 12 cfm/pig

The target minimum ventilation rates, shown in Table 1, should be provided on a continuous basis and in a uniform manner. Cycling of ventilation systems on and off at a moderately high ventilation rate to give an equivalent required minimum air change over time in a building results in documented increases in ammonia levels within the building regardless of the manure management system.

The ventilation rate needs adjust to maintain desired inside conditions depending upon the outside temperature or season. Ventilation curves can be developed to show how the ventilation rates should adjust depending upon outside temperature. Basically, the required ventilation rate increases as outside temperature increases. As the outside temperature approaches the desired inside temperature, the required ventilation rate quickly approaches impractical rates and is then set for a maximum rate.

For hot weather conditions, one reasonable upper limit for the maximum ventilation rate would be for a ventilation system to deliver between 1 and 1.5 air changes per minute (acm) to the entire pig space being ventilated. Since the required ventilation rates significant changes with outside temperature, a ventilation system needs properly designed to allow for numerous delivery rates between required minimum and maximum rates and include a control system to allow the system to adjust ventilation rates automatically as the outside temperature changes.

3) Functional Components

All ventilation systems have five functional components. The five functional components are listed below.

1. **Inlet** - provides a location or locations for air to enter the pig space.
2. **Outlet** - provides the location for air to leave the pig space.
3. **Driving force** - provides the means to move air into, through and out of the pig space.
4. **Distribution** - defines how air moves through the pig space.
5. **Path** - must exist so that air can enter the facility, go through the inlet, pass through the pig space, leave through the outlet and finally exit the facility.

If all five functional components exist and are operating properly, the ventilation system probably is working for the given weather and animal stocking conditions. Identifying which functional component is missing or improperly operating solves most ventilation problems.

4) Operational Targets

The primary operational targets for a ventilation system include the desired air temperature and indoor relative humidity. These operational targets should be met as the first step to insure a ventilation system is operating efficiently. If these targets are compromised, pig health may be adversely affected.

The target air temperature will vary depending upon pig age and management preferences. Typical air temperatures and ranges are provided in Table 2. Setting the air temperature at low end of the temperature range for a given pig size will tend to optimize utility type energy usage. However, pig health must be diligently monitored.

Table 2. Target Temperature Ranges for Growing and Adult Pigs

Weight	Optimum	Range
Litter-newborn	95 8F	90-100 8F
Litter - 3 weeks	80 8F	75-85 8F
10-30 lbs	80 8F	75-85 8F
30-50 lbs	75 8F	70-80 8F
50-75 lbs	65 8F	60-70 8F
75-180 lbs	60 8F	55-70 8F
180 lbs - Adult	60 8F	50-70 8F

The indoor relative humidity should range between 40% and 70% for all pig sizes and temperatures. This humidity range tends to be the healthiest range. If the indoor humidity level is consistently below 40% or above 70%, the operation of the ventilation system should be examined. Low levels of humidity tend to increase dust problems and may indicate excessive energy use. Constant high humidity levels may lead to animal health problems.

Monitoring the inside relative humidity level provides a method to evaluate the delivered minimum ventilation rate. If the humidity level is low, the minimum ventilation rate is probably excessive. However, the minimum ventilation rate should be reduced only if other indoor air quality parameters remain acceptable. If the relative humidity levels are consistently high, the minimum ventilation rate should be increased.

During hot weather (when outside temperature is higher than 5 8F below inside desired temperature), the inside temperature should be within 2 to 5 8F of the outside temperature unless evaporative cooling pads are used. If the inside temperature consistently exceeds 5 8F above outside temperature, the hot weather ventilation rate delivered to the pig space should be increased.

5) Heating Options
Supplemental heating is required inside swine facilities when the sensible heat produced by the pigs is less than the combined sensible heat loss from the ventilation system and the building. This additional supplemental heat will typically either raise the inside temperature by warming the air or directly heat the pigs so the depressed inside temperature does not cause any significant cold stress or chilling.

a) Space Heating
Space heating is used to maintain the desired inside temperature by warming the inside air. Space heaters will typically circulate room air through itself while a heater is operating. While air is circulating through the heater, convective heat transfer heats the air as it passes over heated surfaces within the heater. The size and orientation of the heater will affect the room temperature distribution while the heater is operating.

b) Radiant Heating
Radiant heating is used to directly warm the pigs and potentially the floor under the heater. A radiant heater utilizes radiative heat transfer to exchange energy from the heater to the pigs. Therefore, the radiant heater itself does no direct space heating. Some room space heating does potentially occur from the heated floor warming the room air by convection heat transfer. Radiant heaters have been and will continue to be used in swine facilities. Heat lamps in and above sick pens are a typical application of radiant heating.

B) Exhaust Fan Issues
Exhaust fans serve as the foundation, the outlet and driving force, for mechanical ventilation systems. Fans and their accompanying shutters and grill guards should be cleaned on a monthly basis. Dirt on fan propellers and shutters can reduce the airflow delivered by the fan by as much as 40% of the rated fan capacity. So, cleaning fans will improve system effectiveness. Any other maintenance requirements for fans, such as belt tightening and lubrication, should also be done monthly.

Variable speed fans are often used to provide for minimum ventilation rates. When a variable speed fan is slowed to reduce the delivered ventilation rate, the variable speed fan will only effectively deliver about 1/3 or more of its rated full speed capacity. So if 1/3 of the full speed capacity is greater than the required target minimum ventilation rate as indicated in Table 1, the variable speed fan used will not effectively and consistently deliver the required minimum ventilation rate. The solution for these instances is to either physically throttle the existing fan operating at a higher deliverable speed to deliver the required minimum ventilation rate or install a smaller fan to deliver the minimum ventilation rate. Over-ventilating during winter conditions usually does not hinder pig performance but does increase energy usage and heating costs.

C) Inlet Operation and Management

The distribution of air within the swine facility will depend upon the ventilation equipment used and overall design of the system. The distribution of air within the pig space is depend upon the location of inlets and is often independent from the ventilation rate itself. Most draft type problems decreasing pig performance can be associated with distribution problems. All draft type problems are usually caused by one of two problem areas discussed below.

Inlet management and/or maintenance encompass the first problem area. An inlet with an improperly sized opening does not allow the inlet air jet to mix properly. Cold air entering through an inlet too slowly will tend to drop quickly and cause a cold draft on the floor in the pig space. Inlets need to be maintained such that the inlet openings are properly adjusting so the air jet blends and stirs with the inside air.

Undesired openings in the building shell encompass the second problem area. A common example of undesired openings are gaps around door. Exterior doors should not have gaps under them and should close tightly. Leaks around exterior doors typically cause drafts on the pigs because they will serve as misplaced inlets.

If the leaks are significant enough and numerous enough, leaks through the building shell can serve as natural ventilation openings that are not controlled. Uncontrolled openings will result in the inability to control the ventilation rate itself. Excessive ventilation rates in cold weather will cause a facility to be very dry and will usually increase heating costs. Or, inside temperature control will not be possible because the ventilation rate is essentially “out of control” due to uncontrolled openings.

D) Curtain Management and Maintenance

The curtain leakage issue is very important during cold weather periods. Curtain leakage problems begin in warm and hot weather. Curtains should be fully raised and lowered on a weekly basis during hot weather. Raising the curtains will dump any water from the curtain folds as well as discourage rodents from building nests in the curtain. Rodent control is very important to curtain maintenance.

In the fall, the following curtain maintenance steps should be performed.

- Repair all holes.
- Inspect and repair or replace the ropes and cable system.
- Adjust ropes to remove any curtain sags.
- Inspect and repair “pockets” on the end of curtains.
- Inspect and repair tie-down ropes, which keep curtains from “flopping” in the wind.

Fixing small holes is usually easier than repairing large tears, which can grow from small holes. If the curtain sags any where along its length, the sag can serve as an uncontrolled opening to ventilate the facility. If the "end-pockets" are not tight, excessive ventilation will occur around the ends of the curtains. This amount of curtain maintenance may seem extensive, but it should minimize the likelihood of a curtain failure during a winter storm.

E) Ventilation System Control

An important segment of a ventilation system is the control system or scheme to coordinate the five ventilation system components. The control segment provides the logic and control necessary for the ventilation system equipment to adjust the ventilation rate depending upon pig size and outside weather conditions. Control systems are required for both mechanical and natural ventilation systems.

Integrated controls and/or thermostats can automatically operate the ventilation equipment to adjust the ventilation rate. Inside temperature is the primary parameter to control ventilation equipment. Control for a ventilation system can be provided watching inside temperature and manually adjusting the equipment to vary the ventilation rate. However, manual control is not recommended because the operator must be available to adjust the system when weather conditions change and must completely understand the entire operation of the ventilation system itself. If the operator does not understand the operation of the system and how to match the various system components at various ventilation rates, the ventilation system will not function properly. An improperly functioning ventilation system can not only increase operating costs but also reduce pig performance due to inadequate environmental control.

The control system and the various ventilation system components operate in harmony when a system is functioning properly. Once a system is operating properly, all system settings should be left alone. If caretakers require and/or desire the need to adjust the inside temperature for pig comfort, integrated controllers should be used, and allow only the overall setpoint temperature to be changed. The setpoint temperature for an integrated control will allow the inside temperature to be increased or decreased without upsetting the overall operational harmony of the ventilation system.

F) Shallow Manure Pit System Impacts

In nursery facilities, shallow pit manure handling systems can be a significant source of moisture within the pig space. These shallow pits are gravity drain, pull-plug type systems and store liquid manure and/or effluent in a shallow pit under pen flooring. When newly weaned pigs are placed in a nursery, the room air temperatures are relatively high (greater than 85 8F) during the first week or so. The high room temperatures will warm the effluent in the pits. As the effluent temperature increases, the moisture evaporation rate increases from the surface. At this same time, the ventilation system is operating at minimum rates to minimize the amount of supplemental heat required to maintain room temperature. Sometimes, the increased moisture evaporating from the warm pit effluent causes excessive humidity levels in the nursery room. This excessive humidity can be removed by increasing the ventilation rate, but more supplemental heat will be required. A less expensive method to reduce the humidity would be to drain the warmed fluid from the pits and recharge them with cooler recharge water. Moisture will evaporate much slower from the cooler effluent resulting in a lower room humidity level without increasing the ventilation rate. This pit-recharging scheme works best with recycled water because no significant additional water is added, but this scheme can work with fresh water as long as the manure storage and handling system can accommodate the added water.

G) Multiple Room Issues

Multiple rooms within a common building shell are quite common with swine facilities. The concern with multiple rooms is to insure that air from one room does not enter another room. This issue is usually not a problem if considered during the initial planning stages of building construction.

Common Hallways can be considered a path for air to leave one room and enter another. This type of air exchange is not considered an issue when negative pressure ventilation is used in all rooms connected by the common hallway because any air leakage with an individual room will be into the room and not into the hallway. The same cannot be said for neutral pressure systems. If positive pressure systems are used in rooms, air will not be mixed unless exhaust air can enter the incoming air.

Common Pits will often serve as a path for air to travel from room to room. Only a positive pressure ventilation system in each room could minimize air exchange between rooms with common pits. However, all of the potential problems of using positive pressure ventilation will arise. The only sure fix for common pits is to construct the facility initially to have separate pits for each individual room. If interior doors exist between rooms in a multiple room facility, these doors can allow air to exchange from room to room like a common pit unless the doors close tightly and are always kept shut.

Building Effectiveness

How well a swine facility performs can be determined by its effectiveness. The effectiveness of a swine building is defined as whether a building can provide conditions needed for good pig performance and how well these conditions are maintained throughout the year. The conditions that need to be provided include temperature; humidity level; air velocity or movement; indoor air quality; space; waste removal or handling; and feed and water access. For a swine building to be effective, the building needs to have had all five of the following criteria addressed:

1. Properly **sited** to minimize any off site impacts;
2. **Designed** to incorporate any site limitations and management preferences;
3. **Constructed** to meet design specifications;
4. **Operated** to incorporate selected management preferences, and;
5. **Maintained** to meet design requirements and equipment recommendations.

All five of these criteria and activities must be integrated for the building to provide an optimal environment for profitable swine production.