pork industry handbook

Michigan State University Extension

Troubleshooting Swine Ventilation Systems

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Poor environmental conditions inside enclosed swine facilities are common throughout the country. Foggy, humid conditions, stale and smelly air, wet and/or frosted surfaces, messy pens, and excessively dusty rooms are symptoms caused, to some extent, by inadequacies in the building's ventilation system. Environmental problems may not be solved completely by a few ventilation adjustments, but these adjustments can result in significant improvement in the environment.

This fact sheet identifies common environmental problems that occur in mechanically and naturally ventilated pig facilities. Most of the problems described can be diagnosed by visual observation or with some simple tools. Troubleshooting environmental problems varies from relatively straightforward to very complex. Because every pig housing facility is different, the general advice or solutions presented may not solve a specific problem. Seek the help of an agricultural engineer or other professional who has an understanding of environmental control systems in pig facilities if simple adjustments do not help. However, for a majority of the time, significant improvements will occur when the general suggestions given in this fact sheet are implemented.

A properly designed and operating livestock ventilation system provides an environment which is desirable for pigs as well as for people. Pig well-being must have first priority. Farm workers unfamiliar with a properly operating system often will report the building is too cold or the fans are moving too much air. But, in fact, the system may be operating as designed and creating the proper environment for animal growth. Table 1 presents optimum temperatures and allowable ranges for pigs. Information on ventilation rates can be found in PIH-60, *"Mechanical Ventilation of Swine Buildings."*

Table 1. Air temperature optimums and ranges for housed swine.*

Animal Age/weight	Temperature (°F) at animal level Optimum	Desirable limits
Lactating sow	60	50-70
Litter, newborn	95	90-100
Litter, 3 weeks old	80	75-85
Prenursery, 12-30 lb	80	75-85
Nursery, 30-50 lb	75	70-80
Nursery, 50-75 lb	65	60-70
Growing-finishing	60	50-70
Gestating sows	60	50-70
Boars	60	50-70

* The effective "temperature" experienced by an animal is a function of air temperature, air speed, wall and ceiling temperature, and floor characteristics. High temperatures are required to compensate for the cooling effects of air moving across an animal during cold weather. In hot weather, pig comfort can be increased by purposely increasing air speeds in the pig zone. See PIH-54, *The Environment in Swine Housing.*

Troubleshooting Tools

Several simple tools can greatly aid in system diagnosis. Most can be obtained at relatively low cost from suppliers of safety and ventilation equipment or local heating contractors. Listed in Table 2 are some suppliers of troubleshooting equipment and the approximate cost.

Thermometer. Ventilation systems rely mainly on temperature sensing devices to control air exchange rates. A

Table 2. Ventilation troubleshooting equipment list.

The following listing of equipment is intended as an aid in obtaining equipment useful in evaluating ventilation systems. No endorsement is intended. Similar equipment by other manufacturers might be suitable.

Types of equipment	Approximate cost	Source/ Vendor
Equipment and instruments for measuring environmental factors that affect pig health and performance	call for catalog	Animal Environment Specialists, Inc. 7870 Olentangy River Road Suite 300 Columbus, OH 43235 Phone: 800/969-0114
4 in. Davis Vane Anemometer No. D1 10102	$424	Universal Precision Inst. 1199 Dunloe Road St. Louis, MO 63021 Phone: 314/394-4693
Carrying Case, No. D1 10203	$40	
Bendix Gas-Tec Detection Kit Catalog No. 363309 (syringe only)	$285	Curtin Matheson Scientific, Inc 9733 Loiret Lenexa, KS 66219 Phone: 800/650-0650
Tubes: Carbon Monoxide, No. 1LL (extra low range, 5-50 ppm) Carbon Dioxide, No. 2LL (extra low range, 300-5000 ppm) Ammonia, No. 3L (low range, 2-30 ppm) Hydrogen Sulfide, No. 4LL (extra low range, 5-60 ppm	$42/10 (all gases)	
***Note: "Extra low range" (LL) tubes are not listed as stock items in catalog but are available.		
Dwyer Air Velocity/Static Pressure Meter, No. 460	$20	Dwyer Instruments, Inc. P.O. Box 373 Junction Ind. 212 & U.S. 12 Michigan City, IN 46360 Phone: 219/879-8000
Sling Psychrometer, No. A-525	$60	
Pocket Thermometer (heavy duty/ plastic) No. A-510	$14	
Smokesticks, No. 15-049 (the type on which end of glass tube is crushed with cotton tip)	$46/12	E. Vernon Hill, Inc. 940 Adams St., Suite # G Benicia, CA 94510-2950 Phone: 707/747-5577
Syringe, No. 5607	$21	Mine safety Appliance Co. 8932 Bond Overland Park, KS 66214 Phone: 800/672-2222
Smoketubes, No. 5645 (used with syringe to force air through tube)	$46/10	

good thermometer is essential to checking actual conditions and calibrating thermostats which control fans. Thermostats should be calibrated at least twice a year. Thermostat "range" (points at which they turn on and off) also should be checked at the same time.

Psychrometer. A sling psychrometer consists of two thermometers suspended on a chain or sling. The sensing bulb on one thermometer is covered with an absorbent sock which is dipped in water prior to using (Figure 1). The two thermometers are then whirled on a sling in the area being investigated. A motorized psychrometer has the same basic components, but instead of manually swinging, this unit has a small electric fan which blows air over the thermometers. Both types of psychrometers produce readings known as "wet bulb" and "dry bulb" temperatures. These are used in conjunction with a chart furnished with the psychrometer to give relative humidity. Digital relative humidity meters are also available but at a higher cost, and with less accuracy

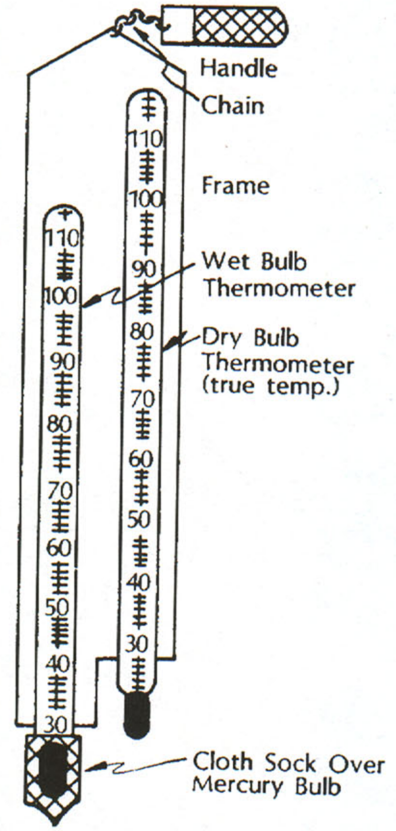

Figure 1. An inexpensive sling psychrometer can be used to measure wet and dry bulb temperatures which are used to determine relative humidity.

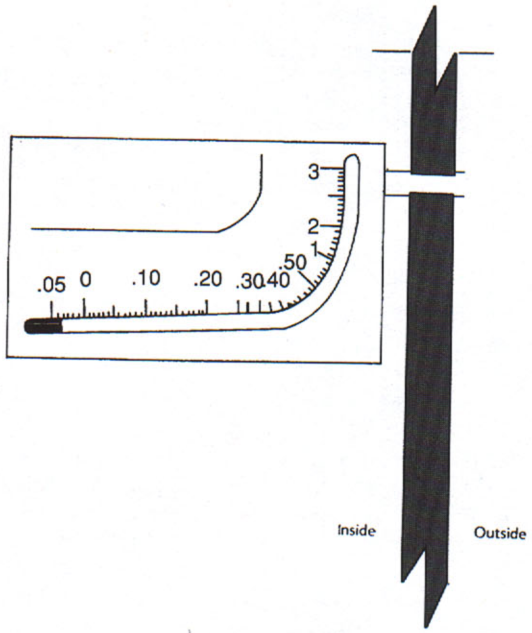

Figure 2. The manometer is used to measure static pressure difference between the inside and outside of a ventilated structure.

Figure 3. Measuring gas concentration.

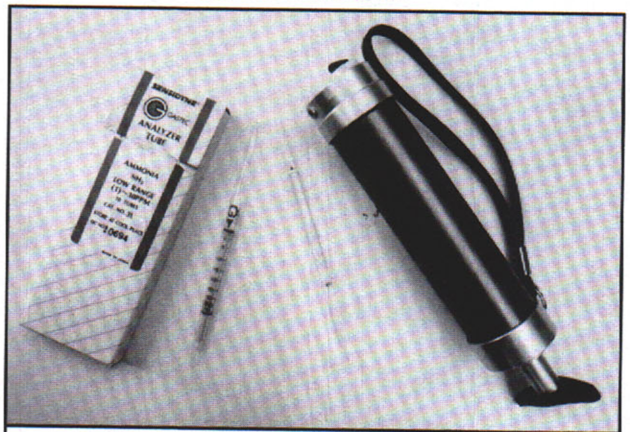

Figure 3a. Indicator tubes and syringe used to measure concentration of gases.

Figure 3b. Drawing an air sample.

than psychrometers.

Winter-time relative humidity within mechanically ventilated buildings should be between 50% and 80%. Humidities above 80% will result in excessive moisture condensation on building and equipment surfaces. High humidity frequently increases the incidence of disease.

Smoke Generator. Devices which produce smoke are used to "see" air patterns within a building. Smoke "sticks" produce relatively small amounts of smoke, but are very useful in showing air mixing if placed near inlet openings. Bee smokers and "foggers" produce considerably more smoke and can be used to locate dead spots or drafty locations within a building. Bubbles also can be used to trace airflows.

Manometer. A manometer measures the difference in atmospheric pressure between the inside and outside of a building (Figure 2). The difference is measured in inches of water column and is referred to as static pressure. Ventilation systems are usually designed to operate from .04 in. to 0.1 in. of static pressure. Measured static pressures below this range usually indicate poor distribution of incoming ventilation air. Static pressures above this range mean fans are prevented from delivering their rated air capacity or there are inadequate inlet openings in an exhaust ventilation system.

Anemometer. An anemometer measures air velocity or speed generally in units of feet per minute (fpm). This measurement is important when determining the presence of drafts, and if air inlet velocities are within the operating range of 200 to 800 fpm.

Gas Tubes. The measure of the concentration of certain gases found in pig facilities can be of value in troubleshooting ventilation systems. For example, the concentration of carbon dioxide (CO_2) may indicate that the building is over- or underventilated. The ammonia concentration may show how well the manure collection system is being managed.

Gas "indicator" tubes are small diameter glass cylinders filled with a chemical that is sensitive to a particular gas compound, for example, ammonia. Gas concentration is measured by breaking both ends of the tube and drawing a quantity of room air (typically 100 ml) through the tube using a special syringe (Figure 3). The concentration of the gas is indicated by a length-of-stain color change that the user compares to a scale printed on the side of the tube.

A variation to the instantaneous gas "indicator tubes" are the "diffusion" tubes. These determine the gas concentration using the same technology without the use of a syringe. The tubes are simply left in the space to be sampled and air moves into the tube by diffusion. The readings are given in concentrations per time period, so gas levels are determined by dividing by the number of hours of sampling.

Recommended Insulation Levels

When troubleshooting pig housing systems during the winter, check the inside surfaces along foundations and on walls and ceilings. Even though the ventilation system is properly designed and managed, wet or frosted surfaces during the winter months may indicate a lack of building insulation. For a mechanically ventilated barn, wall insulation should have R-values that range from the low teens in the southern U.S. to 20 in the northern states. Ceiling insulation R-values should range from the low 20's in the south to the low 30's in the north. In naturally ventilated barns, recommended R-values in the walls vary from 6 to 12, and from low to high teens under the roof, as one moves from southern to northern states. Foundation insulation levels should have an R-value of 6 to 8.

Any type of insulation needs to be covered on the inside by a vapor retarder. A vapor retarder (typically 4 or 6 mil polyethylene film) protects the insulation from getting wet from moisture that migrates from inside the barn through the wall and ceiling surfaces. Wet insulation has a greatly reduced R-value.

Troubleshooting Mechanically Ventilated Barns

Two common winter environmental complaints concerning fan ventilated pig barns are the excessive humidity (greater than 80%) and stale air which can result in high gas levels and/or excessively dusty conditions. The cause of this condition is a lack of ventilation or not enough air exchanges. This is more of a problem in the northern states where warm barn temperatures are maintained without the use of supplemental heaters in farrowing, nursery, and growing facilities. To solve the problem, remove a small amount of air from the barn and continuously replace with fresh outdoor air either directly or through a tempering area. Recirculating air within the pig space does not solve the minimum air exchange requirement.

Although inadequate ventilation is the primary cause of poor air quality, other influencing factors are: the method of manure collection and storage; slotted floor design; method of feed handling and distribution; and sanitation management.

Minimum ventilation requirements for various sizes of pigs are listed in Table 3.

Table 3. Minimum ventilation requirements for pigs housed in mechanically ventilated buildings.*

Pig size/age	Weight, lb	Cold weather rate, cfm/pig
Sow and litter	400	20
Prenursery pig	12-30	2
Nursery pig	30-75	3
Growing pig	75-150	7
Finishing pig	150-220	10
Gestating sow	325	12
Boar/Sow	400	14

*Adapted from **Mechanical Ventilating Systems for Livestock Housing,** MWPS-32, Table 2.

The following list presents the problem, cause and solution to above-normal barn concentrations of ammonia, hydrogen sulfide, carbon dioxide, carbon monoxide, and dust in mechanically ventilated swine facilities.

Problem: Excessive (greater than 10 ppm) levels of ammonia (NH_3)
Cause: Too much manure, especially urine, is being left on solid surfaces, either in drain gutters or on floors.
Solution: Keep pen floors clean and leave some water in gutters to completely cover solids that are stored temporarily.

Problem: Excessive (greater than 5 ppm) levels of hydrogen sulfide (H_2S)
Cause: Most measurable levels of H_2S will occur during the agitation of below-floor (pits) manure storage prior to its removal.
Solution: Provide more airflow through pig zone. Check fans and inlets.

When manure in the pit is being agitated and pumped, do not allow people inside the building. If possible, remove pigs from the barn when the manure in the pit is being agitated and pumped. Provide maximum ventilation through the barn during this critical time period and for 24 hours after stirring.

CAUTION: Hydrogen sulfide is a very dangerous gas which can cause serious complications for both pigs and people even at very low concentrations.

Problem: Excessive (greater than 3000 ppm) levels of carbon dioxide (CO_2)
Cause: Carbon dioxide is almost exclusively produced by the pig's respiration, so its concentration is a good indication concerning sufficient air exchanges in the barn. Concentrations up to 5000 ppm can be tolerated for brief periods. Levels above 20,000 ppm are needed to have any physiological effects on people or animals.
Solution: Increase ventilation rates to minimum or cold weather levels.

Problem: Excessive (greater than 50 ppm) levels of carbon monoxide (CO)
Cause: The most common source of carbon monoxide in a pig barn is from the incomplete burning of fossil fuels like LP gas, fuel oil or kerosene.

Solution: Make sure gas and oil heaters, and gas powered washers are regularly cleaned, maintained and operating properly.

Problem: Excessive levels of dust

Causes: Dust sources in pig barns are feed, dried manure, and dander from the pig's skin. A high level of pig activity, excessive ventilation rates, and poor sanitation and cleaning practices all can increase the airborne dust concentrations.

Solutions: Workers should wear a dust mask in problem pig barns. Use pelleted feeds and/or add oil or fat to the diet. If possible, use lids on feeders to reduce dust when adding feed via an automatic delivery system. Use pipes on feed augers to limit the distance feed "drops" into feeders. Do not overventilate the barn, since this tends to make the air drier and dustier especially if supplemental heat is being provided. Over ventilation also increases heating costs. Spray pigs with an oil-water solution to reduce dust from the pigs themselves and also during periods of animal activity.

Problem: Drafts. A draft is cold or cool air moving in the pig zone at a velocity which is chilling the animals.

Cause: Drafts are caused by improperly adjusted air inlets of negative or exhaust ventilation type systems.

Solutions: Many individuals incorrectly attempt to solve a draft problem by closing up air inlets, which means that the same amount of air (assuming the same exhaust fans are operating) must now enter through less inlet area. The result is that MORE drafts are created and the problem gets worse. If, instead, air inlet area is INCREASED, while the same amount of air exchange is provided by the exhaust fans, the velocity of the incoming air through these inlets will be reduced and the draft will be eliminated.

Cause: Incoming air is shooting or falling directly on pigs.

Solutions: Adjust inlets so fresh air mixes more within the room and the air velocity is sufficiently reduced in the pig area. Maintaining a static pressure in the barn between 0.04 in. and 0.1 in. water gauge generally will insure that the air velocity through inlets will be sufficiently low to avoid a draft. Young pigs are much more sensitive to drafts than are most older animals. Providing a hover or covered creep area may be necessary to totally eliminate drafts for piglets. Eliminate timer-controlled and variable speed fans. Install a continuous operation cold weather fan and adjust inlets.

Cause: Obstructions, (e.g. light fixtures or feed auger tubes), are deflecting the incoming air jet (draft) down into the pig area.

Solution: If possible, remove or move obstruction, or adjust air inlet so incoming air is not deflected.

Cause: Excessive recirculation systems are causing drafts.

Solution: Reduce or avoid ventilation systems with high recirculation rates to not only eliminate drafts but also to lower airborne dust levels.

Problem: High temperatures, wide fluctuations in building temperatures, non-uniform conditions within the building and high heating bills. High temperatures inside a pig barn often are a problem during summer months, but can be a concern in northern climates during temperate times of the year. Animal production levels often are reduced because of these excessive inside temperatures, primarily because of depressed feed intake. Therefore, having the temperature too warm may be less economical than if the barn is too cold.

Causes: Insufficient air exchange caused by:

-inadequate fan capacity (not enough ventilation)
-variable-speed fans blowing in the wind
-insufficient air inlet area which does not allow for the recommended air exchange
-too much recirculated air
-inadequate attic or hallway inlet area
-poorly maintained and dirty fans which reduce air delivery capacity
-short-circuiting
-improper locations of thermostats
-controls either on fans or heaters are not functioning properly
-inlet air is not being directed into the pig zone which causes pigs to be too warm even though airflow rates are correct

Solutions: Make sure warm weather ventilation rates are followed.

- Provide at least 1 sq ft of inlet area for every 800 cubic feet per minute (cfm) fan capacity.
-If air is removed from an attic or hallway/storage space, sufficient inlet area into that space also is needed (suggest 1.5 times or 50% additional open area than the ceiling or slot inlet area in the pig space).
-Service and maintain (at least yearly) ventilation components such as fans, inlets, and controls.
-Use controls which "interlock" the operation of heaters and thermostatically controlled ventilation fans so these two components never operate simultaneously.
-Make sure inlet air is being directed into the pig space (within 2 ft of the floor), not just the people space.

Cause: Too many pigs in a facility. Pigs, especially finishing and breeding animals, produce a sizable amount of heat which needs to be removed with ventilation air exchange.

Solution: Do not overpopulate or crowd a pig facility because the ventilation system will not be adequate and other stresses will be placed on the pigs with generally adverse results. Match stocking rates to the facility design.

Problem: "Dead" air areas

Cause: In the summer, many fan-ventilated pig barns experience very poor air distribution or the existence of numerous "dead" air areas. Air distribution is determined almost exclusively by the size and location of the air inlet system in the barn. If large doors or windows are left open in the summer, the effectiveness of the ventilation system is greatly hindered. In order for air to enter the barn through the designed air inlets at a velocity to provide sufficient mixing (at least 800 feet per minute), a static pressure of at least 0.1 in. of water gauge is needed. Opening large windows and doors in a barn will reduce the static pressure (or vacuum), lowering incoming air velocities. The result is "dead" air areas.

Solution: Keep doors and windows closed in fan-ventilated barns so the system can function as it was designed.

Naturally Ventilated Facilities

Many of the same environmental problems already mentioned for mechanically ventilated units also occur in naturally ventilated pig facilities. The causes and solutions differ somewhat because natural ventilation operates under very different principles. It is important to remember that ventilation control is not as precise with natural systems as it is with mechanical ventilation systems. Therefore, do not expect to maintain as warm or uniform a temperature inside a naturally ventilated barn as compared to a mechanically ventilated barn. The following is a list of causes and solutions to common problems in naturally ventilated systems:

Problem: Humid, stale, warm air
Cause: Inadequate air exchange.
Solution: Open inlets and/or outlets so more air can be exchanged in the barn.

Problem: Too cold in the barn
Causes: -Insufficient number and/or size of pigs in the barn.
-Too much air flow through the barn for the number and/or size of pigs.
-Not enough insulation in walls and under the roof.
Solutions: -Maintain adequate stocking densities, especially during the winter.
-To obtain more precise control of air exchange, use a temperature-sensing controller that automatically adjusts the barn inlets and possibly the ridge opening or outlet.
-Provide adequate insulation levels under the roof and on the sidewalls (see section on insulation) to prevent condensation, provide warmer interior surfaces, and reduce overall heat loss.

Problem: Static or dead air during warm outside temperatures
Cause: Natural ventilation is driven in the summer primarily by wind forces. During periods of high outside temperature with little or no wind, very little air exchange will occur.
Solution: Provide inlet openings which are at least equal to half the wall area on the prevailing wind side (generally south) and 1/3 of the wall area on the opposite side. Consider the use of circulation fans (generally providing a circular inside air flow pattern) during warm and windless days.

Summary

Ventilation systems should be designed, constructed and installed so that a minimum of troubleshooting is necessary once the unit is installed and operating. However, the same principles used in the design of new systems can and should be used when an existing system needs modification. This fact sheet has presented a brief description on troubleshooting mechanical and natural ventilating systems. For more information on mechanical and natural ventilation, or heating, cooling and tempering air, refer to the MidWest Plan Service (MWPS) series of ventilation handbooks. Contact the Midwest Plan Service, 122 Davidson Hall, Iowa State University, Ames, IA 50011-3080 (1-800-562-3618) for more information on the Mechanical Ventilating Systems (MWPS-32), Natural Ventilating Systems (MWPS-33), or Heating, Cooling and Tempering Air (MWPS-34) handbooks.

Also, Pork Industry Handbook fact sheets PIH-60, *Mechanical Ventilation of Swine Buildings*, and PIH-120, *Non-mechanical Ventilation of MOF Swine Buildings* are useful references.

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