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David Brown

Logo Design
Ruth Cronje, and Jan Swanson;
based on the original design by Dr. Robert Dunlop

Understanding common ventilation system mistakes

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While many readers of this proceedings are expecting to see a listing of mistakes, along with examples of problems and solutions, the biggest problem with ventilation management on farms is a lack of understanding by builders, growers, managers, and owners of what 'normal' is for a given production facility. This lack of understanding of 'normal' leads to the litany of mistakes commonly seen in production facilities.

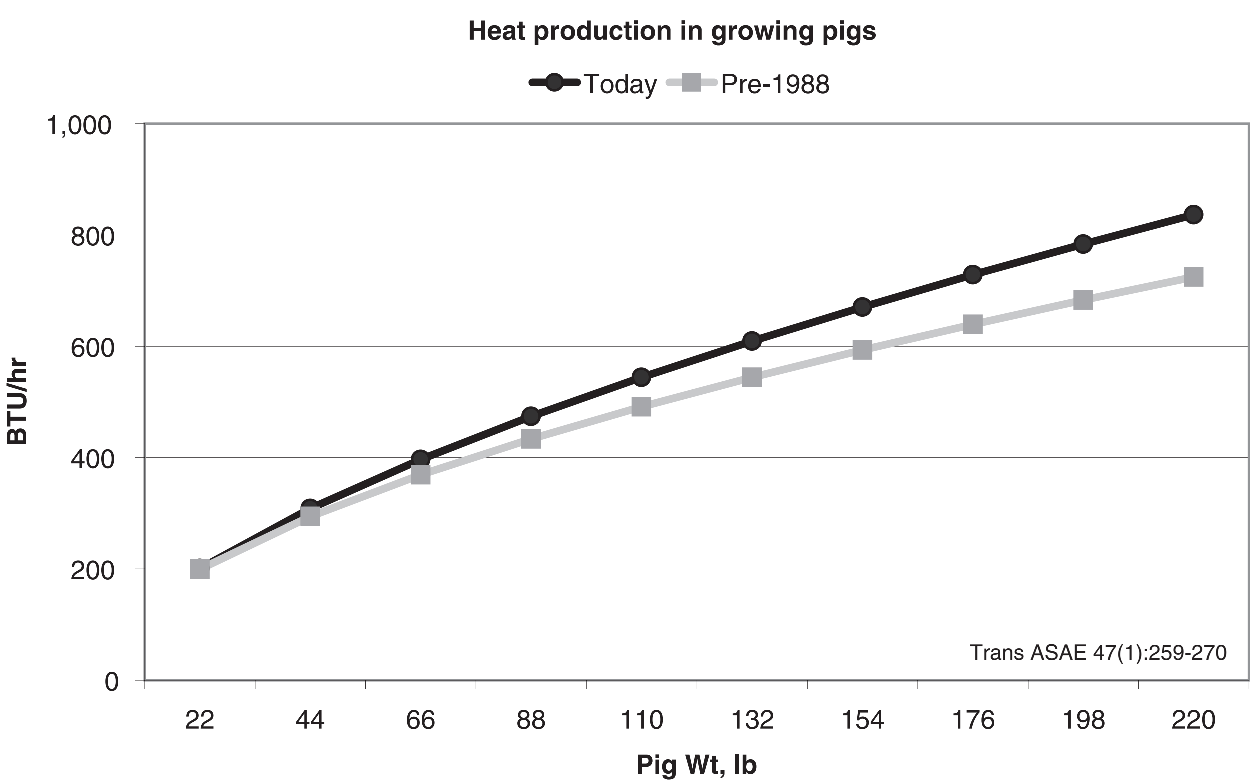
Almost 100% of the ventilation systems installed are controlled using temperature as the decision criteria. This means fans and heating devices turn on and off depending on the temperature sensed by a probe or series of probes in the animal space.

For a majority of the year, even in northern climates, ventilation systems are operating in heat removal mode. That is, pigs in the facility are producing enough heat that the ventilation system responds by increasing the air exchange rate, resulting in excess heat being removed from the facility. The challenge lies in the fact that genetic progress in regards to lean gain and milk output in lactating females has resulted in pigs which create more heat than pigs of 10 or 20 years ago.

Pig heat production

Figure 1 depicts the total heat production (sensible heat plus latent heat) from grow-finish pigs for studies done before 1988 and 1989-2002 (Brown-Brandl et al, 2004). Note the 10-15% increase in total heat production for the 1989-2002 generations of growing pigs. While data is not currently available in the literature for the current generations of growing pigs, based on the relative improvements in lean growth and overall health, the current generations

Figure 1: Estimate of total heat production by growing pigs.



Production

of pigs are estimated to be 10-15% above previous generations in regards to heat production.

The same increases in heat production have been occurring in lactating females as the industry has made progress in increasing the milking ability of these females. Danish researchers estimate that a lactating female weighing 400 pounds generates 1438 btu/hr of heat, with 932 btu as sensible heat and 506 btu as latent heat (Pedersen, 2002).

Modeling balance point temperatures

With estimates of pig heat production, building shell heat loss and the physics of air heat transfer (MWPS, 1977), it is possible to model how production facilities should operate. Table 1 is a model for a typical upper Midwest wean-finish facility. The building shell is estimated to have ceiling insulation at R = 30 and have curtain side walls and un-insulated concrete stem walls. For a 1200 head room (40 × 240 ft or 50 × 196 ft), a typical installed ventilation system would be:

Stage 1 – 2 24" variable speed fans installed on pit pump plenums

Stage 2 – 2 24" variable speed fans installed on pit pump plenums

Stage 3 – 1 36" single speed wall fan

Stage 4 – 1 52" single speed wall fan

In most installations, the 24 inch pit fans are rated at 5000-6000 cfm when operated at 0.05" static pressure. For purposes of this discussion, assume 6000 cfm as the capacity of these fans. With this information it is now possible to model how the ventilation system responds to changing temperatures as the pigs grow. The temperature estimates in Table 1 are 'balance point' temperatures. That is, these represent the temperature of the air entering the room at the ceiling inlet which results in the room being in balance for heat. Heat loss from the ventilation system at the cfm given along with heat loss from the building shell just equals heat production by the growing pigs. If incoming air temperature is lower than balance point, the room will gradually cool and furnaces or other heat sources will be needed to maintain desired temperature in the facility. If incoming air is warmer, the room gradually gains heat. Other than days when there is significant solar heat gain in an attic area, these temperatures can be thought of as outside air temperatures.

Table 1 has been very helpful in trouble shooting ventilation concerns as it helps define what should be happening within a wean-finish or grow-finish facility. If fans are not operating at the approximate temperatures indicated in Table 1, is the problem with the sizing of the fans in the various stages, with the controller settings or with possible restrictions in air inlets into the facility?

Table 2 is a model of ventilation performance for a breed-wean site with 24 crate farrowing rooms. Heat production by the sow is estimated for the second week of lactation when milk production is rapidly increasing, as is feed intake by the lactating female.

Note the balance point temperature of 44˚F when the ventilation rate is 31 cfm/crate. In facilities with pre-heat hallways, this means that anytime the pre-heat hallway is warmer than approximately 44˚F, the ventilation system within a farrowing room will increase speed as the incoming warm air results in the room gradually warming. As a general rule of thumb when using pre-heat hallways for farrowing or nursery facilities, the hallway temperature should be decreased as the minimum ventilation rate decreases. In most cases, preheat hallway temperatures warmer than 45˚F result in increased fuel expense since the warm incoming air into farrowing and nursery rooms results in increased ventilation rates aimed at heat removal.

Variable speed fans

Another major ventilation mistake common to the swine industry is a failure to understand how variable speed fans operate and how they are controlled by various controllers. All too often, producers and their advisors assume that 50% minimum speed on a controller equates to 50% of the cfm of the fan.

Most variable speed controllers vary the speed of the fan by altering the voltage to the fan. Every fan motor responds differently to voltage. In Figure 2, the response of 3 commonly installed variable speed fans is graphed versus voltage. Note that the 12" fan responds to very small increments of voltage change, and the fan is at almost 100% of its cfm output when the fan is supplied with 120 volts when wired into a 230 volt system.

Contrast the 12" fan to the 24" fan, where it is at only 20% of rated capacity at 120 volts. The fans graphed in Figure 2 attain 50% of their cfm at 107 volts for the 12" fan, 132 volts for the 18" fan and 142 volts for the 24" fan. While each fan varies in response to voltage, they may all be installed using the same controller.

Thus, each controller installation must be customized for the fan(s) that are installed in the variable speed stage(s). Many controllers have user selectable motor curves that allow the controller voltage signals to fans to be tailored to specific fans. In the case of Thevco controllers (Airstream, Acme and Aerotech), there are 10 user selectable curves that define this response. Varifan controllers have 8 motor curves while HiredHand controllers have 3 or 4 curves. The Phason Supra has 5 curves, while other controllers manufactured by Phason often have a 'power factor correction'. Failure to use the correct curve or correction

Production

Table 1: Estimates of balance point temperatures in wean-finish facilities.

No Pigs	**2400**						
Curtain Sided Tunnel - 2 room 81' x 240'							
Ventilation Stage	**No Fans**	**Diameter**	**cfm/ fan**	**Variable Speed**	**Controller Settings**		
					Bandwidth	**Differential**	**Minimum**
1	2	24	6,000	yes	2		50%
2	2	24	6,000	yes	2	1	50%
3	1	36	12,000	no		2	
4	1	48	20,000	no		2	

			Stage 1			**Stage 2**		**Stage 3**	**Stage 4**
	cfm/pig:	2.5	5	10		15	20	30	47
	Set Point								
Pig Wt	**Temperature**	**1 fan @ 50%[a]**	**50%**	**100%**		**50%**	**100%**		
lb	**F deg**		-----------------------------**F Degree Balance Point------**						
25	78	16	43	61					
50	70		23	45		54	61	67	73
100	68		-4	29		42	51	60	67
150	65		-27	14		31	42	53	61
200	63		-47	2		22	34	47	57

[a]This is 50% of fan output, not necessarily 50% minimum speed setting on the controller

Note - At outside air temperatures between stages, the next larger stage will be cycling on/off. The balance point is the outside air temperature at which the indicated stage operates 100% of the time.

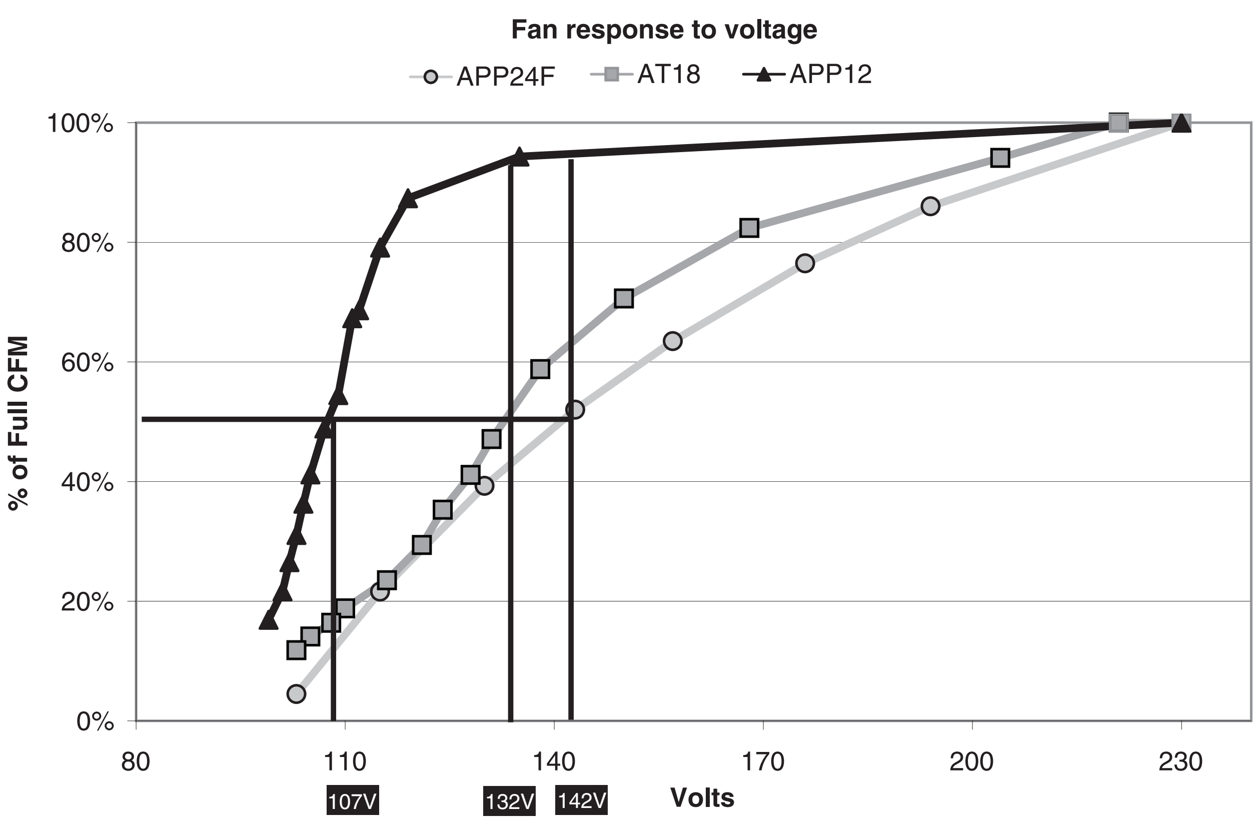
Table 2: Estimates of balance point temperatures for farrowing facilities.

No crates/ room	24						
Ventilation				Variable	Controller Settings		
Stage	No Fans	Diameter	cfm/fan	Speed	Bandwidth	Differential	Minimum
1	1	12	1,500	yes	2		50%
2	1	16	3,200	yes	2	1	50%
3	1	24	7,200	no		2	

		Stage 1		Stage 2		Stage 3
	cfm/crate:	31	62	129	196	495
	Set Point					
Sow Wt	Temperature	50%	100%	50%	100%	
lb	F deg	-----------------------------F Degree Balance Point------------------------				
400	68	44	57	65	69	74

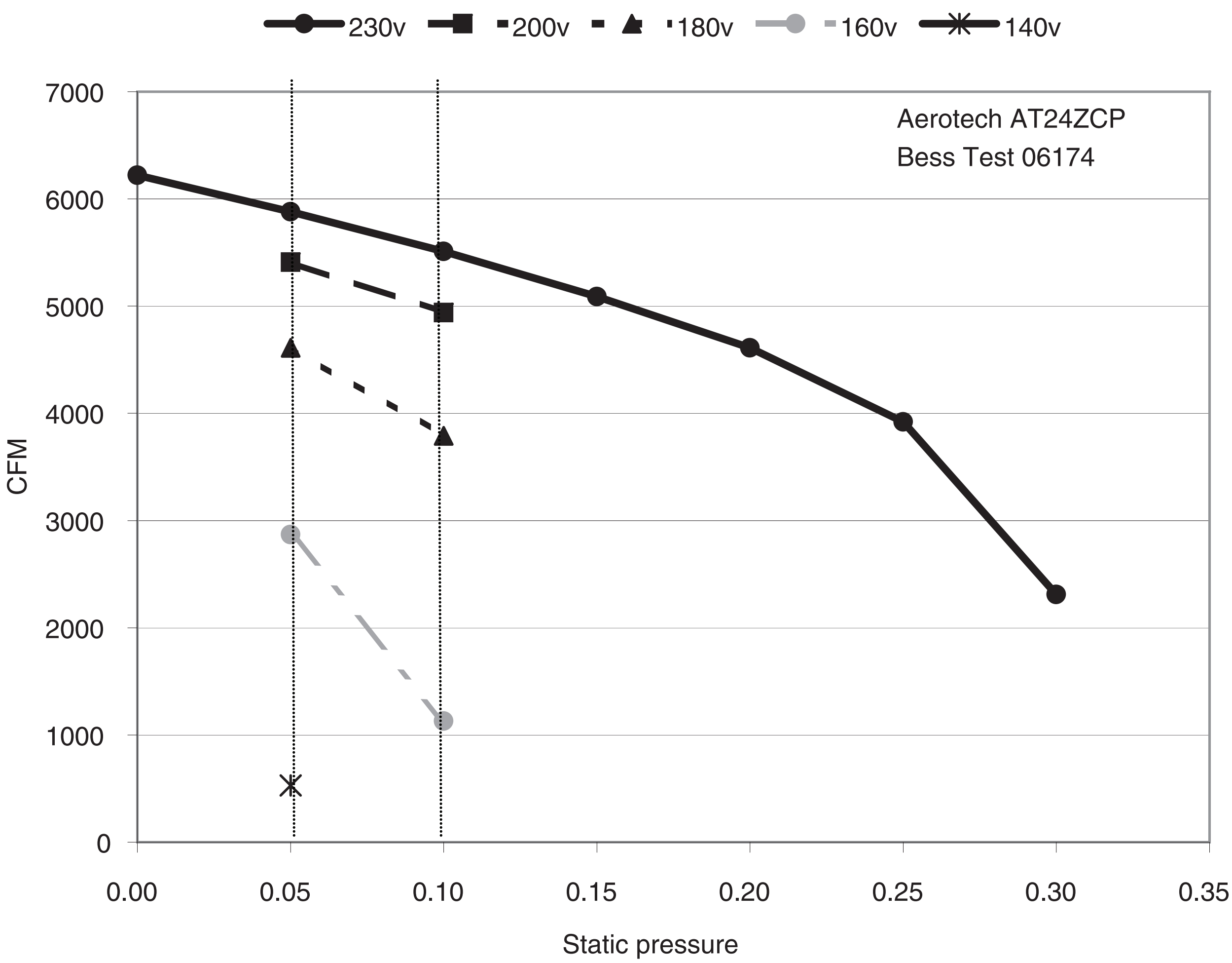
Note - At outside air temperatures between stages, the next larger stage will be cycling on/off. The balance point is the outside air temperature (or pre-heated hallway) at which the indicated stage operates 100% of the time.

Figure 2: Response of 3 commonly installed variable speed fans to controller voltage.



Production

Figure 3: Response of a commonly installed variable speed fan to static pressure.



factor is a common reason why variable speed fans do not perform as expected.

A second common mistake made with variable speed fans is to run the fans at a speed that is too slow. In general, most variable speed fans use TEAO (totally enclosed air over) motors. Because of the need for constant air movement over the motor for cooling, these motors should never be run for extended periods of time at anything less than 50% of the rated rpm of the motor. Assuming correct motor curve usage in Thevco controllers, this means they should never be set at less than 40% minimum speed.

As variable speed fans slow down, their ability to create static pressure decreases, Figure 2 depicts the Bess Laboratory (www.bess.uiuc.edu) results for a 24" fan commonly installed as a variable speed fan in wean-finish facilities. Note that when static pressure increases to 0.1 inches (as would happen when wind blows into a fan), the fans ability to move air declines. In general, the slower a variable speed fan runs, the greater the effect of wind on the fan. In installations where there are 2 or more variable speed fans on stage 1, anytime the fans need to run at less than 50% of the rated cfm to attain the desired minimum ventilation, consider unplugging or otherwise turning off one of the fans and run the remaining fan(s) at a higher speed.

The following are general rules of thumb that apply to variable speed fan applications:

- 65% speed generally equates to 50% cfm.
- 50% voltage does not equal 50% cfm/rpm for every fan.
- Every fan motor reacts to voltage differently in terms of rpm response.
- Minimum speed should be no slower than 50% of the rated rpm.
- How variable speed fans are controlled varies by brand and model of controller.

Attic inlet errors

While fans often receive the blame for ventilation mistakes, another common cause of problems is improper inlet sizing. In many situations, the improper sizing isn't related to the ceiling inlets, but rather relates to the attic inlet. Ceiling inlets are sized to provide air at 0.05–0.1 inches of static pressure, the same static pressure that fans are sized to operate at. To avoid problems with restrictions in ceiling inlets, the openings into the attic space must be large enough so there is minimal static pressure restriction.

Ridge ventilators cannot be used as attic inlets for ventilation purposes. Dr Jay Harmon, extension ag engineer at Iowa State University, has calculated that a 10 mph wind blowing across the ridge of a roof equates to 0.05 inches of static pressure up draft, while a 20 mph wind equates to 0.2" of static pressure uplift. Static pressure restrictions are additive in ventilation systems. This means in systems which rely on ridge ventilators as attic inlets, on days with a 20 mph wind, the variable speed fans must operate at pressures of 0.25" or higher (0.2" from the ridge ventilators and 0.05" or higher from the ceiling inlet).

A second common error with eave and gable attic inlets is insufficient area. The rule of thumb is 1 square foot of attic inlet for each 400 cfm of fan capacity. This rule of thumb is often violated in double-wide facilities. The north or west eave (depending on building orientation) is often closed to prevent snow from blowing into the attic area during winter conditions. If the eave inlet on the opposite side is only 6" wide, for a 196 ft long facility, the total fan capacity that can be serviced by the inlet is 39,200 cfm (98 sq ft of inlet area × 400 cfm/sq ft). If the facility has 2 rooms, and each room has 2 24" variable speed fans per stage for stages 1 and 2, the attic inlet capacity for these stages is 48,000 cfm (8 × 6000 cfm/fan).

Add to this sizing error mistakes in installation of insulation stops and other restrictions to air entry to the attic and the result becomes rooms starved for air in stages 2, 3, and 4 of the ventilation system. The net result is higher operating costs as fans don't operate to design capacity, meaning heat removal per stage is less. More fans operate at higher static pressure, leading to more motor failures and higher electricity bills.

References

1. Brown-Brandl, T.M., J.A. Nienaber, H. Xin and R.S. Gates. 2004. A literature review of swine heat production. Trans. ASAE 47(1):259–270.

2. MWPS. 1977. Structures and Environment Handbook. MWPS-1. Midwest Plan Service, Iowa State University, Ames.

3. Pedersen, S. 2002. Heat and moisture production for pigs on animal and house level. ASAE Paper 024178, Amer. Soc. Ag. Eng., St Joseph, MI