A warm confinement livestock building is one that is closed, insulated and operated in a way that keeps inside temperatures higher than and independent of outside temperatures during winter months. A mechanical ventilation system is an essential part of the warm confinement building.

A good ventilation system must

- Provide fresh air to meet respiration needs of the animals
- Control the moisture build-up within the structure
- Move enough air to dilute any airborne disease organisms produced within the housing unit
- Control and/or moderate temperature extremes.

Each of these four provisions requires some optimum rate of air exchange. However, if respiration and temperature control are provided for, moisture build-up and disease control will be satisfactory.

The basic process that occurs with all successful ventilation systems is as follows:

- Cool, dry air is drawn into the building.
- Heat and moisture are added to the air.
- Warm, wet air is expelled from the building.

Failure to provide for any part of this process will result in failure of the ventilation system.

**Insulation**

During winter months, heat is the energy that makes a ventilation system work. Heat added to cool outside air increases its temperature and its ability to hold moisture. About 1,200 Btu of heat energy are required to evaporate each pound of free moisture removed by the ventilation system.

Mature and growing animals produce enough heat to operate a ventilation system if insulation is used to reduce heat losses. Maternity buildings and
other facilities to house young animals require supplemental heat to maintain an optimum environment during winter. Supplemental heat may also improve the ventilation system performance in poorly insulated growing or production facilities. However, this practice has never proven to be economical on a long-range basis.

Minimum insulation levels for buildings where artificial heat is not required are:

- Walls: Resistance = 9-12
- Ceilings: Resistance = 16

Increasing energy costs have made increased insulation economical in any building where artificial heat will be used to maintain a desired environment. Minimum insulation levels for maternity buildings, farrowing houses and brooding facilities are:

- Walls: Resistance = 13
- Ceilings: Resistance = 24

Resistance (R) is a measure of a given material's ability to resist the flow of heat through it. The higher the resistance number, the better an insulation material is. All insulating materials sold today have a resistance value marked either on the package or on the material itself.

Several publications on insulation of agricultural buildings are available through your local MU Extension center.

**How much air?**

Air requirements vary with animal size and outside environmental conditions. The ideal ventilation system would be infinitely variable. During extremely cold weather, it should move just enough air to satisfy respiration needs, and in hot weather, the maximum rate should eliminate heat stress. Unfortunately, the equipment and control cost for such a system is prohibitive today.

A ventilation system should be designed to provide at least three levels of air movement. The lowest, or minimum, level provides enough air to meet respiration requirements and operates continuously. This lowest level provides all the air necessary during periods of extremely cold weather or in buildings where a supplemental heating system is in operation. A thermostat may be used to shut off the minimum level in the unlikely event that building temperature drops to near freezing.

The second, or intermediate, level of ventilation provides enough additional air movement to control both temperature and moisture during normal winter conditions. Fans that provide this additional air are usually controlled by thermostats that turn them on whenever building temperature reaches the desired level.

The high, or maximum, ventilation rate is intended to provide some degree of temperature control during summer months. Maximum rate fans are controlled by thermostats that turn them on when interior temperature exceeds some set level, usually 75 to 80 degrees Fahrenheit.

Table 1 presents the recommended ventilation rates for several different types of livestock. The rates shown are totals required for each level and
not additive. This means that a total of 120 cubic feet per minute of air (cfm) per 250-pound pig is required for summer ventilation. This would be delivered by a winter minimum fan providing 10 cfm, a winter average fan providing 25 cfm and a summer fan providing 85 cfm, all operating to make up the total of 120 cfm.

### Table 1
Recommended ventilation rates for livestock in warm confinement buildings

<table>
<thead>
<tr>
<th>Animal</th>
<th>Desired room temperature (degrees Fahrenheit)</th>
<th>Ventilation rate in cubic feet of air per minute per listed unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Winter minimum</td>
</tr>
<tr>
<td>Sow and litter</td>
<td>60-80</td>
<td>20</td>
</tr>
<tr>
<td>40-pound pig</td>
<td>70</td>
<td>2</td>
</tr>
<tr>
<td>100-pound pig</td>
<td>60</td>
<td>5</td>
</tr>
<tr>
<td>150-pound pig</td>
<td>60</td>
<td>7</td>
</tr>
<tr>
<td>250-pound pig</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>Dairy cow</td>
<td>55</td>
<td>35</td>
</tr>
<tr>
<td>Dairy calf</td>
<td>55</td>
<td>10</td>
</tr>
<tr>
<td>Beef — per 1,000 pounds</td>
<td>55</td>
<td>15</td>
</tr>
<tr>
<td>Poultry — per pound</td>
<td>55-60</td>
<td>0.125</td>
</tr>
<tr>
<td>Horse — per 1,000 pounds</td>
<td>55</td>
<td>25</td>
</tr>
</tbody>
</table>

Ventilation rates based on animal weight or per animal tend to eliminate animal density as a factor in ventilation system performance. Rates based on air changes per hour for the building neglect the variation in animal heat and moisture production associated with different housing densities. For example, a 40-by-200-foot poultry house containing 10,000 birds in cages needs a different ventilation rate than the same building with 4,000 birds in a floor operation.

The summer rates given in Table 1 provide a reasonable degree of temperature control at an economical operational level. Higher rates provide slightly lower temperatures; however, they can not be economically justified.

The desired room temperatures indicated provide a basis for adjustment of the fans that provide intermediate levels. The temperatures given are those that give optimum animal performance.

**Fans**
Most of the agricultural ventilation systems installed today are exhaust-type systems. These systems use exhaust fans to provide a partial vacuum within the building that causes fresh air to enter.

Fans used in livestock buildings are subjected to a dusty and corrosive environment. They must be designed and constructed to withstand these conditions or they will not perform satisfactorily. When selecting fans for your farm, make sure they are designed for agricultural use. Look for sealed motors and bearings, heavy duty blades and solid construction.

Ventilation fans must work against a partial vacuum and often exhaust into an oncoming wind. They must be capable of delivering a rated capacity against these load conditions. The load is referred to as static pressure, and fans selected should be able to deliver the required volume of air against 1/8 inch of static pressure. This is the amount of pressure required to raise a column of water 1/8 inch. It is not much pressure, but it is not uncommon for the air delivery of a poorly designed fan to decrease by 25 to 30 percent when subjected to this pressure as compared to their delivery against no pressure.

The Air Moving and Conditioning Association (AMCA) is an independent organization that tests and rates fans. Fans that carry the AMCA rating will deliver the rated amount of air under normally expected operational conditions.

In modern, well-constructed farm buildings, fans provide the vacuum that causes fresh air to enter the building. They are not relied on to provide air distribution as they were in older, poorly constructed buildings. Because of this, fan location is not a critical item in system design. They should be located where they are convenient to install and service and out of reach of the animals housed in the structure. The recommended maximum distance from the farthest corner of the ventilated area to the nearest fan is 125 to 150 feet. This restriction prevents the accumulation of large masses of warm, stale air in the area adjacent to the fan.

Fans that are intended to cycle on and off should be equipped with louvers. Louvers prevent the entry of cold air and birds during periods when the fan is not operating. They should also have protective guarding or screening to prevent injuries to either animals or people who work around them.

**Fan controls**

The most commonly used fan controller is the reverse acting thermostat, which is simply a temperature-activated on/off switch. "Reverse acting" means it turns on when temperature rises, while the heating type thermostat turns off when temperature rises.

Controls must also contend with the dusty, corrosive agricultural environment and should be selected on the basis of their ability to do this.

Table 2 lists some of the fan controls and their use.

**Table 2**
Controls used for fans in agricultural ventilation systems

- **Low temperature cut-off**
  On winter-minimum fans; to prevent freezing in the building in the event of unusually cold weather or heating system failure.
• **Time clock (percentage timer)**  
  To provide a variable winter minimum that can be increased as animal size increases. Usually found in brooding or nursery situations.

• **Thermostat**  
  Temperature activated on/off fan operation. In multiple fan systems, thermostats set at different levels can approximate a continuously variable ventilation rate.

• **Time clock/thermostat**  
  Combination control that provides a temperature-activated continuous fan for warm weather and a variable-guaranteed minimum for cold weather.

• **Humidistat**  
  A desirable, but to date unreliable, method of controlling fans based on moisture levels in the air.

• **Throttling**  
  Provides high and low ventilation rates by throttling fan intake. Usually accomplished by thermostat-controlled power louvers.

• **Reversing**  
  Provides exhaust in winter and pressure during summer by either electrical reversal or by turning fan around in its housing. Fans are less efficient, and there are no proven benefits from this technique.

• **2-stage thermostat**  
  Provides high and low ventilation rates when used in conjunction with a 2-speed fan motor. The thermostat provides automatic switching between high and low speeds depending on room temperature.

• **Solid state**  
  Temperature activated and controlled. Used with variable speed fan motor to provide infinite variation in air delivery within the capacity of the fan. Used to best advantage in units where requirements are varying due to fluctuations in outside temperature or animal growth.

**Air inlets**

The air inlet is the most important part of the ventilation system. It provides both control and distribution of fresh air entering the building. Poorly designed or maintained inlets are the number one cause of ventilation system failure. There are two things every good inlet must have:

- Adjustability to accommodate the variation in air flow rates required at different times of the year, and  
- Distribution that ensures a supply of fresh air will be delivered to all parts of the building.

The most popular type of inlet for exhaust ventilation systems is the adjustable slot inlet. It consists of a continuous slot area open to a source of fresh air with some type of adjustable board or baffle to control its width. Slots are usually located along the long dimension of the building at the junction of the wall and ceiling. They may also be located in the ceiling itself — usually down the center of the building. Figures 1a and 1b illustrate cross sections of some commonly used slots.

Slot width is designed based on the amount of air it will deliver when there is a static pressure differential of 0.04 inches across it. At this pressure differential, a 1-inch wide, 1-foot long slot will deliver 50 cfm. A 2-inch wide slot will deliver 100 cfm per foot of length and a 3-inch slot, 150 cfm.
General recommendations for slot locations are:

- For buildings up to 30 feet wide, use either a center ceiling slot or a slot along one outside wall.
- For buildings 30 to 48 feet wide, use slots at the ceiling along both outside walls.
- For buildings more than 48 feet wide, use slots at the ceiling along both outside walls and one or more center ceiling slots.

Slot design problem. A 28-by-100-foot building is used to finish 300 hogs to 250 pounds. Find the width of a single slot inlet to provide ventilation air for the building.

**Step 1**

300 hogs at 250 pounds will require a maximum of 36,000 cfm for summer ventilation (from Table 1)

**Step 2**

36,000 ÷ 200 feet of slot = 180 cfm per foot of slot.

**Step 3**

A 1-inch slot width provides 50 cfm per foot. Therefore, 180 ÷ 50 = 3.6 inches of width required for this slot.

If the same slot is used for a winter inlet, it will have to be partially closed to accommodate the lower air requirements.

**Manure pit ventilation**

Ventilation systems in buildings with slotted floors and manure storage areas must be modified to prevent build-up of toxic gases. Toxic gases are either lighter than air or heavier than air. Gases lighter than air rise up into the animal housing area and are rapidly diluted and removed by the normal ventilation system. You don't need to make special provisions to remove these gases from the housing unit.

Gases heavier than air tend to build up in the manure pit and then move up into the housing area where their weight keeps them next to the floor. These gases can be diluted and removed from the building by exhausting the winter minimum ventilation rate through the manure pit. This can be accomplished by either locating the winter minimum fans in the manure pit or by constructing an exhaust air duct from the pit to the minimum level fans. Although heavy gases in the pit will flow to the exhaust fan or duct, some distribution of outlets is desirable in larger buildings. The maximum distance from the farthest point in the pit to an exhaust outlet should be 100 to 125 feet.

The amount of ventilation air moved down through the floor slots and out of the pit area should be restricted to the winter minimum rate. Higher volumes can cause manure to dry on the slots and clog the slot area and may cause excessive drafts at the floor level.

**Warning systems**

Ventilation systems employ mechanical components that stop working when the power goes off and will occasionally break down. If your
ventilation system stops working without your knowing about it, the results can be disastrous. Fortunately, there are a number of alarm systems available that will warn you in the event of system failure. Every confinement building that relies on mechanical ventilation should be equipped with an alarm system.

The two most common types of ventilation system failure alarms are the power failure alarm and the temperature rise alarm. Either of these may be fitted with a visual (light) or an audible (horn or buzzer) alarm. They may also be connected to your home over a rented telephone line in the event that the building is located away from the home farm.

Power failure alarms should be connected in the fan circuit, not just into the service entrance box. This will ensure that you are warned in the event that a fuse blows or a circuit breaker trips and causes power outage at the fan even though the power is still on in the building.

Temperature rise alarms will sound when temperature rises above some predetermined level, or in some models if it rises too rapidly. When the ventilation system fails, temperature rises and trips the alarm. A fire in the building will also trigger the temperature alarm system.

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Related MU Extension publications

- G1004, Buying a Packaged Farm Building
- G1880, Gases and Odors From Swine Wastes

Order publications online at http://extension.missouri.edu/explore/shop/ or call toll-free 800-292-0969.