



Basic Ventilation Considerations for Livestock or Poultry Housing

J. A. Moore

Most producers would agree that all buildings that house livestock and poultry need ventilation. The real discussion begins when you try to determine how much ventilation you must provide. Any discussion of how much ventilation is needed must start by asking, “Why ventilate?” The answer varies with season, type of building and floor, number and age of livestock, and your waste-handling system.

We ventilate to remove moisture, gases like ammonia and hydrogen sulfide, disease organisms, and heat. Ventilation air also replenishes oxygen consumed by gas brooders used to heat some poultry buildings. Under most conditions, we ventilate in the summer to remove heat and in the winter to remove moisture.

When the ventilation rates are adequate to remove heat or moisture, the organisms and gases are usually well diluted and present no problem. But a lot depends on your type of waste-handling system and on how frequently you clean the building and empty your manure storage units.

Heat balance

While ventilation is important at all times, perhaps winter ventilation is the

most critical. We humans can measure heat (temperature) quite well when we determine summer ventilation needs, but we have some problem sensing moisture levels (humidity) when we try to regulate winter flow rates.

Let’s use a winter example to demonstrate how the heat balance determines the required ventilation rate and possible needs in the building for supplemental heat.

The heat coming into the building takes two forms (excluding mechanical heat from lights, motors, etc.). The primary source, in most buildings, is generated by the animals. The second is supplemental heat from furnaces, brooders, or lamps.

This quantity of heat must satisfy three heat losses to keep the room/building at some selected temperature:

1. There will be a heat loss through the doors, walls, etc., depending on the type of construction and the level of insulation.
2. Some heat will be lost in the exhausted ventilating air.
3. You’ll need heat to evaporate water.

The heat added to the system tends to raise the air temperature. The heat lost to each of these three sources tends to cool the air. If the building

temperature is to remain constant (for this example, 60°F), the heat produced or generated in the building must heat the incoming air to 60°F and provide enough other heat to equal these three losses.

A further examination of these relationships reveals that we can easily calculate the heat lost from the building when we know the room size, type of construction, level of insulation, and the inside and outside temperatures.

With the building size, we know the animal capacity, and we can look up both the heat and moisture generated by the housed animals.

We can determine the heat lost in the ventilation air if we know inside and outside air temperatures and the recommended ventilation rate for the number of animals we house. Table 1 provides these values.

So, for any given set of conditions—outside and inside temperature, building conditions, animal numbers—you can calculate whether you’ll need supplemental heat to maintain the indoor temperature you select.

If you do need supplemental heat—but choose not to provide it—the inside

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Table 1.—Recommended minimum ventilation rates for livestock^a and poultry

	Weight (lb)	Ventilation, cfm/hd		
		Cold weather rate	Mild weather rate	Hot weather rate
Sow and litter	400	20	80	500
Prenursery pig	12-30	2	10	25
Nursery pig	30-75	3	15	35
Growing pig	75-150	7	24	75
Finishing pig	150-220	10	35	120
Gestating sow	325	12	40	400
Boar	400	14	50	300
Sheep	1000	25	100	200
Dairy cows	1400	50	170	470
Heifers, 2-12 mo		20	60	130
12-24 mo		30	80	180
Calves, 0-2 mo		15	50	100
Broilers		System capacity, cfm/1000 birds		
		(below 35°F)	(35-75°F)	(over 75°F)
Up to 3 wk		300 ^b	600 ^b	1000
3-6 wk		1500 ^b	3000	5000
5-8 wk		2500 ^b	5000	8000
Layers, 4-6 lb		2500 ^b	5000	8000
Breeders, 5-9 lb		3000 ^b	6000	15000
Turkeys				
Up to 2 lb (up to 4 wk)		600	1250	2500
2-5 lb (4-7 wk)		2000	3000	7000
5-8 lb (7-9 wk)		3500	5000	10000
8-12 lb (9-12 wk)		6000	7500	15000
12-15 lb (12-14 wk)		7500	9500	19000
15-20 lb (up to 18 wk)		8500	12500	25000

^aAdapted from publications of the Midwest Plan Service, Iowa State University, Ames, Iowa: *Sheep Housing Handbook*, *Dairy Housing Handbook*, and *Swine and Equipment Handbook*. These rates are for solid-floor systems, which evaporate all the moisture. Slatted-floor, partial slatted-floor, and flushing-waste systems remove some of the moisture (urine and water); therefore, they can use lower cold weather

ventilation rates. All rates shown are actual air-delivery rates. Extra capacity allowance must be made for losses caused by dust on fan blades or louvers or by other air-restricting conditions.

^bAt these low air-exchange rates, increase the air mixing or recirculation of the heat inside the structure by using paddle fans, centrifugal fans, or fan-powered convection tube recirculation systems.

temperature will fall. This cooler air will reduce the amount of water carried from the building in the ventilation air, and humid conditions will prevail (see figure 1).

Other solutions would be to increase the heat input (provide more animals) or reduce the losses (add insulation to the building). Unfortunately, too many operators try to save heat by reducing the ventilation rate—which usually causes odor and moisture problems.

While you can't accomplish these calculations quickly, the concept is rather simple. You can calculate a heat balance for your set of conditions to answer questions about your ventilation system. This design logic works for evaluating the ventilation and heating needs of any livestock or poultry building.

Characteristics of air

Researchers have measured the heat and moisture produced by the different kind, sizes, and species of livestock and poultry. Other researchers have studied the characteristics of air and have determined its moisture and heat-carrying capacity at different temperatures.

The higher the air temperature, the greater is its ability to carry moisture in the form of water vapor. Figure 2 shows a simple relationship between temperature and water-holding ability.

Complete properties of air are shown on a psychrometric chart. It's a good idea to have a chart of your own; you'll find that it can help you better understand the relationships between air and moisture. (I'll be glad to send you a chart.)

You use the moisture-holding capacity of air when you calculate the quantity of air necessary for winter ventilation to carry water vapor (from breathing, urine, and spilled water) from the building.

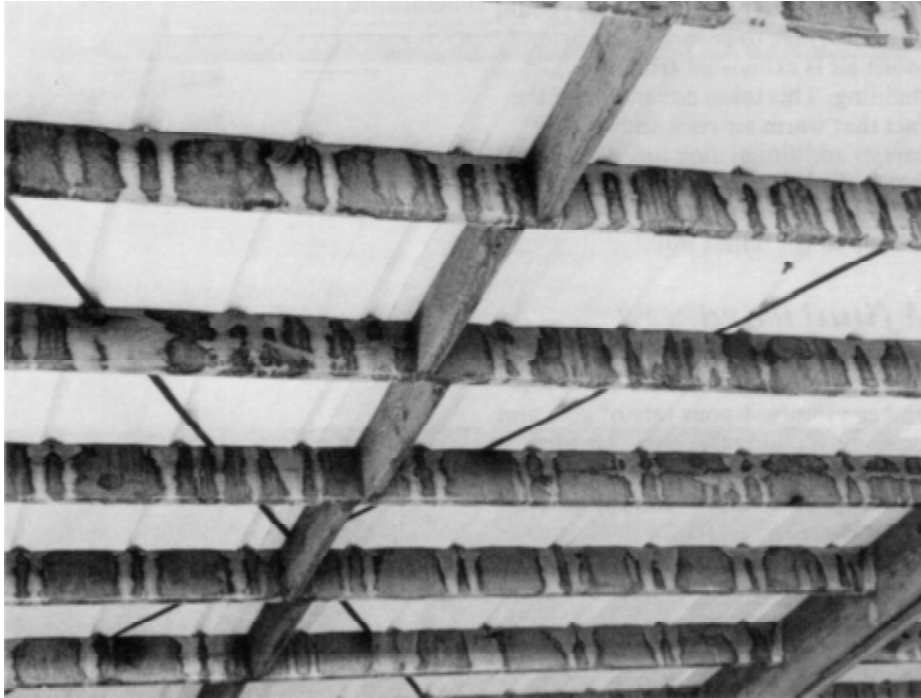


Figure 1.—Stains on purlins show excess moisture, which collected against the cold roof and condensed. An increased ventilation rate will solve this problem.

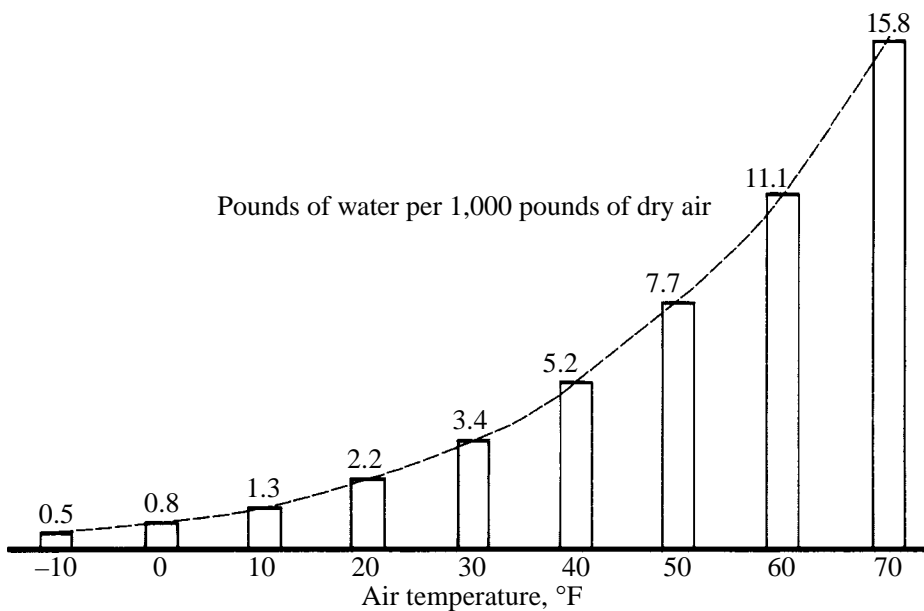


Figure 2.—A simple relationship between temperature and the water-holding capacity of air.

A second important characteristic that you use in ventilation systems is that cool air sinks and warm air rises. We use this phenomenon to locate and size air inlets and outlets in natural ventilation systems.

You can calculate an adequate air flow rate by using the number of animals in the building and outside air conditions. Researchers have done this for general conditions, and table 1 shows their recommended ventilation rates in cubic feet per minute (cfm) per head or per 1,000 birds.

These rates are designed to remove adequate moisture in the winter and heat in the summer. They're calculated to remove the unwanted moisture (urine, spilled water, etc.) from a building with a solid floor. A different floor type, such as a slatted floor, removes some of the moisture and allows a reduction in winter ventilation rates.

Natural and mechanical systems

There are two possible systems that you can select to provide the required ventilation air—natural and mechanical.

The natural system uses no fans; it relies only on the wind and animal heat thermal buoyancy (the fact that warm air rises) to move air. The advantages of this system are its low initial cost (no fans to buy) and its ability to move air without requiring any electricity (no operating cost).

The disadvantage is that natural systems require some management to set the inlet openings that control the range of ventilation rates. The actual ventilation rate and building temperature cycle through the day. This range is influenced by air temperature, wind, insulation level, and animal numbers and their activity level in the building.

Because the wind is one of the driving forces, the building orientation influences the design of inlets, outlets, and controls. This orientation must reflect the needs of the building in a natural ventilation system. This type of system is most often used to ventilate housing for rabbits, mature chickens and turkeys, weaned lambs, ewes, calves, finishing hogs, and gestating sows—situations where building temperature variations and drafts cause few, if any, problems.

Mechanical ventilation uses fans to provide the required air flow rate. These systems are common in poultry houses and in swine-farrowing and nurseries units.

Their advantages include:

1. better control of the air flow rate to match the needs of the livestock in the building (this allows you to mix the air, warm it up, direct it over the floor, and evaporate water);
2. a reduced number of drafts;
3. better, more efficient use of building heat; and,
4. when you must add supplemental heat, the fact that this system might be used to distribute and blend the warmer air.

The major disadvantages are cost (initial purchase and operating expenses) and the serious problems you could have during hot weather if a power outage stops all fans in a building full of livestock or poultry.

Basic system types

When fans pull air from the building and exhaust it outside, this is called negative pressure. In this design, the static air pressure inside the building is lower than outside (atmospheric) pressure, so it's negative. Negative pressure designs are commonly used in livestock housing.

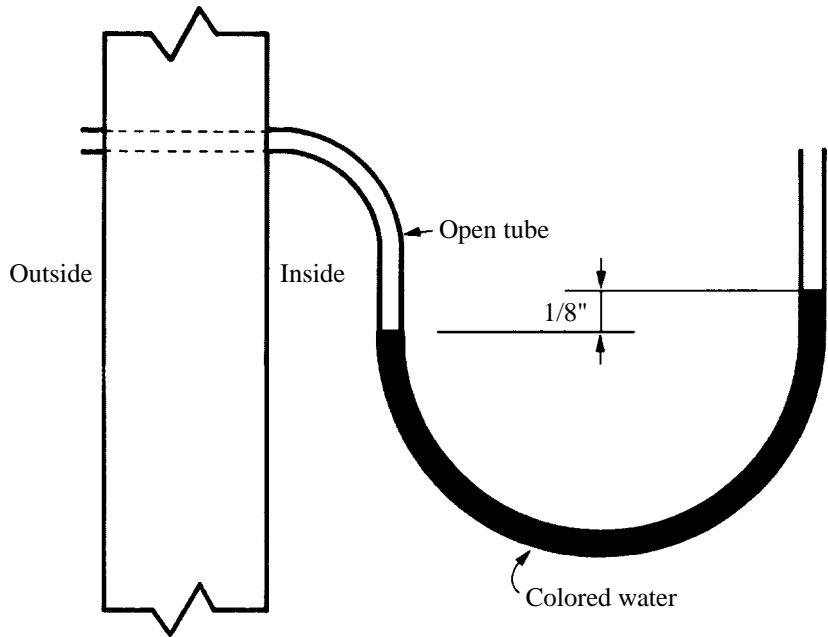


Figure 3.—The manometer is used to determine building static pressure.

In a positive pressure design, fans blow outside air into the building, creating an increase in pressure inside. The major disadvantage is that warm, moist air is under pressure and moves into all the cracks in the building walls and ceiling (seeking openings to the lower pressure outside).

In the winter, air cools as it moves toward the outside, and moisture condenses in the walls and attic. This makes the insulation wet, causing it to get heavy and compress, which in turn reduces the effectiveness of the insulation. An additional disadvantage is that this moisture will eventually cause structural problems.

Unless you have a vapor barrier, the recommendation is that you do not use fiberglass, mineral wool, and cellulose insulation with positive pressure systems.

The term *static pressure* means the difference between the air pressure inside and outside the building. It's easy to measure this pressure—and knowing it is necessary when you select a fan and adjust inlets.

Figure 3 shows a simple manometer, a section of clear plastic tubing partially full of water bent into a “U” shape. You can place this U-tube inside or outside the building. Note, however, that you always expose one end of the tube to the outside air pressure and the other to the inside conditions.

You can make a manometer with a piece of tubing (as in figure 3) or buy one from a fan supplier.

In a negative pressure design, the air is moving from the outside into the building. In figure 3, the manometer is inside the building, and the outside air is pushing the water up the tube that's exposed to the pressure inside the building. This room has less pressure inside than outside, a negative pressure system.

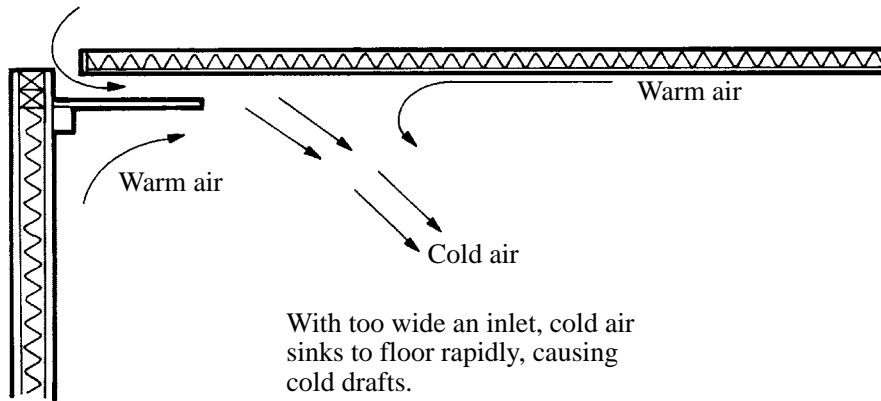
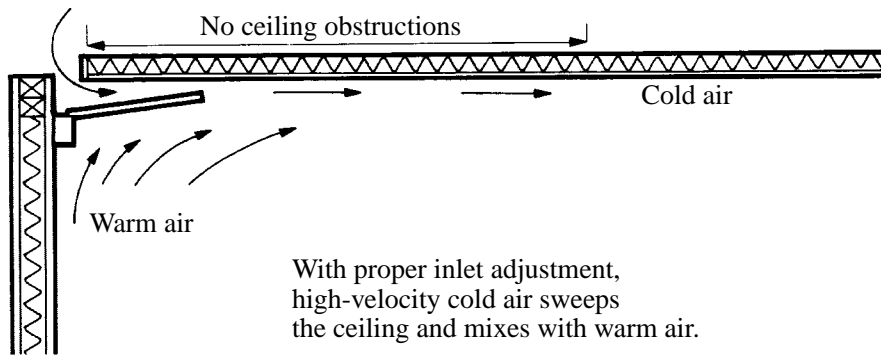


Figure 4.—With proper adjustment, inlets direct high-velocity cold air along the ceiling, which allows mixing with the warm air.



Figure 5.—Openings may be moving enough air, but it appears that inlet distribution is not uniform.

Your system operates best when the manometer shows a reading between 1/16 and 3/16 inch of water. Pressures below 1/16 inch make it difficult to uniformly distribute the incoming air.

Pressures above 3/16 inch (generally caused by inadequate inlet area) reduce the fan capacity, reduce efficiency, and increase operating costs.

Ventilation inlets and outlets

Inlets. In both the natural and mechanical systems, the inlet controls the direction, path, and distribution of fresh air into the room (see figure 4).

Inlets are perhaps the most important part of your ventilation system. By opening or closing the inlet, you regulate the thickness of the air jet, the air velocity, and (therefore) the distance the air flows into the room. See figure 5.

When you need more air because of seasonal changes, adjust the inlet to maintain the air flow path and velocity. Inlets can be self-adjustable (for example, by using weighted curtains), or you can adjust them manually as required by temperature changes through the season.

In poultry buildings with large rooms, the inlets are designed with the building. In swine units, plan the locations of the inlets after you've selected the sleeping and dunging areas.

You need the "best" air in the sleeping area; direct the poorest air into the dunging area. The best air will be the warmest in the winter and coolest in the summer. Feeders and waterers also influence inlet selections.

Summer inlets should provide lots of turbulence and volume—their purpose is to cool the building and animals. Winter air flows are smaller, but proper control and distribution are quite important. The large winter temperature differences between inside

and outside air can make drafts a big health problem.

In most cases, you'll need a different inlet system for summer and winter. In some natural ventilation systems, however, you can adjust the same inlets to function properly in all seasons.

Outlets in mechanical systems can usually be located on any wall. In swine and calf units, air should not have to move more than 40 feet to get to a fan. Poultry units use larger fans and can increase this distance to 50 feet. Locating the fan on a wall away from the wind or providing a fan shield will ensure uniform and consistent air flow rates.

The outlet in natural systems should be at the ridge to ensure that warm, moist air is exhausted from the building. This takes advantage of the fact that warm air rises and usually carries additional moisture with it as it leaves the building. In single-sloped buildings, the outlet should be along the top of the tallest wall.

A final word...

Proper ventilation of livestock facilities can reduce disease and death loss and can improve your rate of gain and feed-conversion efficiency. Unfortunately, most livestock and poultry buildings need improved ventilation systems.



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