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Poultry Housing Tips

Answers to basic questions about negative pressure ventilation

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What is a negative pressure?

Quite simply, when you turn on an exhaust fan in a poultry house it pulls air out of the house and air from outside the house moves into the house to replace the air the exhaust fan removed. In a house where the side wall curtains are fully opened, the exhausting of this air basically goes unnoticed due to the large amount of air that even the slightest of breezes is constantly moving in and out of the house. For instance, a 36" fan pulls 10,000 cubic feet of air out of the house every minute it operates. But, with the curtains fully opened in a 500' house, just a 1/4 mph wind will move nearly 50,000 cubic feet of air in and out of the house each minute. Now keep in mind a 1/4 mph wind is basically imperceptible (with a 1/4 mph breeze, 20 ft/min, it would take a full minute to for the air to move half way across a house). If the wind speed increases to just to where you can just start to feel it (two mph), over 400,000 cubic feet of air moves through a house each minute, 40 times what the fan is removing! As you can see, the 36" fan is removing just a small portion of the air that is constantly flowing through the house. In either case the fan does not have to work to pull air into the house because the wind is doing the work for it.

But what happens when the curtains are closed? In fact, let's say we had a house which was perfectly airtight. When an exhaust fan is turned on, it would pull air out of the house but there would be no air coming into to the house to replace the air lost, in a sense creating a "partial vacuum" or more precisely, an area of low pressure. Theoretically, if the fan was very powerful, it could pull all the air out of the house, creating a vacuum. This of course could never happen in a poultry house because in even the tightest of houses there is always a way for air to enter the house. Furthermore, poultry house fans are incapable of moving air under very high pressures. As a result, exhaust fans in poultry houses tend to slightly reduce air pressure, not eliminate it.

The low pressure created by exhaust fans in a poultry house is commonly referred to as a negative pressure. A negative pressure simply indicates that there is less air pressure inside the house than outside the house. When you have a negative pressure, air outside the house wants to flow into the house to relieve the low pressure created by the exhaust fans. The level of negative pressure is determined by the ease at which air can flow into the house to replace the air the exhaust fan removed. If there is a lot of opening in the house so the outside air can easily move in to replace the air exhausted, there will be a very low pressure difference. If there is very little opening available for the fan or the opening is restricted with light traps or evaporative cooling pads, the pressure difference would be greater.

It is important to realize that the curtains can be fully closed and a negative pressure may not be generated when a fan comes on. It is simply a question of whether the fan is moving more air out of the house than the amount of air naturally moving through cracks and openings in the house due to outside air movement. For instance, if you cannot measure any negative pressure when you turn on a single 36" fan, this indicates that there is at least 10,000 cubic feet of air moving through the house each minute. A house this loose of course would be very expensive to heat due to the large amount of air that is constantly moving through the house. Furthermore, bird performance would likely suffer due to the fact that house temperature, litter conditions, and air quality would be difficult to manage due to the lack of control over how much air is entering the house. As the house is made tighter, the amount of negative pressure generated by the fan would increase, indicating that the amount of air that is naturally flowing through the house has been decreased, thereby allowing the producer greater control over environmental conditions as well as heating costs in his/her houses.

The pressure difference created by the exhaust fans in a negative pressure house is typically measured in terms of "inches of water column." Simply put, if you ran a tube from inside the house into a glass of water outside the house, the low pressure created by the exhaust fans would pull water up the tube. The greater the negative pressure created by the exhaust fans, the further the water would be drawn up the tube. If water was drawn up the tube an inch, we would say that we had a negative pressure of one inch of water column. The pressure created by exhaust fans in poultry houses is never this high. The typical range of negative pressure experienced in most poultry houses ranges from 0.01" to 0.25".

Though it is possible to measure the amount of negative pressure in a house using a tube and a glass of water it is impractical due to the relatively low levels of negative pressure that are typically experienced in poultry houses (trying to see if the water is pulled up a tube 0.05" or 0.10" when it is 30°F outside is difficult to say the least). There are a number of different instruments that allow producers to easily and accurately measure the amount of negative pressure in a house. They range in price as little as $30 (wall mounted manometer) to as high as $400 (hand held electronic gauge).

Manometer

"Air meter"

Magnehelic Gauge

Probably the most common stand-alone pressure measuring device is a Magnehelic gauge (approximately $60). With a Magnehelic gauge, as with most pressure gauges, there are two ports, one labeled "high pressure" the other "low pressure." Standing inside the house a tube is connected to the "high pressure" port and run outside the house (the pressure is higher outside than inside). Since the Magnehelic gauge is inside the house no tube is needed on the "low pressure" port. When the fans are turned on the air will try to flow from outside the house through the Magnehelic gauge to inside the house, thus allowing the gauge to measure the pressure difference. If a pressure gauge is placed in a stand-alone control room, not only does a tube has to be run from the high pressure port to outside, but a second tube

has to be run from the low pressure port to inside the house.

Most modern poultry house environmental controllers have built-in electronic pressure sensors. Electronic pressure sensors are no more accurate than the manual gauges, but allow for the automatic control of side wall inlets. If the pressure is too high the controller will open the side wall inlets and if the pressure is too low the controller will close the side wall inlets until the proper pressure is obtained.

It is important to realize that when we measure pressure created by the exhaust fans we are measuring the pressure *difference* between inside and outside the house not the *absolute* pressure. When meteorologists report the pressure during a weather forecast they are referring to barometric or absolute pressure. For instance, on the evening news a meteorologist might say that the pressure is 30" and rising. The unit of measure that meteorologists use is inches of mercury not water. Since mercury is approximately 14 times heavier than water, 30" of mercury would be equal to about 408 inches of water column. So, if we had a pressure difference of 0.10", the absolute pressure outside would be 408 inches of water and the pressure inside would be 0.10" less, or 407.90 inches of water. From a ventilation standpoint, absolute pressure has a negligible effect on oxygen levels or on how the air flows into and out of the house.

Why is having a negative pressure important?

One of the important characteristics of a negative pressure ventilation system is that the level of negative pressure created by exhaust fans throughout a house is constant. It is just like blowing up a balloon, but in reverse. The air blown into a balloon pushes out equally on all surfaces. One area of a balloon isn't soft while another is very hard. Similarly, in a house where a negative pressure has been established, the negative pressure is uniform through out the house, whether it is 100' long or 1,000' long (Figure 1). Air is trying just as hard to get in the ceiling as it is the side walls. So when there is a negative pressure, the curtains in a curtain-sided house are sucked up against the sides of the house with equal force no matter where you are in the house.

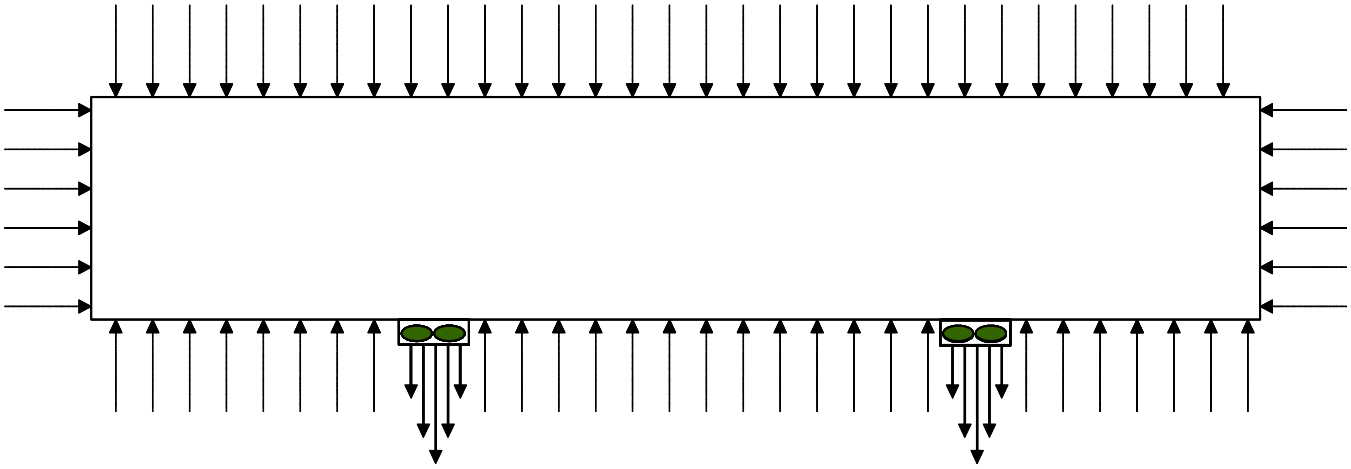

Figure 1. Consistent level of negative pressure throughout a house.

Now it is important to realize that the amount of negative pressure determines the speed at which the air will enter the house. The greater the negative pressure, the faster the air wants to enter the house to relieve the pressure difference. For instance, if there were a negative pressure of 0.05" and there were a hole in the wall air would enter this hole at a speed of approximately 700 feet per minute. If we increased the negative pressure to 0.10", the air speed would increase to 1,300 feet per minute (see Chart 1). Now, since the pressure is equal throughout the house, air will enter through all openings throughout the house at the same speed. So if we have a negative pressure of 0.05", the air will enter through any hole (regardless of its size) in the house at a speed of 700 feet per minute whether that opening is 5' from the fan or 500' from the fan.

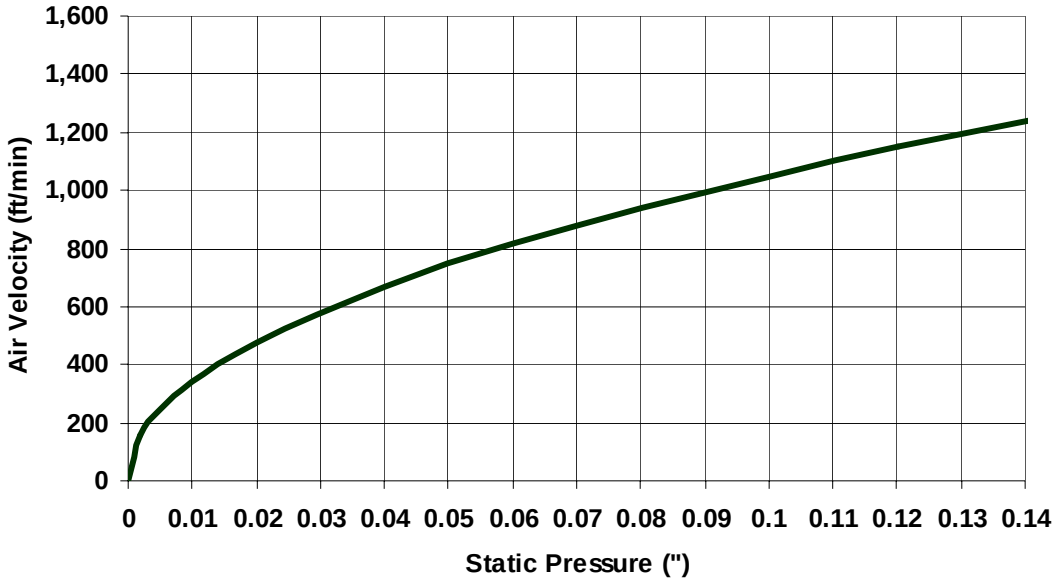

Chart 1. Approximate Air Speed Through an Inlet Opening Vs. Static Pressure.

Since air enters through all openings throughout the house at the same speed, and if we have openings throughout the house of the same size, we will get the same amount of air entering through all the openings throughout the house (cfm = velocity x area). This is a very important fact, because we can turn on a fan or two in a house and if we can generate a negative pressure we will know that birds throughout the house will be receiving the same amount of fresh air if the openings that the fan(s) is/are drawing air through are equally distributed throughout the house.

For instance, let's say we turned on a couple of 36" fans in a house without side wall inlets and we obtained a static pressure of 0.08". If the cracks are uniformly distributed down the length of the house evenly the air will enter through all the cracks evenly and we will have uniform fresh air distribution resulting in uniform house air temperatures as well as uniform air quality (Figure 2). But, of course, if there are a lot of cracks in the end walls or north curtain is not as tight as the south curtain the exhaust fans will pull more air into these areas of the house simply due to the fact that there is more opening in these areas and house air temperatures, as well as air quality, will not be uniform (Figure 3).

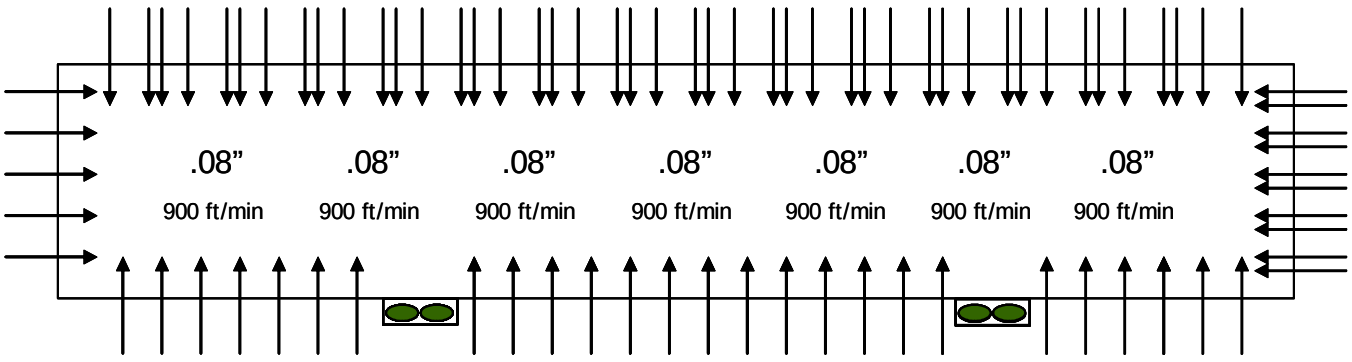

Figure 3. Uneven cracks/openings in a house with a negative pressure.

In tight houses where side wall inlets are used it is of course very important that all the side wall inlets open the same amount. When the inlets open two inches in one area of the house and one inch in another, even though the air will enter both openings at the same speed, twice the air will enter the inlets that are open two inches than those opened one inch and we will end up with cold spots where the air is very fresh and hot spots where the air is warm but stale.

Another equally important aspect of having a negative pressure is that we can gain control over how the air moves once it enters the house. Since with a negative pressure the air enters with force/speed, it can be directed to go where we want it. To minimize bird cooling as well as fuel usage, we want to direct the incoming cold air along the ceiling where the heat produced by the brooders/furnaces and birds collects. This not only warms the incoming air, but also tends to dry out the air because warm air can hold more moisture than cold air.

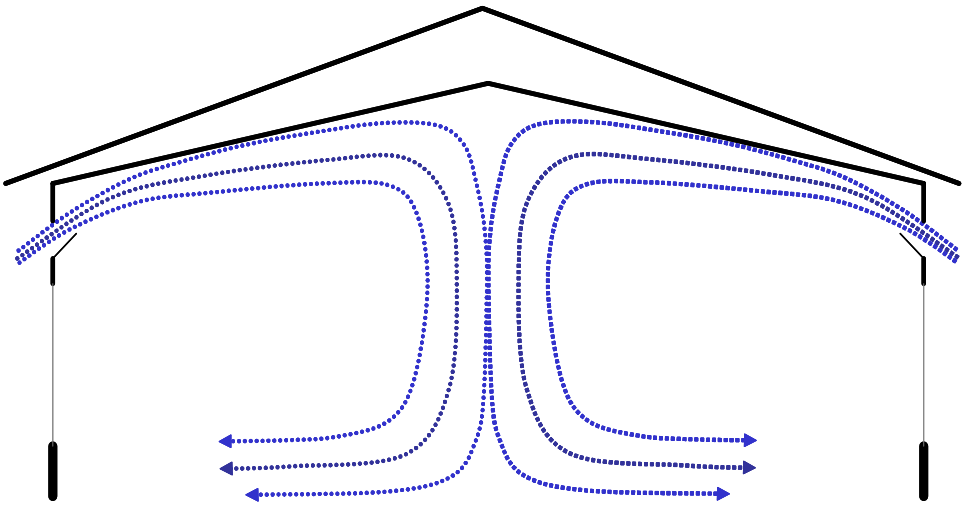

Figure 4. Inlet air flow in a house with a proper negative pressure.

How much of a negative pressure do I need?

Though the amount of speed or force required to promote proper air mixing can change from house to house, it is generally found that a static pressure between 0.05" and 0.12" produces the best results. With a static pressure below 0.05", air tends to enter with too slow of a speed to make it to the center of the house where maximum heating and drying take place. This is especially true when it is very cold outside. The colder it is outside, the heavier the air is and the more it tends to fall to the floor as it enters the house. This is why a MINIMUM static pressure of 0.05" is recommended. The best air mixing typically takes place when the negative pressure is between 0.07 and 0.10". It is, however, possible to operate at a static pressure as high as 0.12", especially during very cold weather (less than 30 F) when the air is very heavy and we want to make sure that we get maximum heating of the incoming air.

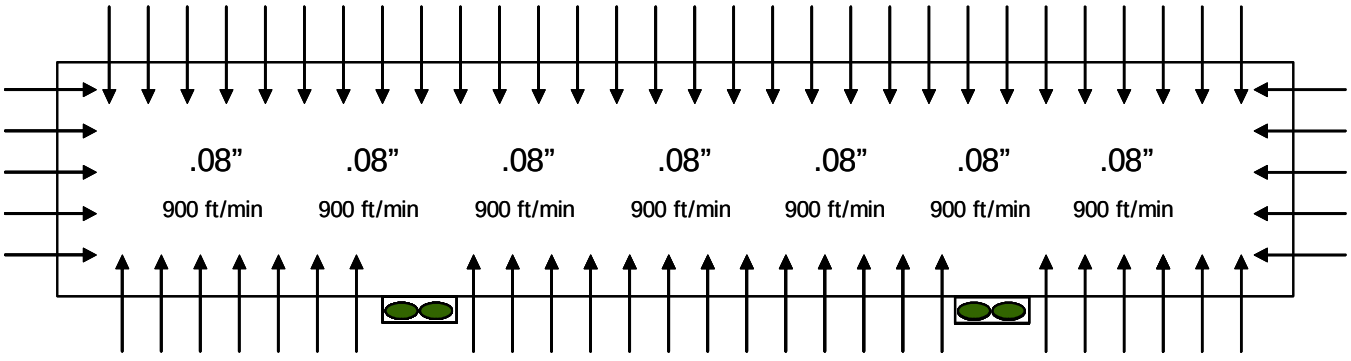

Figure 2. Even cracks in a house with a negative pressure.

It is important to realize that the air speed associated with the different static pressure is only the speed at which the air enters the house. Once the air enters the house, the jet of air spreads out and slows down. So though air might enter the house at 1,200 ft/min (13.6 mph), by the time it has moved five feet along the ceiling the air speed will be reduced by well over 50% . By the time the air reaches the center of the house the speed is even slower. As the air begins to move towards the floor it slows further, producing just a slight amount of air movement at floor level which since it is warmed, tends not to be stressful to the birds and helps to dry the litter.

In a modern broiler house with air inlets the amount of pressure is controlled by changing the amount the side wall inlets are opened. By closing the inlets the air comes in faster, opening them more the air comes in slower. It is important to realize that in the typical pressure operating range of 0.05" to 0.10" there is essentially no difference in the amount of air moved by most exhaust fans. So the inlets may be open a very small amount with a high air speed or a little more with a lower speed and we are bringing in the same amount of air.

It is important to realize that proper mixing of the cold outside air with the warm air collecting at the ceiling is determined not only by the amount of negative pressure but also by the amount of inlet opening. Even with a high negative pressure (i.e., 0.10"), air entering through inlet openings less than an inch may not make it all the way to the center of the house before dropping to the floor because it simply does not have enough mass. For the most part, optimal air mixing takes place with a static pressure of approximately 0.10" and a side wall inlet opening of approximately 1 ½" or a ceiling inlet opening of approximately 1".

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