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Cooperative Extension

Poultry Housing Tips

Small Variable Speed Fans Operating Continuously Vs. Larger Fans on Timers

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The purpose of a minimum ventilation system is to bring in small amounts of cold fresh air into a house and to warm it as much as possible before it moves down to floor level so as not to chill the birds and to maximize the litter drying potential of the incoming air. Traditionally, poultry producers have utilized a "negative pressure" minimum ventilation system. In a negative pressure system, exhaust fans draw air out of a house, thereby making the pressure lower inside the house than it is outside. When the pressure is lower inside the house than outside, fresh air will flow into a house to relieve the low pressure created by the exhaust fans. The level of negative pressure is determined by the amount of inlet opening available to the fan relative to the air-moving capacity of the fan. If there is a lot of inlet opening in a house, there will be an extremely low difference in pressure, and if there little inlet opening available to the fan there will be a high difference in pressure (Figure 1).

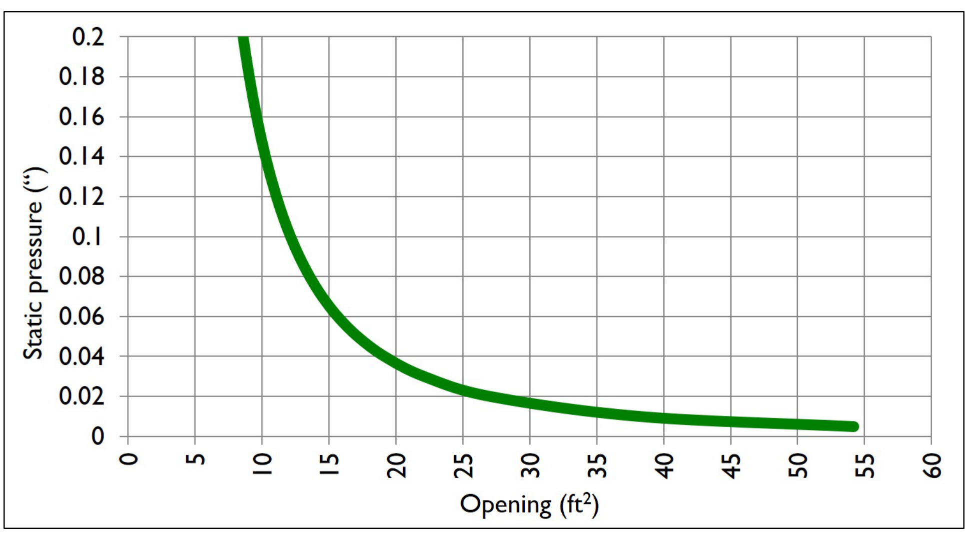

Figure 1. Static pressure vs. available opening (10,000 cfm fan)

There are primarily two reasons why a negative pressure is desirable. First, when a negative pressure is created by an exhaust fan(s), the level of negative pressure will be essentially the same throughout the house (Figure 2). This means no matter how far an inlet is from an exhaust fan the pressure difference between inside and outside of a house will be the same. Second, by controlling the level of negative pressure a producer can control the speed at which the air will enter a house The greater the pressure difference, the higher the speed. The smaller the pressure difference, the lower the speed (Figure 3). Now if all the inlets throughout a house are opened the same amount, and the air is entering though all the inlets at same speed, then the same amount of air will entering through all the inlets no matter where they are located in a house (Figure 2). This is very important because this means that in a properly functioning negative pressure system all the birds in a house will receive the same amount of fresh air regardless of how far they are from an exhaust fan. Control over speed of the incoming air is also important because it provides control over how the air moves once it enters the house. If the air enters the house slowly (low pressure) the cool, heavy, damp, incoming air will tend to quickly fall to the floor. But if the air enters the house quickly (high pressure) it can be directed along the ceiling far from the birds and where warm air tends to accumulate. The longer the cool air stays along the ceiling, the more it warms before moving down to floor level (Figure 4). Just as important, because the moisture holding ability of air will roughly double for every 20ºF rise in temperature, the longer it stays along the ceiling, the drier it will become and the greater the amount of moisture which can be removed from a house.

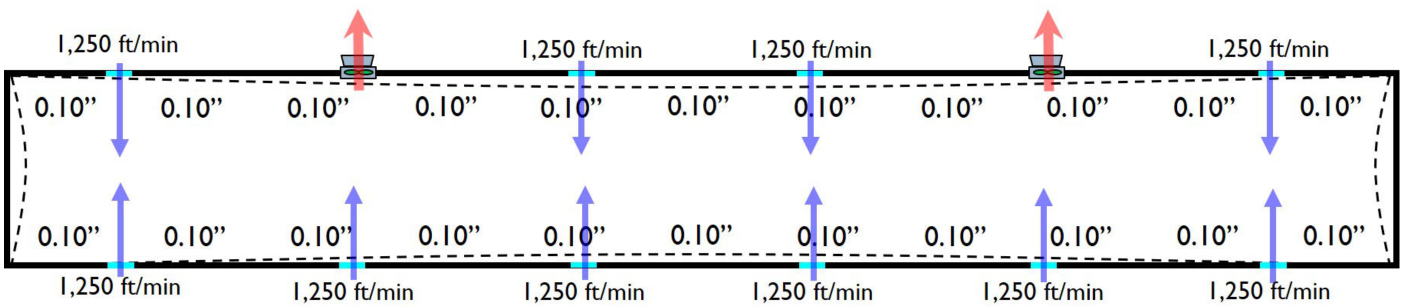

Figure 2. Pressure and entrance air velocity uniformity in a house utilizing negative pressure ventilation

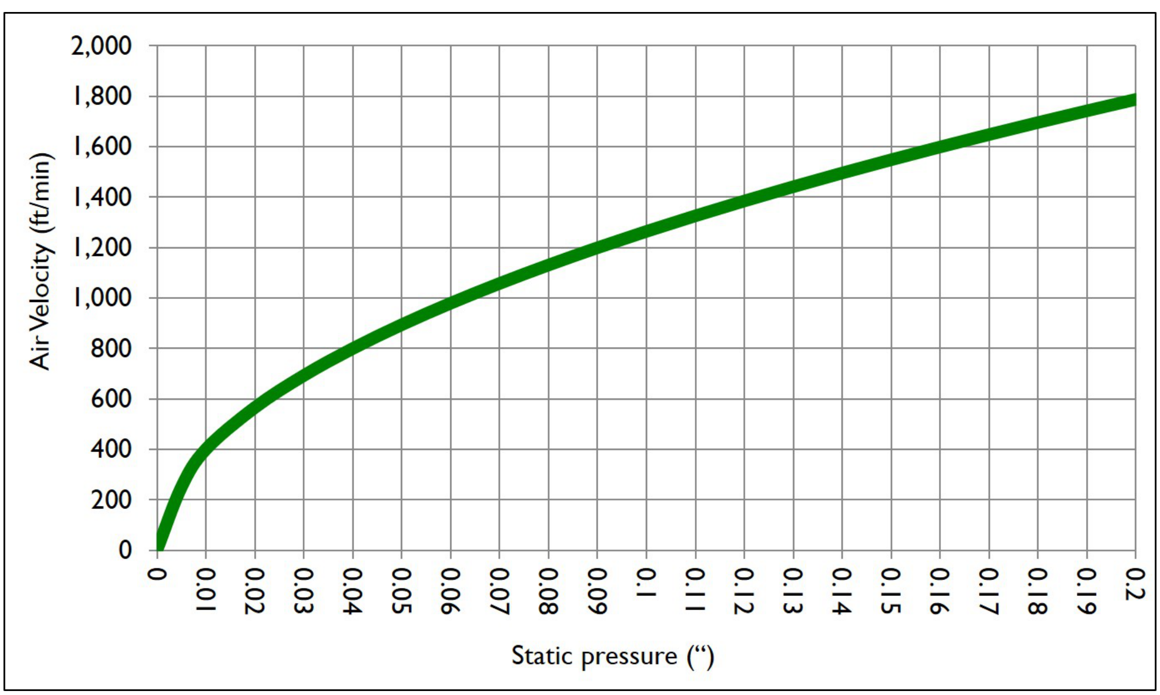

Figure 3. Inlet air velocity vs. static pressure

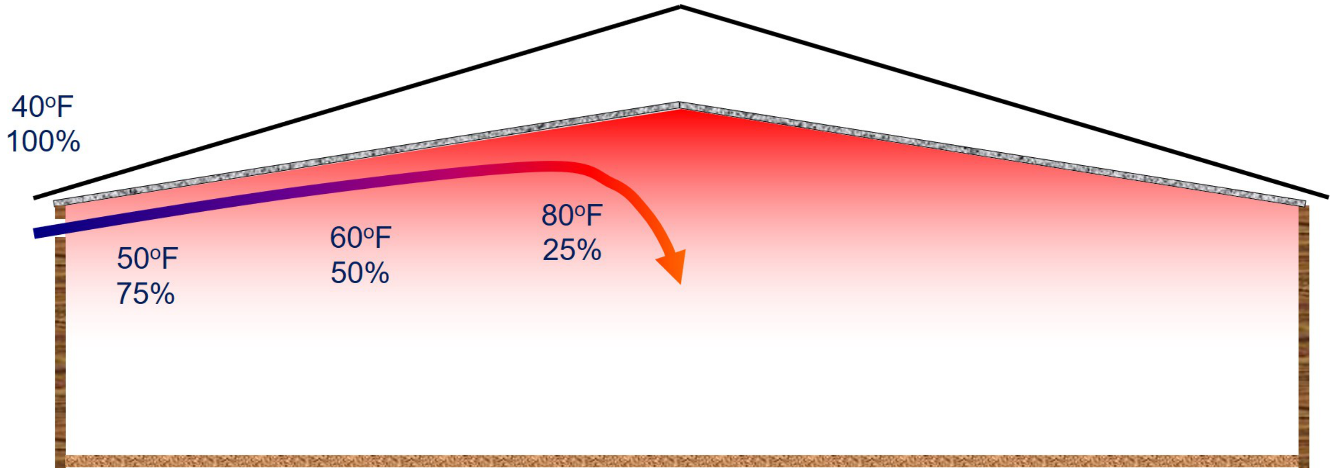

Figure 4. Desired inlet air flow pattern during cold weather

A common question about negative pressure minimum ventilation system is why we use large fans operating on an interval timer instead of using smaller fans that operate constantly? For instance, to remove the moisture that 30,000 six-day-old chicks are adding to a house on a cold winter day (40ºF / 50% Rh) requires the exchange of approximately 3,000 cubic feet of air each minute (Table 1). Wouldn't it be simpler, and better, to use a single 18" fan that moves 3,000 cfm or even a variable speed 24" fan (6,000 cfm capacity) operating at 50% rather than using a couple of 36" fans (10,000 cfm) on a five-minute-timer ? Though in theory a smaller fan operating continuously would produce a more consistent house temperature and air quality, the primary reason why we can't use a smaller fan is that poultry houses are simply not tight enough to do so.

Age (Days)	Temperature (F)	Daily Water Usage (Gals - 30,000 birds)	Minimum Vent. Rate to maintain 50% Rh (cfm)	"On Time" (seconds) for five-minute-timer (20,000 cfm)
0	90	61	370	6
1	89.5	125	770	12
2	89	190	1,200	18
3	88.5	254	1,610	24
4	88	319	2,070	32
5	87.5	383	2,540	39
6	87	447	3,020	45
7	86.5	512	3,530	54
14	76	1,090	12,110	183
21	72	1,560	20,000	360

Table 1. Minimum ventilation rates to remove bird moisture and maintain an inside relative humidity of 50% (Min. vent. rates determined using Poultry411 App - outside conditions = 40ºF / 50% Rh)

At a static pressure of 0.10", an exhaust fan requires roughly one square foot of opening for every 750 cubic feet of air it moves. Therefore, an 18" fan only requires a total of four square feet of inlet opening (3,000 cfm / 750 cfm/ft^2). If the opening area is greater, the pressure will be lower, and the fresh air may not enter with sufficient speed to travel along the ceiling far enough to be properly warmed before moving down to bird level. Worse yet, if the amount of opening available to a fan is so large that the fan is incapable of generating a negative pressure, then only birds in the immediate vicinity of the fan will receive any fresh air when the fan is operating.

Four square feet of inlet opening is not very much relative to size of the typical modern poultry house. For instance, most producers would consider a house where a negative pressure of 0.20" could be obtained with a single 48" fan (with all the air inlets closed) to be fairly airtight. But, in truth there would be roughly nine square feet of "cracks" scattered throughout the house, over twice the opening required to feed an 18" fan (Figure 5). With nine square feet of opening available to it, an 18" fan would only generate a negative pressure of approximately 0.01". In order for an 18" exhaust fan to be used for minimum ventilation, the pressure generated with all inlets closed would need to be well over 0.10" (for example 0.15" - 0.20") so that when the inlets were opened, and the pressure decreased, a static pressure of approximately 0.10" could be maintained. To obtain a static pressure of 0.20" with an 18" fan, a house would need to have less than two square feet of leakage area, which would be essentially impossible in even the best built totally enclosed 40' X 500' house. From a practical standpoint, if an exhaust fan is not capable of generating a pressure of at least 0.15" in a closed house, it would be very difficult for it to be used by itself for minimum ventilation during cold weather.

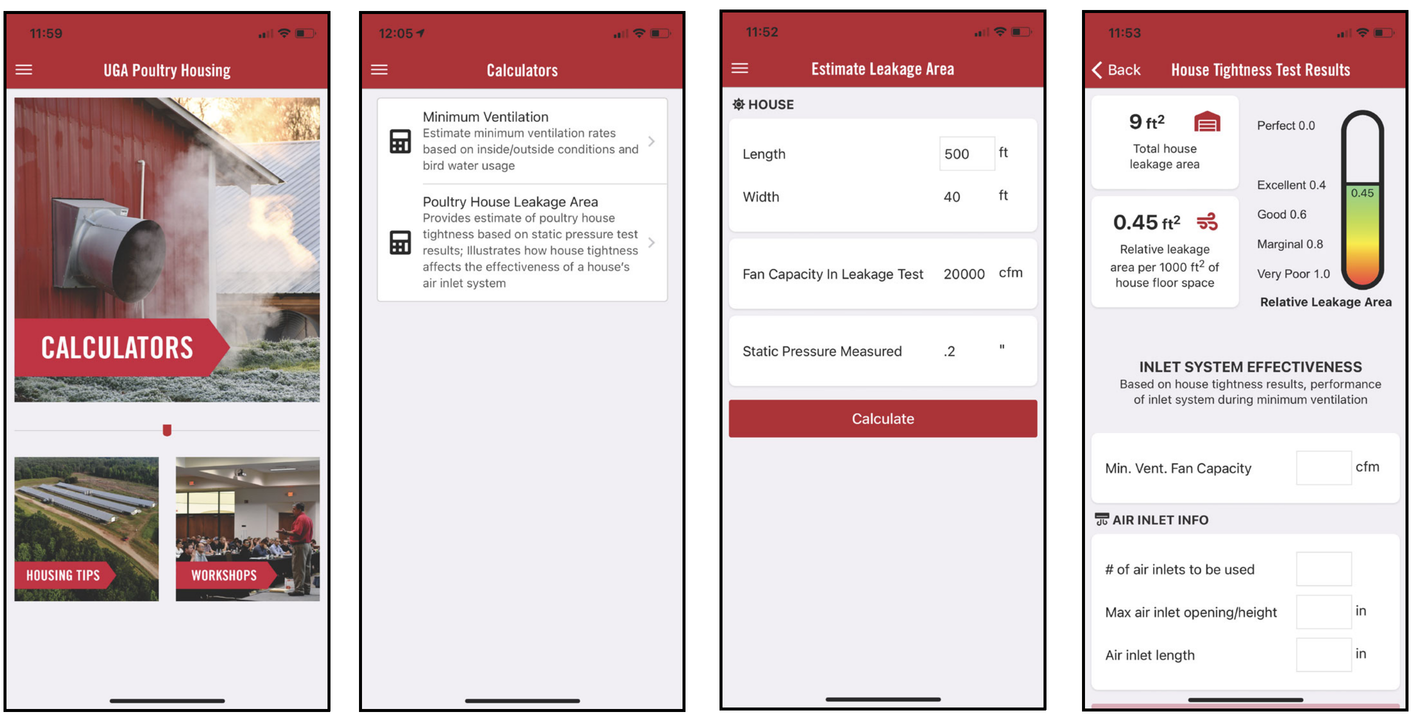

Figure 5. Poultry411 App used to estimate house leakage area

Another potential issue with using small fans for minimum ventilation in large houses is fresh air distribution. At 0.10" static pressure, approximately 450 cfm will enter through a 42" long air inlet opened two inches. So if all the air moved by a single 18" fan were to enter though a house's air inlets, only seven inlets would be required. The problem is this assumes the house were perfectly tight, which is never the case. Even if a house were tight enough to obtain a static pressure of 0.15" with an single 18" fan, there would still be a significant amount of air entering through cracks. In fact, roughly half the air brought into a house by an 18" fan would enter through the cracks, which means only three or four air inlets would be required. Three or four air inlets in a 500' house would result in dramatic variations in air quality and temperature along the length of that house.

In most cases it takes one cfm or better of exhaust fan capacity per square foot of floor space to generate sufficient pressure to produce a functioning negative pressure inlet system. A functioning inlet system would be one where a pressure of around 0.10" can be maintained with a majority of the inlets in the house opened a couple of inches. For instance, as noted previously, if a static pressure of 0.20" could be obtained in a closed 40' X 500' house with a couple of 36" fans that move 20,000 cfm (1 cfm per square foot of floor space), it would indicate that there is nine square feet of leakage area. Assuming 750 cfm will enter through a square foot of inlet opening at a pressure of 0.10" (cracks are "inlets"), this means that approximately 6,800 cfm of the 20,000 cfm of fresh air will enter through the cracks in the house and the remainder, 13,200 cfm, will enter through air inlets. If the house has 42" long inlet doors, open two inches (450 cfm), this means that roughly 30 air inlets (42" long, opened two inches) could be used with two 36" minimum ventilation fans (Table 2).

Minimum ventilation fan(s)	40' X 500' closed house static pressure in a house with 9 ft^2 of leakage (very tight)	Amount 30 inlets would open with a target pressure of 0.10"
Two 36" fans (20,000 cfm)	0.20"	2"
One 36" fan (10,000 cfm)	0.08"	0
One 24" fan (6,000 cfm)	0.03"	0
One 18" fan (3,000 cfm)	0.008"	0

Table 2. Amount 30 inlets would open with various sizes of minimum ventilation fans in a tight 40' X 500' house

Minimum ventilation fan(s)	40' X 500' closed house pressure test in a house with 5 ft^2 of leakage (exceptionally tight)	Amount 30 inlets would open with a target pressure of 0.10"
Two 36" fans (20,000 cfm)	0.30"	3"
One 36" fan (10,000 cfm)	0.17"	1"
One 24" fan (6,000 cfm)	0.10"	0
One 18" fan (3,000 cfm)	0.03"	0

Table 3. Amount 30 inlets would open with various sizes of minimum ventilation fans in an exceptionally tight 40' X 500' house

If a 40' X 500' house were exceptionally tight and a pressure of 0.17" could be obtained with a single 36" fan (0.5 cfm/ft^2) then only 15 air inlets, opened 2", would be required. Fifteen air inlets in a 500' long house would result in air inlet spacing of approximately 30', which is toward the upper limit of what most people would find acceptable (Table 3). If 30 inlets were used, to maintain the same static pressure (0.10") the inlet opening size would have to be reduced to one inch and chances are the cold incoming air would not have enough momentum to travel very far along the ceiling before falling to the floor. The problem is that a ventilation rate of 10,000 cfm is still greater than minimum ventilation requirements the first couple weeks of a flock and an interval timer would still be required to limit the amount of fresh air brought into a house.

If a static pressure of at least 0.15" can be obtained using a single exhaust fan in a closed house, it is a good indicator that the fan could be used effectively to provide fresh air for the birds throughout a house during minimum ventilation. The problem is that in virtually all commercial poultry houses there is simply too much leakage area for most smaller fans (24" and smaller) by themselves to generate the level of negative pressure required to create a properly functioning inlet system. Though using a larger fan(s) capable of creating a sufficient pressure to allow inlets throughout a house to be opened the proper amount and allow the air to enter with sufficient speed to create a proper minimum ventilation air flow pattern requires the use of a five-minute timer, it is better than operating a smaller fan continuously that will end up just pulling fresh air through cracks resulting in drafts, poor air quality control, and increased likelihood of caked litter.

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