The University of Georgia
Cooperative Extension Service
College of Agricultural and Environmental Science/Athens, Georgia 30602-4356

Poultry Housing Tips

High Tunnel Air Velocities = High Static Pressures

Volume 22 Number 8 **July, 2010**

In the early 1700's Daniel Bernoulli studied the relationship between pressure and velocity for a moving fluid. One of the basic laws of physics he uncovered was that pressure increased with the square of velocity. More simply put, if you double the velocity of a fluid, the pressure/work required to move a fluid through pipe or fitting increases four fold. Though you may not realize it, Bernoulli's discovery nearly 300 years ago has a significant impact on our ability to keep birds cool during hot weather.

One of the most common examples of how Bernoulli's discovery affects a modern poultry farmer is in the area of pipe sizing. It takes pressure/work to move water in a pipe from a well to a house. How much pressure/work depends primarily on the size and length of the pipe as well as how fast the water is flowing in the pipe. For instance, to move water in a 1" PVC pipe at a rate of 5 gals/min. a hundred feet requires approximately 0.6 psi of pressure. If we double the flow rate (velocity) to 10 gals/min, the pressure required increases four fold to 2.4 psi. This same relationship holds for the various fittings water may flow through on the way from the well to a house. For instance, the pressure required to move water through a single 1" PVC 90 degree elbow at 5 gals/min. is 1.5 psi. Double the flow rate to10 gals/min. and the pressure required increases four fold to approximately 6 psi. Double the flow rate through a water filter, the pressure increases approximately four fold and so on. A number of producers have inadvertently learned of this law of physics after installing a new six-inch evaporative cooling pad system and found the water pressure at the house dropping as demand increased in the middle of a hot afternoon.

Another less obvious place where the relationship between pressure and velocity comes into play is in our tunnel-ventilated houses. After all a tunnel house is basically a large pipe where we are moving a fluid (air) with large pumps (tunnel fans). The first "fitting" the air encounters when flowing into a tunnel house is the evaporative cooling pads. It takes work/pressure to draw air in through an evaporative cooling pad system and like a pipe or fitting how much work depends to a large extent on the velocity at which the air moves through the pad. For instance, it takes approximately 0.055" of pressure to pull air through a six-inch evaporative cooling pad at a typical design velocity of 350 ft/min. If we were to double the velocity of the air through the pad to 700 ft/min, the pressure would quadruple to 0.20". This dramatic increase in static pressure could reduce the air moving capacity of our tunnel fans 20% or more resulting in lower air speeds and reduced bird cooling.

In addition to the pressure/work required to pull the air through the evaporative cooling pads there are two other areas where Bernoulli's discovery comes into play; the "transition zone" and the "pipe zone". In practically all poultry houses the evaporative cooling pad area is larger than the cross-sectional area of the house. As a result, after the air travels though the pads it turns and speeds up as it moves into the smaller house cross-sectional area. How much air speed increases depends on the total air moving capacity of the tunnel fans and the cross-sectional area of the house. The greater the number of fans, the smaller the cross-sectional area of the house the greater the increase in speed. In older tunnel houses, with relatively few tunnel fans, the increase in air speed may be relatively minimal (i.e. 350 ft/min to 400 ft/min) and as a result the required pressure to pull the air into the cross-section of the house is minimal. But, in newer tunnel houses the air speed may double from 350 ft/min to 700 ft/min as it transitions from the pad area into the cross-section of the house the static pressure associated with the transition area can be up to four times higher what it was in the past.

After the air transitions from the pads into the cross-sectional area of the house it now has to travel the length of the house before exiting the fans. With traditional tunnel air velocities of 400 to 500 ft/min, the pressure required to pull the air down the house was fairly minimal (0.01" - 0.02"). But, with target air speeds increasing 50% or more over those in the past the pressure required to pull air down a tunnel house has doubled in many instances. Like the transition zone, what was a relatively minor source of pressure in the past, with today's higher target velocities can now have a significant affect on the total static pressure tunnel fans are working against.

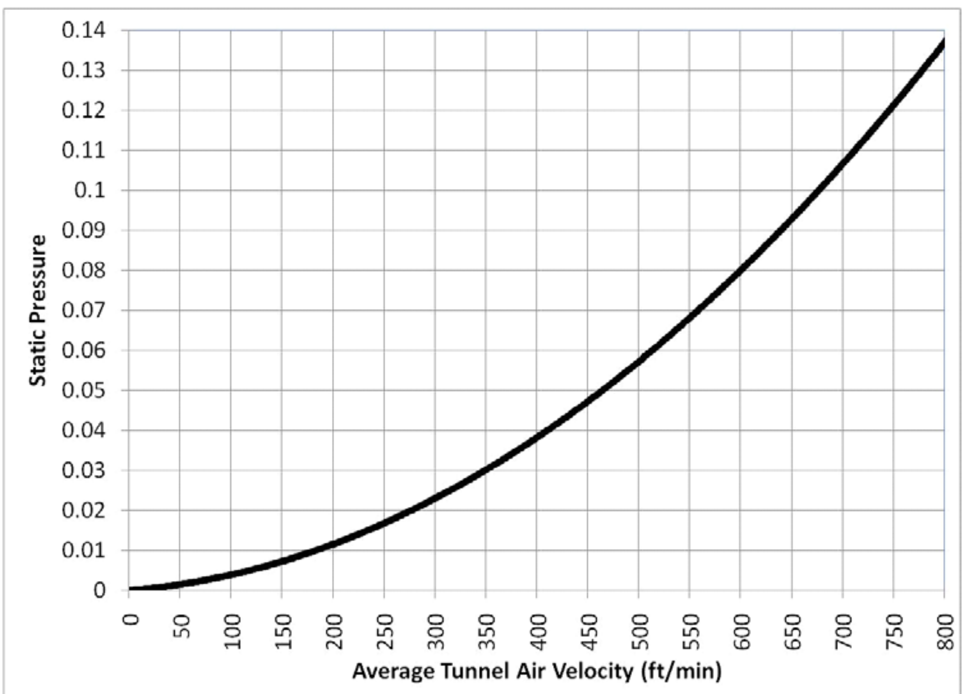

Figure 1. "Transition and Pipe" static pressure Vs. Average Tunnel Velocity.

As part of an ongoing study of the factors affecting air velocity in tunnel houses, University of Georgia Extension engineers and poultry scientists have been exploring the relationship between air velocity and the static pressure in modern tunnel-ventilated houses. Hundreds of air velocity and static pressure measurements have been taken in multiple locations throughout a half a dozen totally enclosed poultry houses. From these measurements a curve has been developed relating average tunnel air velocity to the static pressure generated in the transition and pipe zones of a tunnel-ventilated house (Figure 1). Though the study is in its initial phases, it is becoming quite clear that the latest generation of high air velocity tunnel houses produce significantly higher operating static pressures than those seen in the past.

Figure 1 illustrates the relationship between average tunnel velocity and the static pressure required to pull the air into the cross-section and down the length of the house (transition + pipe zone pressure). To determine the total pressure/work required of the tunnel fans the static pressure required to pull the air through the pads would have to be added to the pressure indicated in Figure 1. For example, let's say we had an older 500' tunnel-ventilated house with six-inch evaporative cooling pads (sized for a pad velocity of 350 ft/min) and an average tunnel velocity of 400 ft/min. The pressure required to pull the air through the pads at a velocity of 350 ft/min would be approximately 0.055". To this we would add the "transition and pipe" pressure (Figure 1) to obtain our total static pressure of 0.095" (0.055" + 0.04 = 0.095").

Now let's say we had a new tunnel-ventilated house with design velocity of 600 ft/min. The pads would still be sized based on an air velocity through the pad of 350 ft/min and therefore the pad static pressure would remain approximately 0.055". To this we would again add the "transition and pipe" pressure to obtain a total static pressure of 0.135" (0.055" + 0.08" = 0.135"). It is important to note that though the pad static pressure remains the same, the higher tunnel velocity would result in a substantially higher "transition and pipe" pressure (0.08") than that seen in the 400 ft/min house (0.04") leading to a significantly higher total static pressure (0.135" vs. 0.095") that the tunnel fans would be working against. What if we wanted an average tunnel velocity of 800 ft/min? The total static pressure the tunnel fans would be working against would increased to 0.19" (0.055" + 0.135" = 0.19")!

It is important to realize that there are other factors that can increase the total static pressure tunnel fans are working against that may have to be taken into account when designing a tunnel house. Tunnel doors can increase the total static pressure by one or two points. Lowered half house curtains, exposed side wall posts, deflector curtains, dirty pads, etc., can also increase the static pressure the fans are working against. The static pressures our tunnel fans are working against are increasing as the desire for increased bird cooling through higher air velocity increases. Whereas in the past with average tunnel air speeds of 400 to 500 ft/min the total static pressure (measured at the tunnel fans) between 0.10" to 0.12" were the norm, in many of today's houses with air speeds of often exceeding 600 ft/min static pressures between 0.14" and 0.20" will tend to be the norm. It is important to realize that there is essentially nothing you can realistically do to decrease the static pressure down to those levels seen in the past. Yes, you could add pad area to decrease the pad static pressure portion of the total static pressure the fans are working against, but it will have a rather limited effect. For example in the typical 50' X 500' house with an air velocity of 600 ft/min it would take approximately 20 additional feet of 5' tall pad to decrease the pad static pressure by one point. Though this may decrease the total static pressure the fans are working against from 0.14" to 0.13" it would only increase in amount of air moved by the fans by approximately 1%. If a producer wished to decrease the total static pressure the fans are working against to 0.10", approximately of 160' X 5' of pad would need to be installed on each side of the house! Though this would increase the average tunnel air velocity, the amount of air movement in the first 160' of the house would be minimal as would the level of bird cooling. It is important to realize that adding evaporative cooling pads in most instances will not tend to dramatically decrease the total static pressure because in many high air velocity tunnel houses the pad pressure represents only a small portion of the total static pressure (possibly less than 25%). It is the "transition" and "pipe" pressures that are becoming the major contributors to static pressure and there is little a producer can do to lower these.

In the end the best way to insure that you obtain your target air velocity is to calculate the number of tunnel fans a house requires based on a realistic operating pressure. For instance, if you want an average air speed of 750 ft/min you would likely need to determine the number of tunnel fans required based on their air moving capacity at a static pressure of 0.20". For 600 ft/min, a design static pressure of approximately 0.15" would be advisable and 0.10 for a design velocity of 500 ft/min. Failure to take into account the high static pressures generated in high air velocity houses will tend to result in lower than expected levels of bird cooling.

Michael Czarick
Extension Engineer
(706) 542-9041 542-1886 (FAX)
mczarick@uga.edu
www.poultryventilation.com

Brian Fairchild
Extension Poultry Scientist
(706) 542-9133
brianf@uga.edu