TECHNICAL FOCUS

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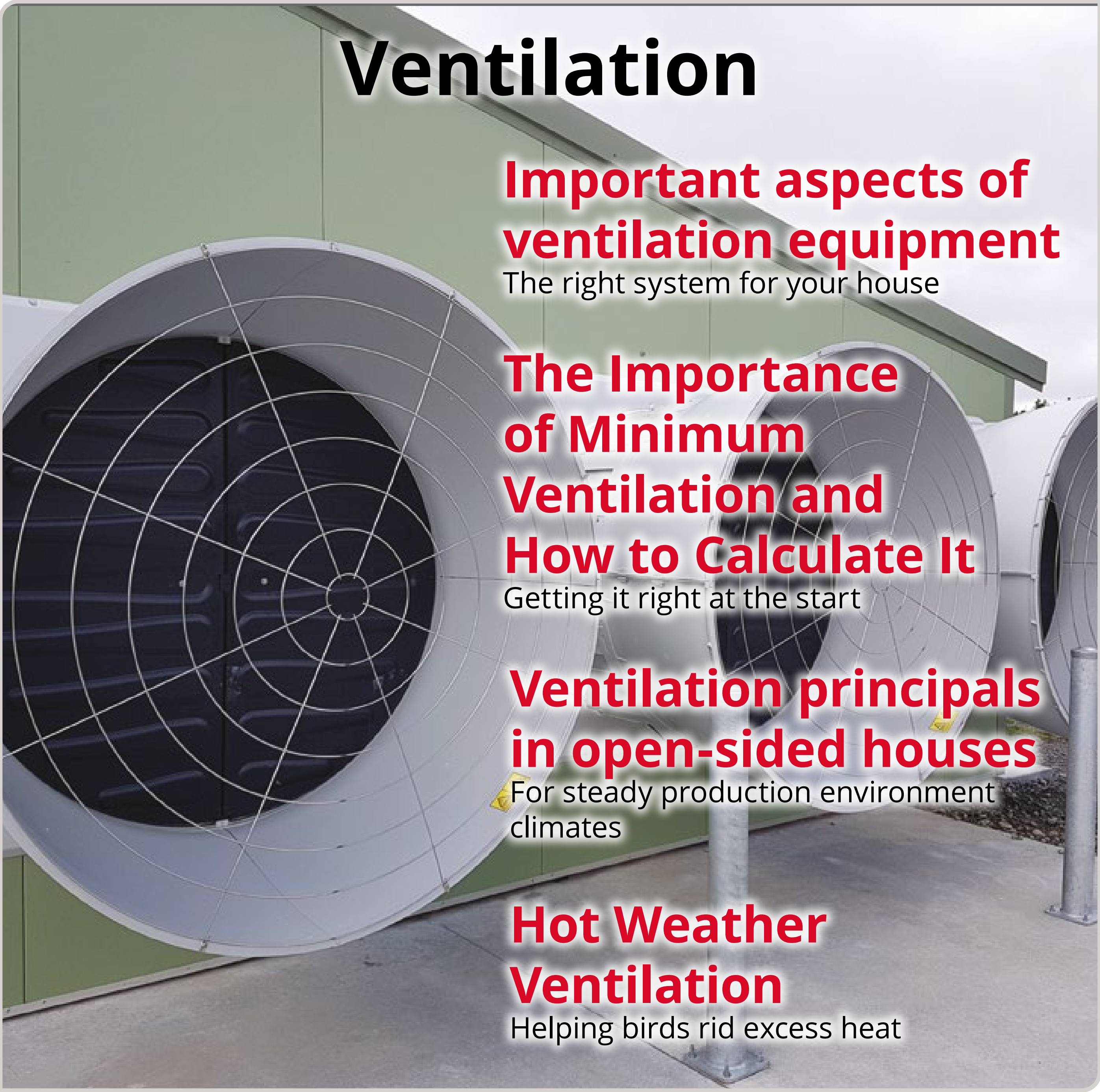

Ventilation

Important aspects of ventilation equipment
The right system for your house

The Importance of Minimum Ventilation and How to Calculate It
Getting it right at the start

Ventilation principals in open-sided houses
For steady production environment climates

Hot Weather Ventilation
Helping birds rid excess heat

In this issue
Providing birds with the correct house environment is key to unlocking the full genetic potential and performance of a flock. Poultry growers often focus on limiting house energy and heating costs. In most cases, this is a false economy as it leads to a sub-optimal environment which is detrimental to final bird performance and therefore overall profit. In this issue we take a look at equipment involved in the ventilation system of a poultry house and the importance of minimum ventilation and how to calculate it. Also ventilation management in open-sided houses will be discussed as well as the role of ventilation in removing excessive heat and keeping the birds comfortable.

Important aspects of ventilation equipment

Martijn Gruyters, Senior Technical Manager, Cobb Europe

In the management of modern broilers, ventilation plays an important role in keeping the birds comfortable and attaining their genetic potential. Over the last few decades, the industry has moved from open-sided houses with natural ventilation towards closed housing systems with better environmental control. The development of automated systems has been the driver for this industry move and now a large range of ventilation equipment is available on the market. This article will cover some important aspects and management of ventilation equipment.

When discussing ventilation, the following parts play an essential role:

- Fans
- Inlets
- Sensors
- Cooling system (if required)

Fans

In most houses with automated ventilation systems, the houses are run on negative pressure, as this is the most efficient way of moving air. The negative pressure created inside the house is lower than outside allowing air to be pulled into the house through the inlets. The driver for this negative pressure is fans which will actively pull air out of the house. There are two different types of fans: variable speed fans and fixed speed fans. With variable speed fans, the rpm of the fan is adjusted based on the required air exchange. The rpm is directly related to capacity. A 10% increase in rpm will deliver a 10% increase in capacity. Variable speed fans are generally set to operate in the 50 to 100% range, while the fixed volume or on/off fans always runs at 100% capacity.

When designing a ventilation system for any type of poultry house, it is important to rate the capacity of a specific type of fan (whether it is variable or fixed) at the negative pressure it needs to operate. The pressure drop selected will depend on the house width, how far the incoming air jet must travel once it enters the house, and the outside temperature. When outside temperatures are below 5 ºC, the inlet pressure drops, and the opening must be increased. The ability of the incoming air jet to attach to the ceiling depends on the temperature differentials between outside and inside the house.

Table 1 shows the desired negative pressure (in Pa or inch of water) for different house widths.

Required inlet airspeed and pressure difference			
House width (m)	**Pressure (Pa)**	**Airspeed**	**Distance air travels**
10	20	5.7	5.0
12	25	6.5	6.0
15	31	7.2	7.5
18	37	7.8	9.0
21	43	8.4	10.5
24	49	9.0	12.0

Guideline: for every 61 cm the air needs to travel, a pressure drop of 2,5Pa is required.

Fan suppliers will publish the fan capacity in m^3 of air/hour (cubic feet per minute) over a range of pressure drops starting at 0 Pa of pressure (free airflow). As negative pressure in the house is increased the amount of work the fan needs to do increases, which in turn reduces the efficiency and capacity of the fan. All manufactures will test their fans in their own facilities or at an independent facility such as BESS labs (Bioenvironmental and Structural System, University of Illinois – *http://bess.illinois.edu*) which is a great resource for many international fan manufacturers.

The following are some important considerations when choosing fans:

1. All tunnel fans should have a cone. The cones will significantly improve the performance of the fan.
2. Fan shutters should be well sealed to prevent air leaks, and always mounted on the inside of the fan.
3. High-capacity cone fans with diameters ranging from 127 cm (50 in) to 145 cm (57 in) are the most suitable for a tunnel ventilation system.
4. When comparing fans for tunnel ventilation use, it is always best to use their operating capacities at 25 Pa (0.10 in wc) or more.

When considering what tunnel fans to buy, it is also important to look at efficiency in terms of energy usage. Efficiency is like car milage, except that it is expressed in m^3/Watt instead of liters/kilometer. A difference of 3.4m^3/watt (2cfm/W) between 2 fans typically equates to a difference of 10% in energy usage. Tunnel fan energy efficiency ratings should not exceed 0.0109 m^3/s (23 cfm) per Watt. Air flow ratio should be a minimum of 0.75. The "Airflow Ratio" is the ratio of a fan's airflow at 50 Pa (0.2 in wc) divided by airflow at 12.5 Pa 0.05 in wc) or the capacity lost over these pressure ranges.

When chimney fans are used, they need to be installed at a minimum of 1 meter into the house to create a heat pocket in the ridge of the roof to prevent extracting the heat generated by the heating system.

A circulation fan system is an integral part of any ventilation system.

The primary function of a circulation fan system is to disperse the natural heat stratification in the house. It is not unusual to see up to 5 °C (25 °F) difference between the ceiling and floor level. These fan systems are designed to mix the air from the floor to ceiling by producing air movement at floor level between 0.25 to 0.76 m/s (50 to 150 fpm), removing moisture from the litter, and improving energy costs. There are two different circulation fan systems, horizontal or vertical. The horizontal circulation system requires a smooth roof or ceiling.

In wider high-volume houses, a double row of circulation fans can be installed. The fan orientation can be similar to Figure 1 or the fans can be used to create a "race track" effect with all fans facing in the same direction.

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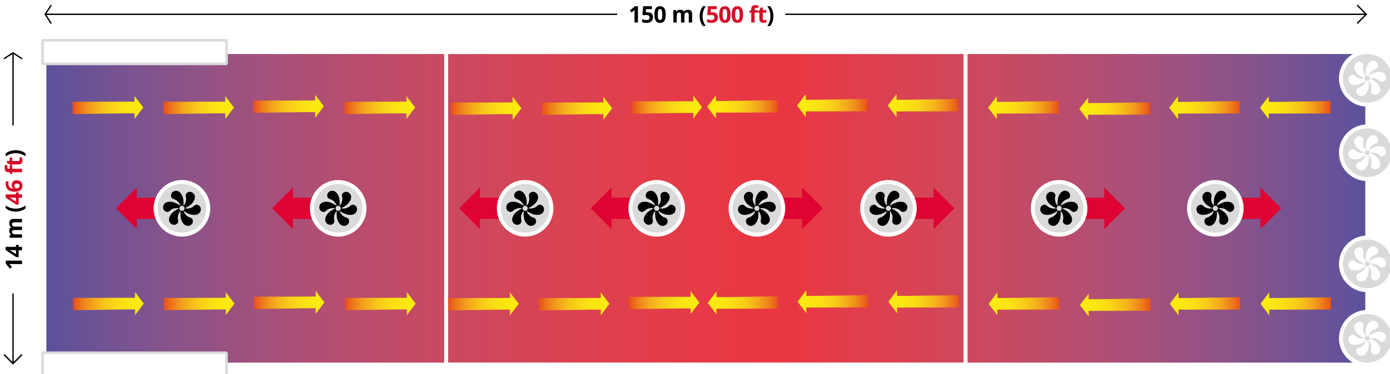
An example of a horizontal circulation fan system in a tunnel ventilated house



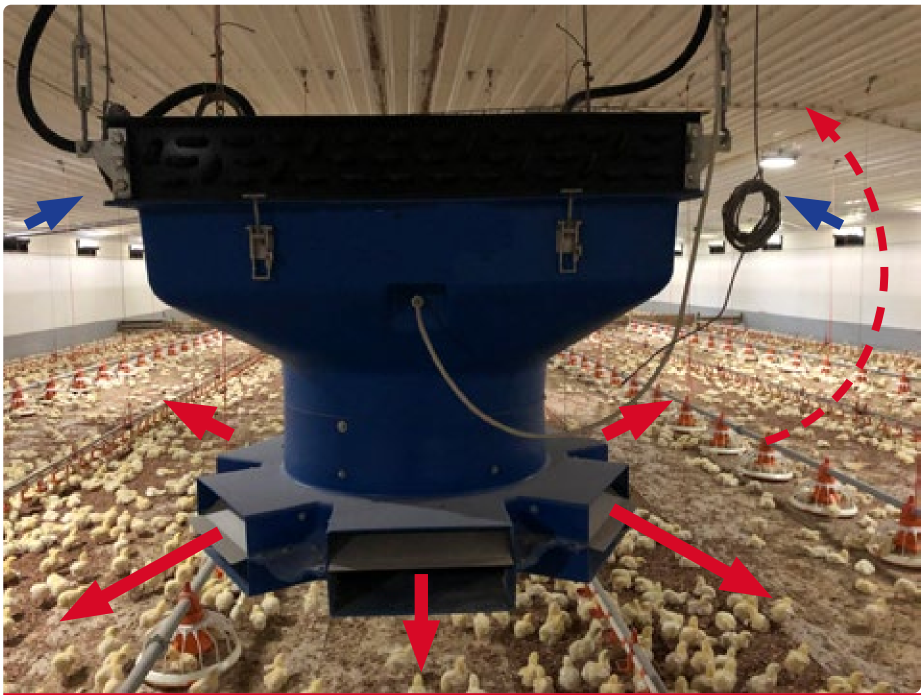
The large red arrows indicate high velocity movement at ceiling level, while the smaller yellow / orange arrows indicate the low velocity return created at floor level. Increasing circulation fan capacity will increase the "return" air movement at floor level. If the return air is warm, then moving warm air does not constitute as a draft! The more circulation capacity, the drier the litter.

Capacity of the circulation fan system should be approximately 10 to 20 % of house volume. Typical circulation fans have a diameter of 450 mm (18 in) with an operating capacity of 70 m³/min (2500 cfm). In high ceilings and new tunnel ventilated houses, larger 600 mm (24 in) circulation fans with a capacity of 140 m³/min (5000 cfm) are being used.

Inlets

Inlets are a very important part of the ventilation system, and the choice and quality of installation is often ignored. The primary function of a perimeter inlet is to direct the incoming air. Inlets can be divided into 2 different types depending on their function in the ventilation process and position in the house:

- Side wall inlets or perimeter inlets
- Tunnel inlets



An illustration of a vertical circulation fan system. The thick red arrows show high velocity distribution and a thinner dashed red line shows the return air going back to the ceiling. The thick blue arrows indicate the cold air coming in through the perimeter inlets.

Perimeter inlets play an important role in the minimum and transition part of the ventilation process. The number of inlets must always match the required fan capacity that will be used, so knowledge of perimeter inlet capacity at pressure is important. They must be pressure controlled and respond to fan volume and, in doing so, maintain the desired airspeed and pressure drop.

All inlets require wind proofing covers on the outside of the house to help to prevent outside wind to open the inlets. The inlet cover should be at least 30% greater than the cross-sectional area of the inlets to minimize air restriction. Wind proofing will also help prevent heat from being drawn out of the house on the leeward side (opposite side of the wind direction). Without wind proofing of the sidewall inlets, the mechanical pressure control system cannot properly adjust the pressure or inlet opening to get the desired airspeed at the inlet.

Houses greater than 100 m should install two perimeter inlet drive units in the center of each side wall. A solid 5 -8mm rod is always the preferred method for operating the perimeter inlets. Cables are prone to stretch and twist causing variation in the inlet opening over the length of the house.

All the equipment in a modern poultry house can be linked to a central controller in which the data from the sensors can be translated into actions based on the set parameters. This central point is the controller and it can range from a simple device with a number of relay switches to a highly sophisticated computer (Figure 2). The basic function of a controller is to manage house environment, the two most important factors being the minimum ventilation program which is independent of temperature, and the house temperature. Another very important role of the controller is to be an early warning alarm system any time settings like temperature get out of a pre-set range.

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As access to the internet and cellular data grows in rural areas across the world, so does the capability to remotely monitor housing conditions and make necessary changes as needed.

Sensors

Since birds cannot send information to the controllers, sensors are necessary to collect information on house conditions for the controllers. They are the eyes and ears which will continuously monitor what is happening inside the house. The two most important sensors in a modern broiler house are the temperature and pressure sensors, which together stage the fans, heating, and perimeter inlet systems.

Temperature sensors must always be positioned close to the birds. The number of temperature sensors usually depends on the number of heating zones in the house. A heating zone can be defined as the area which is heated by a single or group of heating units (whether it is a furnace or radiant heat source). A single temperature sensor is never a good option. The number of zones depends on house area/length, with 4 internal temperatures sensors and a single external sensor being standard. A temperature sensor must not be installed close to a heat source. Since the air temperature tends to be lower along the side walls of a poultry house, the temperature sensors need to be placed around the 1st drinker or feeder lines closest to the sidewalls. The center of the house is almost always the best house environment in terms of temperature.

A static pressure sensor measures the difference between the pressure inside a poultry house relative to the outside (atmosphere). The pressure difference between outside and inside is the driver for the opening position for both the perimeter and tunnel inlets. Wind protection for the outside measuring tube is important for precise control of the house inlet openings. A single pressure sensor is sufficient, and in a tunnel ventilated house, should always be located away from the tunnel inlet end of the house.

A broiler house with pad cooling.

Cooling systems

In many locations around the world, airspeed is not enough to effectively keep the birds comfortable. In regions that experience ambient temperatures higher than 28 °C, a cooling system should be considered to lower the ambient temperature and keep the birds comfortable. The cooling system either preconditions the incoming air using an evaporative cooling system installed in the tunnel inlets or a fogging system installed throughout the length of the house.

Evaporative cooling systems

The primary role of evaporative cooling systems is to maintain the house temperature below 28°C. The evaporative cooling system is very effective at dropping incoming air temperature, but for every 1°C cooling the relative humidity (RH) will increase by 4.5%. For this reason, evaporative cooling systems should only be used when all the tunnel fans are operational, with the only exception being during very high temperature conditions in the first two weeks.

Traditionally cooling pads are made of paper. The lifespan of a paper evaporative cooling system is influenced by many management factors, with water quality being the most important. More recently, plastic pads are being used because they can be easily cleaned especially in regions with poor water quality. For both paper and plastic systems, sizing and installation of the pumps to ensure adequate water flow across the pads is essential. Always follow the manufactures specifications.

Fogging systems

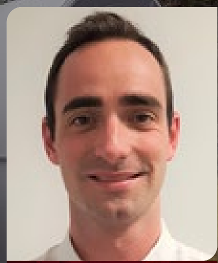
Fogging systems produce droplet sizes ranging from 30 micron in the case of low-pressure systems, to as small as 10 microns with high pressure systems. The smaller the droplet size, the larger the relative surface area for evaporation and the more effective the cooling. Like the evaporative pad, cooling systems will reduce temperatures but also increase relative humidity. In a cross ventilated house, the fogging lines need to be installed in front of the perimeter inlets approximately 1.5m from the side wall. For some more detailed information see the Cobb Broiler Management Guide (available at ***https://www.cobb-vantress.com/resource/management-guides***).

Keeping birds cool and supplying them with sufficient fresh air are key aspects of modern poultry management. Different systems have been developed over the years which all work together to make up the ventilation system. This article has briefly described the most important equipment involved in the ventilation system and how they work together. Developments in this technology have greatly improved how we manage our birds, but still requires the skills and knowledge of the producer to make it work.

About the author:

Martijn Gruyters has 21 years of poultry industry experience, 14 of which have been at Cobb. He services the European region. Martin holds bachelor's and master's degrees in animal science from the University of Wageningen.

The Importance of Minimum Ventilation and How to Calculate It



Brendan Graaf, Broiler Specialist, Cobb Europe

Providing birds with the correct house environment is key to unlocking the full genetic potential and performance of a flock. Poultry growers often focus on limiting house energy and heating costs. In most cases, this is a false economy as it leads to a sub-optimal environment which is detrimental to final bird performance and therefore overall profit. Performance damage due to poor minimum ventilation in the early stages of the flock are realized towards the end of the cycle when it is too late to correct. This article will cover the key considerations and basic calculations for minimum ventilation. The minimum ventilation system is designed to ensure good air quality and moisture control throughout the life of the flock, thus helping to achieve both optimum performance and bird welfare.

Minimum Ventilation

Minimum Ventilation is the minimum amount of ventilation (air exchange) required to maintain the full genetic potential of the birds by ensuring an adequate supply of oxygen while removing moisture, waste products, and combustion from the environment. Table 1 is a reference guide for air quality standards that must be maintained by the minimum ventilation system.

The system uses fans on a cycle timer and is independent of temperature control. Poultry houses need sufficient heating capacity (Table 2) to maintain house set-points on the cold days, while still allowing sufficient minimum ventilation, since the minimum ventilation system is the primary source of heat loss from the house. The minimum air exchange is linked to the amount of moisture added to the house by the birds, the drinking system, heating system and ventilation system. Under most conditions, maintaining good moisture control should supply adequate air quality for the birds and ensure carbon dioxide levels remain below 3000 ppm.

The preferred cycle time for minimum ventilation is a 5-minute (300sec) on/off cycle with a minimum run time of approximately 20% of this time (five minutes = cycle of one minute on, four minutes off). Any time the air quality begins to deteriorate, small increases (10 to 15 seconds) to the ON time must be made, but the total cycle time should always remain the same i.e. if you increase the ON time by ten seconds you need to remove ten seconds from the OFF time so that the total cycle length remains at 300 seconds. The minimum time the fans are turned on needs to be approximately 60 seconds to ensure adequate mixing of the cold incoming air with the warm internal air and adequate extraction of moisture through the exhaust fan. However, if your house only has large (1.2 to 1.5 m/ 50 to 60") tunnel type ventilation fans as opposed to the smaller (600 to 900 mm /24 to 36") minimum ventilation fans then the cycle on time can be lowered to achieve similar air exchange rates.

Table 1. Air quality guidelines for broiler houses.

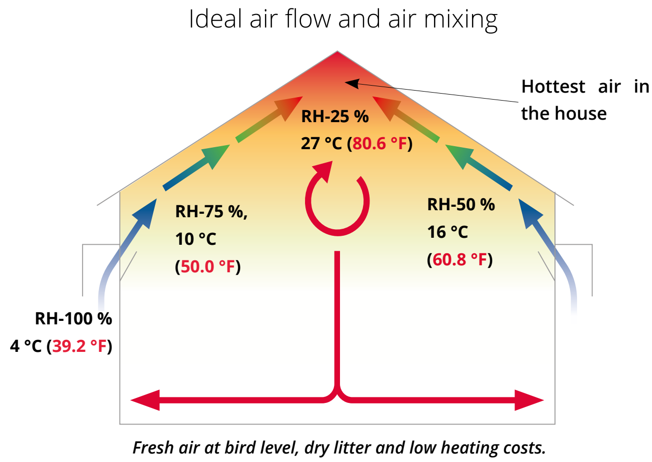
Air quality guidelines	
Oxygen	> 19.6 %
Ammonia	< 10 ppm
Respirable Dust	< 3.4 mg/m³
Relative Humidity	< 65 %
Carbon Monoxide	< 10 ppm
Carbon Dioxide (CO_2)	< 0.3 % / 3,000 ppm
Air exchange (with minimal air movement at chick level)	<0.30 m/s (**60 fpm**)

Table 2. Heating Capacity Requirements

Forced Air Heating System Requirements kW/m³	
Tropical climates	0.05
Temperate climates	0.075
Cold climates	0.10

The incoming cold air must be conditioned correctly by easily attaching to the ceiling, moving towards the peak of the house where it is heated, expand and its relative humidity reduced. The air jet must then start detaching from the ceiling near the centre of the house generating a return movement at floor level in the opposite direction. This return movement towards the side walls will ensure distribution of the warmer dry air thus bringing fresh air to the birds while also removing moisture and waste gases from the litter, the birds, and the heating system (Figure 1). The stale moist air is then extracted from the house through the fans.

Figure 1. Ideal air flow for negative pressure ventilation in a broiler house.



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The system runs when the house is at or below set point temperature and will operate on a timer program – see the example of a simple timer fan program opposite (Table 3).

Table 3. Minimum ventilation timer program

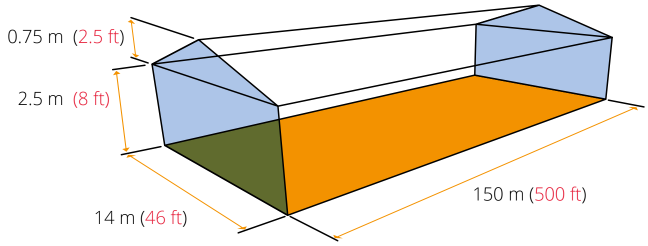
Minimum ventilation timer settings (5 min (300 sec) timer)		
Day	**ON (seconds)**	**OFF (seconds)**
1	45 to 60 (20 %)	240
3	45 to 60	240
5	75	225
8	90	210
11	105	195
14	120	180
18	135	165
22	150	150
25	165	135
30	180 (60 %)	120

The timer fan capacity should be a minimum of 0.3 m3/min per m^2 (1.0 cfm per ft^2) in hot climates where outside temperatures rarely drop below 20 to 25 ºC (68 to 77 ºF). In cold climates a timer fan capacity of 0.61 to 0.77 m3/min per m2 (2 to 2.5 cfm/ft2) of floor area, will be needed. The challenge will always be matching the requirement with fans available in the market. Do not use large tunnel fans for the minimum ventilation system, smaller capacity fans will always afford more stable environmental control and flexibility.

Some ventilation systems do not use cycle timer programs for minimum ventilation, but instead run a continuous ventilation system using variable speed fans. These systems are designed to produce a more uniform house environment, but it is strongly dependant on the fans pressure stability at low rpm. In practical terms can the incoming "air jet" attach to the ceiling to provide effective conditioning of the cold incoming air? These systems will require good quality environmental controllers, perimeter inlets and fans. They are not suitable for older (leakier) houses and will generally require a higher level of technical knowledge.

Example calculation

House dimensions used in example:
150 m long, 14 m wide and 2.88 m average height.
Average height = 2.5 m + (0.5 x 0.75 m) = 2.88m
House floor area: 150 m × 14 m = 2,100 m^2



Fans used for example:
Fans capacities used in the examples are rated at 25 Pa
Exhaust or side wall fans: 900 mm, working capacity of 340 m^3/min.
Air exchange range: 0.3 to 0.60 m^3/min per m^2 of floor area
Note: These fans can be fixed volume or variable speed.
The 0.61m^3/min per m^2 of floor area fan capacity is only needed in cold climates.

How many fans to install or allocate for minimum ventilation:
Number of fans required = (House floor area X Air exchange rate) ÷ Working capacity
2,100 m^2 × 0.3 to 0.61 m^3/min per m^2 of floor area = 630 to 1260 m^3/min
630 to 1260 ÷ 340 m^3/min = 1.85 to 3.70 or **2 to 4 fans**

The sizing and run times should be adjusted to suit an individual house but the basic principles remain the same. The minimum ventilation cycle run times are only guidelines and daily adjustments should be made based on air quality and maintaining humidity below 65 % where possible. If the number of fans works out to be less than 1, then cycle on time can be adjusted to less than 60 seconds to maintain correct air exchange rates and not over ventilate the house. Some newer controllers use m3/bird/hr as an input setting for their minimum ventilation rates. In order to convert to these units, first calculate the total ventilation capacity at each age based on the number of fans used and the cycle timer program and then divide by the number of birds in the house.

E.g. Capacity of 2 fans = 40,800 m3/hr
Cycle time at day 0 = 60s ON; 240s OFF = 20% run time
Total capacity on cycle time = 20% of 40,800 m3/hr
= 8160 m3/hr
House has 40, 000 birds,
so = 8160 m3/hr ÷ 40 000 birds
= 0.20 m3/bird/hr

Static Pressure Test

The number of fans to run for minimum ventilation has been calculated and a timer program for their run time has been designed. Next, it is important to achieve correct air conditioning. First, we need to ensure the house is as air tight as possible in order to effectively generate a negative pressure and ensure air enters through the inlets and not through leaks or gaps around the house. Conducting a static pressure test will let you know how tight or leaky your house is (see details of static pressure test in Martijn Gruyters article). Once a tightly sealed house has been established it is important to ensure correct inlet management.

Inlets

Important points about inlets:

- Minimum ventilation inlets should be sealed especially at the hinge, sides and along the leading edges, to prevent the cold air being directed down to the floor.
- When open, the air should only enter over the top of the inlet and not from the sides or through the bottom of the inlet
- All minimum ventilation inlets should direct air towards the peak of the house. The pressure drop across the inlets should be adjusted to ensure that the incoming air reaches the peak where the heat has accumulated.
- The pressure drop selected will depend on the width of the house or how far the air must travel once it enters the house.
- Correct air pressure is achieved by matching the inlet area and the fan capacity.

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- Air inlets should be pressure controlled to maintain constant air speed throughout the ventilation stages.
- Table 3 can be used as a reference for the correct static pressure/inlet air speed required to ensure incoming air stays as close to the ceiling until it reaches almost half way across the house.
- The pressure drop selected will depend on the house width, how far the incoming air jet must travel once it enters the house, and the outside temperature.
- When outside temperatures are below 5 ºC the inlet pressure drop, and opening size will need to be increased. The ability of the incoming air jet to attach to the ceiling depends on the temperature differentials between outside and inside the house.
- Always use a smoke test to ensure that the incoming air reaches the centre of the house. Smoke tests should only be done when the outside temperatures are significantly colder than inside, and when there is no wind.
- Inlets need to open enough to achieve the required static pressure and airflow. Depending on inlet design, a minimum opening of 2.5 to 5 cm is required to ensure cold air reaches the centre of the house.
- Inlets should be installed as close to the ceiling as possible – about 30 cm below the eaves provided there is no interruption of airflow.
- In open truss houses, the angle of the inlet opening must be such that the air is not directed onto a purlin which will redirect the air down to the floor.
- Any obstructions (electrical conduit/ concrete or wooden beams) should be removed because they interrupt the air flow, forcing air to the floor.
- In the case of existing obstructions, a directional flap can be used on top of the inlet and/or a solid "air ramp" to aid the air in passing the obstruction.
- When using a negative pressure ventilation system, it is not the placement of the fans which dictate uniformity of air distribution but rather the placement of the inlets.

Table 3. The required inlet airspeed and pressure difference.

Required inlet airspeed and pressure difference							
House width m	House width ft	Pascals (Pa)	Inches of water (in wc)	Airspeed m/s	Airspeed fpm	Distance air travels m	Distance air travels ft
10	30	20	0.08	5.7	1,112	5.0	16
12	40	25	0.10	6.5	1,280	6.0	20
15	50	31	0.12	7.2	1,417	7.5	25
18	60	37	0.15	7.8	1,535	9.0	30
21	70	43	0.17	8.4	1,654	10.5	35
24	80	49	0.20	9.0	1,772	12.0	40

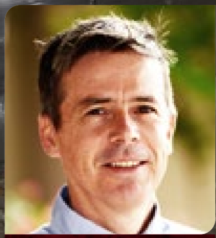
- To achieve uniform air distribution, inlets should be evenly spread throughout the house and open the same amount.
- Houses over 100 m (330 ft) should have the inlet drive units installed in the centre of the side wall to reduce any inlet opening variation. Solid 5 to 8 mm (0.2 to 0.3 in) steel rods eliminate any stretch and twisting.
- It is common for cables to stretch and twist and can cause variability in perimeter inlet openings. Inlets closer to the drive unit are open more than those at the end of the house. This can be minimized by ensuring a sufficiently sized counterweight or spring.
- Guide pulley position and size is very important for efficient closing and sealing of inlets.
- All inlets require wind proofing covers on the outside of the house. The inlet cover should be at least 30% more than the cross-sectional area of the inlet to minimize air restriction. These inlet covers also help to reduce natural light entering the house.

When it comes to minimum ventilation, there is rarely a one size fits all solution. However, by applying the information from this article together with good stockmanship, such as making daily adjustments to minimum ventilation based on air quality, humidity, and bird behaviour, will greatly assist with providing an optimum environment to achieving excellent bird performance.

About the author:

Brendan Graaf is a broiler specialist with 10 years of experience in the poultry industry. He services the EMEA region. Brendan holds a bachelor's degree in Animal Science and a master's degree in Poultry Science.

Ventilation principals in open-sided houses



Andrew Bourne, Broiler Specialist, World Technical Services

The aim of the article is to give the reader a general overview of the basic principles for natural ventilation of poultry houses. Also included are some key ideas when converting naturally ventilated houses to tunnel ventilation along with management tools to help optimize ventilation.

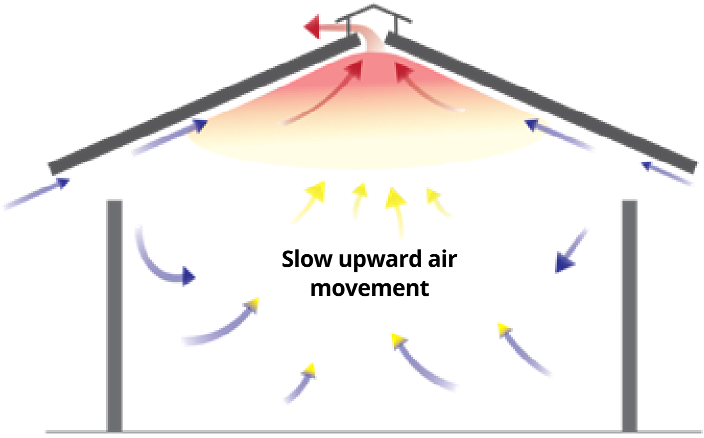
Natural ventilation is the supply of fresh air through natural forces. It is common in temperate regions where the climate is like the desired production environment and where access to electricity is limited. This system is not recommended in regions with wide seasonal differences. There are two types of natural ventilation: thermal buoyancy ventilation and wind-driven ventilation.

Thermal buoyancy ventilation occurs naturally when there is no wind and is the preferred method for cold weather or during brooding because air is exchanged slowly. Wind-driven ventilation is not ideal for cold weather but can be used in hot weather because the high air exchange rates facilitate the removal of metabolic heat and provide some wind chill effect.

Natural Ventilation Key Points

- Minimize temperature fluctuations, especially at night. Better temperature control will improve bird comfort, feed conversion, and improve growth rate.
- A reflective roof surface with a minimum insulation R-value of 10 and a 1.5 m (5 ft) roof overhang must be considered.
- Successful natural ventilation depends on house location. Houses should be built in an east to west orientation to reduce solar heating of the sidewalls during the hottest part of the day.
- Ideally the house should be oriented perpendicular to the prevailing summer wind. Consider the wind direction in the morning and open the curtain on the leeward (non-windy) side first.

Figure 1. Natural Ventilation without wind.



Natural ventilation (without wind)

- Planting trees or using shade materials on the north or south side of the house will help reduce solar heating. However, structures or vegetation must not restrict wind movement. Prevailing winds should be used advantageously.

How to ventilate an open house without wind?

Thermal buoyancy ventilation works because hot air rises. The flock and heating system in a naturally ventilated house heat the air, the hot air rises and is released through a ridge vent. The size of the ridge vent opening and distance between the inlets and outlet will determine the rate of air exchange.

The larger the openings or the greater the distance from inlet to the outlet in the ridge, the greater the air exchange. In houses without a ridge opening, creating an air exchange without wind or outside air movement will be very difficult as the curtain opening has to function as both an inlet and outlet.

Because natural ventilation is very reliant on the weather, it can be challenging to manage air exchange rates. Thermal buoyancy requires a significant temperature difference between the inside and outside of the house. However, if the incoming air temperature drops below 5 ºC it is nearly impossible to get any significant mixing of the cold incoming air and the warm air in the peak of the house.

How to ventilate an open house in windy conditions?

During brooding and cold weather, wind is a major concern because it can easily increase ventilation. Wind-driven ventilation occurs when wind enters through the open curtain on the windward side of the house. Wind speed and angle as well as the windward and leeward curtain opening amount affect the amount of ventilation. The following are a few management tips:

- ✓ Wind-driven ventilation will increase as the curtain opening on the windward side is increased. An opening ratio of 1 to 2 or, 1 to 3 is ideal, but will depend on local conditions, house design and whether a ridge outlet is installed.
- ✓ Consider the wind direction in the morning and open the curtain on the leeward (non-windy) side first. To facilitate air exchange and ensure incoming cold air is not directed to floor level, the curtain opening on the leeward side is always open more than the windward side.
- ✓ Until 14 days of age, the curtains should be opened minimally to provide sufficient air exchange in the house but no air speed at chick or floor level. Air speed across the chicks in the first fourteen days of age leads to chilling, decreased feed and water consumption and increased energy use for heat production.

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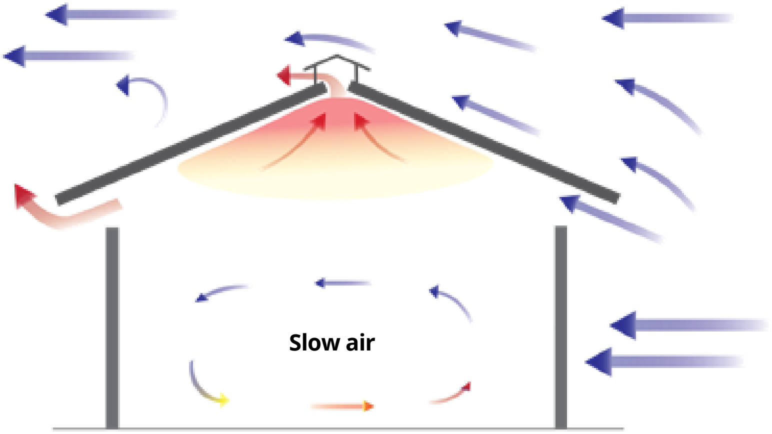
Figure 2. Natural ventilation for cold weather with wind.



Natural ventilation for cold weather (with wind)

In hot weather, to achieve maximum air speed (air exchange) across the birds, the curtain should be opened the same amount on both sides and as low as possible, taking full advantage of the wind. The following are a few management tips:

- ✓ During hot weather walk through the flock slowly and regularly to encourage air circulation around the birds and stimulate water consumption.
- ✓ Remove feed from the flock by lifting the feeding system six hours before the hottest part of the day. This reduces the body heat output due to feed metabolism. Feed can be returned to bird level in the early evening hours when the outside temperature is cooler.

If the power supply to the farm is sufficient, the installation of a combined stirring and fogging system will greatly improve broiler performance in hot weather. The following are some key points to consider when installing the systems.:

- ✓ Minimum fan size: not less than 900 mm (36 in) direct drive fans with an operating capacity of 5.75m³/s or 345 m³/min (10,500 cfm) at 50 Pa.
- ✓ A 900 mm (36 in) fan will only draw air from 1 m (3.3 ft) and move air 12 m (40 ft). Maximum dispersion that a 900 mm fan will distribute air is 2.2 m (7.2 ft).
- ✓ Fans should be suspended perpendicular to the floor and 1 m (3.3 ft) above the floor.
- ✓ Houses wider than 14 m should consider 3 fans per row.
- ✓ A fogger line should be installed in front of each group of fans.
- ✓ For more detailed advice on fogging systems see the Cobb Broiler Management Guide (available at: ***https://www.cobb-vantress.com/resource/featured***).

Figure 4. Stirring fan and fogging line setup.

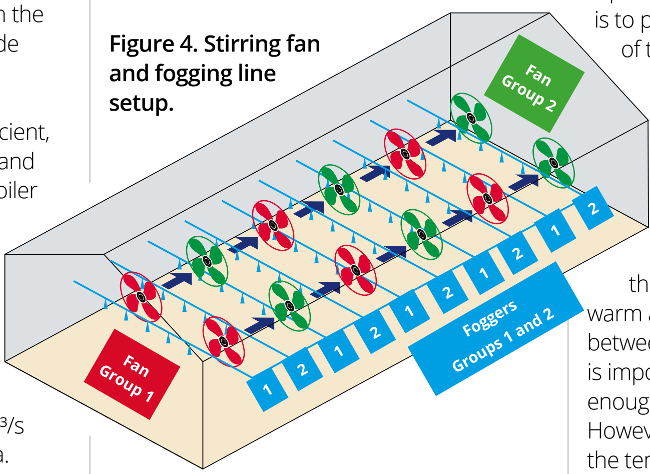
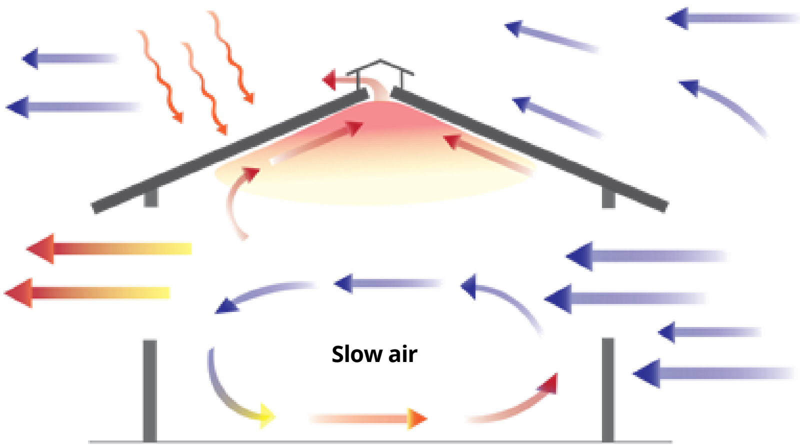


Figure 3. Natural ventilation for hot weather with wind.



Natural ventilation for cold weather (with wind)

	28 days (°C)	35 days (°C)	42 days (°C)
Fan line Group 1	25	22	20
Fan line Group 2	27	24	22
Fogger line Group 1	30	27	27
Fogger line Group 2	32	29	29

The following is a simple temperature-based guide for the operation of the stirring and fogging systems:

- ✓ Do not use cooling fans in the first 14 days!
- ✓ Fans divided into two groups
- ✓ Group 1 (red fans in model) on 2 °C above set point
- ✓ Group 2 (green fans in model) on 4 °C above set point
- ✓ Foggers on 6 °C above set point

How to operate minimum ventilation in a newly converted open-sided house without perimeter inlets?

The dilemma we face is how to create the ideal environment for the brooding phase, especially in the cold season. The best option is to place the reception area in the center of the house.

During minimum ventilation, the incoming fresh air to the brooding area needs to enter preferably over the top of the brood curtain, to limit air movement at chick level. The goal is to achieve some mixing of the cooler incoming fresh air with the warm air at the ceiling. The opening or gap between the top of the curtain and ceiling is important to try to create an air jet with enough velocity to generate some mixing. However, this will have only limited success if the temperature differential is relatively low.

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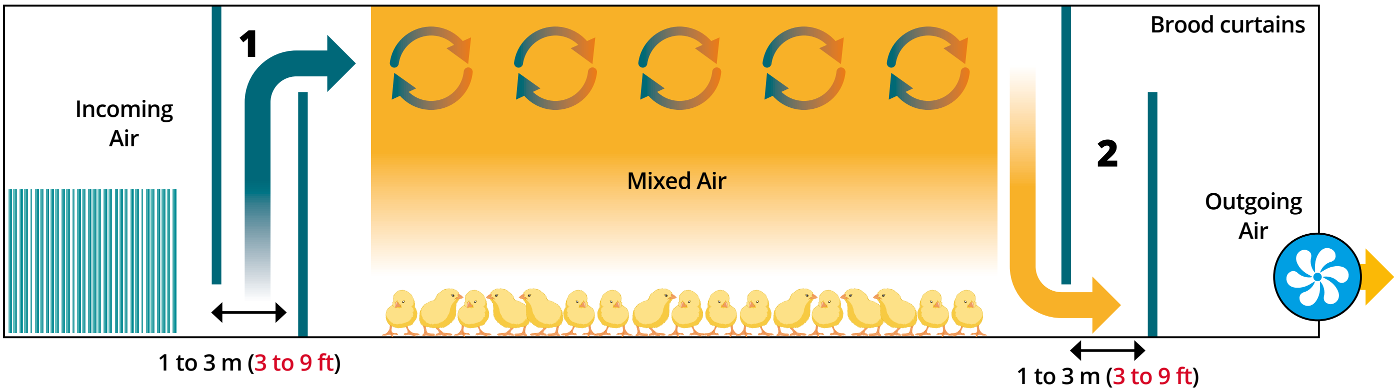
Figure 5. A brooding curtain configuration in a tunnel house without perimeter inlets.



The space between the curtains that form the limit of the chamber, should be 1 to 3 m (3 to 9 ft) wide, to facilitate air movement. To help pre-heat the incoming air from the tunnel inlet, an additional heater can be placed in this section. (See the Figure 5 for an example of a brood curtain configuration in a tunnel house without perimeter inlets).

Air tightness and the importance of curtain installation to ensure energy efficiency.

Air tightness is the most important criterion for open-sided houses.

- ✓ The top of the curtain must always overlap a solid surface to prevent air leaks by having an overlap of at least 15 cm (6 in).
- ✓ A 25 cm (10 in) mini curtain installed on the outside of the curtain will also help prevent air leaks over the top of the curtain.
- ✓ The curtains should fit into an envelope which is a 25 cm (10 in) mini curtain that seals the curtain vertically on both ends.

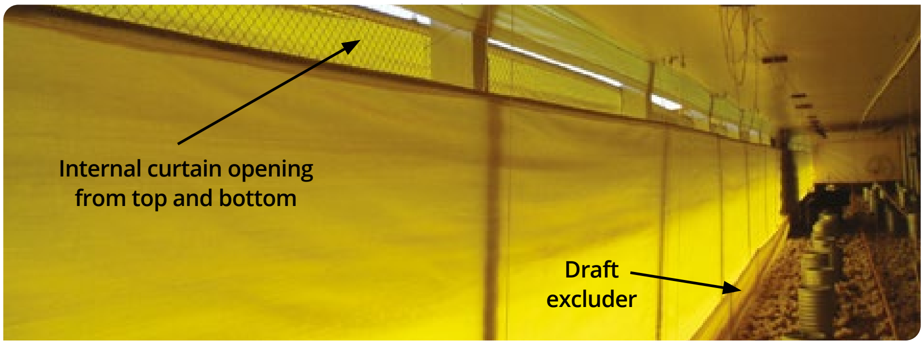


Figure 7. An example of an internal curtain with a draft excluder.

- ✓ Curtains need to be sealed at the base to prevent air leaks at floor level.
- ✓ All holes and tears in sidewall and/or inlet curtains must be repaired.
- ✓ The optimum stem wall height is 0.50 m (1.6 ft).
- ✓ An internal curtain is also an excellent option with a draft excluder installed at floor level.

About the author:

Andrew Bourne is a broiler management and ventilation specialist with the World Technical Services team. He joined Cobb in this role in 2005. Andrew has 21 years of experience in broiler production and technical services experience. His expertise is in ventilation and new technologies. Andrew holds a bachelor's degree and Master of Business Administration from the University of Stellenbosch South Africa.

Figure 6. An example of correct curtain installation on an open-sided house.

Hot Weather Ventilation: Helping birds rid excess heat

Andrea Pizzabiocca, Cobb Europe

In our previous issue, we thoroughly discussed heat stress and the importance of mitigating its effects on birds' welfare and performance. It is not surprising that heat stress situations primarily happen during hot weather seasons. Therefore, the ventilation that will be applied in those months will play a major role in removing the heat allowing them to be comfortable and productive. Of course, the farm's geographical position will dictate temperatures and, in turn, the ventilation that will be needed to keep the birds in their thermoneutral zone. If temperatures rarely go above 25° C, transition ventilation will be used. When temperatures are much higher than 25° C, tunnel ventilation will be needed, most likely in combination with a cooling system.

Table 1: Maximum airspeed at bird level based on age (from Cobb Broiler Management Guide available at *https://www.cobb-vantress.com/resource/management-guides*)

Age (Days)	Max Airspeed (m/s)	Max Airspeed (fpm)
0 to 5	0 to 0.3	0 to 60
5 to 14	0.3 to 0.5	60 to 100
14 to 21	0.5 to 1.8	100 to 350

Transition ventilation is used when house thermostat overrides the cycle timer so that the fans start running continuously and air enters through the perimeter inlets. The key to transition ventilation is to increase air exchange rate and manage temperatures but limit air speed at bird level (Figure 1). Remember that regardless of air temperature, air speed that is too high will chill young birds (see table 1). The only occasion to use some air speed on chicks in the first 14 days is if the ambient temperature is very close to their body temperature.

The fan capacity needed for transition ventilation can be expressed in terms of floor area (1.7 to 1.85 m³/min per m² of floor area). In a standard tunnel ventilated house typically 50% of the total tunnel ventilation capacity will be used. As a rule, transition ventilation should completely exchange the house air in 2 to 3 minutes. Here are some examples of how to calculate fan capacity needed for a sample house 150 m long, 14 m wide and with 2.88 m average height (note: all capacities are rated at 25 Pa).

Fan capacity needed = floor area (150m x 14m = 2,100m²) x 1.7 to 1.85 m³/min = 3,570 to 3,885 m³/min.

If we use 1.2 m fans with a capacity of 680 m³/min this will mean 5 to 6 fans needed. Will this fan capacity be enough to fully exchange house air in 2 to 3 minutes?

House volume (150m x 14m x 2.88m = 6,048m³) ÷ fan capacity (680m³/min x 6 = 4,080m³/min) = 1.48 YES

The fan capacity then will be used to calculate how many perimeter inlets to install. Here's an example with a single inlet capacity of 34.5 m³/min:

Number of inlets = 4,080m³/min (total fan capacity) ÷ 34.5 m³/min (inlet capacity) = 118 inlets or 59 inlets per side.

When houses do not have tunnel ventilation (cold climates), and transition ventilation is used to cope with hot conditions, the maximum air exchange capacity should

be less than 1 minute to provide enough temperature control. Furthermore, perimeter inlets should be placed slightly lower in the sidewalls so that when fully opened they might direct air on the birds to create some wind chill effect.

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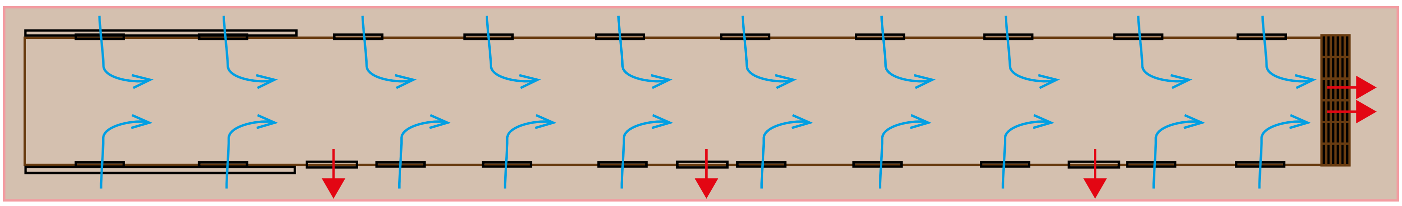
Figure 1: Transition ventilation using both side wall and tunnel fans, with air entering from perimeter inlets, even air distribution, and correct air speed.



When hot weather temperatures get very high, a tunnel ventilation system can reduce the effective temperature felt by the birds through air speed. Air speed is key to remove heat from birds. The higher the air speed the more heat removed from the birds (wind chill effect) and the lower the effective temperatures will be. This of course will depend also on their age and weight, since bigger birds will struggle more to release heat due to the lower body volume/body surface ratio (Figure 2). Relative humidity will also have an impact on the effective temperature felt by the birds.

A typical tunnel ventilated house will have all tunnel ventilation fans at one end of the house and the tunnel inlets at the opposite on both sides (Figure 3).

With the modern, high-yielding commercial broilers which produce a lot of heat the tunnel ventilation should provide the following:

- An airspeed of 2.5 to 3.5 m/s
- A complete house air exchange in 40 to 50 seconds
- Start when the temperature is 2.8 to 3.5°C above setpoint

When broiler final market weights are below 2.0 kg, an airspeed of 2.0 to 2.5 m/s should be enough. However, when building new houses, it is always better and advisable to calculate for maximum capacity in case the market should start requiring heavier birds.

As the air removes the heat from the birds and flows from the inlet side to the fan end, it will become warmer, which is why a fast air exchange is required. The faster the exchange, the cooler the air will be. Ideally the temperature differential (ΔT) from the front to the end of the house should be 2.8°C. To achieve this ΔT, the house must be well sealed with the correct airspeed (generally the target velocity is 2.9 m/s) and negative pressure drop at the tunnel inlets. Very low inlet airspeeds and pressure drops will cause “dead spots” by the front

Figure 2: the effect of air speed on the effective temperature felt by birds at different ages.

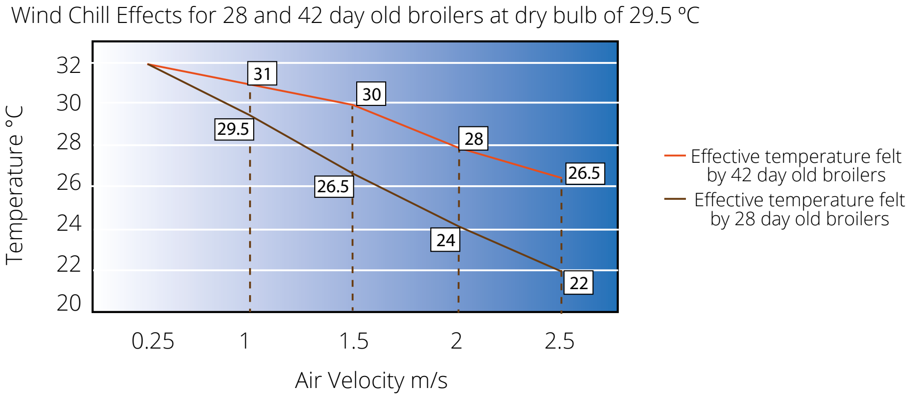


Figure 3: a tunnel ventilated house with fans at one end and inlets at the other end (on both sides).

wall and the first section of side walls after the tunnel inlet opening (Figure 4 and 5). The tunnel inlet pressure drop must be adjusted to help reduce dead spots. If air speeds are not sufficient, temperatures will be higher in these areas and the flock will experience heat stress. Tunnel doors, unlike tunnel curtains, can improve air movement in the tunnel inlet area reducing dead spots near the side walls just past the tunnel inlet opening. This improves the airspeed uniformity over the cross section of the house.

To improve flock uniformity and house distribution, it is always advisable to put migration fences from the beginning of the cycle 30 meters center.

To calculate fan capacity needed to achieve an air speed of 3 m/s, use the house cross section because, by using the same cross section, same number of fans will be needed.

Using the same numbers from the previous example:

Fan capacity needed to achieve a 3 m/s air speed = cross section (14m x 2.88m = 40.32 m^2) x airspeed (3 m/s) = 120.96 m^3/s or 7,257 m^3/min

Number of fans required = 7,257 m^3/min ÷ 680 m^3/min (single fan capacity) = 10.67 or 11 fans

Is the complete house air exchanged in 40 to 50 seconds?

Air exchange = House volume (6,048 m^3) ÷ total fan capacity (11 x 680 m^3/min = 7,480 m^3/min) = 0.80 minutes or 49 seconds.

It is important to know how air speed is distributed across the house to understand the cooling effect on the birds.

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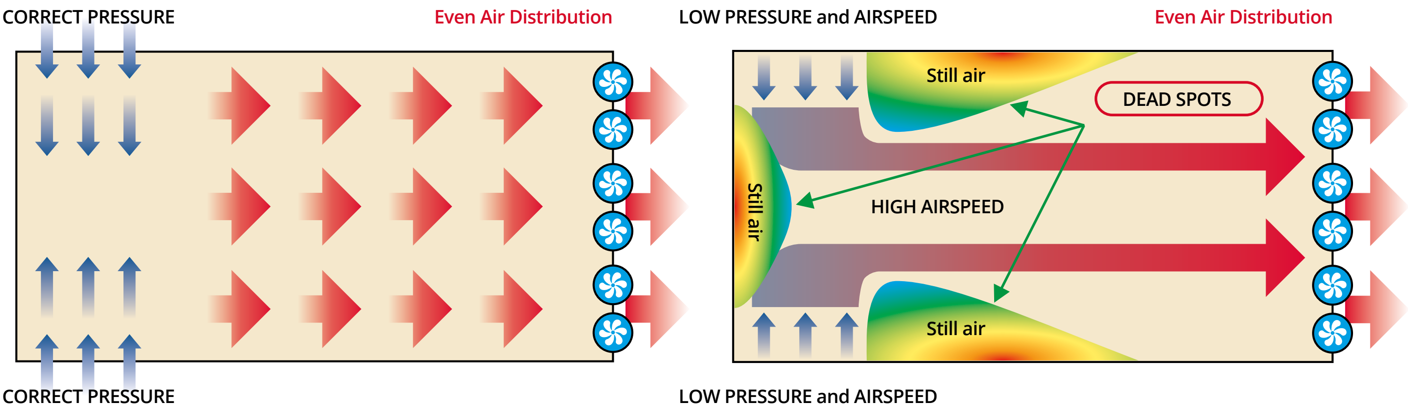
Figures 4 and 5. The correct pressure and airspeed at tunnel inlet level will allow even air distribution and speed, while low pressure and windspeed at the same inlet level will cause dead spots and uneven air velocity.



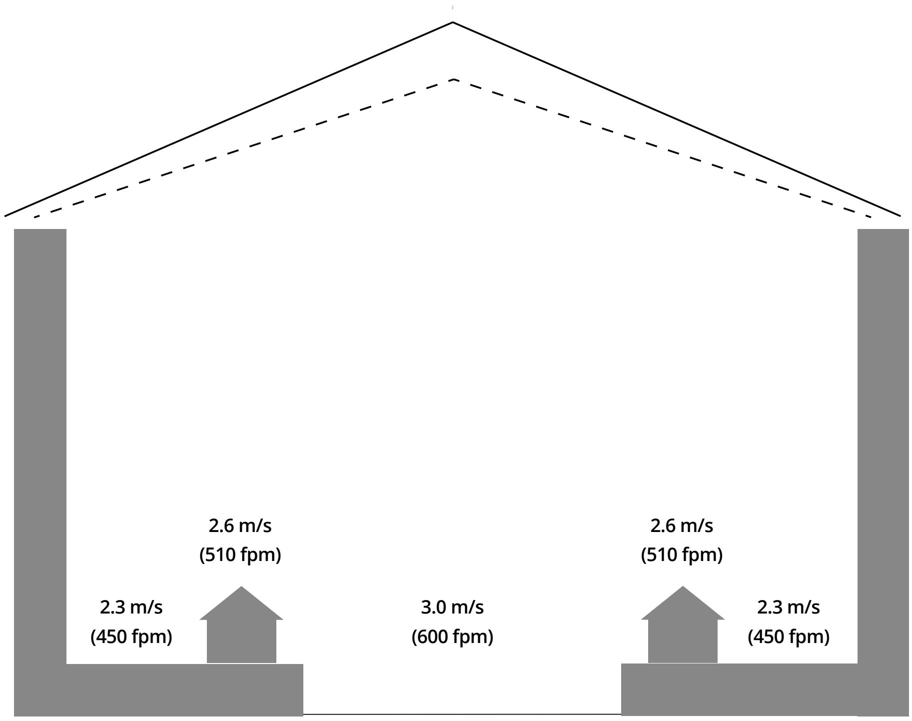
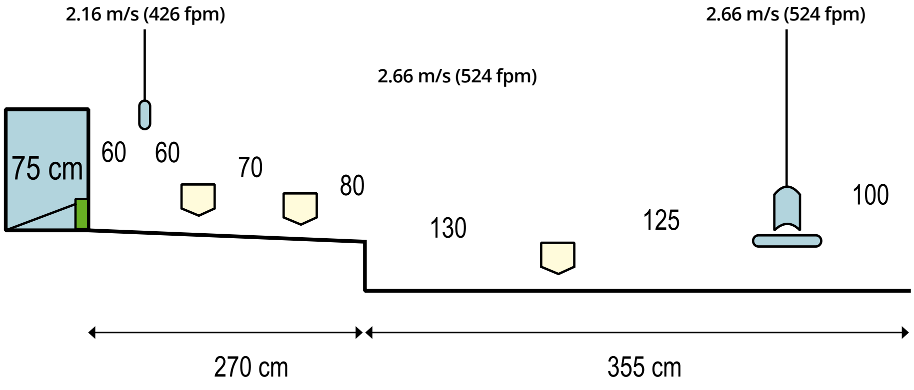


Figure 6. Air speed distribution in a USA type breeder production house.

Figure 7. Air speed distribution in a breeder production house with community nests.



The best way to measure air speed is to check it 25 to 30 meters from the tunnel fans about 1 meter from the ground in three positions, the middle of the house and at the two outermost feeder lines. Ideally, use an anemometer with the average feature and measure the average over 1 minute. The average of the three recordings provides a good indication of the average air speed in the house. Air speed in the middle of the house will always be the highest, but how much declines at the sides will depend on the sidewall roughness and the presence of obstructions (heaters, perimeter inlets, beams). The smoother the sidewalls, the closer air speed at the sides will be to the air speed in the middle.

Achieving even air speeds across the house will be more challenging in breeder production houses, due to the presence of equipment like feed hoppers, nests and slats. Typically, air velocities on slats will be 15 to 25% lower than on the scratch area in both USA type breeder houses (with nests on the sides) and European type breeder houses (with community nests in the middle; Figures 6 and 7). To limit these differences in air speeds, do not use exposed structural posts on sidewalls (especially important in USA style houses) and limit the difference in height between slat and ceiling compared with scratch area and ceiling.

If the fans in a tunnel ventilated house do not have enough total capacity to achieve the desired air speed, deflectors or baffles can be used to reduce the cross section therefore increasing the air speed. Place deflectors with a spacing of 8 m at a height of 2.7 m above the floor, which will give a more uniform airspeed (Figure 8 overleaf).

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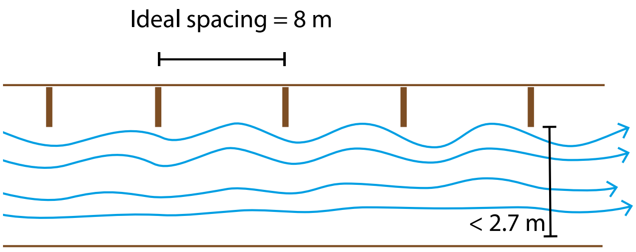

Figure 8. The best setup for deflectors/baffles that creates a uniform air speed and environment (from UGA 2019 Hot Weather Management Workshop).

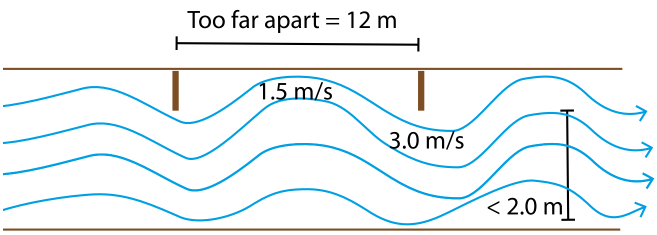

Figure 9. When deflectors are too close to the floor and too far apart the air speed will not be uniform and only a few birds (those standing right below the deflectors) benefit from good air speed (from UGA 2019 Hot Weather Management Workshop).

If the deflectors are lower and placed further apart, the air speed will be much less uniform with only a limited number of birds benefitting (Figure 9).

When outside temperatures become extreme and get closer to the birds own body temperature tunnel ventilation alone will not be enough to cool the birds (moving hot air does not help at all) and evaporative cooling will be needed.

Evaporative cooling uses the energy produced by the evaporation of water to cool the air. Evaporation is promoted by heat, air velocity and small water droplets. For every 1°C of cooling the relative humidity (RH) inside the house will increase by approximately 4.5%. The cooling potential of an evaporative system will depend on the outside temperature and RH. Table 2 shows the cooling potential of an evaporative cooling system with 75% efficiency (like most of the 15 cm cooling paper pads with 45/15° flute angles in use).

Table 2: Cooling potential of an evaporative cooling system with 75% efficiency: the colored cells indicate cooling potential as acceptable (blue cells), marginal (yellow) and insufficient (red).

Expected Cooling Produced by 15 cm (6 in) Pad System													
Outside % RH													
100	27	28	29	30	31	32	33	34	36	37	38	39	40
95	26	27	28	29	31	32	33	34	35	36	37	38	39
90	26	27	28	29	30	31	32	33	34	36	37	38	39
85	25	26	27	28	29	31	32	33	34	35	36	37	38
80	24	26	27	28	29	30	31	32	33	34	35	36	37
75	24	25	26	27	28	29	31	31	32	33	34	36	37
70	23	24	26	27	28	29	29	31	32	33	34	35	36
65	23	24	25	26	27	28	29	30	31	32	33	34	35
60	22	23	24	26	26	B 27	28	29	31	31	32	33	34
55	22	23	24	24	26	27	28	28	29	31	32	33	33
50	21	22	23	24	25	26	27	28	29	30	31	32	33
45	21	21	22	23	24	25	26	27	28	29	30	31	32
40	20	21	22	23	23	24	26	26	27	28	29	30	31
35	19	20	21	22	23	24	24	26	27	27	28	29	30
30	18	19	20	21	22	A 23	24	25	26	27	27	28	29
25	18	18	19	21	21	22	23	24	25	26	27	27	28
20	17	18	19	19	21	21	22	23	24	25	26	27	27
15	16	17	18	19	19	21	21	22	23	24	24	26	27
10	16	16	17	18	19	19	21	21	22	23	24	24	26
5	14	16	16	17	18	19	19	21	21	22	23	23	24
0	14	14	16	16	17	18	19	19	20	21	22	23	23
	27	28	29	30	31	32	33	34	36	37	38	39	40
	Outside Temperature °C												

A series of rules must be followed when using evaporative cooling, the main ones are:

- All tunnel fans must be running before operating cooling pads. Air speed through the pads must be constant (1.78 m/s for 15 cm paper pads) to achieve the best evaporation and cooling.
- Do not use cooling at temperatures below 28 to 29°C, it could affect litter moisture.
- Do not use cooling when house RH goes to 85% or above.
- Normally cooling is used between 9AM and 6PM (based on daily humidity cycles). Using at night when RH is high will cause heat stress.
- Do not use cooling before 25 days of age. During the first two weeks, it should be used only under extreme temperature conditions. Pads should be used only to temper the air and with wetting limited by an interval timer.
- Flush the system weekly.
- For cleaning and disinfection refer to the manufacturer's guidelines.

Here's an example of how to calculate the cooling pad area required using the previous example houses and a 15 cm paper pads 1.8 m high (standard pad height) which require a 1.78 m/s air speed through them:

Pad area required = total fan capacity (11 x 11.3 m³/s) ÷ 1.78 m/s = 70 m² of pad area

70 m² ÷ 1.8 m (standard pad height) = 39 m or 20 m on each side

During hot weather conditions it is crucial that the ventilation system in the houses can cope with the highest temperatures. Keeping birds in their thermoneutral zone will promote good welfare and performance outcomes.

About the author:

Dr. Pizzabiocca has 25 years of experience in the poultry industry including 12 years with Cobb. He holds a DVM with specialization in genetic improvement through selective breeding.