Environmental Management

In The Broiler Breeder Laying House

Acknowledgements

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Introduction: Economic Value of Proper Environmental Management

Whether producing meat, eggs, milk or other animal production products, it is well established that effectively managing environmental conditions reduces the total cost of production. In the broiler meat production business, all components of the production process – from parent stock broiler breeders to broiler progeny – benefit from effective environmental control. Given the economic implications, environmental control management for broiler meat production has received much more attention than that for broiler breeder hatching egg production. Consequently, much less tangible information is available concerning proper environmental management in broiler parent stock housing – rearing and laying. However, this information is critical as the production of good quality hatching eggs is the starting point in economically producing broiler meat. This publication therefore has a three-fold purpose:

It is well established that effectively managing environmental conditions reduces the cost of production.

1. To clarify what environmental criteria and conditions are necessary to achieve the genetic potential bred into modern parent stock;
2. To outline the most important factors in design of modern broiler breeder laying housing to be able to provide optimum environmental conditions; and,
3. To provide basic operational guidelines for this housing during the laying phase.

During the laying phase, the goal is to maximize production of fertile hatching eggs in a cost-effective manner. Further, we must not only meet the nutritional and health needs of the parent stock, but also ensure that their diet, environment and health status promote good quality chick production from their hatching eggs. The key to optimizing reproductive performance lies in achieving consistency in husbandry and environmental conditions in the laying house. We cannot achieve high peaks in egg production without having a high degree of uniformity in sexual maturity – a function of bodyweight control which is heavily influenced by environmental conditions.

The goal is to provide cost-effective amounts of feed to adequately prepare pullets and cockerels for optimal reproductive performance.

If environmental conditions are poor, reproductive performance will be impaired.

From early in life, the parent stock female's maintenance energy requirement is much larger than the energy requirements for growth or reproductive function. Even at peak egg production, the energy requirement to maintain normal temperature and body functions for females is about 75% of the total energy required per day. The male's maintenance energy requirement from 40-50 weeks of age is approximately 98% of the total energy required since, unlike females, the only components of the energy requirement are maintenance and growth.

Allowing house temperature to drop excessively increases feeding requirements since birds must consume more feed to maintain normal body temperature and functions. This situation results in increased feeding cost (see Example, page 2). Added feeding cost, however, is only one of the possible consequences of allowing sub-optimal temperatures. If sufficient additional feed is not provided, growth and/or reproductive function will be impaired, since maintenance energy always takes priority over growth and reproductive functions.

Maintaining optimal temperatures keeps feed cost to a minimum.

During hot weather, on the other hand, feed intake will decline excessively unless sufficient cooling ventilation is provided to prevent heat stress. Heat-stressed poultry exhibit impaired immune systems due, in part, to stress-induced hormonal influences. Digestive processes can also be impaired under such conditions. Sub-optimal environmental conditions thus create a scenario where hens

If house temperatures are allowed to drop below optimum, additional feed must be provided for birds to achieve target bodyweights.

Example shows typical additional feed cost may be $1,225 to compensate for low temperatures in a house without supplemental heat.

Allowing below-optimal temperatures will cause even worse problems in reproductive performance if bird energy requirements are not met by providing additional feed.

Maintenance energy requirements are a large part of birds' total energy needs – important because maintenance needs must be met before energy goes to growth or reproduction.

Example: Two different breeder layer houses are identical in management except for the environmental temperature experienced by the birds from 40-50 weeks of life. In house A, the temperature is maintained, via supplemental heat sources, at 68-70° F. In house B, no supplemental heat is provided and the internal house temperature fluctuates with external temperatures (Figure 1 shows typical daily temperature profiles of the two houses).

Assuming we make feeding allocation changes to achieve the same target weights (Aviagen published bodyweight targets) in both flocks, the estimated energy requirements of the two groups of males and females appear in Figures 2 and 3 (see page 4).

• Total energy requirements (Etotal) for males in House A, with controlled optimum temperatures, averaged almost 40 kcal ME/bird/day less than that for males in House B, with no temperature control.

• Total energy requirements (Etotal) for females in House A averaged almost 30 kcal ME/bird/day less than that for females in House B.

Clearly, the overall cooler temperatures of house B result in increased maintenance energy requirements (Em), thereby causing an increase in total energy requirements.

What does this mean economically? With respect to feed costs, assuming one is feeding a 1300 kcal ME/lb dietary energy level and that both flocks are managed to achieve the same bodyweight profile, Flock B would require approximately 2.3 lb more feed/male and 1.52 lb feed/female during the 40-50 week time period. Assuming an average feed cost of $175/ton, a flock size of 8,000 females and 800 males per breeder house, and a time period of ten weeks, Flock B would have an increased feeding cost of approximately $1225 ($161 for males and $1064 for females).

The economic consequences of failing to maintain optimal temperatures are likely to be even worse if additional feed is not provided to achieve target bodyweights. Obviously, not providing additional feed to the females would damage egg production. Also, it would be impossible for the males to maintain their bodyweights, much less gain weight properly. In an effort to conserve energy and survive, males continuing to lose weight will go out of semen production and reduce mating activity – damaging flock fertility and subsequent hatchability. Additionally, uniformity of bodyweight will decline, creating further management problems. When feed becomes increasingly limiting, the larger, more aggressive males will dominate smaller males at the feeder and actually over-consume feed – creating problems with overweight and underweight males. In summary, there is a high price to pay for not meeting the parent stock's energy requirements – which are highly influenced by how one manages the environment.

Note: The energy requirements of the males and females are presented as that required for maintenance (Em) and total (Etotal). The maintenance energy requirement is that required for maintaining constant body temperature and normal body functions. Sex-specific growth energy requirements are not presented in either graph because they do not change with environmental temperature changes and, practically speaking, they are very low at this stage due to minimal growth rate (e.g. only approximately 5 and 8 kcal ME/bird/day are required for female and male growth from 40-50 weeks of life, respectively). Egg mass energy requirements are not affected by environmental temperature either (estimated to decline from 102 to 90 kcal ME/bird/day as the bird ages from 40- 50 weeks and egg production declines according to performance target objectives).

and roosters have poorer bodyweight gain and uniformity, feed utilization and immune response – resulting in poor reproductive performance and, subsequently, poor chick quality.

With the growth in demand for de-boned meat, many modern breeds have been selected to produce significantly more breast meat yield. These genetic products have increased muscle mass and less body fat. This additional muscle mass produces a correspondingly greater amount of metabolic body heat. Thus, such birds will be less able to tolerate high environmental temperatures. Given this characteristic, it is even more critical to prevent excessive temperatures from occurring during the laying phase. Faced with excessive temperatures, high breast meat yielding parent females will reduce feed consumption even more quickly due to heat stress – resulting in poorer reproductive performance and increased floor eggs, mortality and hatching egg production cost.

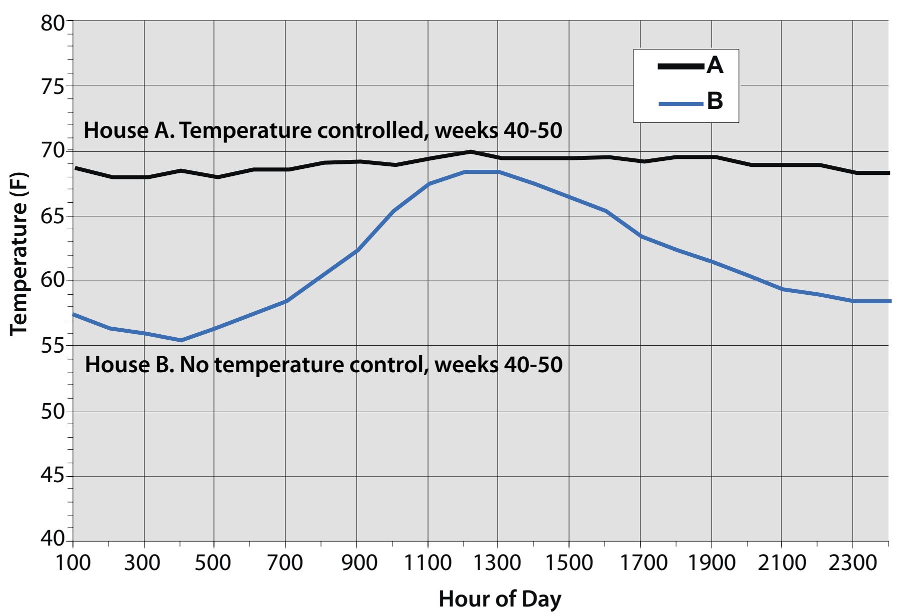
Increased demand for de-boned meat brings increased need to keep in-house temperatures from rising excessively.

However, with proper environmental management these genetic products can exhibit very good reproductive performance. Therefore, it is essential that sound environmental management be practiced in order to competitively exploit breeds with high breast meat yield as the industry moves further toward de-boned products.

Clearly, the quality of day-old broiler chicks, and their subsequent live and processing performance, will be heavily influenced by how one manages their parents. Therefore, it is prudent to give renewed and careful consideration to how we design and manage housing for parent stock breeders – as we have been doing for some time now with broilers. As a percent of the total costs, the parent stock production component is smaller than the broiler grow-out component. However, wise investment in parent stock housing and management will improve broiler meat production costs.

Wise investment in parent stock housing and management will improve broiler meat production costs.

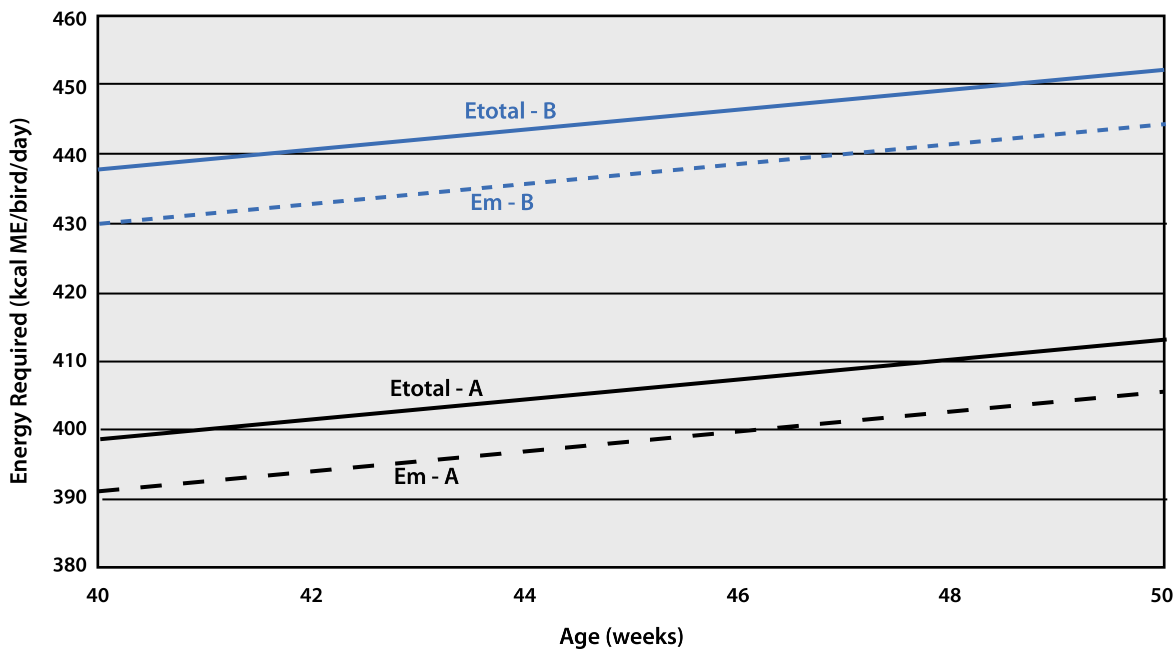
Figure 1. Daily Temperature Profiles of Two Different Breeder Laying Houses



Graph shows typical wintertime daily temperature variations in laying houses with and without supplemental heat for environmental control. Example on page 2 explains how lack of cool-weather temperature control can affect feed costs and reproductive performance.

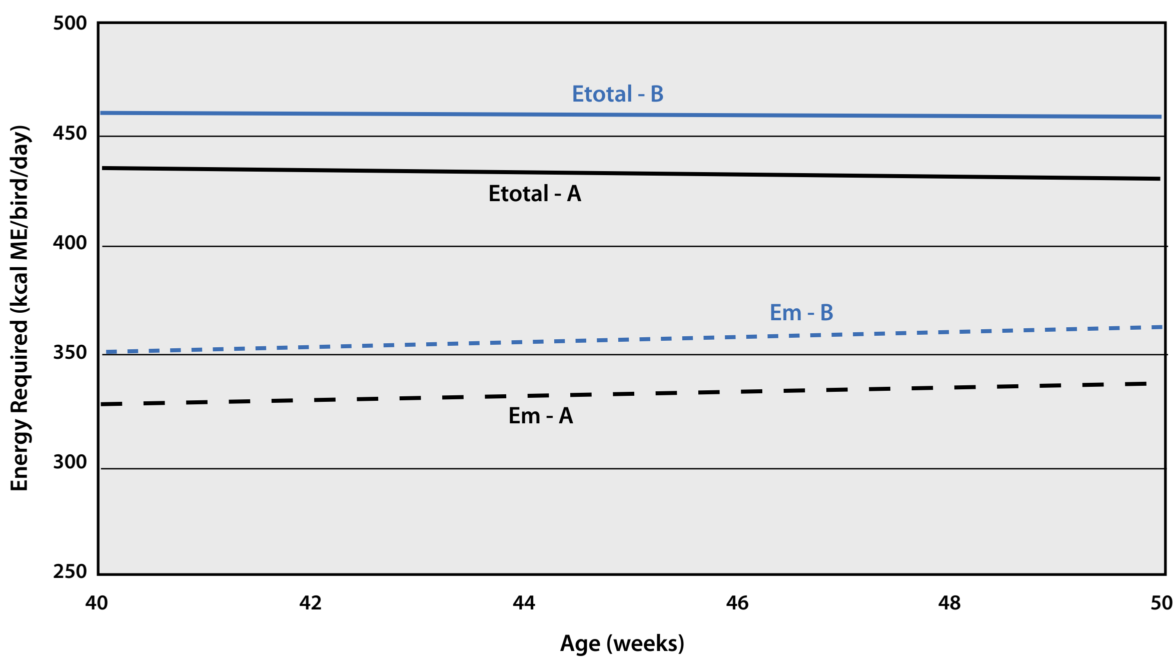
Supplemental heat in wintertime helps keep in-house temperatures consistently near optimum for best reproductive performance.

Figure 2. Energy Needs of Parent Stock Males at Differing Environmental Temperatures



Benefits of in-house environmental control are shown in these two graphs, depicting otherwise identical houses and flocks. In House A, with supplemental heat provided to keep house temperature between 68° F and 70° F, birds required less feed (Etotal-A vs Etotal-B). To achieve target bodyweights, birds in House B with no temperature control would require $1,225 more in feed cost. An even worse economic consequence in House B would be very poor reproductive performance resulting from lower than optimum temperatures if additional feed was not supplied.

Figure 3. Energy Needs of Parent Stock Females at Differing Environmental Temperatures



Critical Environmental Factors in the Broiler Breeder Laying Phase

As pointed out in the introduction, maintaining a good environment for broiler breeders is essential to keep hatching egg production cost down and achieve optimum reproductive performance. This includes achieving optimum egg numbers, egg size, shell quality, fertility and hatchability. The critical environmental factors are temperature, moisture, air quality and light.

In-house environmental management goals, to achieve the positive attributes we are looking for, should be as follows:

1. Be at the right temperature and acceptable air quality range so that birds will be within their comfort zone for optimum reproductive performance.
2. Be at the same temperature throughout the house - uniformity is critical.
3. Build in the capability (both heating and cooling) to maintain in-house temperature consistently, so that weather extremes do not affect reproductive performance.
4. Maintain good air quality and relative humidity (RH) while paying particular attention to manure and litter moisture.
5. Maintain correct intensity and uniformity of light in all areas of the house.

In the laying house, we want to maintain consistent and uniform optimum temperature, good air quality and relative humidity, and proper lighting.

Temperature is usually the most critical factor. Since ventilation plays a primary role in management of temperature, air quality and moisture in the house, ventilation management is the primary tool used in house environmental control.

Temperature is usually the most critical factor in getting good reproductive performance.

Why Temperature Matters

We spend a tremendous amount of time and effort monitoring our breeder management programs. We frequently weigh males and females to determine if they are achieving the proper bodyweight curve for optimum reproductive performance. Feed nutrient levels and feeding allocations are carefully designed to promote excellent reproductive performance. However, a major oversight in many management programs is not taking into account the effects of in-house environmental factors, especially temperature, on reproductive performance. If conditions inside the house are not maintained within an acceptable range, the feeding program cannot achieve desired results. The more environmental variation we remove, the more consistent reproductive performance will be.

When rations are formulated and feeding programs are designed for the laying phase, the goal of the nutritionist is to provide the energy, amino acids and other key nutrients necessary for body maintenance (i.e. maintaining normal body temperature and metabolic functions), growth and, in the case of females, egg production. For both males and females, the largest portion of the feed is required for body maintenance. If the house environment is too cool, more calories are spent to stay warm. If the house is too warm, more calories are spent in labored breathing and panting. In either case, calories are robbed from semen and egg production just to support the bird's vital life functions, and the result is lowered reproductive performance.

Rations and feeding programs are based on bird needs at optimum temperature.

Since bird heat tends to keep the flock and the house warm enough even in fairly cool weather, dealing with too-high air temperature is the most common challenge. It is especially important to prevent birds from reaching the stage of panting to relieve internal heat build-up. Excessive temperatures very quickly show

Preventing bird stress in too-high temperature is the most common environmental control challenge.

up in reduced shell quality, fertility, and egg production. Obviously, temperature extremes, either hot or cold, can also affect the rate a given quantity of feed is consumed (i.e. "clean-up time").

Temperatures close to 68-72°F usually produce best egg production performance.

Integrated company breeder management programs vary, and there will always be some variation from flock to flock and from time to time, but field experience indicates that temperatures close to 68-72°F usually produce best reproductive performance. Note that this is the effective temperature we would like the birds to experience. In warm weather we often cannot reduce actual air temperature to this range, but we can use tunnel ventilation wind-chill and evaporative cooling to make the birds feel as though the thermometer was reading 68-72°F.

Maintaining temperature consistency is as important as exactly hitting target temperature.

Maintaining consistent and uniform temperature throughout the house is equally as important as targeting a precise optimum temperature. There is always some variation in temperature over time and from one end of a house to another. However, a flock that experiences only one or two degree differences up or down, around even a not quite optimum target, will perform better than a flock experiencing large temperature swings around an average temperature precisely on-target.

Heat in Laying Houses

Even in warmer climates such as the Southeastern U.S.A., temperatures can be extremely low for short periods of time in winter. During this time, bird body heat alone may not be enough to keep the laying house at an acceptable temperature level. Running minimum ventilation fans in cold weather, which must be done to remove moisture, brings house temperatures even lower. As the previous example comparing heated and unheated houses illustrated, allowing lower than optimum temperature can exact a significant cost in impaired reproductive performance if not in added feed cost.

Installing forced air furnaces to maintain optimum temperature in cold weather is becoming common in layer houses.

Many integrated companies have therefore been installing forced air furnaces in layer houses to maintain temperatures without sacrificing air quality during these times of extreme cold. These heaters can achieve the goal of maintaining consistent optimum temperatures, by allowing us to keep a background temperature such that birds will never be exposed to extremely low temperatures during the winter months.

Moisture Management and Air Quality in the Laying House

A critical purpose of ventilation in a modern laying house is the removal of moisture in order to maintain proper RH for good bird health. When RH is above 70% it becomes more difficult for the birds to dissipate heat so as to remain comfortable in above-optimum temperatures. As RH drops below 40%, increased respiratory heat dissipation occurs, so birds are more likely to be chilled in below-optimum temperatures. The optimum RH range in laying houses is between 50% and 70%.

In cold weather, ventilation is the primary tool for moisture removal.

During warm weather, ventilation normally accomplishes moisture removal at the same time it is providing temperature management. During cold weather, however, ventilation must be run based on timer fans and not the thermostat so excess moisture will be removed. Inadequate ventilation during cold weather will cause high RH, moisture build up underneath the slats, caked litter in the scratch area and increased ammonia levels. Approximately 70% of the water consumed each day by a laying flock will be deposited into the litter or manure. It is imperative to run adequate ventilation to remove moisture from the manure.

Basic Principles of Negative Pressure Ventilation

Modern broiler breeder houses utilize negative pressure ventilation (Figure 3). This means that fans are exhaust fans pulling air out of the house, which then draws fresh air into the house through provided air inlets or cracks in the house. This is called negative pressure ventilation because it works by creating a partial vacuum inside the house. Houses must be tight so that all air entering the house will come through desired air inlets. Negative pressure ventilated houses are usually equipped to be operated in different modes to cope with changing environmental conditions.

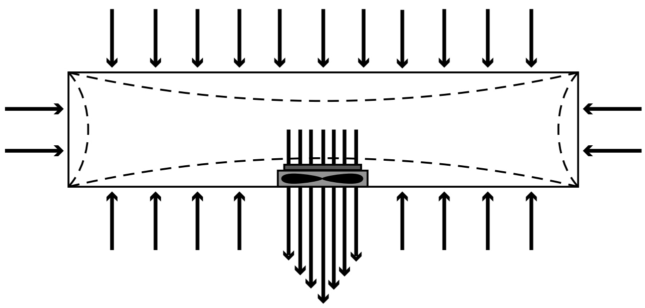


Figure 3. In negative-pressure ventilation, exhaust fans pull outside air into the house. When fans and air inlets are matched (and the house is tight), this creates a partial vacuum inside the house. Air then enters uniformly at the same speed through all inlets. By choosing which inlets to use (tunnel or sidewall), we can then control the airflow pattern in the house.

Laying House Tightness

A modern negative pressure ventilated laying house must be tight. Many older laying houses are operated in a natural ventilation mode during much of the year. When weather becomes extremely hot, curtains are raised and tunnel ventilation is used. In contrast, modern laying houses typically operate, regardless of time of the year, with the curtains in the raised position.

House tightness is essential because air leaks defeat the airflow patterns negative pressure ventilation is designed to create.

With negative pressure ventilation, the key to giving birds the best environment is to control how and where air enters the house. Again, house tightness is of paramount importance. During cool weather operation, air coming under footers, around doors, or through curtain cracks only serves to chill or discomfort birds and creates moisture problems by condensation in the manure underneath the slats. During tunnel ventilation, air leaks along the length of the house destroy the single, high-velocity airflow path from tunnel inlets to exhaust fans needed for good wind-chill cooling. House tightness promotes uniform house temperature and allows for much better moisture control, thus improving air quality.

A house tightness test that has been used in the poultry industry for many years for 40x400 ft or 40x500 ft houses is to turn on two quality 36-inch fans or one quality 48-inch fan with all inlets and doors completely sealed. The static pressure read from the house interior to the house exterior will then represent the level of negative pressure achieved by the fans. The higher the level of negative pressure, the tighter the house. The goal for a broiler breeder laying house should be a minimum of 0.15 inches of water column negative pressure; for newer houses, static pressure should exceed 0.20 inches of water column.

A house tightness rest is easy to perform and can alert you to ventilation maintenance or management steps needed to keep birds comfortable and performing well.

Ventilation Modes

Modern poultry house ventilation systems are typically set up to operate in three different modes, often referred to as *minimum*, *transitional*, and *tunnel* ventilation.

<u>Minimum ventilation</u> – In this mode, fans draw air into the house through sidewall or ceiling air inlets, and in such a manner that incoming air does not directly flow over birds. Ventilation is regulated by a timer, not by thermostat or tem-

perature sensor. The purpose is to maintain good air quality and exhaust excess moisture during cool weather. Many laying houses do not have sidewall air inlets for cooler weather ventilation, and instead try to utilize slightly opening or "cracking" the curtains to serve as air inlets. A cracked curtain is a very poor air inlet and will not direct air properly into the house. It is recommended that new houses be equipped with sidewall perimeter air inlets for cool weather operation.

Using vent box sidewall air inlets actuated by a static pressure controller is the best way to ensure that proper minimum ventilation airflow pattern is achieved.

Transitional ventilation – This mode uses tunnel fans to bring air into the house through sidewall or ceiling air inlets, and is regulated by thermostat or temperature sensor. The primary purpose is temperature control. This mode is used when excess heat must be exhausted from the house, but wind-chill cooling is not needed or wanted. Transitional ventilation is often called *power mode* ventilation.

Tunnel ventilation – In this mode, tunnel fans bring air into the house through tunnel air inlets at the opposite end of the house. Ventilation is regulated by thermostat or temperature sensor. The purpose is to create a high velocity airflow which exhausts heat from the house at a higher rate and also flows over the birds to provide wind-chill cooling. Tunnel ventilation also provides a vehicle for evaporative cooling.

Minimum Ventilation in Laying Houses

Even in cold weather, ventilation is essential for moisture removal from the house as well as to provide fresh air and oxygen and remove noxious gases from the house. Minimum ventilation must be utilized even when it is extremely cold and damp outside and the thermostat does not call for heat removal, and even if a small amount of heat must be removed from the house in the process. The principle is that incoming cold wet air will be warmed and dried as it enters and flows across the house ceiling area (Figure 4). This warmed and dried air is then able to pick up moisture from the manure and carry it out of the house. Failure to maintain minimum ventilation rate leads to wet houses, high ammonia and RH, and other problems associated with these conditions.

Timer-controlled minimum ventilation is essential for cold-weather moisture removal, and must be maintained no matter what outside weather is like.

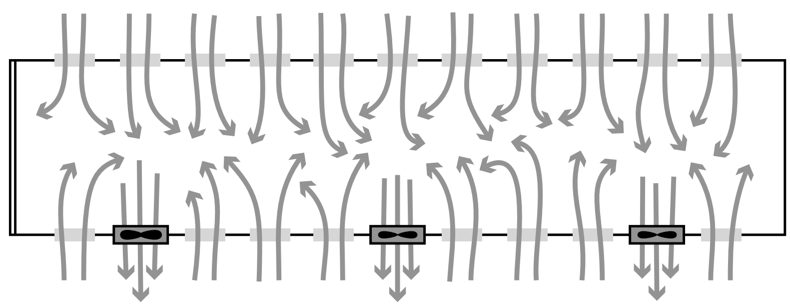


Figure 4. Minimum ventilation setup uses various combinations of 36-inch and 48-inch fans, depending on ventilation rate needed. Objective is to bring air in through vent boxes to mix with warm inside air, and avoid chilling birds. Note: Light traps and false wall not shown here.

In modern laying houses, the minimum ventilation setup typically uses two 36-inch exhaust fans and/or one or several 48-inch fans to bring air into the house through sidewall or ceiling air inlets (Figure 5). Minimum ventilation is timer driven - preferably by using a 5-minute timer (not a 10-minute timer). Timer settings and the number and size of fans used will determine the ventilation rate.

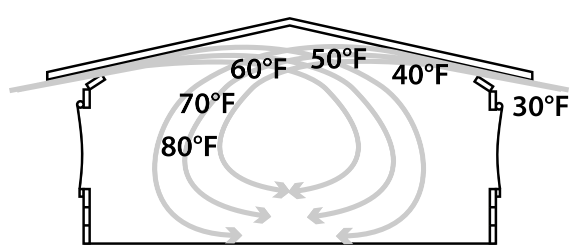


Figure 5. Minimum ventilation setup uses various combinations of 36-inch and 48-inch fans, depending on ventilation rate needed. Objective is to bring air in through vent boxes to mix with warm inside air, and avoid chilling birds. Note: Light traps not shown here.

Example: Determining minimum ventilation fan run time.

Find the correct fan run time for a negative pressure ventilating laying house with 11,000 birds at 30 weeks of age. The timer fans are two 36-inch fan at 9,000 cfm air-moving capacity, operated on a 5-minute (300 seconds) timer. (Using one 48-inch fan delivering 18,000 cfm would yield the same result.)

Step 1: From table at right note that cfm/bird required is 0.35.

Step 2: Determine total air needed

0.35 cfm/bird x 11,000 birds = 3,850 cfm

Step 3: Divide needed cfm by fan power

3,850 / 18,000 = 0.214 (21.48%)

Step 4: Determine actual fan run time

0.214 x 300 seconds = 64 seconds; set timer to run about 1 minute on and 4 minutes off.

Approximate Minimum CFM's per Bird by Week

Age	CFM/bird
Move - 35	0.35
36 - sell	0.45

Note: Adjustments may also be made for different outside temperature; see Keys to Managing Minimum Ventilation, page 12.

Why 5-minute timers are preferable to 10-minute timers: Many older laying houses have 10-minute timers to control the minimum ventilation fans. The problem with using 10-minute interval timers is that they can cause extreme variations in air temperature and air quality. For example, with a 10-minute timer, if the minimum ventilation cycle needed requires running a 36-inch and one 48-inch fan 1 minute on and 9 minutes off, then during the 9 minutes that the fans are off heat, moisture, ammonia, and dust build up in the house. The net result is that the environment cycles between a warm, stale environment and a cold, fresh environment. Extreme variations in air temperature and quality can be avoided if we go to a shorter duration timer such as a 5-minute timer. Running a 5-minute timer 30 seconds on and 4 1/2 minutes off for two cycles is exactly the same amount of ventilation as a 10-minute timer at 1 minute on and 9 minutes off. However, the environment for the birds is much better, with less drastic temperature and relative humidity changes, and better overall air quality.

A 5-minute timer provides more consistent conditions, avoiding large swings in temperature and RH.

Transitional Ventilation

Transitional ventilation is used when heat removal from the house is needed, but we don't want or need to go to tunnel ventilation. In transitional ventilation, we use tunnel fans with sidewall or ceiling air inlets to bring cool outside air in and mix it with warmer in-house air in the house ceiling area (Figure 6, page 10). In transitional or power ventilation in layer houses, we typically install enough sidewall air inlets to run either 40% or 50% of the installed tunnel ventilation fans. Outside air enters and mixes with in-house air the same way that it does during a minimum ventilation negative pressure setup, but the ventilation rate is higher and control is by thermostat or temperature sensor and not by timer.

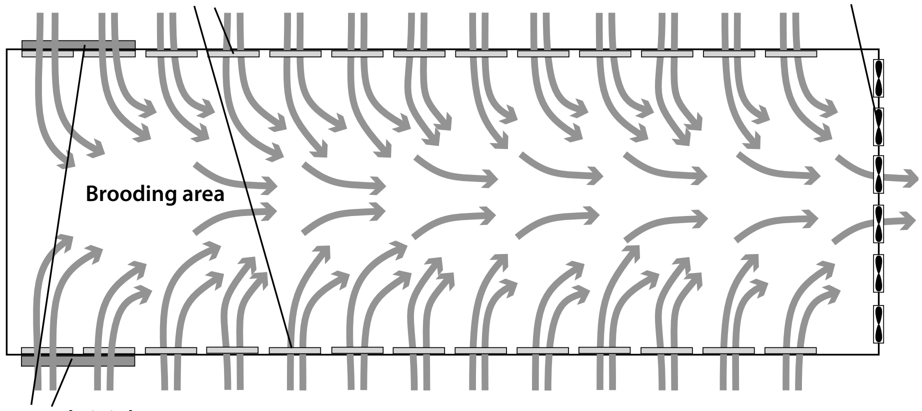
Transitional ventilation, using tunnel fans with sidewall air inlets, allows removal of heat from the house without putting cold air directly on birds.

The switch to transitional ventilation comes when the flock is producing enough heat and the weather conditions are mild enough that the temperature in the house is going to rise. That is, the minimum ventilation timer fans, even running constantly, are not sufficient to remove the heat from the house. The thermostat (or electronic controller) senses a temperature rise in the house and generally will activate the same fans that were used in minimum ventilation to run as the first stage of ventilation for heat removal. If the in-house temperature continues to rise, more and more fan stages will be activated to keep the house at target temperature.

Tunnel Ventilation

Tunnel ventilation is a form of negative pressure ventilation that has been very popular in laying houses for many years. Tunnel ventilation systems use 48-inch

Figure 6. Transitional ventilation uses the same basic setup as in minimum ventilation. The difference is that tunnel fans are used and ventilation is temperature controlled, not timer controlled.



or larger fans at one end of the house, pulling air through inlets at the other end. Tunnel ventilation will normally exchange the air in a hen house approximately once per minute. Tunnel ventilation handles heat removal by providing a high air exchange rate, and in addition places cool air directly on the birds. A wind speed of approximately 500 ft/minute is suggested for design of new laying houses. When wind speeds of 500 ft/minute are placed on laying hens or roosters, they will feel an effective temperature drop of as much as 10 degrees F below what the actual thermometer reading is. This wind chill cooling helps rapidly dissipate built up bird heat and is a very important tool for use in laying houses.

In hot weather tunnel ventilation at an air velocity of 500 fpm can reduce the "effective" temperature by as much as 10 degrees F.

Tunnel ventilation should be staged on when signs indicate the maximum transitional ventilation setup is no longer able to remove enough heat from the house to keep birds comfortable. Tunnel ventilation is staged from approximately 3 tunnel fans (the minimum amount of tunnel ventilation that will be run) to all of the tunnel fans being run at approximately 78°F.

Tunnel with Evaporative Cooling Pads

The value of pad evaporative cooling is well established for poultry houses, and most laying houses have used pad type evaporative cooling for many years. In most U.S.A. locations the maximum cooling possible is not more than 15°-18° F. This means that the goal is not to cool air to the 68°-70° F target, but to achieve enough actual cooling so that the added wind-chill effect gives an effective temperature near 68°-70° F.

The total cooling pad area required for a hen house is directly related to the total air-moving capacity (cfm) of the installed tunnel fans. It is very important that the pad area be determined in conjunction with the fan ratings. The most desirable evaporative cooling system in laying houses is a 6-inch recirculating pad system (Figure 7). The advantage of the recirculating cooling system is that all water not evaporated is caught and recycled. There is virtually no wasted water using a recirculating cooling system. In addition 6-inch recirculating systems have extremely high cooling efficiencies. Usually, over 70% of the cooling that can be achieved on a given day will be achieved if a 6-inch system is used. This means that a good 6-inch recirculating pad system will provide significantly more cooling on the hottest days than will a 2-inch or 4-inch pad system or a fogging system

Six-inch recirculating cooling systems recycle water, require less management attention, and have very high evaporative cooling efficiency.

Growers and managers need to be cautioned that two styles of pads have found their way onto many existing laying houses. These pads look similar but have very different cooling capabilities. The difference is in the size of the flutes or channels

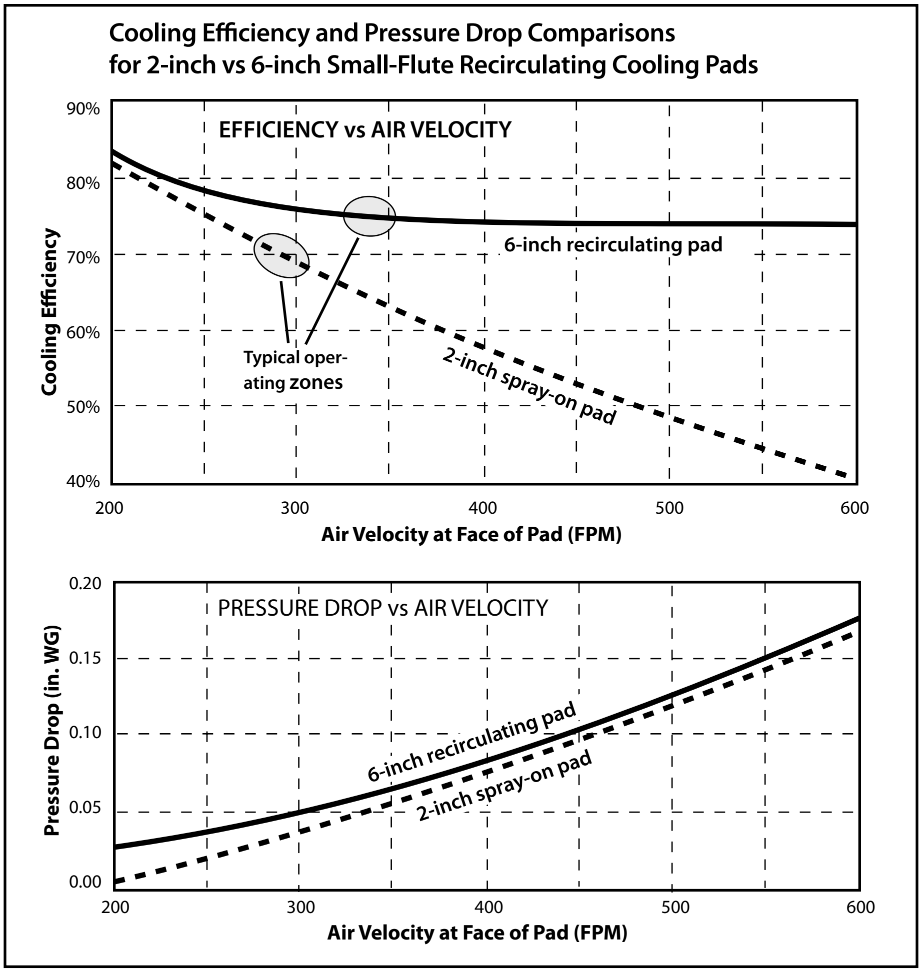


Figure 7. The most desirable evaporative cooling pads for broiler breeder laying houses are high-efficiency, small-flute 6-inch recirculating pads. The ideal cooling pad provides highest efficiency cooling while offering little resistance to airflow.

The more a pad impedes airflow, the greater the pressure drop across the pad will be. Since this means lowered air velocity, which both tunnel ventilation and evaporative cooling depend on, more total pad area has to be installed to achieve adequate airflow. It is also important that quality, high airflow ratio fans be used.

Graphs show that the 6-inch pad has significantly higher efficiency than the 2-inch pad while offering very little more resistance to airflow, so that higher air velocity can be maintained without having to install larger total pad area.

where air flows through the pad. They are often referred to as small flute and large flute pad. Small flute 6-inch recirculating pads can achieve approximately 70–75% cooling efficiency in comparison to large flute 6-inch pad that can achieve only 50–55% cooling efficiency. There is no place for large flute pads on modern poultry houses.

Determining the efficiency of your pad system: On any given day, one can evaluate the performance of the evaporative cooling system. You need to know three things. Firstly, the outside wet bulb temperature of the air. The lower the wet bulb temperature, the lower the RH of the outside air. Secondly, outside dry bulb temperature of the air. The difference in the outside wet bulb temperature and the outside dry bulb temperature is known as the wet bulb depression. This is the absolute total cooling that can take place if the pad system were 100% efficient.

The importance of maintaining good evaporative cooling makes it well worth while to check cooling pad efficiency to spot problems.

Lastly, from inside the poultry house, measure inside dry bulb temperature downstream of the pads. With this number, you can determine how well the system is performing. For example, it is 95°F outside with a RH of 50%. The outside wet bulb is 79°F. The total possible cooling is 16 degrees F at 100% efficiency (95°F - 79°F = 16 degrees F. A good pad system might capture 70% of this 16 degrees F or about 11 degrees F. If the pad system is running properly, inside dry bulb should be about 84°F just downstream of the tunnel inlet.

Keys to Managing Ventilation in a Modern Broiler Breeder Laying House

The goal of the ventilation or environmental control system in a modern broiler breeder laying house is to provide the optimum temperature and air quality in the house to promote good bird health and optimum reproduction efficiency. A properly equipped house can provide good temperature and air quality for broiler breeders with almost any type of weather outside.

Master key to managing laying house ventilation is understanding ventilation modes and having controls set so proper mode is always used.

In many respects the laying house is simpler to manage than the broiler and pullet house because the body weight of the bird is not changing as much. The key to managing a laying house is to understand when each ventilation mode is needed and have house controls set so the proper ventilation mode used is based on outside temperature conditions.

Which Ventilation Mode Is Needed?

The key to making the right ventilation mode decision is to know how much, if any, heat needs to be removed from the house, and whether outside air should be allowed to flow directly over the birds. The basics are:

Minimum ventilation is for maintaining air quality and moisture removal during brooding or cold weather.

Minimum ventilation: Use in cold weather when we do not need to remove heat from the house, and do not want cold outside air to contact the birds directly. Fans are on a timer, not a thermostat, and the ventilation goal is to prevent moisture build-up and provide fresh air. We want to stay in minimum ventilation as long as it is possible to keep birds comfortable this way.

Transitional ventilation starts when we need to remove heat from the house, but do not want to put cold air on he birds.

Transitional ventilation: Starts when outside air gets warmer such that in-house air temperature rises and we begin to need to exhaust excess heat from the house. We need a higher air exchange rate, but we still do not want outside air to contact the birds directly. Using some number of tunnel fans, in combination with sidewall fans, to bring air in through sidewall vent boxes accomplishes this. We want to stay in this transitional mode as long as we can remove the excess heat from the house in this way.

Tunnel ventilation is turned on only when transitional ventilation air exchange can't keep birds comfortable.

Tunnel ventilation: We switch to tunnel mode only when it is no longer possible to keep birds comfortable using the transitional setup. That is, we need to be cooling the birds by the wind-chill effect of tunnel ventilation. We want to be in (and stay in) tunnel only when birds need wind-chill to stay in their comfort range.

Keys to Managing Minimum Ventilation

In order to remove excess moisture from the house and maintain good air quality, it is imperative to ventilate at least some minimum amount of time, no matter what the outside weather is, and even when there is no need to remove heat from the house. We can – and must – operate minimum ventilation even when an all day cold rain is falling outside.

Use a 5-minute timer to run minimum ventilation. Make sure static pressure is high enough for good air velocity through vent openings.

Key 1. Use a 5-minute timer and make sure it is set properly according to the average outside temperature. A common rule of thumb for laying hens is 0.2 cfm per hen when average temperatures are in the 20- 40°F range, 0.30 cfm per hen when average temperatures are in the 40 - 60°F range, and 0.50 cfm per hen when temperatures are between 60 and 80°F.

Key 2. A critical factor for successful minimum ventilation is making sure that incoming cold air mixes uniformly with, and is warmed by, in-house air before coming in contact with the birds. Adjustable vent boxes operated by static pressure-sensing controllers are by far the best way to accomplish this on a consistent and continuing basis. If the inlet area is not adjusted properly according to the fan cfm's being used, either the ventilation rate will be choked down below what is needed, or incoming cool air is likely to fall directly to and chill-stress the birds. One of the most common problems with perimeter inlet ventilation run by static pressure control vent machines is non-uniformity of vent opening. Vents opening one-half inch on one end of a laying house and two inches on the other end of the house will cause great imbalances in temperature in the house. Vents should be operated at uniform openings, approximately 1½ inches at static pressures between 0.07 inches of water column in warm weather and 0.10 inches of water column in colder weather. This will insure maximum air mixing, maximum moisture removal and an improvement in air quality.

Vent box doors and cables should be checked frequently to make sure vent doors open uniformly. If doors don't open the same, non-uniform conditions in the house will be detrimental to flock development.

Key 3. In a laying house, minimum ventilation will almost always be accomplished using the smallest number of fans that can achieve the static pressure to move the air. In the wintertime, static pressure levels for minimum ventilation in a modern laying house with perimeter inlets should be about 0.10 inches of water column. In the summer, the minimum ventilation static pressure may be as low as 0.07 inches of water column. What location of fans to run is largely determined by the perimeter inlet layout and degree of house tightness.

Minimum ventilation should use the smallest number of fans possible. The number of perimeter air inlets to be unlatched and used depends on the total fan capacity in use.

Key 4. While in the warmer months all perimeter vents may be used, during the coldest periods only 50% of the perimeter inlet vents might be used for bringing in fresh air. The number of inlets installed on houses is determined by maximum non tunnel ventilation needs. Thus, if only minimal ventilation is needed with just a portion of the ventilation fans, it will be advisable to close sufficient inlets to achieve good air velocity through the remaining inlets. This is an important, but often overlooked, management concept that must be understood by growers and flock managers.

Keys to Managing Transitional Ventilation

The goal of transitional ventilation is to exhaust enough heat to keep the house temperature within the birds' comfort range, while preventing outside air from flowing directly onto birds.

Key 1. To be successful with transitional ventilation, it is essential to have the sidewall inlets on a static pressure controller. It is very difficult, if not impossible, to manually adjust the size of the inlet openings and maintain the proper static pressure as the number of fans running changes.

Perimeter vents should be operated by a static pressure controller for both minimum and transitional ventilation.

Key 2. In a well-designed house, if the outside temperature is more than 6-8 degrees F cooler than the inside target, then we should be able to maintain target temperature with transitional ventilation. Generally, in laying houses it is desirable to try to achieve comfort levels for birds when running 30 - 40% of the tunnel ventilation fans in the transitional ventilation mode. Switching into tunnel mode too soon is likely to produce a large temperature difference from one end of the house to the other. If this happens, most of the laying flock will not be experiencing the optimum temperature for reproductive performance.

Key 3. There is no problem with switching from one ventilation mode to another – minimum, transitional or tunnel – as conditions change. A flock typically needs transitional ventilation during the evening and early morning, and tunnel during the heat of the day. The question is, "What will keep the birds most comfortable?"

There is no problem with switching from one ventilation mode to another as conditions change; but beware of switching to tunnel too soon.

Keys to Managing Tunnel Ventilation

As outside temperature rises, at some point we will max out the number of fans that can be operated using the perimeter inlets. At that point it is necessary to change ventilation modes from transitional to tunnel ventilation in order to maintain in-house temperature in the birds' comfort range.

Set point for starting to stage on tunnel ventilation is usually 6-8 degrees F above target temperature, adjusted for season.

Key 1. When shifting from transitional to tunnel ventilation, it is important to determine how many degrees above set point will be a threshold level for changing to tunnel ventilation. Depending on time of year, this threshold should be 6 - 8 degrees F above target temperature. Generally the lower increment will be used in the summer time and the higher in the wintertime. The switch to tunnel, with approximately 50% of the tunnel fans running, will provide additional cooling in the form of wind chill effect compared to what was observed in the transitional mode. This is true even though the air change rate may be similar to that of the transitional mode.

Normally, all tunnel fans should be on by the time house temperature reaches 78°F in summer.

Key 2. As the weather becomes warmer, or the day progresses, it will be necessary to stage on tunnel ventilation fans to achieve the exact wind chill cooling effect to bring the birds back to their comfort zone. Normally all tunnel fans will be operating by the time that the house temperature reaches 78°F in the summer.

Regular fan maintenance and cleaning are essential for achieving effective tunnel ventilation.

Key 3. For any tunnel ventilated hen house to work properly, we must take care to maintain fans, belts, and shutters in good condition. Good air speed of at least 500 fpm is absolutely required for heat removal from large birds in hot weather. The cool cells or evaporative cooling pads serve to provide additional cooling and are dependent upon wind speed. Dirty fan blades, dirty shutters, slipping belts, and leaking curtains will make it impossible to achieve adequate air speed.

Monitor the temperature difference from inlet end to fan end of the house; if it is over 5 degrees, you are either in the wrong ventilation mode or have a problem with the ventilation system or with air leaks.

Key 4. Monitor the temperature difference in the house from inlet end to fan end. This can indicate two different things, depending on the situation:

1. During tunnel in hot weather, a temperature difference much greater than 5 degrees F can indicate insufficient airflow or air leaks allowing hot air into the house. In this situation, check air velocity and look for dirty fans, shutters and/or pads, and for open doors or other leaks.

2. A more than 5 degree F rise in temperature from one end of the house to the other during tunnel ventilation may indicate that you should be in transitional ventilation, and not tunnel. Under these conditions, the temperature rise from one end to the other may be telling you that the incoming air is too cold, and as it passes through the house is picking up more heat than is desirable. You don't experience this with transitional ventilation because the air is coming in uniformly throughout the perimeter vents around the house.

Keys to Managing Pad Cooling

As explained above, evaporative pad cooling works in conjunction with the wind-chill effect of tunnel ventilation, creating an actual temperature drop to keep hens comfortable and feeling as though the temperature is near 70°F even when outside temperatures rise above 90°F.

Turn evaporative cooling on before birds begin to feel heat discomfort, but usually not before outside temperature reaches about 80°F.

Key 1. Evaporative cooling should be turned on, or programmed to come on, before birds begin to feel heat discomfort, but not too soon. One of the first rules of thumb with regard to tunnel ventilation and cool cell systems is that very little cooling will take place if cool cells are turned on before the outside air temperature reaches 80°F. Each morning we start out with relatively cool and humid outside air. As hen houses heat up in the morning, we should be adding fans to increase tunnel wind speed, but not turning on the cool cell pumps. A good operational rule of thumb is to have all fans running by 78°F to achieve maximum wind-chill cooling if needed and to turn on cool cell pumps at 82°F. By first using wind chill and then adding evaporative cooling after we reach 82°F, we are assured of not adding too much humidity to the air or running pads and achieving very little or no cooling.

Key 2. Pad cooling systems work well only when all incoming air goes through a completely wetted and clean pad – which means it is especially important to properly maintain and monitor the system and house. No doors can be open or any air leaks permitted. Side curtains must fit tight against the house. Water pumping rates must be correct, and pads must not be allowed to clog. Evaporative cooling pads act as large air filters for incoming air. The importance of maintaining clean pads free of algae, dust, and dirt cannot be overemphasized. A blocked pad not only provides little or no cooling, it increases static pressure and reduces airflow to birds during the most critical time of the summer.

For effective pad cooling, house must be tight and pad systems must be well maintained and monitored to make sure pads are clean and are being completely wetted.

Management Includes Monitoring

Probably the toughest part of doing ventilation right is that you can't usually see air movement. Bird behavior is the first and most important item to monitor. If birds are eating and drinking normally and distributed evenly through the house, they're OK. If they aren't, you have a problem to investigate. It's also important to keep watch on other key indicators. Monitoring temperature, air movement, RH and static pressure can show you expensive problems you weren't aware of, and help you head off problems before they occur. Here are some ways to keep watch:

Temperature: The large dial thermometers seen in most houses are convenient but inaccurate. High/low recording mercury thermometers are more accurate and allow you to see and keep a log of temperature ups and downs. Recording ("data logging") thermometers and humidistats print out a record of temperature or RH swings in the house, which can be extremely valuable. Mount thermometers high and low in the house to see how much air/temperature stratification you have. The critical reading is the temperature where the birds are. You need at least three thermometers at bird level: at the front, at the middle, and at the rear of the house.

Temperature monitoring is an important management element; make sure you have accurate thermometers in the right places.

Handheld digital thermometer/humidistat combinations are not too expensive, are fast reacting and can be used to calibrate mercury thermometers. An infrared thermometer shows you the temperature of any surface you point it at, not the air temperature. These are more expensive, but can reveal expensive problems you might otherwise miss (i.e., ceiling insulation breaks, cold floors, overheating motors or circuit breakers).

Air movement: Simple to use, accurate, and affordable electronic airspeed meters are now available and are very useful for monitoring house conditions. A handheld model that includes a thermometer is especially useful and convenient. Strategically placed lengths of light ribbon, like surveyor's flags, are useful airflow indicators. Generally you want them along the ceiling and at bird level. A fluttering streamer does not tell you that air movement at that place is perfectly OK, just that there is some air moving. A streamer hanging still when it should be fluttering definitely signals a problem.

Monitoring air speed and airflow patterns allows you to quickly spot any problems with the ventilation system.

Relative humidity can make a difference in flock development; digital humidistats are available at reasonable prices.

Relative humidity: Monitoring RH also requires some instrumentation. There is no way you can "feel" RH differences. To easily check RH trends up or down, use an inexpensive digital RH meter (humidistat), accurate to about ±5%. A high-accuracy digital costs more, but is accurate to about ±2%. Again, you want to know what's going on at bird level, so get down with the birds to make your checks.

Static pressure can be critical to effective ventilation, and being able to check static pressures helps you spot problems easily and quickly.

Static pressure: Monitoring static pressure over time and in given conditions is especially useful to spot problems such as air leaks, shutters not opening fully, declining fan performance, etc. Easy to use and inexpensive handheld or wall-mounted manometers are available. Magnehelic type meters are slightly more expensive but also more accurate.

Get expert help: Integrated company service personnel will have or have access to good monitoring equipment. They can give advice, help you check your house periodically, and show you how to do it all yourself. In addition, Aviagen technical service personnel can assist you in environmental management of broiler breeders.

Example Broiler Breeder Laying House Design

Environmental control systems for poultry houses have evolved so that we now have a practical and cost-effective means of controlling in-house conditions for consistently optimum broiler egg production. House designs will vary based on location and climate. From an engineering standpoint, if a house is to be designed from scratch, a complete heat flow calculation should be done looking at all building surfaces, insulation values and climatic extremes. Because laying programs vary widely among integrated companies, it is more difficult to find agreement on a standard ventilation system design for a breeder-laying house than it is for, say, a broiler house.

Perimeter air inlets should be included in the design of modern laying houses so fresh air can uniformly enter at all points in the house during cool weather operation. In a modern laying house it is typical to have 20 to 25 inlets on each side of either a 400 or 500 ft long house. Inlet doors or perimeter inlets should be operated by a power vent machine that senses static pressure. As the need for ventilation and number of fans running changes, the vent doors are adjusted to the proper open position by the static pressure vent machine controller. It is also advisable to equip vent door inlets with latches, or other means, to hold the doors closed when not needed.

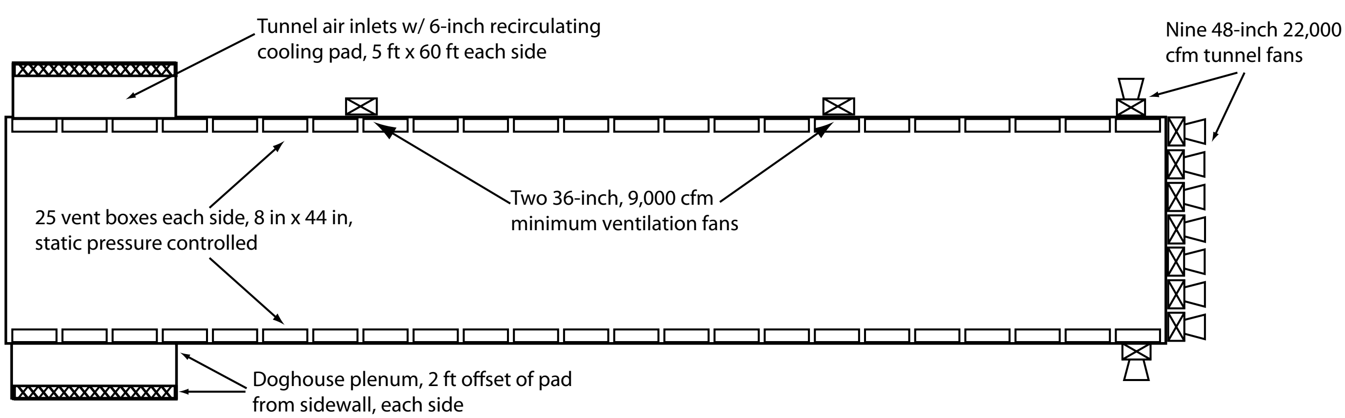
House design requirements vary by location and company, but the basic elements of broiler breeder laying house design for effective environmental control can be approximated as in the following typical set of specifications.

Recommended Typical 42 ft by 500 ft Broiler Breeder Laying House stocking approx. 11,000 birds

1. 42 ft x 500 ft breeder laying house (does not include space for processing).
2. 10,000 head female & 1,000 male capacity, depending on program.
3. Dropped ceiling - insulation R-19 or better - sidewall height 8 ft., center ceiling height 11 ft.; average ceiling height 9.5 ft.
4. Exterior curtain sidewalls – 36-48 inch curtain openings typical - clear curtain – must have flap over curtain with strip at top to achieve house tightness
5. Tunnel ventilation with recirculating evaporative cooling pad desired - minimum wind speed is 500 fpm. Use 48-inch or larger fans rated at 22,000 cfm at 0.05 inches S.P.
6. Minimum ventilation: two 36-inch fans rated at 9000 cfm at 0.05 inches S.P. installed on sidewall.
7. Enough minimum ventilation sidewall inlets will be installed so that at least three 48-inch fans can be operated without opening tunnel curtain.
8. Evaporative cooling: 6-inch small-flute recirculating with sufficient pad area for maximum 0.08 inches S.P. drop across pad in full tunnel operation. Design air speed through pad 350 fpm. Tunnel inlet will be dog house with 2 ft clearance between pad and tunnel curtain.

<u>Design Calculations</u>

1. Tunnel air speed 500 fpm desired; choose fan that will produce this at 0.05 inches S.P. minimum:
   500 ft x 9.5 ft x 42 ft = 199,500 cfm
   199,500 cfm ÷ 9 fans = 22,166 cfm; choose 22,000 cfm minimum fan, or 198,000 cfm total installed fan capacity
2. Evaporative cooling pad determination:
   198,000 cfm ÷ 350 fpm face velocity (6-inch small flute pad) = 565 sq ft for 0.05 inches S.P. or less across pad;
   Use 60 ft x 5 ft tall each side, total pad area = 600 sq ft
3. Number and size of perimeter air inlets/vent boxes:
   Design based on ability to run a minimum of three 48-inch fans with tunnel inlets fully closed.
   3 tunnel fans x 22,000 cfm = 66,000 cfm
   15 sq ft of vent box needed for each 10,000 cfm of fan capacity to be used:
   66,000 cfm ÷ 10,000 cfm = 6.6
   6.6 x 15 sq ft = 99 sq ft of vent box opening needed
   99 sq ft ÷ 2.44 sq ft (8-in x 44-in vent box area) = 40.57
   Install 40 vents minimum, 20 on each side of house, equally spaced and staggered; suggest installation of 50 inlet boxes.



HELPFUL CONVERSION FACTORS

Following are approximate Imperial (English) to metric and metric to Imperial (English) conversion factors for measurements and units commonly encountered in discussions of commercial poultry ventilation considerations.

Air velocity	in feet per minute ÷ 197 = meters per second in meters per second x 197 = feet per minute
Area	in square feet ÷ 10.76 = square meters in square meters x 10.76 = square feet
Airflow	in cubic feet per minute ÷ 2119 = cubic meters per second in cubic meters per second x 2119 = cubic feet per minute
Static pressure	in inches of water x 249 = Pascals in Pascals ÷ 249 = inches of water
Volume	in gallons x 3.785 = liters in liters ÷ 3.785 = gallons
Heat	in Btu's x 1.055 = kilojoules in kilojoules ÷ 1.055 = Btu's
Heat loss	in Btu's per hour per pound x 2.323 = kilojoules per hour per kilogram in kilojoules per hour per kilogram ÷ 2.323 = Btu's per hour per pound
Length	in inches x 2.54 = centimeters in centimeters ÷ 2.54 = inches in feet x 0.305 = meters in meters ÷ 0.305 = feet
Weight	in pounds ÷ 2.2 = kilograms in kilograms x 2.2 = pounds
Light intensity	in lux ÷ 0.093 = foot-candles in foot-candles x 10.764 = lux

Temperature Conversion Chart

Fahrenheit to Celsius (°F-32) ÷ 1.8		Celsius to Fahrenheit 1.8°C + 32	
°F	**°C**	**°C**	**°F**
105	40.56	40	104
100	37.78	35	95
95	35.00	30	86
90	32.22	25	77
85	29.44	20	68
80	26.67	15	59
75	23.89	10	50
70	21.11	5	41
65	18.33	0	32
60	15.56	-5	23
55	12.78	-10	14
50	10.00		
45	7.22		
40	4.44		
35	1.67		
30	-1.12		
25	-3.90		
20	-6.68		

Note: In converting temperature differences or intervals, the ±32° constant is not used. For example, a 15-degree Fahrenheit interval equals an 8.3-degree Celsius interval: 15 (F) ÷ 1.8 = 8.333 (C)

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