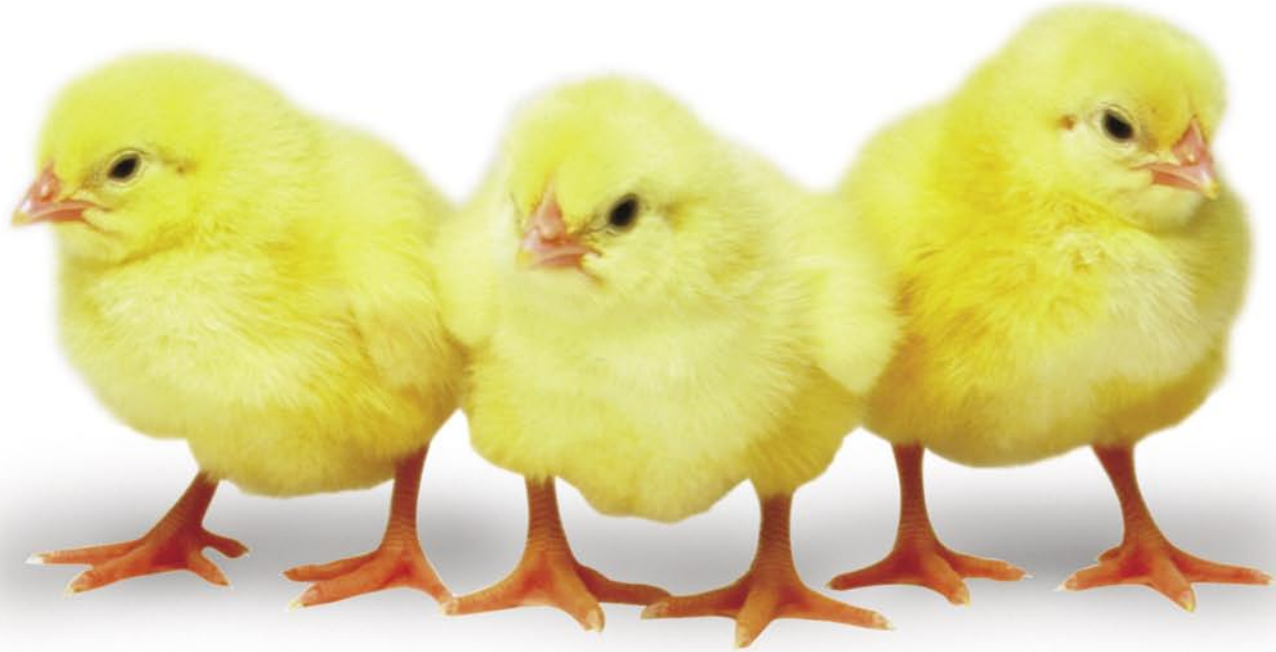

Environmental Management

In The Broiler Breeder Rearing House

Acknowledgments

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Introduction: Economic Value of Proper Environmental Management

Whether producing meat, eggs, milk or other animal 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 pedigreed broiler breeding stock to broiler progeny, benefit from effective environmental control. Given the economic implications, environmental management for broiler meat production has received much more attention than has that for broiler breeder hatching egg production. Consequently, much less tangible information is available concerning proper environmental management in 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 rearing housing to be able to provide optimum environmental conditions; and,
3. To provide basic operational guidelines for this housing during the rearing phase.

Energy is the first limiting nutrient for broiler breeders and is, therefore, the key nutrient which determines required feed allotments. During the rearing period, the energy requirement for birds has two main components: energy required for growth, and energy required for maintenance of body temperature and body functions. From early in life, the female's maintenance energy requirement is the largest component of the total energy requirement. Even at peak egg production, the maintenance energy requirement for females is about 75% of the total energy required per day. The male's maintenance energy requirement is an even larger component of the total energy requirement. In fact, the male's maintenance requirement after 30 weeks is approximately 98% of the total energy required.

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.

During the parent stock rearing phase, we want to rear pullets and cockerels that are healthy and achieving bodyweight targets in a uniform manner, while providing cost-effective amounts of feed to adequately prepare them for optimal reproductive performance. An inadequate environment will negatively impact these goals. For example, allowing houses to drop excessively in temperature will increase feeding requirements since birds will need additional energy to maintain body temperature. This results in increased feeding cost (see example, next page). However, increased feeding cost is only one of the possible consequences of allowing sub-optimal temperatures. Failure to provide additional feed for Flock B would have an even worse result. If additional feed is not provided, bird growth and future reproductive performance will be impaired since maintenance energy always takes priority over growth and reproductive functions.

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

During hot weather conditions, on the other hand, feed intake will decline excessively unless adequate cooling ventilation is provided. Heat-stressed poultry exhibit impaired immune systems due, in part, to stress-induced hormonal influences. Digestive processes can also be impaired under such conditions. Poor environmental conditions thus create a scenario where pullets and cockerels are poorer in bodyweight gain and uniformity, feed utilization and immune response, and will likely be physiologically impaired when photo-stimulation occurs – resulting in poor uniformity of sexual maturity and serious reproductive performance problems.

Failure to maintain optimal temperatures prevents pullets and cockerels from attaining optimal reproductive performance.

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

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, which results in a higher amount of metabolic body heat being produced. Given this characteristic, it is even more critical to prevent excessive temperatures from occurring. Faced with excessive temperatures, high breast meat yielding parent females will even more quickly reduce feed consumption due to heat stress, resulting in poorer reproductive performance and increased floor eggs, mortality, and hatching egg production cost. However, with proper environmental control management these genetic products can perform very well. Therefore, it is imperative as the industry moves further toward de-boned products that sound environmental control management be practiced in order to successfully exploit breeds with high breast meat yield.

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

It is apparent that the quality of day-old broiler chicks and their subsequent live and processing performance will be heavily influenced by how one treats their parents. Therefore, it is prudent to give renewed and careful consideration about 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 ultimately improve broiler meat production costs.

Example: Two different pullet houses are identical in management except for the environmental temperature experienced by the birds. In house A, the temperature after 4 weeks of age is maintained, via supplemental heat sources, at 68-70º F. In house B, no supplemental heat is provided after 4 weeks of age causing the internal house temperature to fluctuate with external temperatures. See Figure 1 for daily temperature profiles of the two houses.

Energy requirements to maintain a bird's body temperature and body functions are markedly affected by temperature.

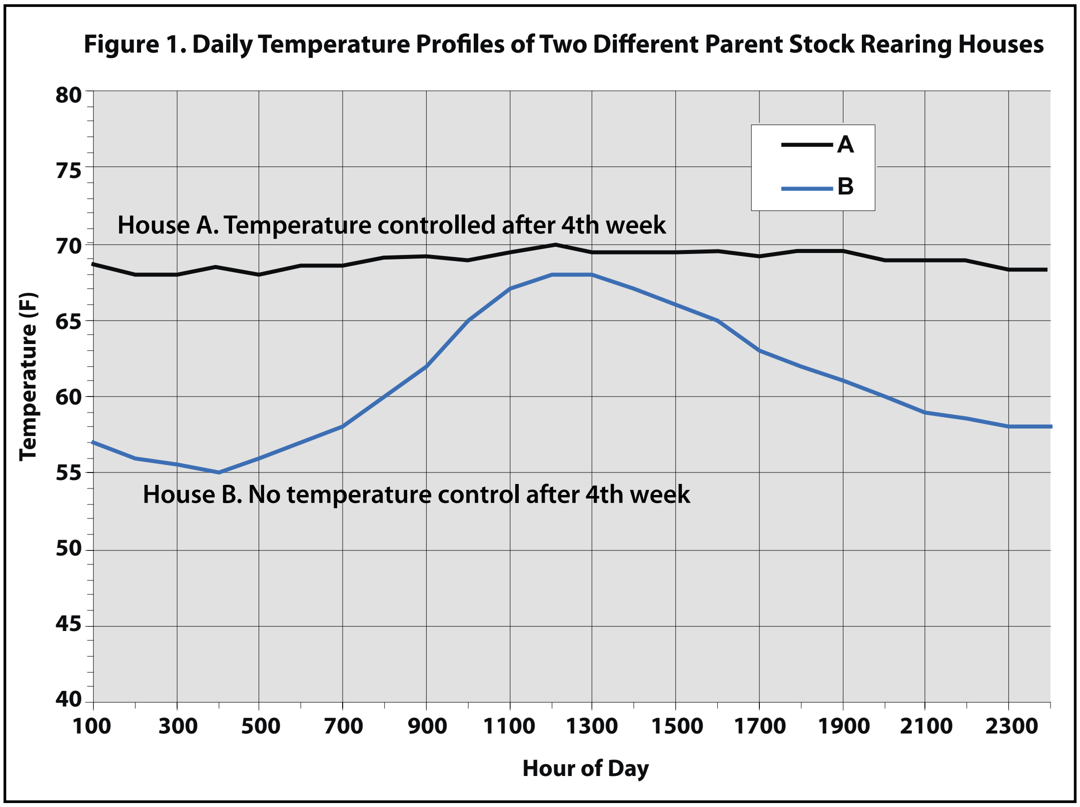
Assuming you make feeding allocation changes to achieve the same target weights in both flocks, the estimated energy requirements of these two groups appear in Figure 2. The energy requirements are presented as that required for maintenance, growth and total. The maintenance energy requirement is that required to maintain a constant body temperature, activity and normal body metabolism. This component is directly influenced by environmental temperature; however, the energy required for growth is not (that is why the Eg lines overlap in Figure 2). Feed energy can be used for growth only after all maintenance needs are met. Thereafter, energy needs for growth are proportional to rate of weight gain.

Thus, one can see the overall cooler temperatures of house B result in an increased maintenance energy requirement, causing an increase in the total energy requirement. Feed allocation must, therefore, be increased if the feed energy level remains the same.

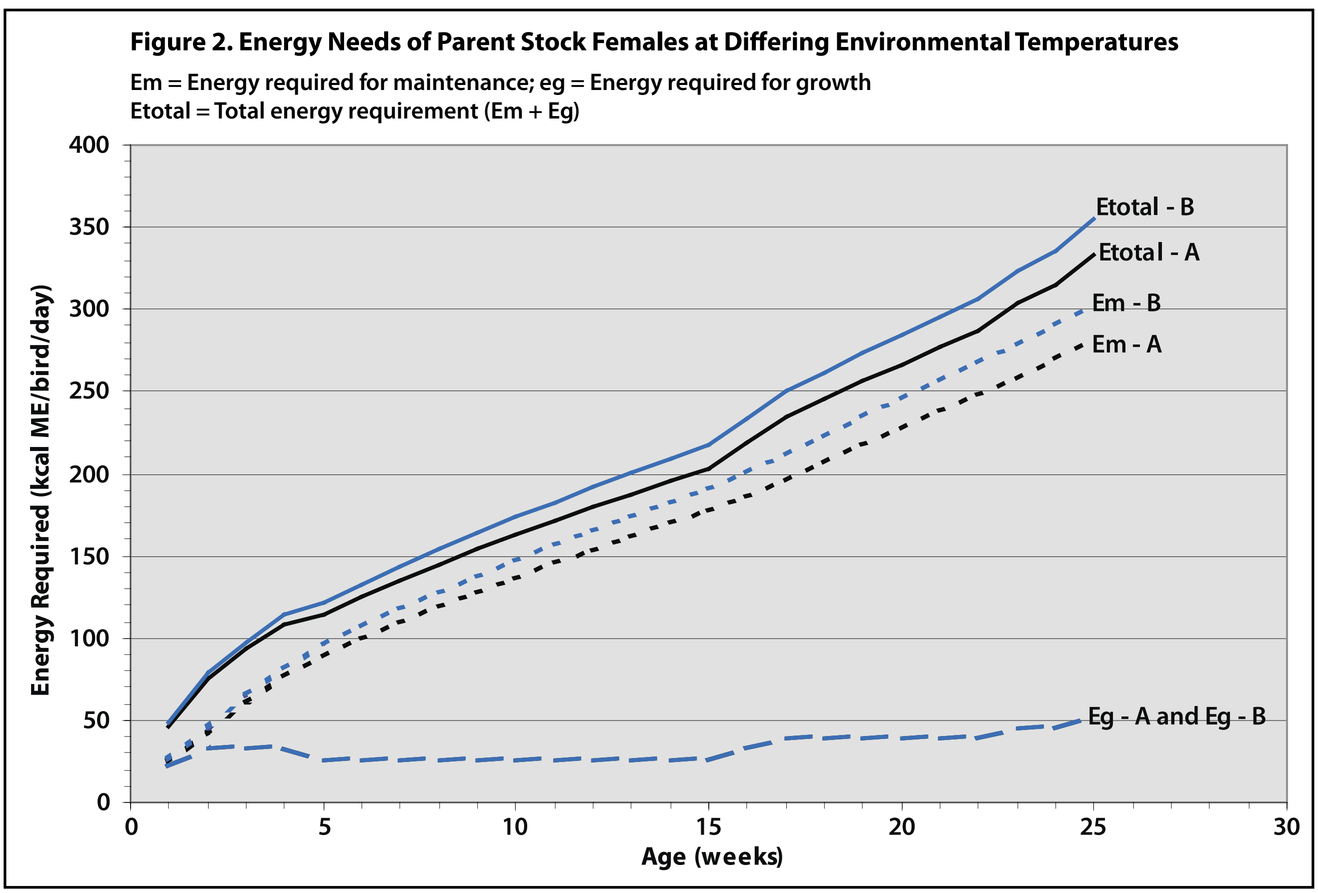
Example shows that failing to maintain optimum temperature could increase a flock's feed costs by $1,612.

What does this mean economically? 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 1.67 lb more feed per pullet capitalized. Assuming an average feed cost of $175/ton, a flock size of 11,000 pullets started per house, and capitalization at 25 weeks, Flock B would have an increased feeding cost of approximately $1612.

In this example, if additional feed was not provided for Flock B, it would be impossible for the flock to achieve the proper growth profile, pullets would become underweight and would demonstrate poorer bodyweight uniformity – all of which will negatively impact future reproductive performance. Flocks cannot achieve high peak egg production and optimal reproductive performance unless they are very uniform in bodyweight and sexual maturity.



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 after the 4th week to keep house temperature between 68° F and 70° F, birds required much less feed (Etotal-A vs Etotal-B below). To maintain desired target weights, birds in House B with no temperature control required 1.67 lb more feed per pullet, for a total additional feed cost of $1,612.



CRITICAL ENVIRONMENTAL FACTORS IN BROILER BREEDER REARING

As pointed out in the Introduction, the key to growing a quality pullet with efficient use of feed and fuel is to provide an optimum environment for the birds. The critical environmental factors are temperature, moisture, air quality and light.

Table 1. Target Floor Temperatures at Feed and Water Locations

Age Days	Target Temperature °F
1-3	91
4	90
5	88
6	86
7	84
14	79
21	73
28-on	70

Temperature

At each day of the birds' development there is a single optimum temperature zone at which the bird makes best use of feed energy and maximizes muscle development. Table 1 shows optimum floor temperatures at feed and water locations for desirable bird development. This table is based on relative humidities (RH) in the range of 50 to 70%. In rearing locations with extremely low RH, temperatures may need to be slightly higher. In locations with extremely high relative humidities, temperatures may need to be slightly lower. Chick behavior is the best indicator of correct environmental temperature.

Moisture

While temperature is usually the most critical environmental factor, managing moisture, air quality and light are also very important.

Birds continually contribute moisture to the house environment, both through breathing and in manure. Allowing moisture to build up in the house leads to ammonia and other air quality problems, causes wet, caked litter, and can be detrimental to bird health. Optimum RH levels in rearing houses should be between 50 and 70%. With RH above 70%, it becomes more difficult for birds to dissipate excess body heat, and with extremely low RH it becomes more difficult for young chicks to maintain optimum body temperature.

Air Quality

Since birds breathe in oxygen and exhale carbon dioxide, fresh air must be provided to restore the oxygen/carbon dioxide balance of in-house air. Providing fresh air also prevents ammonia build-up from bird manure. Since high RH favors ammonia build-up, RH is also considered an air quality factor.

Light

Successful broiler breeder rearing requires adequate light intensity in the first few weeks, and total darkness later.

At the beginning of the birds' life it is very important to provide adequate light intensity. A minimum light intensity of 4 foot-candles (fc) should be maintained at locations where feed and water are present during weeks 0-3 for females and weeks 0-4 for males, and is especially important during the first week. This level of light intensity helps stimulate feeding and drinking so chicks get off to a good start. Many houses in the field do not have sufficient light intensity for early brooding. Lighting systems used during rearing must also be capable of being dimmed to levels in the 0.50–0.75 fc range. Later in the rearing phase, we must be able to achieve total darkness in the rearing house, with light intensity less than 0.04 fc at ALL locations in the house. Care must be taken to insure that all light leaks are eliminated from rearing houses. The days of brown-out housing in quality rearing programs are coming to an end in most parts of the world.

Other Factors

Rodent control and disease prevention are also important, along with providing good water quality .

While beyond the scope of this publication, sanitation and water quality should also be kept in mind as critical for successful broiler breeder rearing. Sanitation includes proper rodent control, good housekeeping and an effective disease-prevention program. Good water quality is important not only for drinking water, but also for effective operation of evaporative cooling equipment.

ENVIRONMENTAL MANAGEMENT OVERVIEW

In the last ten years there have been major changes in the way quality pullets and cockerels are reared. The higher demand of the bird coupled with the increased costs of fuel have forced most pullet rearing operations to a totally enclosed house. This has simplified the task of controlling light in the house, since there are fewer ways for light to leak into a totally enclosed house. Houses must be provided with adequate lighting systems for the early growout phase, and light traps to prevent light from coming in through ventilation inlets or exhaust outlets must be installed to assure that total darkout can be achieved in the later growout phase.

Maintaining proper temperature requires the judicious use of heating and ventilation systems. Pancake or radiant brooders are the preferred source of heat for weeks 0-4 of age. From week 5 on, space heaters may be needed to maintain desired house temperatures in extremely cold weather. For older birds and/or warmer weather, the ventilation system is used to keep in-house temperature from rising too high. Even during brooding or cold-weather heating, however, the ventilation system is also needed, both as a temperature regulator and to maintain proper moisture and air quality.

Maintaining proper temperature requires the judicious use of heating and ventilation systems.

During heating periods, the ventilation system in the modern house must be run to exhaust warm, moisture-laden, stale air from the rearing house and blend incoming fresh air to obtain good air quality, proper RH, and precise temperature control. In hot weather the ventilation system can be used to produce high wind speeds to provide wind chill cooling for the birds, thus removing heat more rapidly from the birds' body than is possible in a static non-tunnel environment. The ventilation system is also the vehicle by which evaporative cooling can be brought into play.

Ventilation is needed both for cooling in warm weather and for moisture control during brooding and cold weather.

One important purpose of ventilation is removal of moisture from the rearing house, thus maintaining the proper RH range for good bird health. In warm weather the ventilation system will accomplish moisture removal at the same time it is providing temperature management. However, in cold weather or during brooding, when there is no need to exhaust excess heat from the house, ventilation must be run on a timer and not on a thermostat, with the timing adjusted to age of the birds so excess moisture will be removed adequately and air quality maintained. This is typically called minimum ventilation.

In most cases in a modern rearing house, if ventilation is set properly to handle daily moisture deposits in the house, proper air quality also will be maintained. However, based on weather conditions, litter conditions, or other factors, it may be necessary to operate more minimum ventilation (i.e., for longer time periods) to ensure pullets are grown in an environment of good air quality.

As pointed out above, temperature management is probably the most critical factor for optimum bird development. Since the need for ventilation is constant in a totally enclosed house, and since ventilation plays a primary role in management of temperature, air quality and moisture in the house, ventilation management is the primary tool in house environmental control.

Ventilation management is the primary tool in house environmental control.

VENTILATION BASICS

Because ventilation is so important in providing an optimum in-house environment for broiler breeder rearing, understanding basic ventilation principles is essential for proper house design and management.

Negative Pressure Ventilation

Both sidewall inlet ventilation and tunnel ventilation are forms of negative pressure ventilation.

Most modern pullet housing utilizes negative pressure ventilation. This means that fans are exhaust fans pulling or sucking air out of the house, which draws fresh air into the house through provided air inlets (Figure 3). 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 the desired inlets. Both sidewall inlet ventilation and tunnel ventilation are forms of negative pressure ventilation.

The amount of air the ventilation system needs to move into and out of the house depends on outside weather conditions and bird age. Generally, the warmer it is and the larger birds are, the more air the ventilation system needs to move (i.e., the higher the air exchange rate must be). In hot weather we might need to completely change house air on average once a minute or even less, while in cold weather and/or with young birds the ventilation rate might exchange air every five minutes or ten minutes, or even once per hour.

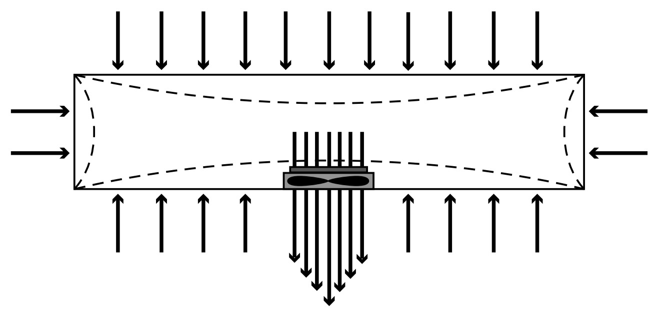


Figure 3. In negative-pressure ventilation, exhaust fans pull outside air into the house. When fans and air inlets are matched (and the house is tight), this creates a partial vacuum inside the house. Air then enters uniformly at the same speed through all inlets. By choosing which inlets to use (tunnel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

House Tightness

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

Modern negative pressure ventilated houses must be tight. Houses of yesterday were often naturally ventilated, so that house tightness was not at all critical. With negative pressure ventilation, the key is to take total control of how and where air enters the house, so house tightness has paramount importance. During cool weather operation, air coming under footers, around doors, or through curtain cracks only serves to chill or discomfort birds, create moisture problems, and detract from optimum rearing temperature environments. Air leaks during tunnel ventilation destroy the needed single air path from one end of the house to the other, causing reduced wind velocity and wind-chill cooling.

A house tightness test 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 differential static pressure read from the house interior to the outside will give an indication of the level of negative pressure achieved by the fans. The higher the negative pressure achieved, the tighter the house. The goal for all pullet housing should be a minimum of 0.15 inches of water column negative pressure; for newer houses, static pressure should far exceed 0.20 inches of water column.

Ventilation Modes – Overview

Modern poultry house ventilation systems are typically set up to operate in three different modes:

Minimum ventilation – 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 temperature sensor. The purpose is to maintain good air quality and exhaust excess moisture during cool weather or brooding.

The three basic ventilation modes use different types and placements of fans and air inlets to create the air exchange rates and airflow patterns needed.

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

Tunnel ventilation – Tunnel fans bring air into the house through tunnel air inlets at the other end of the house, operated by thermostat or temperature sensor. The purpose is to create 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 may also provide a vehicle for evaporative cooling.

Minimum Ventilation

Even in cold weather it is essential to ventilate in order to remove moisture from the house as well as provide fresh air and oxygen and remove noxious gases. This means that some minimum ventilation rate must be maintained even when the thermostat doesn't call for ventilation and even if a small amount of house heat must be removed in the process. The minimum ventilation setup typically uses 36-inch exhaust fans and/or one or several 48-inch tunnel fans to bring air into the house through air inlets mounted high on sidewalls (Figure 4).

Minimum ventilation, used in brooding or cold weather, is controlled by a timer, not by a temperature sensor or thermostat.

Minimum ventilation is timer-driven, preferably using a five-minute timer. Longer timing intervals create too wide temperature swings in the house. The timing and the number and size of fans used determine the ventilation exchange rate. The rate required rises as birds grow, ranging from around 0.10 cfm per bird in the first week to about 0.35 cfm per bird after week sixteen.

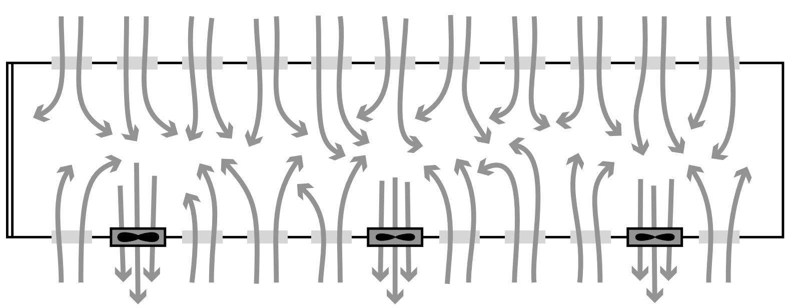
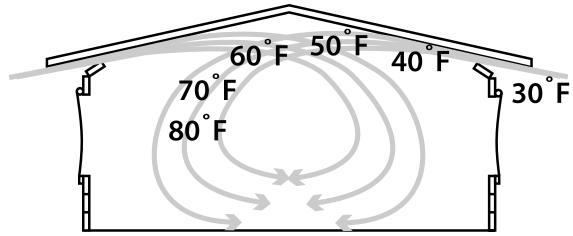


Figure 4. Minimum ventilation setup uses various combinations of 36-inch and 48-inch fans, depending on ventilation rate needed. Object is to bring air in through vent boxes to mix with warm inside air, and avoid chilling birds. Note: Light traps and false wall not shown here.

The key to successful minimum ventilation in a pullet house is creating the proper partial vacuum so that air comes in with sufficient speed and at the same speed through all inlets. Accomplishing this requires a tight house: air leaks will spoil the desired air flow-through pattern. With good negative pressure and air inlets distributed evenly along the whole length of the house, airflow is then uniform throughout the house. Just as important, cool outside air comes into the house at a high enough velocity to mix with warm in-house air above the flock, rather than dropping directly onto and chilling the birds or causing caked litter.

Figure 5. Minimum ventilation setup uses various combinations of 36-inch and 48-inch fans, depending on ventilation rate needed. Object 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.



The amount of house heat lost during proper minimum ventilation is insignificant compared with the benefits gained. Even when ammonia is not an issue (as with new litter and/or litter treatments), failure to provide adequate fresh air and to break up in-house air stratification can be very costly in terms of bird health and growth.

It is important to realize that minimum ventilation can and must be maintained even when a cold rain is falling outside. The incoming cold, wet air will be warmed and dried as it enters and flows across the ceiling area (Figure 5). This enables the airflow to pick up moisture from the litter and carry it out of the house through the exhaust fans. Failure to minimum ventilate properly leads to wet houses and the other associated problems that come with high moisture.

The best way to ensure that proper minimum ventilation airflow pattern is achieved is to use vent box inlets actuated by a static pressure controller.

To get the needed air flow-through pattern in a minimum ventilation setup, the air inlet area must be matched to the fan capacity being used. If the air inlet area is too small (for the number of fans running), fans will have to work against too-high static pressure and will not deliver the air exchange rate needed. If air inlets are opened too wide, static pressure drops too low, and air will come in mostly or only through inlets closest to the fans, creating non-uniform airflow and poor conditions for birds. Using vent box inlets actuated by a static pressure controller makes the inlet area adjustment automatic.

Example: Determining minimum ventilation fan run time.

Find the correct fan run time for a negative pressure ventilating rearing house with 10,000 birds during week 10 of the rearing cycle. The timer fans are one 36-inch fan at 7,000 cfm and one 48-inch at 16,000 cfm, operated on a 5-minute (300 seconds) timer.

Step 1: From table at right note that cfm/bird required is 0.25.

Step 2: Determine total air needed

0.25 cfm/bird x 10,000 birds = 2,500 cfm

Step 3: Divide needed cfm by fan power

2,500 / 23,000 = 0.108 (10.8%)

Step 4: Determine actual fan run time

0.108 x 300 seconds = 32 seconds on time out of 5 minutes

Approximate Minimum CFM's per Bird by Week

Age	CFM/bird
1-8 weeks	0.10
9-15 weeks	0.25
16 weeks-move	0.35

Why are 5-minute timers preferable to 10-minute timers? Many older rearing houses have 10-minute timers to control the minimum ventilation fans. The problem with using 10-minute interval timers is that they cause extreme variations in air temperature and air quality early in the growout. For example, with a 10-minute timer, the minimum ventilation cycle needed for the young pullets and cockerels might require running a 36-inch and one 48-inch fan 1 minute on and 9 minutes off. 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.

These 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 4½ 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 swings, less changes in RH and overall a better rearing environment.

Operating minimum ventilation on a 5-minute timer minimizes temperature and RH extremes and provides a better rearing environment.

Transitional Ventilation

Transitional ventilation is used when heat removal from the house is needed, but we do not want outside cool air to flow directly onto the birds. The transitional setup is the same as for minimum ventilation, except that the rate is thermostat controlled, not timer controlled. In transitional ventilation, typically up to half of the installed tunnel fans (either alone or in combination with sidewall fans) are used to bring air into the house through perimeter air inlets instead of through the tunnel inlets, which are kept closed. Outside air enters and mixes with in-house air in much the same way as in a minimum-ventilation negative pressure system. The big difference over the minimum ventilation setup is that the increased fan capacity gives a larger volume of air exchange. Running four tunnel fans in the transitional setup, for example, gives the same ventilation rate as running four-fan tunnel ventilation, but with no wind directly on the birds.

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

The transitional ventilation setup (Figure 6) enables a pullet grower to provide effective negative-pressure ventilation in conditions where neither minimum nor tunnel ventilation would be advisable. This happens typically as birds grow large enough to contribute significant heat to the house, but outside air is too cool to allow it to flow directly onto the birds. As with minimum ventilation, the air inlet area must be matched to the fan capacity used. Enough sidewall inlet area should be provided to operate approximately half of the installed tunnel fans in the transitional mode without creating excessive static pressure. For most efficient operation, power vent machines which control air inlets based on static pressure are used, as in minimum ventilation.

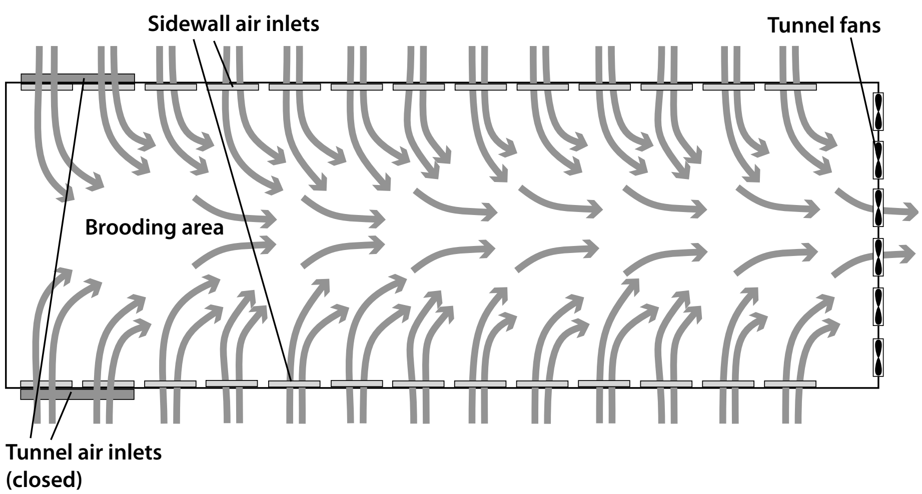


Figure 6. Transitional ventilation uses the same basic setup as in minimum ventilation. The difference is that ventilation is thermostat controlled in transitional mode, not timer controlled. Note: Light traps and false wall in tunnel fan end not shown in this diagram.

Tunnel Ventilation

Tunnel systems use 48-inch or larger fans at one end of the house, pulling air through inlets at the other end (Figure 7). Tunnel ventilation first handles heat removal, providing the air exchange rate needed to exhaust excess house heat in hot weather. The tunnel setup also provides wind-chill cooling, moving air as in a wind tunnel through the length of the house. A minimum velocity of 400 feet

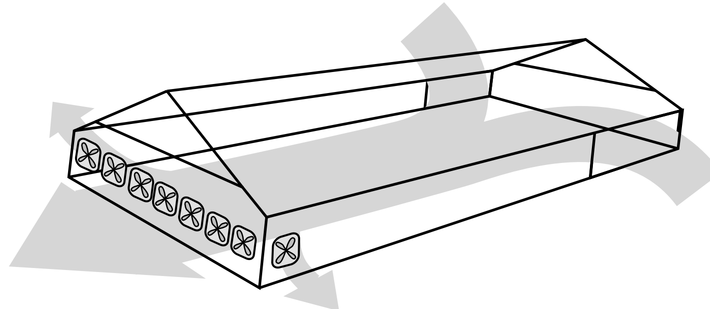


Figure 7. Tunnel ventilation pulls a large volume of air through the house at high velocity. The wind-chill effect makes fully-feathered birds feel as though the air is 10 to 12 degrees F cooler. The effective temperature drop cannot be measured, only estimated by bird behavior. Caution: The wind-chill effect is much more pronounced for young birds.

In hot weather tunnel ventilation can reduce the "effective" temperature by 10-12 degrees F, but must be used with care when birds are young.

per minute is normally considered acceptable for adequate wind-chill cooling in pullets. The wind-chill effect created by high-velocity air can reduce the effective temperature felt by fully feathered birds by as much as 10-12 degrees F. This is a major environmental control tool we use with mature pullets in hot weather.

Caution must be used in tunnel ventilating with younger birds, since they experience greater wind-chill effect for a given air velocity. Note that the "effective" temperature can only be estimated, not read from a thermometer or calculated. Bird behavior must be the guide to judging the right number of fans to turn on to create the air velocity and air exchange rate needed to keep pullets comfortable.

Evaporative cooling can add 10-15 degrees F of real cooling to the tunnel wind-chill cooling effect, thus keeping birds comfortable even in extreme heat.

The high-velocity airflow of the tunnel setup makes it well suited to adding evaporative cooling. This can be done with either in-house foggers or evaporative cooling pads placed outside the tunnel air inlets, and can usually lower actual air temperature by 10 to 15 degrees F. This real cooling of incoming air, on top of the "effective" cooling produced by wind-chill, can keep birds comfortable even in very hot weather. Used alone, the wind-chill effect of tunnel ventilation becomes less pronounced as air temperatures rise much above 90°F, and above 100°F the air begins to warm instead of cooling the birds. Whether your operation will be a fog tunnel or a pad tunnel operation will most likely be determined by geographic location and intensity of heat during hot weather. Both types of systems will provide additional bird comfort during the most extreme heat.

Tunnel Cooling Options

Fogging type tunnel evaporative cooling systems can provide acceptable cooling but require close management to achieve needed cooling without wetting down the house.

Tunnel Fog Option. The tunnel fog option of evaporative cooling is found in many rearing houses that are in climates that cannot justify the expense of installing recirculating cooling pads. One of the advantages of the tunnel fog option is reduced system cost. A major disadvantage of the tunnel fog option is that a fogging system requires close management to avoid wetting the house interior. If maximum cooling is to be achieved during the hottest weather, without putting stress on the house management, recirculating pad evaporative cooling systems are recommended.

A key to good tunnel fog operation is to turn fogging nozzles on in stages. If all fogging nozzles are activated when the need for evaporative cooling is first realized, the quantity of water put into the air cannot be evaporated. This results in floor wetting. Many rearing houses with foggers will have at least two stages of fogging nozzles within the house. The first set of nozzles may come on at approximately 82°F and the second stage may come on at approximately 86°F. In designing houses with tunnel fog option, if we equip the house with enough water and nozzle capacity for the hottest day of the year, then on any day that is not as severe we will not be able to run the maximum number of nozzles that are in the house.

Tunnel Pad Option. There are many different ways to equip rearing houses with evaporative pad systems. The most desirable system uses 6-inch recirculating cooling pads. One advantage of the 6-inch recirculating cooling system is that all water not evaporated is caught and recycled, so there is virtually no water wasted. In addition, 6-inch recirculating systems require less management attention and have extremely high evaporative cooling efficiency. In other words, over 70% of the cooling potential that is available on a given day can generally be achieved with high efficiency 6-inch recirculating systems. In comparing 6-inch recirculating systems with fog systems we often see fogging systems designed to provide 10-12 degrees F of cooling on the hottest day, whereas 6-inch recirculating systems might be able to provide as much as 18 degrees F of cooling. In very hot climates, the most acceptable cooling system for older pullets and cockerels utilizes 6-inch recirculating cooling pads.

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

Ventilation in Non Tunnel Rearing Houses -- Pros and Cons

In cooler climate locations, rearing houses often are not equipped with tunnel ventilation. These houses typically use negative pressure ventilation systems with the capability of exchanging air in the house approximately once every two minutes. This type of rearing house makes it possible to move extreme amounts of air through the house, but does not offer the option or advantage of direct wind chill cooling that is only available through tunnel ventilation.

For years this was the preferred hot weather house, and in cooler climates the cost of tunnel cooling may not be economically justifiable. When designing negative pressure ventilation systems for hot weather situations, it is extremely important to adhere to good principles in selecting fans for high air flow and good airflow ratio. Air inlets for operation in this type of negative pressure system must be carefully calculated so fans are not working at excessive static pressures. Distinct calculations must be made to ensure we have adequate light traps area installed to handle the total capacity of the hot weather fans without exceeding acceptable static pressure levels for the fans. (For example calculations, see Example Broiler Breeder Rearing House Design, page 24.)

In non-tunnel rearing houses, it is especially important to ensure that fans, air inlets, and light traps allow high enough air exchange rates.

SPECIAL EQUIPMENT CONSIDERATIONS FOR REARING HOUSES

Unlike most other poultry operations, broiler breeder rearing houses must be capable of complete dark out during part of the growing phase. This means that both fan and air inlet openings must have effective light traps. Since light traps inevitably place at least some extra burden on airflow, pullet house fans and air inlets must be capable of handling the demands that darkout ventilation imposes.

Understanding Light Traps

Light traps are used in modern pullet houses to block light entry at all air inlets and fan exhaust openings where light would otherwise enter. This includes tunnel fans and tunnel inlets, and side or endwall minimum ventilation fans and sidewall air inlets.

A good light trap must block light effectively without restricting airflow too much.

The dilemma of light traps is that when we restrict light we also restrict the amount of air entering the house. A number of light trap products are commercially available – some do a good job of blocking light but a poor job of allowing air to pass through, while others allow good airflow but have a "light glow" associated with them. Considering all the traps on the market, carefully consider your purchase. The key is to choose light traps that do a good job of blocking light without overly restricting air flow. A second key is to install enough of these light traps (i.e., have sufficient total trap area) so that fans are not over worked and choked down to the point they can't do their job.

There are two common light trap media in use today. These are the "S" or "W" blade or vane type trap (Figure 8) and the honeycomb type trap. Honeycomb material works well for inlets but has a tendency to plug if used for exhaust traps.

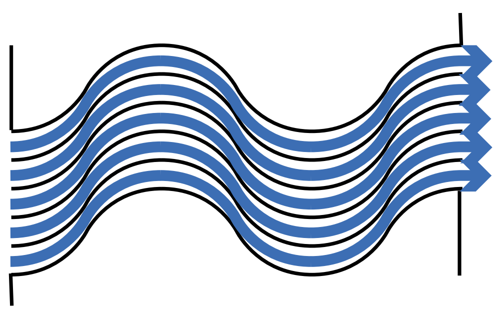


Figure 8. One type of commercial light trap is called variously an "S," "W," "blade" or "vane" trap. This type trap, if well designed, can block light well without overly restricting airflow.

A light trap that does not have a light reduction factor of 1,000,000 or better is not dark!

Table 2 (on facing page) lists commonly used light traps, showing their ability to block light and pass air. A trap that does not have a light reduction factor of 1,000,000 or better is not dark! The exhaust and inlet area requirement columns show the traps' ability to pass air. The higher the airflow per unit of area the easier it is to move air through the trap. This is very important because any restriction on air flow raises the static pressure fans must work against, which in turn will to some degree reduce the amount of air the fans can move. If fans cannot move the air volume required, the whole purpose of ventilation can be defeated. Note that the airflow per unit of area numbers in the table should only be used for comparison purposes because there are other factors that affect the actual amount of light trap that should be installed in a pullet house.

Often growers or house builders try to save on construction costs by building homemade inlet boxes as shown in Figure 9. Because these boxes are not designed to pass air freely, the static pressure they put on the fan is often so great that al-

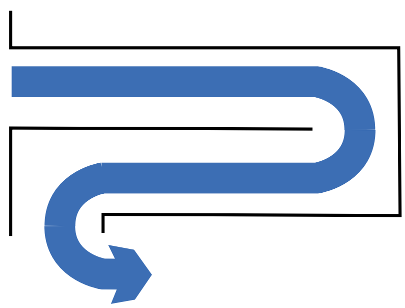
Table 2. Light Reduction and Airflow Characteristics of Common Light Traps

Light Trap	Light Reduction Factor	Exhaust Fan Light Trap Requirements (cfm per sq ft)	Air Inlet Light Trap Requirements `(cfm per sq ft)
Dandy (Black Air®)	2,300	850	575
Acme (Metal)	8,000	800	550
Dandy (MaxFlow)	2,010,000	700	525
Munters (Mi-T-Dark®)	2,100,000	750	500
Dayton	180,000	700	500
Acme (Plastic)	21,000,000	700	475
New Dandy Black Air®	107,000,000	625	425
W.W.F. Light Deflector	11,000	600	425
Gigola (Night Air–97)	5,000	550	375
Dandy (Black Magic®)	3,100,000	500	350
Gen Shelters (Light Eliminator®)	4,700,000	400	275

Note: Traps listed illustrate the range of light blocking and airflow characteristics seen in light traps over the past 15-20 years, and some are no longer manufactured. In the past, true darkout was not considered as critical as it is now. Trap airflow requirements (cfm per sq ft) indicate the ability of a given trap to pass air in exhaust or inlet applications. Higher cfm/sq ft numbers indicate that less total trap area would be needed to maintain acceptable 0.15-0.18 inches static pressure on fans. For a given house design, total trap area needed is obtained by dividing the total house airflow by the listed cfm per sq ft requirement. For example, if the house total airflow is 152,000 cfm, using a trap with a 700 cfm/sq ft requirement as a fan exhaust trap would require 152,000 ÷ 700 = 218 sq ft of pad; a trap with an air inlet requirement of 525 cfm/sq ft as an air inlet trap would require 152,000 ÷ 525 = 290 sq ft of pad. Using less trap area could result in excessive pressure on fans. ***Table is based on work published by the University of Georgia College of Agricultural and Environmental Science, March 1998. Trade or brand names are used for information purposes only, and no approval or endorsement is intended or implied.***

most no air flows. Studies have shown that, in the long run, the use of homemade inlets can cost a grower more money over the life of the house when the cost of operating fans is considered. Buy only quality commercial traps.

Figure 9. Homemade box light traps allow a lot of light to bounce through and at the same time severely restrict airflow and raise static pressure by making the air do sharp turns.



Understanding Fan Air-Moving Capacity and Static Pressure

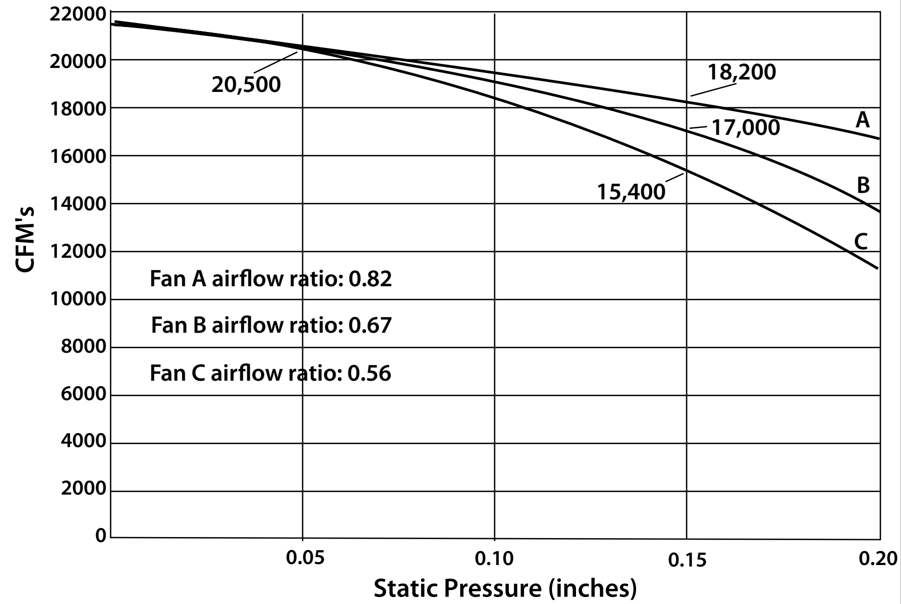
As mentioned above, the static pressure a fan must work against can severely limit its ability to move air. Poultry house fans are rated to move a certain volume of air per unit of time, but only at a given static pressure, normally 0.05 inches of water column. Because pullet house ventilation fans almost always must work against much higher static pressure, it is important to have high quality fans with a high airflow ratio, that is, maintain a high percentage of their rated capacity as static pressure rises. The airflow ratio is the percentage of air that a fan will move at 0.20 inches SP in comparison to what it moves at 0.05 inches. The higher the number, the less drop off in air moving capacity a fan will have as it works against higher and higher static pressure. Cones on fans improve their air-moving efficiency and cone fans are generally preferred in rearing houses.

Darkout houses require high airflow ratio fans that can maintain a higher percentage of rated capacity when working against high static pressures.

Not all fans are created equal, as shown by the airflow curves in Figure 10. Figure 10 shows how three fans can have exactly the same cfm rating at 0.05 inches SP, but have very different air-moving capacity as static pressure increases. Fan A, with the higher airflow ratio, maintains higher air movement as pressure increases.

All three fans move the same amount of air at 0.05 SP, but Fan A moves much more air as static pressure goes up. Pullet houses need quality high airflow ratio fans for good ventilation.

Figure 10. Airflow Changes for Typical Fans as Status Pressure Increases



The greater the light trap area, the lower will be the static pressure drop across the trap and the load on the fan. A false wall tunnel fan room allows using larger light trap area, for lower static pressure.

Because of the need to keep static pressure from going too high, there has been a trend for building tunnel ventilated pullet houses that have fan rooms at one end of the house, so all tunnel air is pulled through a false wall at the fan end (Figure 11). This is by far the most efficient and best way to design a tunnel ventilated pullet house because it allows more light trap area to be available to a fan than when traps are bolted directly to fans. The higher the light trap area, the lower will be the static pressure drop across the trap. Having a fan room also makes it much easier for the grower to keep belts tight, and shutters and light traps clean. These are often neglected maintenance items, and are likely to be totally neglected in houses with traps bolted directly to fans.

If traps must be mounted on tunnel fans, they should be the largest available and placed on the fan intake side.

Many older houses are still equipped with one light trap per fan. In this case, we should make every effort to get the largest light trap possible. Light traps should be installed on the intake side of the fan and not on the exhaust side. A rule of thumb that many managers have used with some success is to rate a 36-inch fan at no more than 7,000 cfm and rate a 48-inch fan at no more than 16,000 cfm. Adjust these ratings downward for deficiencies found in installation of light traps and shutters.

Many field managers have difficulty deciding upon the level at which to rate fans used in older rearing houses. It is difficult to provide an easy method or rule of thumb for determining the output of fans. Experience is the best teacher. If belts are slipping and shutters are drooping, it is a pretty good indication that the fans are not moving much air.

If house has a false wall fan room for light trap mounting, static pressure the fans work against is measured from the fan room to the outside.

Figure 11 also shows static pressure drops in a typical tunnel ventilated pullet house using the false wall/fan room design. While in most poultry houses static pressure is measured between the bird chamber and the outside, for the design in Figure 11 static pressure for the tunnel fans is measured from the fan room to the outside. Note that while the working static pressure of 0.15 inches is fairly high, a pullet house with light traps installed directly on the tunnel fans (instead of in the false wall) would have much higher static pressure.

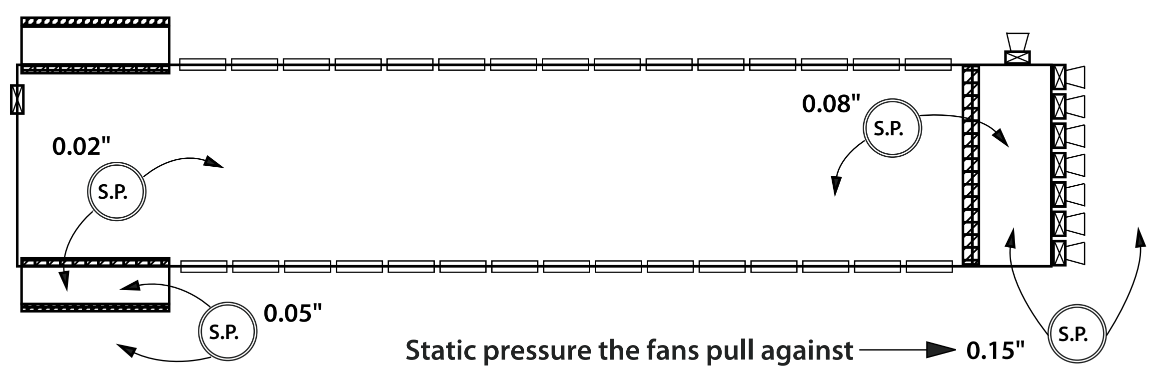


Figure 11. The false wall tunnel fan room makes it much easier to perform maintenance on fans, and allows using much greater light trap area installed in the false wall, so that fan static pressure loading is reduced. The static pressure fans will work against in a fan-room house must be measured from inside the fan room to outside, and is the total of pressure differences across cooling pads (if used), inlet light traps, and false wall exhaust light traps. Bird chamber-to-outside static pressure in this house is only 0.07 inches, but tunnel fans must work against 0.15 inches pressure – still lower than it would be if light traps were bolted directly to the tunnel fans.

Operation of Vent Doors or Inlets

Vent doors and perimeter inlets are the ways we bring air into negative pressure houses. In cool weather, the operation and management of the vent door is critical to house uniformity. In hot weather, the operation of the tunnel inlet is very important.

In cool weather ventilation, many rearing houses typically have 15-20 inlet doors on each side of a 400 or 500 ft house. These doors are operated by a power vent machine that senses static pressure. As the need for ventilation increases, vent doors are adjusted to a more open position by the static pressure vent machine controller. Thus, if only two fans are need for ventilation, a proper inlet door opening for two fans is achieved; if three fans are needed for ventilation, the proper door opening for three fans is achieved. It is advisable to equip vent door inlets with latches, or other means, to hold the doors closed when not needed. The number of inlets 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 many of the inlets to achieve good air velocity through the remaining inlets in use. This is an important management concept and is often overlooked by flock managers.

Static pressure actuated controllers are very effective in matching the proper vent openings with the fans that are turned on, so that proper airflow is maintained at all times during minimum and transitional ventilation.

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 pullet house and two inches on the other end of the house will cause great imbalances in house temperature. It is imperative that vent doors be set for proper air velocity needed to throw air to the top center of the house and that all vent doors within a pullet house be adjusted to achieve similar results. A non-uniform inlet system will produce non-uniform temperature conditions, which greatly affect flock development.

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.

KEYS TO MANAGING VENTILATION IN A MODERN BREEDER REARING HOUSE

There are three ventilation modes used in modern pullet houses: minimum mode for cold weather and small birds, transitional mode for moderate weather and medium-size birds, and tunnel mode for hot weather. Managing a house year-round for top bird comfort and development firstly requires being able to judge which ventilation mode is best for the birds at any given moment; and then making the fine-tuning adjustments to keep temperature and other air quality factors as close to optimum as possible.

Integrated electronic controllers make pullet house management easier, but humans must still understand management principles and provide intelligent oversight.

Integrated electronic control systems now make the management job easier, since they can automatically switch modes and adjust ventilation rates as conditions change. However, even the smartest controller is not infallible, and must be monitored. Even more important, the controller settings themselves must be determined by a knowledgeable human. There is just no substitute for a good poultry manager who is in the house frequently, watching the birds and making the control adjustments they need for best growth and development.

Which Ventilation Mode Is Needed?

The key to making the right ventilation mode decision is knowing 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:

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

Minimum ventilation: We do not need to remove heat from the house, and do not want outside air to contact the birds directly. Either the birds are too small and/or outside air is too cold. 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 begin to need to remove heat from the house, but do not want cold air contacting the birds.

Transitional ventilation: Starts when birds grow larger and/or outside air gets warmer so 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 side wall 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, so wind-chill cooling is needed.

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 have to be very careful in switching from transitional to tunnel mode when birds are under four weeks old, because they experience a greater wind-chill and may be stressed by the sudden drop in the effective temperature.

We want to be in (and stay in) tunnel only when birds need wind-chill to stay in their comfort range.

Importance Of Staying On Target Temperature

Each given day during a growout, the operator needs to know what the target temperature should be for that day, and manage the ventilation system to maintain that temperature. It's a good idea to post the target temperature on the wall by the controller every day. For pullets, the optimum temperature typically starts near 91°F on day one and drops gradually to near 70°F by the 4th week. Someone should be comparing actual and target temperatures at regular intervals throughout each day of the rearing phase, and making adjustments as needed.

Important: When a house is switched into the tunnel ventilation mode, the temperature birds will experience is not the same as the thermometer reading. In the tunnel mode, the management goal is to keep the equivalent temperature on target. We do not need to, and do not want to, lower the thermometer temperature to target if the birds are experiencing wind-chill.

It's important to stay on target temperature; but realize that during tunnel ventilation the birds will be experiencing an effectively lower temperature.

Day One Preparation

It is extremely important to keep young birds from being chilled. Even mild chilling during brooding results in decreased weights and increased feed conversion, vaccine reactions, and mortalities. Monitoring thermometers and thermostats must be set at bird level and outside cold air must not be allowed to flow directly onto birds. It is also critical to pre-heat the house and litter before chick placement. A good rule of thumb is that litter should ideally be at 85°F at the time of placement. This can only be achieved if brooders are lit 24 hours ahead of placement. If forced-air furnaces are the sole source of brooding heat, they should be turned on 48 hours before placement. The costs of not pre-heating are illustrated by one integrator study which found that the best ten flocks for lowest seven-day mortality (0.7%), placed chicks on litter at recommended temperatures. The worst ten, which placed chicks on litter averaging 72.5°F, experienced 4.0% seven-day mortalities.

If houses are not pre-heated well ahead of chick delivery, cold litter can stress chicks and seriously impair flock development.

Keys To Managing Minimum Ventilation

The goal of minimum ventilation is to maintain air quality during any time when it is not necessary to exhaust heat from the house. This means bringing in enough fresh air to provide adequate oxygen and to prevent moisture build-up and ammonia problems.

KEY 1 – It is imperative as long as birds are present 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.

We can – and must – operate minimum ventilation even when an all day cold rain is falling outside.

KEY 2 – A rule of thumb is that the minimum ventilation rate needed for starting chicks is about 0.10-0.20 cfm per bird, depending on outside air temperature. As birds grow larger and put out more moisture and heat, system on-time and/or number of fans on needs to be increased. In-house RH and litter moisture, along with bird behavior, serve as guides in setting the minimum ventilation rate.

KEY 3 – 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 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

It is critical that inlet air velocity be high enough so that incoming cold air mixes with in-house air above the birds, and cold outside air does not drop to bird level.

KEY 4 – The switch to transitional ventilation mode comes when birds are producing too much heat for the minimum ventilation fans to cope with. The cooler the outside air and the younger the birds, the longer it will take to get to the point where ventilation must be switched out of minimum and into transitional mode. The warmer the outside air and the larger the birds, the sooner we will need to switch.

Litter treatments are effective in keeping ammonia in check, but they are definitely not a license to turn minimum ventilation off!

KEY 5 – Litter treatments that inhibit formation of ammonia from fecal material or old litter have proven very helpful and are now widely used in major poultry production areas. These treatments simplify management of minimum ventilation by greatly lessening the threat of ammonia build up in the house. They allow growers to ventilate during brooding truly based on minimum needs of the birds, and not on the need to get rid of ammonia. They are not, however, a license to turn off minimum ventilation entirely. There is still need to bring in fresh air and control moisture. But the treatments where used properly have reduced fuel costs and improved bird health for many producers.

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 at the same time not allowing outside air to flow 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 or impossible to manually adjust the size of inlet openings to keep proper static pressure as the number of fans running changes.

We never want to switch to tunnel ventilation while it is still possible to maintain bird comfort in transitional ventilation mode.

KEY 2 – As birds get older and give off more heat per unit of body weight, or as outside weather gets hotter, we must get rid of more and more heat from the house. But we never want to switch to tunnel ventilation while it is still possible to maintain bird comfort in transitional ventilation mode. For large birds in a well-designed house, if the outside temperature is more than 10 degrees F below the inside target, then we should be able to maintain target temperature with transitional ventilation. We should not be using tunnel ventilation. If birds are smaller, we should be able to maintain target temperature with transitional when there is even less than 10 degrees F spread between inside target and outside temperatures. Switching into tunnel mode too soon is also likely to produce a large temperature difference from one end of the house to the other, which will cause crowding and affect bird health. This is one more reason to stay in transitional ventilation mode as long as possible.

There is no problem with switching from one ventilation mode to another as conditions change; but beware of chilling young birds with a premature switch to tunnel.

KEY 3 – In judging the time and need to switch to tunnel, we must keep the wind-chill effect in mind. If we are using maximum transitional ventilation capacity – running, say, four tunnel fans – and switch into tunnel mode, the birds will experience a drop in the "equivalent temperature," which may be quite a bit lower than the thermometer reading. When birds are younger and more sensitive to wind-chill, the effective temperature drop may feel like a blast of cold air and be difficult for them to cope with.

KEY 4 – With the above cautions in mind, there is no problem with switching from one ventilation mode to another – minimum, transitional or tunnel – as conditions change. A flock may need transitional ventilation during the night and in the early morning, but some form of tunnel during the heat of the day. The question is, "What will keep the birds most comfortable?"

Keys To Perimeter Inlet Management

In both minimum and transitional ventilation, achieving proper airflow through the perimeter air inlets is essential. Inlets control direction of air movement and velocity of air entering the house, and thus control air mixing. In cold weather, inlets are the tool to help blend cold outside air with warm inside air to save fuel and maintain precise temperatures. Good inlet management prevents all the hot air from being in the top of the house. In houses with poor inlet management, as much as 15 to 20 degrees F difference in floor and ceiling temperature have been observed. Good inlet management can keep this temperature difference to 5 degrees F.

The economic benefits of good inlet management start with saving fuel costs. Houses with poor air mixing will use 20-25% more fuel. Extreme temperatures can be devastating -- particularly during the brooding period. Too cold conditions dramatically impact the ability of young birds to get adequate feed and water. If early growth is slowed, the losses cannot be recovered during the subsequent life of the flock. The bottom line is -- proper management of air inlets is absolutely essential to provide birds the temperature and air quality they need.

Properly maintaining and managing perimeter air inlets saves on fuel costs and allows optimal bird development.

KEY 1 – Inlet management starts with making sure the house is tight, with no air leaks around doors, curtains, torn insulation, etc. to rob from the inlet air stream.

KEY 2 – The next step is to make sure inlets are opening properly. The size of the inlet openings must be set so as to achieve both the static pressure desired and the airflow "throw" needed. For perimeter inlets to flow air properly they must open a minimum of 2 to 3 inches for a sidewall inlet or 1 to 1½ inches for a ceiling inlet. Inlets opened beyond the "fully open" position (opening at tip of board equal to inlet throat opening) don't increase air flow. Too wide board openings tend to direct air downward toward the birds. The right airflow happens only with the right amount of inlet opening.

For perimeter inlets to have proper air flow, they must open a minimum of 2 to 3 inches for a sidewall inlet or 1 to 1 1/2 inches for a ceiling inlet.

KEY 3 – Managing inlets manually is a nearly impossible job. Each time a fan came on and went off, an inlet opening adjustment would be required. That is why the static pressure inlet control machine was invented. The static pressure control senses static pressure in the house and then opens or closes inlets to achieve the proper opening that will produce the static pressure desired – and thus produce the airflow pattern desired. These machines work very well and have greatly benefited our industry.

KEY 4 – One aspect of inlet management does need to be taken care of manually, and that is deciding how many of the installed inlets will actually be used. A typical pullet house will have enough inlets installed to handle about 3 of the tunnel fans. During brooding we do not need all the inlets. The reason for this is that if too many inlets are operating for the number of fans running, the static pressure machine will have to choke the inlet openings down too far in order to maintain static pressure, and the airflow "throw" needed will not be achieved.

The number of perimeter air inlets to be unlatched and used depends on the total fan capacity in use; fewer inlets should be open during brooding, and more opened as birds grow and higher ventilation rates are needed.

With all inlets in use, running only one 48-inch fan results in the static pressure machine opening the inlets only about 0.25 to 0.5 inches , and the air barely leaks into the house at the inlets and then falls to the floor. In this situation, proper air mixing cannot happen because there is no real air stream with any air velocity. This leads to wet litter, high humidity, ammonia, high fuel usage and poor air quality.

To get good airflow during the early days of the rearing phase when using only one 48-inch fan (or two 36-inch fans), we usually need to latch closed every other inlet in the brood chambers (and all the inlets in the back end). This allows evenly distributed inlets in the brood chamber to respond to the inlet machine. We would unlatch more inlets in the brood chamber only if there was need to run additional fans. After turnout of chicks, more inlets in the back end are unlatched as more fans are used.

A good rule of thumb in a pullet house is to have about 10 operating inlets for each 48-inch fan that will be brought on during that phase or that prevailing weather. This varies with size of inlet used.

A good rule of thumb in a pullet house is to have about 10 operating inlets for each 48-inch fan that will be brought on.

KEY 5 – Avoid having any obstructions to airflow being placed directly in the airstream from the inlet. For example, water lines and electrical conduit are often strapped to the ceiling right in the path of airflow from the inlets. When the airflow stream hits such an obstruction it breaks up and drifts downward. This defeats the goal of having a high velocity air stream flowing smoothly along the ceiling to the center of the house.

Keys To Managing Tunnel Ventilation

The goal of tunnel ventilation is cooling. We are in the tunnel mode only when it is no longer possible to keep birds comfortable by removing heat from the house. At this point, birds need the wind-chill effect, and in hotter weather, the real temperature reduction of evaporative cooling.

KEY 1 – For success in managing tunnel ventilation, we must understand effective or equivalent temperature. To determine equivalent bird temperature, you must take the in-house thermometer reading and subtract the number of degrees of wind-chill cooling you estimate the birds are experiencing. Table 3 at left shows approximate estimated wind chill effect for various air speeds on birds of different ages. Determining equivalent temperature is not an exact science. The temperature experienced by birds is very much affected by bird age (that is, feathering and body size) and air speed. Other things being equal, the effective temperature drop will be:

The effective temperature birds experience during tunnel ventilation varies with the age of the bird and the actual air temperature. The wind-chill effect cannot be measured, but must be estimated.

Greater for younger birds, less for older birds;

Greater for lower temperatures, less for higher temps.

The wind chill effect decreases as we approach 95°F and completely goes away as we approach 100°F.

KEY 2 – Extreme caution should be exercised when tunnel ventilating young birds. As the numbers in Table 3 indicate, the effect of wind-chill on 4-week birds may be double that for 7-week birds. Growers often get into trouble when trying to tunnel ventilate young birds when the weather is too cold.

Table 3. Estimated Effective Temperature Reduction When Air Temperature is 85°-90° F

Air velocity	Bird age		
ft/min	1 week	4 weeks	7 weeks
100	-4°F	-2°F	--
200	-12°F	-5°F	-2°F
300	-22°F	-10°F	-4°F
400	--	-15°F	-7°F
500	--	-18°F	-10°F

KEY 3 – To determine the wind-chill effect in a given situation, you must observe bird behavior to pick up any signs of their being too warm or too cool. There is no way to predict or calculate exactly what the wind-chill effect will be. Table 3 at left provides only a guide for planning purposes.

The key signs of bird discomfort to look for are:

When birds are too warm they migrate to cooler or higher airflow areas, hold feathers closer to the body, droop or lift their wings to get more air cooling, drink more and eat less. If they stop eating and begin panting, and especially if normally pink skin areas turn dark red, they are definitely getting over-heated.

When birds are too cold, they tend to go to the floor to try to avoid the cool airstream, move away from the direction of air movement and huddle together, and "fluff" feathers to increase their insulating value.

KEY 4 – Following are some further example guidelines for judging whether you should be in tunnel or transitional mode. Caution: these are general guidelines only, and must be checked against bird behavior.

If the outside temperature is less than 70°F and birds are four weeks old, stay in transitional mode.

If the outside temperature is 65°F and the birds are between 8 and 16 weeks old, stay in transitional mode.

If the outside temperature is 60°F or lower and the birds are 16 weeks old, stay in transitional mode ventilation. The fact is, if it's too cold outside, tunnel ventilation hurts rather than helps.

Under normal conditions, don't consider running in tunnel mode with fewer than half of your tunnel fans. This has more drawbacks than benefits, especially regarding temperature uniformity. If you can do the job with fewer than half of the fans, stay in transitional ventilation mode.

Under normal conditions, don't consider running in tunnel mode with fewer than half of the tunnel fans.

KEY 5 – Monitor the temperature difference in the house from inlet end to fan end. This can indicate two different things, depending on the situation:

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.

During tunnel in hot weather, a temperature difference much greater than 5 degrees F (normal) can indicate insufficient airflow or air leaks letting 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.

Particularly in cooler weather with smaller birds, 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 because the air is coming in uniformly throughout the perimeter vents around the house.

KEY 6 – Migration fences should be installed as soon as we move from the brooding phase to full house ventilation. When using tunnel ventilation for cooling, birds will tend to move toward the cooler, inlet end of the house, resulting in crowding. Migration fences will keep them spread out. Keeping birds uniformly spread out ensures conditions for growth are the same throughout the house. Properly installed fences are vital for proper operation of tunnel houses.

Migration fences should be installed as soon as we move from the brooding phase to full house ventilation.

KEY 7 – If you see any sign of birds being too warm during full tunnel ventilation (and the system is operating properly), it's time to turn on evaporative cooling.

Keys To Managing Tunnel + Evaporative Cooling

The goal of evaporative cooling in a modern tunnel house is to work in combination with wind-chill cooling to extend the range of conditions under which we can keep birds comfortable. An evaporative cooling system does not have to lower the air temperature to the actual target thermometer reading – it only has to get it into the range where the added effective temperature drop produced by the tunnel airflow will keep the birds in their comfort zone.

For example, if it is 95°F outside and we can get 12 degrees F of evaporative cooling from our system, the real air temperature coming into the house is 83°F. If the wind chill effect from the 400 feet-per-minute air velocity is another 10 degrees F, the effective temperature felt by the birds will be 73°F – very close to optimum for fully-feathered birds.

In 95°F weather, if we get 12 degrees of evaporative cooling and the wind-chill cooling is 10 degrees, the birds will experience an effective temperature of 73°F.

KEY 1 – Evaporative cooling should be turned on or programmed to come on before birds begin to feel heat discomfort. For fully-feathered birds, this may be

Evaporative cooling should be turned on before birds begin to feel heat discomfort; for fully-feathered birds, this may be in the 82°-85°F range.

in the 82°-85°F air temperature range. It is easier and better to keep heat build-up from happening in a house than it is to reduce the heat load after it has progressed too far.

KEY 2 – A good rule of thumb is that evaporative cooling systems should not be used after dark or before 9 a.m. The RH during nighttime hours is so high that almost no cooling will be experienced. But generally, there are rarely conditions during the daytime that would necessitate turning off properly-staged foggers or pads. Evaporative cooling does little good if the RH is much over 80 percent. However, as a warm day progresses and air temperatures increase, RH also drops, so the potential cooling we can get from evaporative cooling increases.

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

KEY 3 – 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 the house. No doors can be open or any air leaks permitted. Side curtains must fit tight against the house. Water pumping rates must be right, and pads must not be allowed to clog. Reducing the number of on-off cycles helps, as does allowing pads to dry out completely during the night by turning the water off but keeping fans on.

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

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.

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).

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

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.

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.

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

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.

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

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 Rearing House Design

Many of the factors that affect the design of a dark-out pullet house have been mentioned. Perhaps the best way to get a feel for what is involved in design of such a house is to take a look at typical design. Following are the basic specifications we believe you should consider when building a new broiler breeder rearing house.

Recommended Typical Rearing House Ventilation Design

(for climate where it is very warm in summer, for example, in Alabama 100°F in summer and 20°F in winter)

1. 40x400 Dark-out pullet house
2. 11,000 birds, 4.6 lb maximum weight
3. Ceiling is insulated – minimum R-11, preference R-19, ceiling is dropped or can be high type. If ceiling is high type, building should be low profile. Sidewall height 8 ft, center ceiling height 11 ft; average ceiling height 9.5 ft.
4. Exterior curtain side walls – total dark-out is desired. House to be equipped with black on white sidewall curtain with 12-inch curtain pocket installed to block light and air leaks.
5. Tunnel ventilation with evaporative pad cooling is desired – minimum wind speed is 400 fpm.
6. Recommend using 48-inch or larger fans for tunnel ventilation.
7. Minimum ventilation will be accomplished by use of two 36-inch fans located in brood end wall and use of additional 48-inch tunnel fans.
8. Minimum ventilation side wall inlets will be light trapped dark-out type equally spaced on side walls of house to allow running of 3 tunnel fans with tunnel inlet closed. Minimum ventilation inlets may be reduced or omitted for climates where it is very mild (never below 50°F). In such locations it is possible to modify tunnel inlets as minimum air inlets.
9. A false wall will be built on the tunnel fan end of the house to allow ease of mounting of light traps. False wall will be at least 5 ft from end wall. Maximum S.P. drop across fan trap will be no more that 0.10 inches S.P. when in full-tunnel all fans running.
10. Evaporative cooling will be 6-inch recirculating with sufficient pad area for maximum S.P. drop across pad to be 0.05 inches when in full tunnel operation. Design air speed through pad will be 350 fpm.
11. Tunnel inlet trap will be same area and dimensions as cooling pad, using a higher light transmission trap (lower quality), since trap will be shaded by 6-inch evaporative cooling pad. Maximum S.P. drop across inlet trap will be 0.02 inches S.P. when in full tunnel operation.

<u>Design Calculations</u>

1. Tunnel air speed
   400 fpm desired; choose fan that will produce this at 0.15 inches S.P.
   400 ft x 9.5 ft x 40 ft = 152,000 cu ft
   152,000 cfm ÷ 8 fans = 19,000 cfm rating for each fan at 0.15 inches S.P. minimum requirement
2. Evaporative cooling pad determination
   152,000 cfm ÷ 350 fpm face velocity = 434 sq ft needed for 0.05 inches S.P. or less drop across pad
   Suggest 480 sq ft of total pad to be installed because pad area should equal light trap area
   Use 5-ft pad, so 48 ft each side
3. Inlet light trap determination
   If 480 sq ft of inlet light trap is used, the face velocity will be 152,000 cfm ÷ 480 sq ft = 316 fpm
   Suggest an inlet trap with a pressure drop of 0.015 to 0.020 inches. Check manufacturer's pressure curves.
   Often a brown-out trap is used in conjunction with evaporative cooling pads.
4. Size of light trap on false wall and pressure drop on fans
   Put sufficient trap area on false wall so that S.P. drop across trap is less than 0.10 inches.
   False wall will hold only 40 ft x 6 ft area of light trap, or 240 sq ft unless traps are stacked
   152,000 cfm ÷ 240 sq ft = 633 fpm face velocity.
   Suggest stacking traps to obtain 280 sq ft on false wall, which will lower face velocity and S.P.:
   152,000 cfm ÷ 280 sq ft = 542 fpm face velocity, which produces lower S.P. drop on fan

5. Total pressure check

Pads 0.05 in. + inlet traps (or brown-out traps) 0.02 in. + exhaust traps 0.08 in. = 0.15 in. S.P.

When in full tunnel with 8 fans operating, we should be able to have full 6-inch recirculating pad cooling and 400 fpm tunnel wind speed operating adequately at 0.15 inches S.P. With fewer than 8 fans operating, this design will be more than adequate.

6. Number and size of minimum/transitional ventilation vent boxes

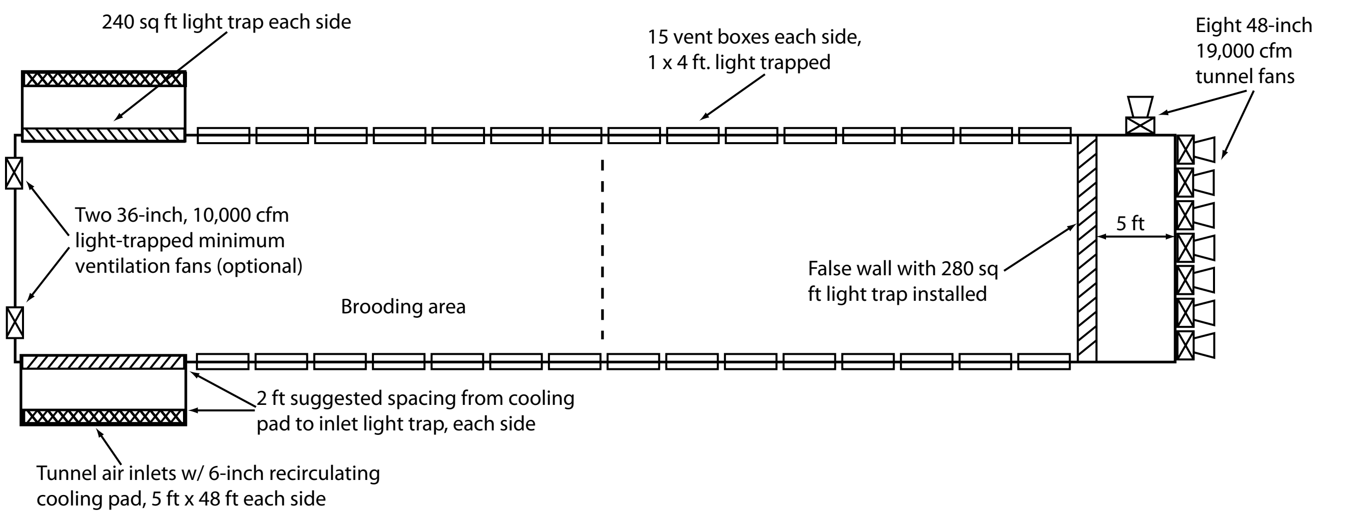
Design based on ability to run three 48-inch fans with tunnel inlets fully closed, at static pressure of 0.10 inches

3 fans x 21,086 cfm = 63,258 cfm

63,258 cfm ÷ 600 fpm face velocity = 105 sq ft minimum

Suggest 120 sq ft, or 30 vents, 1 ft x 4 ft on each side of house, equally spaced

Typical 40 ft by 400 ft Broiler Breeder Rearing House
11,000 birds, 4.6 lbs maximum
(not to scale)



Sample calculation for recirculating evaporative cooling pads for a typical rearing house:

A rearing house has 152,000 cfm of fan capacity installed for tunnel ventilation. It is desired to put 6" recirculating pads on this house. Approximately how much pad should be placed on the house to achieve good cooling efficiency without placing an extreme static pressure load on the fans. All evaporative cooling pads have an air velocity curve versus static pressure and cooling efficiency that should be used to aid in this calculation. For many of the modern 6-inch small flute pads an air velocity through the pad of approximately 350 fpm will yield a cooling efficiency of about 70-75% without placing an undue static pressure load on the fans. So the calculation for the amount of pads to install on this sample house would be as follows.

1. 152,000 cfm installed fan capacity ÷ desired face velocity 350 fpm = 434 sq ft of pad needed
2. Pads are normally 5' tall so, 434 ÷ 5 = 86 linear ft
3. Install 43 ft of 5 ft tall pad or more on both sides of this house for maximum cooling.

Sample calculation for fogger nozzles neededor a typical rearing house:

A rearing house has 152,000 cfm of fan capacity installed for tunnel ventilation. Determine the approximate number of 1 gal/hour fogger nozzles that should be located in this house for 10°F actual cooling. Assume that 1 gal/hour fogger nozzles will actually put out 1.5 gal/hour of water when operated under fogger pump pressures of 160-180psi.

1. Gallons of water needed/hour = (fan capacity in cfm x .125 x design degrees of cooling) ÷ 1,000

   Calculation: 152,000 x .125 x 10 = 190,000 ÷ 1,000 =190 gallons/hour must be evaporated

2. 190 gallons ÷ 1.5 gallons/nozzle = 126 nozzles needed in the house.

4. Care must be taken in nozzle choice and fogger line layout not to wet the house.

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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