Poultry Science and Technology **Guide**

Hot Weather Management of Poultry

Hot weather can have a severe impact on poultry performance. Production efficiency can be affected long before the temperature reaches a level at which survival becomes a concern. Table 1 is a general guide to the reaction of adult poultry to various temperatures. Heat stress begins when the ambient temperature climbs above 80°F and is readily apparent above 85°F. When a bird begins to pant, physiological changes have already started within its body to dissipate excess heat. Even before the bird reaches this point, anything that you do to help birds remain comfortable will help maintain optimum growth rates, hatchability, egg size, egg shell quality, and egg production.

Methods of Heat Loss

During the summer months, when daily temperatures regularly reach the mid- to upper 90s, it becomes critical for the birds to dissipate body heat to the surrounding environment. Poultry do

Table 1. Heat Stress and Ambient Temperature

55° to 75°F	Thermal neutral zone. The temperature range in which the bird does not need to alter its basic metabolic rate or behavior to maintain its body temperature.
65° to 75°F	Ideal temperature range.
75° to 85°F	A slight reduction in feed consumption can be expected, but if nutrient intake is adequate, production efficiency is good. Egg size may be reduced and shell quality may suffer as temperatures reach the top of this range.
85° to 90°F	Feed consumption falls further. Weight gains are lower. Egg size and shell quality deteriorate. Egg production usually suffers. Cooling procedures should be started before this temperature range is reached.
90° to 95°F	Feed consumption continues to drop. There is some danger of heat prostration among layers, especially the heavier birds and those in full production. At these temperatures, cooling procedures must be carried out.
95° to 100°F	Heat prostration is probable. Emergency measures may be needed. Egg production and feed consumption are severely reduced. Water consumption is very high.
Over 100°F	Emergency measures are needed to cool birds. Survival is the concern at these temperatures.

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not sweat and therefore must dissipate heat in other ways to maintain their body temperature at approximately 105°F. Body heat is dissipated to the surrounding environment through radiation, conduction, convection, and evaporation (Table 2). The first three avenues are known as *sensible heat loss*; these methods are effective when the environmental temperature is below or within the thermal neutral zone of the bird (55° to 75°F) (Figure 1). The proportion of heat lost through radiation, conduction, and convection depends upon the temperature difference between the bird and its environment. The bird loses heat from surfaces such as wattles, shanks, and unfeathered areas under wings. To maintain body temperature by sensible heat loss, the bird does not need to drastically alter its normal behavioral patterns, feed intake, or metabolism. The purpose of poultry house ventilation is to maintain a high enough air velocity or a low enough temperature in the house that the birds can maintain body temperature by sensible heat loss.

Once the environmental temperature reaches approximately 77°F, the method of heat loss begins shifting from sensible to *evaporative heat loss*, as shown in Figure 1. Dissipation of body heat by the evaporative process requires the bird to expend energy by panting (hyperventilation), which begins to occur at about 80°F.

Table 2. Methods of Sensible and Latent Body Heat Loss

Heat Loss Method *Definition*	Direction of Heat Flow
Sensible Heat Loss Methods	
Radiation *Flow of thermal energy without the aid of a material medium between two surfaces.*	All surfaces radiate heat and receive radiation back; **the *net* radiation heat flow is from higher to lower temperature surfaces.**
Conduction *Thermal energy flow through a medium or between objects in physical contact.*	Direction of energy transfer depends on a temperature gradient; **heat moves from areas of higher to lower temperature.**
Convection *Heat flow through a fluid medium such as air; thermal energy moves by conduction between a solid surface and the layer of air next to the surface, and the thermal energy is carried away by the flow of air over the surface.*	Energy transfer to the air depends on temperature and movement of air across the skin surface; **heat is transferred to air moving across the *skin surface* if the air is at a lower temperature than the skin.**
Latent Heat Loss Method	
Evaporation *The transfer of heat when a liquid is converted to a gas; when water is converted from a liquid to a vapor, heat is utilized.*	Energy transfer is influenced by the relative humidity, temperature, and air movement; **heat is transferred from the animal's body to water, turning it to water vapor.**

Physiological Effects of Panting

Panting removes heat by the evaporation of water from the moist lining of the respiratory tract. However, panting itself generates body heat, and it causes poultry to eliminate water from the body. It can induce respiratory alkalosis, which occurs because the bird "blows off" excessive carbon dioxide (CO_2) when it pants. As a result, body fluids become more alkaline, causing the kidneys to excrete excessive amounts of several electrolytes.

As the shift in body fluid pH occurs, feed intake is increasingly depressed, adversely affecting growth, production, and overall performance of the bird. During the hot summer months, evaporative heat loss typically becomes the primary method by which birds regulate their body temperature unless proper ventilation is provided and other steps are taken to reduce heat stress.

Feed and Feeder Management

Any management technique that increases nutrient intake during heat stress will minimize the drop in production efficiency. Three easy ways to increase nutrient consumption are to increase nutrient density, take advantage of natural increases in feed consumption at certain times of the day, and adjust ventilation fans to provide more cooling during the evening.

A very direct way to ensure optimum nutrient intake despite decreases in feed consumption is to increase the nutrient density of the ration. Recent research indicates that low phosphorus consumption can contribute to increased heat prostration losses.

A second alternative is to feed the birds at the time of day when feed consumption is highest. The light-to-dark cycle results in a U-shaped feed consumption curve. Shortly after lights come on, feed consumption is high. It gradually declines during midday and then increases about 1 hour before lights are turned off. If birds are fed during the cool part of the day, feed consumption will be higher. Birds should not be fed during the afternoon in periods of hot weather since this will increase the amount of body heat that they must dissipate and thus increase the potential for heat prostration. Abrupt changes in feeding times should be avoided.

reduce problems with stale air and contaminants, air temperature, air speed, and relative humidity must be controlled by careful management of the ventilation system.

Natural Ventilation

Curtain-sided houses rely extensively on natural air movement. These houses work best when they are located away from obstructions such as other buildings or trees that can block natural air currents. To avoid total reliance on natural air movement, most producers have added circulation fans in curtain houses to increase air movement and promote the loss of body heat from the birds. These fans should be spaced and positioned to maintain air movement between fans and to direct their flow in a way that will increase the turbulent air movement around the birds. Spacing of the fans depends somewhat on their size, but they are generally spaced about 25 to 30 feet apart in curtain layer houses and 40 to 50 feet apart in broiler houses.

Circulation fans should be controlled by thermostats set at about 85°F (or lower in hot weather). To save energy, the fans should shut off when the temperature drops below 85°F except during periods of extended hot weather. At those times, it is advantageous to leave the circulation fans running through the cool evening hours by turning the thermostats down to 75°F or even lower. This practice will lower the inside temperature faster, providing the birds with a cooler environment in which to dissipate stored body heat.

Foggers reduce air temperature in the house on hot days (90° to 95°F) when humidity is low, especially during midday when humidity levels are lowest and temperature is highest. The foggers inject fine water particles into the warm inside air. As the water vaporizes, heat is absorbed from the air, lowering its effective temperature. When foggers are used, they should be operated intermittently or designed to avoid excessive water flow into the environment. If too much water flows through the foggers, humidity levels may increase to the point where birds can no longer cool themselves by evaporation. In addition, litter made wet by excessive fogging can lead to performance and health problems. The appropriate water flow rate and timer settings depend on the method of ventilation, ventilation rate, bird size, and outdoor conditions. Fogging systems in naturally ventilated houses are typically designed for a water flow rate of 50 to 100 gallons per hour.

Forced Ventilation

In forced ventilation systems, all air movement is produced by fans in the building walls. Houses that use this type of ventilation are also referred to as controlled environment systems. Power ventilation houses can provide good, uniform airflow patterns under hot summer conditions if correct static pressure is maintained and airflow obstructions are avoided. It is very important to determine how much air should be moved through the building. This can be accomplished in two ways. Approximate values for the minimum volume of air required per pound of poultry body weight are given in Table 3. These values can be used to determine the total fan capacity required for the house. Keep in mind, however, that the rates shown are minimum estimates, and it is best to plan for the worst possible case. For example, the efficiency of fans is greatly reduced if they are allowed to become excessively dirty, reducing the airflow through the building.

Table 3. Recommended Minimum Ventilation Rates Based on Body Weight

Body Weight (pounds)	Airflow Per Pound of Body Weight (cubic feet per minute)
1 to 6	1.0
6 to 15	0.8
15 to 30	0.7

A second method for determining airflow rate is to plan for a summer ventilation rate of one complete air exchange per minute. The necessary airflow volume per minute is equal to the interior volume of the house, which can be calculated from building measurements.

Negative pressure systems use exhaust fans to provide air movement. Stale air is expelled from the house by fans at a slightly higher rate than air is allowed to enter through the vents. This creates a partial vacuum, causing the air to enter the house at a high velocity. The increased velocity creates more turbulent air movement. Negative pressure systems are designed to operate best with a static pressure drop of 0.03 to 0.08 inch of water. This pressure difference induces the air to travel from inlets along the ceiling until it meets a stream from inlets on the opposite side of the house. As the two streams meet in the center of the house, the air drops, creating turbulence. The air then travels toward the exhaust. If the pressure difference is too low, the velocity of the air is reduced as it enters the building. In that case, the resulting air drops to floor level and travels directly toward the exhaust fan. Conversely, if the static pressure is greater than 0.08 inch of water, the velocity of the inlet air is increased, but the volume of air is restricted and fan efficiency is reduced because of back pressure on the fan blades. This condition can result in pockets of stale air where there is little or no air movement, which is detrimental under summer conditions. Dead air zones must be avoided by proper inlet placement and system management. The location and orientation of the inlets is the single most important factor influencing the airflow pattern inside the building.

Positive pressure systems use fans to blow fresh air into the building, creating a slightly higher pressure inside the house. Stale air is allowed to escape through strategically placed exhaust vents. Air movement is controlled by automatic environmental control mechanisms.

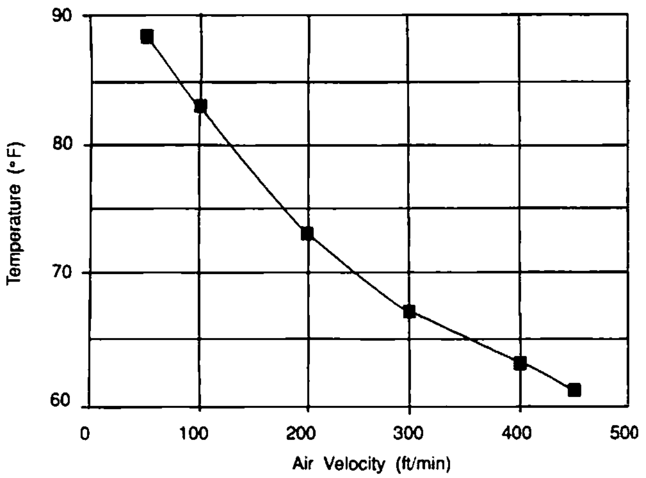

Figure 2. Effective temperature. Source: Timmons, 1989.

Tunnel Ventilation

A new arrangement for ventilating poultry houses in the summer is tunnel ventilation. Simply put, this method involves moving air along the building axis from inlets to exhaust fans, providing high airflow velocities. This rapid air movement increases convective heat loss, reducing the effective temperature experienced by the birds. Figure 2 shows the effective temperature (wind chill) that the bird feels at a given air temperature and velocity. Most of the benefits of tunnel ventilation occur at an air velocity of 350 feet per minute. This velocity should be considered the minimum for most house designs. Tunnel ventilation systems do not operate on a static pressure difference. In fact, they work best when there is no pressure difference between the inlets and the fans.

Evaporative Cooling with Power Ventilation

Fogging nozzles and evaporative cooling pads are options that can be used in combination with power ventilation systems and especially with tunnel ventilation. Evaporative cooling uses heat from the air to vaporize water, increasing humidity but lowering air temperatures. Evaporative cooling can be effective in North Carolina during the hottest part of most days because that is when humidity is lowest. On rare occasions the humidity remains high the entire day or immediately before or after a storm; evaporative cooling is ineffective under such conditions and should not be used.

Evaporative cooling pads operate on the same cooling principle as foggers, except that the air is cooled when it passes through the wet pads as it enters the house. This method avoids the problem of wet litter sometimes encountered with foggers, allowing evaporative cooling pads to be used on a continuous basis. Aspen fiber and corrugated cellulose are two materials widely used as cooling pads. Regular maintenance is necessary to ensure long life of the pads. First, the pads must be allowed to dry out once each day. They can be dried by turning off the water supply but allowing the fans to continue running. The best time to dry the pads is in the early morning hours when the outside temperature is relatively low. Drying allows the adhesive that holds the pad together to maintain its integrity and also helps reduce the buildup of algae. To further reduce the growth of algae, an algicide can be used in the water supplied to the cooling pads. Calcium hypochlorite, ethylene dichloride, or ammonium chloride can be administered at a rate of 6 ounces per thousand gallons of water, applied once each week. In addition, the pads should be washed monthly to remove dust and sediment. The entire system should be flushed monthly to remove the mineral salts and dirt that accumulate in the pipes and reservoir.

Evaporative pads constructed of aspen or cellulose ranging in thickness from 2 to 6 inches are being used in the industry in conjunction with power ventilation systems. On a hot, dry day these pads evaporate water at a rate up to 100 gallons per minute per hundred square feet of pad surface area. Using tunnel ventilation, they can evaporate up to 200 gallons per minute per hundred square feet of pad on a hot, dry day.

Fogging systems have also been used successfully in environmentally controlled poultry houses. Fogging systems that provide a reliable fine mist and that have water filters (to keep nozzles from clogging) and also have a positive shutoff to prevent dripping can provide successful cooling without causing wet litter. The water pressure should be at least 100 pounds per square inch (psi) to achieve a fine mist; a pressure of 200 psi is preferred. The volume of water that goes through the fogging system and the number and placement of the nozzles are critical design considerations. A total flow rate of up to 1 gallon per hour per thousand cubic feet per minute (cfm) of ventilation can be used in tunnel-ventilated houses.

The design of the fogging system is critical for tunnel-ventilated houses. Cross lines of nozzles that provide a "curtain" of fog across the house at various intervals are fairly effective. Nozzles or lines of nozzles should be located close together near the air inlets, then spaced farther apart along the house, ending 60 feet from the exhaust fans. Tunnel-ventilated houses can use substantially more fogging capacity (50 to 100 percent more) than naturally ventilated houses because the forced air movement is able to carry the mist.

The value of a summer ventilation system should not be underestimated. If the system is operating properly, it can improve litter quality, reduce dust levels, and improve the flock's rate of gain or production level. The key to operating any ventilation system is understanding how it works. In addition, a good maintenance program of cleaning, adjusting, and monitoring controls for the curtains or inlets will maintain system efficiency. Fans in any ventilation system should be cleaned and lubricated frequently, and fan belts should be adjusted periodically, especially during times of heaviest use. If foggers are used, they should be serviced periodically to ensure that they produce a uniform, fine fog. If questions arise concerning the operation of your ventilation system, consult your flock supervisor.

A third technique is to cool the birds as much as possible during the evening hours. Hens or meat birds tend to build up body heat during extended periods of hot weather. If their body temperature can be reduced during the evening, the birds will be able to consume more feed in the early morning. The house can be cooled in the evening by setting the fan thermostats so that the fans will continue to run until the internal house temperature reaches 75°F (65°F for mature birds).

Building Construction

The building site, orientation, insulation, roof overhang, and equipment design all affect the temperature inside the poultry house.

The broiler and turkey industry has shifted from pole-construction curtain houses having very little insulation to houses with well-insulated walls and ceilings. The latter type is easier to ventilate if certain procedures are followed. Air movement is particularly important in houses that are ventilated by natural air currents. All poultry houses, but particularly curtain-sided houses, should be positioned so that the roof line runs from east to west. This orientation will keep direct summer sunlight from coming through the sidewall and causing heat to build up within the house. Adequate insulation in the ceiling and sidewalls will pay dividends by reducing the amount of the sun's radiant heat energy that reaches the interior. Installing insulation to the end of a 24-inch roof overhang will prevent solar radiation from penetrating the sidewalls. Insulation also reduces heating costs during winter months.

The trend for the layer industry is toward light-tight houses with mechanical ventilation. The new houses are of tighter construction and allow for greater bird density, requiring closer attention to building details. Insulation with an R-value of 18 is recommended for the ceilings of all poultry houses in North Carolina. If the building has an attic, vents must be provided to reduce heat and moisture buildup above the insulation. The inside surface of the ceiling and sidewalls should be covered with a heavy plastic vapor barrier to keep moisture away from the fiber insulation. During cool months, the vapor barrier will prevent condensation from forming inside the insulation. Condensation reduces the resistance to heat transfer and can eventually destroy the insulation.

Techniques for Managing Heat Stress

A grass cover on the grounds surrounding the poultry house will reduce the reflection of sunlight into the house. Vegetation should be kept trimmed to avoid blocking air movement and to help reduce rodent problems. Shade trees should be located where they do not restrict air movement.

Fans should be routinely maintained. Maintenance should include cleaning the fan and keeping pulleys and belts in good condition and properly adjusted. Poultry netting on sidewalls or air inlets often will pick up enough

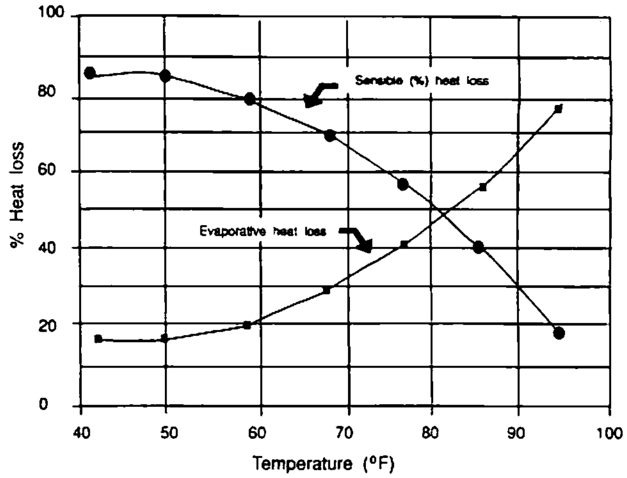

Figure 1. Method of heat loss from birds as temperature changes.

dust to restrict air movement and should be cleaned regularly.

Keeping a reliable, clean, cool source of water available to poultry is essential to help the birds cope with high temperatures. Because the birds excrete electrolytes during periods of heat stress, electrolytes can be added to the drinking water to replace those that are lost and to stimulate water consumption. Avoid placing water pipes near the ceiling where the water will gain extra heat. Lines in which the water has become warm can be drained to allow cooler water to reach the waterers. A second well or access to an emergency source of water should be available in case the primary water source fails.

Another factor that affects heat gain of a house is the condition of the roof. A shiny surface can reflect twice as much solar radiation as a rusty or dark metal roof. Roofs should be kept free of dust and rust. Roof reflectivity can be increased by cleaning and painting the surface with a metallic zinc paint or by installing an aluminum roof. These practices are particularly effective for buildings that are underinsulated.

Equipment and Ventilation Techniques for Reducing Heat Stress

During the summer when the temperature and humidity are high, proper poultry house ventilation is vital to ensure the necessary removal of heat and the continued productivity of the flock. Poultry house ventilation systems have a number of components. These include curtains, fans, fogging nozzles, evaporative cooling pads, timers, static pressure controllers, and thermostats.

Most ventilation systems can provide an adequate indoor environment when properly managed. If the design and management of the ventilation system fails to satisfy the flock's ventilation needs, stale, contaminated air can build up in the poultry house. Stale air and contaminants, including ammonia, moisture, carbon dioxide, carbon monoxide, and dust, can cause stress and lead to depressed performance. Stress may impair the immune system and increase susceptibility to disease. To

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Prepared by
Kenneth E. Anderson, Extension Poultry Specialist
Thomas A. Carter, Specialist-in-Charge, Poultry Science Extension

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