Alabama Cooperative Extension System Auburn University

Poultry Ventilation Pointers

Need for Insulation in Warm-Climate Poultry Housing

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The value of insulation is generally recognized in temperate and cold climates, where its function is often thought of as primarily to help keep birds warm in cold weather, with minimal fuel use. However, insulation has a valuable although different function in summer also: protecting birds from heat stress caused by solar heat gain through the roof. This protection is needed in moderate to cool climate areas, and even more in warm to hot areas. It is extremely important for producers and industry personnel in warmer climates to realize that under-roof insulation is essential in both open-sided and fan-ventilated poultry houses. If birds are kept in uninsulated houses in hot weather, even with the best ventilation system, bird performance is likely to be very poor and mortality rates of 10% to 15% or even higher should be expected.

Lack of roof insulation leads to poor performance, high mortalities

Research in the Southeast U.S. in conventionally built fan-ventilated poultry houses, identical except for having or not having insulation in the roofs, has shown the following mortality rates for market-size broilers when outside average maximum temperature was only 91°F (32.8°C):

	inside max. temp.	mortality rate
House with insulated roof	**92°F/33.3°C**	**0.5%**
House with no roof insulation	**99°F/37.2°C**	**14.3%**

Losses are likely to be even higher in lower-latitude conditions, where the sun will be more directly overhead and air temperatures higher. Here's what you need to know to make the best decisions on warm-climate poultry house insulation –

Effects of Heat and Cold on Birds

Birds need the right temperature range

The normal deep body temperature of chickens is over 106°F (41°C). Birds use energy from feed to maintain this internal temperature and operate their internal organs and muscles. Feed energy above that needed for these "maintenance" functions is used for growth and reproductive functions. The temperature of the birds' surroundings needed for best performance depends on growth stage and function. For broilers and pullets, the optimum temperature ranges from about 92°F (33°C) at birth to about 73°F (23°C) at four weeks, then leveling off. Laying hens perform best in the temperature range from 78°F to 82°F (26°- 28°C).

Under normal conditions, fully-feathered birds actually produce *excess heat*, which their bodies must shed, and which results in warming their surroundings. For this reason, little supplementary heat is usually needed in poultry houses even in cold climates, except in the early brooding period. The birds heat the house. This means that in most cases and most of the time, and even more so in warm to hot climates, the problem is keeping birds from over-heating, not in seeing that they do not get too cold.

Heat stress lowers performance, and eventually kills birds

If for any reason birds gain heat at an excessive rate or cannot get rid of their excess body heat, they will reduce their feed intake to lower their heat production, and will change both their internal metabolism and their behavior to promote faster heat loss. Birds shed excess heat by *respiration* (breathing), getting the cooling effect of moisture evaporating from the surfaces of their airways and lungs, and by transferring it to the air circulating over their bodies. Birds feeling too hot, for example, will pant, drawing more air inside their bodies to absorb heat. They will also lift their wings to expose more body surface area to the air, and will alter their blood circulation to pump more blood to surface air-cooling areas such as the wattles and feet.

All of these responses of course lower the feed efficiency and performance of both broilers and laying hens. If the birds are unable to get rid of the excess heat, eventually they will die.

What Insulation Does

In cold weather, insulation reduces heat loss through roof and walls

Insulation is any material that resists or slows down the rate of heat transfer from one place to another. The function of insulation under cold-weather conditions is to reduce heat *loss from* the house, whether the heat is produced by the birds or by supplemental heaters. This reduces the amount of supplemental heating fuel that must be burned, and allows the birds to make most efficient use of their feed intake.

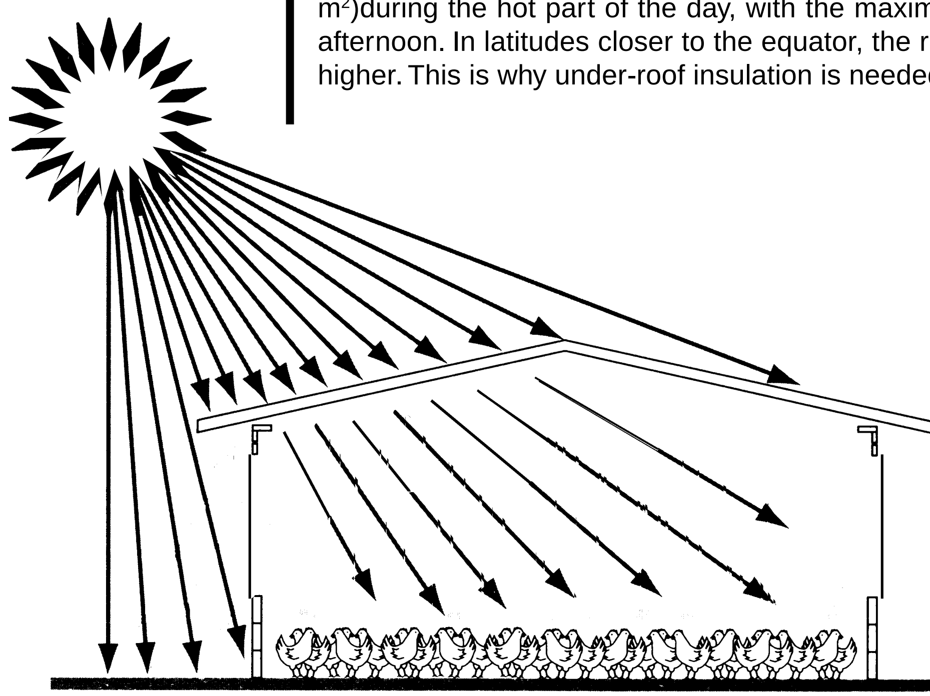
In cold weather, heat is lost by conduction through both the roof and walls. For example, assuming that the walls are made up of typical uninsulated building materials, if the outside temperature is 40 degrees F (22 degrees C) colder than the desired in-house temperature, an uninsulated house will lose about 27 Btu's of heat per hour per square foot of surface area (307 kJ/hr/m^2). Adding moderate insulation in both roof and walls, for example 2 inches (5 cm) of polyurethane foam, cuts this heat loss to about 3.3 Btu's/hr/sq ft (37.5 kJ/hr/m^2).

In hot weather, insulation is needed to reduce heat gain through the roof

The function of insulation in hot weather is to lower the rate of heat gain from the outside into the house and into the birds. Typically, all hot-weather heat gain is through the roof, and the mode is primarily by radiant heat transfer rather than by conduction. Radiant heat is a form of electromagnetic radiation in which heat moves from a warm object to a cooler one through the air but without warming the air. The sun, fires, and heaters with glowing elements (such as brooders) are all radiant heaters. The source of radiant heat does not, however, have to blaze or even glow. Any object warmer than another one in sight will radiate heat to the other one, either by visible or infrared rays. Radiant heat may be beneficial, as with chicks kept warm by radiant brooders, or it may be disastrous – typically for larger birds receiving radiant heat from an uninsulated or poorly insulated roof.

Radiant brooders keep chicks warm, but solar radiant heat hurts birds

Sheet metal roofs on houses may easily be heated to 150°F (66°C) or higher in summertime, even at fairly high latitudes. Research in the Southeast U.S. has shown that a sun-heated and uninsulated weathered galvanized roof will radiate heat into a poultry house at from 30 to 35 Btu's per hour per square foot (340 to 398 kJ/hr/m^2)during the hot part of the day, with the maximum usually occurring in the early afternoon. In latitudes closer to the equator, the rate of solar heat gain will be even higher. This is why under-roof insulation is needed.



Metal roof heated by sun to 150°F (66°C) or more radiates large amounts of heat to birds below.

The higher the sun angle, the more heat delivered. Under-roof insulation is needed to block radiant heat transfer to birds.

Effects of Uninsulated Roof Heat Gain on Birds and Ventilation

The magnitude of the problem of radiant heat gain is shown in the following example:

1. For a 40- by 500-foot house (12 X 152 m),a 35 Btu per hour per square foot (398 kJ/hr/m^2) rate of solar radiant heat gain will total at least 700,000 Btu's per hour (739,000 kJ/hr).
2. Based on the rule of thumb for mature birds of about 5 Btu's per hour per pound (11.6 kJ/hr/kg), this house with, for example, 25,000 five-pound (2.27 kg) broiler birds would have heat gain from excess bird heat of about 625,000 Btu's per hour (660,000 kJ/hr).
3. Modern ventilation systems typically are designed to handle excess bird heat plus a small amount of heat gain from a properly insulated roof or ceiling. For this house, a typical installed system would have a fan capacity of about 200,000 cubic feet per minute (94.4 m^3/s).
4. Since the heat gain from the uninsulated roof is even larger than the excess bird heat, a ventilation system designed and installed *under the assumption that the roof will be properly insulated* would not be able to remove the total heat gain encountered of 700,000 + 625,000 = 1,325,000 Btu's/hr (1,398,000 kJ/hr).

Ventilation system cannot handle large heat gain through an uninsulated roof

The Particular Danger of Radiant Heat to Birds

Radiant heat coming from an uninsulated roof is difficult to combat and is especially dangerous for birds because it transfers heat not to the inside air but directly to the objects below the roof – the birds. The air temperature in such a house will rise by the air absorbing heat from the already radiantly heated birds. Ventilation removes heated air, and ventilating air moving over the birds certainly helps them get rid of heat. But in the radiant heat gain situation the ventilation effects operate only *after the birds have already absorbed this heat*. Further, poultry personnel who do not spend long periods of time in the house and whose clothing (often white) shields them from feeling the radiant heat, may become aware of the effects on the birds without realizing the source of the problem, and *blame the ventilation system instead of the true culprit, the uninsulated roof*.

Danger: radiant heat affects birds *before* ventilation comes into play

The particular danger of radiant heat was shown in research conducted in the U.S. mentioned above. In two environmentally controlled chambers with and without simulated roof radiation, with air temperature in both chambers controlled at 105°F (41°C) and the same relative humidity, the bird death rate was 40% in the chamber with simulated roof radiation, almost twice the mortality rate (22%) in the chamber without radiant heat. This test indicates that the effects of direct radiant heat are much more severe than the same heat load without radiation.

Effects of radiant heat are twice as severe as same heat load with no radiation

Advantages of Under-Roof Insulation

Placing insulation under the roof blocks the downward heat radiation and converts the heat transfer mode from mostly radiation to mostly conduction (at a slow rate) through the insulating material. Because of the heat transfer mode conversion, the exact effects are difficult to calculate, although easily seen in field experience. Installing 2 inches (5 cm) of extruded polystyrene insulation in the roof of the above example house can be expected to cut the maximum rate of heat gain of 35 Btu's per hour per square foot (397 kJ/hr/m^2)to near 3.5 Btu's per hour per square foot (39.7 kJ/hr/m^2). That would reduce the heat load from the roof from 700,000 Btu's per hour (739,000 kJ/hr) to only about 70,000 Btu's per hour (73,900 kJ/hr). The ventilation system then can be properly sized for only 695,000 Btu's per hour (733,000 kJ/hr), including excess bird heat of 625,000 Btu's per hour (660,000 kJ/hr).

Under-roof insulation blocks downward radiation of heat to birds

Thus it is clear that under-roof insulation, not added ventilation or evaporative cooling capacity, is the solution to the problem. Insulation is fairly costly in some parts of the world, but preventing exposure of birds to radiant heat in the first place is certain to yield a much better cost-benefit ratio than oversizing ventilation or cooling systems in an attempt to lessen the effects of the extra radiant heat load.

Selecting Insulation Materials

At least R-8 insulation is needed under roof

The chart below shows the average resistance to heat flow of typical insulation materials in terms of R-value.* Different terms are used in different parts of the world, but the principle of resistance to heat flow per unit of thickness is the same. For warm to hot climates, under-roof insulation of at least the equivalent of R-8 is recommended. For example, this can be provided by 1.5 inches (4 cm) of easily-installed polyurethane board, as shown in the chart. Insulation beyond about R-12 value is not likely to provide significant further benefits in comparison to cost. For any given insulation product, the actual insulating value is likely to vary, and selection should be made on the basis of a stated and if possible certified value for the particular product.

Many insulation products are available – key is to get adequate R-value

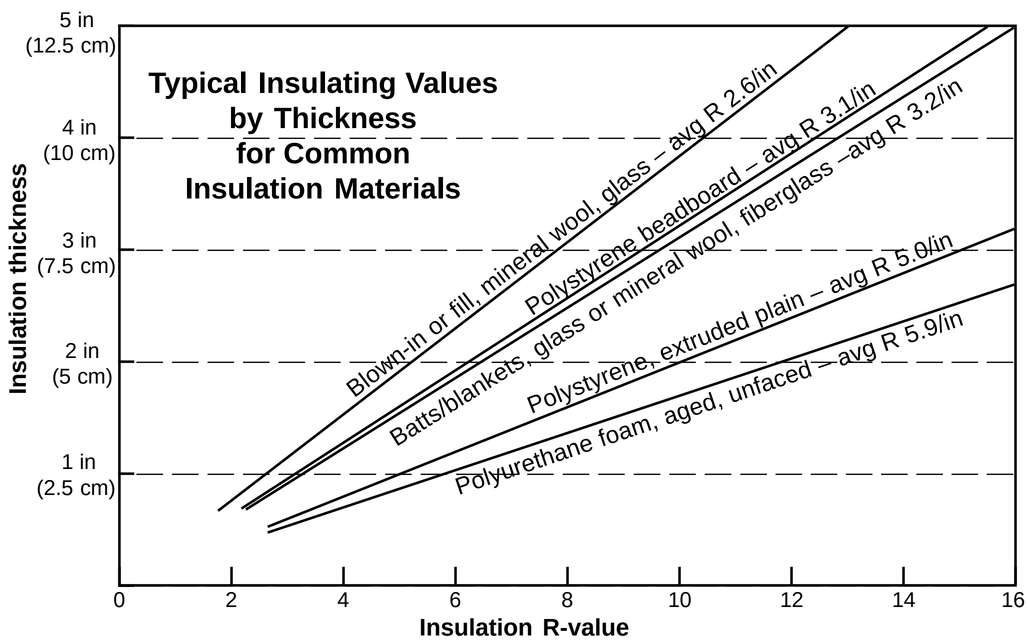
A convenient way to add insulation to existing buildings is spray-on polyurethane foam (care must be taken to achieve adequate thickness). Dropped ceilings are easily insulated with blanket, batt, or blown-in mineral wool or fiber glass. Ceilings create an attic space that can be naturally ventilated, removing heat and moisture and resulting in longer house life. A dropped ceiling also improves the efficiency of tunnel ventilation by reducing the house cross-sectional area.

Foil-type reflective insulation alone will not give adequate protection

Foil-type reflective insulation is widely advertised as an ideal solution to the problem of radiant heat gain. However, side-by-side tests in poultry houses in the United States have shown these materials to be much less effective than conventional insulation when used alone. Factors contributing to their lack of acceptance in the U.S. are that they lose a significant amount of their initial insulating value within a few years because of dust accumulation; are usually difficult and costly to install; and often lack durability. It should be said that installing foil-type reflective material is preferable to leaving the underside of a metal roof exposed. However, reflective materials alone provide much less protection than conventional insulating materials, even when these appear to be very expensive. Reflective insulation alone is not recommended unless no other kind of insulation is available.

Reflective roof coatings or white paints can provide some benefit but are not nearly as effective as under-roof insulation. So-called reflective roofs will still absorb solar heat and re-radiate this heat downward into the house. As with foil-type insulation, using reflective roof coatings is better than doing nothing, but will not provide adequate protection from solar heat gain.

Select insulation by R-value cost, not just price or thickness



* For a given material, R is the reciprocal of the material's overall heat-transmission coefficient, which is measured in Btu's per hour per square foot of surface area per degree Fahrenheit temperature difference from one side of the material to the other.