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Feature article

Where Insulation Counts Most for Fuel Savings

Normally at this time of year you expect a poultry housing newsletter to be emphasizing topics such as getting houses ready for summer, checking fans, belts, shutters and evaporative cooling systems to make certain we are ready to handle the hot weather that is just around the corner. For sure, these are things we should be doing, because hot weather can take a serious toll on performance of today's broiler.

However, based on the severity of this past winter, the price of propane and other heating fuels, the number of phone calls we are getting, and the number of retrofits and remodeling jobs that are being planned by growers this summer, this newsletter is going to look at the value of insulation in reducing heat losses in broiler houses in cold weather. If we are going to get our houses ready to keep fuel bills to a minimum next winter, now is the time to decide if additional insulation is needed, and if so, where it will give the best payoff. And now is the time to decide if any further renovation of houses is called for. We cannot wait until cold weather hits again to check out our houses and schedule any insulation upgrading that will be needed.

Now is the time to act if we are to keep fuel bills down next winter

Although we will be focusing on the value of insulation in conserving heat in a building in cold weather, insulation has very real benefits that go beyond reducing the amount of heating fuel you have to burn in winter. Insulation also reduces heat gain during warm summer months, so it is a mistake to think of insulation as only a wintertime tool. It is very important to us in the broiler business to help keep the heat of the sun out of the house during summertime operation. Another benefit is that insulation provides warmer surface temperatures on the inside of the building and therefore helps reduce the amount of condensation or sweating that we get in a house. As we build tighter and tighter broiler houses we have been noticing more and more sweating. By reducing this condensation, insulation helps prolong the life of the structure.

Insulation not only saves fuel in winter, it has year-round benefits

There are about four different types of insulation materials that are used in most broiler houses. Some are easier to install than others, or more suited to particular uses, or more durable, and we will note these characteristics. The most important thing to know about an insulating material is its R-value. This is a measure of how good the material is in slowing down the movement of heat through its thickness. The higher the R-value, the slower the heat loss (or gain), and the more valuable the material is as insulation. Even materials we don't think of as insulation will have some insulating value. For example, 2-inch lumber has an R-value of about 2. The least insulating part of a broiler house will be single-thickness curtain material, at around 1.5. The R-value of a given insulation material will vary within a certain range, depending on manufacturing processes, aging, etc. Following are typical average values of the most common insulating materials:

Polystyrene beadboard – avg R-3 per inch
Blown-in or fill, cellulose, glass – avg R-3.2 per inch
Batts/blankets, fiberglass –avg R-3.2 per inch
Polystyrene, extruded plain – avg R-5.0 per inch
Polyurethane foam, aged, unfaced – avg R-6 per inch

R-values tell you how effective a material is at slowing down the rate of heat loss (or heat gain) through its thickness

For dropped-ceiling houses the most common insulation in the ceiling is a blown-in cellulose type material that has R-value of about 3.2 per inch. Other ceiling insulation can be batt or blanket insulation, which is installed in different thicknesses. A 3 $^1/_2$- to 4-inch batt of fiberglass has an R-value of approximately 11 and a 6-inch batt of fiberglass has an R-value of approximately 19. Most new broiler house specs in the broiler belt suggest a minimum ceiling insulation of R-19.

Many different types of wall construction are used in broiler houses across the broiler belt. Some of the older houses use a board type insulation underneath the tin, but the modern trend is to build a wall that is approximately 3 $^{1}/_{2}$ inches thick, which is insulated with the batt type insulation mentioned above. There are still areas where broiler houses are being built with solid lumber walls such as 2 x 6's. The walls will be covered with tarpaper or other materials to stop air leakage, but the insulation value of the wood is all that we have for keeping the heat in the building.

Most new broiler belt houses are being built with R-19 ceiling insulation; many are totally enclosed and insulated

Endwalls are often insulated with fiberglass batts, and in some cases with a board type insulation. Common board type insulation can be either polyurethane or polystyrene. Polystyrene R-values range from around 3 to 5 per inch of thickness. Polyurethane has an average R-value of 6 per inch of thickness.

In retrofitting or redoing an older house, board type insulation can be extremely helpful in keeping up the R-value as we try to modernize the house. Board type insulation is often the only type of insulation we have available to us for insulating high ceiling or open-truss houses. It is particularly valuable in insulating end doors. One of the disadvantages of using board type insulation in broiler houses is that it is often worked on by rats, darkling beetles, birds and other varmints, and over a period of time may not hold up as well as batt or blown-in insulation.

Board type insulation is helpful in retrofit work; the main thing is to achieve high enough R-value

Now let's look at several examples of broiler houses to see how much heat losses are with different types of walls, curtains, and ceilings. In doing this, we can use R-values to fairly accurately estimate both the heat losses and the amount of fuel it would take to maintain a desired temperature in the house, with a given outside temperature. All we need to know to figure the heat loss through any surface is to apply the simple formula:

$$\text{Heat loss in Btu's per hour} = \frac{\text{Area (sq ft)}}{\text{R value}} \times \text{Outside - Inside temperature difference}$$

For example, if outside temperature is 10°F and we need 80°F inside (70°F difference), a five-foot curtain (R-1.5) running the length of a 400-foot house will bring about a heat loss of 93,333 Btu/hr:

$$\frac{5 \times 400}{\text{R-1.5}} \times 70 = 93{,}333 \text{ Btu/hour}$$

The low R-value of curtains means they leak heat rapidly; if curtain area is large, they can cause large heat losses

Since a gallon of LP gas contains about 90,000 Btu's, we would have to burn a little over one gallon of LP per hour to make up the heat loss just through this much curtain.

The examples outlined on the facing page apply this formula to five different broiler house insulation scenarios, starting with a typical curtain-sided house with minimum insulation. This is a 40 ft x 500 ft broiler house with 8 foot sidewalls made of 2x6 lumber, a 5-foot curtain opening and a dropped ceiling with 3 $^{1}/_{2}$ inches of fiberglass insulation. We assume a winter day when we want to keep the temperature at 80 degrees F inside the broiler house when it is 10 degrees outside.

The scenarios include propane per-hour figures needed to make up heat losses. Note that the calculations in these examples are intended for comparative purposes. The heat loss and propane calculations assume no losses due to leakage of outside cold air directly into the building through cracks. This could be very significant for a loose house. The numbers also do not take into account the value of any heat lost due to minimum ventilation. Additionally, some amount of bird heat will be present in the building which would serve to reduce the costs of heating fuel, although this amount of heat would be small for young birds. Thus the numbers given here for heat losses and fuel burned are generalized estimates. Nevertheless, these calculations do portray the ability of a poultry house to hold heat based on the insulative value of its building materials, and they do represent the kind of differences that are actually seen in the industry. The baseline house, which is typical of many older broiler houses in the U.S, requires almost 6 gallons of LP per hour to maintain target temperature under these conditions, almost four times as much as the fully-insulated house in scenario #5.

Knowing R-value and area allows simple calculation of heat loss in any situation

You can also see through these scenarios where additional insulation or insulating value is likely to save the most money. Generally, these are parts of a house that take up a large area and have low R-value. In the baseline house, almost half of the total heat loss is through the curtains, with over 233,000 Btu/hr being lost. Our second largest heat loss area is the ceiling at 133,000 Btu/hr, which is about 27% of the total heat loss.

WHERE INSULATION SAVES MOST FUEL

Scenario #1 – 40 x 500 dropped-ceiling, curtain house with minimum insulation

Temperature difference: 70°F (80°F desired inside, 10°F outside)

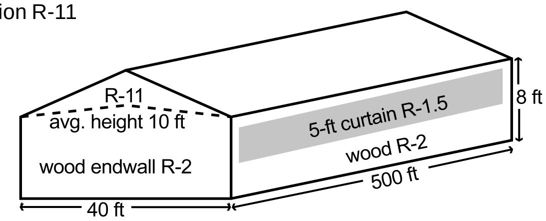
8 ft sidewall (5-ft curtain R-1.5, 3-ft wood R-2), Endwall 2 x 6 R-2, Ceiling insulation R-11

Ceiling loss = $\frac{42 \times 500}{11} \times 70$ = 133,636 Btu/hr (27%)

Sidewall loss = $\frac{3 \times 500 \times 2}{2} \times 70$ = 105,000 Btu/hr (21%)

Endwall loss = $\frac{10 \times 40 \times 2}{2} \times 70$ = 28,000 Btu/hr (5%)

Curtain loss = $\frac{5 \times 500 \times 2}{1.5} \times 70$ = 233,333 Btu/hr (47%)



Total losses =499,969 Btu/hr – requires 5.6 gal LP/hr to maintain 80°F

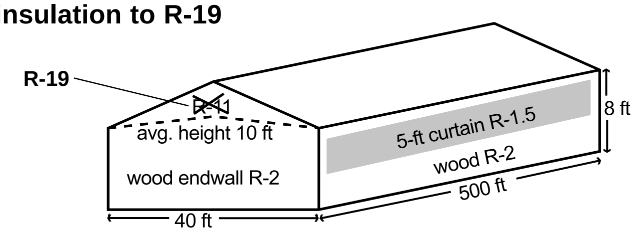
Scenario #2 – Same as #1, except upgrade ceiling insulation to R-19

Ceiling loss = $\frac{42 \times 500}{19} \times 70$ = 77,368 Btu/hr (17%)

Sidewall loss = $\frac{3 \times 500 \times 2}{2} \times 70$ = 105,000 Btu/hr (24%)

Endwall loss = $\frac{10 \times 40 \times 2}{2} \times 70$ = 28,000 Btu/hr (6%)

Curtain loss = $\frac{5 \times 500 \times 2}{1.5} \times 70$ = 233,333 Btu/hr (53%)



Total losses = 443,701 Btu/hr – requires 4.9 gal LP/hr to maintain 80°F – saves 0.7 gal/hr

Scenario #3 – Same as #2 plus wall up north sidewall with wood (no curtain on that side)

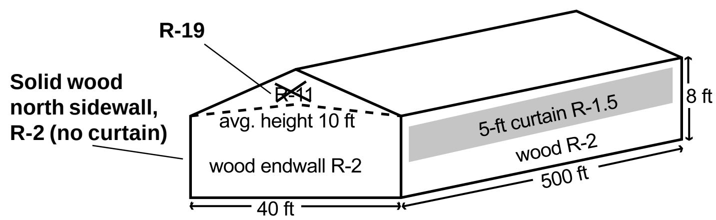
Ceiling loss = $\frac{42 \times 500}{19} \times 70$ = 77,368 Btu/hr (19%)

Sidewall (N) = $\frac{8 \times 500}{2} \times 70$ = 140,000 Btu/hr (33%)

Sidewall (S) = $\frac{3 \times 500}{2} \times 70$ = 52,500 Btu/hr (13%)

South curtain = $\frac{5 \times 500}{1.5} \times 70$ = 116,666 Btu/hr (28%)

Endwall loss = $\frac{10 \times 40 \times 2}{2} \times 70$ = 28,000 Btu/hr (7%)



Total losses = 414,534 Btu/hr – requires 4.6 gal LP/hr to maintain 80°F – saves 1.0 gal/hr

Scenario #4 – Same as #3 plus insulate north sidewall to R-11, insulate both endwalls to R-11, reduce curtain opening to 3 ft, insulate rest of south sidewall to R-11

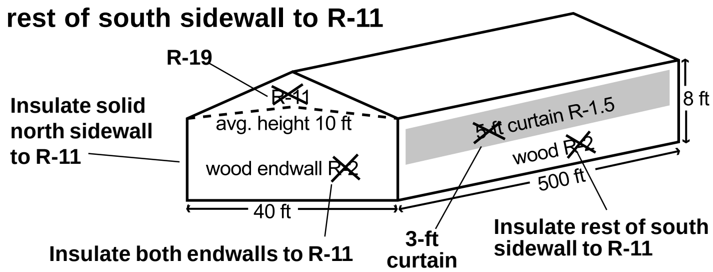
Ceiling loss = $\frac{42 \times 500}{19} \times 70$ = 77,368 Btu/hr (40%)

Sidewall (N) = $\frac{8 \times 500}{11} \times 70$ = 25,454 Btu/hr (13%)

Sidewall (S) = $\frac{5 \times 500}{11} \times 70$ = 15,909 Btu/hr (8%)

South curtain = $\frac{3 \times 500}{1.5} \times 70$ = 70,000 Btu/hr (36%)

Endwall loss = $\frac{10 \times 40 \times 2}{11} \times 70$ = 5,090 Btu/hr (3%)



Total losses = 193,821 Btu/hr – requires 2.2 gal LP/hr to maintain 80°F – saves 3.4 gal/hr

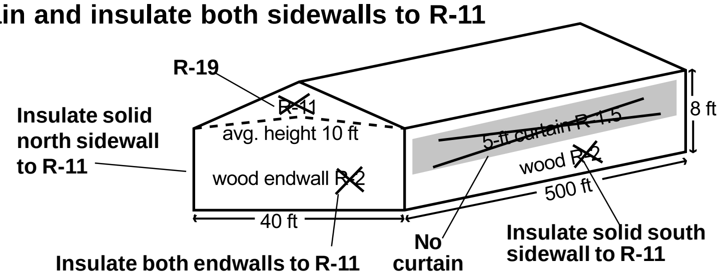
Scenario #5 – Same as #4 plus eliminate curtain and insulate both sidewalls to R-11

Ceiling loss = $\frac{42 \times 500}{19} \times 70$ = 77,368 Btu/hr (58%)

Sidewall (N) = $\frac{8 \times 500}{11} \times 70$ = 25,454 Btu/hr (19%)

Sidewall (S) = $\frac{8 \times 500}{11} \times 70$ = 25,454 Btu/hr (19%)

Endwall loss = $\frac{10 \times 40 \times 2}{11} \times 70$ = 5,090 Btu/hr (4%)



Total losses = 133,366 Btu/hr – requires 1.5 gal LP/hr to maintain 80°F – saves 4.1 gal/hr

We should stress here that heat lost through the ceiling of a poultry house in winter will become heat gain in summer. This of course is potentially true also of walls, curtains, etc. But having no or too little insulation in the ceiling or under the roof is especially dangerous in summer because this is where most of the summer sun will strike. Temperatures under the roof may build to over 140°F, and without insulation this heat will be radiated directly to the birds. Adequate ceiling insulation is absolutely essential year-round.

The Bottom Line

The examples shown in this newsletter show estimated heat losses from poultry buildings under fairly severe winter conditions. Average per-hour fuel consumption over an entire winter will be much less. However, heating fuel is still a large part of a grower's operating costs. At 80 cents per gallon, LP gas accounts for between 35 and 45 percent of the total "out of pocket" expense incurred by growers, depending primarily on bird size and number of flocks grown per year. Exact costs depend also on the severity of the winter, along with the varying cost of fuel, but at 80 cents per gallon will average about $4,000 a year for a Class A house similar to the specifications shown in Scenario #2.

Surfaces with low R-value and large area should get high priority for insulation upgrading

Although heating fuel consumption is quite variable across the U.S. broiler belt, field studies show that the average 40 ft x 500 ft Class A house (similar to Scenario #2) may use 5,000 gallons of LP over the course of a year. If we compare the fuel consumption rate of the Scenario #5 house with the Scenario #2 house, we see that if insulation is the only factor affecting fuel use, the fully-insulated (#5) house will require less than one-third the fuel needed to maintain a given inside temperature. This would be true in any weather, severe or mild.

At 80 cents/gallon, LP gas may be 35-45% of operating costs – insulation offers big potential savings

All other things being equal, then, insulating the #2 house to values close to Scenario #5 would translate into saving close to 3,500 gallons of LP per year. We know that all things are not likely to be equal in the real world, so actual savings this large cannot be counted on, even though this is the potential that is indicated if insulation is the only factor involved.

On the other hand, it is very realistic to expect that with good heating and ventilation management a grower making this kind of insulation upgrade could realize a large part of that savings potential. If actual fuel consumption was reduced by only 1,500 gallons per house per year, the grower would save more than $1,200 per house at 80 cents per gallon. Savings could approach $2,000 a year with LP priced at $1.30 per gallon.

Thus, fuel savings could within 4-5 years very easily offset the added expenses associated even with such a major insulation upgrade. There are other ways a grower can save money on fuel, such as tightening up houses, improving heating and ventilation management, and doing a better job of locking in acceptable fuel prices ahead of severe-weather price increases. But it is clear that for any grower operating houses that are not totally enclosed and fully insulated, there is very great potential for savings through upgraded insulation.

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