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Poultry Housing Tips

Radiant Tube Heater Floor Heating Patterns

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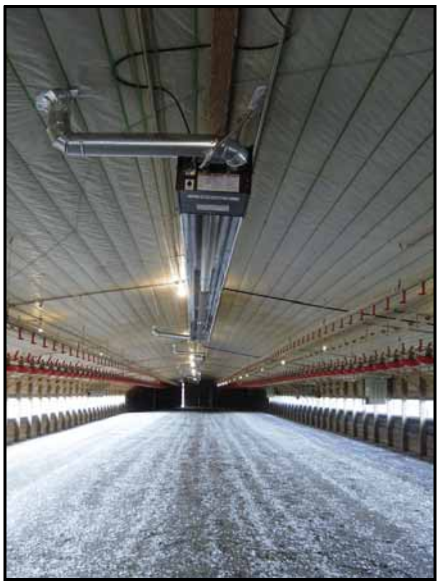

Figure 1. Radiant tube heater.

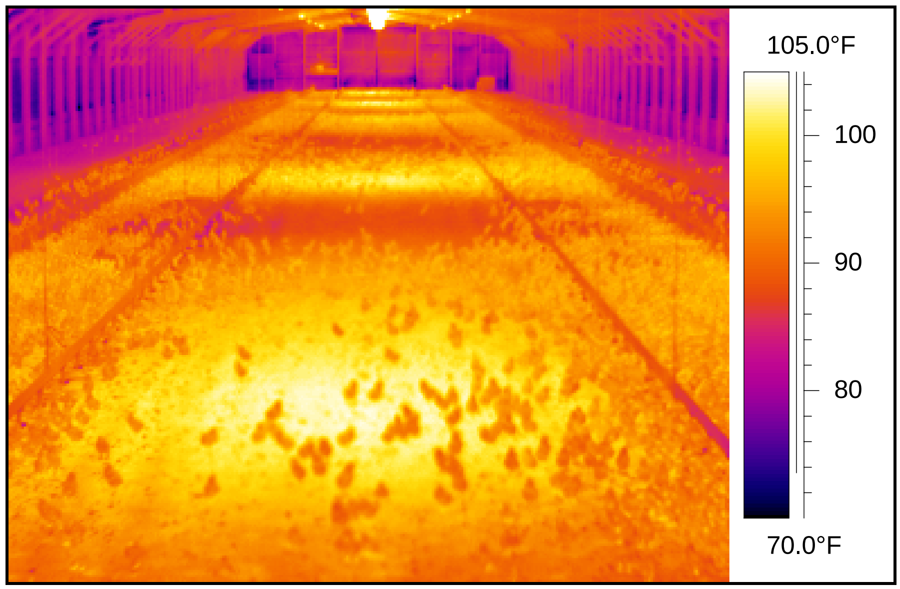

Figure2. Floor heating produced by a radiant tube heater.

Radiant tube heaters are the latest heating system to come on the market for use in poultry houses. They are in many ways the next logical step in the trend towards increasing the size of the radiant heat zone produced by an individual brooder. By increasing the coverage area of an individual brooder not only can the number of brooders be reduced, but overall floor space receiving radiant heat can often be increased at the same time. A radiant tube heater consists of a metal tube approximately four inches in diameter and 30 to 40 feet in length, a reflector to reflect the radiant heat produced by the heated tube down towards the floor and a burner box. A small fan draws fresh air from outside the house and into a burner box. Propane or natural gas is then burned and the resulting flame and hot air are then pushed down the tube. The flame and hot air heat the metal tube to a temperature between 1,000ºF and 400ºF which then radiates heat to the floor. The air then is typically exhausted from the opposite end of the tube into the house, but can be piped outside to rid the house of combustion gases.

What makes a radiant tube heater so different from other types of radiant brooders is the large amount of radiant heat produced by a single heater. The amount of radiant heat produced by a brooder is to a large extent a function of the size of the radiant surface which the gas flame is heating. For instance, the ceramic element of the typical pancake brooder is relatively small (approximately 110 square inches) and as a result has a relatively low radiant heat output. Since the radiant heat output is relatively limited, it needs to be kept close to the floor to focus the small amount of radiant heat produced in a small area (approximately six feet in diameter). In contrast, a radiant brooder has a radiant emitting surface roughly twice the size (approximately 250 square inches) and as a result has a greater radiant heat output (roughly twice). Since it produces a greater amount of radiant heat it can be installed higher above the floor so that a larger area is covered with radiant heat (approximately 16 feet in diameter) and as a result fewer radiant brooders are generally required than pancake brooders (Figures 3 and 4).

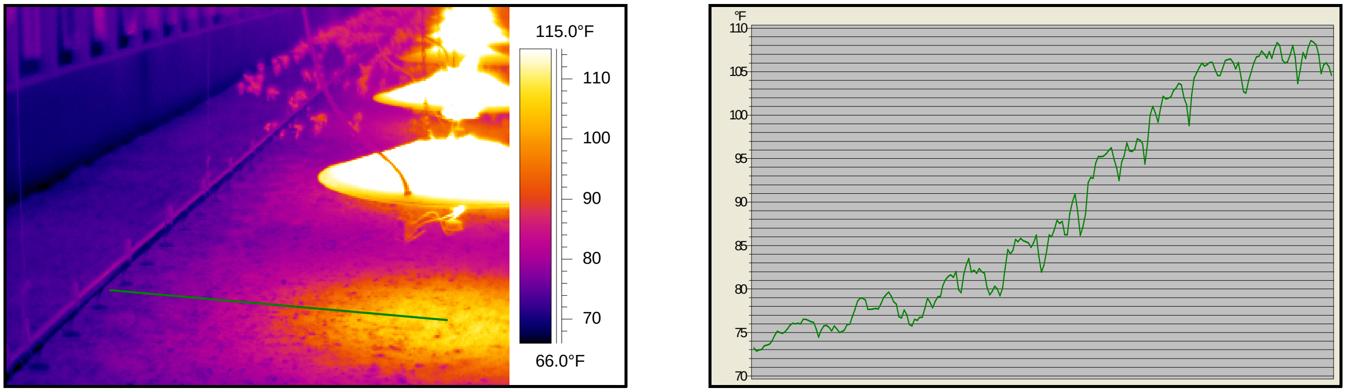

Figure 3. Thermal image and floor temperature profile in house with pancake brooders (line 3' in length)

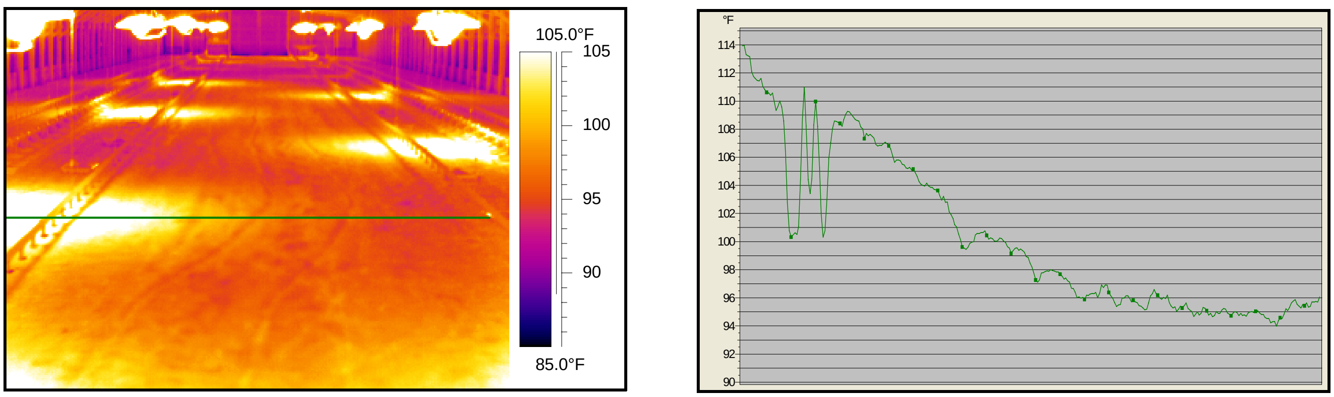

Figure 4. Thermal image and floor temperature profile in a house with radiant brooders (line 20' in length)

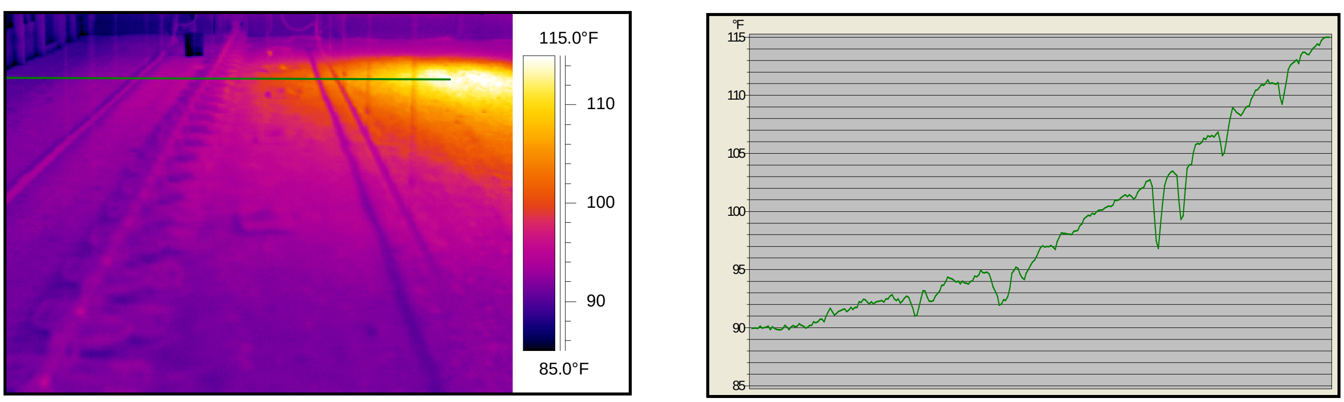

Figure 5. Thermal image and floor temperature profile in a house with radiant tube heaters (line 20' in length)

It is often best to think of brooders as if they were light bulbs. A pancake brooder would be comparable to a 25-watt light bulb, whereas a radiant brooder would be more comparable to a 60-watt light bulb. In order to get a specific light level at floor level a 25-watt light bulb would have to be placed relatively close to the floor. Since the 25-watt bulb would be installed relatively close to the floor a large number would be required to light the entire floor in of a house. A 60-watt light bulb produces more light and as a result can be installed higher above the floor to produce the same amount of light that was achieved with a 25-watt light bulb. With the higher height each light bulb would cover more area and therefore fewer would be required to achieve the proper level of floor lighting.

Now we come to radiant tube heaters. Technically, a 40-foot-long, four-inch-diameter radiant tube has a radiant surface area of approximately 6,000 square inches, 25 times that of an individual radiant brooder. It is important to note that on average a radiant tube operates at a lower surface temperature than either a pancake brooder or a radiant brooder, which means that in general per square inch it would produce less radiant heat and therefore you can't say that since a radiant tube has 25 times the surface area of a radiant brooder it produces 25 times the radiant heat. But, the fact remains that a single radiant tube can produce dramatically more radiant heat than a single radiant or pancake brooder.

Since a radiant tube produces significantly more radiant heat than a radiant brooder it can be placed even higher above the floor to distribute its radiant heat over an even larger area, further reducing the number of heating units required to heat a poultry house (Figure 5). So instead of installing two rows of brooders or radiant brooders, a single row of radiant tubes is typically installed down the center of a poultry house within a foot or two from the ceiling. Again, using the light bulb analogy, a radiant tube heater would be roughly equivalent to a powerful 40-foot-long fluorescent light bulb.

To provide some idea of how the radiant coverage area differs between the three, a single pancake brooder will produce a significant amount of floor heating over an area of approximately 40 square feet, a radiant brooder will produce floor heating over an area of approximately 200 square feet, and a 40-foot radiant tube heater will produce floor heating over an area of approximately 1,200 of square feet.

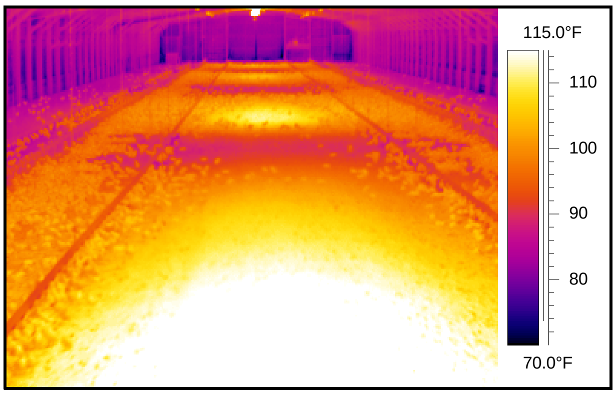

Figure 6. Center house floor temperatures in house with radiant tube heaters.

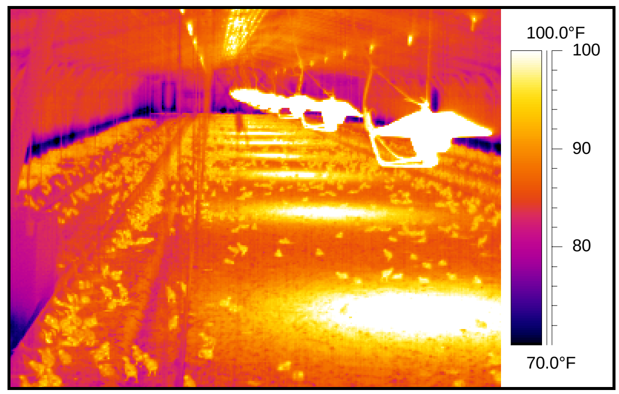

Figure 7. Center house floor temperatures with radiant brooders.

As you might suspect, the floor temperature profile produced by a radiant tube heater is not that different from a single row of radiant brooders installed down the center of a house (Figures 6 and 7). The floor heating is greatest in the center of the house and decreases as you move toward the side wall. Since the tubes are installed at a higher height than radiant brooders they tend to "throw" more radiant heat toward the side wall, resulting in a wider coverage area than a single row of radiant brooders. Furthermore, the high installation height tends to result in more of a gradual decrease in floor temperature as you move toward the side wall than is with the case with radiant brooders or even pancake brooders for that matter (Figures 3,4 and 5).

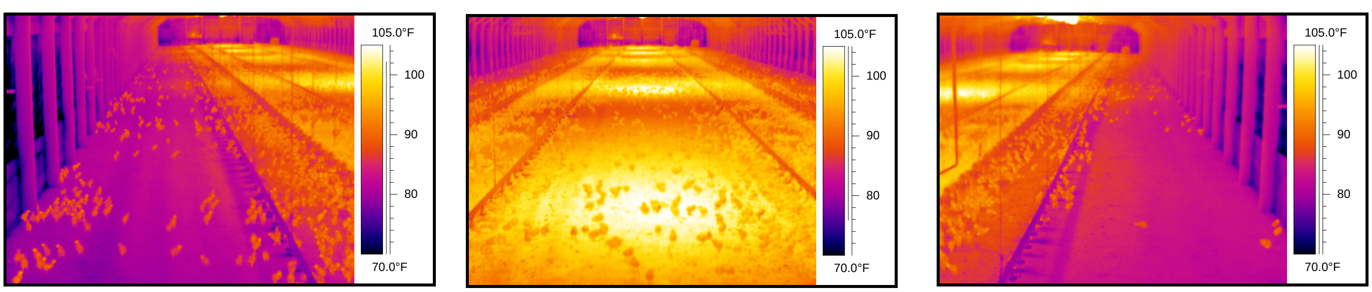

Figure 8. Floor temperature profile in a house with radiant tube heaters.

As with the case with radiant brooders installed in the center of a house, a radiant tube system tends to put most of the radiant heat where it is least needed, the center of the house. Though technically a radiant tube heater will throw radiant heat all the way to the floor near the side wall of a 40-foot-wide house, as would radiant brooders, the amount is dramatically less when compared to what is typically seen in the center of the house. Since radiant floor heating near the side wall is rather limited, floor temperature near the side wall is determined more by house air temperature than by the radiant heat produced by the tube heater (Figure 8).

The amount of floor space heated by a radiant tube is significantly affected by reflector design. Radiant tubes were initially installed in factories and warehouses with high ceilings. In order to better focus the radiant heat to the floor fairly "closed" reflectors were required to focus the radiant heat to the floor and not to the walls and ceiling (Figures 9, 10). Again using the light bulb analogy, without a reflector in a high ceiling the light produced by a light bulb would strike the walls and ceiling and as a result less light would be focused on the floor where it is needed. High ceilings require a fairly closed design to insure that most of the radiant heat produced does not end up directed to the walls of a building.

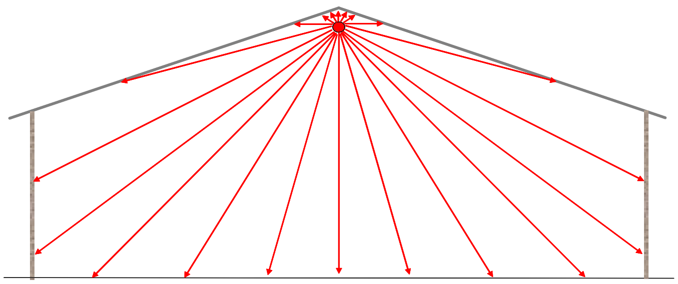
Figure 9. Radiant tube without reflector.

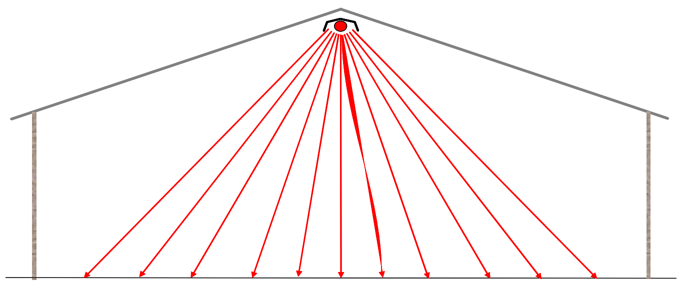
Figure 10. Radiant tube with reflector.

In open ceiling poultry houses the traditional relatively closed reflector design works well to insure that the radiant heat is not wasted on heating the side walls (Figures 11, 14). But, there is a potential weakness when the same radiant tube heater is installed in a lower or dropped ceiling house. Many reflectors are so focused that they tend to direct very little radiant heat to the floor near the side walls, leading to relatively low side wall floor temperatures and excessive floor temperatures in the center of the house (Figure 12). To reduce this problem in lower ceiling houses, radiant tube heater reflectors need to be of a more open design to allow more radiant heat to be directed to the side walls where it is most needed (Figures 13, 15).

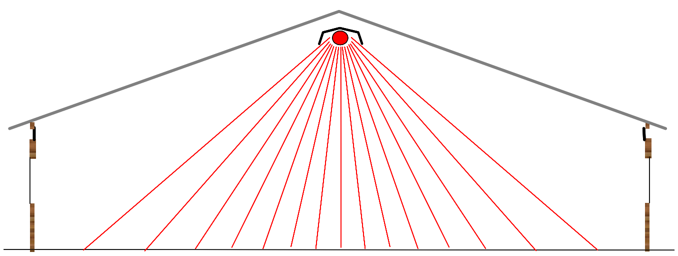
Figure 11. Traditional reflector in open ceiling house.

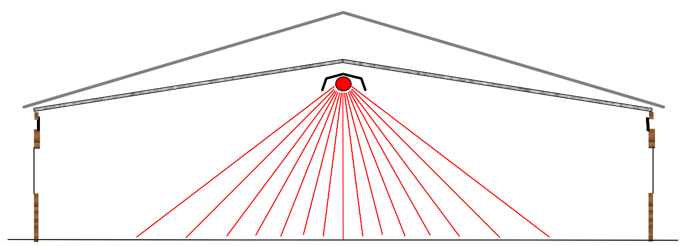
Figure 12. Traditional reflector in dropped ceiling house.

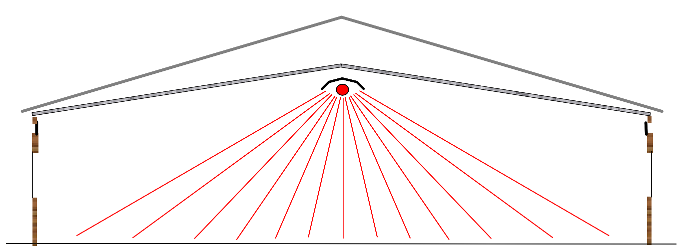
Figure 13. Open reflector in dropped ceiling house

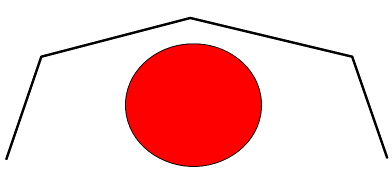
Figure 14. Traditional reflector

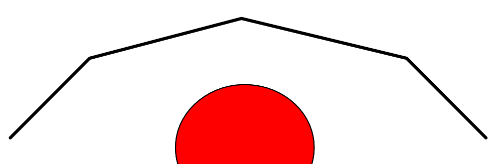
Figure 15. Open reflector

The thermal images in Figures 16 and 17 were taken in a dropped ceiling broiler house with three radiant tubes with the traditional more closed reflector and one with a more open type reflector. The open type reflector increased floor temperatures just past the outside water line by between two and four degrees over those with the more traditional reflector. The higher floor temperatures near the side walls resulted in a significantly larger number of chicks congregating around the open reflector tube heater than the other radiant tube heaters in the house. Floor temperatures directly under the radiant tubes with both types of reflectors were fairly similar.

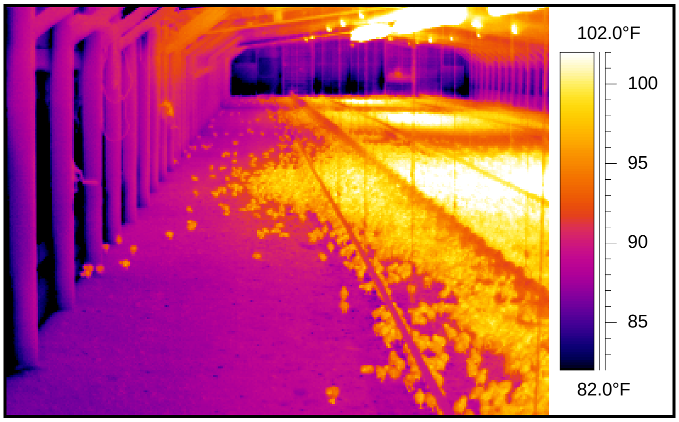

Figure 16. Open reflector design in foreground, more traditional closed design in background.

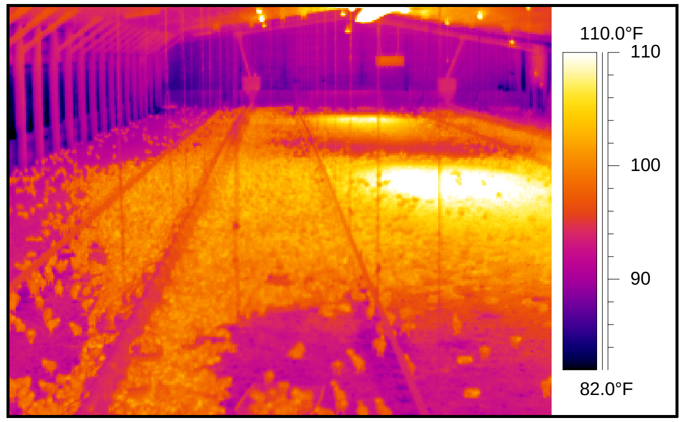

Figure 17. Open reflector design in foreground, traditional more closed reflector in background.

The importance of a radiant tube's ability to direct a significant amount of radiant heat to floor near the side walls depends somewhat on whether a house is totally-enclosed or curtain-sided. In a curtain-sided house, floor temperatures near the side walls tend to be significantly cooler than those found in the center of the house due to heat loss from the low insulating value and leakiness of side wall curtains. The problem of course with a radiant tube is that it puts most of the radiant heat in the center of the house far from the side wall where it is most needed. As a result, it is important that when a radiant tube is used in a curtain-sided house it is designed to direct as much radiant heat to the side wall as possible. In a totally-enclosed house where floor temperatures tend to be more uniform from wall to wall a radiant tube's ability to direct heat to the side wall would be somewhat less crucial but a more open design would likely still prove beneficial.

Another factor that affects radiant heat distribution from a tube heater is reflector cleanliness. It is important to keep in mind that roughly half of the radiant heat produced by a tube is directed towards the ceiling. It is the job of the reflector to redirect this radiant heat back to the floor. The cleaner the reflector, the more heat that will be reflected back to the floor, and the warmer the floors will be. A dirty reflector tends to reflect less heat, absorbing it instead leading to higher reflector temperatures and in turn higher ceiling temperatures directly over the tube. To achieve maximum radiant efficiency the underside as well as the top of the reflector typically should be throughly cleaned twice a year (Figure 18).


Figure 18. Underside of reflector before and after cleaning

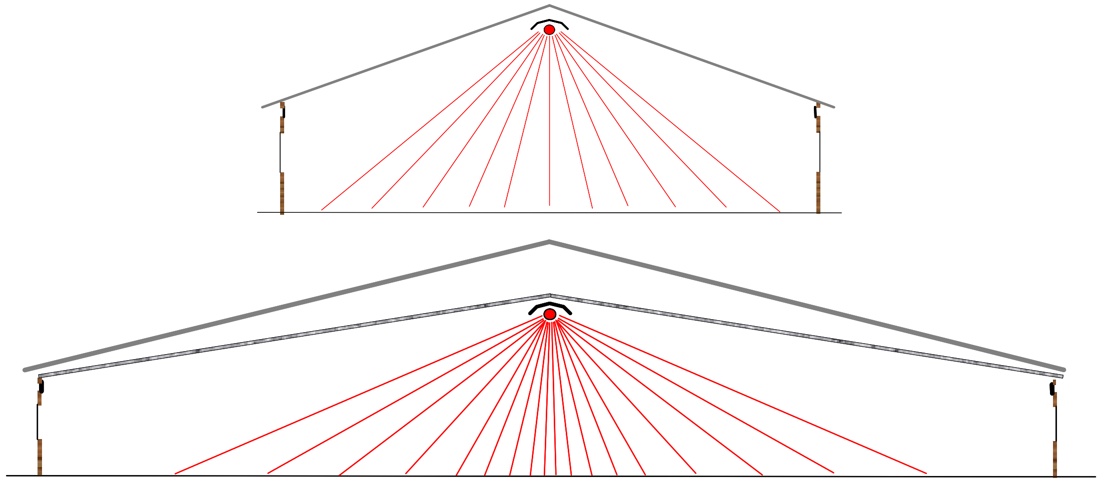

Figure 19. Radiant heat pattern in 40' wide house with high ceiling vs. 60' wide house with dropped ceiling

Because the amount of radiant floor heating decreases as the distance from a radiant tube increases, wide houses can be a challenge to heat evenly with radiant tubes. This is because the wider the house, the greater the difference in radiant heat density will be between the center and the sides of the house, the greater the difference in floor temperature there will be (Figure 19). At typical peak ceiling heights in dropped ceiling houses, it is difficult to get significant floor heating past a distance of approximately 15 feet from the center of the house. As a result, radiant floor heating will only occur in the center 30 feet of either a 40- or 60-foot-wide house. Birds outside this 30-foot zone will be warmed by the hot air produced by the radiant tube heaters as well as that produced by the heated floor in the center of the house. The greater the number of birds there are outside the radiant heating zone of a tube the more important it is to maintain a relatively high house temperature during brooding. For instance, in a 40 foot wide house a producer could possibly get away with brooding at an air temperature of let's say 88°F, because there are just a few chicks near each side wall that are dependent on air temperature for their comfort. Furthermore, since the radiant heat zone may be as little as three to five feet from the side wall the chicks near the side wall could easily move towards the center of the house a little and get any additional heating they may require (Figure 17). But, in wider houses half the floor space may be out of the radiant zone of the brooder making maintaining a high house air temperature during brooding more important. This is not to say that a single row of radiant tube heaters will not work in wider houses, but obtaining proper floor heating across the entire width of a house can be a challenge.

Now one of the best ways to make floor heating more uniform in wider houses is to increase ceiling height. The problem of course is that though the higher ceiling would improve radiant heat distribution it would decrease the air speed in a tunnel-ventilated house therefore reducing cooling during hot weather. Another possible method would be to install two rows of tubes. Though this would improve radiant heat distribution it would significantly increase cost.

Another potential problem with installing radiant tubes in wider houses is that there would likely be a center row of feeders directly underneath the radiant tubes. During very cold weather or when ventilation rates are high due to the presence of ammonia, the tube heaters could run so much that floor temperatures may become excessive directly under the tube possibly running the chicks off the center feeder (Figure 20).

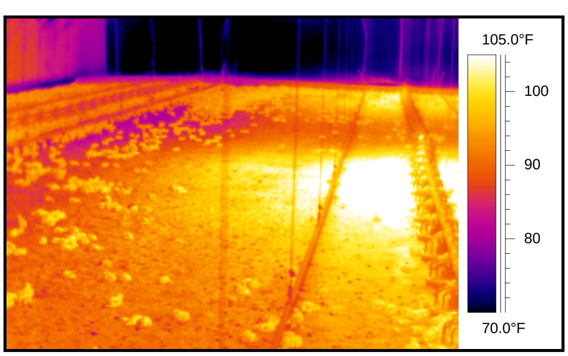

Figure 20. Radiant tube over center feed line in 60' wide house

Figure 21. Tube with secondary reflector.

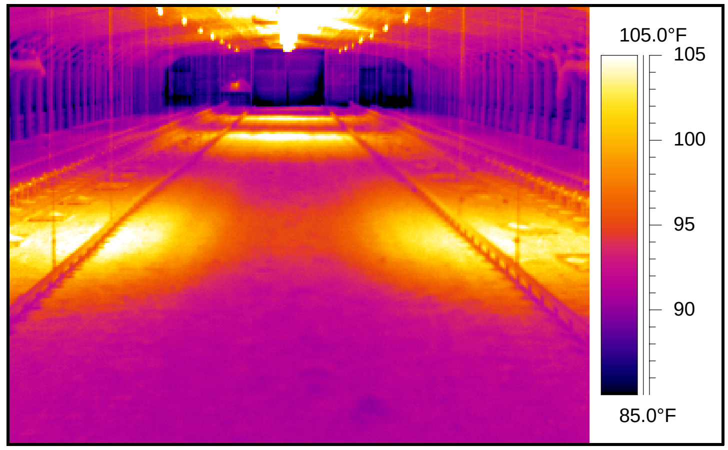

Figure 22. Thermal image of radiant tube with secondary reflector (foreground)

This is not to say that you can't put a radiant tube heater over a feed line. If the tube heater is installed high enough above the feed line, feed temperatures can be kept to a reasonable level. The other important factor to keep in mind that since radiant heat can be reflected, a secondary reflector could be installed under a radiant tube heater to redirect the radiant heat away from directly underneath the brooder and towards the side wall where it is more needed (Figures 21 and 22).

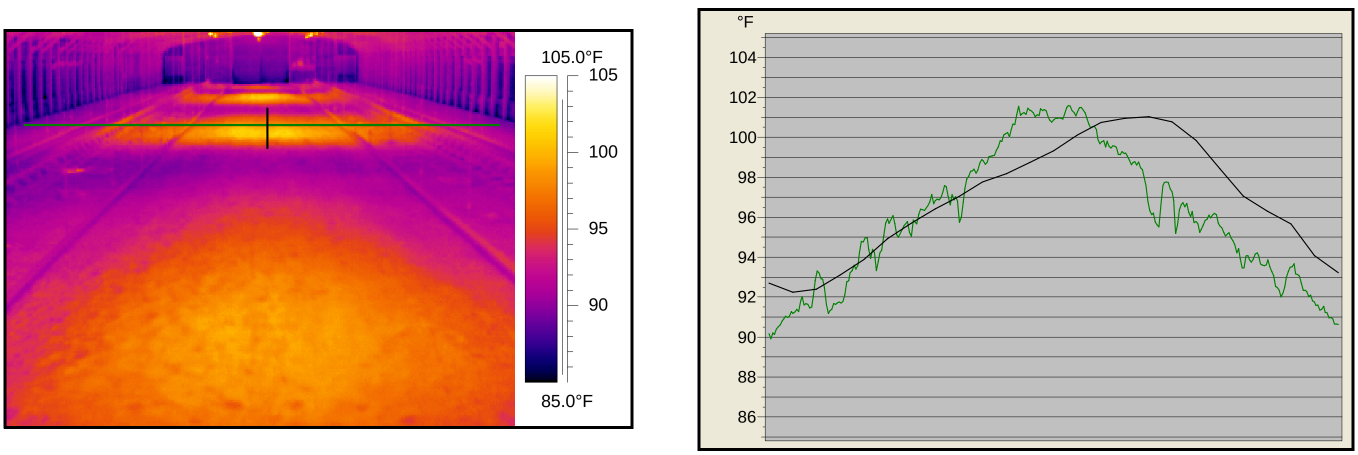

Figure 23. Floor temperature profile of radiant tube heater from end to end and side to side. The green line shows floor temperatures across the width of the house while the black line shows floor temperatures from the exhaust end to the burner end of the tube (graphed left to right)

Along with variation in floor temperature from wall to wall there are variations in floor temperature from one end of a radiant tube to the other (Figure 23). This variation is caused by the fact that the tube is not the same temperature from end to end. As you might suspect the tube is hottest near the burner and coolest near the exhaust end. To try to compensate for the temperature drop down the length of the tube most manufacturers construct the tubes at the inlet and outlet with different types of metal. Though the amount of radiant heat produced is determined to a large extent by temperature, the type of metal a tube is constructed with also affects its radiant heat production. For instance, iron pipe has a radiant emissivity around 0.85 while stainless steel has an emissivity around 0.15. The higher the emissivity of the metal the more radiant heat the metal will produce. So to minimize floor temperature differences from one end of the radiant brooder to the other the tube nearest the burner tends to be made out of a type of metal that puts out less radiant heat while the tubes toward the exhaust end are made of metal that emits more radiant heat. To further compensate for the temperature drop from inlet to outlet most radiant tubes have some type of air baffle in the last 15 feet or so of the tube. The air baffle helps to increase air turbulence at the end of the tube thereby increasing tube temperature. As a result of these measures, for most 30 to 40' tubes the floor temperature directly under the tube will only vary between 10 to 20ºF (Figure 24).

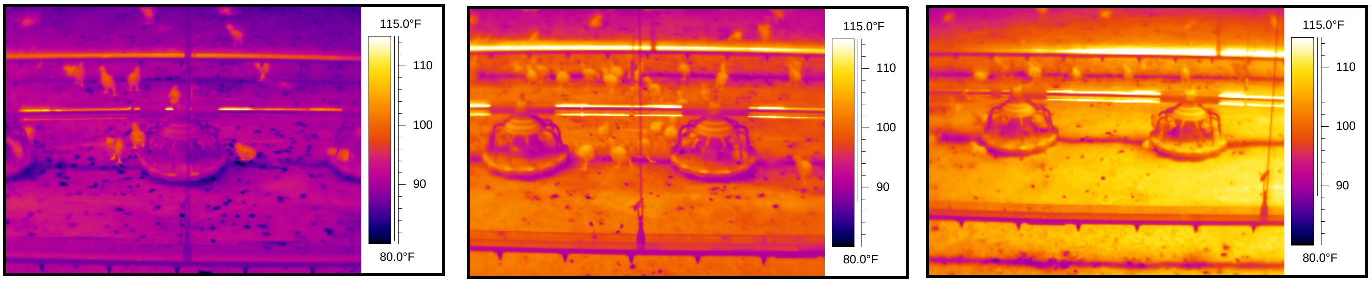

Figure 24. Floor temperatures directly underneath radiant tube heater (exhaust end, center, burner end)

It is important to note that it is generally not recommended using radiant tubes longer than 40 feet in length. Even with the use of tubes made of different metals and air baffles it is difficult to compensate for the significant tube temperature differences that tend to occur in tubes of longer lengths. Another point to keep in mind is that in order to minimize the size of cool spots between radiant tubes, they should be placed no more than 20 feet apart.

One of the unique characteristics of radiant tube heaters is that since they have such a large radiant heat emitting surface area they can heat a large percentage of the floor in a poultry house relatively quickly. The thermal images in Figure 25 were taken in side by side broiler houses. The initial floor temperature in both houses was approximately 60ºF. The thermal images were taken in both houses 20 minutes after the heating systems were turned on. The average floor temperature was 69ºF in the house with radiant brooders and 79ºF in the house with radiant tube heaters. The radiant tube heaters ability to heat the floor quickly could significantly reduce the time required for preheating thus leading to reducing heating costs (Figure 26 presents histogram of floor temperatures pictured in Figure 25).

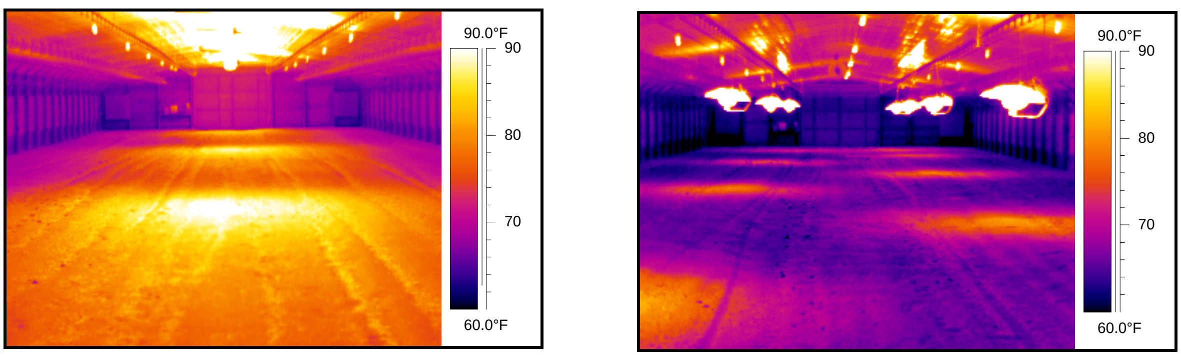

Figure 25. Thermal images of houses after the heating system was operating for 20 minutes.

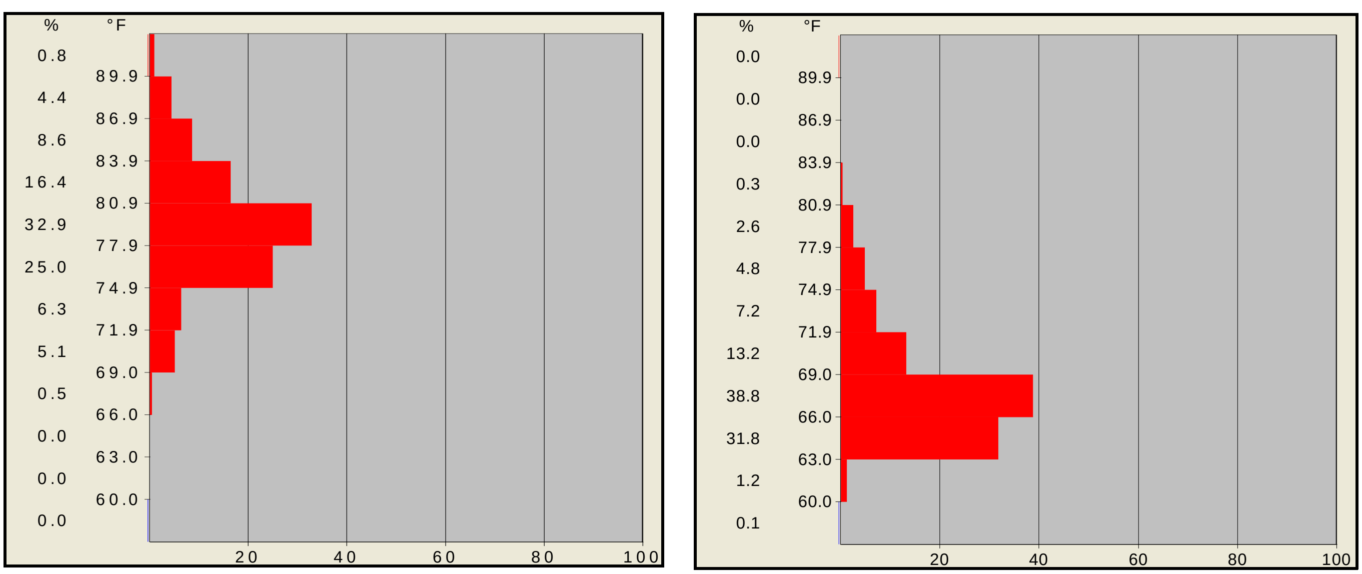

Figure 26. Histograms of floor temperatures for houses in Figure 24 (radiant tube, left. radiant brooders, right).

One downside to radiant tube heaters is that in order to maximize their coverage area they generally need to be placed as high as possible in the house which can place them relatively close to dropped ceilings. Since they tend to be closer to ceilings compared to pancake or radiant brooders, higher ceiling temperatures can result in the vicinity of the radiant tube than most people tend to see in houses with pancake or radiant brooders. Even when mounted over a foot from the ceiling, surface temperatures can range between 150 and 200°F (Figure 27). Though this is not hot enough to start a fire directly, it is warm enough for some plastics to become fairly flexible which could lead to pipes, wiring, and ceilings sagging onto the top of the reflector which can be hot enough to cause a fire. This is why it is important that radiant tubes are not placed too close to the ceiling and why it may be advantageous to place some type of reflective insulation above the tube to minimize ceiling heating. Furthermore, recognizing that ceiling heating is greatest over the first 1/3 of the tube, wires and pipes should ideally not be placed in this area.

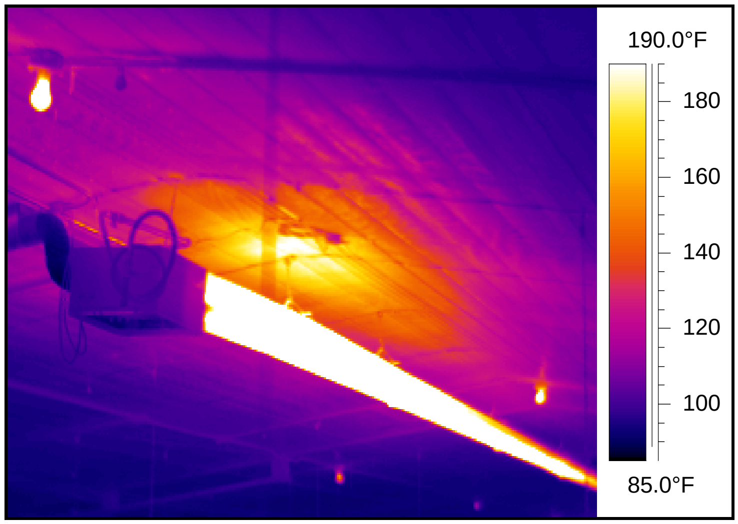

Figure 27. Ceiling temperatures above radiant tube heater.

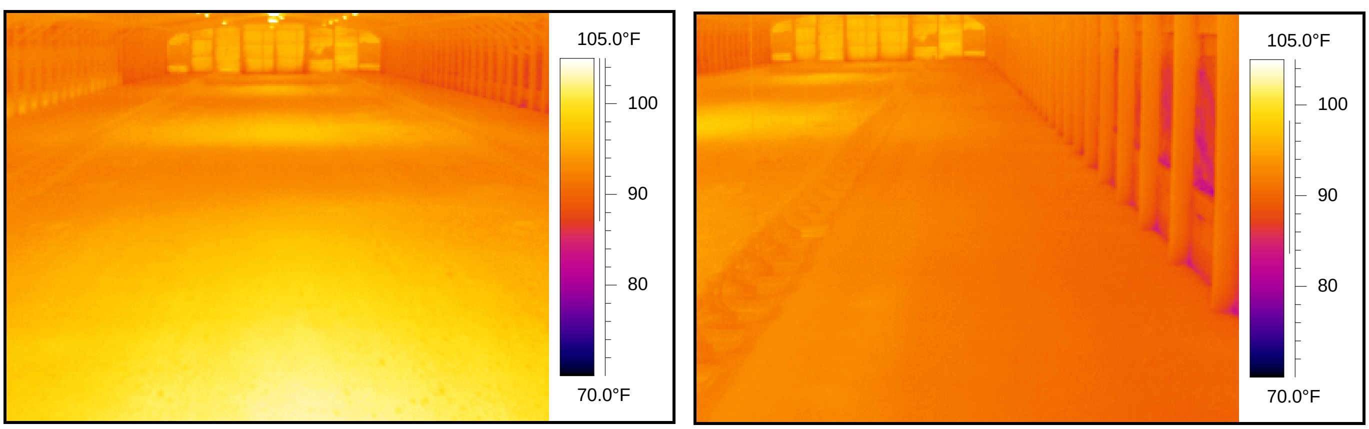

Figure 28. Floor temperatures during warm weather (outside temperature = 65°F)

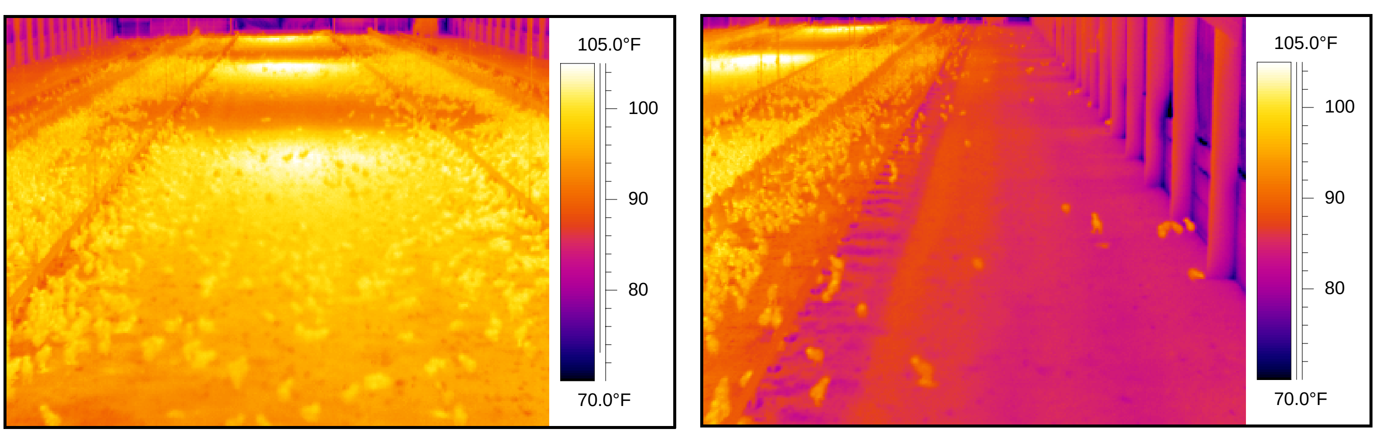

Figure 29. Floor temperature during cold weather (outside temperature = 40°F)

It is important to realize that floor temperature patterns will change with the amount of time a radiant tube heater operates. During warm weather when the radiant tube doesn't have to operate much to maintain the proper house conditions floor temperatures will tend to be very uniform because in a sense a radiant tube is as much an air heater as it is a floor heater (Figure 28). But, during cold weather and the radiant tubes are operating a large percentage of the time there tends to be more significant floor heating which leads to differences in floor temperatures noted in many of the above thermal images (Figure 29). So a radiant tube system that may look great during warm weather, or even during cold weather when ventilation rates may be very low due to a house having fresh litter, could be less than optimal when temperatures fall and ventilation rates may be higher than the minimum due to the need to get rid of ammonia from built-up litter.

Radiant tube heaters are yet another option for producers looking to use radiant heat to keep their birds warm during cold weather. Their higher radiant heat output allows them to be installed higher above the floor thus distributing heat over a wide area and reducing the number of heating units required. Obtaining proper floor heating near the side walls of curtain-sided houses and wider houses can be a challenge, but not impossible. Radiant tube heaters ability to heat a large percentage of the floor space in a poultry house quickly, will no doubt lead more and more growers considering installing them in the new or existing houses.

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