

Evaporative Cooling Systems: *How and Why They Work*



Many poultry houses today are equipped with cooling systems that consist of an arrangement with cool cell pads at one end of the house and large tunnel exhaust fans at the other end. To master operation of their evaporative cooling systems, poultry growers must have a working understanding of the relationship between temperature and humidity and the effect it has on chickens. The relationship is both simple and complicated.

The simple part is that **as temperature goes up, humidity goes down** and vice versa. That relationship is quite linear, and it works well. Consider the weather in Phoenix, Arizona, on a sunny summer afternoon. It may be 110 °F, but, as they say, “it’s a dry heat.” There is almost no moisture in the air when the temperature is that hot—often it’s less than 10 percent humidity. As a result, evaporative cooling works great in the desert.

Now consider the weather on your farm on a summer morning at sunrise. It’s around 70 °F and the humidity is at or near 100 percent. Dew formed overnight, and water is dripping off the chicken house roof. Why? The air temperature dropped overnight. Because cold air holds less moisture, the air became saturated and condensation formed on surfaces.

Evaporative cooling is practically useless under these conditions because the humidity is too high. That’s why there’s no value to running cool cells at 6 a.m. However, something similar to desert evaporative cooling happens when cool cell pads run during hot afternoons.

Water Evaporation Alters Both Temperature and Humidity

Water evaporating from your wet, cool cell pads has a cooling effect on the hot air passing through the cool cell inlets. This is the complicated part of the relationship between temperature and humidity. To evaporate water, heat (energy) is required. The heat comes from whatever object the water is in contact with as it evaporates. In our cool cell situation, that object is the hot outside air as it passes through the wet pads. As heat is removed from the air, the temperature of that air decreases, but the heat remains in the air in another form.

Consider this: **for every gallon of water that is evaporated, 8,700 Btu** of sensible heat is taken out of the air (temperature drop) (Donald, 2000) and converted to latent heat (air humidity). The decrease in air temperature of the hotter, drier air passing through the wet pads has to be accompanied by an increase in humidity of the now cooler air inside the house. You did not destroy the 8,700 Btu of heat, you simply changed its form (hot, dry air to cooler, moister air).

If you are wondering whether the temperature of the water trickling through the pad would make any difference in the cooling potential, the answer is not enough to matter—only about a 3 percent difference. A gallon of water at 50 °F has a cooling potential of 8,900 Btu. A gallon of water at 90 °F has a cooling potential of 8,700 Btu. The change to the air due to a water temperature of 50 °F versus 90 °F is relatively small (Simmons and Lott, 1996) compared to the overall efficiency of the evaporative cooling system. Basically, **the temperature of the water going through the pad doesn’t matter**. The cooling potential is essentially the same.

The 80-80 Rule

Something that does matter is outside air condition. Outside temperature and relative humidity are inversely related: the hotter the temperature, the drier the air. The drier the air, the better the pads will work. There is a “tipping point” that can help determine whether or not to run cool cells. In most cases, that tipping point is an **air temperature of 80 °F**. If the air temperature is above 80 °F, then running cool cells will likely be beneficial. If the air temperature is below 80 °F, the cooling effect of running the pads is minimal, gaining maybe a degree or two difference between inside and outside air temperature. The reason for this is the humidity in the air associated with a particular air temperature.

In most cases during the summer, if the air temperature is 80 °F, the relative humidity in the air is roughly 80 percent. That’s just how nature works, and we deal with it. As air temperature gradually increases above 80 °F (late morning, afternoon), relative humidity gradually

decreases. As air temperature gradually decreases below 80 °F (late evening, overnight, early morning), relative humidity gradually increases. **Once relative humidity has increased to the 80 percent level**, for example, between 10 p.m. and 10 a.m., **running cool cells offers little benefit.** Why? Because it is difficult to evaporate water into air and get much cooling when the air already is 80 percent full of moisture (Czarick and Lacy, 2000).

There are rare exceptions each summer when extreme heat keeps the temperature above 80 °F until after midnight. When these conditions occur, running cool cells after 10 p.m. would likely be an advantage. In general, the 10 p.m. to 10 a.m. scenario is a good rule of thumb.

In almost all cases, cool cells should not be operated 24 hours a day. **Pads must be allowed to dry out at least once per day** (Campbell et al., 2006). Keeping the pads wet for extended periods of time and not allowing them to dry out at least once per day increases the risk of algae growth and reduces their life expectancy. Life of the pump will also be shortened by needlessly using it overnight. Also, high in-house humidity levels created by running pads overnight will make it difficult to keep litter dry.

A common question is, **“When should the pads start running?”** Often, growers tend to run pads too soon (at too low a temperature) in an attempt to do what they think is best for their birds. If your house has adequate air speed (minimum of 500 feet per minute in a 500-foot house; 600–700 feet per minute is better), there is little benefit to running pads before the temperature reaches **about 82–85 °F** with larger birds. Running the pads at 80 °F or less is counterproductive in terms of house humidity levels and litter conditions.

Wind-chill Effect Provides Major Cooling

Keep in mind that pads are only part of your overall cooling system. Tunnel fans are the other and more important part. Understand that evaporative cooling systems (cool cells) work to enhance tunnel ventilation. **The first requirement for successful cooling is airflow.** Sufficient air velocity that provides a good wind-chill effect is more important than any other item in a hot weather broiler house (Donald, 2000). Pad cooling is complementary to tunnel ventilation. It relies on the large volume of airflow created by the tunnel fans to improve sensible heat loss from the birds (Donald et al., 2000; Donald, 2000).

The wind-chill effect produced by the fans serves as the primary cooling mechanism. How much wind speed you have down the house will determine whether you can accept the 80–85 percent humid air from the standpoint of keeping birds alive and litter reasonably dry. Evaporative

cooling helps to increase the cooling produced through air movement, but increased humidity reduces the bird’s ability to cool itself through respiratory evaporation. Evaporative cooling systems are successful only when the house and ventilation system are adequate (Donald, 2000).

Part of the difficulty in cooling chickens is that **chickens do not sweat.** Instead, they have two other ways to cool themselves: 1) air movement (created by the fans) and 2) moisture evaporation from the respiratory tract. Respiratory evaporation may be enhanced by an increase in the volume of air breathed per unit of time, which is usually achieved by rapid, shallow breathing or by panting. The amount of heat a bird loses through panting depends on the relative humidity of the air it breathes. The lower the relative humidity, the more moisture and heat are removed from the body (Czarick and Fairchild, 2009). On the other hand, the bird can’t evaporate much water off its respiratory system if the air it breathes in is already 85–90 percent saturated; thus, heat stress increases.

Why can high air speed alleviate a high humidity issue? Air speed increases the amount of heat loss to the air surrounding a bird which reduces its need to rely on respiratory evaporation for cooling (Czarick and Fairchild, 2009). High humidity inside the house is less of a problem when the bird does not rely as much on panting as a cooling mechanism. **Air speed down the house should exchange the air at a minimum rate of once per minute, even with cool cells.** A faster air speed is better. 600–700 feet per minute on a 500-foot house is more advantageous than 500 feet per minute (Dozier et al., 2005).

How the fans and pads work together to provide high wind speeds is extremely important in keeping your birds alive! There are numerous combinations between fans and pads depending on your controller set up, but to achieve maximum bird cooling for older birds, **all tunnel fans should be on before water ever starts to trickle through the cool cell pads.** This provides maximum air speed down the house and produces the greatest wind-chill effect. It is critical that none of the fans shut off when water is added to the pads and house temperature begins to drop. If some of the fans shut off, air speed down the house decreases at the same time humidity is increasing. This leaves the birds dependent on panting instead of air movement for cooling, which increases the heat stress level. It may take some work with your controller, but make sure you have a wide enough range in the settings between fans and pads so that fans are not shutting off because pads are running.

None of the fans should shut off until house temperature has dropped low enough that heat stress is no longer an issue. With older birds in hot weather,

this may not happen until late at night or in the early morning hours before sunrise. In some cases, depending on nighttime temperatures, it may not happen at all when additional nighttime cooling may be necessary for older birds. Research suggests that running all tunnel fans when temperatures are more than 77 °F during the last two weeks before harvest is beneficial to weight gain and feed conversion (Dozier et al., 2006).

Base temperature settings for the pads on the **average of sensors only in the tunnel fan end** of the house. Do not include sensors near the pads as this will tend to increase the possibility of pads coming on at too high of a temperature for birds in the tunnel fan end. Also, litter in the pad area tends to be damper than in other areas of the house. The higher the temperature setting for the pads, the drier you can keep litter in front of the pads.

The coolest air in the house (which also contains the most moisture) is directly in front of the pads. As air moves down the house, its temperature increases (up to 3–5 °F), and the humidity decreases (up to 20 percent). This allows it to pick up more moisture from the litter than was possible in front of the pads. As a result, the litter down the house is drier than litter near the pads. With older birds, if you have the last tunnel fans on by the time the tunnel fan end of the house reaches 80 °F and your pads are set to operate at 82–85 °F, then you should be able to maintain relatively dry litter at a manageable house humidity level while still keeping your birds reasonably comfortable.

Foggers in Evaporatively Cooled Houses

One area of concern, especially on hot afternoons, is running foggers in combination with cool cells. Numerous times growers have commented, “I didn’t lose birds until I turned the foggers on.” This is because running the foggers adds additional humidity to the air. If the air gets too humid, the birds can no longer cool themselves and will succumb to heat prostration even with air movement from the fans.

For example, on hot afternoons, the birds are already in a high heat stress situation. They are surviving, but you can see that many are panting, uncomfortable, and in some degree of distress, so you decide to turn on the foggers. However, turning on foggers at 3 or 4 p.m. often makes things worse, and by 6 or 7 p.m., you are picking up dead birds. It might be hard to believe, but **running foggers in a cool cell house may actually increase the heat stress** load on birds if humidity levels are already borderline high.

The more humid the air is, the fewer water droplets can be evaporated. Droplet evaporation depends on droplet size as well as ambient conditions. When fogging is used, droplets sprayed in the air vary in mean size and distribution according to the pump pressure and

nozzle type. For misting systems that produce droplets of approximately 65 micrometers, the fraction evaporated ranges from 32 percent at 27 °C (82 °F) and 73 percent relative humidity to 66 percent at 31 °C (88 °F) and 54 percent relative humidity (Berman, 2008). That leaves a lot of additional moisture in the air for the birds to have to overcome.

The effects of temperature and relative humidity on evaporation are opposite (Singletary et al., 1996). In other words, high temperatures increase evaporation, but high humidity decreases evaporation. Temperature and relative humidity move together in a numerically similar fashion, but they are always moving in opposite directions. For example, on most days, temperature gradually increases from early morning until late afternoon, while at the same time, humidity gradually decreases. The opposite occurs overnight as temperature gradually decreases from late evening until early morning, while relative humidity gradually increases. They move in a similar manner and at a similar pace, but when one is headed up, the other is headed down.

Furthermore, **running foggers could decrease air movement over the birds**. When foggers are running, tunnel fans often pull some of the fog outside. As it passes through the fans, fog gradually wets the shutters, fan blades, belts, pulleys, motors, etc. Observations at a commercial farm in Arkansas indicated that dust collecting on wet shutters formed a heavy coating of mud that weighed the shutter down and reduced airflow through the fan. In addition, wet fan belts would sometimes slip on the pulleys and reduce airflow even further. This is equivalent to a lack of proper fan maintenance, which may reduce air speed by 20 percent or more. Wet equipment may further reduce air speed on poorly maintained fans to practically nothing.

With reduced air speeds, birds will become heat stressed at lower temperatures. If wind speed goes from 500 feet per minute to only 300 feet per minute due to poor fan maintenance, wet equipment, etc., a significant amount of wind-chill is lost (Czarick and Fairchild, 2003). This causes birds to show signs of heat stress at temperatures as low as 78 °F. Birds already in a severe heat stress situation will likely not survive the loss of a significant amount of the wind-chill effect. Heat losses are almost certain in this situation! **If we lose our wind speed, we lose our chickens**. It’s that simple.

Excess moisture from foggers may also wet other equipment, including feed line motors and electrical connections, which can trip circuit breakers, melt connections, or start electrical fires. Foggers may also cause litter conditions to deteriorate rapidly. Wet litter can result in poor paw quality and will generate

additional heat and ammonia, making conditions even more difficult for birds in the days to come.

One other factor important to litter quality is **migration fences**. Use migration fences throughout the house to prevent too many birds from migrating to the cool cell area. Without fences, birds will move toward the cool air (cool cell area). Birds may become so crowded that little or no airflow can make it to the floor, further restricting litter drying. Crowded conditions will also restrict feed and water space and make it extremely difficult for you to walk the cool cell area.

Summary

Evaporative cooling systems have benefits to the poultry industry, but they are not without their problems. In combination with tunnel ventilation, they allow production of healthy, profitable flocks during extreme summer conditions. However, they create high humidity conditions in the house, which must be combated with increased air movement over the birds. The key to getting the most out of any evaporative cooling system is to **move the maximum amount of air through the house**. Wind speed and airflow keep birds alive. Growers must understand this if they are to properly manage evaporative cooling systems and raise birds successfully during hot weather.

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