

APPLICATION AND MANAGEMENT OF DAIRY CATTLE HEAT STRESS RELIEF SYSTEMS

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Traditionally, when heat stress is mentioned, dairy producers thought about southern dairy farms. In the South, producers combat heat stress with the primary objective of keeping cows alive and secondary to maintain some realistic level of production. Even though the Northeast doesn't get as many total heat stress days as our southern neighbors, substantial periods of hot, humid spells do occur and they can rival conditions found anywhere else in the country. The effects of heat stress on dairy cattle are enormous and cost the northeastern dairy industry significant lost revenues each year.

Some northeastern farms are very aware of the economical effects of cows suffering from heat stress. One dairy near Auburn, New York has kept complete production records for many years. They track lbs./cow per day sold on a daily basis. This data is graphed and displayed in the herdperson's office offering a visual impact to the effects of a number of production variables, including summer heat stress. Their data showed a production loss of about 20 lbs./cow during one significant heat wave a few years ago. Using a milk price of \$16/cwt that translates to a daily loss of \$1,600 for a herd of 500 cows; when the milk price is about the cost of production, the daily loss would be about \$1,850. The drop in production may times continues after the heat stress event, and higher producing cows are more sensitive to heat stress. There are other impacts of heat stress that also negatively affect a producer's bottom line.

EFFECTS OF HEAT STRESS

Decreased dry matter intake and subsequent loss of milk production are not the only adverse effects of heat stress. Daytime feed intake depression and subsequent nighttime slug feeding can cause acidosis and possibly lead to laminitis. Nutrient absorption of consumed feed is reduced, decreasing feed utilization efficiency.

Heat stress can cause reproductive systems to shut down, possibly for several months afterwards. Consequently, rates of conception are lower and those animals that do conceive subject their fetuses to conditions within the uterus that compromise growth, causing lower birth weights of calves. Milk production even in the subsequent lactation (occurring in cooler weather) has also been shown to be adversely affected by previously endured heat stress.

The economical effects of heat stress clearly cannot be based on lost production alone. Fortunately, there are methods available to relieve heat stress, which are cost effective to implement and practical.

HEAT STRESS – FACTORS

Heat stress in dairy cattle is actually the result of four variables; they are:

- Air dry bulb temperature
- Air relative humidity
- Air speed
- Radiation

These factors, acting together on a cow, determine the effective degree of heat stress that the cow is subjected to at any given time. As the temperature increases, less humidity is required to create a stressful situation. On the contrary, as temperature decreases, more humidity is required to cause the same level of stress. Charts and tables have been developed that relate these factors to predict the relative heat stress in cows.

SYMPTOMS OF HEAT STRESS

Researchers at the University of Florida in the mid-1990s developed the following rules of thumb to determine if cows are stressed and need relief:

- When the respiration rate is over 80 respirations per minute for 7 or more out of 10 cows
- When the rectal temperature is 102.5°F or above for 7 or more out of 10 cows
- When dry matter feed intake drops 10 percent or more in hot weather
- When milk production drops 10 percent or more in hot weather

In New York and other Great Lakes States, cows have been observed to begin to stand in their freestalls when air temperatures reach the mid to high 60's for some pens indicating they would benefit from heat stress mitigation.

HOW A COW COOLS HERSELF

In looking for ways to effectively relieve heat stress from a dairy cow, it is prudent to understand how a cow cools herself and subsequently design relief mechanisms that are targeted at enhancing her natural cooling system. There are four basic pathways to remove metabolic heat produced within or heat transferred to a cow's body. Non-evaporative means include: 1) conduction, 2) convection, and 3) radiation. These first three ways require a thermal gradient (temperature difference) between the cow and her ambient environment for cooling to take place. When a high thermal gradient exists, heat is readily transferred from the cow to the surrounding environment. However, as summer temperatures rise to 70°F and above, the gradient becomes too small to

effectively cool cows solely by non-evaporative means. During these conditions, evaporative cooling, the fourth pathway, is most effective at keeping cows comfortable.

Evaporative cooling takes place at two primary sites on a cow's body: in the upper respiratory tract and on the outer body surface. As ambient temperatures rise, there is an increased potential to lose more heat from the outer body surface than via the respiratory tract. Therefore target heat stress relief efforts towards removing heat from a cow's outer body surface in order to receive the most benefit.

FANS FIRST (FORCED AIR CONVECTIVE COOLING)

Locating fans in strategic locations throughout a dairy facility is the first step in providing supplemental cooling to your cows. (We are assuming that adequate ventilation is present and plenty of fresh water is available throughout the barn.) Research has shown that airflow over a cow with a velocity between 400 and 600 feet per minute will increase cow comfort by providing heat stress relief.

When locating fans in a dairy facility, use the following guideline (*revised*) in order of importance when incrementally installing fans:

1. Calving area
2. Close up dry cows
3. Holding area
4. Milking area
5. Fresh cows
6. High producers
7. Low producers

Holding Area

Cooling fans should ideally be positioned in a holding area to direct air away from the milking area (Figure 1a) and tilted to blow at the ground below the next line of fans. Fans should be spaced so there are only a few feet between fans in the transverse direction to avoid dead air spots. Fans located as shown provide the opportunity for airflow to penetrate between cows thus increasing the surface area cooled.

When limited vertical space does not allow for placement of fans over the cows, locate fans along the sidewall to blow laterally across the pen in the direction of prevailing summer wind (Figure 1b). Fans positioned in this manner will not be as effective at cooling cows since the cow surface area exposed to the moving air is less, but these fans will also provide ventilation of the holding area since ambient air is being blown into the barn.

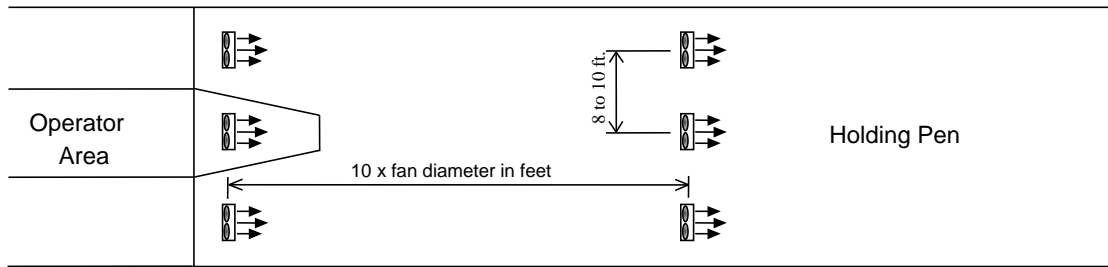


Figure 1a. Preferred placement of fans for cooling cows within a holding area.

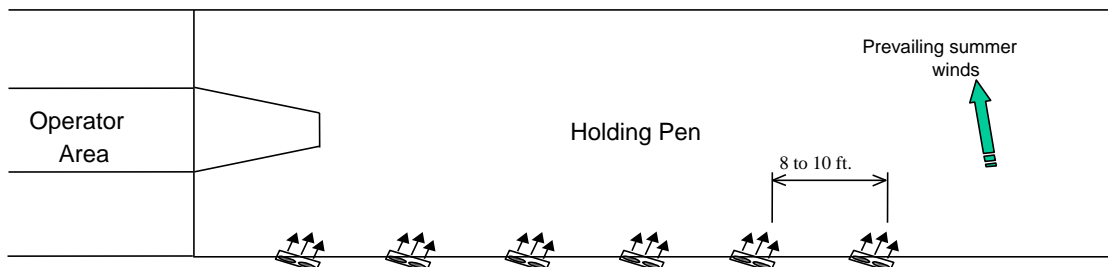


Figure 1b. Compromised option for locating cooling fans when ceiling heights and/or crowd gate clearance requirements prohibit preferred arrangement.

Lactating Cow Barns

When fans need to be installed incrementally in a lactating cow barn because of limited capital, one approach is to incrementally install fans as follows:

1. Over the feed alley
2. Over the inner rows of stalls
3. Over the outer rows of stalls

If sufficient capital is available to outfit all rows of stalls but not the feed alley then consider providing fans over each row of stalls first except in the case with direct evaporative cooling (see below) is going to be used and in this case fans over the feed alley are required.

Fans should be installed so that they are spaced longitudinally down the barn with a spacing of no more than 10 times their blade diameter (Figures 2a and 2b). Three-foot fans should be spaced no more than 30 feet apart while four-foot fans no more than 40 feet. Fans spaced more than 10 times their diameter lose effective velocity and as a result all cows will not be adequately cooled.

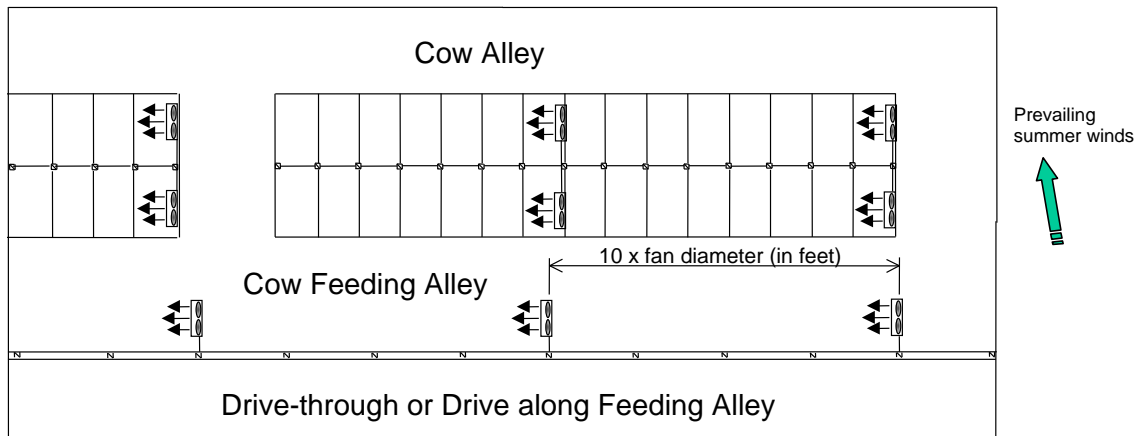


Figure 2a. Plan view of placement of supplemental cooling fans in a freestall barn.

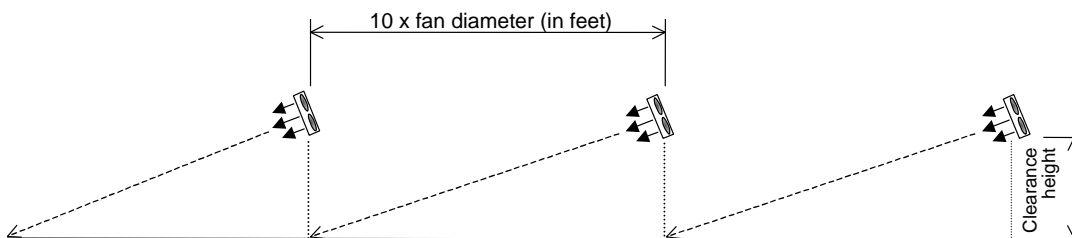


Figure 2b. Side view of placement of supplemental cooling fans in a freestall barn.

Fans should be located vertically just high enough so they are out of each of cattle and don't interfere with alley scraping or bedding operations, as shown in Figure 3. Tilt fans approximately 15 to 20 degrees from the vertical so they are aimed at the ground directly below the next fan down the line. If structural limitations require that fans be mounted directly above the feed barrier (cannot be cantilevered over the feeding cows) then consideration should be given to rotate these fans so they are blowing at an angle into the cow zone.

Fan Controls

Fans are best controlled by a thermostat. This eliminates the need for daily human attention. Mount the sensor for the thermostat so its reading represents the conditions in the cow zone. Set the thermostat so the fans start running at about 70°F or even lower if multiple hot days followed by hot nights are predicted. Continue running the fans well into the evening, even after air temperatures may drop down below the set point temperature, to allow the cows to cool overnight – there are specific

controllers called time integrated variable (TIV) controllers that will do this automatically based on keeping a running record of the degree-hours in the barn.

Fan Safety

OSHA requirements state that protection of rotating fan blades, pulleys, and belts by either installing wire mesh (max opening $\frac{1}{2}$ "-inch) over the fan or by having at least seven (7) feet from the bottom of the fan to the ground immediately below the fan must be provided. Wire mesh placed over rotating components can quickly accumulate dust and dirt and consequently significantly reduce their performance; therefore, more regular cleaning may be needed than what is required otherwise. Another important safety item is all fans need to be electrically isolated ("locked out") or otherwise disconnected from their electrical supply prior to being cleaned and/or serviced.

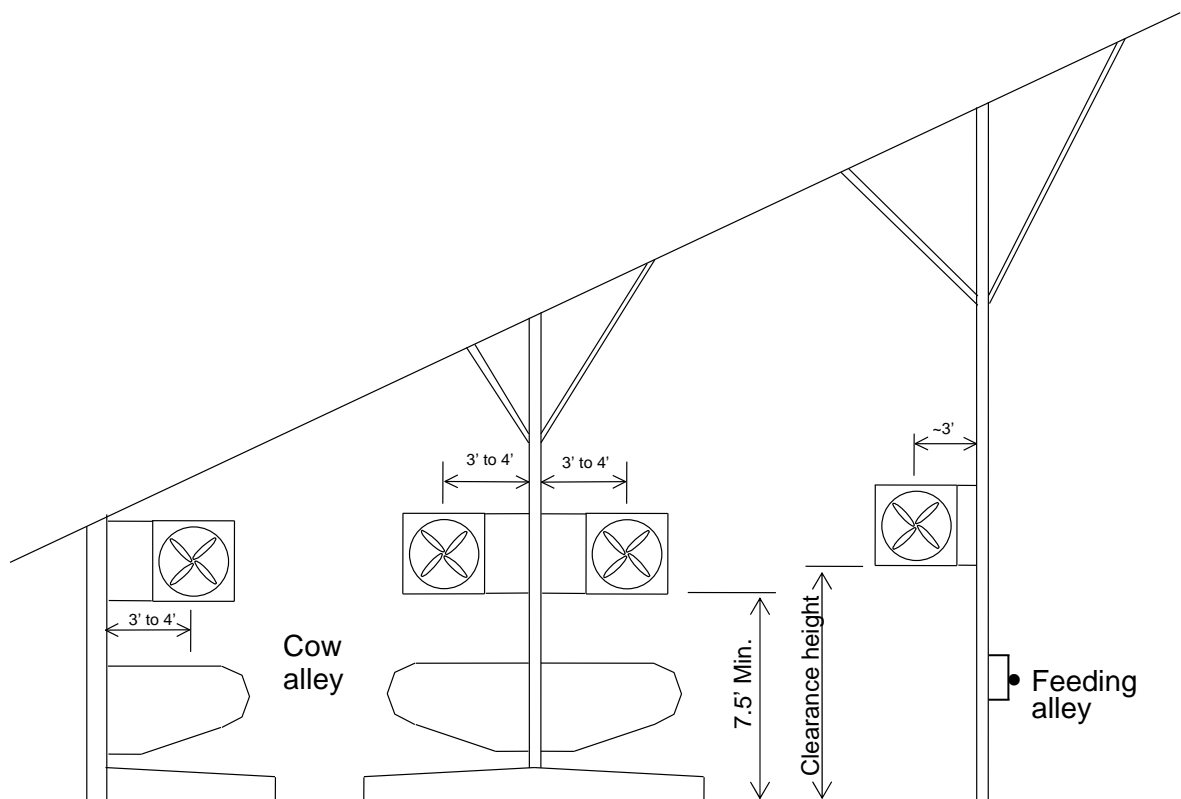


Figure 3. Placement of fans over feeding and resting cows in a freestall barn.

EVAPORATIVE COOLING – THE PROCESS

Providing substantial air movement over a cow's body doesn't always offer her complete relief. Additional mitigation can take place by evaporating water – evaporative cooling. The process of evaporative cooling is nothing more than using heat to convert

water from a liquid phase to a vapor phase. The heat “consumed” during this change in state results in a temperature reduction.

Evaporative cooling can be employed to cool a dairy cow in two distinctly different ways:

- Indirect evaporative cooling
- Direct evaporative cooling

With indirect evaporative cooling, the ambient air that surrounds the cow is cooled and in turn cools the cow by removing heat, predominately via convective heat transfer. Misters and foggers are examples of this method. Alternatively, the cow’s outer body surface can be cooled directly by evaporative cooling. Sprinkler systems used in conjunction with fans are an example of direct cooling. The method ultimately used depends on several factors, including ambient air conditions.

AMBIENT AIR CONDITIONS EFFECT COOLING

One of the major factors that determine which method of evaporative cooling to use is your geographic location. Location has an influence on the predominate condition or state of the ambient air conditions that are present during the summer months.

In the Southwest, where summer conditions are hot and dry, cows are successfully cooled by evaporative cooling of the ambient air. Air temperature reductions of over 18°F or more have been reported with well-designed systems.

However, in the Northeast, summer conditions are typically hot and humid. Humid conditions make it hard to cool the air by evaporative cooling because the air already has relatively high levels of moisture vapor. Primarily for this reason, sprinkler systems used in conjunction with fans to directly cool cows offer an advantage. Cooling by this method compensates for high ambient humidity as large volumes of air are passed over the animals.

SPRINKLING AND FAN COOLING

Using a sprinkler system to provide heat stress relief is effective but can only be used in barns that have adequate ventilation. The extra moisture generated in the barn must be removed by air exchange in order to provide a quality environment. Additionally, barns must be appropriately outfitted with fans as described above for a sprinkling system to be effective. In hot, humid conditions sprinklers alone will not effectively cool cows.

Like lawn sprinkling systems, cow sprinkling systems are designed to operate at low water pressures, about 10 psi. Low water pressures result in large water droplets that will effectively soak a cow’s hair coat to the skin. After the hair coat is soaked, the

water is allowed to evaporate until such time application of water is again required. Fans located throughout the sprinkling area help in the evaporation process by quickly removing water just evaporated off the cow's skin.

Caution should be used to ensure that the hair coat is soaked and not merely covered with a light mist. Application of a light mist will result in the outer portion of the hair coat only to be covered creating an insulating layer which will impede heat loss from the cow. Conversely, over application is a waste of water and can possibly be counter effective if the udder becomes wet potentially promoting disease. Target rates of application are to apply 0.05 inches of water in 0.5 to 3-minute time intervals during a 15-minute cycle. The recommended schematic layout of a sprinkler system is shown in Figure 4.

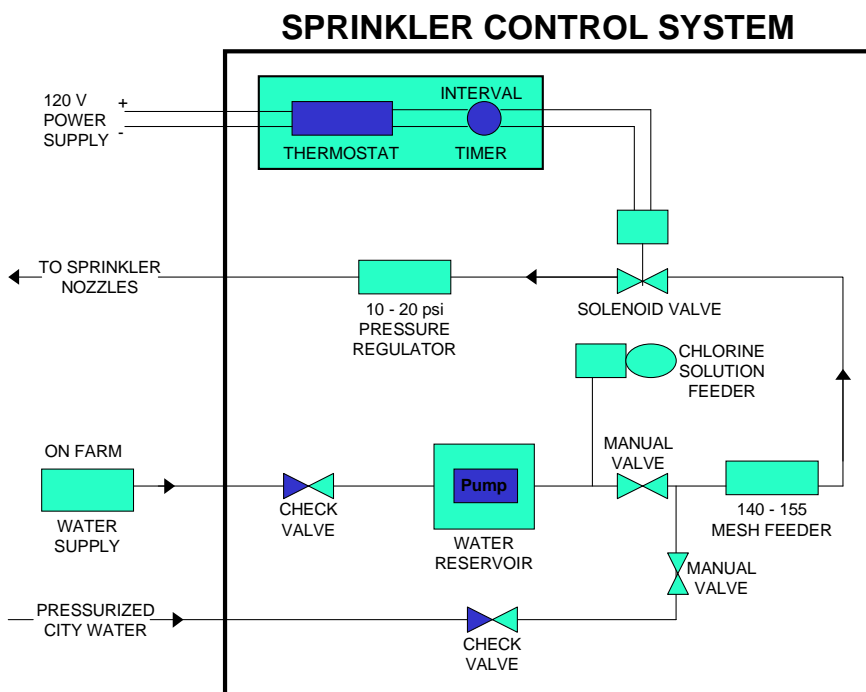


Figure 4. Schematic layout of the components of a sprinkler cooling system.

Sprinkler Nozzles

The type of sprinkler nozzles used depends on the specific application. Sprinklers that are mounted on the feed barrier for use over the feed alley should cover a 150 to 180 degree area. Sprinklers in a holding area or return alley can cover 360 degrees. Sprinklers should have at least a ½-inch base and ideally threaded to easily connect on the distribution line. High capacity sprinklers typically have a ¾-inch base.

Sprinkler nozzles should be spaced so that their coverage area overlaps. This ensures complete coverage. Exact spacing is determined by reviewing manufacturer's literature.

Pipe Size

The size of the pipe delivering water to the barn must be sufficient to meet all of the peak water demand needs. Water usage for sprinklers, up to 50 gallons per cow per day, must be accounted for when sizing the farm water supply pipe, updating the farm's overall water budget, and sizing a manure storage. The length of area to be sprinkled, and the number and size of sprinkler nozzles employed will govern the size of the sprinkler manifold pipe.

Sprinkler Manifold Pipe Location

This depends on the height of the barn, location of structural posts or other attachment points, width of area to be sprinkled, the type of sprinkler used, and vertical position of fans. For drive through or drive along feeding systems, the supply pipe can be installed either on or above the feed barrier or above the center of the feed alley.

Considerations When Selecting Sprinklers

1. Define the area you want the sprinkle to cover (feed alley, holding area, return alley).
2. Determine where you want to mount sprinklers (from a horizontal or vertical member).
3. Determine what specific sprinkler nozzle is to be used (150 to 180 degree nozzle for the feed alley if mounted immediately above the feed barrier [8 foot spray radius] or 360 degree nozzle if mounted over the feeding cows [4 foot spray radius]).
4. Determine the water pressure that provides the proper radius.
5. Determine the proper nozzle size (specified in gallons per minute [gpm] of water delivery). Select nozzles with a rating of 0.5 to 2 gpm.
6. Determine trajectory of the nozzle.

SUMMARY

Dairy heat stress needs to be mitigated, now, and morose in the future based on predicted rises in summertime air temperature. Providing supplemental cooling is important to minimize milk production drops and maintain herd health. Outfit your barn first with cooling fans in all prioritized areas and then add sprinkler systems for additional heat stress protection. Use thermostatic controls and timers to optimize system response and overall effectiveness.