UNIVERSITY OF MISSOURI
Extension
Commercial Agriculture Program

231 Agricultural Engineering Building
1406 East Rollins Street
University of Missouri
Columbia, Mo 65211-5200
Phone: (573) 882-0868
Fax: (573) 884-5650
E-mail: ZulovichJ@missouri.edu

February 2014

Implementing Heat Stress Relief Systems

Joseph M. (Joe) Zulovich, Ph.D., P.E.
Extension Agricultural Engineer

Agricultural Systems Management
University of Missouri - Columbia

Commercial Agriculture Program
University of Missouri Extension

Abstract

This paper discusses some of the basic issues related to implementing heat stress relief for dairy cows. Heat stress relief is accomplished by provided plenty of fresh drinking water, by providing shade at strategic locations, by increasing air movement around the cow and by increasing water evaporation from the cow's skin. Shade will reduce the heat load on a cow from the sun. Air movement is increased through the use of fans. Wetting the cow and letting her dry increase water evaporation. Fan and sprinkler selection and installation issues are discussed.

Introduction

The need is quite well documented for heat stress relief systems in warm and hot weather like summer in Missouri. If the heat stress relief system is effective, cows will usually maintain normal feed intake levels. Cows eating well will usually maintain milk production, maintain body condition, and have fewer reproductive problems. During warm and hot weather, five main systems are used to maintain productivity from dairy cows. The five systems are 1) drinking water systems; 2) shade systems; 3) adequate ventilation; 4) stirring fan systems, and 5) sprinkler systems. How these systems are incorporated will vary depending upon the design of the total housing system. However, several basic characteristics exist for each system regardless of housing design. These basic characteristics are discussed below.

I) Drinking Water Systems

Drinking water systems are an integral part of all dairy housing systems. Providing plenty of fresh, clean drinking water is the first system that should be used to reduce heat stress problems. Dairy cows can consume up to 50 gallons or more of water per day in hot weather. Another way of estimating water intake is based on dry matter intake. Drinking water requirements range from about three to eight pounds of water per pound of dry matter intake. The higher water requirements are correlated with high environmental temperatures.

Minimum drinker space of one cup or 2' of trough space per 15 to 20 cows is not adequate space for warm and hot weather conditions. During hot weather, about 25% of the cows in a group should have access to water at any given time. So, if 50 cows are in a group, a minimum of 12 drinker spaces (24' of trough space) should be provided. Open troughs or tanks are the best choice to provide drinking water during warm and hot weather.

Single cups or holes can be "guarded" by the "boss" cow, which will reduce the amount of space available for the remainder of the cows in the group.

Drinking water should be provided at the exit of the milking parlor. Cows will want to drink water immediately after milking and may consume a significant portion of their daily consumption immediately following milking. Water provided at the parlor exit is important during warm and hot conditions but is probably not needed during freezing weather. So, a tank with a float valve control would be an easy method to provide adequate drinking water space for cows exiting the parlor during the summer.

II) Shade Systems

Shade systems will reduce the heat gained from solar radiation. During hot weather, any additional heat gained by the cow must be dissipated causing the cow to work harder to stay cool. Shade should be provided in all locations where cows are crowded or spend a significant amount of time. The three main locations where shade systems should be used include 1) holding pens, 2) confined feeding areas and 3) resting areas.

If a roof does not exist above a holding pen, shade cloth should be suspended above the holding pen to reduce the heat gained by cows crowded in the pen. Shade cloth can be easily suspended using ropes or cables attached to poles. The shade cloth should be removed in the fall and re-installed in the spring. By removing the cloth in the winter, the sun will melt any ice, and snow will not collapse the shade system.

Shade should be provided above any feed bunks. Shade will improve cow comfort when eating. Cows will tend not to go from a shaded to a non-shaded area to eat when weather is hot. With shade provided, cows may eat more often. Shade will also tend to improve the "bunk life" of the feed. Feed that is shaded will not dry out as quickly and will tend to stay fresh longer. Both of these feed benefits will tend to help maintain feed intake.

Shade should always be provided in resting areas regardless of housing and feeding system. Cows in lots or on pasture will benefit from adequate shade systems. At least 25 ft^2 of shade per cow is required. Up to 50 ft^2 of shade per cow is better in hot, humid conditions because the increased space provides for more air movement and ventilation around the cows under the shade. Shades for resting areas should be oriented with the length running north and south to allow sun to dry the area under the shade in early morning and late afternoon. The shadow under a shade oriented north and south will move from west to east during the day. So don't locate a shade east of a fence because cows may not be able to access the shadow in the afternoon.

III) Adequate Ventilation

Adequate ventilation is a requirement anytime cows are housed inside a building. Ventilation is defined as the exchange of air from inside a building with outside air. When ventilation is adequate during warm and hot weather, the inside temperature will be no more than 2 to 3 °F above outside temperatures. If the inside temperature exceeds 5 °F above outside temperature, the ventilation system should be evaluated to identify corrections that are needed.

Naturally ventilated barns depend upon the wind to provide most of the ventilation. Naturally ventilated barns need to be located so that normal summer breezes can blow through the barn. To help ensure wind can

blow through the barn, the sidewalls and endwalls need to be open as much as possible during warm and hot weather to easily allow air enter and exit the building volume. An opening high in the building, such as an open ridge, will help during hot weather and is a must during cold weather. Curtain sides on walls are typically used to provide the needed wind protection in winter weather. If a closed building seems hot in hot weather, removing the sidewall and endwall covering materials will improve the comfort level within the building.

Some dairy barns are mechanically ventilated during warm and hot weather. In mechanically ventilated barns, fans typically draw air out of the building volume resulting in fresh outside air to enter the building volume. As with naturally ventilated barns, the inside temperature should not exceed 2 to 3 °F above outside temperatures.

IV) Stirring Fan Systems

Stirring fans for heat stress relief are used to increase the air speed around a cow. These fans generally do not ventilate the building. The stirring fans will improve general air movement within a building but generally will not really ventilate the building. Stirring fans will generally only "blow around" the air within the building.

A) Fan Location

Fans for heat stress relief should be used in primarily two locations. First, fans should be used in the holding pen to move air across cows while they are waiting to be milked. Cows are generally crowded and the use of fans will reduce heat stress problems in the holding pen. The other primary location is the resting area for the cows.

Fans in holding pens should blow from the parlor toward the back of the pen. At least two and sometimes three fans are recommended as the minimum number of fans. These fans should be located above the entrance to the parlor and near the center of the front if three fans are used. If the holding pen is relatively long (greater than 30 to 40'), additional rows of fans are recommended to get air movement over cows located closer to the back of the pen.

Fans in resting areas provide air movement across cows lying down. For freestall installations, the fans should be located above the neck rail and should be tilted slightly so the air blows down across the cows lying in freestalls. For loose housing or lot installations, fans are located so that air movement is provided across cows lying down. The pattern of the fans will depend upon the typical lying arrangement of the cows.

Sometimes, fans cannot be installed in the resting area such as pasture systems. If fans along with sprinklers are installed in the holding pen, these fans and sprinklers can be used to provide additional heat stress relief by moving to cows from the pastures to the holding pen during extreme heat stress events. Cows can be moved to the holding pen a couple of hours prior to milking to allow for cow cooling during extreme hot, humid weather.

B) Fan Selection

Fans used for air movement are basic ventilation box fans. Effective air movement from a fan is generally 10' of throw per foot of fan diameter. So a 36" fan will provide about 30' of effective air movement. The most common fan used for providing air movement is a 36", ½ h.p. direct drive fan. A number of companies provide this type of fan

for air movement applications. If a 30' pattern does not fit a given situation, 24" and 48" fans provide 20' and 40' patterns, respectively. The number of size of fan used for a given application will depend upon the air patterns desired.

Some fans are advertised as high velocity fans for air movement. These "high velocity" fans may have a longer throw than the typical fan, but the proof of the fan location and orientation is to check where air movement is provided. A relatively new fan manufacturer offers a long throw option. This option uses fins to develop a vortex so the air can be effective a longer distance from the fan. A high velocity or long throw fan can theoretically reduce the number fans needed for a given application. However, one needs to be aware of the 'stadium effect' that can happen. If 'boss cow' stands directly by the fan and blocks the air movement from reaching more cows, the given fan impacts less area and reduces the impact of the fan. If several cows block several fans, one may actually have a less overall desired outcome because fewer cows feel the increased air movement from the fans.

C) Electrical Supply

The electricity needed to operate fans for air movement can be a significant consideration if a large number of fans are used. The typical 36" diameter, ½ h.p. direct drive fan will use 5 to 6 amps at 110 volts or 2½ to 3 amps at 220 volts. So, the electrical circuits and the service panel required to operate a number of fans in a facility are significant requirements that must be addressed.

If the required electrical system is not currently available, the additional cost of the electrical system must be considered. However, effective heat stress relief systems are economically beneficial even when the additional costs of fans, electrical system and operational costs are included. But, an effective sprinkler system must be used in conjunction with fans to realize the economic benefits that are possible.

D) Operation and Management

Fans should be operated in the holding pen during the milking period. If fans are not available in resting areas, cows may be brought to the holding pen to be "cooled" prior to milking.

Fans located in resting areas should be operating at all temperatures greater than 75 °F and even at all temperatures greater than 70 °F. These temperatures may seem low, but operating fans during the night is very important and may be more important than operating during the day. Cows will have their highest body core temperatures occur during the night. Also a greater potential for cooling exists during the night because the air temperature is generally lower. So the lower temperature setting for the fans insures fans will operate during a warm night to help cool cows for the next hot day.

V) Sprinkler Systems

Sprinkler systems as defined here include any type of system that uses water to help cool cows. The goals for sprinkler systems include cooling the air by evaporating water into the air or wetting cows and then letting them dry off. The evaporation of water from the cows provides cooling. About 1,000 BTU's of heat are dissipated from a cow for every pound of water that evaporates from the skin surface of the cow. So a significant amount of cooling can be provided using sprinkler systems.

A) Emitter Types

Emitters are the component of the system that actually sprays the water. Four major categories of emitters are sprinklers, drippers, misters, and foggers. The selection of emitter type will depend upon application.

1) Sprinklers - Sprinklers spray water as large droplets into some predetermined pattern. Sprinkler emitters designed specifically for sprinkler cooling systems typically have adjustable rates and have either a 180° or 360° circular pattern. Other sprinkler emitters, which spray relatively large droplets, are lawn sprinkler emitters. Lawn type sprinkler emitters are usually fixed rate emitters but are typically available in circular, rectangular or square patterns.

Sprinkler emitters are the recommended type of emitter for most dairy sprinkler applications. The large water droplets will easily soak through the hair coat of cows to wet their skin. The evaporation of water from the cows' skin surface is what creates most of the cooling process.

2) Drippers- Drippers will drip water at a relatively slow rate as individual droplets. The individual droplets will drip from the emitter and tend to all land in the same general, small location. Since drippers do not really create a wetted pattern, they are not used much for dairy applications.

3) Misters - Misters spray water as relatively fine droplets into some predetermined pattern. The flow rate tends to be fixed, but the patterns available can be circular or rectangular. Misters are not recommended for wetting cows because misters generate relative small droplets. The small water droplets tend to collect on the hair coat surface and not soak through to the skin. The resulting water film will tend to insulate the cow instead of creating the desired evaporative cooling.

4) Foggers - Foggers spray water into a very fine mist or aerosol. This mist or aerosol will evaporate into the air and decrease the temperature of the air. In order to create this aerosol, the fogger is operated at pressures typically around 100 psi. Special plumbing components including an effective filter and a booster pump are required to install and operate fogger emitters. Foggers are used to provide some temperature relief in areas where a wet surface is not acceptable. A common application of foggers is to spray an aerosol into the air blowing from circulating fans. This aerosol will evaporate into the air and reduce the temperature. A temperature reduction of 5 to 10 °F is fairly typical when foggers are used on fans.

B) System Selection and Location

Sprinklers are recommended in feed bunk and holding pen areas because cows can be easily wetted and wet floor surfaces are generally not a problem. The 180° circular pattern works well next to feed bunks, and the 360° circular pattern works well in holding pens. Wet floor surfaces often occur with the use of sprinklers. So, the housing system must accommodate the wet floor surfaces. If wet floors are not acceptable within the housing system, sprinklers are not an option.

Areas and locations where cooling is desired and wet surfaces are not acceptable, foggers on circulating fans can provide some heat stress relief for cows. In order for cows to receive the cooling, the cows must be located in the airflow pattern created by the fan. If a fairly large number of cows need heat stress relief, a significant number of fan/fogger systems will be required.

C) Water Supply

The water supply required for sprinkler systems must be addressed in order to have an effective system. The quality of water, the quantity of water and the delivery rate of water must all be addressed.

The quality of water will have an impact on the system. Most sprinkler emitter systems have a basic filter to keep particles from plugging emitters. The filter requirements for fogger systems are typically fairly extensive. Also, if the water is relatively hard, fogger emitters may need to be cleaned as often as daily to insure correct operation.

The quantity of water needed to operate a sprinkler system is usually not a real issue. If sprinklers are cycled on and off correctly to allow for drying, problems with water quantity typically do not exist. If sprinklers are operated continuously, the excess water dripping from the cows not only does not provide much additional heat stress relief but also and can cause significant problems for the manure handling system. All the unnecessary additional water may not be easily handled by the manure system.
The rate at which water must be delivered to a sprinkler system can be significant. A sprinkler system can easily have 15 emitters operating together. If each emitter is set to deliver 20 gallons per hour, the system will need a water delivery rate of 5 gpm (15 emitters times 20 gallons per hour divided by 60 minutes per hour) to insure proper operation of the system. For a system with 40 emitters at 20 gallons per hour, the system would require a flow rate of 13.3 gpm to insure proper operation. The number of emitters operating at one time can be limited, but if emitters are divided into different branches, a control system will need to be provided for each branch.

D) Operation and Management

Sprinkler systems in all areas except the holding pen should operate when the temperature exceeds no more than 80 °F. A lower on temperature is required for high producing cows. The sprinklers should cycle on and off to wet cows and then let them dry off. The “on time” of the sprinklers will depend upon the delivered water flow rate and area covered by the emitters. By observation, the “on time” should be long enough to thoroughly wet cows to the point water just begins to run off. Generally, “on time” ranges from 1 to 5 minutes. Again, by observation, the “off time” should allow most of the water to evaporate from the cows before the sprinkler system is turned on again. The “off time” can be as long as 45 minutes or longer. Also, sprinkler systems should not operate during the night in most cases. Using a 24-hour timer in conjunction with a sprinkler control system will ensure the system does not operate the entire night so alley floors can dry out at least for a while.

Summary

Implementing a heat stress relief system is required on any dairy operation when afternoon conditions cause heat stress behavior on approximately 10-20% of the herd for a period exceeding 2-4 hours per day (typically in the afternoon). If an operation is experiencing heat stress conditions, implement relief systems in the following order of importance.

1. Make sure adequate drinking water space and quantity are available. If cows are crowding around watering systems, an evaluation of adequate access should be completed.
2. Provide as much shade as recommended in as many locations as feasibly possible for a given operation. Some operations can easily provide shade 24 hours per day (freestall barn systems) or may be somewhat limited due to system design and operation (pasture systems).
3. If cows are kept inside a building during hot weather, make sure adequate ventilation is occurring. Areas inside a building where the inside temperature is greater than 5 °F more than outside temperature are not ventilated adequately.
4. Stirring fans will increase air movement on cows when properly installed. Make sure any stiffing fans are oriented so that they enhance ventilation rather than reduce ventilation. So orient stirring fans as much as possible to help wind driven ventilation in naturally ventilated buildings. Don't have fans blow into the natural wind direction.
5. Install and use sprinklers or other evaporative cooling system as the last step when implementing heat stress relief systems. The benefit of evaporative cooling is reduced when adequate ventilation and air movement are not already in place.