DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Agriculture and Natural Resources

FSA4019

Cooling Dairy Cattle in the Holding Pen

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Introduction

The holding pen or pre-milk area of the milking center is usually the most stressful area for a dairy cow in hot weather. In the holding pen, a cow is confined in a small area with other cows, and the cow dissipates heat by respiration. As cows dissipate heat, the humidity rises, often exceeding 90 percent relative humidity. If the holding pen is not properly cooled, this environment adds great stress to the already overheated cows.

Extension publication FSA3040, *Heat Stress in Dairy Cattle*, describes the effects of heat stress on dairy cattle. Heat stress can decrease milk production by 15 to 30 percent per day as cattle eat less. Heat stress also can lower reproductive performance and animal health. The holding pen should be given priority over other areas of a dairy when implementing practices to improve the cows' comfort during hot weather.

The holding pen should be shaded and cooled during warm and hot weather. In a typical Arkansas summer and in a dairy facility with no housing other than the milking center, a well-cooled holding pen should result in cows wanting to go into the holding pen with fans and sprinklers in use. In extremely hot weather, milking cows may run to a cooled holding pen when the fans and sprinklers start. Cows that are cooled in a holding pen usually produce 1.7 to 4.0 pounds more milk per day than cows that are not cooled in the holding pen. In one study, cows that were cooled five times per day for 30 minutes in the holding pen produced 5 additional pounds of milk per day compared to cows that were not cooled. If cows are allowed to stay in a cooled holding pen for 3 to 4 hours per day, they usually provide at least 5 pounds more milk per day during extremely hot weather. However, it is important to keep the standing time for cows as low as possible or lack of rest may also decrease milk production. Hot weather can last for 30 to 90 days during a typical summer in Arkansas.

Figure 1. Used chicken house fans can be used in the holding pen, but they should have guards or be positioned where the cows and humans can't reach them.

For most dairy producers who already have a covered holding pen, the most economical method of cooling is to combine the use of fans and a sprinkler system where the fans mechanically ventilate the area and a sprinkler system is used to increase the evaporative cooling of the cows. Any side walls should be removed from the holding pen and, if possible, the ridge row of the roof should be opened to enhance natural ventilation.

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However, sufficient shade must be maintained. Examples of fan and sprinkler placement are shown in figures 1, 2 and 3.

Consider natural ventilation and prevailing winds as much as possible when placing fans to increase their effectiveness. In most cases, cows should have water readily available in the holding pen and, if possible, at the milking parlor. In some cases, the schedule for milking may be altered so that cows are milked during the cooler parts of the day rather than from 1 p.m. to 7 p.m., when environmental temperatures are at their highest. Tables 1, 2 and 3 indicate ventilation, sprinkler nozzles and pipe requirements for a cooling system.

Many factors, such as cost of installation and the amount of increase in milk production, affect the economical return on investment from cooling the holding pen. If a 2-pound increase in milk per cow is obtained for 80 days after cooling the holding pen, this increase in income is $2,160 when milk is $13.50/cwt in a herd milking 100 cows. There are also costs for equipment, installation, maintenance, operation and increase in feed costs, but most dairies should be able to pay for a cooling system in the holding pen in about one to two summers. Additional benefits of cooler cows include increased reproductive efficiency and fewer health problems due to heat stress.

Example of Design

The following is an example of a cooling system for a holding pen located in Arkansas. It was designed by John M. Langston, retired extension engineer, and has been used on several dairy farms and slightly modified for use on other dairies. **In general, the goal of the cooling system is to provide 0.05 inch of water per cycle in ½ to 3 minutes and then blow air on the cows for 10 to 15 minutes to increase evaporative cooling.** It is recommended that both fans and sprinklers be used. Fans are needed to ensure that the environment from the sprinkler does

Figure 2. Fans and sprinklers in the holding pen should use the same principles as fans and sprinklers on a feeding floor.

Figure 3. If fans and water run continuously, then the water droplets must be large enough so that they do not blow out of the holding pen. In addition, the manure collection and storage system should be designed to handle any extra water.

Table 1. Ventilation requirements based on holding pen capacity.

Holding pen capacity	Typical pen size (feet by feet)	Total fan capacity (cfm)	Number of 30- to 36-inch fans	Number of 48-inch fans
40	24 by 32	40,000	4	NR*
60	24 by 42	60,000	6	NR
80	24 by 50	80,000	8	4
100	32 by 48	100,000	10	5
120	32 by 56	120,000	12	6
160	32 by 75	160,000	16	8
200	32 by 96	200,000	20	10
300	32 by 144	300,000	30	15
400	32 by 192	400,000	40	20
500	32 by 240	500,000	50	25

*NR = not recommended

Table 2. Sprinkler nozzle requirements based on holding pen capacity.

Holding pen capacity	Typical pen size (feet by feet)	Water required (gallons)***	Minimum flow rate (gpm)*	No. of 360° nozzles required**
40	24 by 32	20	10	14
60	24 by 42	25	12	20
80	24 by 50	30	15	27
100	32 by 48	40	20	34
120	32 by 56	45	23	40
160	32 by 75	60	30	54
200	32 by 96	80	40	68
300	32 by 144	120	60	102
400	32 by 192	150	75	136
500	32 by 240	200	100	170

* Flow rate based on a 2-minute on cycle with 10 minutes off.
** Assume nozzles have an 8-foot spray diameter and 0.5 gpm capacity.
*** Assumes 0.025 gallons (0.04) of water per cycle per sq. ft. of pen area is applied

Table 3. Recommended maximum PVC pipe length based on pipe diameter and flow rates and limiting the pressure drop to 5 pounds per square inch (no allowances made for fitting or coupling).

Pipe diameter (in)	Flow rate (gallons/minute)					
	10	20	30	40	50	100
½	50	Not Recommended (NR)				
¾	75	Not Recommended				
1	180	40	Not Recommended			
1¼	700	200	100	60	Not Recommended	
1½	1500	400	200	120	80	NR
2	4000	1400	660	400	240	80

not become so humid that cows cannot dissipate heat, which may lead to death of the cows if the holding pen is enclosed and/or too humid.

Water Supply

The target design is about 1 gallon per minute (gpm) per 80 square feet of holding pen. The water system should provide this flow at 15 to 20 pounds per square inch (psi) water pressure for the micro-sprinklers to work properly.

Most home or farm water wells with typical piping will be limited to a maximum of about 12 to 15 gpm. Pressure may be as high as 50 psi at no flow but will fall as the flow increases. A pressure regulator can limit pressure to 25 psi.

A rural water supply system may provide water depending on the size meter installed for the farm and the pressure on the main line. In many cases, even with a 1-inch meter, flow may not exceed 10 or 12 gpm at the pressure needed to operate a system. Pressure and flow can be improved by increasing the meter size, increasing the size of the service line from the meter to the barn and/or adding a booster pump. Adding a holding tank with a pump is another option.

System Size

A water system that will provide 12 to 15 gpm can service a holding pen up to 1,200 to 1,500 square feet with one sprinkler circuit. This will handle as many as 100 cows at 15 square feet per animal. Larger systems will require higher flow or zoning the holding pen so fewer sprinkler heads operate at one time. If 12 gpm is available for service, a 2,400-square foot pen could be sprinkled by operating two sprinkler circuits to wet half the pen per cycle. This requires adequate controls.

Sprinklers

Micro-sprinklers work better than larger sprinklers, especially with limited water supply and/or pressure, because more micro-sprinklers can be installed over the pen to provide better distribution of the water. Select those that have a flow rate of

about 0.5 gpm at 20 psi pressure. These are small landscape/shrubbery type sprinklers available at most stores where landscape irrigation supplies are sold. Typically, micro-sprinklers have a low angle of throw as the water leaves the sprinkler head, which is important to avoid wetting the roof structure in the holding pen. The radius of throw is typically about 7 to 10 feet, and the spray heads are available in full circle (360 degrees), half circle (180 degrees) and quarter circle (90 degrees). The micro-sprinklers allow for good design to conserve water. Some sprinklers have an adjustable valve built in for custom adjustment of the flow and throw of each head. **If sprinklers hang down, then a pressure-sensitive valve may be necessary to prevent drainage of water out of the pipes when the sprinklers are not under pressure from the pump.**

Figure 4. When hanging sprinklers, consider electrical wiring, rafters and other items affected by the sprinklers. Sprinklers that face up will not drain water when they are not under pressure from the pump unless the slope is great enough to allow the end sprinklers to be lower than the initial sprinklers.

Figure 5. Concrete in the holding pen with sprinklers should be rough or grooved so the cattle do not slip. The concrete also should be well-drained so the cattle do not stand in water.

Piping

All piping should be PVC plastic. Schedule 40 can be used; the less expensive Class 160 is also adequate. It also has the advantage of carrying more water with less friction loss because the wall thickness is less and the inside diameter of the pipe is bigger for a given size. Piping can be expected to carry the following flow rates up to about 100 feet without unreasonable friction loss.

1 inch = 15 gpm
¾ inch = 9 gpm
½ inch = 5 gpm

For longer runs, it is desirable to increase the pipe size to reduce pressure loss. See a pipe friction chart at your pipe dealer.

Main lines for sprinkler systems should generally be 1 inch or greater.

Lateral lines can be as small as ½ inch.

Design

For systems up to 1,500 square feet, use a 1-inch main line down one side of the holding pen. Cross the pen with ½-inch lateral lines every 8 to 10 feet. The piping must be supported at 3- to 4-foot intervals with high tensile wire or treated lumber.

Mount the sprinklers as low as possible but with enough space to allow you to drive a tractor or walk under them. Seven feet is the minimum height.

Install sprinklers in lateral lines about 7 or 8 feet apart.

Lateral line spacing and sprinkler spacing can be varied more or less by one or two. The amount of water placed in the pen will be adjustable by the run time set for each cycle. More water requires less sprinkler time, while less water will require the sprinklers to be on longer each cycle. If the fans are cycled off while the sprinklers are on, it is best to keep the sprinkler cycle to 2 minutes or less out of a 10-minute cycle.

Fans

Select 240-volt, ½-horsepower and 36-inch fans to blow air about 20 to 30 feet across or down a holding pen. They will cover an area about 8 feet wide. Larger 48-inch fans should have 1-horsepower motors and will blow air about 30 to 40 feet over an area about 10 feet wide. **Fans should be tilted about 15 degrees so the air is blowing on the cows.** A typical holding pen that is 20 to 28 feet wide will require three 36-inch fans every 20 to 25 feet of length or two 48-inch fans across the pen for each 30 to 40 feet of length. FANS MUST BE GROUNDED AND SHOULD HAVE GUARDS!

Controls

The fans can be run continuously or intermittently, but the water should be cycled on and off to avoid wetting the cows' udders and to keep the pen as dry as possible. It is generally unnecessary to run the water more than 2 minutes out of a 10- to 15-minute cycle. The system is more efficient if the fans are cycled off when the water is on so the droplets can fall on the cows rather than be blown out of the barn.

Figure 6. Adequate controls to regulate the amount of water are essential, both to conserve usage and to get the proper amount on the cows. An outlet to drain the pipes before winter and a valve to turn the water on and off are also required.

The water can be cycled on and off with a 1-inch lawn sprinkler valve in the main line. If lawn sprinkler valves are used, a 24-volt transformer is needed to reduce the voltage to the valve.

A 10- or 15-minute percentage timer that can be set to cycle the valve on for 1 or 2 minutes out of 10 is needed. **Do not run the fans directly through the contacts in this timer. Use the timer to control larger, heavy-duty power contactors.**

A heavy-duty power contactor for each fan circuit is needed to cycle the fans off when the water comes on. This should be a double pole contactor and can have either a 115-volt or 24-volt operating coil since both voltages will be available. The power contactor should be a minimum of 20 amps or, to prolong service life, at least double the amperage of the fan load circuit. Up to three fans can be operated on one circuit, but more fans will require adding fan circuits. One set of contactors is required for each fan circuit.

One additional small double-pole, double-throw relay is needed to cycle between the fan and sprinkler circuit. The contacts are wired so the control circuit powers either the "fan-on" or "sprinkler-on" circuits.

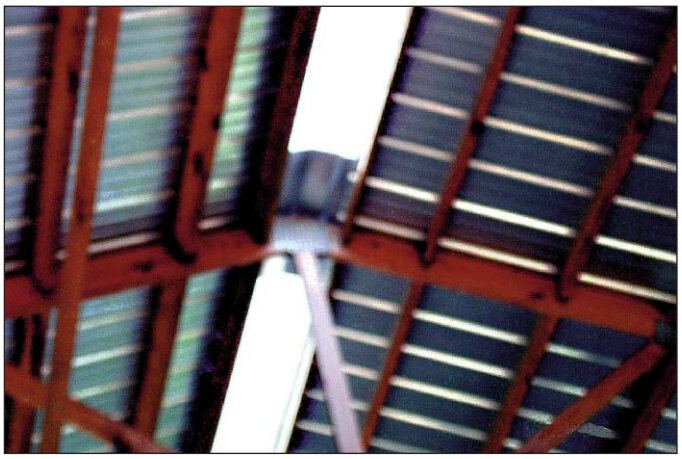

Figure 7. An open ridge row at the top of the holding pen allows heat and humidity to move away from the cows.

Figure 8. A pressure gauge and regulator can be beneficial in controlling variations in pressure from water systems.

Figure 9. Sprinklers that point up maintain pressure and fill more quickly than sprinklers pointed down.

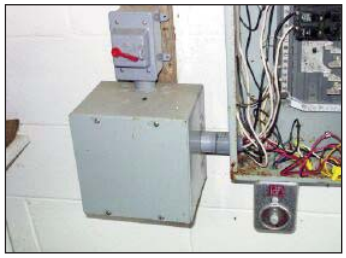

Figure 10. A percentage timer can control the amount of time for water and fans to run.

Summary

For most dairies in Arkansas, the installation of fans and sprinklers in the holding pen is an economical investment. In general, the goal of the cooling system is to provide 0.05 inch of water per cycle in ½ to 3 minutes, and then blow air on the cows for 10 to 15 minutes to increase evaporative cooling.

Acknowledgment: This publication was based on work done by John Langston, former Extension agricultural engineer, and Jodie Pennington, former Extension dairy specialist.

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FSA4019-PD-2-13RV