SPRAY COOLING DAIRY COWS
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Dairy cattle lose milk production and experience reproduction difficulties when exposed to conditions causing excessive heat stress. Techniques to protect cows from heat stress are:
- provide shade;
- provide fresh, cool drinking water;
- provide air exchange in confinement;
- sprinkle (wet) cows with water;
- and increase air velocity.

In tie stall barns, increasing air velocity is more practical than sprinkling. Freestall barns, yards with outside bunks, and holding areas can benefit from sprinkling. Sprinkling systems should apply water in large droplets (not a mist) to the cows' backs, wetting the cows to the skin. Cooling occurs when body heat evaporates the water. Research in Florida, Kentucky and California has demonstrated positive benefits from this process. Increasing air velocity (using fans) aids the evaporation process and thus improves cooling. However, adding fans and controls increases the system's cost.

Several factors should be considered before installing a sprinkling system to cool dairy cows. The following management issues will affect the selection of system components.

Water in Feed and Stalls

Sprinklers should be positioned so as to wet the cows while keeping stall beds and feed dry. Prevailing winds and/or fans could cause water to drift into stalls or onto feed. Aim the fans used near nozzles to minimize drift problems or turn them off while the sprinklers operate.

Water in Manure and Runoff

Not all of the cooling water applied to cows will evaporate. Some sprinkled water will come in contact with manure. Can the manure handling system cope with the extra volume of water in the manure? If the barn slopes, where will the contaminated water go? Will more frequent barn cleaning be needed to keep stall beds clean when the manure is wetter?

Water Supply and Delivery Capacity

When all sprinklers are operating, the water supply system must be able to deliver sufficient water at the design pressure, and satisfy all other farmstead water needs (drinking water, flush water, parlor/milkhouse needs, farm home, etc.) which could occur simultaneously. When the water supply flow rate (gpm) is limited, consider a reservoir for water accumulation during off periods. See Figure 31, page 25 of *Heating, Cooling and Tempering Air for Livestock Housing* (MWPS-34) for a schematic on how to arrange a reservoir system.

THE SPRINKLER SYSTEM

The system generally includes:
- a controller (timeclock) and thermostat;
- 180° and/or 360° sprinklers;
- pressure regulator;
- line filter, with flush valve;
- flexible pipe or tubing; connectors, valves, couplers, ties, elbows, hangers, goof plugs;
- pressure gage.

SELECTING THE COMPONENTS

Controller and Thermostat

The controller switches the system on and off with a solenoid valve automatically, either by setting a cycle run-time and time between cycles on a controller and/or with a thermostat.

Select a controller with a 30-minute timer. Plan to operate the system for 1 to 3 minutes on and 12 to 14 minutes off. The controller will open a normally closed solenoid valve. If the valve is in the delivery line, all branches of the distribution system will operate simultaneously. A valve/ timer combination in each distribution line can balance flow in a water supply limiting situation. Adjust the on-time to allow for best cow wetting (to the skin). Excessive on-time will cause wasted water to accumulate on floors (excess water in manure, puddles, possibly wet feed or freestall beds). It will also encourage cows to remain standing under the sprinkler far too long. The off period, and fans moving air over freestalls, will encourage cows to leave the sprinkled area to lie down.

A thermostat activates the sprinkling system when the air temperature exceeds a given set point and turns the system off when the temperature drops below this point. Use a thermostat with a switch designed to close on temperature rise (i.e., ventilation fan or air conditioner type applications). Recommendations are to set the thermostat for a range of 75 to 80°F. Experience and type of system design will determine the best set point for a given application.

Sprinklers

Fans and 180° sprinklers have been used successfully at or behind the manger; 360° sprinklers with a cone-shaped pattern have been used in holding areas and yards. Emitters or nozzles are available with flow rates of 1 to 25 gallons per hour (gph) and wetting patterns of 4 to 15 feet in diameter. For example, one 180° (half-circle) sprinkler can reach about 12 feet when placed at a height of 9 feet. A 360° sprinkler will have a 15-foot diameter pattern if placed 12 feet above the floor. Operating pressure is normally 15 to 20 pounds per square inch (psi) but can be up to 60 psi for some nozzles.

Locate nozzles out of the cow's reach (about 9 feet) and aimed to deliver the majority of water in the middle of the cow's back. Spacings of 4 to 10 feet have been recommended, based on nozzle

height and the spray pattern discharge angle of the nozzle. Select nozzles which emit large drops, not a mist, at a rate of 0.1 to 0.5 gpm, or 6 to 25 gph.

The sprinkler line will drain during the off-period. Check the time needed to fill the line and to get all sprinklers operating properly. If it is a minute or more, add the fill time to the operating time when setting the timeclock.

Pressure Regulator

A pressure regulator (often present) is used to reduce the delivery line pressure to the desired operating range of the sprinklers. Manufacturers will normally recommend an operating pressure.

Line Filter

A line filter, usually a Y-filter with a flush valve and a 200 to 500 mesh screen, will protect emitters from plugging with sand and rust particles.

Distribution Pipe/Tubing

Suppliers usually provide 1/2-inch poly-tubing on which to mount sprinklers. Long lines may require tubing of larger diameters because of high pressure losses. The poly-tubing is flexible, so it may need rigid supports. Flexible pipe (black plastic) may also need extra support. One method is to attach the flexible pipe/tubing to the top of the feed manger fence if it is about 9 feet high. Provide a valve or removable plug at the end of each lateral to flush sand and rust from the lines. Make sure you can drain the lines prior to freezing weather.

VENTILATION

Water evaporating in an unventilated space results in air with high humidity and little cooling capacity. Provide sufficient air exchange between the inside and outside to allow evaporated moisture to be removed from the area around the cows. Proper location, design, and management of naturally ventilated buildings will accomplish the objective, if the wind is blowing. When the wind is not blowing or is blocked from passing through the building, fans will be needed to accomplish the desired air exchange. Provide at least one air exchange per minute.

AIR VELOCITY

After air exchange requirements are met, consider increasing the velocity of air past cows to increase evaporation rate and cow cooling. Fan capacity used to accomplish air exchange can also be used to increase air velocity if fans are properly sized and located. When fans are not used to give air exchange, circulation fans aimed at cows can increase air velocity to a minimum of 2 mph (180 ft/min). Axial flow fans should be spaced no more than 30 feet apart for fans less than 36 inches in diameter. Larger fans can be spaced 40 feet apart. Paddle fans are also used to blow air downward onto cows. Aim axial flow fans to blow air along the barn length and slightly downward toward the

floor below the next fan in the series. Aim fans so sprinkled water does not blow onto feed or free-stalls. Consider switching fans off during sprinkling to keep water from feed and/or stalls.

System Design Examples

Consider two arrangements for a sprinkler distribution pipe in a 400-cow, 4-row drive through barn that is 400 feet long. Distribution pipes (laterals) are located above the two feeding alleys and all sprinklers operate simultaneously. In the first case, the supply line enters the barn at the center with four distribution lines branching into the four quadrants of the barn. In the second case, the supply line enters the end of the barn and branches into two distribution lines. Assume sprinklers are spaced at 10-foot intervals and each delivers 15 gph (0.25 gpm) operating at 20 psi.

Table 1 provides a friction loss for each pipe size at a given flow rate. Blank spaces represent a situation where the velocity is greater than 5 feet per second. At greater velocities, water-hammer can be a problem.

Table 1. Friction Loss in Plastic Pipe

FLOW RATE (gpm)	NOMINAL PIPE SIZE (inches)							
	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
	FRICTION LOSS (psi/100 ft of pipe)							
1	1.41	0.20	0.05	0.02	0.01	0.00	0.00	0.00
2	5.09	0.71	0.17	0.06	0.02	0.01	0.00	0.00
3	10.78	1.50	0.37	0.12	0.05	0.01	0.00	0.00
4	18.36	2.55	0.63	0.21	0.09	0.02	0.01	0.00
5		3.85	0.95	0.32	0.13	0.03	0.01	0.00
6		5.40	1.33	0.45	0.18	0.05	0.02	0.01
7		7.19	1.77	0.06	0.25	0.06	0.02	0.01
8		9.20	2.27	0.76	0.31	0.08	0.03	0.01
9			2.82	0.95	0.39	0.10	0.03	0.01
10			3.43	1.16	0.48	0.12	0.04	0.02
11			4.09	1.38	0.57	0.14	0.05	0.02
12			4.80	1.62	0.67	0.16	0.06	0.02
13			5.57	1.88	0.77	0.19	0.06	0.03
14			6.39	2.16	0.89	0.22	0.07	0.03
15			7.26	2.45	1.01	0.25	0.08	0.03
16				2.76	1.14	0.28	0.09	0.04
17				3.09	1.27	0.31	0.11	0.04
18				3.43	1.41	0.35	0.12	0.05
19				3.80	1.56	0.38	0.13	0.05
20				4.17	1.72	0.42	0.14	0.06
22				4.98	2.05	0.50	0.17	0.07
24					2.41	0.59	0.20	0.08
25					2.60	0.64	0.22	0.09
26					2.79	0.69	0.23	0.10

FLOW RATE (gpm)	NOMINAL PIPE SIZE (inches)							
	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
	FRICTION LOSS (psi/100 ft of pipe)							
28					3.20	0.79	0.27	0.11
30					3.64	0.90	0.30	0.12
35						1.19	0.40	0.17
40						1.53	0.52	0.21
45						1.90	0.64	0.26
50						2.31	0.78	0.32
55						2.75	0.93	0.38
60							1.90	0.45
70							1.45	0.60
80							1.86	0.77
90							2.31	0.95
100							2.81	1.16

NOTE: Friction losses are shown for flow velocities of 5 ft/sec
        or less, so water hammer will not be a problem.
Nominal I.D. = Inside pipe diameter.

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Table 2 recognizes that friction loss is reduced because multiple outlets reduce the flow. A reduction coefficient is provided to reduce pressure loss.

Table 2. Reduction Coefficient
for Adjusting Friction Loss in Pipe with Multiple Outlets.

Number of Outlets	Reduction Coefficient*
1	1.00
2	0.64
3	0.53
4	0.49
5	0.46
6	0.44
7	0.43
8	0.42
9	0.41
10 – 11	0.40
12 – 14	0.39
15 – 20	0.38
21 – 35	0.37
> 35	0.36

*Pressure Loss (psi) =
    Pressure Loss (psi)/100 ft [Table 1] $\times$ Pipe Length (ft) $\times$ Reduction Coefficient [Table 2].

CASE 1

In the first case, each distribution line is about 200 feet long with 19 sprinklers. Each line must receive 4.75 gpm (19 sprinklers $\times$ 0.25 gpm/sprinkler). Limit the pressure drop in the line to 20% of operating pressure or 4 psi. Using 4.75 gpm and Table 1, a 3/4-inch line would have a pressure loss of 3.53 psi/100 feet (interpolating between 4 and 5 gpm in Table 1). With 19 outlets, Table 2 reports a reduction coefficient of 0.38. The head loss (H_L) for each distribution line is:

$$H_L \ = \ (3.53 \text{ psi}/100 \text{ ft}) \ \times \ 200 \text{ ft} \ \times \ 0.38 = 2.68 \text{ psi} \ (< 4 \text{ psi}).$$

The supply line must provide 19 gpm (4 distribution lines $\times$ 4.75 gpm/line). The operating pressure will be in the 30 to 40 psi range. Applying the rule of permitting a 20% loss, the maximum pressure drop could be 6 to 8 psi. A 1 1/4-inch line would lose 3.80 psi/100 ft (Table 1). If the supply line is 200 feet or less, the pressure loss is acceptable. A longer line will require increasing the diameter to 1 1/2 inches.

CASE 2

In Case 2, the water supply line enters the barn from one end. The two distribution lines, each 400 feet long, must receive 9.5 gpm (38 sprinklers $\times$ 0.25 gpm/nozzle). Using 9.5 gpm, a 1-inch line and Table 1, and the pressure loss coefficient from Table 2, the pressure drop is:

$$H_L \ = \ (3.13 \text{ psi}/100 \text{ ft}) \ \times \ 400 \text{ ft} \ \times \ 0.36 = 4.5 \text{ psi}.$$

Selecting a 1 1/4-inch line yields a pressure drop of:

$$H_L \ = \ (1.06 \text{ psi}/100 \text{ ft}) \ \times \ 400 \text{ ft} \ \times \ 0.36 = 1.52 \text{ psi}.$$

A 1 1/4-inch diameter pipe would be very satisfactory for each distribution line. The water supply line selected in Case 1 carries the same total flow rate as in Case 2. The total pressure loss for the system is 4.64 psi (1.52 psi + 3.12 psi) which is less than the desired 5 psi total. It will take 9 gallons to fill the laterals in Case 1 and 25 gallons in Case 2. In both cases, the water supply must be able to deliver 19 gpm for 1- to 3-minute intervals every 15 minutes. If this is not possible, options for reducing the demand on the water supply system include:
1.   Controlling each branch of the system separately with multiple timer/solenoid valves that are scheduled to operate at different times. The flow then becomes 4.75 gpm for Case 1 or 9.5 gpm for Case 2.
2.   Using a reservoir and a separate pump. The reservoir could be filled at a steady pace from the water supply system and from clean wastewater sources (i.e., plate cooler).
3.   Using another source of water. Examples include a farm pond or rainwater cistern. When a pond is used, a chlorination system may be needed to control algae in the sprinkling system.

With a 3-minute on-time and a 12-minute off-time (15-minute interval) and a flow of 19 gpm, the amount of water entering the barn is 288 gph (19 gpm $\times$ 12 min/hr) or 1995 gallons in a 10-hour operating period. Not all of this water will enter the manure, but 30 to 50% may. This could be an additional 90 to 150 ft^3/day. For comparison, the manure produced by the 400 cows could be about 760 ft^3/day. Using larger flow rates will increase the amount of water in the manure storage.

CASE 3 -- HOLDING AREA

The 400-cow barn is divided into 4 quadrants with 100 cows in each group. The parlor is designed to milk each group in an hour. Therefore, cows are in the holding area for 4 hours per milking. Using 15 ft^2/cow in the holding area, the holding area is 1500 ft^2. A 20-foot wide holding area would be 75 feet long. Using a 360° nozzle with a 90° apex angle located 10 feet above the floor, a 10-foot spacing can be used between rows of nozzles. Using two rows of nozzles located 5 feet from each side of the holding area and 7 rows along the length of the holding area, a total of 14 nozzles are needed. At 0.5 gpm/nozzle, 7 gpm must be supplied to the holding area. If the supply line is 100 feet long, a 1-inch line will have a pressure drop of 1.77 psi (Table 1) when the flow rate is 7 gpm. Each of the two rows of nozzles is a distribution line receiving 3.5 gpm. The pressure drop in a 1/2-inch line will be:

$$H_L \ = \ (14.57 \text{ psi}/100 \text{ ft}) \ \times \ 75 \text{ ft} \ \times \ 0.43 = 4.7 \text{ psi}.$$

The total pressure loss becomes 6.47 psi (1.77 psi + 4.7 psi). This is larger than the 5 psi desired, so select a larger distribution pipe. Selecting a 3/4- inch pipe, the pressure loss becomes:

$$H_L \ = \ (2.78 \text{ psi}/100 \text{ ft}) \ \times \ 75 \text{ ft} \ \times \ 0.43 = 0.9 \text{ psi}.$$

The total pressure loss is then 2.67 psi (1.77 psi + 0.9 psi), well below the 5 psi desired. The 7 gpm will be an additional demand on the water supply system. Additional water in the holding area floor must also be handled.

Sources of Sprinkler Components

The following companies can supply various components for sprinkler systems. This list is not exhaustive. If you know of other sources, please contact the authors so these sources can be added to this list.

Circle B Agriculture Products
2540 Foothill Dr.
Vista, CA 92084
800 / 776-6947

Dairy Cool, Inc.
3555 Agricultural Center Dr.
St. Augustine, FL 32092
800 / 345-7930

Edstrom Industries
819 Bakke Ave.
Waterford, WI 53185
800 / 558-5913
     OR 414 / 535-5181

Farm Tek
RR 2, PO Box 17
Hopkinton, IA 52237
800 / 327-6835

Farnam Equipment Co.
Dept. HGM-102, PO Box 34820
Phoenix, AZ 85067
800 / 234-0592

Meter-Man, Inc.
2 S. Main St., PO Box 746
Winnebago, MN 56098
800 / 338-5756
     OR 507 / 893-4806
FAX: 507 / 893-3517

Nelson Irrigation Corp.
Route 4, Box 169
Walla Walla, WA 99362
509 / 525-7660

Rain Bird Sprinkler Co.
633 W. Foothill Blvd.
Glendora, CA 91741
818 / 963-9311

Senninger Irrigation, Inc.
6416 Old Winter Garden Road
Orlando, FL 32835
407 / 293-5555

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