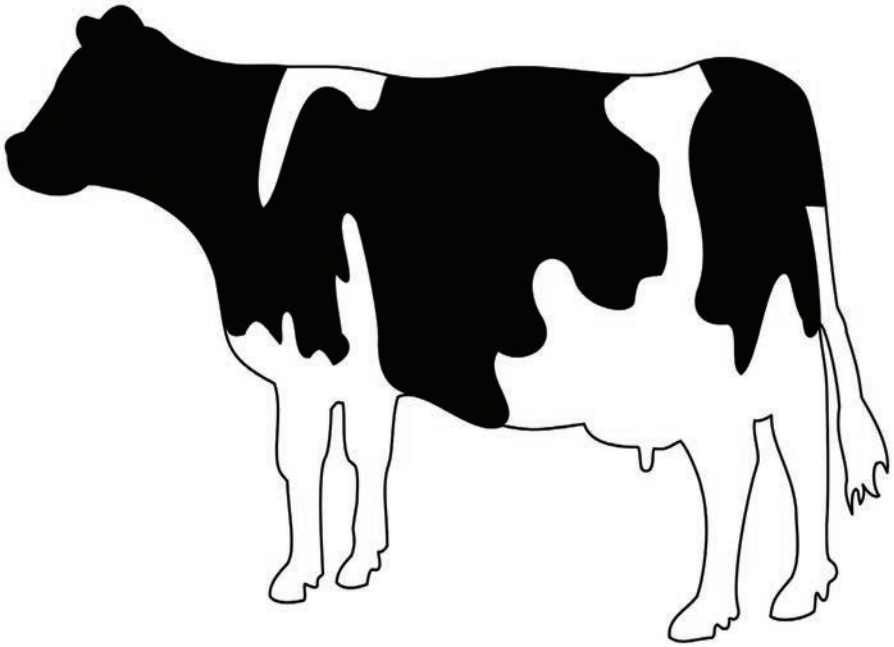
Cooling Systems for Georgia Dairy Cattle

Dr. John W. Worley, Extension Engineer



Heat stress can reduce summer milk production in dairy cows by 15 to 22 percent according to University of Florida research. The cow's natural defenses cause her appetite to be suppressed in times of high heat stress. Less feed intake naturally leads to less milk production. Reproductive efficiency also suffers in times of heat stress, costing dollars for delayed lactation and rebreeding fees. A number of strategies have been used successfully to reduce the heat experienced by cows, and thus increase feed intake and milk production during the summer.

Shade

The first and most basic step is to block solar radiation by providing shade. Trees provide effective shade, but usually die quickly with cows around them due to rubbing and soil disturbance. Trees can also be a dangerous place for cows in a lightning storm.

Portable shade cloth can be used. Usually, 2-inch diameter pipes are used for frames and hooks are provided for moving the cloth. Shade cloth is usually 12 feet from the ground with 50 square feet/cow provided. High density (75%+) shade cloth should be used.

Permanent shade structures can be used. These should be 16 feet high with a dirt floor, mounded to promote drainage. The structure should be oriented with the long axis in a north-south direction so the cows can follow the shade outside the roof, and the sun can dry out the dirt floor. Fans and foggers can be added for increased cooling effectiveness. See Figure 1 for a typical shade structure.

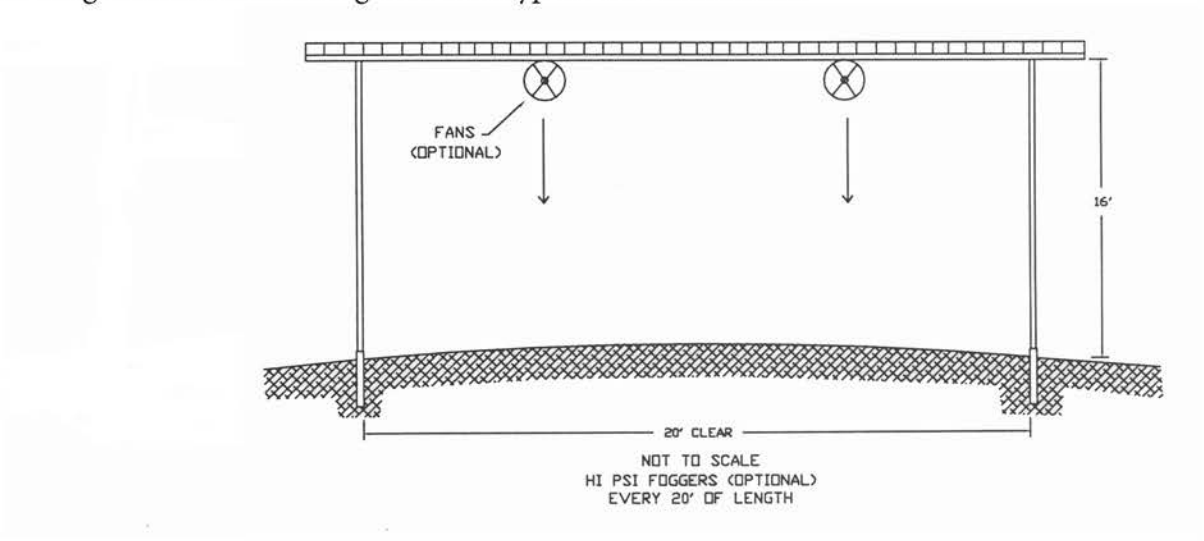


Figure 1. Typical Shade Structure

Barns provide shade, but have other functions and benefits as well. There are two main types of dairy cattle housing barns, feed barns and freestall barns. Feed barns are like freestall barns without the stalls, but are narrower than freestall barns (Figure 2).

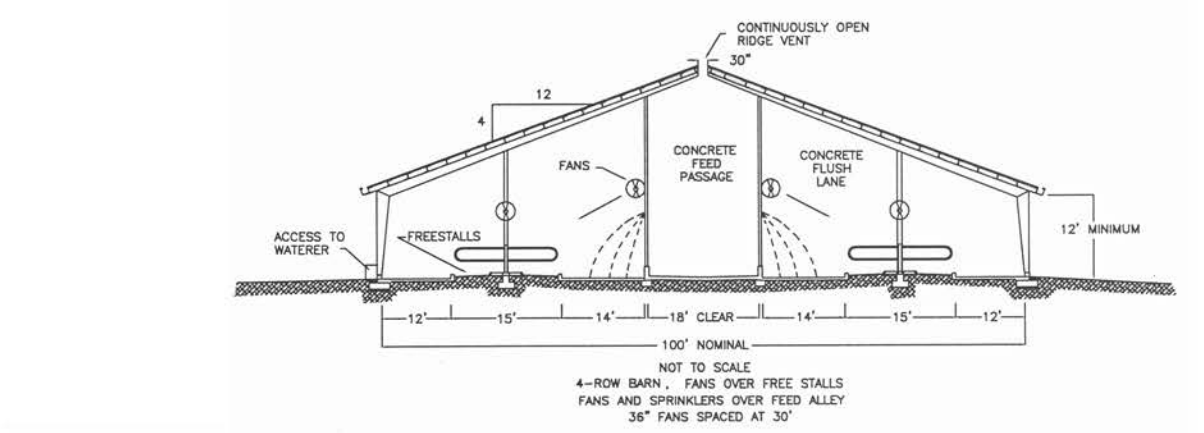


Figure 2. Typical Freestall Barn

Air Movement

Some air movement is provided by natural ventilation in feeding and freestall barns. This provides removal of stale, warm air, but does not provide enough airflow across the cow's body on days of high heat, high humidity, and low windspeed. Fans are needed to increase air flow across the cows' bodies. Fans can be added to permanent shade structures, feeding or freestall barns, and/or holding areas.

Evaporative Cooling

Fans cool by moving air over the body at a faster speed. They do not cool the air. When fans are not sufficient, additional cooling can be achieved economically using evaporative cooling. Research at the University of Florida showed a 10 percent increase in milk production for cows cooled by fans and sprinklers over those in freestalls with no additional cooling. Two types of evaporative cooling systems are available:

(1) Sprinkler systems wet the cows and then use fans to blow across the cows' bodies to evaporate the water and cool the cows. These systems work very well, but sometimes put a lot of water on the floor. They should be avoided if your water supply and/or your lagoon capacity are limited. In addition, wet floors can contribute to foot problems. Floors should be smooth with grooves for skid resistance to minimize foot wear.

(2) High pressure fogging systems cause water to be evaporated between the fan and the cow, thus cooling the air before it is blown across the cow. These systems waste less water and keep floors dryer, but require more management. Water must be kept very clean or the fogging nozzles will plug, thus filters must be checked, cleaned, or replaced as needed on a regular basis.

Barn Design Recommendations

- Roof pitch should be a minimum of 3:12 and preferably 4:12 pitch (4 ft vertical for each 12 horizontal ft.) A steeper pitch will allow moisture and gases to vent more quickly giving longer life to the roof and cooling the cows more effectively.

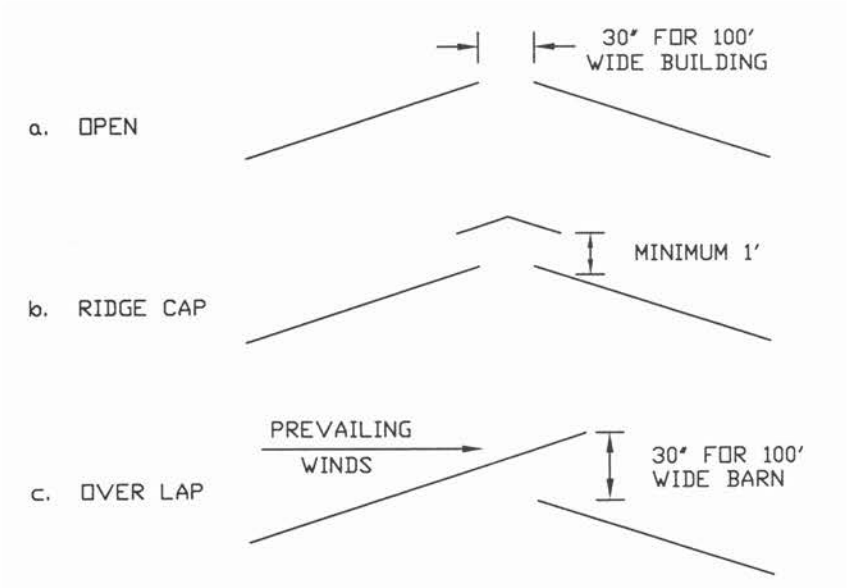


Figure 3. Alternative Ridge Openings

- The ridge vent (Figure 3) should be at least 1 foot wide plus 2 inches for each 10 feet of structure width over 20 feet (about 30 inches for a 100-ft wide building). The vent is best if uncapped (Figure 3a), but if necessary a ridge cap (Figure 3b) may be installed. It should have at least 1 foot of clearance between it and the roof peak. Another type of ridge vent extends one side of the roof over the vent (Figure 3c). If this is used, the open side should be away from prevailing winds (usually on the South side) to minimize rain entering the opening. This type should only be used if wind direction is fairly constant and known with certainty, since wind from the wrong direction keeps the system from working as designed. The feed alley should be sloped to the middle, to let any rainwater drain away from the feed.
- Eave height should be a minimum of 12 feet; 14 to 16 feet is better. Natural ventilation (ventilation without fans) uses wind and thermal buoyancy (the chimney effect) to provide air movement inside the barn. This air movement removes stale air and gases from the barn and also provides a cooling effect by passing air over the cows. The taller the barn the more natural movement is provided.
- Allow a minimum space of 50 square feet/cow.
- The floor should be concrete. If the floor is to be flushed, it needs a 1.5 to 2.0% slope. The finish of the floor is often the biggest mistake made in barn construction. In the southeast, flushing, fans and sprinkler cool ing will cause the cows' feet to be constantly wet. A rough finish will speed foot wear up to 20%, with cows being culled in the first three weeks of new barn occupancy due to lameness. The finish should be smooth with grooves 1/2" wide by 3/8" deep and spaced 3-4" apart.
- The feed alley should be 12 to 14 feet wide. This gives enough room for cows to move around behind cows that are eating. The alley between stalls should be 10 to 12 feet wide. The more room provided, the better. Wider alleys give more space and air movement, and more chance that cows will reveal signs of heat.
- Most southeastern barns are 100 to 105 feet wide and 300 to 500 feet long. This width seems to be the most efficient for four-row barns. Also, six-row barns do not provide enough space at the feed bunk for the extra population of cows. Six-row barns that have rows of stalls at the eave line are not desirable. The stalls are of ten wet due to high rainfall amounts and are in the sun many hours of the day. Six-row barns then need to be in the 140-foot-wide range to provide sufficient overhang to protect the cows from sun and rain.
- The length of the barn is determined primarily by the size of milking group, which is primarily a function of the type and size of parlor. Cows should not have to wait in a holding area over about one hour, so the num ber of cows in a group should be approximately the number that can be milked in an hour. A 300-foot, 4-row barn will house approximately 150 cows on each side and should be used with a parlor that will milk 150 cows per hour. The size of milking groups also determines the size of the premilking holding area, which should provide at least 15 ft^2 per cow in the milking group.
- Many holding areas (Figure 4) have high enclosed sides. These should be removed to provide ventilation during the warm weather and curtains used in cold weather. The ridge vent in the holding area should be large, (24" opening) to exhaust heat and moisture, especially when a cow wash system is used. The holding area often is where the cows experience the highest heat stress during the day, so it is important to provide good design here.

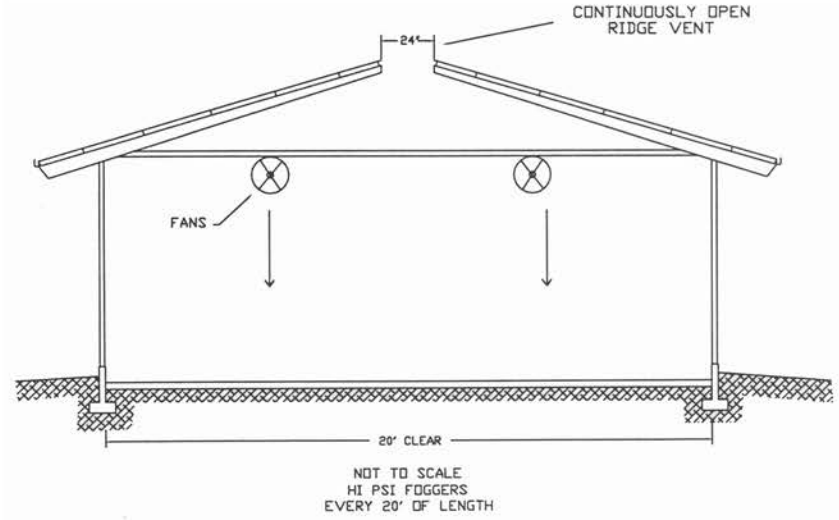


Figure 4. Typical Holding Area

Fan and Sprinkler Systems

Farm Requirements

- An ample water supply (25 gallons per cow per day). A separate water well, or reserve tank and booster pump may be needed to supply the short term high demand needed by the sprinkler system.
- A shaded area where cows are to be cooled; e.g., an open-sided barn.
- Facilities to collect and handle runoff water (sloped concrete floor).
- Adequate electrical service.
- Feed and water in close proximity to cooling area. **The cooling system is only effective if it results in more feed intake and milk yield.**

If these requirements cannot be fulfilled, other cooling methods should be considered.

Sprinkling and Fan Cooling Principles
(15-minute cooling cycles)

- Sprinkle cows for a short period of time, from 0.5 to 3 minutes, apply 0.05 inches of water per cycle; time enough to soak cows to skin, but before water runs onto the udder. Adjust the sprinkling cycle length until you get the wetness you want.
- Blow forced-air onto cows with fans to evaporatively cool them. The fans should run continuously.
- Use evaporative cooling in freestall barns, feeding barns, shade structures, holding areas and under shade cloth, or any covered area with a concrete floor.
- **Sprinkling without fans or fans without sprinklers WILL NOT result in an effective evaporative cooling system in the hot humid Southeast.**
- If possible, visit other existing installations in your area to see systems dairymen have made work.

System Design Principles
(Each application and installation will differ.)

- Timer: A 15-minute adjustable type, to control sprinkler cycle.
- Electrical remote control valve (solenoid): To turn water off and on; this should be the same diameter as water supply line to sprinklers.
- Thermostat: To control sprinkler and fans; sprinklers should shut off below 75 degrees F to prevent overcooling and chilling. Fans should be run all night unless the temperature drops below about 70 degrees F to allow cows to lose heat built up during the day.
- Pipe size: Depends on 1) length and area of facility to be sprinkled and 2) number of sprinklers and their flow rates. (See Table 1.) Remember that the water can come into the barn at the mid-point and go both ways. This will reduce the size of distribution pipe necessary, but the main supply pipe must be properly sized for all sprinklers that will be on at the same time. If the barn is divided into four quadrants with only one quadrant sprinkling at any given time, the main supply pipe can be sized smaller.

Table 1. Some pipe diameter guidelines.

Barn Length	Diameter of Pipe
Up to 100 feet	1¼ inches
100 to 200 feet	2 inches
200 to 500 feet	First 1/3 length, 3 inches Middle 1/3 length, 2 inches Last 1/3 length, 11/2 inches

- Pressure regulators: Low pressure sprinklers (10 psi) work best. A main pressure regulator can be installed at the beginning of the pipeline or smaller regulators on each sprinkler nozzle. Low pressure will produce larger droplets and less mist. Spray drift will be reduced, and larger droplets will better penetrate the cow's coat. Smaller droplets can create an insulating layer of water on the cows' coat which can actually make the cow hotter instead of cooler.
- Location of pipe depends on height of barn, posts or other attachment points, width of area to be sprinkled and height at which fans can be mounted. The pipe may be installed next to the feeding area (feed bunk) of a drive-through freestall barn or feeding barn. With 180-degree nozzles, throw water toward freestalls; in a wide feeding area, 360-degree nozzles may be installed in the center of the cow alley under the fans. They should be installed high enough so that cows riding other cows don't hit the pipes and so equipment can pass beneath, but low enough so water doesn't hit the fans or fans don't blow water where it is not wanted.

Selecting Sprinklers

If sprinklers cost only a dime each, they aren't good enough! The type of nozzles or sprinklers depends on many factors and may differ for each application. Sprinklers should have a base of at least 1/2 inch; most high capacity sprinklers have a 3/4 inch base.

- Choose the sprinkler to get the right spray radius at the water pressure at which you will be operating. This information should be provided by the catalog or sales information for the sprinkler.
- Determine where you will locate sprinklers. Next to the feeding area, you will want a 180-degree pattern. Over a holding area, you may want a 360-degree pattern. In a freestall barn with a 12-foot alley between the feeding area and freestalls, 180-degree nozzles should be mounted next to the feeding area (feed bunk). You will want a spray pattern with a 10-foot radius so the freestalls don't get wet. In this same barn, 360-degree nozzles mounted in the middle of the cow alley would need a 5-foot radius. **You must know your water pressure** to get the right spray pattern for each nozzle.
- Determine nozzle size. Nozzles will have specifications listing gallons per minute (gpm); use nozzles in the 0.5 to 2 gpm range. Water flow rate (gpm) combined with the number of nozzles on a pipeline will determine if your water supply line is the correct size.
- Determine nozzle spacing. Once you have determined the correct spray pattern for your nozzles and your water pressure, space the sprinklers as far apart as the radius of throw of each sprinkler. With an 8-foot radius, space sprinklers every 8 feet. This gives an overlapping coverage pattern.
- Determine the trajectory of the nozzles. If the fans are mounted low, you will need a flat or 5-degree trajectory so the spray doesn't hit the fans and motors.
- Install sand filters if necessary. If sand might clog the nozzles (usually not a problem with high volume nozzles) a filter can be installed in the water line before the first sprinkler.
- Install check valves. Check valves can be used to prevent backflow of water in the pipeline. These are effective at preventing water from draining from the system when turned off, but expect to maintain check valves.
- If the existing barn has low overhead clearance, sprinklers may be located beside or above the fans as long as water does not hit the fans. In this case, use a timer that shuts off the fans while sprinkling.

Fan Selection and Installation

In choosing fans, remember that a fan made by a company that specializes in fans for livestock facilities will tend to give longer life in the harsh environment it will be operating in. Comparisons are best made using perfomance data from an independent testing lab such as BESS (Bioenvironmental and Structural Systems Laboratory.) Manufacturers should be able to supply you with this information in their sales literature or you can go to the

BESS Labs Web site (http://www.bess.uiuc.edu/) to obtain the information directly. Without such independent information, it is impossible to fairly compare one fan with another. Air-flow should be compared at 0.00" of static pressure since these fans will not be operating against a vacuum.

- Efficiency (cfm/watt) is also measured by these testing labs and should be compared. A higher efficiency fan will pay dividends in the long run in the form of lower energy costs. A 36" fan delivering 11,000 cfm at 20 cfm/watt and running 4,000 hours/year at $0.10/ kWh will cost $220/year to run. If a barn has 30 of these fans, a 10 percent more efficient fan will save $660/year in electrical costs.
- A 48" fan with 1 hp motor delivers approximately twice as much air as a 36" fan (1/2 hp) and uses about twice as much power. It will not, however, throw air twice as far, so more power (and usually more initial cost) is needed to ventilate barns with 48" fans than 36" fans. Sometimes, pole spacing dictates the need for 48" fans. (It is usually easier to install fans on existing poles in the barn rather than hanging them from a high ceiling or rafters.) Otherwise, 36" fans are usually a better choice.
- A good 36-inch fan will effectively move air in a plume about 15 feet wide and 30 feet long in front of the fan. A 48-inch fan will create a plume 20 feet wide and 40 feet long. The direction of flow normally should be with the prevailing wind. There are some 36-inch direct drive 1 hp airplane propeller type fans on the market. These high velocity fans (16,000 cfm) will dry the cows faster, so sprinkler cycles may have to be adjusted to run more often.
- In barns, fans can be arranged in many ways. Fans can blow down alleys spaced according to the effective throw (generally 10 times its diameter) of the fan or blow diagonally across the barn if needed.
- In a freestall barn or drive-through feed barn with up to 15-foot-wide cow alleys, it is easiest to have fans blow down the cow alley; spacing for 36-inch fans should be every 30 feet; for 48-inch fans, every 40 feet.
- In wide loafing barns or feeding barns, the side-by-side spacing width of 36-inch fans should be 20 feet, whereas for 48-inch fans, the width can be 30 feet. This creates parallel paths of forced-air down the long axis of the cow alley.
- Fans should be tilted so that they blow down to the floor directly under the next fan.
- Holding areas require more fans because cows are packed more tightly than in barns. Thirty-six or 48-inch fans with at least 1/2 hp motors (sealed) should be placed in banks side-by-side across the holding area, usually blowing away from the parlor. A 24-foot-wide holding area should have three fans spaced 4, 12, and 20 feet across the width of the holding area. With 36-inch fans, the row of three fans should be every 30 feet down the long dimension of the holding area; with 48-inch fans, the row should be every 40 feet down the length of the holding area.
- Ask or hire an electrician to determine wire sizes. Always use 240-volt motors if possible to reduce wire size and help prevent stray voltage problems. Wire size depends on the number and size of fans used and length of wire needed. Wires sized too small will result in wasted energy and may result in shortened motor life due to voltage drop.
- It is usually best to keep the fans running during the sprinkling cycle. This saves wear and tear on belts and motors.

High Pressure Fogging Systems

- **Caution**: Use this system only in tall (12 feet plus), open sided and ridge vented barns.
- Research has demonstrated that high pressure fogger (200 psi) systems are equal to the fan and sprinkler systems in cooling cows. These systems cool the air instead of wetting the cow. Water is applied to the air where it vaporizes, absorbing the heat and cooling the air, which is then blown across the cow to more effec tively cool her.
- Enough fans and high pressure foggers to cool the entire area must be provided. The fogger nozzles attach to the front of the fan.

System Design Considerations

- **Freestall barns**: one set of fans and foggers over the feed lane, angled down and toward the freestalls. Taller, cooler barns may use a 30' spacing of fans; hotter or wider barns may need to add a second set of fans and foggers on the outside eave blowing toward the free-stalls at the same spacing.
- **Feed barns**: fans and foggers every 20 to 30 feet depending on the height of the barn, fan and fogger place ment over the feed lane, angled slightly toward the outside of the barn.
- As in sprinkler systems, holding areas require more fans because cows are packed more tightly than in barns. Thirty-six or 48-inch fans with at least 1/2 hp motors should be placed in bands side-by-side across the hold ing area, usually blowing away from the parlor. A 24-foot-wide holding area should have three fans spaced 4, 12, and 20 feet across the width of the holding area. With 36-inch fans, the row of three fans should be every 20 feet down the long dimension of the holding area; with 48-inch fans, the row should be every 30 feet down the length of the holding area.
- In holding area situations where cows are crowded together, it is a good idea to sprinkle the cows with water as they enter the holding area. This will provide additional evaporative cooling.

High Pressure Fogger System Components

- High pressure pump and pressure regulators capable of 200 psi.
- Twenty-four hour timer. The foggers run continuously above 78 degrees F from about 3 hours after dawn to 2 hours before dusk to prevent internal rainstorms and premature rusting or rotting of the barn. Fans should run all night unless the temperature drops below about 70 degrees F.
- Thermostat to shut foggers off below 78 degrees F, to prevent over-cooling.
- Five-micron filters to prevent nozzles from clogging.
- Three-quarter-inch PVC pipe able to withstand 200 psi is adequate for most applications.
- Adequate water supply (typically 12 gal/hr/fan, but check for your specific fan.).
- Adequately ventilated barn to prevent respiratory problems.

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