Questions and Answers about Heat Stress

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Why is cow cooling so important?

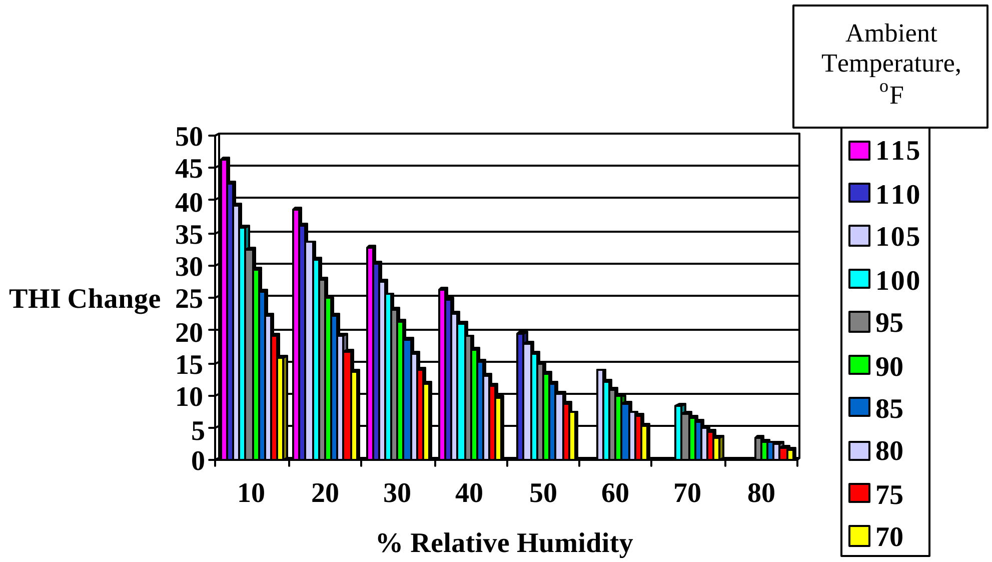
In 1978 Esmay discussed some data collected in the 1950's and 60's that dairy cows have a maximal sustained rates of evaporative cooling of about 30 BTU/ft^2/hr and 10 BTU ft^2/hr through non-evaporative cooling. However, to balance the total heat production rate of 55 BTU/ft^2/hr, an additional 15 BTU/ft^2/hr must be removed from the cow surfaces when the temperature ranges between 80 to 95^{o}F. It must be remember that genetics, milk production and feeding strategies have changed since this data was collected and thus heat production may be greater. Heat stress reduces intake, milk production, health and reproduction of dairy cows. The dry matter intakes of lactating cows under heat stress are reduced 6-16% as compared to cows in thermal neutral conditions. Heat stress depresses the dry matter intake of cows more than heifers. In addition to a reduction in feed intake, there is also a 30 to 50% reduction in the efficiency of energy utilization for milk production. Dairy cows can be cooled to reduce the effects of heat stress.

What options are available for reducing summer heat stress for cows?

Dairy producers have two options for cooling cows. These including cooling the air around the cow or cooling the body surface of the cow. In both cases, the objective is to increase the heat transfer from the body of the cow to the air. In arid regions, the air can be effective cooled using evaporative cooling. Evaporative cooling deceases the air temperature while increasing the relative humidity. In more humid regions, sprinklers and fans are used to soak cows to increase the evaporative heat losses from the surface of the cow. In humid climates, producers will want to use systems where they soak the cow and dry her multiple times per hour. Evaporating 1 pound of water off the cow's back requires 1,000 BTU's. The majority of this energy comes out of the cow's body. It is also important that air is a relative poor conductor of heat as compared to water. Thus, evaporating water to cool the air rather than evaporating water with heat from the cow's body reduces the overall efficiency.

Will a high-pressure system work under any environmental conditions?

A high-pressure system works in arid regions where evaporative cooling is effective in cooling the air. The following graph shows the potential change in the temperature humidity index at different levels of temperatures and relative humidity. As the relative humidity increases, the change in THI decreases regardless of temperature. Once the humidity exceeds 60%, the maximum reduction in THI is less than 15 regardless of temperature. At 80 ^{o}F, the humidity has to be less than 30 % before the THI is decreased more than 15 units. This figure is based on 100 % percent efficiency in the moisture exchange through the evaporative cooling. In hot, arid climates, high-pressure systems will reduce the air temperature.



How do you compare fans manufactured by different companies?

Fans are rated based on airflow delivered (CFM) at a given static pressure. The static pressure is the amount of resistance encountered by a fan as it tries to pull or push air through a building. Examples of resistance are moving air through an inlet or evaporative pad. In most freestall buildings, the fans operate at 0 inches of static pressure. The static pressure may increase to 1/10 to 1/8 inches in tunnel-ventilated barns. If the static pressure is above ½ inch, then the inlet area may be too small. Fan ratings are established using laboratory equipment and standards developed by the Air Movement and Control Association (AMCA). If a fan manufacturer test fans following these procedures, an AMCA label and certification can be listed in the company's literature. The AMCA seal is similar to the UL sealed used in testing other products. Fan performance data is then provided based on airflow delivered at various static pressures. As the static pressure increases, the airflow decreases.

Is there a difference between airflow rate and velocity?

The airflow rate refers to a volume of air being delivered while the velocity is the speed the air moves. Velocity is measured in terms of feet per minute (FPM or MPH) while airflow rate is measured in cubic feet of air per minute (CFM). The airflow rate is equal to the area times the velocity. Therefore if the area remains constant, as the velocity increases, the volume also increases proportionately. For example, the average volume of milk flowing through a pipeline during a minute is similar to the airflow being delivered by a fan. However, the speed the milk travels through the pipeline is the velocity.

What is a CFM?

CFM is an abbreviation for cubic feet of air per minute. One cubic feet is equal to a box that measures 1 foot by 1 foot by 1 foot. For example a typical 36-inch fan moves 10,000 CFM or 10,000 of these one foot cubed boxes of air each minute it operates.

Why is air velocity so important?

Research data shows that heat loss from a cow increases as the air velocity increases regardless of the wetting cycle. Hillman et al. showed as air velocity was increased from 0.4 mph to 4.4 mph the evaporative heat loss increased from 128 to 276 BTU's/hr/ft^2 with a 20 minute wetting cycle. Esmay (1978) states that evaporative heat loss depends upon the wetted area, difference in vapor pressure between the skin surface and air, evaporative constant, and the velocity to an exponential power. The velocity component is an important factor in determining the evaporative losses.

How does fan rating impact cooling cows?

The fan rating has an indirect impact on cooling cows. Research data shows optimal air velocities of 4 to 6 mph for cooling cows. Therefore, fans must be able to deliver the desired air velocity to effectively cool the cows. There is not a significant improvement in cow comfort or productivity when the air velocity exceeds 6 mph.

Can you have a fan with a high airflow output but low velocity? (Or vice versa)

The answer is yes, a ceiling fan is an example of a fan with high airflow rate (20,000 CFM or more) but a low velocity (less than 3 mph). A 1/10 hp ceiling fan turns about 200 to 300 revolutions per minute. This compares to a one hp vane axial fan that turns at 800 or more revolutions per minute and delivers 10,000 CFM. The ceiling fan more efficiently creates air exchanges within a building but the air velocity is much lower. Some of the new ceiling fans have higher airflow rates but turn at velocities less than 100 rpm's. These fans are very energy efficient but may not provide the air velocities necessary to improve cow comfort.

Is fan spacing and mounting height critical?

The maximum fan spacing is based on the axial fan diameter. At a distance 10 times the fan diameter, the airflow velocity will decrease approximately 75 %. The air velocity at the fan is approximately 1,200 feet per minute (13.5 mph) and at a distance 10 times the fan diameter the velocity is approximately 300 feet per minute (3.5 mph). Therefore, the maximum recommended spacing for a 36-inch fan is 30 feet and a 48-inch fan is 40 feet. The actual fan spacing is often determined by the post spacing in the freestall building. Often if support posts are 12 feet on center, 36-inch fans are placed every 24 feet. Buildings with post spacing of 13-20 feet often using 48-inch fans on every other post or at 40-foot intervals. Buildings with post spacing greater than 21 feet but less than 36 ft should consider mounting 36-inch fans on every post.

Fans should be mounted 7 to 8 feet above the surface the cows are standing or laying on. The velocity of the air exiting a fan decreases as you move further from the fan. The air pattern is similar to a funnel with the fan blowing air from the small end of the funnel back towards the larger end. When fans are mounted high, the fan spacing has to be decreased in order to maintain a 3 to 4 mph breeze across all of the stalls or along the feedline. In some cases, it may be necessary to train employees on proper equipment operating procedures to avoid damaging fans that are mounted lower. Fans should be tilted down about 15^o , for example the top of a 36 inch fan should lean out about 8 to 9 inches further than the bottom of the fan.

Is fan maintenance important?

Poor fan maintenance may reduce fan efficiency by 40% or more. Annual cleaning of the fans is recommended. If the blades become out of balance due to difference in dust accumulation, the life of the fan will be shortened. Manufacturer's recommendations for cleaning and lubricating the fans should be followed. The control system should be checked weekly to insure the thermostat and timers are correct. Often thermostats are only within plus or minus 5 ^{o}F of the dial reading. Therefore, using a thermometer to measure air temperature and compare it's reading to the thermostat setting is recommended. The bigger maintenance problem is timely repairs to fans when they are damaged by equipment or malfunction.

Question and Answers about Sprinkler Systems

Does water line pressure impact cow cooling?

Water line pressure does not directly impact the cooling of cows. Adequate line pressure must be available for proper nozzle and check valve operation. The most important component is to make sure adequate water is delivered to each nozzle.

Why is pipe size important when installing a low-pressure system?

Pipe size is important in order to ensure adequate water is delivered to the sprinkler system. The pipe bringing water from the water supply to the freestall barn must not only meet the demand of the sprinkler system but also the water troughs. If the pipe is to small, then water may not reach the sprinkler nozzle farthest away before the on cycle is completed. When this happens, cows can only be wetted along a portion of the feed line and heat stress problems may be increased since the cows will tend to bunch and feed at one end.

What impact does the length of feed line have on a low-pressure system?

The length of feed line does not impact the low-pressure system as much as what is the length from the where the water enters the feed line sprinkler system to the farthest nozzle. Using the 0.05 inches of water, the water used per 2 ft headlock or feeding space is approximately 0.4 gallons per cycle. A feed line that is 400 ft line requires a flow rate of 25 gallons per minute (gpm) using a 3-minute on and 12-minute off sprinkler cycle. If the water enters at one end of the feed line, then the sprinkler pipe size should be 1 1/2 inch. However, if the water enters in the middle of the feed line, then the sprinkler pipe size can be reduced to 1 1/4 inches. The longer the pipe length, the larger the pipe size required to ensure adequate water is delivered along the entire length of the feed line.

Is there a correlation between pipe size and nozzles used in low-pressure systems?

The recommended pipe diameter for different nozzle capacities is based on feed line length. The nozzle capacity influences the time required to apply 0.05 inches of water per on-cycle. The table below shows the recommended pipe diameter based on different nozzle capacities. The nozzles used in developing this table are nozzles used to spray agricultural or horticultural crops. The spray pattern allows them to be spaced 8 feet on-center.

	NOZZLE CAPACITY (gallons per minute)						
Pipe Diameter (inches)	**0.5 gpm**		**0.75 gpm**		**1.0 gpm**		Inlet Water Demand (gpm)**
	Feedline Length (feet)	Number of Nozzles*	Feedline Length (feet)	Number of Nozzles*	Feedline Length (feet)	Number of Nozzles*	
1.00	200	25	140	18	100	12	12
1.25	320	40	210	25	160	20	20
1.50	480	60	320	40	240	30	30
2.0	800	100	530	70	400	50	50
2.5	1600	200	1000	125	800	100	100
On Cycle for 0.05 in	2.5 minutes (150 seconds)		1.7 minutes (100 seconds)		1.25 minutes (80 seconds)		

* Assume nozzle spacing is 8 feet on center using the agricultural spray nozzles with a minimum of 20 psi pressure at the outlet of the nozzle.
** Water demand based on a maximum of 5 feet per second flow velocity in the pipe.

What are the most common mistakes made when installing systems for cow cooling?

The most common mistake made is not being prepared. Most producers begin to worry about heat stress to late and are not prepared when the first heat wave arrives. In the northern half of the United States, systems should be ready by April 1st, central states – March 1st and southern states, February 1st. Common mistakes made with the fan systems include placing fans to far apart and mounting fans to high. The most common mistake made with sprinkler systems is installing pipe that is to small to deliver the quantity of water necessary. This assumes there is an adequate quantity of water being delivered to the housing area. Unless there has been planning, in most cases the water system cannot handle the demands placed on the system by the sprinkler system and then system performance is compromised.