

Dairy Heat Stress Management and Energy Use Planning Guide

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Heat Stress Management Planning

Planning for heat stress involves:

1. Understanding the negative impacts of heat stress
2. Identifying and evaluating weather and facility heat stress risks
3. Setting goals and developing a plan to reduce heat stress
4. Implementing the plan
5. Monitoring plan effectiveness regularly and adjusting as needed

Heat stress exposure can be short term, a few days at a time during the summer months, or long term, when very hot weather lasts for months at a time (ex. Florida or Arizona). It also depends on the humidity of the area (ex. Florida vs. Arizona) because at similar ambient temperatures cows in humid climates will suffer more heat stress than in drier climates due to higher temperature humidity index (THI) values. Heat stress can depend on the housing and management practices in place. Heat stress impacts calves, heifers, dry cows, and lactating cows to varying degrees. Heat stress can lead to reduced feed intake, poor animal well-being, decreased milk production, reduced body condition and pregnancy rates, reduced heifer growth, pregnancy loss and animal deaths.

A heat stress management plan provides a basis for evaluating animal well-being and production gains/losses against the increased costs of implementing heat abatement methods. A heat stress management plan also identifies areas for improved energy

efficiency in relation to milk production and animal comfort.

Figure 1 shows key components to the development and maintenance of a heat stress management plan. The components are described in more detail in this factsheet. For each section, a suite of measurements or tasks are described that can be adapted into a custom heat stress management plan for a dairy, regardless of size. Managers can divide tasks into cool or hot season tasks. For example, cool season preparation may include evaluating previous year's abatement methods and records, performing maintenance on equipment, and planning for upcoming heat stress periods by making changes as necessary to continually improve cow performance and well-being. During hot seasons, all caretakers should monitor weather, animals and facilities to make timely adjustments to minimize negative effects of

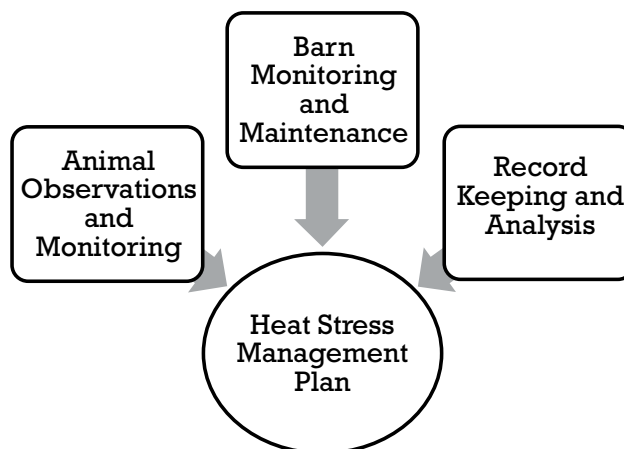


Figure 1. Components of a heat stress management plan.

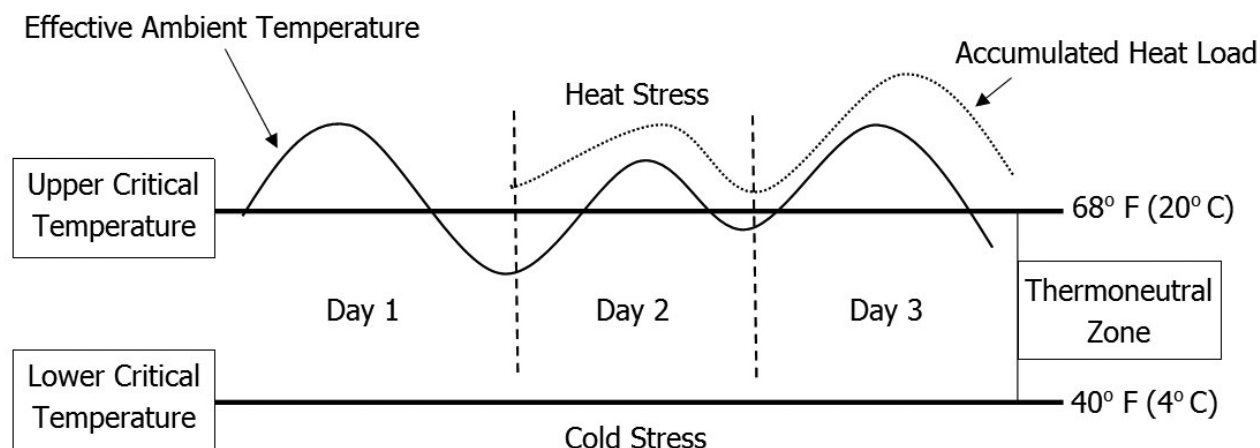


Figure 2. Dairy cattle thermoneutral zone and heat load over a given time period.

heat stress and keep records for future management decisions.

Heat Stress Management Plan: Recognizing The Risks

Between the upper and lower critical temperatures is the cow's thermoneutral zone (Figure 2). The thermoneutral zone is the environmental conditions where a cow does not expend extra energy to either cool or heat its body; this is between 40° to 68°F for a lactating dairy cow. Heat stress occurs when the effective ambient temperature rises above an animal's upper critical temperature eliciting physiological changes to reduce the heat load in the body. Heat stress negatively affects all ages of dairy cattle.

The effective ambient temperature is the combined effect of air temperature, humidity level, and air movement on perceived temperature. When the effective ambient temperature is above the upper critical temperature for a period of time, heat accumulation or "heat load" results. If the effective ambient temperature drops back within the thermoneutral zone, a heat recovery period can occur. Periods of heat recovery can balance out the heat load each day to alleviate heat stress before the next day. Accumulated heat load is seen when several hot days with high night temperatures and humidity occur (Figure 2). Using a THI can help estimate heat stress in dairy animals (Table 1). However, for animals housed in open lots exposed to the sun, the THI underestimates heat stress because it does not take into account

solar radiation. Dairy cows can begin experiencing heat stress when the THI reaches 68 units and high producing cows may experience heat stress at lower THI values (Collier et al., 2012). Data shows that after 17 hours of exposure to an average THI of 68, cows may decrease milk yield by almost 5 pounds per day (Collier et al., 2012).

Table 1. Temperature humidity index (THI) values and corresponding cow responses			
THI Range	Heat Stress Level	Respiration Rate (bpm)	Cow Body Temperature
68–71	Mild	> 60	101.3°F (38.5°C)
72–79	Mild-Moderate	> 75	102.2°F (39°C)
80–89	Moderate-Severe	> 85	104°F (40°C)
> 90	Severe	> 100	106°F (41°C)
Adapted from Collier et al. (2012)			

As the THI increases, cows begin to sweat and breathe faster. Once increased respiration and sweating are not enough to maintain body temperature, cows begin open mouth panting and increase standing time in an attempt to stay cool. Excessive open mouth breathing can lead to drooling with losses of bicarbonate-rich saliva, which can contribute to rumen acidosis. Cows that are open mouth breathing have been observed to have body temperatures above 104°F. Embryo damage and pregnancy loss can occur when cow body temperatures exceed 102.2°F (Bailey, 2012). The cow also makes changes to feed and water

intake. Decreasing feed intake is a way to reduce heat generation from fermentation of the feed in the gastrointestinal tract. As a result of the decrease in feed intake and increase in water intake, a change in manure consistency may be observed. Additionally, decreases in milk production and milk fat will result.



Figure 3. Example of open mouth panting.

Practices for Managing Heat Stress

Having knowledge of the physiological effects of heat stress on dairy cattle is essential for understanding why certain cooling practices are effective for minimizing negative impacts on production measures. When heat stress occurs it is recommended to look at existing cooling practices and optimize those available. Long-term, monitoring of the animals and facility may identify opportunities to incorporate additional cooling strategies through management or infrastructure.

There are several effective nutritional and environmental practices that can help minimize the negative effects of heat stress on animal well-being and productivity.

- Shade reduces solar radiation heat. Ideally pastures and lots should have either temporary or permanent shade structures that allow all animals to utilize shade simultaneously (25 square feet per calf; up to 50 square feet per cow). Some basic structure recommendations can be found in the factsheet *Heat Stress in Dairy Cattle* from the University of Arkansas (Fidler and VanDevender, FSA3040). Evaluate barns to determine if additional overhangs may be beneficial to provide extended shade at certain times of the day; this is especially important to ensure feed bunks are in continuous shade to encourage comfortable feeding.
- Barn ventilation cools cows by providing air exchange between the inside and outside. The recommended air exchange rate during hot weather is 470 cubic feet per minute (cfm) for each 1,400 lb cow (MWPS, 2013). Air exchange can be either natural (wind) or mechanical (fans). In hot weather, provide maximum ventilation to facilitate the cows' physiological cooling efforts. For a naturally-ventilated barn, this means maximizing the open sidewall area. In mechanically-ventilated barns, air may be pulled in through an end wall, flow lengthwise through the barn, and be exhausted by fans out the opposite endwall (tunnel-ventilated). Another popular design is when air is pulled in through a sidewall, flows across the pens or rows, and is exhausted by fans out of the other sidewall (cross-ventilated). During hot weather, we can expect that the fans will be running almost continuously and the inlets are wide open. Well-maintained and operated ventilation system components (fans, inlets, control settings) provide the most cooling performance per unit of energy.
- Mixing fans, or cooling fans, hung from rafters or trusses create air movement during hot weather to help cool cows by blowing air past or over the cows. Mixing fans do not provide air exchange between inside and outside the barn but they supplement the cooling effect of ventilation and aid in evaporative cooling efforts.
- Low pressure sprinklers in combination with air movement along feed bunks or in holding areas wet the cows' skin to provide evaporative cooling. Low pressure sprinkler systems should cycle on and off. The cow's body transfers heat to evaporate the water and cools the cows when the sprinklers are off. Mixing fans enhance the effect. DO NOT use sprinklers in holding areas without fans; it creates a "sauna" effect in the holding area. Details on cooling in holding pens can be found in the factsheet *Cooling Dairy Cattle in the Holding*

Pen by the University of Arkansas (VanDevender, FSA4019). Additional research results on strategies for cooling in pens can be found in the article *Strategies to Improve Dairy Cows' Feed Intake during Heat Stress by South Dakota State University* (Díaz-Royón and García, 2014).

- High pressure misters cool the air temperature by creating a fine mist or small droplets that absorb sensible heat from the air to evaporate the water. The droplets need to evaporate before they hit the stalls or bedding. Misters are either located near mixing fans or near inlets. Misters are not as effective when ventilation blows the mist out of the barn before the air cools.
- Evaporative pads cool and humidify the inlet air in low-profile cross-ventilated barns. The pads need to be uniformly moist for best effect. Fresh water needs to be added regularly. Mineral accumulation and algae growth need to be monitored and managed. Evaporative pads require a high amount of maintenance to remain effective.
- Dairy animals need plenty of clean fresh drinking water access. Check water flow rates and amount of waterer space to provide enough capacity to refill drinking fountains under high stress times or provide additional temporary water sources. Provide 3 to 4 feet of accessible linear water space per 10 cows and place waterers within 80 feet of any stall in the barn. A minimum of 2 water locations per pen of cows is needed.
- Consider nutritional changes, such as using high quality forage, higher percentages of grain, or adding supplemental fats to the diet. Work with a nutritionist to balance diet changes and minimize the risk of acidosis.
- Electrolytes and minerals (Na^+ , K^+ , Mg^+ , HCO_3^-), yeast, or fungal cultures and niacin can also be added to the feed or water as recommended by a nutritionist.
- Changes to the feeding time and frequency can promote continued feed intake. Feeding 60 to 70 percent of the ration in the late evening and early

morning can have positive impacts on milk yield. This strategy promotes fewer flies around the feed, which may decrease the total insect population in the barn.

- Ensure adequate bunk space during times of extreme heat. All cows should be able to eat at the same time without overcrowding.

Heat Stress Management Plan: Animal Observations And Monitoring

As warm weather approaches, monitoring animals, facility, and production records, can help identify when heat stress is likely to occur. The information can be used to prioritize actions for heat stress abatement, and evaluate the effectiveness of a heat stress management plan over time. The following provides a list of activities that can be adapted to the animal monitoring component of a custom heat stress management plan for a dairy.

Animal observations are vital to identify heat stress in a timely manner and to consider future improvements to one's heat stress management plan. Respiration rate is the best indicator to alert animal caretakers of current heat stress situations. Production parameters are typically impacted by heat stress events occurring in previous days from the observation date, so these measurements may be more useful in evaluating the year's heat abatement methods overall and deciding what improvements can be implemented the following season.

When and where to take measurements?

Every animal responds slightly different to heat. Observing and monitoring every cow is not feasible in most cases, but observing 10-20% of the animals, or a minimum of ten animals, in a pen, area, or group can suffice. Important considerations before taking measurements to determine appropriate observations in an operation include:

- The highest producing cows with higher intakes will likely undergo heat stress sooner than lower producing cows with lower intakes.
- Microclimates can exist within a barn or pen with varying temperatures, airflow, and humidity levels.

- Lactating cows, dry cows, calves, and bulls will likely be in different locations on the operation.

When taking animal measurements, the goal is to get an accurate picture of heat stress throughout the entire operation for animals at every age and stage of production. Managers and animal caretakers should be aware and communicate observed signs of heat stress to implement in a timely manner the heat stress management plan that minimizes negative effects.

Monitoring animals in one's facilities at various days within each season, including spring, fall, and winter, in addition to summer, gives a more complete picture of animal responses to temperature conditions below, at, and above their thermoneutral zone. Measuring cow responses during conditions in the thermoneutral zone provides a baseline for comparison during heat stress periods for one's specific genetics. Recording seasonal animal responses provides valuable information to evaluate one's current heat abatement methods and determine if additional improvements can be made to optimize production and minimize energy costs.

What measurements to take and how to take them

1. **Respiration rate** – Respiration rate is the most practical way of measuring heat stress. A cow's normal respiration rate is 10 to 40 breaths per minute. Respiration rates of 60 breaths per minute or more indicate cows are experiencing heat stress. To take a cow's respiration rate, observe the movement of the cow's flank and rib area as the cow breathes. A cow's nostrils can also be observed for inhalation and exhalation to count the respiration rate. However, if cows are open mouth breathing, watch the cheeks. Observe the cow for 15 seconds counting the number of breaths, complete inhalation and exhalation cycles, and multiply the number of breaths by 4 to get the number of breaths per minute. Note areas of the barn that have a higher frequency of animals exhibiting open mouth breathing and the reasons or potential sources of environmental differences between areas. Record respiration rates and the number of open mouth breathing in 10 to 20% of the animals in each pen. Making at least one observation in the morning before feeding will

allow caretakers to see if the cows fully recovered overnight from the previous day's heat load. Cows that have recovered should have normal respiration rates.

2. **Coping behaviors and cow comfort** – Cows that have access to comfortable lying surfaces will spend 12 to 14 hours a day lying down and have been shown to have increased milk production. When a cow's body temperature rises, she spends more time standing to maximize heat loss through her skin's surface area. Observing the proportion of cows standing as compared to lying is most influential for noting areas of the barn where few or no animals are lying down. Evaluate the environment at cow level to see if improvements can be made to increase cow comfort and promote rest during hot weather.

Some means for quantifying visual observations are a cow comfort index, stall use index, and stall standing index (Garcia and Endres, 2008). These calculations can be performed with a proportion of the animals, as long as a random group of animals is observed.

Cow comfort index = $[(\# \text{ cows lying in stalls}) / (\# \text{ cows lying} + \# \text{ cows standing in a stall})] * 100$

Stall use index = $[(\# \text{ cows lying in stalls}) / (\# \text{ cows not eating})] * 100$

Stall standing index = $(\# \text{ cows standing or perching in stalls} / \text{all cows in stalls}) * 100$

The cow comfort index should realistically be around 80 and be measured before the cows are disturbed in the morning (2 hours before milking). The stall use index should be around 75 and the stall standing index has been shown to range from 6 to 35%.

Seeking shade is a natural behavioral response by cows to lower their body temperature. Access to shade should be available during summer months to all calves, heifers and dry cows to provide relief from solar heat. For the given environmental conditions, monitor the number or percent of animals that have access AND are using the shade.

Bunching, or crowding, behaviors are typically observed as heat rises. Bunching may help cows swish flies from one another, but it also creates an environment that encourages more flies because of manure and urine build-up in a single location. Bunching also decreases air flow for individuals in the middle creating potentially higher levels of heat stress. Note where cows congregate to determine if changes need to be made to water placement, shade, or other resources. Consider insect repellants or other pest management programs to minimize negative effects and improve cow comfort.

3. **Feed intake** – Cows spend 3 to 5 hours a day eating (9 to 14 meals). Heat stressed cows have lower dry matter intake (DMI), resulting in decreased milk production. Consult with a nutritionist to make diet formulation and feed management changes at the beginning of the summer to prepare for heat stress. Monitor daily feed intake closely during periods of heat stress to measure how much it decreases to anticipate a subsequent drop in milk production.
4. **Water intake** – Water consumption assists animals in cooling. Cows tend to consume 30 percent of their daily water intake (50 to 60 gallons per cow during hot weather) after leaving the milking parlor. Provide at least 3.5 linear inches of waterer space per cow and adjust fountain flow rates to 6 to 7 gallons per minute to supply adequate water availability. A minimum of 2 tanks per group is recommended and additional waterers could be considered throughout the barn and return walkways during periods of heat stress. Monitor waterers and fountains closely to ensure sufficient water intake.
5. **Milk production** – Milk production is negatively impacted by heat stress events. Managers and caretakers monitor production closely and likely know when cows have been stressed by observing a reduction in milk yield. Reducing the percentage drop in milk production from month to month or year to year can be used as a measurable indicator of the success of a heat abatement plan.

6. **Milk fat** – Milk fat is negatively impacted by heat stress events and achieving higher concentrations over time during periods of heat stress can be used as a measure of the success of a heat abatement plan.

7. **Reproduction** – Conception and pregnancy rates are negatively impacted during periods of heat stress and can be used to evaluate the success of a heat abatement plan.

An example animal monitoring record sheet (Figure 3) is provided. Recording these animal parameters regularly will help managers evaluate how cows are coping within their facilities. Managers can use the animal monitoring records in conjunction with the facility monitoring records to determine if the optimal barn settings have been achieved and are being maintained during times of heat stress.

Heat Stress Management Plan: Facility Monitoring And Maintenance

Dairy barns and ventilation systems are designed to economically and safely provide animal comfort and facilitate feed delivery, manure collection, ventilation, and cow movement between areas. Construction, site layout, barn age and other conditions influence how

Energy Assessments

An energy assessment is a systematic examination and evaluation of a dairy operation's equipment and energy use data. When performed by qualified personnel in accordance with ANSI/ASABE Standard 612, producers and business owners are eligible for local, state and federal energy conservation programs.

During an assessment, in cooperation with a producer, the assessor will obtain at least one year of gas and electric use records from the farm's utility suppliers. The assessor will also conduct a thorough farm visit to identify and inventory equipment that uses energy. With special software, farm energy assessors can assess energy use and identify potential ways or equipment to save energy. A good farm assessment will also identify opportunities for financial assistance.

the barn performs and the degree that the desired conditions are met.

Monitoring barn temperatures, relative humidity and air speed at cow level can be used to assess how well the barn and the equipment are performing and when additional cooling practices are needed. Combining these measurements with animal monitoring and production and electricity/water use records can help provide a picture of how production is affected during weather extremes.

What measurements to take and how to take them

Electronic and/or mechanical sensors ranging from approximately \$50 to \$200 exist for many of these measurements. Sensors should be checked annually against another to confirm that they are reading correctly. Some sensors have logging or recording capabilities and can be put in place to collect data over several hours, days or months. The advantage of data collected over several days and weeks is that they describe what is happening at night as well as during the day. However, a device is needed for each location of the operation to be monitored simultaneously, which is added cost. Some devices do not have logging capabilities, but still provide a spot-check of current conditions and one sensor serves multiple locations. Consistent data collection at the same times and locations can provide a good record of barn conditions. If disagreements arise between sensor readings consider contacting your local Extension Specialists or another professional to check the accuracy of the readings.

- **Temperature** – There are numerous electronic and mechanical instruments that measure air temperature. Most of these devices measure dry-bulb temperature.
- **Relative humidity** – Electronic instruments are most commonly used to measure relative humidity. Relative humidity is measured in percent and is dependent on air temperature.
- **Dew-point temperature** – Some electronic devices that measure relative humidity calculate dew-point temperature. The dew-point temperature is the temperature at which moisture

starts to condense from the air. Dew-point temperature is not dependent on air temperature and can be used as a good estimate of the amount of moisture in the air. If a relative humidity sensor is not available, the dew-point temperature given in local weather reports can be used as an estimate of the moisture in the air for the next several hours.

- **Temperature Humidity Index** – There are numerous instruments that measure both temperature and relative humidity and calculate the Temperature Humidity Index. Managers may be interested in exploring the use of mobile Smartphone applications (e.g. Thermal Aid®, The University of Missouri) that measure current THI for either dairy or beef breeds and has some data tracking abilities for respiration rate along with management tips.
- **Air speed** – From an animal comfort perspective, monitor the airspeed in the following locations: over the cattle in the feed alley, and at cow level in the pen and milking parlor holding areas. Some hand-held devices used to measure temperature and relative humidity can also measure air speed. When measuring air speed, extend the device out with your arm perpendicular into the airflow to reduce the influence of your body on the air flow conditions. Hold the device steady, and if equipped with “averaging feature” use it to provide a stable reading. Hold the device the same way every time to get measurements that can be compared; slight changes in orientation can change the measurement. Air velocities in tunnel ventilated barns can range from 2.5 to 6 mph (220 to 526 feet per minute, fpm). Baffles in cross ventilated barns are designed so that air velocity below them is 6 mph (526 fpm). These feel like nice strong breezes. Air velocities at 60 fpm or below are barely noticeable.
- **Air Exchange Rate (Airflow)** – A very basic indication of air exchange through the barn is to multiply the inlet area (in square feet) by the average air speed through the inlet (feet per minute), producing a ventilation rate in cubic feet per minute (cfm). If there are multiple inlets, sum the airflow through each opening.

- **Static Pressure** – In a mechanically-ventilated barn, the exhaust fans create lower pressure inside the barn relative to outside the barn. The pressure, in turn, affects the ability of the fans to move air efficiently. A manometer is a simple device to monitor this difference continuously, or as a spot check.

Components of a maintenance plan

A written maintenance schedule complements facility and animal monitoring portions of a heat stress management plan. When a facility is properly maintained, cow comfort can be better managed year round for a more efficient use of the facilities and equipment available. Maintenance is important because it extends the barn equipment life and helps minimize energy consumption, which translates to farm savings.

For a year round heat stress management plan it is important to prepare the cow cooling equipment in the cool season and maintain it throughout the hot season.

A facility maintenance schedule is specific to one's facilities and equipment. Managers should evaluate and include all areas of the barns and parlors when creating a maintenance checklist. Consider the following items for a facility maintenance checklist that address both heat stress management and energy use (not an exhaustive list):

- Ventilating exhaust fans for tunnel and cross-ventilated barns. Numerous research studies have found that poorly maintained fans move 40 to 60% of the fans capacity. Check for slipping belts, corroded and dirty louvers, and shutters that do not fully open or do not open easily. Use graphite to lubricate shutter hinges since oil collects dirt.
- Mixing fans. Mixing fan alignment may change over time if the fan is hit or moved. Make sure airflow is aimed properly and reaches cow level.
- Sprinkler systems. Low pressure sprinkler systems must cycle the sprinklers on and off. Sprinkling continuously wastes water, adds water to the manure system, and does not help cool the cows. Cows are cooled during the period when sprinklers

are off and the water evaporates from their skin. Pipe size for low pressure sprinkler systems have to be large enough to provide water to the sprinkler the farthest away from the water supply. An in-depth discussion on dairy water systems and water demand can be found in the factsheet *Water System Design Considerations for Modern Dairies* (See References for Martin and Harner, 2012). A design guide is available online at <http://www.uwex.edu/ces/dairymod/cowhousing/documents/LoPresSprnkSysDsgn-Janni.pdf>.

- Mister systems. High pressure misters generate very small droplets that evaporate before hitting the floor, bedding or feed. The misters can easily become plugged with dirt or accumulated minerals. Most systems have a filter; check the filter and replace or clean it regularly. Check the high pressure pump; insufficient pressure leads to large droplets which do not evaporate and may wet bedding or feed.
- Evaporative cooling pads. Evaporative cooling pads can plug with dirt, debris and algae so clean them regularly. Check for holes in the pads that short-circuit the cooling system.
- Curtains. Repair and realign curtains. Calibrate curtain opening with controller settings.
- Thermostats and settings. Check thermostat and controller settings. Review set-points and differentials. Remove any accumulated dust and dirt.
- Lighting. Replace burnt out lights. If applicable, check timer settings.
- Waterers. Clean regularly. Make sure that water flow is sufficient to provide all the water needed when several cows drink at the same time. If the operation's water supply provides water to waterers and other water-related systems (sprinklers, parlor, etc.), ensure that all functions can occur simultaneously without decreasing performance.

A plan for winterizing these cooling systems will reduce the need for repairs in the future.

Once the items applicable to one's facilities have been determined, a checklist can be created. The basic components of a checklist are simple. Checklists should include a column for the item of interest, the action performed to the item of interest, the date completed, the initials or signature of the person completing the task, and any pertinent comments (i.e. repairs or adjustments). An example of how to organize a checklist is given (Figure 5). Another option for creating a barn-specific maintenance schedule is to organize tasks by season. Compiling all tasks that need to be completed at a certain time allows for easy planning and tracking. Regardless of the format or chosen timeframe for a facility maintenance schedule a manager determines, it will be a critical part of developing a sustainable dairy farm and maximizing the efficiency of the overall facility.

Once a barn-specific maintenance checklist exists, a manager must answer several questions. How often does each task need to be completed? What is the best location to post or keep the checklist? Who is responsible for performing the maintenance tasks and ensuring the checklist is up-to-date? Answering these questions will help guide communication between managers and employees. If employees are in charge of completing the tasks and filling out the checklist, maybe the best option is to have individual sheets for each barn posted by a common entrance. If a manager will be in charge of completing the checklist and verifying all tasks are completed, then maybe the checklist can contain all areas of the operation and the checklist can remain in the office as part of a heat stress management plan binder. Clear communication between employees and management is essential for the accurate completion of the maintenance checklist and the entire heat stress management plan to the expectations of the manager.

Heat Stress Management Plan: Record Keeping And Analysis

It takes effort to implement the animal and barn observation and monitoring suggestions. It takes additional work to review all of this information and make sense of the numbers. However, this component of a heat stress management plan is where continuous improvement can be made by informing decision

makers for facility or management changes.

The animal and facility monitoring records suggested earlier can be combined with milk production and energy use data to demonstrate changes in efficiency. For example, energy use may increase, but if cows are comfortable and maintain milk production, the return of that energy use is improved. All of these records, however, are only useful if the values are accurate and/or easily accessible.

These cumulative records have two important functions. When collected for the first time, these baseline measurements 1) identify system functionality before a change occurs, and 2) provide a means of measuring the effectiveness of any changes implemented. The units are not critical; nor are these calculations meant to be compared between operations. They should be considered for internal evaluation only.

There are multiple ways to review your records. Figure 6 illustrates one approach to review milk production, energy use and temperature data simultaneously:

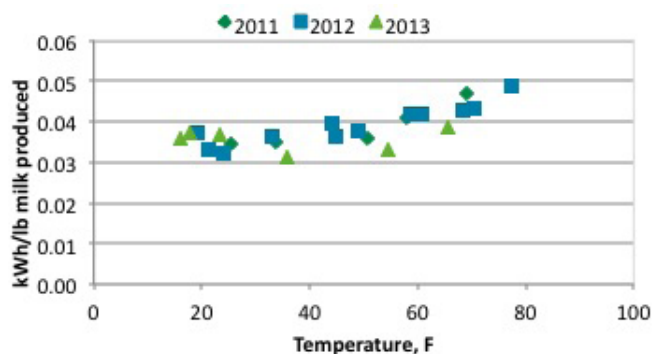


Figure 6. Example review of monthly energy use (kWh) per pound of milk produced, based on the monthly mean temperature. In this example, data for August 2011 through July 2013 are shown; there was extensive maintenance and renovations of the ventilation system before the summer of 2013, and the energy use per pound of milk produced decreased.

1. Divide monthly energy use values by milk production for the same time period.
2. Plot the energy use per milk production numbers calculated previously against average temperature or daily average THI values for the same period. Some power company records report the monthly mean ambient temperature.

Summary

Heat stress is a costly environmental challenge from many perspectives: milk production losses, reproductive losses, animal well-being, and increases in energy and water usage to maintain cow comfort. This document provides producers with tools to develop a heat stress management plan by monitoring important animal indicators and facility components to maximize production efficiencies within a given environment during times of prolonged heat. When producers understand the inter-relationship of animal monitoring, facility monitoring and maintenance, and record evaluation, they can better manage environmental fluctuations within the operation to continue producing affordable dairy or beef products in a sustainable manner.

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Figure 3. Animal monitoring record sheet

Pen/Group Name:		Date & Time:	Initials:
Measurements	Normal	Observations	
Respiration rate (breaths/min)	Calves: 30-60 breaths/min Cows: 10-40 breaths/min		
Animals open mouthed breathing (# or %)	0%		
Animals lying down (# or %)	Your barn's avg.		
Animals lying down & chewing cud (# or %)	50-60% of the animals lying down		
Shade usage outside	High-medium-low		
Feed intake – DMI (lbs/head)	Your barn's winter avg. or last year's avg.		
Water intake (gallons/head)	21-32 gal/hd daily or 50-60 gal/hd in heat stress		
Milk production (CWT or avg. lbs/head)	Your barn's winter avg. or last year's avg.		
Milk fat (avg. %)	Your barn's winter avg. or last year's avg.		
Conception & pregnancy rates (%)	Your barn's winter avg. or last year's avg.		
Comments & Notes:			

Figure 4. Barn Monitoring Record Sheet

Pen/Group Name:	Barn Design:	Date & Time:	Initials:
Current Ambient Temperature:	Current Ambient Relative Humidity:	Current Ambient Dewpoint:	
Temperature setpoint (if applicable):			
Size & number of exhaust fans running (if applicable):			
Number of mixing fans running (if applicable):			
Is mister system currently operating (if applicable)? Yes / No			
Is sprinkler system currently operating (if applicable)? Yes / No			
Barn Measurements	Observations		
Temperature			
Relative Humidity			
Dewpoint Temperature			
THI			
Air Speed			
Static Pressure			
Air Exchange Rate (approx.)			
Fan Systems			
Lighting System			
Comments & Notes:			

Figure 5. Facility maintenance checklist

[illegible]