W 836

Mechanical Ventilation: Making It Work for You

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In Tennessee and the southeastern U.S., heat stress has a massive impact on reproduction, production and overall animal well-being. Farmers can alleviate heat stress through fans for ventilation, to bring fresh air into barn through structural openings, and internal air movement to create air velocity to cool cows and remove dead air spaces. This mechanical ventilation is critical in three main farm areas: holding pens, feed alleys and resting areas. Correct fan placement, choice and maintenance are key to maximizing cow cooling in warm/hot seasons and removing excess moisture or improving air circulation in cooler seasons. This publication will attempt to clear up some questions associated with the type of fan that is best for a particular housing application and the areas in which they are placed.

Why is ventilation rate important?

The required ventilation rate (cubic feet of air moved per minute (**cfm**) through a barn) animals need will change depending on the weather. When the external temperature is high, cows will need a higher ventilation rate (400-470 cfm/cow; Heber, 1990, Holmes et al., 2013). Conversely, when the temperature is mild or cool, cows will need a lower ventilation rate (50 to 210 cfm/cow; Heber, 1990, Holmes et al., 2013). Ventilation plays a role in:

1. Air Exchange — Bringing “fresh” air into the barn and removing “stale” air.
2. Air Quality — Removing odors (ammonia) and moisture from the barn.
3. Heat Reduction — Cooling cows through high velocity air movement.

For most housing in Tennessee, we rely heavily on natural ventilation with added fans (mechanical ventilation) to combat heat stress. Now, our thought process might be, “It’s not too hot outside, why would I need fans on?” Not only do cows prefer cooler temperatures than we do (Figure 1), but we also have to consider more than just heat stress when we make the decision to turn on the fans. Just like us, cows benefit from having air move throughout the barn, preventing stale or dead air areas. When we are in a room without airflow, the air tends to smell and we tend to feel hot, even if the temperature is cooler than an area with good airflow. We can see the effects of stale air when cows actively seek fresh air by holding their heads over walls, poking noses out of barns, or other air-seeking behaviors. If we see behaviors like this, we know ventilation rate is too low. We are not achieving enough air exchanges through the barn, so air quality is reduced.

When do we turn on fans for heat stress?

If we see other signs within the barn such as:

- Bunching
- Panting
- Perching

We can assume the cows are experiencing **heat stress**. Heat stress begins at a much lower threshold than when we see physical signs. We calculate this through an equation called ***Temperature Humidity Index (THI)*** (NOAA, 2016) where

THI = temperature (degrees F) – (0.55 – (0.55 x (relative humidity/100)) x (temperature – 58.8))

The THI looks at both the effects of temperature and humidity and their impact on an individual

(Figure 1). Cows begin experiencing heat stress at a **THI of 68**. From Figure 1, we can see that can be a 72 F day with humidity of 45 percent or greater. For farmers who use thermostats to turn on fans, setting them to **70 F** will help ensure your fans kick on as soon as cattle start to experience heat stress.

Figure 1. *Heat stress zones of (a) dairy cattle and (b) humans.*

a)

Temperature		% Relative Humidity																		
°F	°C	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
72	22.0	64	65	65	65	66	66	67	67	67	68	68	69	69	69	70	70	70	71	71
73	23.0	65	65	66	66	66	67	67	68	68	68	69	69	70	70	71	71	71	72	72
74	23.5	65	66	66	67	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73
75	24.0	66	66	67	67	68	68	68	69	69	70	70	71	71	72	72	73	73	74	74
76	24.5	66	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75
77	25.0	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76
78	25.5	67	68	68	69	69	70	70	71	71	72	73	73	74	74	75	75	76	76	77
79	26.0	67	68	69	69	70	70	71	71	72	73	73	74	74	75	76	76	77	77	78
80	26.5	68	69	69	70	70	71	72	72	73	73	74	75	75	76	76	77	78	78	79
81	27.0	68	69	70	70	71	72	72	73	73	74	75	75	76	77	77	78	78	79	80
82	28.0	69	69	70	71	71	72	73	73	74	75	75	76	77	77	78	79	79	80	81
83	28.5	69	70	71	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82
84	29.0	70	70	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	83
85	29.5	70	71	72	72	73	74	75	75	76	77	78	78	79	80	81	81	82	83	84
86	30.0	71	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	84
87	30.5	71	72	73	73	74	75	76	77	77	78	79	80	81	81	82	83	84	85	85
88	31.0	72	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	86	86
89	31.5	72	73	74	75	75	76	77	78	79	80	80	81	82	83	84	85	86	86	87
90	32.0	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88
91	33.0	73	74	75	76	76	77	78	79	80	81	82	83	84	85	86	86	87	88	89
92	33.5	73	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90
93	34.0	74	75	76	77	78	79	80	80	81	82	83	85	85	86	87	88	89	90	91
94	34.5	74	75	76	77	78	79	80	81	82	83	84	86	86	87	88	89	90	91	92
95	35.0	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
96	35.5	75	76	77	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94
97	36.0	76	77	78	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	95
98	36.5	76	77	78	80	80	82	83	83	85	86	87	88	89	90	91	92	93	94	95
99	37.0	76	78	79	80	81	82	83	84	85	87	88	89	90	91	92	93	94	95	96
100	38.0	77	78	79	81	82	83	84	85	86	87	88	90	91	92	93	94	95	96	98
101	38.5	77	79	80	81	82	83	84	86	87	88	89	90	92	93	94	95	96	98	99
102	39.0	78	79	80	82	83	84	85	86	87	89	90	91	92	94	95	96	97	98	100
103	39.5	78	79	81	82	83	84	86	87	88	89	91	92	93	94	96	97	98	99	101
104	40.0	79	80	81	83	84	85	86	88	89	90	91	93	94	95	96	98	99	100	101

Adapted from Nickerson (2014). Mild heat stress 68 to 72 THI; Moderate heat stress 72 to 79 THI; Sever heat stress 80 to 89 THI.

b)

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Adapted from NOAA (2016)

Other positive fan impacts

Having the fans on, even when it is cool outside, can have positive effects on the cow environment. Having fans on will increase moisture evaporation rate from wet alleyways and water contained in the bedding. An exaggerated example of this is in compost bedded pack barns. Research has shown that leaving fans on below heat stress levels increased the length of time a load of bedding would last. This translated to less money spent on bedding over the year (Eckelkamp, 2014). However, if natural ventilation is working correctly, it usually provides air movement in the 2 mph range. This is similar to velocity provided by fans set to their lowest speed. If you choose to turn on fans at a lower temperature, consider keeping them at least on medium speed.

How many fans do I need?

Once we have determined the amount of fresh air required in a particular area, we can determine the placement of fans and how many fans will be required to achieve air movement and velocity of between 200 fpm to 400 fpm (2 to 4 mph) over the cow's body (Turner et al. 1992). Some general rules of thumb for fan spacing are:

1. No more than 10 times the diameter of the box or panel fan with orifice between fans blowing the same direction (i.e., in a line)
    a. For example, spacing of 480 inches for a 48-inch box fan with orifice
2. No more than 8 times the diameter of the basket, panel or box fans without an orifice between fans (i.e., in a line)
3. No more than 6 to 8 feet between fan rows (i.e., side by side)
4. Fans angled at 15 to 20 degrees from vertical

For example, a panel or box fan with an orifice should have no more than 480 inches (40 feet) until the next fan in a line for a 48-inch diameter fan with 10 feet between rows of fans. Similarly, a 30-inch diameter basket fan could have 240 inches until the next fan in a line with 6 feet between rows of fans. This allows the effective air movement from fan 1 to end right where the effective air movement from fan 2 begins (Gooch, 2000). We want to make sure that the investment in fans has a lasting and effective impact. When we have dead-air spots in the barn, we attribute them to ineffective air movement caused by:

- Not enough fans.
- Improper fan spacing.
    - Too much room between fans in a line.
    - Too much room between lines of fans.

Cows in this scenario still tend to bunch in front of the fans that are there, which can cause issues with heat stress (too many animals in a small area), lying behavior and bedding life in the resting area.

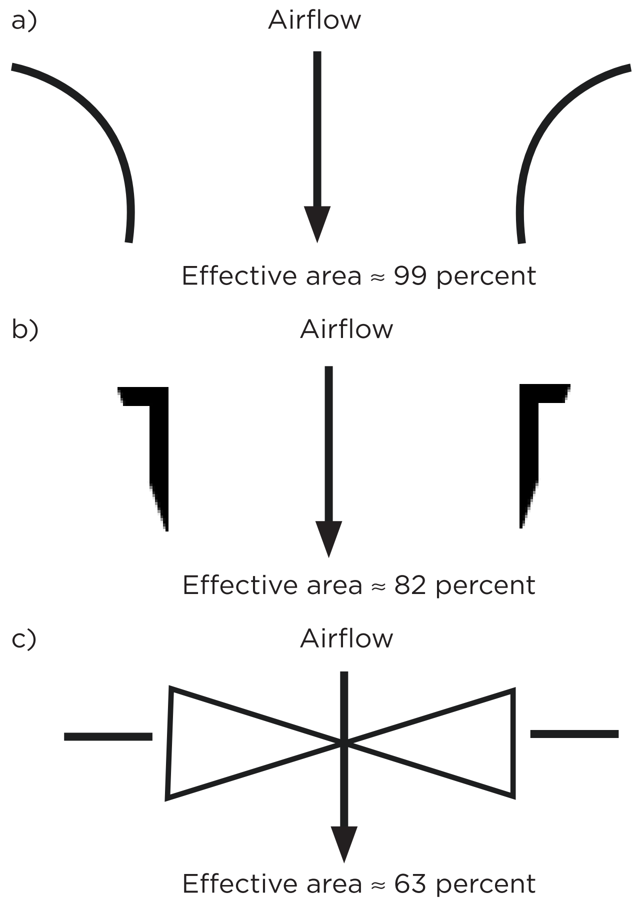
Always reality check

With any recommendation, remember that they are **recommendations** based on averages and assumptions. Always reality check to make sure that the recommendations are working on your farm. Walk through the barn and see if you feel dead-air spots. Call your local Extension agent or state specialist to come out and walk the barn with you. Remember, just because the fans are blowing does not necessarily mean you are meeting the ventilation and cooling requirements. Make sure when checking fan placement that you can feel air movement on the cow level, 4 feet above the ground. Having excellent air movement in a barn is not enough; it has to reach the cows where they rest.

What type of fan do I need?

Choosing the right fan for your barn starts with picking an overall type: axial or cage fans. Axial fans are generally used in livestock applications because they 1) operate at lower static pressures, 2) are less influenced by dirt build-up, and 3) have a lower initial cost. Commonly used axial airflow fans and fan housings include (Table 1 and Figure 2):

Figure 2. *The effect of fan housing on fan capacity for (a) curved edged housing, (b) sharp corner housing, and (c) sharp edged housing.*



Adapted from MWPS-32 (Heber, 1990)

Table 1. *Types of axial airflow fans available for dairy producers.*

Fan Type	Blade Design	Housing Design	Drive Type	GOE[1]
Basket fan	Flat stamped	Metal basket guard	Direct drive	Low
Panel fan	Flat stamped or airfoil	Simple circular orifice	Direct or belt drive	Moderate
Box fan	Airfoil	Metal, wood or plastic box with orifice panel	Direct or belt drive	Moderate to high
Cyclone/Funnel	Flat stamped or airfoil	Round, tubal housing	Direct drive	Moderate
LVLS[2]	Flat stamped or airfoil	None	Direct drive	Moderate
HVLS[3]	Airfoil	None	Direct drive	High

[1]GOE is General Operating Efficiency

[2]LVLS is Low Volume Low Speed fans

[3]HVLS is High Volume Low Speed fans

LVLS (low volume low speed) and HVLS (high volume low speed) ceiling fans create both vertical (directly under fan blades) and lateral (outflow jets) air movement compared to previously discussed fans, which generate primarily lateral airflow jets. The effect on tightly bunched cows in the holding pen can be significantly different. The illustrations below demonstrate this effect. Figure 3 illustrates airflow lines from panel fans around cows in a barn. Figure 4 shows the ambient temperature and air velocity fields (red = high temp/velocity; blue = low temp/velocity) around cows cooled by panels fans. High temperatures around cows are associated with low air velocities. Ceiling fans create more even velocities over the whole area, allowing all the cows to be exposed to similar cooling potential.

Figure 3. *Airflow lines for lateral (left) and vertical (right) air movement from panel fans.*

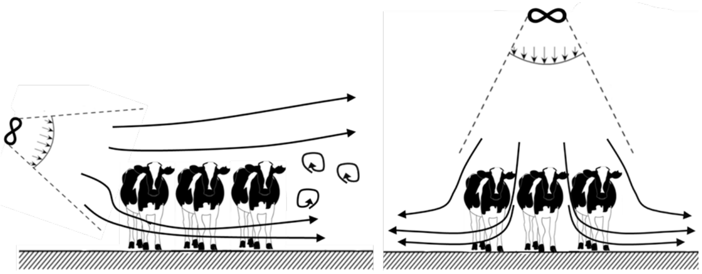
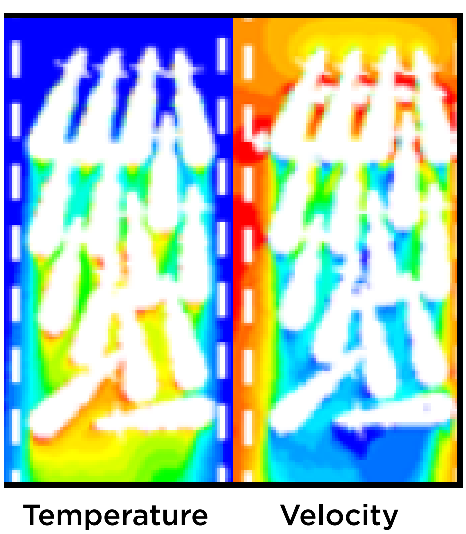


Figure 4. *Temperature (left) and air velocity (right) resulting from panel fans cooling cows.*

Blue indicates low temperature or air velocity.
Red indicates high temperature. or air velocity.



Adapted from M. Mondaca (2016)

Where do I start putting fans?

Now that you have selected the type and size of fan you want, it's time to put them where they will do the most good. Conventionally, we have said to start with the holding pen, but recent findings on heat-stress effects at calving and during the transition period have changed recommendations. If you are starting to add fans incrementally, follow these recommendations (Gooch and McFarland, 2017):

1. Calving area
2. Dry cows
3. Holding pen
4. Milking area
5. Fresh cows
6. High producers
7. Low producers

Although the calving area might seem a strange one to prioritize, keep in mind it is generally one of the smaller areas on your farm. It should require a smaller number of fans, and can have lifelong impacts on your calves and your dams during the next lactation. Historically, our dry cows generally get left out in pasture through calving. Moving dry cows indoors and providing cooling can improve dam milk production, dam immune status during the transition period, and improved fetal nutrition and growth (Tao and Dahl, 2013).

Holding pen fans

Year-round, fans do the most good in the holding pen. Why? Because the holding pen is a high heat-exposure environment. Heat comes from several sources: the sun; metabolic energy required to produce milk; and radiant heat from other animals, roof, sky and nearby objects. Having animals crowded together in the holding pen increases the heat of all of the animals in the pen. Crowding also limits natural or fan airflow to a particular animal. Providing more air movement reduces dead spots, improves air movement, and improves cow cooling in the holding pen. Fans should be angled away from the milk parlor, to prevent blowing hot, humid air into the parlor area. Coupling fans with soakers in the holding pen can further reduce heat stress (Table 2).

Table 2. *Recommendations for adding soakers to a holding pen.*

Pen capacity (cows)	Pen size (ft x ft)	Water required (gal[1])	Minimum flow rate (gpm[2])	No. of 360 degree nozzles required[3]
40	24 x 32	20	10	14
60	24 x 41	25	12	20
80	24 x 50	30	15	27
120	32 x 56	45	23	40
200	32 x 96	80	40	68

[1]Assuming 0.025 gallons of water/spray cycle/sq. ft. of pen

[2]Gallons per minute – based on a 2-minute cycle followed by 10-minute fan cooling cycle

[3]Assuming 8-foot spray diameter with 0.5 gpm capacity

Adapted from VanDevender (2013)

Feed bunk fans

The next important place to provide fans is over the feed bunk. Dairy cattle take in feed at the feed bunk. But just like us, when they are overheated the last thing they want to do is eat. Providing fans over the feed bunk will not only keep the cows cool while they are eating, but a cooler area of the barn may attract cows to the feed alley. Bottom line: providing cows a cool place to eat will keep their core temperature lower, allowing them to eat more, and eat more comfortably. Fan placement should be in a single line along the feed bunk, blowing across the backs of the animals (parallel to the feed). The spacing is the same, no more than 10 times the diameter of the fan, with a 15 to 20 degree tilt from vertical. In the feed bunk, just like everywhere else we would place fans, we want the effective air movement from fan 1 to end where the effective air movement from fan 2 begins.

Resting area fans

The final place to put fans is over the resting area. "Over the resting area" can be a pretty obscure reference. Depending on the type of barn you have, the ventilation will be slightly different. Some freestall or compost bedded pack barns may be able to take advantage of only natural ventilation in the resting area. This would assume that your sidewalls, overhangs and ridge vents are all excellent, allowing maximum airflow through the barn. However, in the Southeast, we experience several weeks of high temperatures. To prevent cows from experiencing as much heat stress as possible and maintain productivity through these hot periods, providing cooling over the resting area should be considered. In a freestall barn, panel or box fans are generally used. When barns have truss roof support, the lower chord of the truss may limit the ceiling height to a point where LVLS and HVLS fans cannot effectively operate when floor to ceiling clearances are critical for equipment movement within the barns. Panel and box fans can also be directed more toward individual stall areas, although more of them are required.

The same general rules apply for these areas. However, some tweaking may be required, particularly in older barns with a more closed design. If you have solid walls within your freestall barn, you will probably need a new bank of fans beginning at or near that particular wall. Air can only flow effectively in one direction. Putting any kind of barrier in the path of the airflow will decrease or completely block it from reaching cows effectively. When you can, remove any obstacles, like solid walls, to improve overall airflow in your barn.

For compost bedded pack barns and bedded pack barns, HVLS and LVLS fans are viable options for cow cooling. For these fans, 2 times the diameter is usually sufficient fan spacing for these open resting areas. A 10-foot diameter fan could be spaced 20 feet between fans (in all directions). Greater HVLS fan separation will reduce the area, or percentage of the resting area where air velocities are greater than 200 fpm. If panel or box fans are used, make sure not to place them blowing against the prevailing wind. If the fans are set to blow against the prevailing wind, the fan airflow velocity is lowered or could be canceled if outside ground opposing wind speed exceeds 3 to 5 mph. This would create dead spots within the barn.

Conclusions and take-home messages

Overall, fans are an important component of any dairy operation. Even dairies without confinement can improve dairy cow comfort and productivity with some well-placed fans. Consider adding them to your operation; your cows will thank you for it. Remember these keys:

- Fans promote air exchange, air quality and reduce heat stress.
- Fans must effectively move air to be a good investment.
- Keep space between fans in line to no more than 10 times the diameter.
- Keep space between fans side by side to no more than 10 feet.
- Start by placing fans in high-impact areas where cows tend to be crowded, like the holding pen or the feed bunk.

For more information on fans and ventilation on your operation, contact your local county extension agent or myself at eeckelka@utk.edu or 865-974-8167.

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