



## Chapter 7: Ventilation and Thermoregulation

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## 1. Principles of ventilation and thermoregulation

### Ventilation

The purpose of ventilation in dairy barn facilities is to maintain a supply of fresh air while removing moisture, dust, gases, and warm air. Inadequate ventilation can substantially impact dairy cattle health and productivity, making it crucial to maintain an adequate rate of air changes in the barn (fresh air in and stale air out). According to the [Code of Practice for the Care and Handling of Dairy Cattle](#), proper ventilation is required to bring fresh air into dairy facilities and prevent the build-up of harmful gases, dust, and moisture, while minimizing the risk of cold and heat stress.

To ensure that your barn is well-ventilated throughout the year, ventilation systems must be able to adjust to the varying seasons. There are different ventilation recommendations depending on the season (hot vs. cold weather). In the winter, protecting cattle from the elements (ex., snow, rain, wind) and extreme cold while maintaining air quality is the primary concern to avoid risks to cattle health and reduce the risk of health disorders (ex., respiratory disease). In the summer, air quality must be maintained while preventing heat stress. **See Figure 1** for details on recommended airflow and air changes by season and cattle stage of life.

Recommended air changes per hour by season:

Winter: 4-8x

Fall/Spring: 15-20x

Summer: 40-60x

### Thermoregulation

Ideally, cattle are housed in an environment where they do not have to expend energy to maintain their average body temperature; this is known as a cow's thermoneutral zone. When ambient temperatures are above or below dairy cattle's thermal neutral zone, they must expend energy to cool or warm their bodies. In general, mature cattle are more susceptible to heat stress (expending energy to stay cool) than cold stress (expending energy to keep warm). Calves, however, generate less metabolic heat and are more susceptible to cold stress.

Approximate thermoneutral zones by age:

- Between 15 and 25°C for calves (0-3 weeks)
- Between 0 and 23°C (32-73°F) for calves (1 month or older)
- Between 0 and 21°C (32-70°F) for heifers and cows

### Temperature Humidity Index (THI)

Both ambient temperatures and relative humidity affect how well cattle are able to thermoregulate, particularly in warm weather. Therefore, the Temperature Humidity Index (THI), which accounts for external temperature and relative humidity provides a more comprehensive understanding of the climate conditions that impact cattle.

THI calculation from NRC, 1971:

$$\text{THI} = (1.8 \times \text{temperature}^{\circ}\text{C} + 32) - [(0.55 - 0.0055 \times \text{relative humidity}\%) \times (1.8 \times \text{temperature}^{\circ}\text{C} - 26)]$$

THI temperatures and humidity examples:

- 21°C with 50% = THI 67
- 24°C with 20% = THI 68
- 22°C with 70% = THI 69

Dairy cows will start to experience heat stress at THI of 65, but studies in Canada have found that milk components can be negatively affected at THIs as low as 58. Differences in study results can be attributed to varying designs, local climate conditions, and individual cows' characteristics. A cow's resilience to heat stress will depend on factors such as genetics, breed, and milk production.

ANIMALS:	AGE (months)	WEIGHT (kg)	MINIMUM AIR FLOW (cold weather)	TRANSIENT AIR FLOW (mild weather)	HIGH AIR FLOW (hot weather)	WIND SPEED (hot weather)
	ft <sup>3</sup> /minute/head				ft/minute	
Young calves	0-2	40-80	15	50	100	200-300
Young Heifers	2-12	80-360	20	60	130	300
Heifers	12-24	360-634	30	80	180	300-500
Cows	24 and over	≥ 635	50	170	500	300-500

Figure 1. Summary of ventilation parameters for dairy cattle adapted from Bickert et al., 2000

#### 1.1 Heat stress

In hot weather, cattle can experience heat stress when the combined metabolic and environmental heat exceeds the cattle's ability to dissipate the heat. Heat stress negatively affects dairy cows, reducing milk production and quality, affecting reproduction, and increasing the incidence of lameness. For late-gestation cows, heat stress can negatively impact their calves after birth, reducing immunity, growth, and future production. Calves and heifers experiencing heat stress can have impaired dry matter intake and growth rates. Therefore, cattle need to be able to adequately dissipate heat to avoid the effects of heat stress.

Some methods of heat exchange and examples of heat dissipation are **(see sections 3 and 4 for more details on heat dissipation options)**:

- Evaporation
  - Ex. panting, sweating
- Conduction
  - Ex. transferring body heat to a cooler object, such as cows lying on a cool surface (bedding or waterbed).
- Radiation
  - Ex. heat absorbed by cows when exposed to the sun. In such cases, shade can help alleviate the heat they absorb from the sun.
- Convection
  - Ex. adequate air speeds (200 – 500 ft/min or 300 – 500 ft/min in humid climates) around cows, replacing hot air with cooler air.

### **Air speed requirements to beat the heat**

In hot and dry weather conditions, air speeds of 200 – 500 ft/min (1 – 2.5 m/s) have been found to reduce heat stress markers in dairy cows (respiration rate, vaginal temperature, and skin temperature). However, to better mitigate heat stress in hot and humid weather conditions, which can be experienced during Canadian summers, an airspeed of 300 - 500 ft/min (1.5 – 2.5 m/s) is recommended. Providing appropriate air speeds can positively affect dry matter intake and the productive performance of dairy cows on hot and humid days.

To effectively cool cows with the recommended air speeds, the air movement must reach them both while standing and lying down. A study by Reuscher et al. (2023) found that fans delivering air speeds of at least 200 ft/min (1 m/s) at the cows' resting height helped maintain lying time, dry matter intake, and milk yield in dairy cows under heat stress. Reuscher et al. (2023) also found that air speeds at approximately 472 ft/min (2.4 m/s) increased dairy cows' lying time compared to air speeds at approximately 335 ft/min (1.7 m/s). This highlights the importance of directing appropriate air movement to microenvironments within the barn, such as pens and stalls. Fans and baffles can help reach appropriate cooling air speeds at a cow's resting height in stalls and pens. **Please see Section 3 on air circulation systems for details.**

Use a vane or hot-wire anemometer to measure air speeds in your barn at the cow's resting height (~0.5 m above the bedded surface) to locate areas with inadequate air speeds (dead air zones). For calves, anemometer measurements should be taken at ground level to determine air speeds at resting height. **For more details on appropriate air speeds for calves, see section 1.1, Calf housing ventilation.**

### **Warm weather ventilation considerations**

Building orientation can influence cattle's exposure to the sun, with north-south orientated buildings exposing cattle to the sun for a longer period of time, especially in the resting areas close to the outside walls. However, if natural ventilation is used, the main focus should be on orienting the building so that summer prevailing winds pass through the narrowest cross-section of the building, ensuring that winds are not obstructed by other buildings surrounding the dairy facility.

Insulating the building will help reduce the amount of heat entering the barn by reducing the heat gained from solar radiation. Barns can be minimally insulated with insulated roofs (R 5-10) and little to no insulation in the walls. Alternatively, barns can be well-insulated with a fully insulated attic and walls.

Changes in temperature and humidity can happen suddenly and frequently, making manual ventilation adjustment difficult to manage effectively. An automated system that allows for quick adjustment to weather conditions is recommended. If possible, use a system controlled by THI that accounts for both temperature and humidity within the barn.

### **1.1 Cold stress**

When cattle experience cold stress, the heat produced from normal metabolic processes is not enough to maintain their average body temperature, and energy is required to maintain average body temperature. It has been found that at ambient temperatures below  $-6.7^{\circ}\text{C}$ , dairy cows may have reduced milk production, and if cold stress becomes too severe, this can lead to hypothermia. However, milk production and reproductive performance are typically unaffected in moderate colder weather. Increasing cow feed intake or providing higher-quality feeds and supplements can compensate for the increased energy requirements. Well-insulated barns conserve heat inside the barn, and in naturally ventilated barns, well-insulated barns can improve the stack effect (hot air rising) and prevent condensation.

Calves are more sensitive to cold weather, and cold stress can increase calf mortality and risk of respiratory illnesses. To mitigate cold stress, it is required by [the Dairy Code of Practice, 2023](#) to increase the quantity of milk/milk replacer offered to calves. The recommendation for Holstein calves is to feed at least 9 L / day for ambient temperatures around  $10^{\circ}\text{C}$  and 10 L / day for temperatures around  $0^{\circ}\text{C}$ . Additional precautions to avoid cold stress include increasing the quantity of bedding, allowing calves to perform nesting behaviour, and providing heat lamps and calf jackets. It is also essential to avoid drafts that can chill the calves in their housing areas. **Please see the calf housing ventilation section for details.**

### **Cold weather ventilation considerations**

It is important to remember that cows can better handle cold temperatures than people. Even during cold weather, air inlets should not be completely closed. Closing air inlets will limit the ventilation rate and create damp conditions in the barn, which could lead to respiratory problems in cattle. Under critical winter conditions, the size of air inlets can be reduced to reduce air flow and the amount of snow entering the building. Once milder conditions return, increase the air inlet size to allow adequate air change (4-8 air changes per hour in the winter).

The arrangement of air inlets is vital to achieving adequate air distribution in the building. Avoid obstructing air inlets and exhaust locations, such as obstructions from surrounding buildings and interior structures.

The relative humidity in the housing facility should be less than 75 %. Humid conditions can be detected by observing fog, condensation or frost on the building surfaces.

### 1.3 How to evaluate ventilation

Environmental and animal-based indicators can help evaluate ventilation systems in dairy cattle housing facilities.

#### Environmental indicators to evaluate ventilation efficiency:

- Ammonia (NH<sub>3</sub>)
  - > 5 - 10 ppm corrective action should be taken for dairy cow facilities.
  - > 5 ppm corrective action should be taken for calf housing facilities.
- Carbon dioxide (CO<sub>2</sub>)
  - > 3000 ppm CO<sub>2</sub> corrective action should be taken.
- THI
  - Measure the temperature and humidity within the barn to check if it is within the cattle's thermal neutral zone. Dairy cows may start to experience heat stress at a THI of 65. **See section 1 on thermoregulation and THI for details.**
- Air speeds in the summer
  - Cooling air speeds of 200 – 500 ft/min are recommended at cow resting height in stalls and pens. A vane or hot-wire anemometer can be used to detect air speeds throughout the barn (stalls, pens, etc.). **For details, see section 1.1 Heat stress, Air speed requirements for cows to beat the heat.**
- Fog and condensation or frost inside building surfaces in the winter
  - > 75 % relative humidity corrective action should be taken.

#### Animal-based indicators to evaluate ventilation efficiency:

- Signs of heat stress
  - Respiration rate
    - Respiration rate higher than 60 breaths/min indicates heat stress
    - Respiration rate higher than 120 breaths/min indicates severe heat stress
  - Panting behaviour
    - Cattle open mouth breathing
  - Body temperature
    - Cows core body temperature higher than normal (38 – 39°C; 101.5 – 102.5°F)
    - Calves core body temperature higher than normal (39 – 40.5°C; 101.5 – 103°F)
  - Bunching behaviour
    - Cattle will bunch towards shaded areas of the barn (darker areas of the barn) or areas with faster-moving air.
  - Increase in standing behaviour
  - A decrease in cow performance
    - Reduced milk production (> 2 kg/cow) during warm weather
    - Reduced rate of conception during warm weather
  - Increased number of cows with lameness in the fall (~ 2 months after heat stress)
- Increased number of pneumonia cases in the winter

For a quick look at considerations and recommendations for ventilation and thermoregulation, see the following factsheet: [Principles of ventilation](#)

## 2. Ventilation systems

There are two main types of ventilation systems:

- Natural ventilation
- Mechanical ventilation

### 2.1 Natural ventilation

Natural ventilation works on the principle of thermal buoyancy (warmer air moves upwards) and the force of the wind. In cold weather, ventilation is driven by thermal buoyancy, with cooler fresh air entering through air inlets and the warmer air around the animals rising and exiting through an air outlet (ridge exhaust) at the top of the building. At the ridge exhaust, the force of the wind will move the air out. In warm weather, natural ventilation relies primarily on summer prevailing winds blowing across the narrowest cross-section of the building through large air inlets along the building's sidewalls. Air circulation systems, such as fans, can be added to improve air speeds, helping to cool cattle and reduce the risk of heat stress during the summer (**see section 3 for more details**). In the fall and spring, air inlets and outlets must be adjusted to use thermal buoyancy and wind entering the building.

For natural ventilation, the building should:

- Be positioned perpendicular to the prevailing summer winds so the wind can pass transversely through the building, crossing the building at its narrowest point.
- Ensure no obstructions are blocking the air flow from entering the building, with buildings parallel to the dairy facility at least 100 ft (30.5 m) away.
- Have large air inlets (height 12 - 16 ft (4 - 5 m)) at cow height, such as sidewalls with adjustable curtains or mobile panels.
- Have air inlets with a bird screen to prevent birds from entering the building, ensuring that the screen is not too coarse that it would limit airflow into the barn.
- Have air outlets/exhaust ridges (e.g., open ridges, chimneys, light vents, and overshot roofs) at the highest point of the building to exhaust hotter, stale air. For details on ridge exhaust systems, visit the OMAFRA website [\*\*Dairy housing: ventilation options for free stall barns\*\*](#).
- Have smooth ceilings, and an internal roof pitch of 4:12 or 6:12 is commonly used.

We recommend to:

- Add circulation fans to improve air speeds in the summer to cool dairy cattle.
- Use automatic adjustable curtains or mobile panels to make quick changes according to varying weather conditions.



Figure 2. Naturally ventilated barn with added HVLS fans to increase air speed under the fans to assist in cooling dairy cows, *Source: Craven Farm.*

## 2.2 Mechanical ventilation

Mechanical ventilation consists of using fans to facilitate air movement throughout the building.

Types of mechanical ventilation:

- Neutral pressure ventilation: uses fans to pull air into the building and fans to extract air from the building.
- Negative pressure ventilation: uses exhaust fans to pull air out of the building and passive air inlets, allowing fresh air to enter (ex., tunnel ventilation, cross ventilation).
- Positive pressure ventilation: uses fans to pull air into the barn with passive air outlets, allowing stale air to exit the building (ex., positive pressure air tube ventilation, positive pressure hybrid ventilation).

Different fan sizes can be used to meet the appropriate air changes in the winter (4-8 air changes per hour or 25-40 cubic feet per minute/cow) and summer (40-60 air changes per hour or 400 – 600 cubic feet per minute/cow). Smaller fans are typically used in the winter, while larger fans are used in the summer. Reducing fan speed in the winter using variable-speed fans can also be used to meet appropriate air changes in the building. However, fans are not as efficient when set to run at one-third to one-half their capacity. Therefore, using a range of fan sizes is recommended to ensure appropriate air changes throughout the year.

Mechanical hybrid ventilation can also be used in dairy barn facilities, combining mechanical and natural ventilation. For example, tunnel ventilation can be used in the summer, and natural ventilation can be used in winter. This approach takes advantage of both systems to optimize airflow year-round.

### 2.2.1 Tunnel ventilation

Tunnel ventilation is a type of negative pressure ventilation in which exhaust fans are located at one end of the barn and large air inlets are located on the opposite side of the barn.

For tunnel ventilation, the building should:

- Ideally be rectangular to facilitate air travelling horizontally through the building without too many changes in air flow direction.
- Have large enough air inlets at the opposite end of the barn from the exhaust fans to bring in a sufficient amount of air while also creating good airflow (2 sq ft per 1000 CFM).
- Have an office area and milk equipment rooms along the side of the building so as not to interfere with air flow throughout the barn.
- Have adjustable air inlets, adjusted to provide enough air speed to mix the air throughout the building. At least 500 ft/min (2.5 m/s) air speeds at the inlet openings throughout the year.
- Use automatic adjustable curtains or mobile panels to make quick changes according to varying weather conditions.
- Add circulation fans over stalls to reach appropriate air speeds in the stalls' microenvironment. Using only exhaust fans makes it difficult to achieve proper cooling air speeds (at least 200 ft/min) at the cows' resting height. **For details on air circulation fans, see Section 3.**

For more information detailing tunnel ventilation design and function, please view the OMAFRA website on [Dairy Housing: ventilation options for free stall barns](#) and the Dairyland Initiative website on [Ventilation and Heat Abatement](#).

### 2.2.2 Cross ventilation

Cross ventilation is a type of negative pressure ventilation in which exhaust fans are located on one sidewall, and large air inlets are located on the opposite sidewall of the building. The air flow travels across the width of the building.

For cross ventilation, the building should:

- Have large enough air inlets on the opposite sidewall from the exhaust fans to bring in a sufficient amount of air, while also creating good air flow (2 sq ft per 1000 CFM).
- Add circulation fans or baffles over the cow's resting area to achieve cooling air speeds (at least 200 ft/min) at the cow's resting height in the summer. **For details on air circulation fans and baffles, see Section 3.**
- Have adjustable air inlets, adjusted to provide enough air speed (500 ft/min) to mix the air throughout the building.

For more information on cross ventilation design and function, please visit the Dairyland Initiative website on [Ventilation and Heat Abatement](#).

#### 2.2.2.1 Baffles

Baffles can redirect air toward the cows' level in specific barn areas, such as resting areas. They are recommended for use in barns with cross-ventilation systems (**Figure 3**).

Baffles should:

- Be retractable so they can be removed in the winter when cooling air speeds are no longer required.
  - In winter, air can become trapped behind baffles, affecting the air flow in the barn.
- Be 2 – 2.5 m (7 – 8 ft) above the barn floor (lowest point of baffle from the ground).
- Have an open space above them (~ 30 cm; 12 in) to allow air to flow over, reducing the risk of condensation.
- Be considered when choosing the type of exhaust fan used in the barn, as they can potentially increase the static pressure in the barn



Figure 3: Baffles positioned over dairy cow resting area in cross ventilation barn, *Source: Ferme Belvallée inc.*

For more information on baffle design and function, please visit the Dairyland Initiative website on [\*\*Ventilation and Heat Abatement\*\*](#).

### 2.2.3 Positive pressure tube ventilation system

A positive pressure tube ventilation (PPTV) system is a type of ventilation in which outside air is pulled into the building through a wall-mounted fan and distributed through a tube with equally spaced holes (**Figure 4**). The tube will be pressurized by the fan blowing fresh air into the tube, and air will be blown

out of each hole evenly. The air entering the barn from the tubes is then removed through a natural ventilation system, such as a ridge exhaust.

The PPTV system, developed by Dr. Ken Nordlund from the University of Wisconsin, can supplement a natural ventilation system, especially for calf housing facilities. During winter, calves may not produce enough heat to support air movement using thermal buoyancy, resulting in insufficient ventilation in naturally ventilated barns. Using PPTV systems to complement natural ventilation systems can be a good way to ensure proper air changes in the winter. During the summer, the PPTV system alone may not provide sufficient ventilation for the entire building. However, it will continue to circulate the air. Larger tubes and fans can also be used to reach 40-60 air changes per hour (wind speed of 250 – 300 ft/min) in the summer. Therefore, PPTV systems can remain active throughout the year. PPTV systems have also become popular in calf barns because they can bring fresh air directly to the calves' microenvironments (pens) and distribute air evenly throughout the building (**Figure 5**). This ventilation system can also be used to deliver fresh air to other microenvironments such as cows' or heifers' stalls.

Although PPTV systems positioned above stalls can bring fresh air to the cow's resting area, there are some challenges. For instance, crosswinds from open sidewalls could change the direction of the air exiting the tube holes. Using a PPTV system to cover long distances can also be a challenge, as it is difficult to provide sufficient air along the length of the tubes.

For PPTV systems, it is recommended to:

- Have wall-mounted fans draw air from the outside to ensure fresh air is distributed to the cattle. Do not pull air from another space within the building, as this could recirculate pathogens in the barn.
- Calculate hole spacing based on the fan capacity.
- Ensure the holes position is correct based on the tube height and pen setup.
- Have an air speed of approximately 1,000 ft/min 1-2 inches from the exit of the holes.
- Have the correct tube size for the fan capacity to maintain proper pressure. Usually, the diameter of a tube will be 1.25 - 1.50 times the diameter of the fan to achieve air speeds of 800 – 1020 ft/min (4 – 5.2 m/sec).
- Be out of the cattle's reach and out of the way of machinery passing through the building.
- Be used in smaller pens/areas of the barn.
- For calf housing, have hole sizes and positions calculated to cover the pen area and to allow for a wind speed of 60 ft/min (0.3 m/sec) at a maximum 3 - 4 feet from the floor (0.91 - 1.2 m) in the winter to avoid wind chill.



Figure 4. Positive pressure air tube ventilation system used to supplement air flow in the building, *Source: Ferme Laperle inc.*



Figure 5. Positive pressure air tube ventilation system in a calf barn supplementing a natural ventilation system, *Source: Ferme Mystique S.E.N.C.*

For more information detailing PPTV design and function, please view the OMAFRA, 2015 factsheet entitled **Positive Pressure Air Tube Ventilation for Calf Housing** and visit the Dairyland Initiatives website on **Natural Ventilation with Supplemental Positive Pressure Tube Ventilation** and **Ventilation and Heat Abatement**.

#### 2.2.4 Positive pressure hybrid ventilation

Low-volume high-speed (LVHS) fans (Ex. panel or basket fans) can supplement natural ventilation systems. LVHS fans can be placed along the length of the building to increase the amount of air entering the barn through air inlets and direct the air towards the centre to improve the supply of fresh air (Figure 6).



Figure 6. LVHS fans placed along the side of the building pulling air into the barn through the sidewall air inlets, *Source: Ferme Caribou.*

For more information on positive pressure hybrid ventilation design and function, please visit the Dairyland Initiative website on [ventilation and heat abatement](#).

### 3. Air recirculation systems

Air recirculation systems should be designed to provide appropriate cooling air speeds (200 – 500 ft/min; recommended 300-500 ft/min in humid climates) to cattle’s resting area or other high-traffic areas in the barn (ex., feed alley and holding pen).

Air recirculation system examples:

- Low-volume high-speed (LVHS) recirculation fans
- High volume low speed (HVLS) recirculation fans

#### **3.1 Low volume high speed (LVHS) recirculation fans**

Low-volume high-speed (LVHS) fans, such as panel or basket fans, refer to fans that displace a low amount of air at high speeds. Recirculation fans can vary in size and be mounted in many ways

depending on the building's layout. LVHS recirculation fans provide high air speeds and can be tilted to direct air movement to desired locations in the barn (Ex. stalls, feed bunk, holding pen; **Figure 7**).

LVHS recirculation fans should:

- Be orientated in the same direction, in line with prevailing winds, or directed towards fan exhaust in mechanical ventilation.
- Activate automatically at temperatures between 18 - 20°C.
- Be spaced and angled appropriately to provide adequate air speeds to cattle.
  - To provide sufficient air speeds and area coverage in dairy cow housing facilities, the recommended spacing between fans is 24 ft (7.3 m) for fans with blade diameters between 48 – 54 in (1.2 – 1.4 m).
  - Larger capacity fans may be capable of moving more air at higher speeds and over larger distances, but the resting area of cows occupying adjacent stalls/areas can block and redirect the airflow. Thus, placing more fans closer together may be required to meet optimal air speeds.
  - The first 2-3 cows immediately in front of angled fans may not receive sufficient air speeds from the fans closest to them due to the angle of the fan. Position fans so that air speeds from the previous fan reach the cows directly in front of the next fan.



Figure 7. LVHS recirculation fans positioned above the cows' stalls (resting area), *Source: Ferme Melga Inc.*

### **3.2 High volume low speed (HVLS) recirculation fans**

High volume low speed (HVLS) recirculation fans are large fans installed on the ceiling (**Figure 8**). HVLS can be used to recirculate ambient air in the building. However, the resulting air speeds from HVLS fans are limited. The air speeds close to the fan are fast; however, the air speeds quickly slow down further from the fan. Therefore, it can be difficult to reach appropriate cooling air speeds in the cows' resting area using HVLS fans.

Installing HVLS recirculation fans near walls with angled roofs may be difficult due to low ceiling height and building support columns interfering with their positioning. It has been observed that HVLS recirculation fans can be used at low speeds to mix the air in the winter.

HVLS recirculation fans should:

- Be evenly spaced so that the entire area is covered with appropriate air speeds to avoid bunching behaviour
- Be placed directly above the cattle's resting area.
- Be installed higher than any overhead door by at least 0.3 m (1 ft).
- Activate automatically at temperatures between 18 - 20°C.



Figure 8. High volume low speed (HVLS) recirculation fans positioned on barn ceiling, *Source: Ferme Caribou*

#### 4. Additional systems used to mitigate heat stress

In addition to air recirculation systems, the following systems/strategies can also be used during the summer to reduce heat stress in dairy cattle.

**WARNING! Adding water via foggers, misters, or sprinklers will increase the humidity in the barn, affecting the cow's heat tolerance. It is important to have excellent air exchange in the building to allow all ambient moisture to escape outside the building and allow humidity levels to be lowered to an acceptable level.**

##### 4.1 Foggers and misters

Misters and foggers use evaporative cooling to cool the air within the dairy barn, reducing ambient air temperatures, but they also increase the relative humidity in the barn. Fogging and misting systems consist of pipes, connectors, shut-off valves, pumps, water nozzles, and recirculating fans, dispersing water droplets into the barn. Although the systems work similarly, misting systems create larger water droplets (15 and 50  $\mu\text{m}$ ) in diameter, while high-pressure (1000 psi) foggers disperse fine water droplets (diameter =  $\sim 5 \mu\text{m}$ ), and it's recommended to use a series of nozzles (0.1 L/min) spaced 0.8-1.0 m apart. These systems can be installed above feeding areas or resting areas (stalls) using recirculating fans to disperse the water droplets. However, installing these systems over resting areas, such as in stalls, can create issues with wet bedding. These systems should be activated at intervals of 15 sec every 30 min during moderate heat stress and 2 min every 10 min during intense heat stress.

The increase in relative humidity created by misters or foggers will depend on several factors linked to the climate and barn characteristics. Misters and foggers have been effective in cooling the environment of dairy cows in tropical and dry climates. However, in humid Canadian climates, precautions must be taken to avoid increasing humidity levels in barns, as this could be detrimental to the cattle's ability to disperse heat, resulting in increased heat stress. THI within the barn, not only ambient temperatures within the barn, should be used to determine whether dairy cattle are at risk of heat stress (**see Section 1 for details**).

#### **4.2 Sprinklers**

Sprinkler systems use large drops of water to wet the cows' skin, combined with recirculation fans (200-500 ft/min or 1.5-2 m/s) to push air over the cow's body, causing evaporative cooling on the skin. These systems are equipped with low-pressure nozzles (20 - 50 psi) and a rotating sprinkler head with flow rates ranging from 1 to 2 L/min to wet an area of 1.8 – 6.0 m in diameter. Sprinkler systems can be installed 6 - 12 inches from the feedbunk and positioned to wet the cow's back, ensuring effective cooling when combined with appropriate air speeds from recirculating fans. However, it is **not** recommended to position sprinkler systems above cow's resting area. For optimal results, activate the systems for 1-3 min every 15-30 min during moderate heat stress, and for 2 min every 5-10 min during intense heat stress.

Sprinklers are effective methods to reduce heat in hot and dry climates. However, similar to misters and foggers, precautions must be taken in the humid climates of Canada to avoid increased humidity levels in barns, which could increase the risk of heat stress of dairy cattle. THI within the barn, not only ambient temperatures, should be used to determine whether dairy cattle are at risk of heat stress (**see Section 1 for details**).

#### **4.3 Shade**

The provision of shade will help reduce the heat from the sun.

Options to reduce cattle exposure to direct sunlight in the barn:

- Oriented buildings from east to west
- Glazed windows

- Awnings and overhangs added to the side of the building, providing extra shade in the summer
- Surrounding trees can provide shade for the barn, but be cautious of tree position to avoid obstructing airflow into the building.

## 5. Ventilation strategies for specific housing types

### 5.1 Calf housing ventilation

Ventilation plays an important role in keeping calves healthy, as they are more susceptible to pathogens. Proper ventilation removes dust, moisture and gases from the air and reduces air bacteria counts. To reduce the spread of pathogens, fresh air should enter the calves' space directly from outside, and ideally, calves should not be housed in the same environment as adult cattle.

Air changes and flow should be uniform, reaching the floor of the calves' resting area. This can be challenging in pens with solid partitions that create microenvironments and reduce air quality. The recommended seasonal air change rates are the same as for older cattle, and calves can also be affected by heat and cold stress (**see Section 1 for details**).

Calf housing facilities can be ventilated either via natural or mechanical ventilation, with proper considerations for calves. For instance, air flow should reach calves at resting levels (ground level) without creating a draft. Air speeds at 60 ft/min (0.3 m/sec) or greater can create drafts, increasing heat loss, and potentially chilling the calves when it is cold. Additionally, stocking density can impact the air quality within the barn, with more air volume (barn volume) per calf potentially improving air quality. The recommended minimum air volume is 600 ft<sup>3</sup> (17 m<sup>3</sup>) per calf.

Air inlet placement is crucial in mechanical ventilation, such as negative pressure systems (tunnel and crossover ventilation). Placing the inlets closer to younger calves ensures they receive fresh air, but it also exposes them to the coldest air. Conversely, placing inlets closer to older calves can allow pathogens to move from older to younger calves. Positioning air inlets in a way that reaches all calf pens evenly can also be challenging. Additionally, air inlets can become blocked (straw, snow, dust) and, therefore, should be monitored and cleaned regularly. Mechanical ventilation in calf buildings can be designed to provide proper air changes and fresh air at the calves' resting height (ground level). For example, fans can pull fresh air through perforated walls and/or large air inlets in the summer, with exhaust fans directing air into the calf pens (**Figure 9**). These pens should have open barriers (ex., gates, fencing) between air inlets and exhaust fans to ensure proper air flow reaches the calves' resting area (just above the floor). Obstacles will push the air up near the ceiling instead of passing through the calf's resting area. Additionally, when using mechanical ventilation, different-sized fans or fans with the ability to produce varying speeds should be used to achieve appropriate air changes in the summer (60-80x) and the winter (4-8x).



Figure 9. Separate calf building using fans to pull fresh air into the building and distribute evenly through the building via perforated walls, using exhaust fans to direct air towards the calf area and expel air out of the barn (neutral pressure ventilation). Additional air inlets can be seen above the perforated wall to increase the flow of fresh air in the summer, *Source: Ferme Belvallée Inc.*

Natural ventilation is commonly used in calf housing facilities and can be more cost-effective than mechanical ventilation, as it requires fewer fans and less electricity. With proper exterior wind speed, natural ventilation can be a good option to ventilate the calf barn; however, on days when the air is still in cold weather, natural ventilation systems become less effective. Therefore, it is recommended to supplement natural ventilation with positive pressure tube ventilation (PPTV; **see Section 2.2 for details**). To prevent drafts in naturally ventilated calf buildings, pens should be 3 ft (1 m) from the exterior walls, with a 20 - 24 in (51 - 61 cm) low solid wall/barrier at the base of the pens to deflect exterior air while allowing air flow at the calves lying surface (**Figure 10**).



Figure 10: Natural ventilation with positive pressure ventilation, *Source: Ferme Mystique S.E.N.C.*

Summary for all calf ventilation systems indoors:

- Air needs to be renewed at ground level, where the calves spend most of their time.
- Avoid creating microenvironments where airflow is blocked. Using barriers that allow for improved air flow (ex., gates, fences), at least at the front and back of pens, to assist air flow within the calf's pen.
- Ensure you have proper stocking density (minimum air volume of 600 ft<sup>3</sup> (17 ft<sup>3</sup>) per calf)
- Avoid drafts (air speeds > 60 ft/min (0.3 m/sec)) that could chill calves, especially in cold weather.
  - Pens should be 3 ft (1 m) from the exterior wall with a 20 - 24 in (51 - 61 cm) low solid wall/barrier at the base of the pens.

For a quick look at considerations and recommendations for calf ventilation and thermoregulation, see the following factsheet: [Calf ventilation and thermoregulation](#)

### Hutches

Housing calves in hutches can provide them with outdoor access and improved air quality. To maintain good air quality, make sure that hutches are not positioned close to other barn exhaust fans.

Cold stress in calves housed in hutches can often be mitigated by adding sufficient straw for nesting behaviour, using calf jackets, and increasing the amount of milk/milk replacer fed to calves. However, heat stress in the summer can be more challenging to combat due to the greenhouse effect that can be created inside the hutch.

Options to reduce heat stress in hutches:

- Position the hutches in the shade (ex., trees, shade structures)
- Build a roof over the hutches to help reduce radiation from the sun.

- A height of at least 3 metres is recommended to provide shade and allow air to circulate. Low roofs will retain the heat in the hutches.
- Have the front of the hutch facing north to limit incoming sunlight (switch the hutch back to facing south in the winter).
- Keep vents in the hutches open to improve air flow.
- Improve air circulation in hutches by lifting the back of the hutches off the ground using blocks (**Figure 11**). Ensure the blocks and calf hutches are secure to avoid calf injury.



Figure 11: Hutches on blocks, *Source: Ignacio Cervantes.*

### **5.2 Compost bedded packs ventilation**

Proper ventilation is essential in compost bedded packs to avoid a build-up of heat and moisture from the pack. Both mechanical and natural ventilation systems can be used, but natural ventilation is more commonly used. According to the OMAFRA factsheet #15-025, Compost Bedding Pack Barns by R. Niraula, it is recommended that sidewall openings be slightly larger (at least 14 ft (4.5 m) in compost bedded pack barns with a recommended sidewall opening of 16 ft (5 m) for barns wider than 40 ft (12 m).

Similar to other housing designs, recirculation fans are recommended to reduce heat stress in dairy cattle. These fans should be positioned evenly throughout the resting area to help prevent cattle from bunching and overly defecating in specific areas of the barn (**see sections 3.1 and 3.2 for recirculation fan options**).

### **5.3 Tie-stall ventilation**

In tie-stall barns, cattle are unable to move into areas with higher air speeds or away from drafts; therefore, targeted ventilation and well-insulated barns are recommended to maintain tight control over the barn environment.

Both mechanical and natural ventilation can be used to achieve appropriate air changes in the barn (**see Section 1 for information on proper air changes in the barn and Section 2 for different types of ventilation systems**). In the summer, it is recommended to place LVHS recirculation fans above the tie-

stall rows to ensure that all cattle receive cooling air speeds (200 – 500 ft/min; **Figure 12**). Placing smaller fans closer together helps provide appropriate air speeds evenly to the cattle. If the recirculation fans are too far apart, cattle may block the air movement to other cows further from the fans or directly beneath it. To provide sufficient air speeds and area coverage, the recommended spacing between fans above tie-stalls is 8 – 10 times the diameter of the fan for fans with blade diameters between 20 – 36 in (0.51 – 0.91 m). This recommendation can vary according to fan types; therefore, it's recommended to install one fan, measure the air speed distance, and then place additional fans accordingly. **For more information, see section 3.1 on LVHS fans.**

When a mechanical ventilation system is used, careful consideration must be taken when positioning and determining the size of air inlets. In winter, multiple small air inlets should be provided throughout the building to even out the temperatures. In summer, tunnel ventilation is a popular choice to provide fresh air to cattle. However, as mentioned above, cattle often block the air flow of other cattle in the same row of stalls. Therefore, it is necessary to add recirculation fans above tie-stalls. PPTV systems can also be used to bring fresh air directly to cattle housed in tie-stalls (**See section 2.2 for information on PPTV ventilation systems**).



Figure 12: Addition of circulators above tie-stalls to ensure proper air speeds reach the cows in their stalls, *Source: Ferme J.C. Lafortune et fils inc.*



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