

# Effective Natural Ventilation Strategies

By  
Curt A. Gooch, P.E.  
Senior Extension Associate  
Agricultural and Biological Engineering  
PRO-DAIRY Program  
Cornell University

## Introduction

What is the function of a dairy housing barn? The answer is simple: to provide sun protection in the summer, and wind and moisture protection in the winter. Modern, naturally ventilated dairy housing barns should be thought of as shelters. Shelters provide relief from the elements, but not total environmental control. Inherently, they are constantly ventilated by the nature of their design.

In theory, natural ventilation is easy to achieve. But in practice, far too many times it does not happen to the extent needed to provide a suitable environment. Many factors influence natural ventilation. But before we talk about the factors that influence ventilation, we need to understand the principles of proper ventilation.

## Basics of Ventilation

Whether using mechanical or natural ventilation, the goal is to provide fresh air uniformly throughout the dairy shelter so all animals receive adequate quantities and qualities. Emphasis here is placed on fresh air! A shelter's fresh air source is the ambient outside air. Therefore, proper ventilation means taking outside air and evenly distributing it throughout the shelter. Incoming air mixes with air contaminants (moisture, dust, pathogens, manure gases, and heat) in the shelter and is discharged, as shown in Figure 1. **Fans hanging over stalls or alleys do not provide air exchange and are not a substitute for open sidewalls and endwalls.**

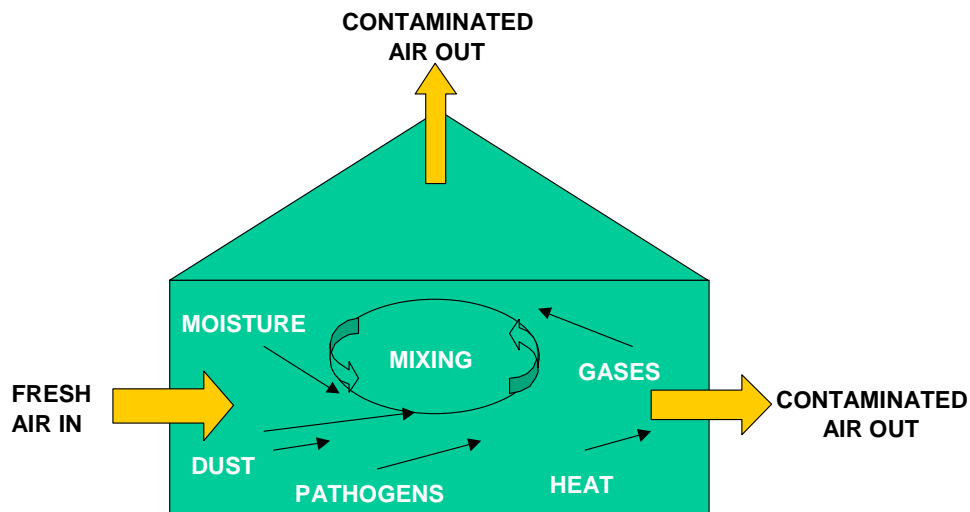


Figure 1. Basic principle of ventilation: fresh air mixes with shelter air contaminants and is discharged.

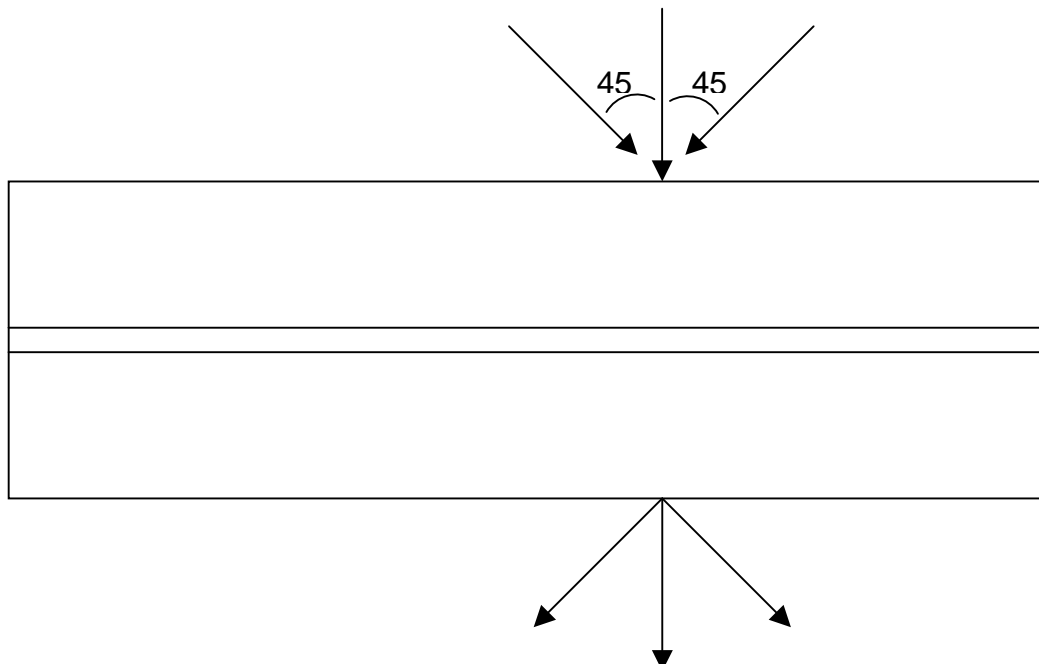
## Natural Ventilation

To naturally ventilate a shelter, only a few things are needed: wind generated by Mother Nature, knowledge of a few simple engineering principles, and a little common sense. That's all there is to it! Design efforts are focused on maximizing the free energy provided by nature. Let's look at the important principles that need to be considered when designing a natural ventilation system.

### Shelter Location and Orientation

A successful natural ventilation system depends on the shelter's location and orientation. Animal housing shelters should be sited so that wind breezes are not blocked by natural or man-made structures. Ideal locations are on the highest ground available on the farmstead. Other structures, such as silos (both uprights and bunkers), other barns, and natural wind barriers should be located on the leeward (downwind) side of the shelter. When constructing multiple animal housing shelters, minimum shelter spacing should be at least 75' and preferably 100' or more to allow for proper air exchange. As shelter lengths increase, the spacing between shelters should also be increased.

The ideal orientation of the shelter allows prevailing summertime winds to intersect the shelter perpendicular to the sidewall as shown in Figure 2. With this orientation, air entering the shelter through the curtain sidewall travels the shortest distance possible to exit the shelter through the opposite sidewall. This improves the rate of air exchange in the shelter and consequently enhances the cows' environment. Since winds change direction, winds striking the sidewall within 45 degrees of the perpendicular will still result in adequate air exchange in most cases.



**Figure 2. Plan view of the orientation of dairy shelter with respect to the prevailing summertime winds.**



In many locations in the Northeast the prevailing summertime wind direction is from the west or west-southwest. (This should be confirmed on your site as prevailing wind direction is truly site specific.) It is not advisable to construct a shelter with stalls along the outside row of a shelter that is oriented north-south (perpendicular to the prevailing wind) due to the fact that afternoon sun will shine on these stall beds. Head to head stall layouts are preferred in this situation with center drive-through feeding shelters. Drive along feeding shelters can be designed with the feed alley on the west side of the shelter thus precluding sun penetration on stalls.

Other factors that affect shelter orientation include future expansion, topography, cow flow, and manure flow. Producers should consider all of these factors when siting and orientating their shelters.

### Sidewall Openings

Sidewalls of naturally ventilated shelters are the air inlet or the air outlet depending on the wind direction. For proper ventilation to take place, the sidewalls of the shelter must be open; fully open in the summer, moderately open in the late fall and early spring, and yes, even somewhat open in the dead of winter.

Sidewall heights should be a minimum of 12' for open front 2- and 3-row shelters, 14' for 4-row shelters, and 14 to 16' for 6-row shelters. With these sidewall heights, large volumes of air can enter and exit the shelter, even with slight breezes. Also, high sidewalls mean that, during periods of little or no natural air exchange, a large volume of dilution air is available in the shelter. This prolongs the period of time until the "stagnant air" in the shelter becomes "stale air".

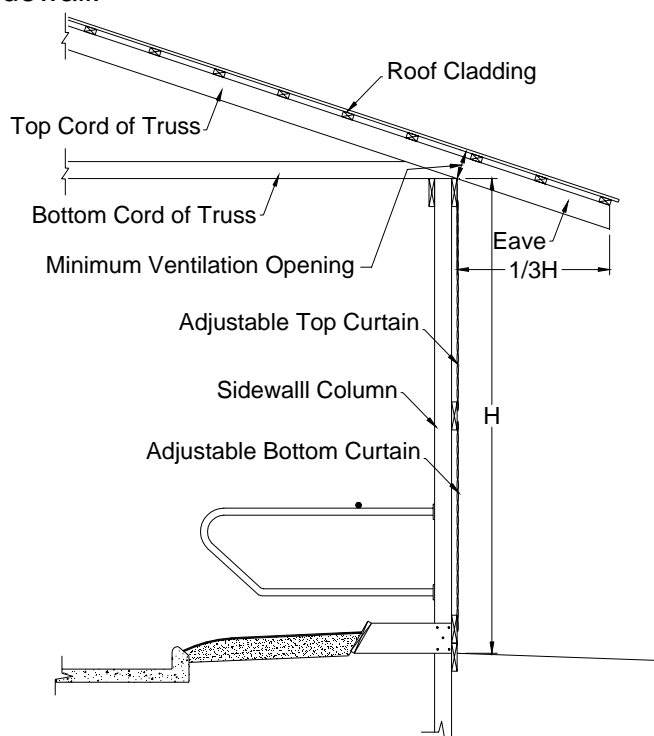
Adjustable curtains are used on shelter sidewalls and endwalls to maximize ventilation openings. Sidewall curtains are usually split in half to form a top curtain and a bottom curtain. In most systems, top curtains drop down to open, and bottom curtains rise up to open. Curtains that roll to open and close are preferred over those that bundle as they take up much less space when opened, and also they do not provide as much habitat for rodents.

Producers must be careful not to block the openings provided by high sidewalls with excessive curtain hardware or support materials. For example, using 1" by 2" welded wire mesh as curtain support is better than using expanded plastic safety netting, which has an increased surface area. Similarly, curtain storage on a split curtain system (specifically those that bundle together when open) reduces the effective opening. Bundling and raising the top curtain to immediately below the eave and up against the structural header keeps the curtain cleaner and minimizes wind blockage.

### Eave Openings

Eaves can be designed to act as the primary air inlet during cold periods with strong blowing conditions and to provide protection from the sun and elements. For 2-, 3-, and 4-row shelters, the effective eave opening should be a minimum of 1" per every 10' of building width. For 6-row shelters, the effective opening should be at least 1-1/2" per

10' of building width. Eave air inlets are openings that cannot be closed down—they are always open. Usually, the distance between the top of the sidewall truss support header and the bottom of the roofing material is sufficient space to provide minimum ventilation. For cases where the soffit is totally enclosed, minimum ventilation can be obtained by making the effective height of the curtain correspondingly less than needed to totally close the sidewall.



**Figure 3. Curtain sidewall for a naturally ventilated shelter. Sidewall height, H, should be a minimum of 12' for 2- and 3-row open front shelters, 14' for 4-row shelters, and 14 to 16' for 6-row shelters.**

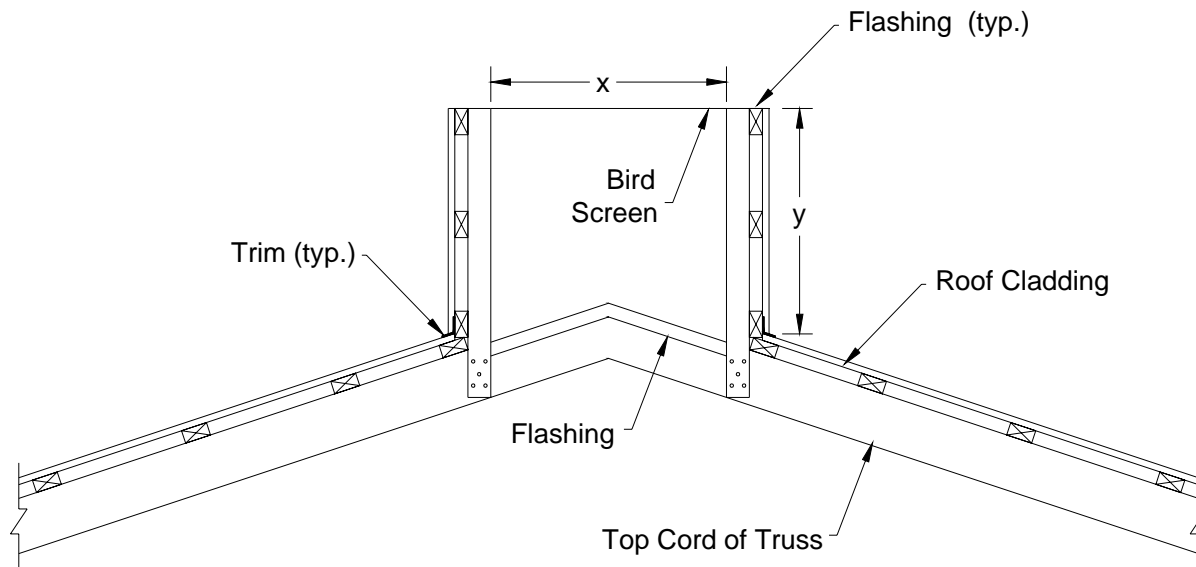
### Ridge Openings

Ridge openings are helpful in naturally ventilated freestall shelters as they allow warm, rising, contaminated air in the shelter to escape through the peak. Effective ridge openings should be two times the effective openings of the eaves—a minimum of 2" of horizontal width for every 10' of building width. Three (3) inches per 10' of width is recommended in 6-row shelters.

Many producers are skeptical about providing such an opening, as they are concerned with precipitation entering the shelter. Numerous methods are available handle this problem. Examples include installing a gutter system below the ridge opening and sloping the concrete feed alley floor to the center of the building away from the feed table eating surface. On-farm research performed in the early 1990's showed that the best adaptation to the open ridge to help preclude the entrance of snow is to install ridge upstands, as shown in Figure 4. Upstand height should be at least equal to the width of the effective opening. One central New York State producer used a 40" ridge opening with upstands in his new 6-row shelter. The first year in use, he reported that

no measurable levels of snow came in through the open ridge despite the severe winter. Several subsequent winters have also proven to be no problem.

Structural members exposed at the peak of the building should be flashed or otherwise protected from precipitation.



**Figure 4. Open ridge with vertical upstands installed to enhance airflow and minimize moisture intrusion into the shelter.  $X = 2''$  per 10' of building width for 2-, 3-, and 4-row barns and  $3''$  per 10' of building width for 6-row barns. The value of  $Y = X$  to  $2X$ .**

### Roof Slope

Roof slope has an affect on the rate that hot air generated by the cows rises vertically in the shelter and discharges through the peak. All shelters with a gable design are best ventilated with a roof slope of 4/12. A pitch of 3/12 is suggested for monoslope roofs.

### Endwall Openings

Endwalls on freestall shelters should be opened as much as possible. This provides another means of allowing fresh air to enter the shelter and for stale air to exit. Opening the endwalls on days when the wind is blowing towards the endwall is especially effective with shelters that are short in length. Open endwalls can be achieved through various methods that can be used separately or collectively together as a system. This includes:

- installing a curtain systems in the gable,
- installing a curtain systems in the endwall,
- installing roll-up doors,
- install removable panels, and/or
- install fabric mesh in lieu of metal siding.

### **Ventilation Management Guidelines**

The following guidelines can be used to monitor air quality in naturally ventilated, cold shelters (those with minimal or no insulation).

- In the winter, the inside dry-bulb temperature should not be more than 5 to 8°F above that of the ambient.
- In the spring, summer, and fall, shelter dry-bulb temperature should be equal to the ambient dry-bulb temperature (if no evaporative cooling is employed in the shelter).
- If your shelter smells like your grandfather's old barn, then you need additional ventilation.

In some cases dairy shelters will not be able to be successfully ventilated with a natural ventilation system. Barns that have inadequate openings or are sited incorrectly are subject to inadequate air exchange. Incorrect siting includes locating barns too close together, orienting them incorrectly, or placing them immediately downwind from seasonal or permanent wind barriers. These barns are good candidates for mechanical ventilation. Many producers in the Northeast, whose dairy barns did not naturally ventilate well with a natural system, are able to provide a quality environment for their confined cows by using mechanical ventilation.

Additional information on ventilation and other dairy facility related topics, including waste management, can be obtained by visiting the PRO-DAIRY facilities web site at [www.prodairyfacilities.cornell.edu](http://www.prodairyfacilities.cornell.edu) or by contacting the author (phone: 607-255-2088 or e-mail at [cag26@cornell.edu](mailto:cag26@cornell.edu)).