THE DAIRY PRACTICES COUNCIL®
In Cooperation with:
NE Regional Agricultural Engineering Services NRAES 119

NATURAL VENTILATION FOR DAIRY TIE STALL BARNS

A COMPANION GUIDELINE TO DPC 37

PLANNING DAIRY STALL BARNS

Publication: DPC 6 / NRAES 119

MARCH 1998

Prepared by:
THE DAIRY PRACTICES COUNCIL
FARM BUILDINGS AND EQUIPMENT TASK FORCE
Stanley Weeks, Task Force Director
AND
NORTHEAST REGIONAL AGRICULTURAL ENGINEERING SERVICE*

AUTHORS

Robert E. Graves
Professor, Agricultural & Biological Engineering, The Pennsylvania State University

Robert Milne
Farmstead Planning & Environmental Consultant, Ontario, Canada

John Porter
Extension Dairy Specialist, University of New Hampshire

Sponsored by:
THE DAIRY PRACTICES COUNCIL®

***NOTE*:**
NRAES is no longer active.
This document in its present form, has been discontinued under NRAES, which was taken over by Cornell University's Plant and Life Sciences Publishing (PALS). This GL is currently archived under the DPC but is still available.

EXCEPTIONS FOR INDIVIDUAL STATES NOTED IN TEXT OR FOOTNOTES
Additional Guidelines may be ordered from:
https://www.dairypc.org
https://www.dairypc.org/catalog/guidelines

Natural Ventilation for Dairy Tie Stall Barns

A Companion Guideline to NRAES/DPC 37

Planning Dairy Stall Barns

Table of Contents

GUIDELINE PREPARATION AND REVIEW PROCESS

The Dairy Practices Council (DPC) Guideline development and update process is unique and requires several levels of peer review. The first step starts with a *Task Force* subcommittee made up of individuals from industry, regulatory and educational institutions interested in and knowledgeable about the subject to be addressed. Drafts, called "*white copies*," are circulated until all members of the subcommittee are satisfied with the content. The final "*white copy*" may be further distributed to the entire Task Force; DPC Executive Board; state and federal regulators; educational and industry members; and anyone else the Task Force Director and/or the DPC Executive Vice President feel would add strength to the review. Following final "*white copy*" review and corrections, the next step requires a "*yellow cover*" draft to be circulated to representatives of participating Regulatory Agencies referred to as "*Key Sanitarians*." Key Sanitarians may suggest changes and insert footnotes if their state standards and regulations differ from the text. After final review and editing, the Guideline is distributed in the distinctive DPC "*green cover*" to DPC members and made available for purchase to others. These guidelines represent our state of the knowledge at the time they are written. Currently, DPC Guidelines are primarily distributed electronically in pdf format without colored covers, but the process and designation of the steps remains the same. Contributors listed affiliations are at the time of their contribution.

DPC DISCLAIMER

The DPC is not responsible for the use or application of the information provided in this Guideline. It is the responsibility of the user to ensure that the information addresses their needs and that any action taken complies with appropriate regulations and standards.

THE DAIRY PRACTICES COUNCIL **DPC 6, March 1998**

Northeast Regional Agricultural Engineering Service **NRAES 119**

Introduction

Naturally ventilated dairy tie stall barns have adjustable ridge and sidewall openings to allow fresh air to move through the barn without mechanical fans. These barns are insulated the same as mechanically ventilated tie stall barns to allow consistent control of inside winter temperatures and humidity. Well-managed natural ventilation provides fresh, dry, and comfortable conditions for dairy cows in tie stall barns. There are several advantages for natural ventilation, including:

- no fan noise
- low-cost operation
- simple and easy management and operation
- low maintenance
- electricity is not required for operation
- bright and airy work space
- shade from hot, summer sun.

Sufficient and continuous air exchange is necessary to replace warm, moist, or stale air inside a tie stall barn with fresh outside air. In a naturally ventilated tie stall barn, properly sized and located openings utilize the forces of wind and the difference between inside and outside temperature to provide the necessary air exchange and air distribution. Wind blows air through openings on the windward side of the barn and pulls air out of openings on the leeward side and the roof. Even low wind velocities will drastically affect air exchange in a naturally ventilated building. Temperature differences between warm inside air and cooler outside air cause air in the barn to rise and exit through high wall openings, stacks, chimneys or ridge openings. Cooler outside air enters through lower openings in the wall to replace the rising warm air. Ventilation due to temperature differences between inside and outside will be greater during cold winter conditions. Openings need regular adjustment to account for changes in wind speed and direction.

A naturally ventilated barn operates under three distinct conditions:

(1) Very cold winter conditions require **continuous, low-level air exchange**, even during sub-freezing periods, to remove moisture that is continuously produced by the animals.

(2) Mild winter, spring and fall conditions require **more air exchange for temperature control** to remove excess body heat from the barn in addition to moisture produced by the animals.

(3) Hot, summer conditions require **air velocity and high rates of air exchange** to help the cow remove large amounts of heat from her body and the immediate space around her.

A well-built and insulated barn is important for satisfactory operation of a natural ventilation system. The barn must be well insulated to limit heat loss and tightly constructed to minimize unplanned air exchange. During hot weather, wide-open side and endwalls expose the cows to any breezes that may be present. During extended periods of temperatures above 85° F (30°C) and no winds, fans blowing air across the cows will increase heat removal and comfort.

Natural Ventilation Systems

Naturally ventilated tie stall barns use a combination of sidewall openings and ventilation chimneys, stacks or intermittent ridge openings to allow maximum control of air quality and distribution (see figures 1a and 1b. Naturally ventilated barns built in the 1980s often used continuous ridge openings the entire length of the barn. It was difficult to build and closely adjust these continuous ridge baffles. Down drafts through the ridge, especially at the ends of the barn, and insufficient attic ventilation are often problems with a continuous ridge opening. Experience and research has demonstrated that intermittent stacks, chimneys, or short sections of ridge openings reduce these problems and still provide good control of air quality and distribution.

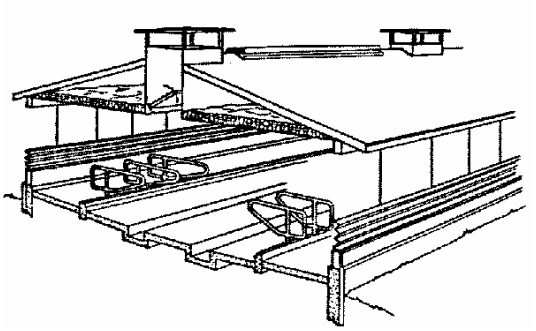

Figure 1 a. Barn with insulated flat ceiling and exhaust stacks or chimneys.

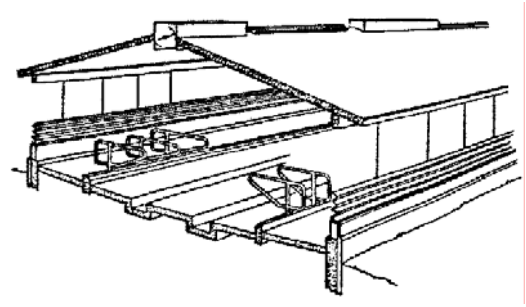

Figure 1b. Barn with insulated cathedral ceiling and intermittent ridge openings.

Control and Operation

Ventilation openings require adjustment in response to wind and temperature changes. Provide for separate control of openings on each sidewall and all of the chimney, stack or ridge openings. Winds can affect one end of a long barn differently than the other end. In barns longer than 100 feet, divide sidewall openings to allow one end to be adjusted independent from the other.

Automatic temperature-adjusting controllers are recommended since they will respond to changes even if no one is in the barn. If openings are controlled manually, careful attention to changes in temperature and wind speed or direction are required. This will mean more frequent trips to the barn especially during changing weather conditions.

REQUIREMENTS FOR NATURAL VENTILATION SYSTEM

(Refer to figures 1a and 1b)

- Exhaust stack, chimney or intermittent ridge area should be a minimum of 1 sq. ft per 300 sq. ft of floor area. (For a typical two-row tie stall barn this is a 2' X 2' stack approximately every 30 feet along the center line of the barn.)
- Space stacks 20 - 50 feet apart along the center of barn.
- Continuous adjustable sidewall opening 2-8 feet high on both sides (8' openings are recommended during prolonged hot weather).
- Large doors, curtains, windows or removable endwall panels for increased hot weather ventilation. Open endwalls allow maximum airflow through the barn regardless of wind direction.
- Provide for separate thermostat-controlled operation of exhaust stacks and openings on each sidewall.
- Excellent air/vapor barrier between animal space and attic space.
- Ventilate all enclosed attic spaces above animal areas (Continuous unobstructed 1" wide opening at each eave and 2" wide opening along the ridge between stacks. Increase opening width to account for obstruction to airflow from insect or bird screens.)
- Use flat chimney caps or roofs and extend a minimum of 8” on all sides of the chimney to reduce blowing ran and snow entry.

Insulation

Insulate naturally ventilated tie stall barns to the same levels as mechanically ventilated barns. This is important to conserve heat and minimize condensation on wall and ceiling surfaces. Typical recommendations for mild and cold climates are in the range of R = 9 to 19 for the sidewalls and R = 12 to 30 for the ceiling. Moisture resistant insulation materials will minimize damage from any moisture that may migrate from the animal space into the insulation. A properly installed vapor barrier is also required. Install and protect insulation to minimize damage by equipment, animals or rodents.

Controlling Moisture Movement

Livestock barns that are kept above freezing require careful steps to protect insulation and unheated attic spaces from being damaged by moisture from the humid animal space. When excessive moisture from the animal space gets into the colder attic space or outer layers of insulation, condensation occurs. Moisture condensing on insulation, on the inside of cold wall or roof surfaces, and on structural members will lead to deterioration and eventual destruction. Moisture contained in humid air gains access to cold attic spaces in two ways. The easiest to understand is when warm moist air flows through holes, tears, or cracks in air/vapor barriers or ceiling coverings. Moisture can also flow from a humid space to a drier space as water vapor without any air movement. Even without the flow of air, the moisture in the more humid air can migrate through porous materials such as wood, organic and fiberglass insulation, and "breathable" building wrap-type materials into a space with drier air.

Steps to protect insulation and cold attic spaces from moisture migration and damage include:

- moisture resistant insulation
- properly installed air/vapor barriers
- ventilation of attic areas to remove any moisture that gets into them.

It is difficult to install and maintain satisfactory sealed joints between panels of rigid board insulation or batt and blanket type insulation with a vapor barrier facing. An excellent air/vapor barrier such as a continuous 6-mil plastic film is recommended. Tightly seal all cracks and crevices at insulation joints, light fixtures, poles or other penetrations through the insulation and vapor/air barrier. Even small openings and cracks can allow large amounts of warm moist air to flow into the cold attic by convection.

Ventilate attic spaces above warm animal spaces by providing 1 square inch of opening for each square foot of ceiling area. Divide opening space equally between the high point (ridge and/or upper end wall) and low point (eaves and/or lower end walls) to provide for intake and exhaust of air.

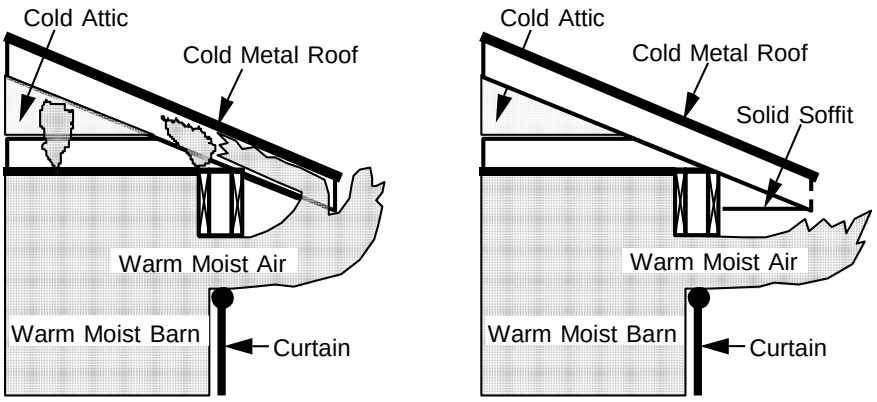

Figure 2. Warm moist barn air can easily flow into enclosed attic spaces. Proper design and careful construction will minimize this problem.

Do not try to ventilate attic spaces into stacks, chimneys, or ridges that are exhausting warm moist air from the animal area. Moisture can migrate back through these openings into the cold attic space even though there is no air exchange.

Barns with only sidewall ventilation are a particular challenge. These barns exhaust warm moist air along both sidewalls. On still days, this plume of warm moist air may flow into attic ventilation openings along the eaves (Figure 2). Large quantities of warm, moist air diverted into attic spaces will condense or freeze on cold roof surfaces and subsequently cause damage to insulation and building components. To minimize this problem, provide as much attic ventilation opening space on end walls and at the ridge as practical. Eaves should be built with solid soffits. Place slots for attic ventilation along vertical fascias.

Sidewall Closures

Continuous, easily adjusted sidewall openings are necessary for satisfactory ventilation. Curtains, panels or gangs of windows that allow adjustment of large sections from one point are recommended. Insulated curtains, panels or windows will minimize condensation and heat loss.

However, insulated curtains or panels do not allow light to enter the barn. Clear, single-ply translucent curtains or windows provide more light but result in extra heat loss and condensation on the curtains or single pane windows during cold weather. Water, from condensation running off curtains or windows, can damage building components and cause wet feed mangers. Protect building areas below single ply curtains to minimize damage from dripping condensation. To minimize the area of increased heat loss and condensation, use insulated curtains or panels on lower openings and single ply curtains for the top portion. For short periods of extreme weather, bales of hay or straw can be stacked along walls with single ply curtains.

Ridge and Stack Opening

Intermittent ridge sections, stacks or chimneys can easily be installed in new single story barns. Stacks or chimneys are easier to install in two story barns and existing single story barns being converted to natural ventilation. Do not use open ridges with king-post-type trusses. Protect portions of trusses or roof rafters exposed within stacks, chimneys or open ridges by painting or sealing with good quality paint or exterior urethane sealer. If there is no ridge cap, place a metal rain bonnet over the peak of any exposed trusses or rafters. All metal gussets and fasteners in this area should be galvanized and painted.

Insulate the sidewalls of chimneys or ridges all the way to the exhaust opening to prevent condensation of warm moist air.

Place chimney caps or covers high enough to allow free airflow beneath them. The total open area beneath the cap should be at least 1.5 times larger than the ridge or stack area. Insulate undersides of chimney covers or ridge caps to prevent condensation and dripping. Use flat chimney caps or roofs and extend them at least 8" beyond all sides of the chimney to reduce blowing rain and snow entry. A flat chimney cap will result in rain being blown off the roof, away from the chimney opening during heavy rains. (Figure 3)

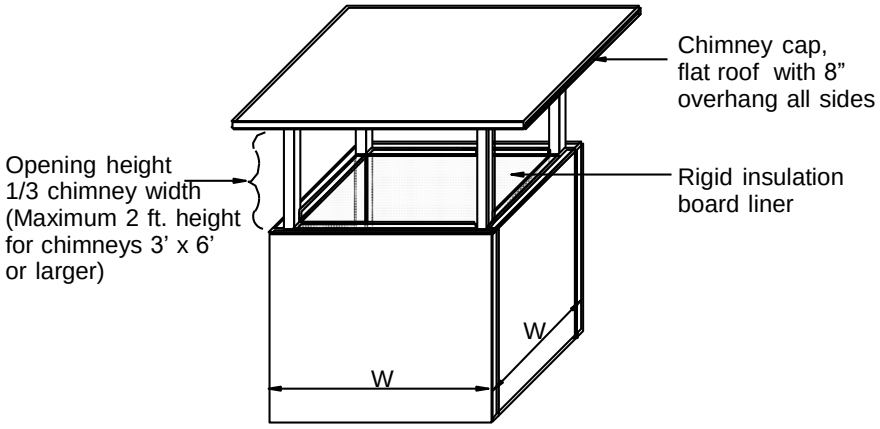

Figure 3. Insulated chimney with overhanging insulated flat cap.

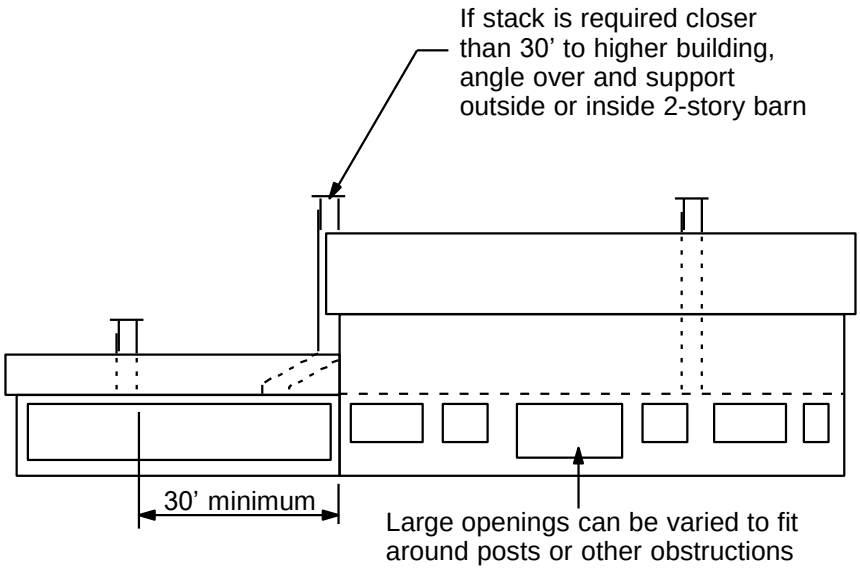

Figure 4. Ventilation stacks with different height buildings.

Increase the area of stack or chimney openings by 50% when new naturally ventilated buildings or additions are built adjacent or attached to higher buildings, silos, or behind windbreaks. Monitor stacks or open ridges closest to these higher structures for down draft effects from different wind directions. These openings may require independent manual operation. If possible, locate these openings at least 30 feet from higher structures or extend them to a point higher than the obstruction. It may be necessary to direct the stack over to the higher building and then up to an exit above the higher roofline. (Figure 4)

Summary

A properly designed and operated natural ventilation system will provide healthful conditions for dairy cattle in tie stall barns. Regular adjustment of ventilation openings is necessary to account for changes in wind speed, wind direction, and temperatures. Automatic adjustment using temperature sensors and power operators is best. Frequent observation and adjustment is necessary if automatic control is not possible. Barns with stacks or ridges seem to be more tolerant of less control than barns with only sidewall openings. It is important to have sufficient air exchange at all times to keep the barn air dry and fresh. In hot weather, maximum sidewall and endwall openings will allow cooling breezes, from any direction, to flow through the barn.