Overview of Ventilation Techniques

Brian J. Holmes, PhD
Professor & Extension Specialist, Emeritus

Department of Biological Systems Engineering
University of Wisconsin - Madison
Q. What is ventilation?

A. Air Exchange Between Inside and Outside

- Removes Contaminated Air
- Introduces Clean Air
Types Of Ventilation Systems

Mechanical Ventilation – Fans cause the air exchange

Natural Ventilation – Forces of nature cause the air exchange
Natural ventilation uses the forces of nature to cause the air exchange -

Wind is the primary force
Natural Ventilation - Winter

Wind

Air In

Air Out
Eave Opening
Natural Ventilation - Summer
Effect of Prevailing Summer Wind

Wind Direction

Orientation #1

Orientation #2
Effect of Prevailing Summer Wind

Orientation #1

Orientation #2

Wind Direction
Effect of Prevailing Summer Wind

Orientation #1

Orientation #2

Wind Direction
Barns Provide Shade From Solar Radiation

Shade Zone
Effect of Solar Gain

Orientation #1

Orientation #2

Afternoon Sun

Noon Sun

Morning Sun
Natural Ventilation Doesn’t Work When:

- Site has obstructions
- Structure can’t meet design criteria
- Site doesn’t allow for correct orientation
- Wind doesn’t blow enough
- Interior air blockages
Silos Obstruct Natural Ventilation In Summer
Ventilation Rate vs Wind Speed

- **4-Row, 10 ft Wall Open**
- **4-Row, 12 ft Wall Open**
- **6-Row, 10 ft Wall Open**
- **6-Row, 12 ft Wall Open**
- **Standard**

**Recommended Summer Ventilation Rate**

12 ft Wall Open
Natural Ventilation Supplements

Heat Stress Relief:
- Circulation Fans
  High Speed Low Volume
  Low Speed High Volume
- Sprinkling Cows
- Evaporative Misters/Foggers
Supplemental Circulating Fans in the Feed Line and Freestall Areas
High Speed Low Volume (HSLV) Fans in Freestall Barn
Cooling Fans for Close-up Cows
Fans in Holding Area
High Volume Low Speed (HVLS) Fans
HVLS Fan Layout

4 and 6 Row Barns
(Over Feed Lane)

3 Row Barn
(Over Freestalls)

Spacing @ 60’ o.c.

Height @ 16-18’ from Floor
Conclusion:

Air Velocity & Sprinkling give best heat stress control
Fans and Foggers in Freestall Barn
Natural Ventilation Supplements

Air Distribution:
- Circulation Fans
- Positive Pressure Tubes/Ducts
Reasons for Positive Pressure Tubes in Naturally Ventilated Barns:

- Design Criteria for building not met
- Wind not blowing
- Wind blocked by other structures or features
- Operator refuses to open eave inlets
- Interior feature causes dead air zones
- Stocking rate is excessive
- Calves entering are sick or have been exposed to pathogens
Positive Pressure Duct

Barn End Wall

Outside Air

Fan

Aim Holes at Floor
Fan Intake

Size Fan for Winter Minimum Ventilation Rate
Compliments UW School of Veterinary Medicine

Positive Pressure Tube

Individual Calf Pens
Positive Pressure Tube in Group Pen

Not to Scale
Mechanical Ventilation Types

- Negative Pressure
- Positive Pressure
- Neutral Pressure
- Mechanical/Natural Combinations
Mechanical Ventilation Requirements

- Fans
- Inlets/Outlets
- Controls (Manual, Temperature, Pressure, Humidity, Software)
Negative Pressure - Fans Exhaust Air
Air enters through inlets

Uniform Air Distribution
Slot inlets
Area inlets
Recirculation ducts

Wind Tunnel

Cross Ventilation
Negative Pressure w Single Slot Inlet

TO 19 Ft
Slot Inlet (Wall Hung Baffle)

6" Wide Slots Continuous Along Both Walls

Air Flow

1/2" Screen or Hardware Cloth

2" x 2" Ledge

1" x 1" Insulation Board Baffle

1" x 10" Chain
Negative Pressure – Single Slot Inlet
Less Than 19 Feet Wide

SLOT INLET

FAN 3

FAN 1

FAN 2

<19 FT
Negative Pressure w Double Slot Inlet

19 - 38 Ft.
Adjustable Four Sided Area Inlet

Perimeter = (2 x L) + (2 x W)
Negative Pressure with Recirculation
Recirculation Duct Inlet
Wind Tunnel

Exhaust Fans

Inlet Area
Tunnel Ventilation

• Air Exchange
• Air Velocity
Wind Tunnel Fans
Wind Tunnel Inlet - Closed
Tunnel Ventilation without Inlet Restrictions and Vault Open – Empty Barn

Plan View

Fans

Waterers

Side View
Tunnel Ventilation without Inlet Restrictions
Baffles Installed - Empty Barn

Plan View

Baffles
Waterers
Fans

Side View

Waterers
When does tunnel ventilation have fewer fans than natural ventilation with circulating fans?
Cross Ventilation

- Exhaust Fans
- Height
- Inlet Area
- Length
Basic Layout of Cross Ventilated Low Profile Freestall Building

Source: Joe Harner, K-State
Cross Ventilation Fans

Low Flow Fans
Evaporative Pads

5 ft

Evaporative Pads

5 ft
Cross Section Air Flow Path at Baffle

Roof

Baffle

Baffle

Freestall

Feed Alley

Freestall
Video of the Barn Being Smoked?

YES
Advantages of Cross-Ventilated Barns w Cooling Pads*

- Better control of cow environment
- Shorter pull distance than tunnel ventilation
- Excellent air quality
- Greater air exchange rate vs tunnel
- Minimal barn air temp. variation vs other barns
- Air past cows at high velocity
- No or limited sprinkling
- Option for short or long day lighting
- Elimination of direct solar heat gain-shade
- Elimination of sunlight on cow behavior

* From Jim Barmore-Five-Star Dairy Consulting & John Smith K-State
Advantages of Cross-Ventilated Barns w Cooling Pads*

• Minimal flies and birds in barn
• Shorter walk distance to parlor vs Natural Ventilation
• Small footprint for barn siting & site preparation
• Minimal concern for barn orientation (N-S vs E-W)
• Air flow is parallel to cow body—better cooling
• Cows do not block air flow from other cows as much as in tunnel ventilation & high speed fans

* From Jim Barmore-Five-Star Dairy Consulting & John Smith K-State
Disadvantages of Cross-Ventilated Barns w Cooling Pads*

- Fans run 24/7/365
- Back-up generator required
- Pressure drops high
- Most experience is w 8-row barns
- Shut down cooling pads in evening to “dry”
- Greater potential for airborne disease transmission??
- Fan maintenance is critical
- Parlor and breezeway must be integrated with negative pressure ventilation

* From Jim Barmore-Five-Star Dairy Consulting & John Smith K-State
Positive Pressure:
- Fans Force Air Into Building
- Air Exits through Outlets
Positive Pressure:
- Fan Into Duct (Cold, Cool, Warm, or Hot Seasons)
- Fans Through Wall (Warm, Hot Season)

Wind Tunnel

Cross Ventilation
Positive Pressure – Duct Only

Barn 40 - 50 Feet Wide
Positive Pressure Ventilation System – Plan View

Outlet

Step 1
Step 2

Step 3

Step 4

Step 1
Step 2
Positive Pressure Fans Forcing Air Into Duct Through Mow Wall Wall

Mow Floor

Duct

Duct Transition

Louver

Adjustable Slot Inlet

Winter Fan

Spring & Fall Fan
Positive Pressure Wind Tunnel

Fans Blow In

Outlet

Milking Parlor

Holding Area
Fans Blow In
Fans Blow In

Circulating Fans
Neutral Pressure:
Fan Force Air into Building and Fans Exhaust Air from Building

- Fan Into Duct (Cold, Cool Seasons)
- Fans Through Wall (Warm, Hot Season)
- Fans Exhaust through Walls, Floor or Roof
Positive Pressure for Winter, Spring/Fall
Natural / Mechanical Combination:

- Natural Ventilation (Cold, Cool, Warm Seasons)
- Mechanical Ventilation (Hot Season)

Example:
Natural & Wind Tunnel
¿QUESTIONS?