SIMPLE TOOLS TO RE-ENERGIZE YOUR SUMMER VENTILATION

Carlyle Bennett, Manitoba Agriculture Food and Rural Initiatives

GOALS FOR SUMMER VENTILATION

Temperature Gain is the difference between the temperature inside versus that outside the barn. On a hot afternoon, it will always be warmer inside the barn than outside the barn. Controlling temperature gain is the number one goal of summer ventilation. For every 1°C increase in temperature gain, the hours of heat stress over the summer are approximately doubled.

An achievable goal is to keep the barn temperature within 1°C of the outside temperature (temperature gain of 1°C). In practice, it is difficult to achieve a temperature gain below 1°C and the benefits to the birds will be limited.

In attic-ventilated barns, the outside temperature should be measured inside the soffit inlets under the eaves. In barns with wall inlets, the outside temperature should be measured either directly inside the inlet and away from direct sunlight or at the inlet opening as the air is entering the barn.

Airspeed at bird level is the second most important characteristic of you summer ventilation. In a cross-ventilated barn, the maximum potential airspeed across the floor surface is approximately 150 feet/minute. In the majority of cross-ventilated broiler and turkey barns, this airspeed is achieved over only 30% to 50% of the floor area. In cross-ventilated layer barns, it is rare to achieve this goal at bird level. The benefit of achieving 150 feet/minute airspeed is that the birds can cool themselves in this breeze and will “feel” a temperature that is 1 - 2°C cooler than the actual air temperature. In tunnel-ventilated barns, airspeeds of 300 – 500 feet/minute are possible and significantly higher air chill will be obtained. An additional benefit of elevated airspeed is that the turbulence helps to break up any pockets of warm air that might build up between birds.

Relative Humidity is not a concern when evaluating your summer ventilation. During the hot part of the day, the relative humidity inside the barn is often lower, and will rarely be more than 3% higher than the relative humidity outside the barn. Almost any barn will have enough airflow to control humidity build up during the hot part of the day.

Ammonia levels are easy to control during summer and usually, do not need to be measured.

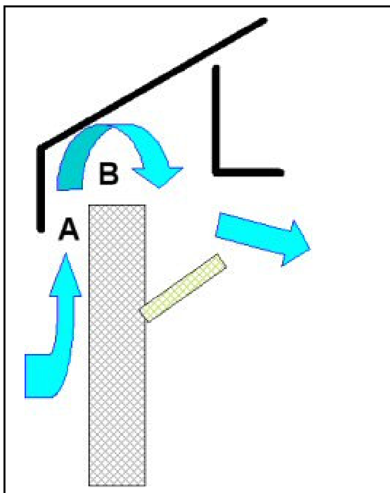
Carbon Dioxide will be far under the 5,000 ppm limit recommended for worker health. It is still useful to measure carbon dioxide because it gives you a measure of how much fresh air is being brought into the barn, relative to the kg's of birds in the barn. With all fans running, any barn should have under 1,000 ppm of carbon dioxide and levels of 500 – 750 ppm are possible. Since the air immediately outside a poultry barn has 380 – 480 ppm of carbon dioxide, barns with under 750 ppm of carbon dioxide are likely approaching the maximum, practical air turnover.

EAVES AND ATTICS

Poorly designed attics are a common cause of ventilation problems in old and new barns. In malfunctioning attics, the incoming air can heat up by 2 – 3°C before it reaches the inside inlets and enters the pen where the birds are. This temperature rise may not seem significant but it is enough to increase the hours of heat stress in the barn by 400% over the course of the summer. Remember that a 1°C increase in temperature, will approximately double the hours of heat stress over the course of the summer.

Some of the problems found in attics are:

- **Insufficient soffit inlet space relative to the inlet space inside the barn:** A crude rule of thumb is that the inlet space at the soffit should be double the inlet space inside the barn. Often the soffit inlet has just not been cut wide enough to allow for this ratio. Another problem is attaching a large storage room or egg processing room to the side of the barn thus eliminating a significant stretch of the potential area for soffit inlets. If the



Airflow through soffits (A) and over heel of rafters (B) must be unrestricted.

attached room is big enough, it will create a dead spot in the attic where the air becomes super heated. A common, but easily preventable problem is dust, which plugs the screens over the soffit inlets.

- **Inadequate space over the heel of the rafters:** Some barns have been built with a smaller opening over the heel than at the soffit itself. In other cases, this space has become restricted when insulation was added or other modifications were made.
- **Installing soffit inlets on only one side of the barn**: The attic cannot act as a plenum and cannot serve its function of limiting wind effects. Total soffit inlet area is often inadequate and, depending on inlet location, the fresh air heats up as it has to travel further through the attic to reach the inside inlets.
- **Inadequate fan capacity and inside-the-barn inlet space:** Air-flow through the attic is slowed.

For barns with inadequate soffit inlets, adding extra outside attic inlets at the ends of the barn and along the ridge of the roof can be inexpensive, although quite effective.

INSIDE INLETS

Everyone should know how much inlet space they have relative to their maximum fan capacity. Engineers today commonly recommend 1.25 - 1.70 square feet of unobstructed inlet space for every 1,000 cubic feet per minute of fan capacity (ft.^{2}/1,000 cfm). In the 1970's and 1980's, only 1.00 ft.^{2}/1,000 cfm was being recommended. This old value is marginal and barns with less than this amount of inlet space often have problems. Barns in Manitoba have inlet space ranging from 0.7 to 2.0 ft^2/1,000 cfm. In addition to, too few or small inlets, failure to open the inlets wide enough can be a problem.

Two signs of inadequate inlet space will be elevated airspeed at the inlets and high static pressure. When all of the fans are running, airspeed of 500 to 750 feet/minute appears to work well and inlet airspeed over 1,000 feet/minute is undesirable. Static pressure in the "0.03 to 0.06" range is often recommended and static pressure over 0.10" can leave the fans susceptible to wind effects. Fans that must pull air through the inlets at high speed and high static pressure will work harder and move less air.

FAN CAPACITY

Published recommendations from engineers often suggest 4 - 6 cfm per broiler chicken and 6 cfm/laying hen. This range translates to about 2 - 3 ½ cfm per kg of chicken. An airflow of 8 cfm/chicken or 4 cfm/kg is common in Manitoba although a wide range is observed between barns. Experience in Manitoba suggests that as the ventilation rate drops below the range of 2 - 3 cfm/kg, the carbon dioxide level (and thus the temperature gain) starts to rise rapidly. Above 3 cfm/kg, the carbon dioxide level (and temperature gain) appears to decline only marginally. Increasing the ventilation rate above 3 cfm/kg will increase airspeed and the beneficial wind chill but will have a limited impact on the temperature gain in the barn.

Producing a significant wind chill requires more airflow than needed simply to control the temperature gain in the barn. When discussing how much fan capacity is needed to generate airspeed in the barn, it is more appropriate to talk about cfm/ft.^{2} of floor space than cfm/bird or cfm/kg. In Manitoba, an airflow of 9 cfm/ft.^{2} is common but 15 cfm/ft.^{2} is used in broiler or breeder barns where a high airspeed, e.g. 150 feet/minute, is desired at bird level. A common goal for barns designed to have high airspeed is to have an air exchange once every 60 seconds. An air exchange greater than once every 120 seconds appears to create noticeable problems.

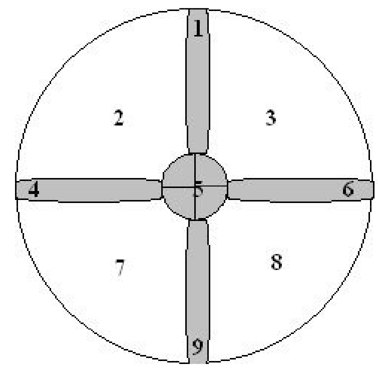
MANAGING AIRSPEED AT BIRD LEVEL

Most cross-ventilated barns have only enough fan capacity to draw air across the barn at an average speed in the range of 30 - 100 feet/minute. Even barns with high fan capacity, e.g. 15 cfm/ft.^{2}, will only generate an average airspeed across the barn of 65 - 100 feet/minute. To achieve high airspeeds at floor level, it is necessary to direct the fast moving inlet air towards the birds before it slows.

In most barns with a flat ceiling, it is only possible to create significant airspeed at floor level for a distance of 20 - 25 feet from the inlet. For this reason, it is usually necessary to have one row of inlets for every 20 feet of barn width if you want to create turbulence to spread across the entire floor area. In a barn 40 feet wide, for example, you need either a row of inlets running along each wall or a row along one wall and another row running down the middle of the ceiling.

It is possible to use re-circulating fans to create the desired air speed at bird level but the fans must be properly located and aimed. Also, the number of re-circulating fans needed, can be significant. As a crude rule of thumb, experience from Manitoba suggests that an additional 3 cfm/ft^2 of re-circulating fan capacity is needed to help generate 150 feet/minute airspeed across the floor surface. The tendency for the air stream from a re-circulating fan to quickly spread out and dissipate is one of the reasons why so much fan capacity appears to be necessary.

MEASURING FAN EXHAUST



Measure Airspeed at Nine Locations

The amount of air exhausted by the fans can be estimated by measuring airspeed at nine different locations on the fan, calculating the average airspeed, and then multiplying by the area of the fan opening. Consider the example of a 24" fan that is exhausting air through a circular, 25" diameter (12.5" radius) fan hood. The area of the circular opening that the air is being exhausted through is:

Area of fan opening = $\pi r^2 = 3.1416 \times 12.5^2 = 491$ $inches^2 = 3.41$ $feet^2$

If the airspeed of the exhaust air is measured and found to average 1,800 feet/minute, the exhaust airflow can then be calculated:

Airflow = Area of fan opening x Average air exhaust speed
= 3.41 $feet^2$ x 1,800 feet/minute
= 6,138 cfm

Given potential errors in measuring the fan hood and the average airspeed, it is quite possible for the calculated airflow to vary by 20% more or less than the actual airflow.

Even with the potential for error it is still worthwhile to estimate the airflow of the fans. The airflow of a fan can differ significantly from the design specifications of the manufacturer:

- Dirty shutters can reduce airflow by as much as 25%
- Light traps on the fans can reduce airflow by 20 to 50%
- Wind blowing into the fan at 15 mph can reduce airflow by 10 to 20%
- High static pressure due to inadequate inlet space can reduce airflow by 5 to 40%
- Different blades or motors can easily vary airflow by 20%

In older barns, it is suggested that the airflow of all fans be measured because the fan blades and/or motors have often been replaced over time. It is also important to measure airflows when light traps are being used. In winter, when variable speed fans are the major source of ventilation, direct measurement of airflow is usually the only way of estimating what the fans are doing.

MEASURING INLET AIRFLOW

By measuring the size of each inlet and the average airspeed at the inlet, the total airflow through the barn can be estimated:

Total Airflow = # of inlets x area of inlet opening x inlet airspeed.

As an example, a barn with 30 inlets, each with a 20" x 18" opening, and an average 700 feet/minute airspeed, will have a total airflow of 52,500 cfm:

Total Airflow = 30 inlets x (20" x 18"/144 inches^2/foot^2) x 700 feet/min.

= 52,500 cfm

The total airflow through the inlets can then be compared to the total airflow based on the design specifications of the different sizes and number of fans in the barn. Due to errors in measuring inlet opening and airspeed, the airflow estimated from the inlets can easily vary by 20% from the value calculated based on fan capacity. If the estimates based on inlet measurement and fan specifications differ by more than 20%, the reason for the possible difference should be investigated.

It can be very educational to perform similar measurements during cold weather. In some barns, air leakage is so great, that only 10% of the air exhausted by the fans appears to be entering through the inlets.

The inlets can be used to estimate the airflow through a naturally ventilated barn. As an example, consider a 40 feet x 250 feet naturally ventilated barn with a 5 feet wide inlet running the length of each side of the barn. A 1 mph or 88 feet/minute wind entering one side of the barn and exiting the other will be produce an airflow of 110,000 cfm through the barn or the equivalent of eleven 36" fans:

Total Airflow = Area of inlet opening on one side of barn x Average inlet airspeed

= (5' x 250') x 88 fpm

= 110,000 fpm

This airflow will provide 14 cfm/ft^2 of airflow or more than found in many mechanically ventilated barns.

TOOLS FOR MEASURING VENTILATION

a. Measuring Tape for measuring inlet openings and fan hood dimensions
b. Vane anemometer
   - Measures airspeed greater than 60 feet/minute. This is the lower limit for airspeed noticeable to well feathered birds.
   - Provides consistent inlet and fan airspeed readings.
   - At low speeds needs a fairly constant airflow to start the vane rotating.
   - Costs $160 to $280.
c. Hot wire anemometer
   - Measures lower airspeed than vane anemometer.
   - Sometimes too sensitive to achieve repeatable fan and inlet air measurements.
   - Can measure narrower air streams than vane anemometer.
   - Costs $450 to $900.
d. Probe Thermometer
   - Digital read-out is easy to read.
   - Probe heats up and cools off faster than thermometers enclosed in a case.
e. Temperature data loggers
   - BEST method of measuring temperature gain in the barn.
   - Buy small “button” loggers or loggers with probes as they heat up and cool off quickly.
   - Get logger with enough memory to record temperature once every 20 minutes for a month.
   - Twelve or more loggers are needed. Use at least four loggers at eaves, inlets and inside the barn.
   - Cost $70 to $200 per logger.
f. Carbon dioxide meter
   - Provides quick initial estimate of airflow in barn.
   - Good for finding where the fresh air goes. Lowest carbon dioxide levels correspond to the highest amount of fresh air.

- Demonstrates that air exhausted from the fans travels all around the barn.
- Takes 5 minutes to equilibrate to a change in conditions.
- Does not stand up well to humid, reduced air quality in winter.
- Costs $900

g. Static pressure gauge
- Measures how hard the fans are working to pull air into the barn.
- Provides quick initial estimate of inlet area relative to fan capacity.
- Often not properly installed or used.
- Can be useless in winter.
- Costs $50.

COMMONLY RECOMMENDED VENTILATION GOALS

a. Barn Design - Targets

- Air turnover once every 60 seconds
- One row of inlets for every 20 to 25' of barn width
- 3 or more cfm/kg of chicken to control temperature gain
- 15 cfm/ft.^{2} if elevated airspeed and turbulence are desired
- 1.25 to 1.70 ft^2 of inside inlet area per 1,000 cfm of fan capacity
- Soffit inlet area double inside inlet area

b. Barn Conditions - Targets

- 1°C temperature gain
- Under 750 ppm carbon dioxide
- 150 feet/minute at bird level (floor reared birds)
- 500 to 750 feet/minute at inside inlets
- Relative humidity inside barn no more than 3% higher than outside of barn
- Static pressure of 0.03 – 0.07" at maximum fan capacity

ADDITIONAL READING

M. Czarick and M. P. Lacy, May, 1999. "Air Temperature/Speed Meter". University of Georgia Cooperative Extension Service (www.engr.uga.edu/service/extension/ventilation/vol12_5.pdf)

H. Huffmann, 2000. “Assessing Your Ventilation Performance – Do You Need Upgrading?”. Ontario Ministry of Agriculture and Food (http://www.gov.on.ca/OMAFRA/english/livestock/poultry/facts/ventilation.htm)

K.A. Janni and L.D. Jacobson, 2003. “Mechanical ventilation for poultry barns”. University of Minnesota, Minnesota Extension Service (http://www.bae.umn.edu/extens/poultry_factsheets/mechvent03.pdf)

E. Wheeler, 1995. “Evaluating Mechanical Ventilation Systems, Evaluating Livestock Housing Environments”. Penn State University (http://www.age.psu.edu/extension/factsheets/g/G82.pdf

E. Wheeler, 1996. “Selecting rated ventilation fans”. Penn State University(http://server.age.psu.edu/extension/factsheets/g/G85.pdf)

E. Wheeler, 1997. “Inlets for Mechanical Ventilation Systems in Animal Housing”. Penn State University (http://server.age.psu.edu/extension/factsheets/g/G91.pdf)