Chapter 8 - COLD WEATHER VENTILATION

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A. Introduction

Moisture removal is the primary design consideration for cold weather ventilation. Excess moisture is often related to elevated levels of air contaminants, such as ammonia. The **minimum ventilation rate** refers to the quantity of fresh outside air which should be moved through the building to absorb and remove moisture and contaminants. Ventilation rates in excess of the minimum level will provide a fresher environment but increase heating costs. Relative humidity (RH) between 50-70% will prevent excessively dusty conditions while staying within a range where pathogens are less viable. Depending on the pathogen, its survival is best at relative humidities below 40% or above 70%.

The strategy for cold weather ventilation moisture removal is to use cold, but relatively dry, outside air as a ‘sponge’ for absorbing moisture within the building. The moisture-laden air is then exhausted from the house. This process depends on heating the cold air to increase its moisture-holding capacity. Warm air holds more water (in pounds of water per pound dry air, the Humidity Ratio) than cool air. ***This is one of the key principles of winter ventilation*** (see Chapter 7 for more on relationship between temperature and moisture).

Minimum ventilation rates for poultry depend on several factors:

- Poultry moisture production (which depends on poultry species, bird age, number of birds in the facility, and building indoor temperature)
- Temperature of outside air (when cold outside air is brought into a building and heated, its ability to absorb moisture is nearly doubled for each 20°F increase in temperature)
- Desired inside relative humidity (recommended range is 50-70%)
- Waste handling practice (A deep-pit layer house requires greater minimum ventilation rate than does a floor-litter broiler house)
- Drinking water delivery method (spillage and leakage of water requires a greater minimum ventilation rate)
- Litter management (flocks raised on old liter may require a higher ventilation rate for ammonia control)

In current ventilation control systems, air temperature, rather than relative humidity level, is used to control fans and heaters during cold weather conditions. This is primarily due to past difficulties in reliably sensing relative humidity in livestock housing environments. Instrumentation sensor and controller technology continues to evolve so that more reliable and affordable **RH sensors and controllers** are becoming available. Instruments are available for spot-checking RH level so that a producer can fine tune the ventilation system control strategy.

With some bird management practices, ammonia level or other air quality issues may demand a higher minimum ventilation rate than that needed for moisture removal. For broilers reared on litter, the method of litter handling between flocks can have a substantial impact on air quality and heating fuel use. Many operations practice limited litter removal between flocks. Some practice a period of one to four days of high temperature ammonia ‘cook-off’ prior to placing a new flock. The added fuel cost for this cooking-off period may be offset when there is less need for an elevated ventilation rate for ammonia control during brooding; however, complete replacement of litter (at least in the brooding section) may be a more cost-effective alternative.

B. Moisture production and removal

Broilers eliminate moisture through respiration, evaporation, and fecal evacuation. Broiler size, environmental temperature, housing type, manure handling practice, and watering systems all contribute to apparent moisture production. Published moisture production rates are either from calorimeter (chamber) studies or from whole-house studies; the latter typically have higher values because they include evaporation of water from feces and the drinking water system. Significant differences in moisture production between broilers raised in houses with conventional versus tunnel ventilation have been found. This difference is presumed to be due primarily to changes in water delivery systems that have occurred over the two decades since the data for the conventional housing system were collected.

Moisture balance

Moisture balance occurs when the rate that water vapor produced by broilers, feces, and the drinking system equals the rate that water vapor is expelled by the ventilation system. The ventilation rate needed to achieve the moisture balance is the **minimum ventilation rate**, usually expressed in cubic feet per minute (CFM).

The recommended values for minimum ventilation rate start at 0.04 CFM per chick for young broilers and increase as broilers grown and their moisture production increases. Broilers reared on fresh litter can withstand short periods of low ventilation because the litter can absorb moisture. However, excess litter moisture will lead to ammonia and disease problems. If a low ventilation rate is used (for example, to save fuel during cold periods), the moisture must be removed later in the production cycle using higher ventilation rates. If broilers are raised on previously used litter, the required minimum ventilation could be as much as nine times that normally recommended to keep ammonia levels within the desired range. For broilers, recent research suggests that ***today’s young broilers and production practices result in significant higher***

moisture production than two decades ago. This translates into higher minimum ventilation rates to remove this moisture.

C. Providing minimum ventilation

The cold weather minimum ventilation rate in broiler barns is often far below the capacity of a single-speed, 36- or 48-inch fan. Continuously modulated airflow, such as that provided by a **variable-speed fan**, is preferred for varying the cold weather airflow. It takes a tightly-constructed house to allow one or two smaller fans to create the **static pressure** necessary for **proper inlet functioning** throughout a large poultry house. Since not all houses are tightly constructed, many use a higher capacity fan (such as 36-inch) on an interval timer for cold weather ventilation. However, the broilers are breathing, water is evaporating, manure gases are volatilizing, and heaters are venting continuously while fresh air is only added a fraction of the time.

Timers

On-off electrical switches activated with a **clock motor**, or **interval timers**, achieve variable airflow rates by running for only a part of each interval. They are manually set to operate a specified number of minutes every five minutes. Some systems use a ten-minute interval, but this results in undesirable temperature swings of roughly 2-5°F. Combustion by-products from unvented heaters may also build up to unacceptable levels during the off-period. These fluctuations can affect broiler comfort and health. Consequently, ***five-minute times are recommended over ten-minute timers***. However, ten-minute times may be an appropriate selection depending on how quickly air inlets respond after the fan is activated.

Ammonia levels should be spot checked one minute before the timer is set to cycle back on. The air should be sampled to broiler level, about one foot of the ground. A hand-held sampler pump and indicator tube, or a passive tube is common sampling tools (see Chapter 14 on litter amendments for more information on measuring ambient ammonia levels.) Readings over 25 ppm ammonia indicate that minimum ventilation rate needs to be increased to reduce ammonia build up. In these cases the on-time interval of the timer should be set to increase the amount of time the fan is on.

It is important that a producer not rely on his or her sense of smell to determine ammonia levels. ***A person's sense of smell will desensitize to ammonia over time.*** Always use a measuring device to determine levels.

Troubleshooting

Many problems during cool and cold weather can be traced to inappropriate ventilation rates. Poor broiler health, respiratory problems, and breast blisters are common with poor ventilation.

An excessive ventilation rate causes:

- Excess fuel use
- Temperatures that are too cool; inability to maintain blood temperatures (Low temperatures could also be caused by inadequate heater capacity)
- High concentration of dust

An insufficient ventilation rate causes:

- High concentration of ammonia and air contaminants
- Areas of excessive moisture; soggy litter (could also be a drinker problem)
- Condensation on interior surface (could also be inadequate insulation)

Poor air distribution (improper inlet function) causes:

- Drafts
- Uneven temperatures; cold spots and/or hot spots
- Areas of excessive moisture, soggy litter

D. Heating needs

Heating requirements will vary with the type of broiler, stage of growth, broiler density, outside weather conditions, ventilation rates, and desired indoor temperatures. The preferred method of heating will depend on the percentage of building space being occupied by the broilers, energy costs, and stage of broiler growth. At times, more than one heating method will be used to economically provide the necessary supplemental heat throughout the growing cycle.

To determine **heating needs**, heat loss through ventilation air and building surfaces is compared to heat gain from bird heat dissipation. When heat loss is greater than the heat gain, supplemental heat is needed to maintain temperatures in the bird’s thermal comfort zone.

Building heat loss consists of heat transfer from the building interior to the outside through conduction, convection and radiation. Heat loss through the ventilation system typically demands the greatest share of fuel in cold weather. More than 50% of building heat loss is from ventilation air exchange. For each cubic foot of cold air brought into a building by fans or natural ventilation, a cubic foot of warm, moist air is exhausted. The cold air must be heated to maintain the desired temperature.

Typical **sensible heat** loss rates for poultry range from 0 to 17 BTU per hour per pound live weight with the lower values for warm air temperatures. Bird heat loss is also greatly affected by lighting, with heat loss rates being much greater when lights are on than when they are off.

E. Heating methods and equipment

Two types of heaters are common in poultry facilities: forced hot-air space heaters and radiant brooders. **Space heaters** heat the air in the building. **Radiant brooders**, such as pancake and infrared brooders provide some heat to the air but are used primarily to heat the birds and floor. Both types of heaters can use natural or propane gas and are rated by their BTU per hour (BTUh) heat output. Houses may employ one or both types of heaters.

The decision on whether to use space or radiant heaters or a combination of the two is not clear-cut. Broilers are successfully raised using all three systems. When the emphasis is chick comfort up to about two weeks of age, floor-level temperatures are very important and radiant brooders are generally used. Older broilers are more tolerant of cool temperatures and have learned to move around to find a comfortable temperature. For these situations, space heaters may be more economical. Many producers have found that the increased initial cost and great complexities when using both types of heating equipment are offset by long-term energy savings and bird comfort.

Space heaters

The temperature in a house with a well-designed **forced-air space heating system** is relatively uniform from floor to ceiling and around the house. Agricultural forced-air heaters range from 15,000 BTUh to over 300,000 BTUh, with poultry houses commonly rated between 80,000 to 250,000 BTUh. The industry standard is to provide around four heaters in a 500-foot long broiler house, rather than one or two large heaters. This improves heat distribution in the house.

Large heaters are only marginally more expensive than units with half the BTUh capacity, so it is common to over-design for houses that will contain brooding chicks. Some heaters can operate down to 60% of their rated capacity without sacrificing combustion efficiency. Units are often installed near one sidewall. Heated air is distributed with the heater fan and through mixing with the incoming ventilation air jet. ***Maintaining warm temperatures near the floor during early brooding is a common problem with space heaters***.

Most **space heaters** use interior air and are unvented, which means they exhaust carbon dioxide, moisture, and incomplete combustion products directly into the building. Approximately 1.7 lbs of water vapor is producer per lb propane gas combusted. ***Thus, to prevent moisture accumulation caused by unvented heaters, it is recommended that minimum ventilation rate be increased*** by 2.5 CFM per 1,000 BTUh heater capacity.

Radiant brooders

Radiant brooders use radiation to direct heat energy at the floor and at broilers near the heater. The amount of radiant heat felt on a surface is dependent on the temperature of the radiating element and the distance between the radiating element and the surface. In order to be heated, an object must be able to ‘see’ the hot radiant element in the brooder. When we experience radiant heating from a campfire, for example, only the parts of the body facing the fire are warmed. Broilers are warmed by the **thermal radiation** from the brooder and warm floor.

The **comfortable temperature zone of a radiant brooder** is doughnut-shaped, as is reflected in the pattern in which chicks distribute themselves under the brooder. For example, with a conventional pancake brooder, floor temperatures directly under the unit may be as high as 150°F, while seven feet away the temperature is down to 75°F. Brooder location recommendations are often based on how many chicks they can comfortably warm without causing chicks to pile up under the brooder unit. Use space heaters in addition to the radiant heaters if air temperatures cannot be maintained or if inadequate radiant heat zones exist. Perimeter insulation becomes more important in radiant-heated houses, since it will reduce heat loss through the warmed floor.

Temperatures in radiant heated houses are not uniform from floor to ceiling as space-heated houses and may feel cool to the operator. A desirably warm temperature can be maintained at broiler-level while the surrounding air is often 5-10°F cooler. Temperature sensors for brooders should be placed about 6 inches off the floor for proper zone control. Provide radiant protection for the sensor, or it too will be heated by the radiant energy and not reflect a true air temperature in the floor zone.

Radiant or infrared brooders come with two major types of radiant elements: a small ceramic disk or large stainless steel cone. Traditionally, radiant ‘pancake’ brooders have been spaced uniformly, hanging near the feed lines and within 18-30 inches of the floor along the brooding section of a house. Low hanging, small brooders have problems providing an adequately-sized, comfortable zone.

Modern radiant brooders have automatic ignition and more uniform radiant heating than older models. Good radiant brooders have large radiant zones because they have large radiant elements, are fuel efficient, and can be hung five feet from the floor. They typically provide a 30-40 foot diameter heated zone.

Various industrial radiant heaters consisting of gas combusting within a long pipe are less common in poultry housing. Electrical lamps are seldom used in large-scale poultry facilities due to the high cost of electric energy compared to other fuels.

Location of heaters and thermostats

Heaters are placed uniformly throughout the large poultry facilities. Common practice is to place proportionally more heaters in the brood end of a partial-brood house. For example, if six heaters are required, four may be placed in the brood half. A forced-air heater is equipped with a small fan so that heated air is distributed into the room. For example, one manufacturer’s 250,000 BTUh heater unit has a ten-inch diameter fan with a 1,300 CFM capacity that can throw air approximately 50 feet.

To avoid hot spots, it is important that hot air be mixed with room air. Mixing in most poultry facilities is accomplished by appropriate placement of fresh air inlets. If inlet air mixing is not adequate, **stratification** occurs, with warmest air near the ceiling rather than at broiler level. Many houses utilize **recirculation fans** (see Figure 8.1), which are hung from the ceiling to blow air in a racetrack pattern around the house in a horizontal direction or slightly canted upward toward the ceiling. A less common destratification technique uses **paddle (ceiling) fans** (Figure 8.2). Either type of circulation fan is designed to activate when heaters are on. Interior mixing fans must not create cold drafts at bird level during brooding. Paddle fans should have forward and reverse speeds so that they can direct airflow upwards in winter to minimize windchill on small birds.

Figure 8.1 - Circulating fan

Figure 8.2 – Paddle fan

It is important that the temperature sensor from the **heater controller** (i.e., thermostat) measure a temperature that is indicative of conditions the birds are experiencing. Place the sensor near the center of the house cross-section that the heater supplies and as close to broiler level as practical. Do not place sensors directly in the path of hot air, in cold drafts, in the path of inlet jet, or near sidewalls. ***Improper sensor placement will cause inefficient heater operation***.

Air tempering

There are various methods for tempering cold outside air before bringing it into a poultry house in an attempt to limit cold drafts and reduce annual heating fuel costs. The two most prevalent methods to temper air are **various configurations of heat exchangers** and **geothermal earth tube systems**. While, in principle, these systems have potential for significant energy savings, practical implementation in poultry facilities has been less successful. Major obstacles have been dust accumulation on heat exchangers, high installation costs, high airflow through earth tubes, and the complexity of controls associated with earth tube systems.

F. Natural ventilation in cold weather

Controlling naturally ventilated buildings during periods of cold weather can be challenging. Excessive air infiltration will substantially increase the need for supplemental heat.

For a 10 mph outside wind speed acting directly on the side of a building, an equivalent crack ¾ inch along the entire length of both sides of the building would be sufficient to supply the required amount of fresh air through the building. However, maintaining a gap this narrow down hundreds of feet of building length is not easy due to normal construction irregularities and flexibility of curtain system rods. For example, if one end of a 200-foot curtain is cracked ¼ inch while the other end is cracked open about 1 inch, the average opening along the length of the building is ¾ inch. But the wider cracker will provide more cold air to that section of the house, and the narrower crack will result in an under ventilated section of the house. A modified top panel on the curtain system or a separate **baffle inlet system** can be used to provide intermittent openings along the house length to allow better control of low airflow direction.

Minimizing cold-weather infiltration

The greatest amount of heat loss in a curtain-sided poultry house will be through the sidewall curtains. This loss is due primarily to the **low insulating value of the curtains**, yet the situation can be made even worse when the curtain does not seal tightly against the sidewall. In houses with very loose curtain straps or ropes, it is not uncommon to see an inch or more of curtain movement away from the house. Even a ¼ inch crack running the length of a 500-ft house provides the equivalent area of a 10 ft^2 opening in the sidewall.

Curtain straps or **anti-billow ropes** should be fastened an inch or two above the curtain rod rests at the top of the sidewall when the curtain is completely closed. Fastening straps six or more inches above the top of the curtains will not hold it tightly in place against the house. The bottom of the curtain must also be tight. For a **double-hemmed curtain**, fasten the strap just below where the bottom rod rests when the curtain is closed. For **single-hemmed curtain**, nail a barren board along the bottom at the base of the curtain opening; then nail the bottom of the curtain strap far enough below the sidewall opening so that when the curtain is lowered, the strap will not obstruct the opening. The **life of straps** can be increased by reducing their flapping in the wind. To do this, nail the bottom of the strap, give it a half twist and then nail the top of the strap in place. **Check curtain straps for tightness each fall**, since the curtain shrinks and straps loosen over time.

Envelopes at the curtain ends should extend at least 12 inches in from each curtain end and be placed as tightly as possible against the curtain while still maintaining an adequate pocket for a fully open curtain. Envelopes can be made from leftover curtain material or treated plywood. Both methods work very well**. Windshields** can be installed at the top of the sidewall. Windshields should be made of treated plywood and securely fastened to the sidewall top. Extending the shield six inches below the top of the opening will provide an excellent barrier.

One of the simplest and most effective infiltration control techniques is overlapping the curtain at the top and bottom of the sidewall openings. Providing a 6-inch overlap at the top and bottom of the sidewall opening will reduce infiltration considerably. This will also accommodate the natural tendency of the curtain material to shrink while providing some overlap. One or two inches of overlap are not enough to reduce infiltration. Over a few years, curtains will shrink a couple of inches on an 8-ft curtain. Providing overlap requires purchasing a curtain that is roughly one foot wider than the maximum sidewall opening size. The added expense will be more than made up for by the savings in supplemental heat required to warm infiltration air. Make sure limit switches on the curtain machines are set to maximize curtain overlap.

On a cold, windy day it is possible that more heat is lost through loose-fitting curtains than through the timer fans set for minimum ventilation. The wind may be creating an opening at the top of the curtain by pulling the curtain and rod away from the house by suction forces. A ½ inch opening the entire sidewall length from wind suction is not uncommon. This problem is frequently the result of leaving curtain straps loose to ensure that sidewall curtains open and close easily. In windy conditions, the windward curtain will be pushed against the wall while the downwind curtain pulls away from the sidewall. It curtain straps or strings are loose the curtain can pull an inch or more off the side of the house and form a large, uncontrolled air exhaust opening. Although some air leakage can be minimized by the overlap and windshield strategies described above, infiltration due to loose-fitting curtains can occur when the curtain is overlapped.

Some air leakage can be minimized by the overlap and windshield described above. Another method is to install a **curtain pocket** for the top of the curtain to slide into when closed. A hemmed curtain 12-18 inches long with a rod is attached a few inches above where the top of the curtain rod rests when closed. This short curtain pocket is installed over the curtain straps or strings, so that it does don’t interfere with the curtain movement. If sidewall curtains are not raised and lowered often (as in a hybrid mechanical and natural ventilation situation), the strings or straps may be installed over the pocket for a slightly tighter seal.

Multi-layered curtains provide better infiltration control than single layer curtains. Constructing envelopes at the curtain ends and a windshield or curtain pocket near the upper opening can dramatically **reduce infiltration**. Adjust curtain straps so that the curtain closes evenly and maintains a sufficient overlap along its entire length. This will also help sidewall curtains open uniformly to provide inlets that will keep house temperature and fresh air exchange more uniform along the curtain length. Consider sealing any side and endwall doors that will not be used with tight-fitting plastic to reduce infiltration. Gaps in the structure that are large enough to be seen through are obviously large enough to allow significant air infiltrations. Gaps around doors, fan housings, and so on should be sealed with foam-in-place insulation.

Sidewall curtains used in naturally ventilated buildings provide a downward direction to the air stream entering through a small curtain opening. This can be a significant disadvantage during cold weather. Fresh air is not warmed before it reaches the floor. This can set off heater thermostats as a wave of cold air passes through the brooding zone. One solution is to install a **separate baffle inlet system** above the curtain sidewall inlets. These inlets can be used during the coldest periods to direct incoming air toward the ceiling. Hybrid systems combining natural and mechanical ventilation use this technique more often than entirely naturally ventilated facilities.

The distance that fresh air will travel in the building depends on its temperature in relation to the indoor air. Cold air will fall upon entering the building sidewall opening because it is heavier than inside warm air. Incoming air of mild temperatures will fall as well, but it will fall further across the building width. Air that is warmer or very near the inside temperature will remain nearly horizontal, or in some cases, can rise when it enters the building.