Ventilating Poultry Houses to Minimize Bird Health Issues

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When it comes to birds healthy...
- We need to keep in mind that oxygen is not something we have to concern ourselves with.

The oxygen requirement for 25,000 day-old chicks is 20 cfm.

When it comes to birds healthy...
- Even for 25,000 market age birds the oxygen requirement is only 300 cfm.

it has very little to do about carbon dioxide...
- Though some animal welfare guidelines indicate must be kept below 3,000 ppm...
- Research indicates carbon dioxide has to be much higher to affect bird performance/welfare...

CO₂ Research
- 1980, Reece & Lott (USDA – Mississippi State)
  - 3,000 ppm, 6,000 ppm, 12,000 ppm from 0 – 28 days
  - 3,000 ppm, 6,000 ppm no effect on body weights
  - 12,000 ppm depressed body weights at 28 days
- 2008, Olarewaju, Dozier, Purswell, Branton, Miles, Lott, and Thaxton
  - Performance, blood chemistry and heart condition
  - Increasing from "0" ppm to 9,000 ppm did not affect blood chemistry
  - Increasing from "0" ppm to 9,000 ppm did not affect 28 and 49 body weight gain or feed conversion
  - Increasing from "0" ppm to 9,000 ppm did affect mortality most likely due to pulmonary hypertension syndrome (changes in heart).

To be on the safe side CO₂ should generally be kept below 5,000 ppm...
- Which in the vast majority of instances it is...
We shouldn’t even be ventilating to control ammonia…Because once you have it, it is very difficult and very expensive to get rid of.

So ammonia levels tend to stay high…even if you are ventilating to remove it.

For example…ammonia concentration was 35 ppm with timer ventilation fans operating 90 seconds out of 300.

The first problem is that ventilation does not eliminate ammonia…it just temporarily decreases it.

The second problem is that it takes a lot of ventilation to significantly lower ammonia concentrations.

This is because reductions in ammonia concentration are roughly proportional to ventilation rate.

Ventilation rate was increased to 120 out of 300 seconds (25% increase).
Ventilation rate was increased to 150 out of 300 seconds (40% increase)

35% reduction

The simple fact about lowering ammonia concentrations is...

- to cut ammonia concentrations in half... requires a doubling of ventilation rates.

Since ventilation typically accounts for 80% of a modern broiler houses heating costs

- this means that a doubling in ventilation rates will result in a near doubling in heating costs!

In a way ammonia is not the primary problem we are trying to solve... it is a symptom of the real problem

It is similar to a sinking boat...

The problem is the hole in the boat

The symptom is that the boat is filling up with water

When it comes to controlling ammonia the real problem is moisture

Moisture is required to generate ammonia

\[
\begin{align*}
\text{Uric Acid} &\rightarrow CO_2 \rightarrow \text{Urea} \\
\text{Allantoic Acid} &\rightarrow \text{Allantoin} \\
\text{CO}_2 + 2\text{NH}_3 &\rightarrow \text{Urine} \\
\text{Urea} &\rightarrow \text{Allantoin} \\
\text{Allantoin} &\rightarrow \text{Allantoinic acid} \\
\text{Allantoinic acid} &\rightarrow \text{Allantoinic acid}
\end{align*}
\]

Uric acid
It takes just the right amount of moisture... too little or too much and ammonia production is reduced.

Excessive moisture levels are at the root of many of our bird health issues...
- Not only ammonia...
- Cocci problems
- Paw quality

Ammonia generation vs. House location
- Miles, Brooks, McLaughlin, and Rowe (USDA – Mississippi State).
  - 100 samples per house
  - Side walls
  - Feeders
  - Drinkers
  - Measured ammonia generation rate, litter moisture and litter pH

Findings:
- Litter moisture:
  - Near feeders (20%)
  - Near side wall (26%)
  - Near drinkers (45%)
- Ammonia generation:
  - Near feeders (2.9 N*kg of litter/hr.)
  - Near side wall (7.6 N*kg of litter/hr.)
  - Near drinkers (12.3 N*kg of litter/hr.)

Findings:
- If you could reduce ammonia generation rate near the water lines to that near the feed lines or side wall....
- Ammonia levels could be reduce by roughly 40% to 80%

Relative humidity vs. Broiler performance
(Weaver and Meijerhof, 1990 – VPI)
- Three relative humidity treatments 45%, 45%-80%, and 75%.
- Infected foot pads:
  - 45% = 13.9%
  - 40% - 80% = 44.4%
  - 75% = 53.3%

Excessive moisture levels are at the root of many of our bird health issues...
- Not only ammonia...
- Cocci problems
- Paw quality
Excessive moisture levels are at the root of many of our bird health issues...

- Wet manure/litter
- Ammonia
- Cocci problems
- Paw quality
- Leg problems
- Respiratory issues
- Etc.

Relative humidity vs. Broiler performance (Weaver and Meijerhof, 1990 – VPI)

- Three relative humidity treatments 45%, 45%-80%, and 75%.
- Twisted legs:
  - 45% = 6.3%
  - 40% - 80% = 8.3%
  - 75% = 9.1%

Excessive moisture levels are at the root of many of our bird health issues...

- Wet manure/litter
- Ammonia
- Cocci problems
- Paw quality
- Leg problems
- Respiratory issues
- Etc.

The simple fact is throughout the year we need to start thinking of controlling moisture like we do house temperature and operating our ventilation systems to precisely maintain those targets.
The same needs to be true with humidity

To control house moisture levels we must of course ventilate our houses properly

- Minimum ventilation rates to control moisture should not be determined by...

charts provided by primary breeders, controller companies, or poultry companies

- Specifically how much water the birds are consuming and house conditions

Moisture removal rule of thumb...

- To remove one gallon of water from a house under typical wintertime conditions requires...

- an exchange of 10,000 cubic feet of air

Moisture removal ventilation rate

- 500 gallons of water consumed
- 500 \times 0.8 = 400 gallons which need to be removed
- 400 gallons \times 10,000 cubic feet of air = 4,000,000 cubic feet of air
- 4,000,000 / (24 hours \times 60 mins) = 2,780 cubic feet/min
A more precise method

- Smart phone app - CHKMINVENT

Enter house specific information…

and obtain house specific recommendations

Excel spreadsheet is another option..

But there is a problem with these calculators…

- What if...
  - Inside temperature/rh changes?
  - Outside temperature/rh changes?

- More importantly…
  - Calculators assume perfectly mixed air…
  - All air enters through the inlets…
  - Heating system is properly set…
  - At best calculators provide a very rough starting point.

Instead of relying primarily on a chart or app…

- We should simply monitor relative humidity
Target Rh is typically between 40% and 60%

Below 40%

Example of poor level of moisture control

Above 60%

Example of proper house moisture control
Example of proper house moisture control

Ammonia control through relative humidity control

To control bird health minimum ventilation rates should be based on controlling moisture

- Continuously monitor RH
- Make adjustments based on house RH
- Nighttime / first thing in the morning

During the spring and fall air exchange rates change significantly from day to night

Which can result in significant differences in air quality from day to night

Conditions can be very good during the day and very bad at night
A very important point when it comes to keeping litter dry

- The drier you want your litter to be…
  - 70% wet litter - damp litter
  - 40% very dry litter

- The lower your target Rh needs to be

  - 70% wet litter - damp litter
  - 40% very dry litter

Ventilation rate to remove 1,000 gallons of water (outside 40°F – 60% Rh)

To maintain 70% Rh =

- If we wanted an Rh of 60%... ventilation rate would need to be increased 25%
- If we wanted an Rh of 50%... ventilation rate +60%
- If we wanted an Rh of 40%... ventilation rate +120%... over double!

Since drier litter requires more ventilation…more heat

- We need to work to be as efficient as possible

Traditional hot air heating systems should be avoided
Radiant heat systems deliver heat directly into the litter which promotes litter drying.

Need to explore the use of indirect heating systems
- Traditional direct fire heating system add a significant amount of moisture to a house.

Burning a gallon of propane
- \(C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O + \text{Heat}\)
- **Consumes:**
  - The oxygen 850 cubic feet of air
- **Produces:**
  - 92,000 Btu’s of heat
  - 108 cubic feet of carbon dioxide
  - 6.8 lbs. of water (0.82 gallons)

With indirect heating systems exhaust gasses can be piped out of the house…which will lower house humidity.
Ventilating poultry houses to minimize bird health issues

1) Minimum ventilation rates should be based on controlling moisture
   - Estimate min vent rates from water consumption
   - Monitor house Rh...especially at night

2) Explore alternative heating systems

Need to explore using alternative heating systems

Inexpensive fuel = Higher ventilation rates

Wood pellet system vs. Propane

Need to explore the use of heat exchangers

Can reduce heating costs 30% or more...

Need to take a look at solar heating of incoming air

Attic inlets in operation
Solar walls are another option (Canada)

Very inexpensive solar walls (China)

Solar walls - China

Solarbrood

Ventilating poultry houses to minimize bird health issues

1) Minimum ventilation rates should be based on controlling moisture
   - Estimate min vent rates from water consumption
   - Monitor house Rh...especially at night
2) Explore alternative heating systems
   - Solar
   - Indirect heating systems
   - Alternative fuels
3) Maximize house tightness

We want as much as possible to enter through air inlets...
Loose house = Low percentage entering through inlets

Tight house = High percentage of air entering through inlets

Evaluating poultry house tightness (static pressure test)

- Close up the house...turn on fan and measure the resulting pressure

The higher the pressure ... the greater the amount of air that will come in through the inlets

Poultry house tightness spreadsheet

- Minimum Ventilation Inlet Opening Requirements:
  - Minimum ventilation fan capacity (cfm) 20000
  - Number of air inlets to be used 40
  - Maximum air inlet height/opening (inches) 10.0
  - Air inlet length (inches) 48.0
  - Total side wall air inlet area (ft²) 133.3
  - Total required opening area for specified fan(s) @ 0.10” (ft²) 26.7

House and fan output information and resulting static pressure

Poultry House Leakage Test:

- House length (ft) 500
- House width (ft) 40
- Total fan capacity used in leakage test (cfm @ 0.10”) 20000
- Static pressure measured (“) 0.04

House and fan output information and resulting static pressure

Poultry House Leakage Test:

- House length (ft) 500
- House width (ft) 40
- Total fan capacity used in leakage test (cfm @ 0.10”) 20000
- Static pressure measured (“) 0.04
- Relative leakage area (ft² per 1,000 ft² of house floor space) 1.32
- Total house leakage area (ft²) 26.5
House tightness ratings:
- Very low level of environmental control
  - >= 1.2 square feet of leakage per 1,000 square feet
- Minimum acceptable level of environmental control
  - 0.8 square feet of leakage per 1,000 square feet
- High level of environmental control
  - <= 0.6 square feet of leakage per 1,000 square feet

Higher pressure...0.11

### Poultry House Leakage Test:

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<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>House length (ft)</td>
<td>500</td>
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<tr>
<td>House width (ft)</td>
<td>40</td>
</tr>
<tr>
<td>Total fan capacity used in leakage test (cfm @ 0.10&quot;)</td>
<td>20000</td>
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<tr>
<td>Static pressure measured (&quot;)</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Even higher pressure 0.25"

House do these results affect the effectiveness of the houses inlet system?

Input inlet information

### Minimum Ventilation Inlet Opening Requirements:

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Loose house (0.04") – 1.32 ft² leakage/ft² of floor area

<table>
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<th>Requirement</th>
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<tbody>
<tr>
<td>Total required opening area for specified fan(s) @ 0.10&quot; (ft²)</td>
<td>26.7</td>
</tr>
<tr>
<td>Total house leakage area (ft²)</td>
<td>28.5</td>
</tr>
<tr>
<td>Total required inlet area @ 0.10&quot; (ft²)</td>
<td>0.2</td>
</tr>
<tr>
<td>Percentage of air that will entering through inlets</td>
<td>1%</td>
</tr>
<tr>
<td>Approximate required air inlet opening size/height (inches)</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Marginal house (0.11") – 0.73 ft² leakage/ft² of floor area

| Total required opening area for specified fan(s) @ 0.10" (ft²) | 26.7 |
| Total house leakage area (ft²) | 14.6 |
| Total required inlet area @ 0.10" (ft²) | 12.1 |
| Percentage of air that will enter through inlets | 45% |
| Approximate required air inlet opening size/height (inches) | 0.91 |

Tight house (0.25") – 0.35 ft² leakage/ft² of floor area

| Total required opening area for specified fan(s) @ 0.10" (ft²) | 26.7 |
| Total house leakage area (ft²) | 7.1 |
| Total required inlet area @ 0.10" (ft²) | 19.6 |
| Percentage of air that will enter through inlets | 73% |
| Approximate required air inlet opening size/height (inches) | 1.47 |

Ventilating poultry houses to minimize bird health issues

1) Minimum ventilation rates should be based on controlling moisture
   - Estimate min vent rates from water consumption
   - Monitor house Rh…especially at night
2) Explore alternative heating systems
   - Solar
   - Indirect heating systems
   - Alternative fuels
3) Maximize house tightness
4) Use a circulation fan system

Traditional circulation fan system objectives:

- Mix the air from floor to ceiling
- Mix air from end to end
- Mix the air from side wall to side wall

Traditional circulation fan system objectives:

- Mix the air from floor to ceiling
- Mix air from end to end
- Mix the air from side wall to side wall
Primary circulation fan objectives:
- Create uniform house temperatures
- Minimize fuel usage

Traditional circulation fan system (40’ X 500’)
- Six, 18” – 20”, 1/10 hp circulation fans

Horizontal circulation fan air flow pattern

These systems worked well...But
- To keep litter dry requires air movement...especially under humid conditions
Inlet systems and air movement
- Inlet systems tend to only produce a significant level of air movement towards the end of the flock when ventilation rates are high.

Traditional circulation fan system do not produce a lot of air movement over the litter
- Air speeds less than 100 ft/min.

Could we keep our litter drier by increasing houses by using more circulation fan capacity?

Traditional circulation fan capacity guidelines
- Circulation fan capacity should be capable of mixing roughly 10% of the house volume each minute:
  - Circulation capacity = \( \frac{\text{Total circulation fan capacity (cfm)}}{\text{house volume (cf)}} \)
  - \( = 6 \times 3,000 / 40' \times 500' \times 9.5 \)
  - \( = 18,000 \text{ cfm} / 190,000 \text{ cubic feet} \)
  - \( = 0.10 \text{ or } 10\% \)

What would happen if we increased it to 20% or more?

Study examining how circulation fan capacity and house relative humidity affects litter moisture and paw quality
- Two houses - 50' X 560' with eight, 1/10 hp, 18" circulation fans.
  - Circulation fan capacity = 9%
  - One house with low Rh (approx. 50%), One with moderate Rh (approx. 60 - 70%)
Study examining how circulation fan capacity and house relative humidity affects litter moisture and paw quality

- One house with 8, 24" 1/3 hp circulation fans
  - Circulation fan capacity = 18%
- One house with low Rh (approx. 50%), One with moderate Rh (approx. 60 - 70%)

Relative humidity

- One house with 8, 24" 1/3 hp circulation fans
  - Circulation fan capacity = 25%
  - Floor air speeds between 100 and 200 ft/min

Relative humidity and litter moisture

Foot pad scores?

Study examining how circulation fan capacity affects litter moisture and paw quality

- Humidity 50 – 60%
  - No circulation fans vs. High volume circulation fan
  - One house with 8, 24", 1/3 hp circulation fans
  - Circulation fan capacity = 25%
  - Floor air speeds between 100 and 200 ft/min

Research funded by USDA – Connie Mou (primary)
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1/3 hp circulation fans – bird reaction

Research funded by USPEA – Connie Mau (primary)