Evaluating tunnel ventilation system performance

Michael Czarick
The University of Georgia

Are you ready for hot weather?

To properly evaluate a tunnel-ventilated house you need a few tools...

Ventilation system evaluation tools

- Air velocity meter
  - Wind speed
  - Averaging feature
  - Air temperature
  - Relative humidity
- Kestrel 3000
  - www.kestrelmeters.com
  - $140

Ventilation system evaluation tools

- Electronic laser tachometer
  - Fan speed
- Monarch PLT200
  - www.monarchinstrument.com
  - $250

Ventilation system evaluation tools

- Magnehelic gauge
  - Static pressure
- Dwyer model 2000-00
  - www.davis.com
  - $75
Ventilation system evaluation tools

- Smoke generator
  - House leakage
- Bonide insect fogger
  - $50

Infrared thermometer
- surface temperature
- Many manufacturers
  - 1% of reading accuracy
  - Be aware of the devices
distance to target ratio
  - 12:1 means that at a distance
  12” away you will be looking
  at an area 1” in diameter
  - Ranges 8:1 to 50:1
  - $150

Ventilation system evaluation -no birds present-
Evaluating tunnel ventilation system performance

- Examine tunnel fans
  - Make sure the fan shutters and blades are clean

Make sure fan screens are clean as well

Examine tunnel fans
- Are the blades center in the orifice?
Examine where the fan belt is riding in the motor pulley

Is the belt riding in the top of the motor pulley?

Or is it riding lower?

Fan belts do not stretch...they get thinner over time

Which effectively changes the size of the motor pulley

The lower in the pulley the belt rides, the slower the fan spins, the lower the amount of air moved

Best way to checking for worn belts is to use a tachometer
Electronic tachometer

- Stand outside
- Push button for a few seconds
- Obtain blade count
- Take blade count divide by number of blades

Electronic tachometer

- Optimal fan speed can be obtained from manufacturer or fan test data.

<table>
<thead>
<tr>
<th>Static Pressure (in H2O)</th>
<th>Airflow (cfm)</th>
<th>rpm</th>
<th>Volts</th>
<th>Amps</th>
<th>Watts</th>
<th>cfm/Watt</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 23800</td>
<td>514</td>
<td>229.9</td>
<td>4.89</td>
<td>96.1</td>
<td></td>
<td>24.8</td>
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<tr>
<td>0.05 22100</td>
<td>512</td>
<td>230.1</td>
<td>5.15</td>
<td>102.6</td>
<td></td>
<td>22.3</td>
</tr>
<tr>
<td>0.10 21900</td>
<td>511</td>
<td>230.5</td>
<td>5.34</td>
<td>1075</td>
<td></td>
<td>20.3</td>
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<tr>
<td>0.15 20600</td>
<td>510</td>
<td>229.7</td>
<td>5.56</td>
<td>1127</td>
<td></td>
<td>18.3</td>
</tr>
<tr>
<td>0.20 19200</td>
<td>509</td>
<td>229.8</td>
<td>5.77</td>
<td>1173</td>
<td></td>
<td>16.3</td>
</tr>
<tr>
<td>0.25 17600</td>
<td>509</td>
<td>229.7</td>
<td>5.97</td>
<td>1217</td>
<td></td>
<td>14.5</td>
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<tr>
<td>0.30 16700</td>
<td>508</td>
<td>229.8</td>
<td>6.15</td>
<td>1255</td>
<td></td>
<td>12.5</td>
</tr>
</tbody>
</table>

When to replace belts?

- Fan speed is proportional to fan output
  - Slower speed lower air flow ratio
- If rpm is >5% below rated fan speed then the belt should be replaced.
- If after replacing belt fan speed is still lower than specified by the manufacturer, check fan motor pulley for signs of wear

Worn motor pulley

Evaluating tunnel ventilation system performance

- Check fan maintenance
- Check static pressure sensor accuracy

Static pressure

- Measuring static pressure accurately is essential in evaluating the performance of a house's ventilation system.
First check the controllers “zero” level

- Turn off all fans and check to see if the controller static pressure reads “0.00”
- You may find it helpful to remove both tubes from the static pressure sensor, especially on windy days

If it is not zero...

- Mechanical type – adjust screw
- Electronic – check manual

Next, check “nonzero” level (electronic sensors)

- Turn on a fan or two with inlets closed to obtain a pressure of around 0.15”
- Check pressure reading against a hand held manegration unit.
- High/low pressure tubes should be in the same location.

If there a difference...

- Check tube for cuts/nicks
- Check for moisture in the line
- After you have done all of this…then calibrate the controller’s static pressure to the manegelic gauge’s reading.

Evaluating tunnel ventilation system performance

- Check fan maintenance
- Check static pressure sensor accuracy
- Check house tightness

Check house tightness

- In order to maximize bird cooling ALL the fresh air brought in by the tunnel fans must enter through the houses’s evaporative cooling pads
Conduct a house tightness test

- Close up the house
- Inlets closed
- Tunnel curtain closed
- In the typical 40’ X 500’ house (20,000 ft²) turn on one 48” fan or two 36” fans
  - (1 cfm per square foot of floor space)
  - Make sure the fan used for testing is properly maintained
- Measure the resulting static pressure

House tightness test

- 0.06” or less extremely loose (22 ft² or more)
  - Very low level of environmental control
- 0.13” is a reasonably tight house (15 ft²)
  - Acceptable level of environmental control
- 0.20”+ is a very tight house (10 ft² or less)
  - High level of environmental control

If the pressure is low...

- an insect fogger is one of the best ways to find where leakage is occurring
- Turn on a couple of fans
- Walk around exterior of house with insect fogger while someone is inside making note of where the air is entering the house.

Evaluating tunnel ventilation system performance

- Check fan maintenance
- Check static pressure sensor accuracy
- Check house tightness
- Check operating static pressure

Operating static pressure

- Ideally this test (as well as a tightness test) should be conducted on all new and retrofitted houses!
- The reason is, is this can provide a baseline that can be used for years to come to evaluate the status of the tunnel ventilation system.
Operating static pressure test

- Open tunnel curtain fully
- Turn on all tunnel fans
- Measure the controller static pressure

Controller/static pressure measurement location?

- If the controller is in the center of the house keep in mind that the static pressure will be higher at the fans.
- Deflectors will result in a significant difference.
- To measure true total static pressure measurement needs to be made by the fans.
- What if the controller is located on the tunnel inlet end walls?

Static pressure at the tunnel inlet end wall is always fairly low

<table>
<thead>
<tr>
<th>Location</th>
<th>Static Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>End wall</td>
<td>0.063</td>
</tr>
<tr>
<td>Inlet</td>
<td>0.084</td>
</tr>
<tr>
<td>1/4 House</td>
<td>0.132</td>
</tr>
<tr>
<td>1/2 House</td>
<td>0.148</td>
</tr>
<tr>
<td>Fans</td>
<td>0.165</td>
</tr>
</tbody>
</table>

Static pressure measurement location?

- If the controller is in the center of the house keep in mind that the static pressure will be higher at the fans.
- If the controller is located at the tunnel inlet end wall then the "low pressure" static pressure tube should be extended to approximately ¼ house (at least 20' past the end of the tunnel curtain.)

Measurements should be made on a relatively calm day

Operating static pressure test

- Open tunnel curtain fully
- Turn on all tunnel fans
- Measure the static pressure
- Record pressure
Operating static pressure test

- In the future compare current static pressure reading to those recorded when the house was new.
- Pressure increases over time:
  - Pads require cleaning
  - Tunnel curtain/door not fully opened.
- Pressure decreases over time:
  - Fans require maintenance
  - Leakage may have increased
  - Conduct pressure test

Example:

- Original pressure
  - 0.10" with all 8 fans
  - 0.09" with 7 fans
- If in the future if you measure a pressure of 0.09" when all the fans are operating, you have effectively lost one fan.

Secondary static pressure test

- Measure static pressure in the center of the house with all fans operating
  - Should typically run around 0.10 – 0.15" in a house with pads
- Using a portable magnehelic gauge measure the static pressure 30' from the end of the tunnel opening and 20' from tunnel fans.
  - Difference between the two is typically 0.04" or less
  - 0.08" = inlet end
  - 0.11" = tunnel fan end
Secondary static pressure test

- If the pressure is low on the tunnel curtain end and high on the fan end...
  - 0.05” inlet end
  - 0.15” tunnel fan end
- You have significant obstructions between the inlet and the fans.

Deflector curtains are the most common cause of pressure differences

- Ideally, deflector curtains should be set so that the pressure difference between the two ends is no greater than 0.04”

Secondary static pressure test

- If the pressure is high on the fan end and high on the tunnel curtain end
  - 0.13” = inlet end
  - 0.15” = tunnel fan end
- You may have obstructed inlet

Typical inlet obstructions

Evaluating tunnel ventilation system performance

- Check fan maintenance
- Check static pressure sensor accuracy
- Check house tightness
- Check operating static pressure
- Check evaporative cooling pad system

Evaluating pad system performance

- Check pad face velocity in the center of the pad system.
  - For a 6” pad air velocity should be approximately 350-375 ft/min.
  - Check first thing in the morning when winds are typically light
Evaluating pad system performance

- Check pad face velocity in the center of the pad system.
  - For a 6” pad air velocity should be approximately 350-375 ft/min.
  - Lower pads require cleaning
  - Higher insufficient pad area portions are restricted

Conduct a “bucket test”

- Take a 5 gallon of water and throw the water at the pad
  - Measure the air velocity in cleaned as well as adjacent dirty pad
  - If there is more than a 50 ft/min difference the pads require cleaning.

Before and after bucket test

- Measure the static pressure in the center of the house with all fans operating and pads dry.
- Turn on the water to the pads and wait 15 minutes.
- Static pressure should not increase more than 0.01”

Another way to check pad status...

- Another way to check pad status is to replace one piece of pad with a new one

Old pad vs. new pad

- Best way is to evaluate pad status is to replace one piece of pad with a new one
When do you know when it is time to replace pads?

- Are they falling out of the system?

When do you know when it is time to replace pads?

- Are they falling out of the system?
- Are the leading edges folded over?

Is the pad becoming thinner?

- The most objective way is to measure the static pressure with all the fans operating (in proper working order)
  - If after cleaning the pressure is 0.05” above “normal” / original pressure

Evaluating pad system performance

- Check water level in the sump
- Make sure the pads are not sitting in water
  - May need to adjust float valve

Turn on pad system and check water flow over the pad surface

- Make sure all the fans are operating!
Measure amount of water coming out of distribution pipe

Minimum water column height

<table>
<thead>
<tr>
<th>Hole Size and Spacing</th>
<th>Manufacturers</th>
<th>Minimum water column height</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8” – 4” spacing</td>
<td>Munters</td>
<td>16”</td>
</tr>
<tr>
<td></td>
<td>Aerotech</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acme</td>
<td></td>
</tr>
<tr>
<td>1/8” - 2 ¼” spacing</td>
<td>CoolAir</td>
<td>11”</td>
</tr>
<tr>
<td>1/8” – 3” spacing</td>
<td>Cumberland</td>
<td>12”</td>
</tr>
<tr>
<td>1/8” – 2” spacing</td>
<td>Cumberland</td>
<td>8”</td>
</tr>
<tr>
<td></td>
<td>Hired Hand</td>
<td></td>
</tr>
<tr>
<td>5/32” – 4” spacing</td>
<td>Choretime</td>
<td>6”</td>
</tr>
<tr>
<td></td>
<td>Aerotech</td>
<td></td>
</tr>
</tbody>
</table>

Check system filter

Check the pump screen

Check the reservoir

Check the fill system pressure

- Check water pressure at house when reservoir is filling
  - Minimum = 40 psi
  - Ideal = 50 psi
If pressure is low check water supply filter

Pressure at control room before and after changing filter

Pressure gauges before and after filter can prove very useful

Check the fill system pressure

- Check water pressure at house when reservoir is filling
  - Minimum = 40 psi
  - Ideal = 50 psi
  - Should ideally be checked at pads as well

Water pressure at pad system

- No flow
- Water flowing

Check the fill system pressure

- Check water pressure at house when reservoir is filling
  - Minimum = 40 psi
  - Ideal = 50 psi
  - Should ideally be checked at pads
  - If there is a large difference in pressure, supply pipe is probably too small.
### PSI loss value table for water flowing through a PVC pipe (per 100')

<table>
<thead>
<tr>
<th>Flow (gpm)</th>
<th>¾”</th>
<th>1”</th>
<th>1 ¼”</th>
<th>1 ½”</th>
<th>2”</th>
<th>2 ½”</th>
<th>3”</th>
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<tbody>
<tr>
<td>5</td>
<td>2.5</td>
<td>0.8</td>
<td>0.2</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>6</td>
<td>3.4</td>
<td>1.1</td>
<td>0.3</td>
<td>0.1</td>
<td>0</td>
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<tr>
<td>7</td>
<td>4.6</td>
<td>1.4</td>
<td>0.4</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>5.9</td>
<td>1.8</td>
<td>0.5</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>7.3</td>
<td>2.3</td>
<td>0.6</td>
<td>0.3</td>
<td>0.1</td>
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<tr>
<td>10</td>
<td>8.9</td>
<td>2.7</td>
<td>0.7</td>
<td>0.3</td>
<td>0.1</td>
<td>0</td>
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<tr>
<td>11</td>
<td>10.6</td>
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<td>0.1</td>
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<td>12</td>
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<td>3.8</td>
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<td>0</td>
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<tr>
<td>13</td>
<td>-----</td>
<td>4.5</td>
<td>1.2</td>
<td>0.6</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
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<tr>
<td>14</td>
<td>-----</td>
<td>5.8</td>
<td>1.5</td>
<td>0.7</td>
<td>0.2</td>
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<td>16</td>
<td>-----</td>
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<td>-----</td>
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</tr>
</tbody>
</table>

### Evaluating tunnel ventilation system performance

- Check fan maintenance
- Check static pressure sensor accuracy
- Check house tightness
- Check operating static pressure
- Check evaporative cooling pad system
- Check tunnel wind speed

### Measurement height

- To obtain consistent wind speed measurements, it is best to measure wind speed 4–5’ off floor.
- Wind speed near birds tends to be very turbulent and as a result, it is difficult to obtain an accurate/consistent measurement.

### Air velocity meter stands can be helpful in obtaining consistent measurements

### Measuring tunnel wind speed

- Measure 100’ from tunnel fans in near the outer feed lines.
- These locations tend to produce readings close to the house average.

### 50’ X 500’ Broiler house

(average air speed = 564 ft/min)
**Houses with air deflectors**

- Measurements should be taken half way between deflectors

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**Measuring tunnel wind speed**

- Measure 100’ from tunnel fans in two locations:
  - Near outer feed lines
- Use averaging feature on wind speed meter
  - Make sure your wind speed meter is in the proper position before turning it on.
- Take two or three measurements on minute apart.

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**Variations in pressure will result in variations in measured air speed.**

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**15 anemometers vs Feed line measurements study**

- Feed line measurements
  - Taken roughly 4 – 5’ above the floor
  - Three one minute average measurements
  - Anemometers were not looked at between measurements.
- 40’ X 500’ totally enclosed house
Wind speed test results

- 3% difference
- 15 anemometers
- Feed line measurements

Evaluating tunnel ventilation system performance
- Check fan maintenance
- Check static pressure sensor accuracy
- Check house tightness
- Check operational static pressure
- Check evaporative cooling system
- Check tunnel air speed
- Electrical system check-up
  - Should be done by electrician once a year

Electrical system
- Are their electrical connection problems?

Loose connections

Evaluating electrical supply
- Breaker spots should be installed to help spot problems.
Electrical system
- Are their electrical connection problems?
- Has the grounding system been checked?

Stand-by generator should be also checked
- Electrical connections
- Fuel
- Batteries
- Weekly generator testing

Spare parts that a producer should have on hand
- Fan belts?
- Fan motors?
- Cool cell pumps?
- Water filters?
- Circuit breakers?
  - Main
  - Fan
- Controller relay boards?

Evaluating tunnel ventilation system performance
- Check fan maintenance
- Check static pressure sensor accuracy
- Check house tightness
- Check operational static pressure
- Check evaporative cooling system
- Check tunnel air speed
- Electrical system check-up
  - Stand-by generator should be also checked

Evaluating tunnel ventilation system performance with birds present
- Older birds, ventilation system running at maximum:
  - Are we producing maximum cooling?
Evaluating tunnel ventilation system performance with birds present

- Check front to rear temperature rise
  - Should be between 3 and 5°F
    - Very low temp rise could be a sign of a problem

If greater than 5°F...

- Check the static pressure

Static pressure

- But generally the static pressure should be between 0.10” and 0.15”
  - In “high” air velocity houses static pressure will tend to be higher (0.15”).
- Too high check tunnel inlet
  - Pads
  - Tunnel curtain
- Too low
  - Check for fan maintenance issues

Fan maintenance

- Look at tunnel fan shutters
  - Are they fully opened?
  - Are they opened the same amount?

Are the side wall inlets closed all the way?

- Check the side wall curtains
  - Are the side wall curtains closed?
  - Are the side wall inlets closed?
Evaluating tunnel ventilation system performance with birds present

- Check front to rear temperature rise
- Check pad cooling "efficiency"

Are the pads producing the cooling they are supposed to?

- Measure outside temperature in the shade.
- Open side wall door and measure air temperature as it enters the house.
- Measure inside wet pad surface temperature with infrared thermometer

Are the pads producing the cooling they are supposed to?

- Pad cooling = (Outside – Pad) X 0.75
  - 0.75 = pad cooling efficiency
  - Pad = wet bulb temperature
  - Incoming = Outside – Pad cooling

Example:

Outside air temperature = 90°F

6" pad cooling check

- Pad cooling = (90°F – 71.8°F) X 0.75
  - = (18.2°F ) 0.75
  - = 13.7°F
- Incoming = Outside – Pad cooling
  - = 90°F – 13.7°F
  - = 76.3°F

Outside temperature = 90°F
If cooling is less than expected…

Is the pad thoroughly wetted?

- Check water column height at system
- Is sump full?
- Check water supply pressure at pads

Check pad room for leakage

Pad room ceiling leakage

Evaluating tunnel ventilation system performance with birds present

- Check front to rear temperature rise
- Check pad cooling "efficiency"
- Check air speed
Measure air speed 100' from tunnel fans

- Do not measure the centerline velocity.
  - We really aren't interested in the maximum air speed in the house.
  - We want the average or really the minimum air speed.
- Measure air speed near the feed lines
  - Is generally very close to the average.
- Compare this measurement to the springtime measurement.
  - Should be the same or higher.

Evaluating tunnel ventilation system performance with birds present

- Check front to rear temperature rise
- Check pad cooling "efficiency"
- Check air speed
- Check controller max/min temperatures
  - Pay special attention to the sensors closest to the fans.

Evaluating tunnel ventilation system performance with birds present

- Check front to rear temperature rise
- Check pad cooling "efficiency"
- Check air speed
- Check controller max/min temperatures
- Check tunnel fan runtime

Tunnel fan runtime

- Did all the tunnel fans run all night long?
  - Big birds – hot weather

550 ft/min

350 ft/min
Evaluating tunnel ventilation system performance with birds present

- Check front to rear temperature rise
- Check pad cooling “efficiency”
- Check air speed
- Check controller max/min temperatures
- Check tunnel fan runtime
- Check relative humidity

Litter quality

- If it is too wet…
  - Are the too many birds in the tunnel opening area?
  - Is water from the distribution system leaking into the house?
  - Are the drinkers too low?

Relative humidity

- Be aware of the fact that most Rh sensors are not very accurate when Rh rises above 85%.
- When 6” pads are operating Rh will typically run 80% or better:
  - If higher, are fogging nozzles operating excessively?
  - If lower, are your pads properly wetted?

Litter quality

- If it is too dry…
  - Is the evaporative cooling system being used enough?
  - If it is a fogging nozzle house, does the house have a sufficient number of nozzles?
  - Are the drinkers too high?
Evaluating tunnel ventilation system performance with birds present

- Check front to rear temperature rise
- Check pad cooling "efficiency"
- Check air speed
- Check controller max/min temperatures
- Check tunnel fan runtime
- Check relative humidity
- Check over all litter quality
- Evaluate bird distribution

Bird distribution

- Are the birds evenly distributed throughout the house?
  - Walk through the house

Check water meters

Evaluating tunnel ventilation system performance with birds present

- Check front to rear temperature rise
- Check pad cooling "efficiency"
- Check air speed
- Check controller max/min temperatures
- Check tunnel fan runtime
- Check relative humidity
- Check over all litter quality
- Evaluate bird distribution
- Check circuit breaker temperature

Circuit breaker temperature

Evaluating tunnel ventilation system performance with birds present

- Check front to rear temperature rise
- Check pad cooling "efficiency"
- Check air speed
- Check controller max/min temperatures
- Check tunnel fan runtime
- Check relative humidity
- Check over all litter quality
- Evaluate bird distribution
- Check circuit breaker temperature
- Check back-up systems
Back-up systems

- Are back up thermostats set?
  - All fans should be set to operate by 80°F with older birds
- Are the curtain drops set?
- Is phone dialer working?
- Has the stand-by generator been recently serviced?