Commercial Layer House Ventilation Systems

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Cold weather ventilation

To understand how to best ventilate a barn during cold weather…

- We first have to keep in mind why we have to bring in fresh air into a barn during cold weather?

It isn't really for oxygen

- Oxygen is not an issue in layer houses…
- In fact there is no such thing as bird "suffocation".

This can be easily proven by doing a little math…

- Layer oxygen requirements…
- 0.05 cubic feet per hour
  - Fresh air requirements = 0.25 ft^3/hr
- Layer house with 100,000 birds
  - Fresh air = 100,000 X 0.25 ft^3/hr
  - = 25,000 ft^3/hr
  - or
  - = 414 ft^3/min

Various fan capacities

(we need 414 ft^3/min)

- 36" fan
  - 10,000 ft^3/min
- 24" fan
  - 5,000 cfm
- 12" fan
  - 1,200 cfm
- 8" fan
  - 600 cfm
- Kitchen range hood
  - 400 cfm

Timer settings for two 48" fans...

- 30 seconds out of one hour.

If it is not oxygen...what is it?

- Carbon dioxide is far more likely to be a problem than is oxygen.

Generally acceptable carbon dioxide concentration

- 5,000 ppm or lower
  - Essentially no research showing detrimental effect for layers at this level.
  - Has to nearly 100,000 ppm to kill a bird.

Ventilation rate required to control carbon dioxide

- A commercial layer produces approximately 0.10 cubic feet of carbon dioxide per hour
- To assure that carbon dioxide does not exceed 5,000 ppm a minimum ventilation rate of approximately 35,000 cfm would be required in a 100,000 bird house (0.35 cfm/bird)

Nearly 100 times higher than that need for oxygen

Minimum ventilation

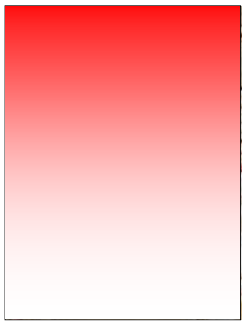
- Even though carbon dioxide is far more like to be a problem than oxygen, it is still not the primary reason we need to ventilate during cold weather.
- What we are primarily ventilating for during cold weather is to control moisture

Suffocation?

- A house full of layers is producing a tremendous amount of heat as well as moisture.
- When the fans shut off:
  - house temperature can increase two or more degrees per minute
  - Relative humidity will increase two percent or more per minute

Suffocation?

- With no air movement, house temperatures can rise to mid to high 80's, relative humidity to 90 to 100% in less than 15 minutes.

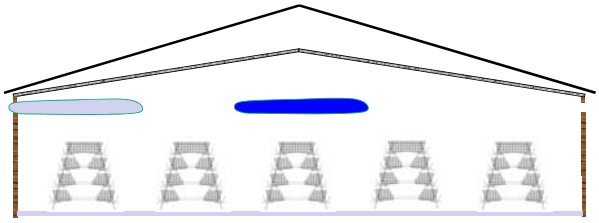


High house moisture levels

- Leads to high ammonia levels
- Fly problems
- Condensation problems
- Bird heath issues

We manage house moisture through ventilation

Basic cold weather ventilation



Proper ventilation involves more than just bringing in air..

- We have to condition the air to be effective:

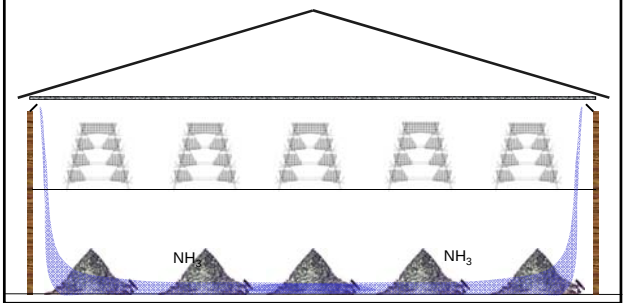
No conditioning of incoming air

Chills the birds

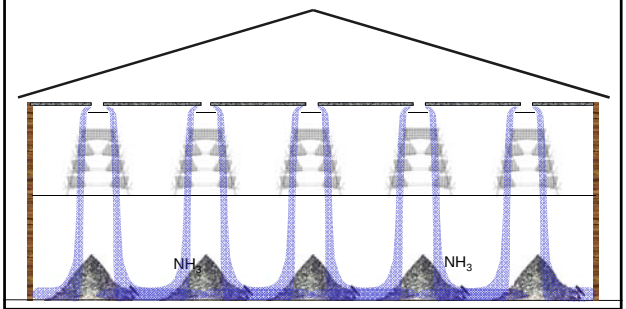
Results poor temperature uniformity

Little moisture is removed from air or manure

Little moisture removal, leads to wet manure and ammonia



Little moisture removal, leads to wet manure and ammonia

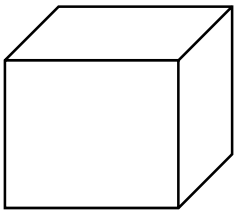


Proper ventilation involves more than just bringing in air..

- We need to condition the air:
  - More specifically we need to heat the air
  - Because the moisture holding ability of air changes with temperature

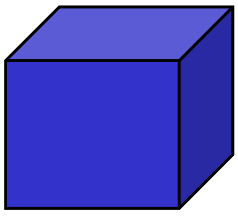
20°F Air

- The maximum amount of water 1,000 cubic feet of air can hold is 3 ounces



20°F Air

- The maximum amount of water 1,000 cubic feet of air can hold is 3 ounces
- 3 oz 100%

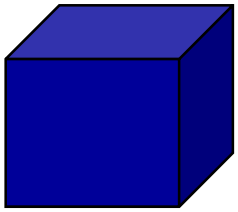


Moisture holding ability of air changes with temperature.

- Increasing air temperature 20°F roughly doubles the moisture holding ability of air.

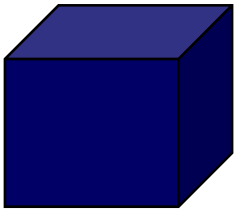
40ºF Air

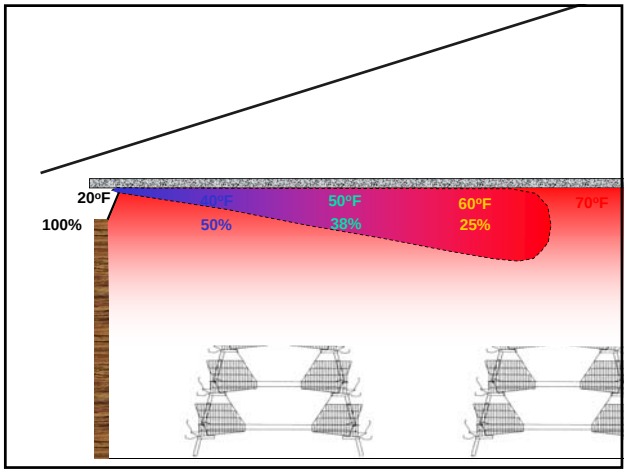
- The maximum amount of water 1,000 cubic feet of air can hold is 6 ounces
- 3 oz 50%



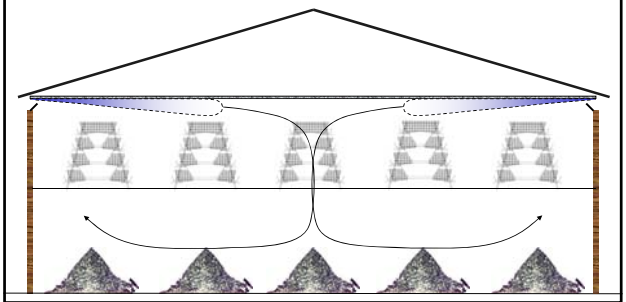
60ºF Air

- The maximum amount of water 1,000 cubic feet of air can hold is 12 ounces
- 3 oz 25%





Conditioning of the incoming air leads to drier manure and less ammonia



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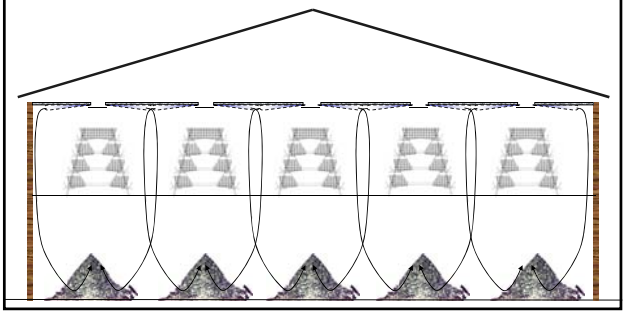
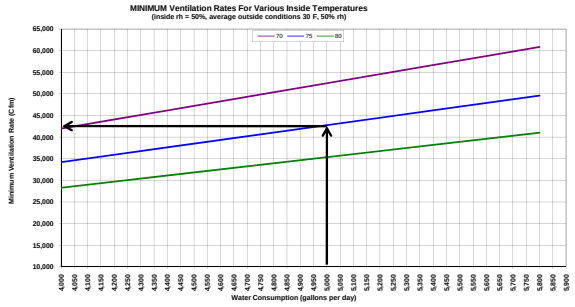


How much fresh air do we need to bring in to control moisture?

- Primarily depends on the amount of water being added to the house

- Inside temperature/Rh
- Outside temperature/Rh

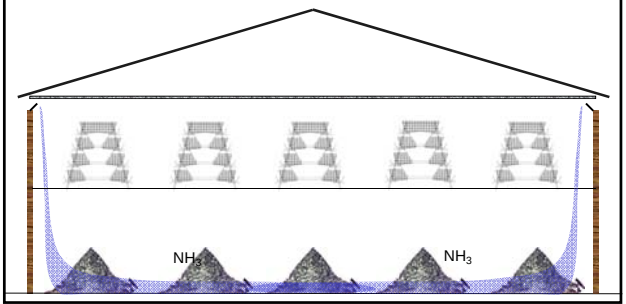
Minimum ventilation rates based on water consumption



Monitor Rh to adjust minimum ventilation rates

- Chart can provide a starting point but the fact is that it is best to simply monitor house Rh
  - The target Rh is typically approximately 50% to 60%

Keep in mind we need to condition the air

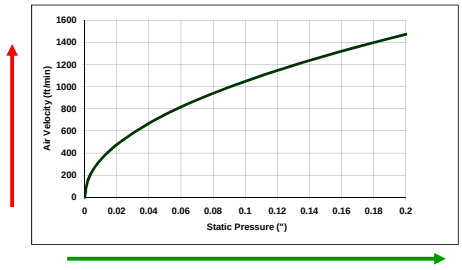


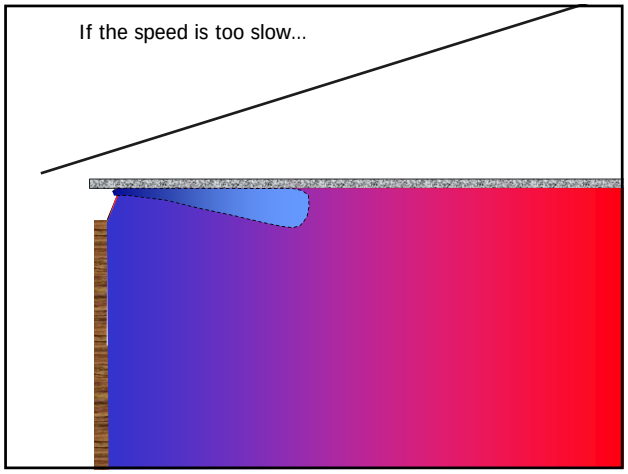
To maximize the conditioning of incoming air…

- We need to make sure that we get the air to move along the ceiling as long as possible which takes the right *combination* of **static pressure** and **inlet opening**

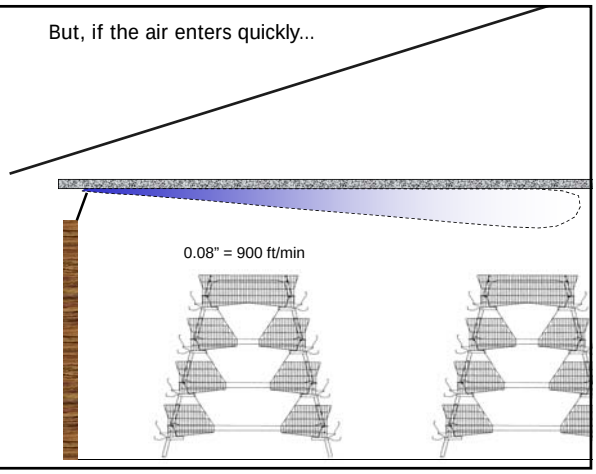
Static pressure determines air speed enter the house

- Higher pressure…greater speed





But, if the air enters quickly...



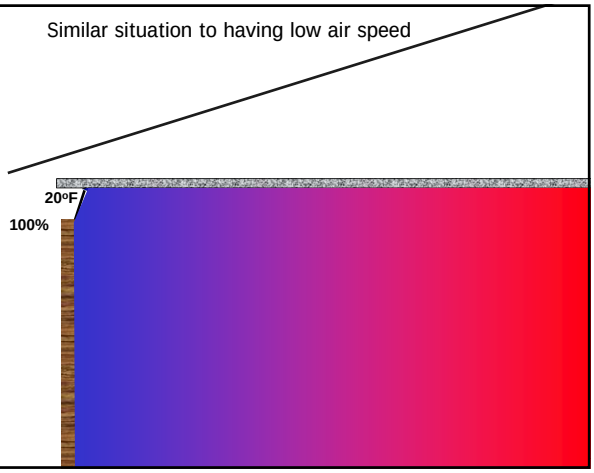
But again speed is not everything...

- We need the right combination of *speed* and *inlet opening* to obtain proper mixing

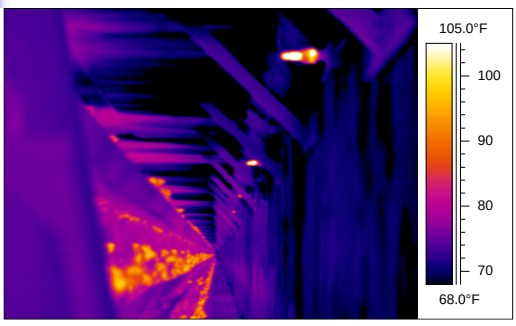
If the inlet open is too small...

1) The air will not have enough mass/momentum to make it to the center of the house

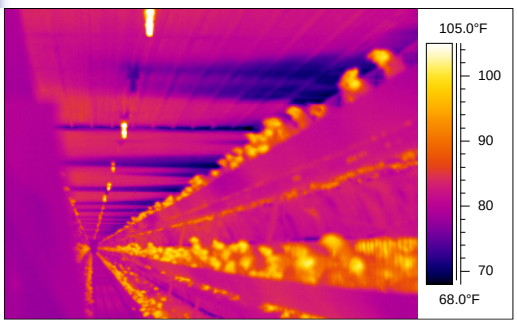
Similar situation to having low air speed



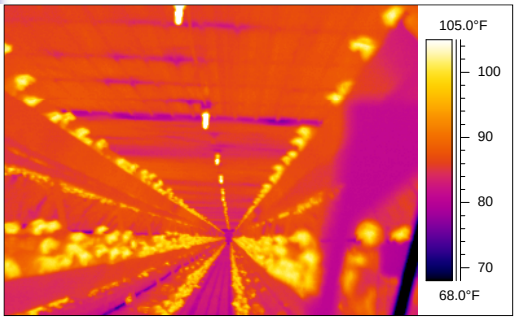
Example of poor cold weather air mixing...



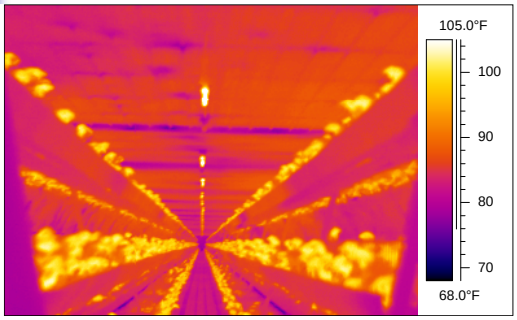
Next aisle over...



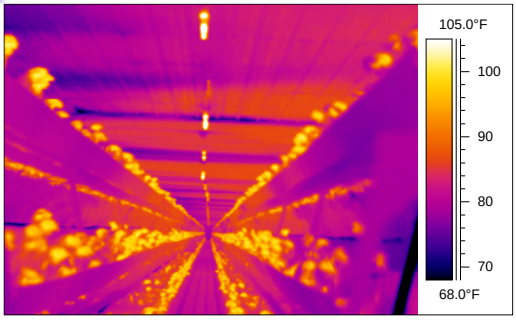
First center aisle...



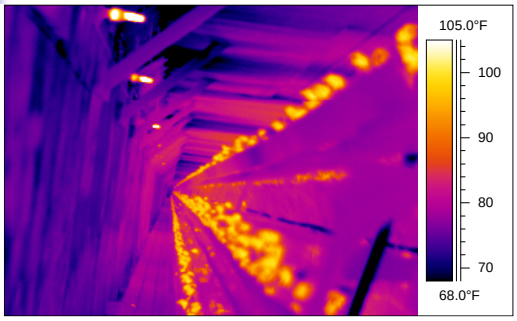
Second center aisle...



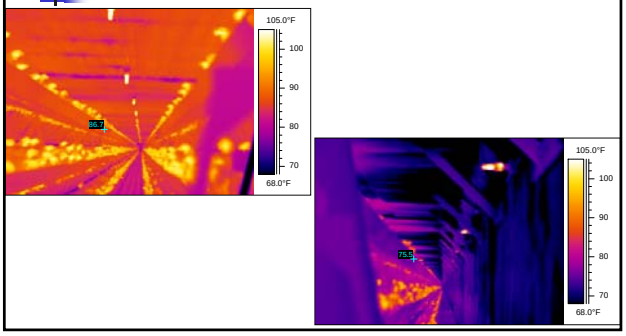
Other outer aisle...



Other outside aisle

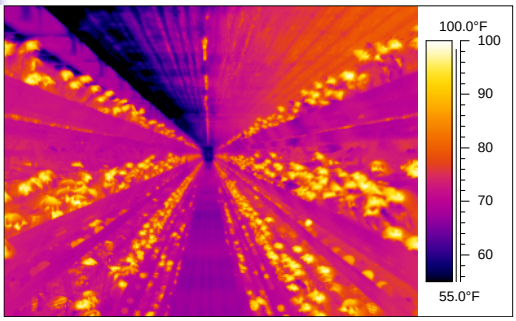


Air temperatures

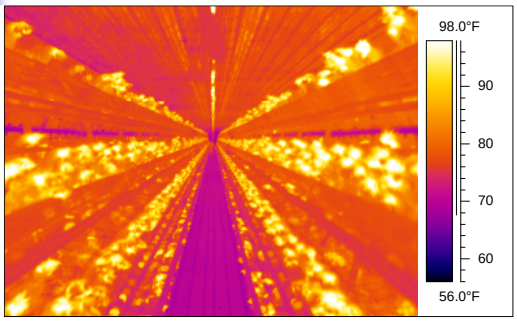


Similar temperature variations can occur with slot inlets

Slot inlet

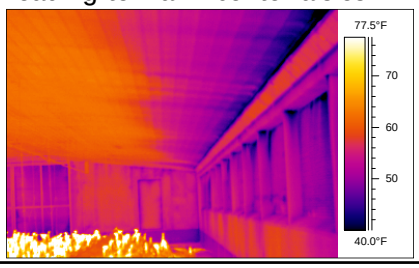


Next aisle



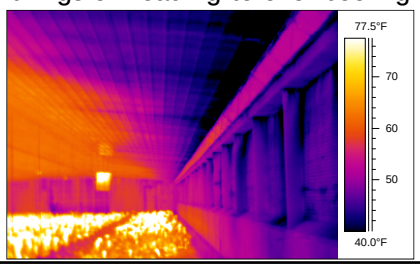
Poor fresh air distribution can also lead to ventilation system cycling

- Outside aisle get all the fresh air leading to warm center aisles.



Poor fresh air distribution can also lead to ventilation system cycling

- Then the fans come on and to cool things off leading to over cooling.



To get proper mixing we would ideally like to have...

- Inlet opening:
  - Side wall
    - 1 1/2 ” to 2”
  - Slot
    - ¾” to 1”
- Static pressure:
  - 0.08” – 0.12”

This is very difficult with a continuous inlet..

- Because during cold weather very few fans are operating...
- which means very little inlet opening is required

Example 500’ layer house

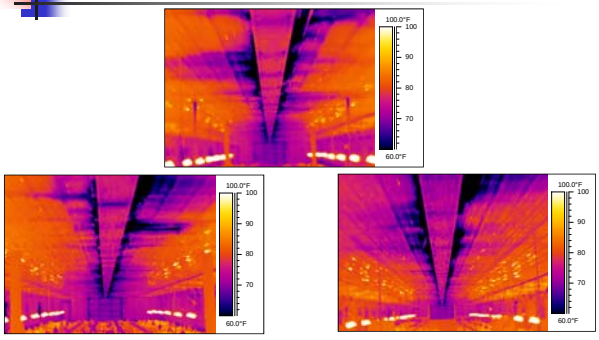
- 100,000 bird house operating two 48” fans for minimum ventilation.
- Continuous side wall inlets

To obtain a static pressure of 0.10” we only need about 25 ft^2 per 48” fan

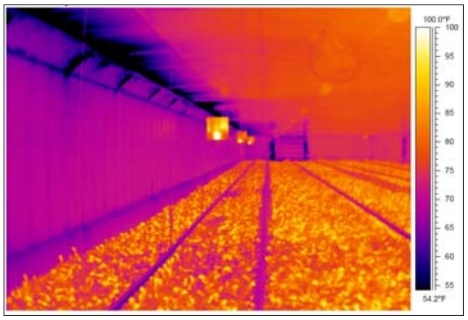
- Two 48” fans operating = 50 ft^2
- 500’ house two rows of inlets…
- Inlet opening = 50 ft^2 / (500 ft X 2)
- = 0.05 ft
- = ½”
- This assumes the house is perfectly tight!

Bottom line, a continuous inlet is not a good minimum ventilation inlet

Difficult to obtain uniform opening with a continuous inlet



Variations in inlet opening



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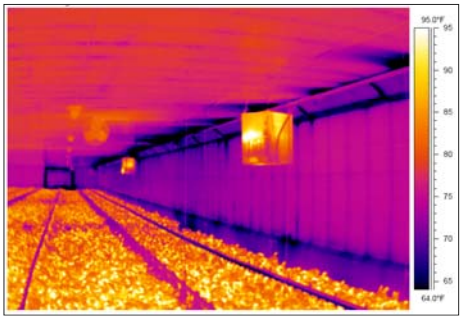
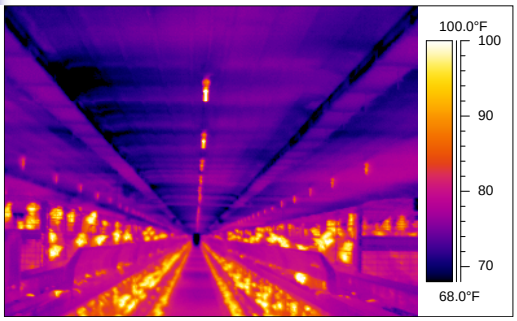


Continuous inlets do not throw air….they tend to dump it during cold weather

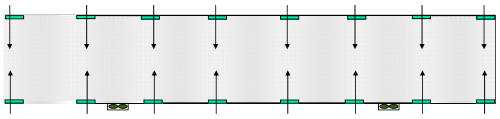
Poor inlet opening uniformity.



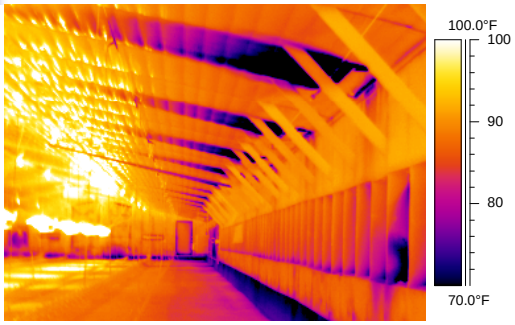
In houses with side wall inlet this problem can be minimized by…

- Block side wall inlets during cold weather
- Close up to 75% of the side wall inlets
- You simply do not need much inlet area during cold weather

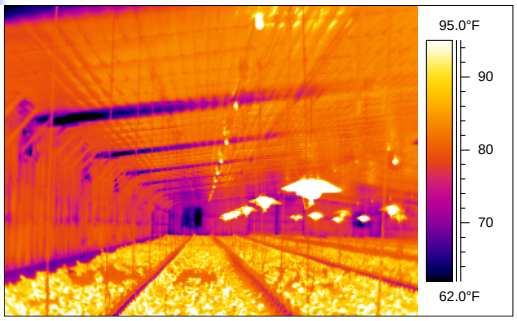
Blocked inlets



Individual inlet air flow



Individual inlet air flow



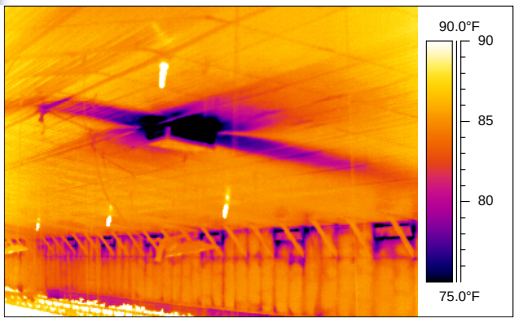
Another possible option is to install a minimum ventilation inlet system

We are looking for an inlet system…

- Specifically designed to be used only for minimum ventilation.
  - Smaller inlet
    - The fact is the only reason we have continuous inlets is for hot weather.
  - Evenly distributed throughout a house

Attic inlet air flow

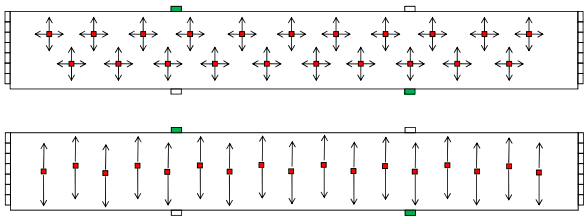
Attic inlet air flow



Attic inlets

- Each inlet can supply approximately 2,000 cfm of fresh air.
- The typical 50’ X 500’ house would ideally have around 20 inlets, installed down the center two aisles
- Enough for a couple 48” fans

Attic inlet placement

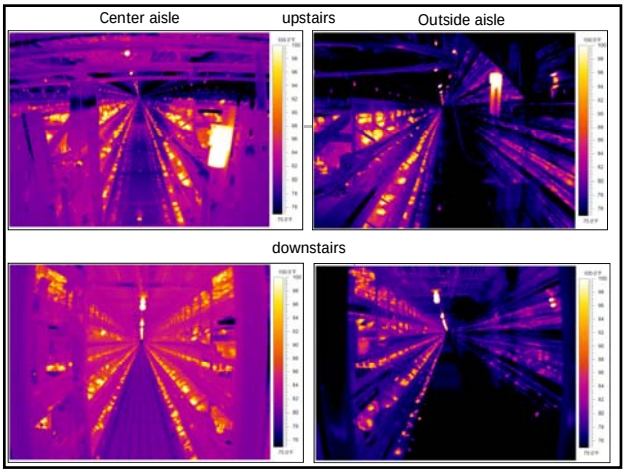


In houses with multiple rows of continuous attic inlets...

- No easy solution...
- Generally it is best if you have multiple rows to close tightly two or three rows of the inlets so the remaining rows open more.

In high density two story houses...

- Manure blower fans are often be configured to bring in fresh air making it a little easier to distribute fresh air during cold weather to the lower cages.



In high density two story houses...

- Manure blower fans are often be configured to bring in fresh air making it a little easier to distribute fresh air during cold weather.
- May require vertical circulation fans

How many exhaust fans should a layer house?

Exhaust fans

- Minimum recommended fan capacity for commercial layer houses:
  - 6-7 cfm/bird high rise
  - 5-6 cfm/bird single story
  - 4-5 cfm/bird two story high density house

Example

- High rise house
- 55’ X 500’
- 100,000 birds
- 600,000 cfm

Exhaust fan selection

Three factors to consider when selecting exhaust fans

- Air moving capacity
- Energy efficiency
- Air moving capacity vs. static pressure

Air moving capacity

- Do not determine the number of fans based on a 0.00” or 0.05” static pressure.
- Most layer house fans operate during warm weather at a static pressure of 0.10”, or higher
- Therefore, the fans we need should be calculated at a pressure of at least 0.10”…in the case of some high density houses 0.15”

Three factors to consider when selecting exhaust fans

- Air moving capacity
  - Between 4.5 and 7 cfm/bird @ 0.10” (possibly 0.15”)
- Energy efficiency

Energy efficiency

- Fans should have a minimum energy efficiency rating of 20.8 cfm/watt at 0.10”
  - The higher the rating the lower the operating cost
  - Energy efficiency ratings typically range between 16 and 25 cfm/watt

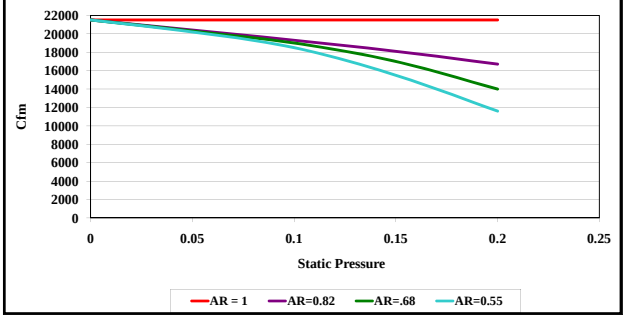
Three factors to consider

- Air moving capacity
- Energy efficiency
- Air moving capacity vs. static pressure
  - Air flow ratio

Air flow ratio

- Provides an indicator of how well a fan holds up under a static pressure.
- It is calculated by dividing the air moved by a fan at 0.20" by the air moved by the fan at 0.05"

Fan Output vs Static Pressure



Air flow ratio

- We want a fan that can hold up to high static pressures
  - Reduces the effect of the wind on house ventilation
  - Reduces the effect of dirty shutters on house ventilation
- The <u>minimum</u> acceptable air flow ratio is for a layer house is 0.76

Fan comparison example

48" exterior shutter

54" interior shutter, cone fan

Fan comparison example

(100,000 birds, 6 cfm/bird)

- 48" fan exterior shutter
  - 15,000 cfm @ 0.10"
  - 17.3 cfm/watt
  - afr = 0.42
- 54" cone fan, interior shutter
  - 25,800 cfm @ 0.10"
  - 22.5 cfm/watt
  - afr = .79

Number of fans

- 48” fan exterior shutter
  - 40 fans
- 54” cone fan, interior shutter
  - 23 fans

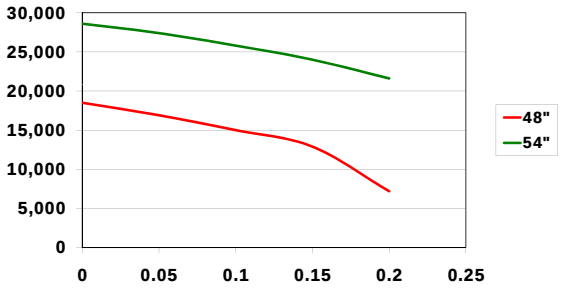
Fewer fans!

- 40% fewer fans
  - Less wiring
  - Fewer fans to maintain
    - Belts to tighten/replace
    - Shutters to clean

Significantly lower electricity usage

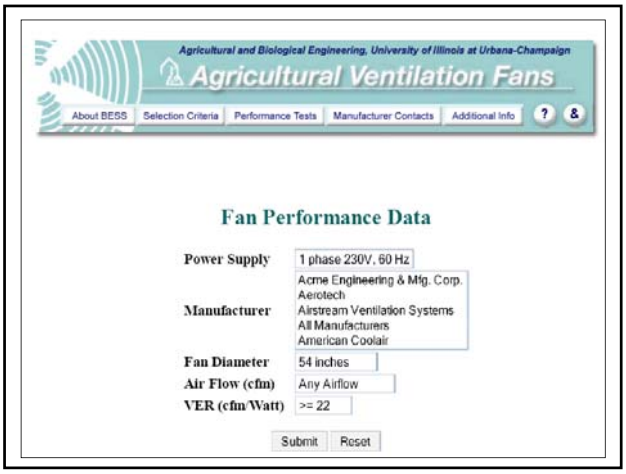
- 48” fan exterior shutter
  - 40 fans
  - Power:
    - Total = 34.7 Kw
    - $1,400.00
- 54” cone fan, interior shutter
  - 23 fans
  - Power:
    - Total = 26.4 Kw
    - $1,140.00 (-25%)

Holds up much better under high static pressures



How do we find a good exhaust fan?

- Use independent fan test information when selecting exhaust fans for a house
  - Bess Laboratory – University of Illinois
    - www.bess.uiuc.edu



Test #	Model	Size	Cone	Shutter	Air Flow (cfm) 0.05" SP	VER (cfm/W) 0.05" SP	Air Flow (cfm) 0.10" SP	VER (cfm/W) 0.10" SP	Air Flow Ratio
Acme									
07204	BDR54J	54"	Y	A	25100	27.7	23500	24.5	0.94
07206	BDR54J1	54"	Y	A	27400	25.4	25900	22.7	0.94
00246	BDR54JL-C	54"	Y	A	19400	33	17100	27.4	0.88
02207	BDRV54J2-C2	54"	Y	A	27400	25.5	25800	22.5	0.94
02217	BDRV54J2-C3	54"	Y	A	27100	25.2	25400	22.2	0.94
02210	BDRV54J-C2	54"	Y	A	26100	25.8	24400	22.4	0.93
02214	BDRV54J-C3	54"	Y	A	25900	25.3	24200	22.2	0.93
02212	BDRV54JL-C2	54"	Y	A	23000	30.1	21000	25.8	0.91
02213	BDRV54JL-C3	54"	Y	A	22800	29.3	20700	25.2	0.91
00301	DC54JL-C	54"	Y	A	21000	31.7	17700	25.7	0.84
04274	DDPSV54J-C	54"	Y	A	25500	25.4	23800	22.1	0.93
Aerotech									
06141	WF541T1CEJ	54"	Y	A	27800	25	26000	22.3	0.93
Airstream									
06222	G54CBF16GAU	54"	Y	B	25000	28.8	21900	23.3	0.53
Hired Hand									
08154	6603-7090	54"	Y	A	27400	26.7	25800	23.8	0.72
Val-Co									
05122	HGS54G340NGA	54"	Y	A	26500	26	24200	22.7	0.70

Project Number: 00300 **Test Date:** October 25, 2000

Fan
Make: Acme
Model #: DC54J-C
Manufacturer: Acme
Blade Size: 54" blade
Orifice Dia.: 54.5"

Blade
Number: 4
Shape: propellor
Material: galvanized steel
Pitch: -
Clearance: 0.3"

Shutter
Material: aluminum
# of Doors: 14 per column
# of Columns: 2
Door Length: 28.3"
Location: intake

Other Attachments:
discharge cone 25.5" deep, 54.5" i.d., 67" o.d.

Motor
Make: AO Smith
Model #: K56A40BB3
H.P.: 1
Amps: 11/5.5
Volts: 115/230
RPM: 1725
S.F.: 1.30

Drive
Drive Pulley Dia. 2.8" o.d. AK28
Axle Pulley Dia.: 13.3" AK134

Housing
Material: galvanized steel
Intake Area: 56" x 56"
Discharge Area: 54.5" dia.
Depth: 32.5" top 17.5" bottom

Guards
Description: wire
Spacing: 2" concentric
Location: exhaust

ACME DC54J-C

Test: 00300

Fan description:
54" belt drive, 1 hp AO Smith K56A40BB3 motor, galvanized steel slant housing, aluminum shutter, guard and discharge cone

Static Pressure in. water	Speed rpm	Airflow cfm	Efficiency cfm/Watt
0.00	356	28,700	27.8
0.05	356	26,800	24.7
0.10	354	24,200	21.3
0.15	354	21,400	18.2
0.20	353	17,800	14.9
0.25	351	10,200	8.4
0.30	350	6,000	4.5

Fan comparison newsletter


The University of Georgia
Cooperative Extension Service

Poultry Housing Tips
Best Performing Tunnel Fans - 2000

Top 7%

Test #	Manufacturer	Model	Cone	Shutter	Cfm @.05"	Cfm/watt @.05"	Cfm @.10"	Cfm/watt @.10"	Air Flow Ratio
07204	Acme	BDR54J	Y	A	25,100	27.7	23,500	24.5	0.78
07206		BDR54J1	Y	A	27,400	25.4	25,900	22.7	0.81
02207		BDRV54J2-C2	Y	A	27,400	25.5	25,800	22.5	0.79
02210		BDRV54J-C2	Y	A	26,100	25.8	24,400	22.4	0.77
02217		BDRV54J2-C3	Y	A	27,100	25.2	25,400	22.2	0.78
02214		BDRV54J-C3	Y	A	25,900	25.3	24,200	22.2	0.78
04274		DDPSV54J-C	Y	A	25,500	25.4	23,800	22.1	0.77
04278		DDPGV54J-C	Y	A	26,500	25.2	24,700	21.8	0.78
08243		BDR54J-C	Y	A	26,100	24.2	24,300	21.4	0.78
08207		DDP54J-C	Y	A	26,400	23.9	24,100	21.3	0.77
02208		BDRV54J1-C2	Y	A	27,100	24.0	25,300	21.1	0.77
99142		DDP54J-C	Y	A	25,400	23.2	23,300	20.9	0.83
06141	Aerotech	WF541T1CEJ	Y	A	27,800	25.0	26,000	22.3	0.77
07160		WF541V1CD	Y	B	27,800	24.8	25,900	21.7	0.77
08158		WF541T1CEP	Y	P	27,400	24.2	25,600	21.7	0.78
08115		WF541T1CJ	Y	A	27,200	23.6	25,400	20.9	0.77
05238	American Cooler	MNBRD05LE	Y	B	24,100	28.1	22,200	22.8	0.78
05233		MNBRD05LE	Y	B	23,800	23.4	22,100	22.3	0.78
05218		MNBRC52L	Y	A	25,800	24.6	24,400	21.7	0.77
05215		MNBRD52L	Y	B	25,100	24.2	23,500	21.4	0.78
07230		NBRD52L-SQ	Y	D	24,800	24.3	23,000	21.3	0.78
05234		MNBRD05L	Y	B	24,800	23.8	23,100	20.9	0.77
04116	Chore-Time	48418-22	Y	B	25,200	24.8	23,700	21.6	0.78
04118		48515-22	Y	B	25,100	24.4	23,600	21.3	0.77
07192		48511-22	Y	B	26,400	23.9	24,600	21.2	0.78
07188		48518-22	Y	B	26,400	23.4	24,500	20.8	0.78
08150*	Hired Hand	6603-7132	Y	B	26,700	24.3	25,200	21.8	0.80
04143		6603-6604	Y	A	27,000	25.3	25,300	20.8	0.78
04150p	Pro Tects Systems	A49431-22	Y	B	25,200	24.8	23,700	21.6	0.78
04120p		A49515-22	Y	B	25,100	24.4	23,600	21.3	0.77
07192p		A49511-22	Y	B	26,400	23.9	24,600	21.2	0.78
07188p		A49518-22	Y	B	26,400	23.8	24,500	20.8	0.78
05201	Val-Co	HGS48G340NGA	Y	A	25,900	25.4	23,800	22.1	0.78

Table 1. Alphabetical listing of best performing tunnel fans as tested by BESS Labs (Top 7%)
(A=Aluminum Shutter, G=Galvanized Shutter, P=Plastic Shutter, R=Roll Seal Shutter, B=Butterfly Shutter, D=Door)
*new test for 2008

Exhaust fan location

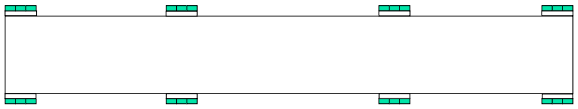
- Traditionally fans have been installed evenly down both sides of a house
- Are there better options?

Exhaust fan placement

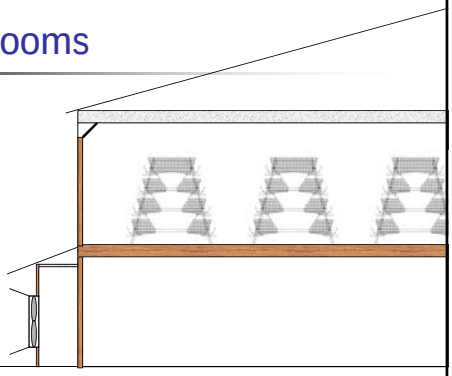
- Grouped
  - There is no reason fans have to be spread out.

Exhaust fan placement

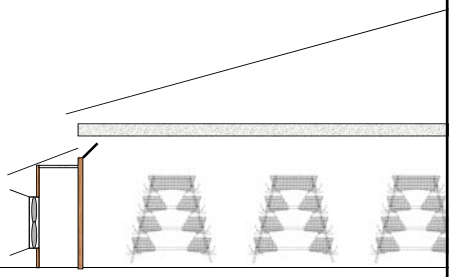
- Grouped with fan rooms



Fan rooms



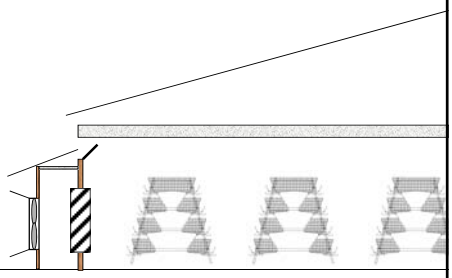
Fan rooms



Fan rooms

- Advantages:
  - Easier access to fans (high rise houses)
    - Easier maintenance
  - Easier to make OSHA friendly
  - Easier to reduce light transmission

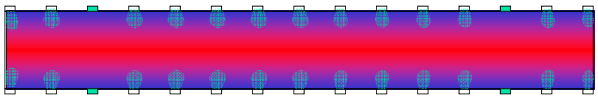
Fan rooms



Fan rooms

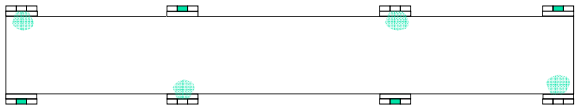
- Advantages:
  - Easier access to fans (high rise houses)
    - Easier maintenance
  - Easier to make OSHA friendly
  - Easier to reduce light transmission
  - Fewer cold spots during cold weather

Exhaust fan location



Exhaust fan placement

- Grouped with fan rooms
  - Ideally there would be a minimum ventilation fan with every group



Exhaust fan placement

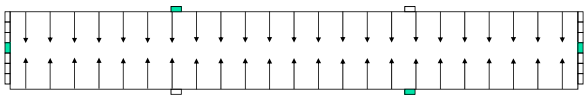
- Ultimate grouped fan placement
  - Tunnel ventilation

A tunnel house has essentially one exhaust fan system

and two inlet systems

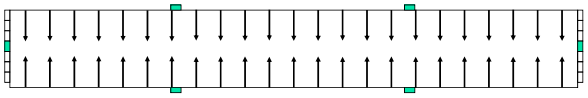
Exhaust fan placement

- Grouped – Tunnel (high rise)
  - Inlets running the length of the house



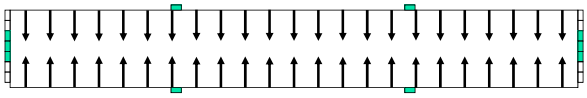
Exhaust fan placement

- Grouped – Tunnel (high rise)
  - Inlets running the length of the house



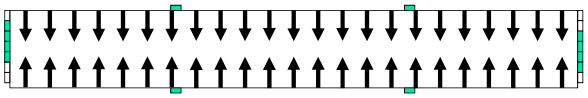
Exhaust fan placement

- Grouped – Tunnel (high rise)
  - Inlets running the length of the house



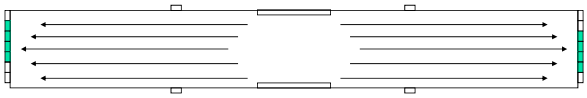
Exhaust fan placement

- Grouped – Tunnel (high rise)
  - Inlets running the length of the house



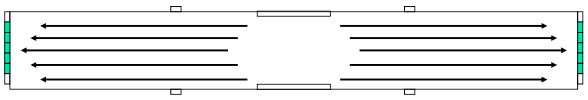
Exhaust fan placement

- Grouped – Tunnel (high rise)
  - Inlets in the center of the house



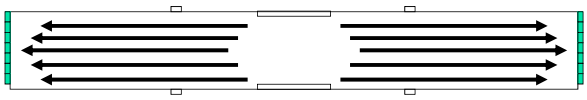
Exhaust fan placement

- Grouped – Tunnel (high rise)
  - Inlets in the center of the house



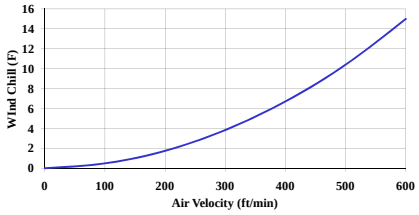
Exhaust fan placement

- Grouped – Tunnel (high rise)
  - Inlets in the center of the house

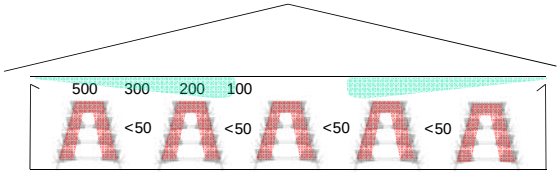


Advantages:

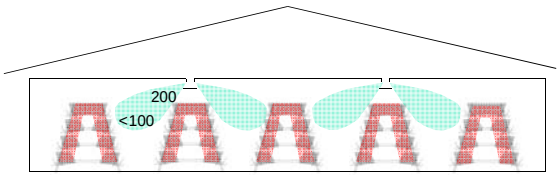
- Dramatically improved cooling during warm weather



Installed in the side walls



Installed in the ceiling



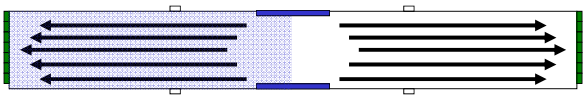
Tunnel wind speed

Air speed profile in tunnel-ventilated layer houses

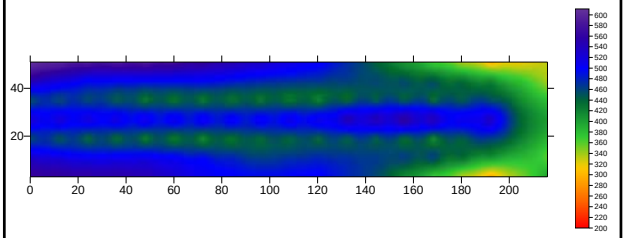
- High rise
  - 54 X 150 m
  - 100,000 – 150,000 birds

Tunnel house

- Air velocity profile



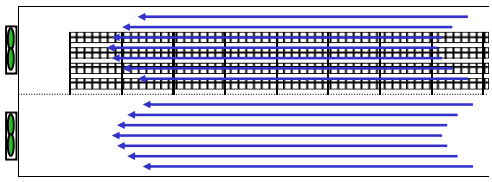
Tunnel air velocities



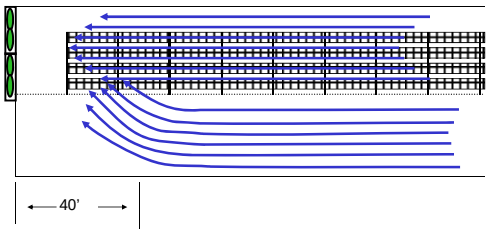
High rise houses

- Fans can be evenly distributed between upstairs and downstairs.

Air flow in high rise houses

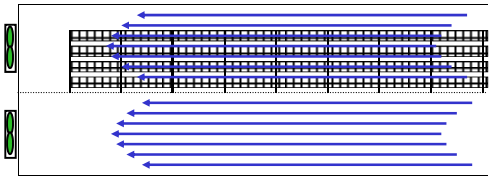


Air flow in high rise houses with all the fans upstairs



It is easier for the air to move downstairs than upstairs.

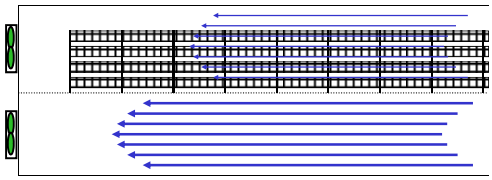
Air flow in high rise houses



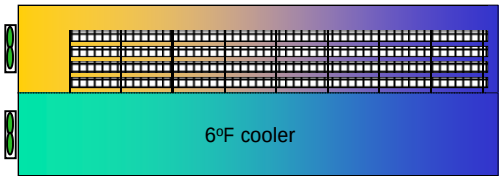
Air flow in high rise houses

Less speed upstairs

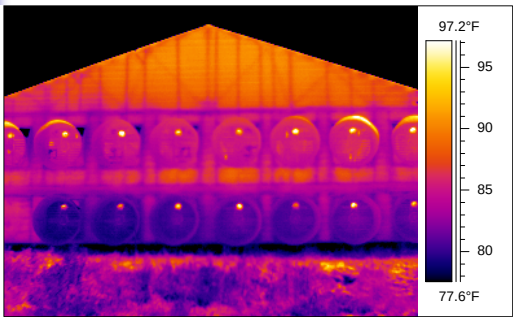
Less volume upstairs



Air flow in high rise houses



Commercial layer houses



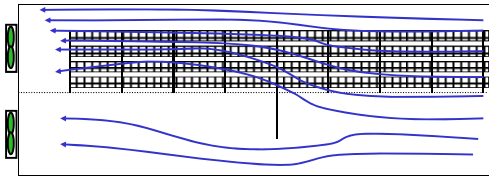
Solution….

Air flow in high rise houses

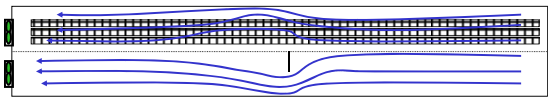
Increases air speed upstairs

Decreases air temperature upstairs

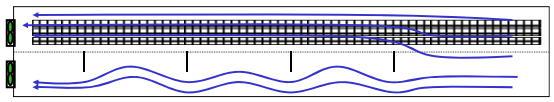
Increases air speed over manure



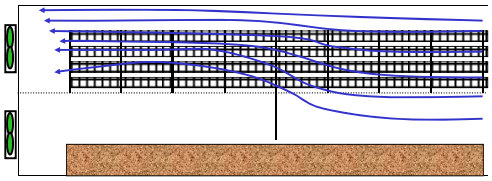
The effect of a deflector is temporary



To get maximum effect should be placed 30’ on center



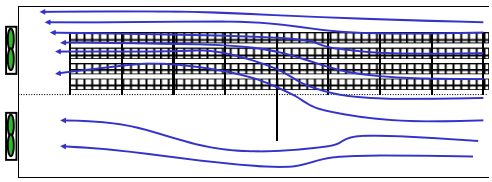
Keep deflector 18” above the top of the manure



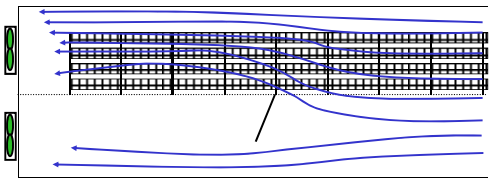
Proper height above manure

Generally, not needed when manure reaches 4’ in height

Deflectors should slant towards fans



Deflectors should slant towards fans



Deflector catching the wind

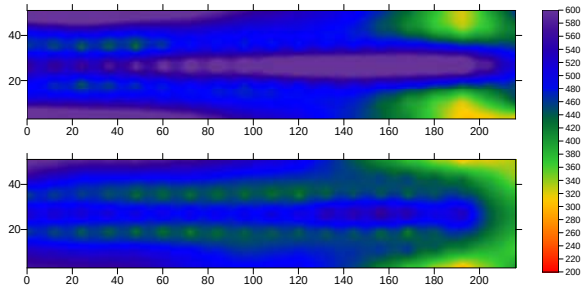
High density two story tunnel-ventilated layer houses

- Manure belt system
- Two floors of birds
- 60’ X 500’
- 160,000

Ultra high density

(160,000 birds)

Upstairs/Downstairs



Advantages:

- Improved litter drying
- Lowering operating costs
- Easier fan maintenance

How much inlet area do I need?

Air inlets

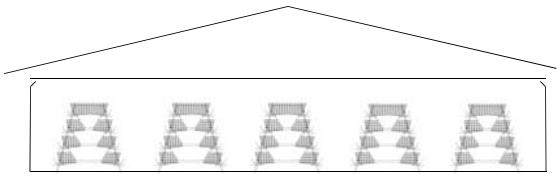
- Approximately 1 square foot of inlet opening for every 750 cfm of exhaust fan capacity

Air inlets

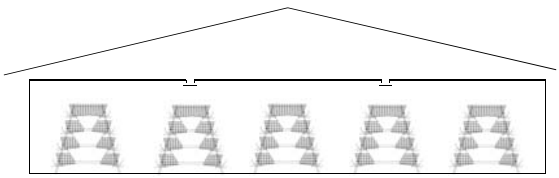
- Inlet area:
  - 600,000 cfm / 750
  - 800 square feet
- Two inlets in a 500' long house
  - (800 ft^2/1000 ft) X 12"
  - 10" inlet opening

Placement

Installed in the side walls



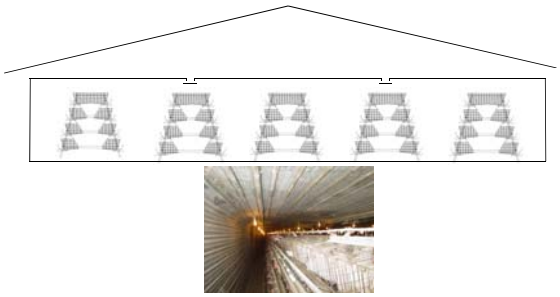
Installed in the ceiling



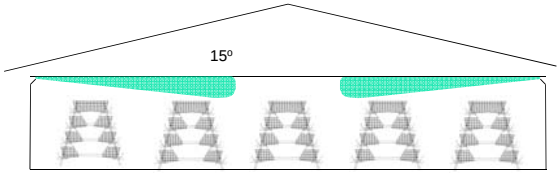
Best location depends on house size and construction

Ceiling inlets are better in house with lower ceilings

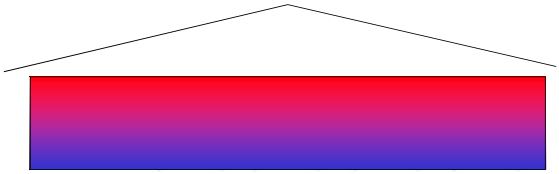
Less than 2' between cage and ceiling



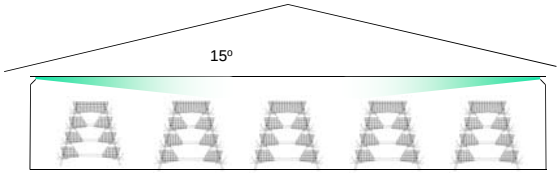
Installed in the side walls



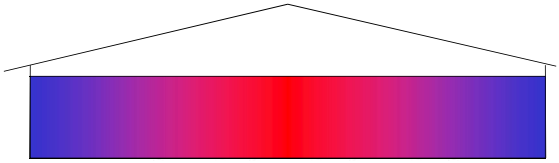
Installed in the side walls



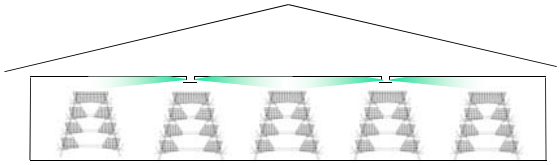
Installed in the side walls

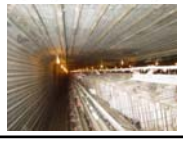


Installed in the side walls

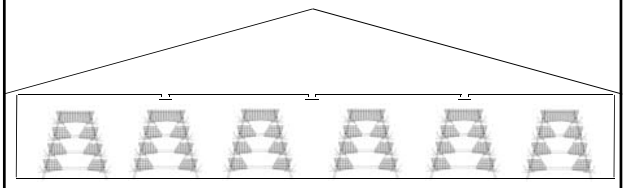


Ceiling inlets are better in house with lower ceilings



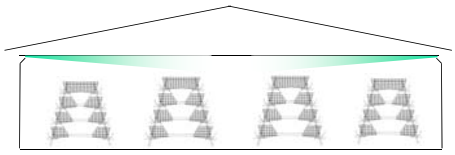


Ceiling inlets are also better in wider houses



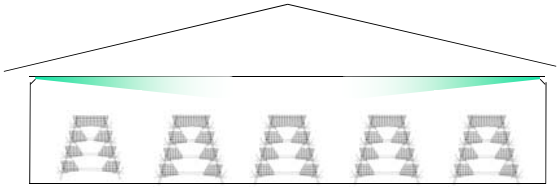
Over 50’

Side wall inlets are better suited to narrower houses

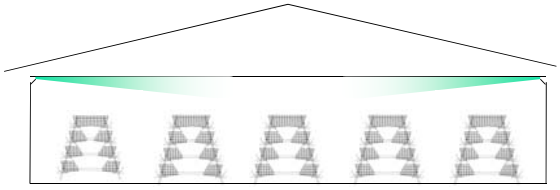


50’ and under

Houses with greater than 2’ between cage and ceiling



Installed in the side walls



Regardless of inlet location/type

- Minimum distance between ceiling and cages should be 2’
  - Significantly improved air mixing
  - Allows installation of small mixing fans

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