

Latest Insights into Hot Weather Ventilation

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It is quite simple...hot weather ventilation is all about air speed

The more you have...the better the birds will perform

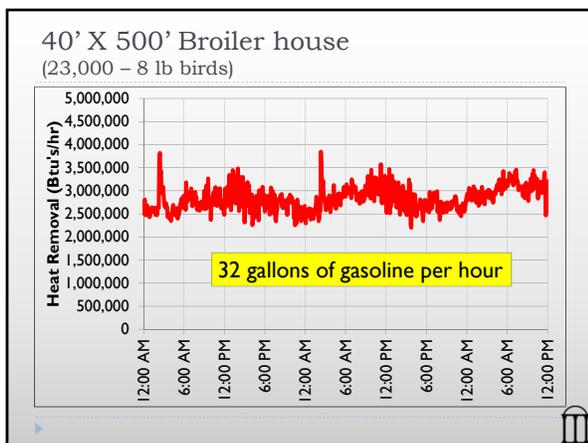


This is because our objective is not as much to cool the houses, but rather to remove heat from the birds.

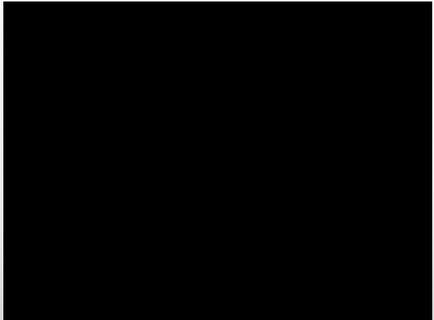


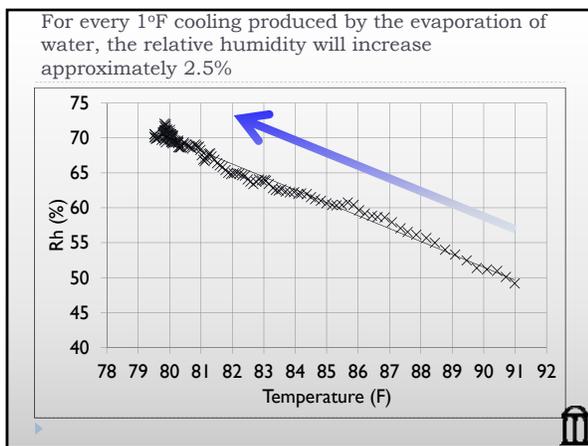
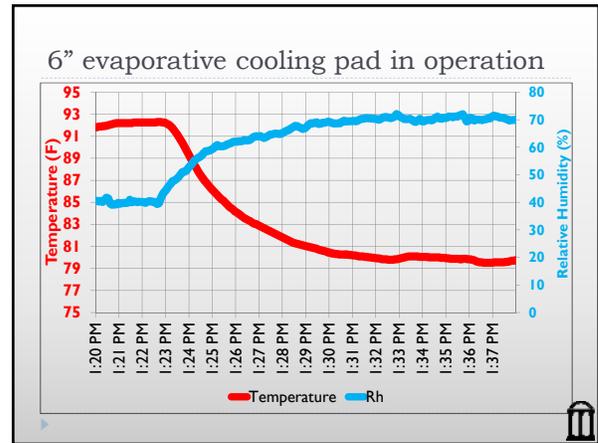
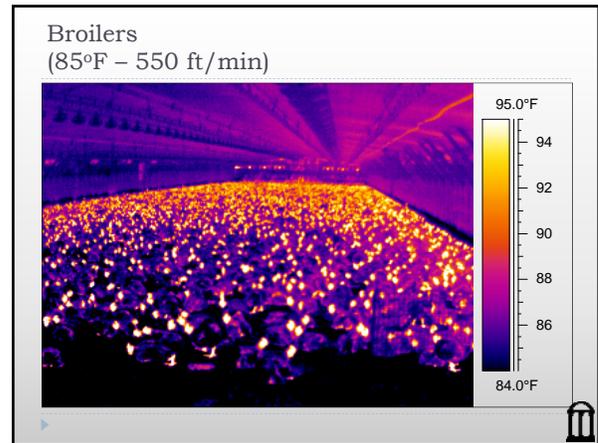
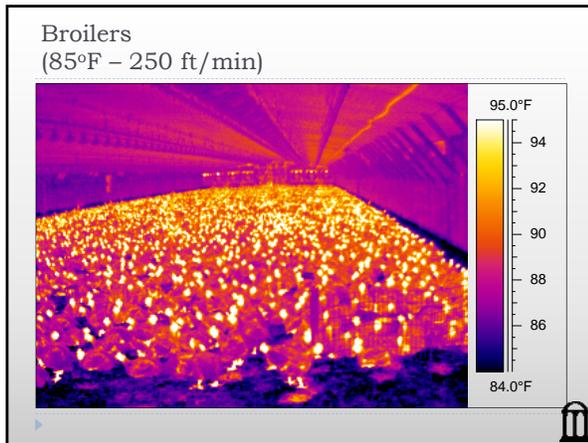
The modern broiler produces a tremendous amount of heat

- ▶ At 70°F a five pound broiler produces approximately 60 Btu's of heat each hour...
- ▶ Same heat as produced by a 25 watt incandescent light bulb
- ▶ Same heat as produced by 60 matches
- ▶ An 8 lb bird...40 watt light bulb...nearly 100 matches!



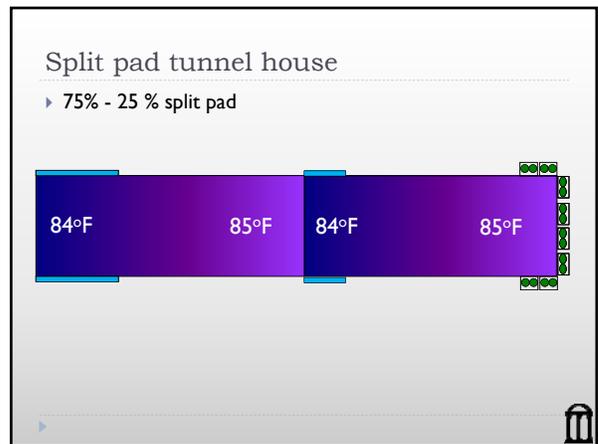
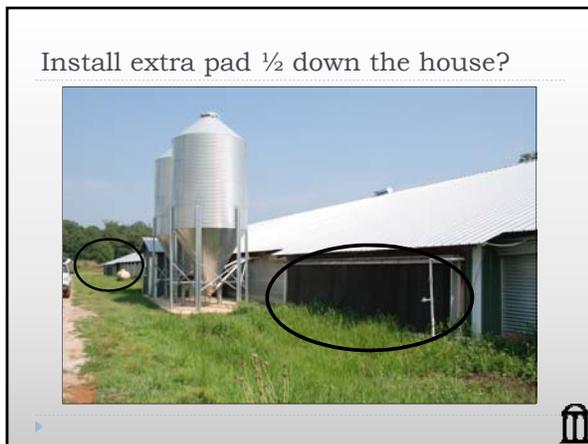
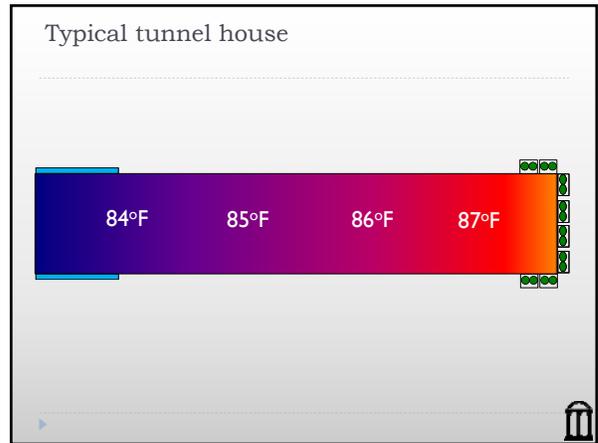
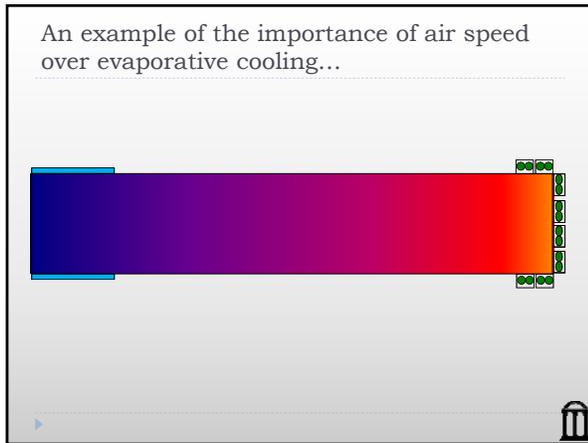
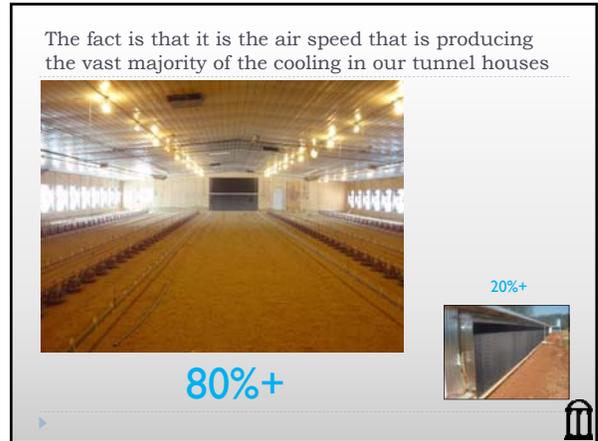
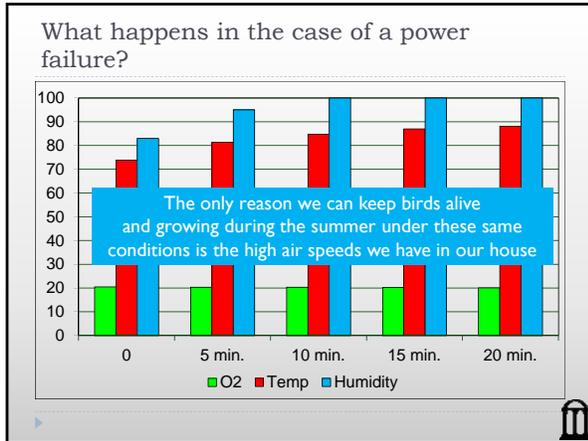
Best way to remove this heat is to simply move air over the birds



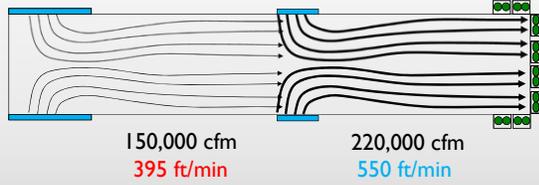


During hot, humid weather  
(95° F – 60% Rh)

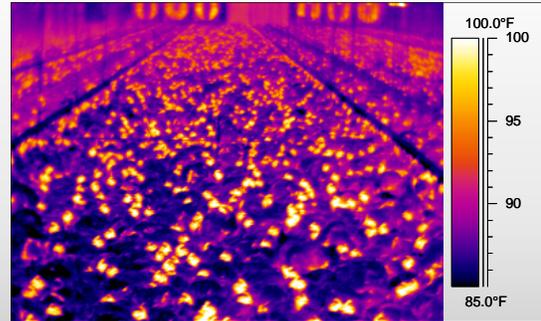
- ▶ Using a 6" evaporative cooling pad will decrease the temperature to 86°F, but the Rh will increase to 86%
- ▶ These same conditions can kill a house full of birds in roughly 20 minutes.



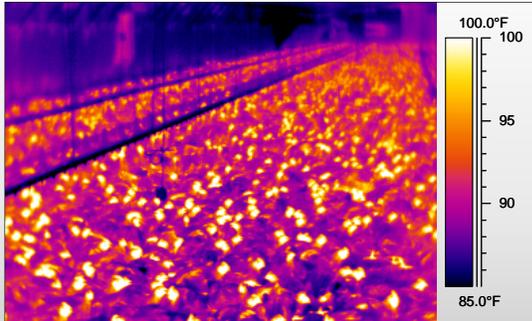
But what effect would this have on air speed...and therefore bird cooling?



Tunnel fan end (550 ft/min)



Tunnel inlet end (395 ft/min)

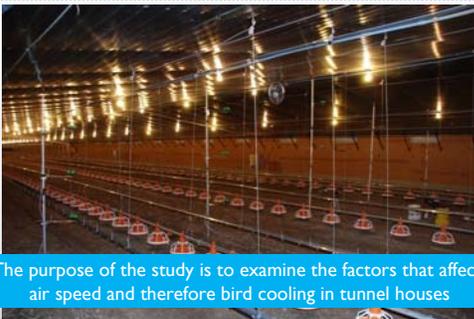


Air speed

- ▶ The question is how do we make sure that we maximize air speed and therefore cooling throughout a house.



Tunnel ventilation system performance study



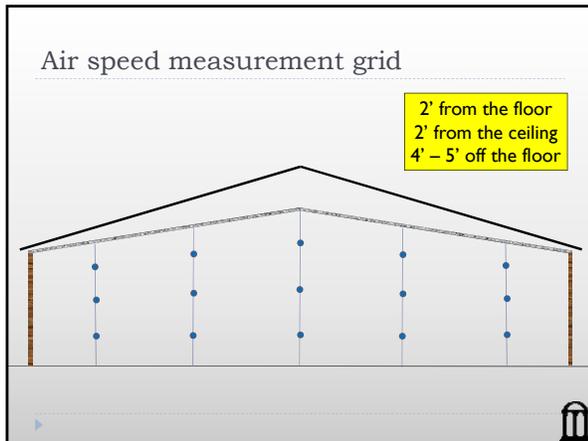
The purpose of the study is to examine the factors that affect air speed and therefore bird cooling in tunnel houses

Funded by USPAAE

Measuring house air speed

- ▶ 15 anemometers on 5 poles (3 anemometers per pole)





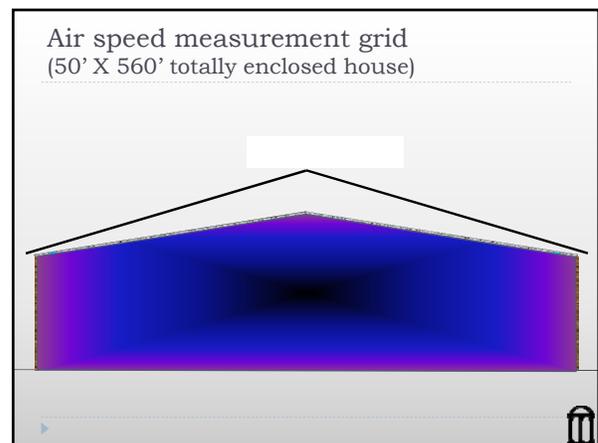
### Measuring house air speed

- Data loggers record average air speed every minute for 10 to 20 minutes under various operating conditions

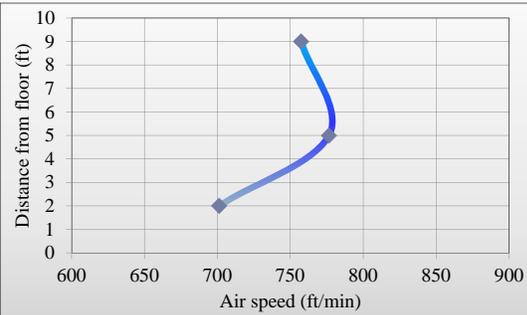
We also install multiple electronic static pressure measurements along the length of the house

The multiple anemometers and static pressure sensors allows us for the first time to...

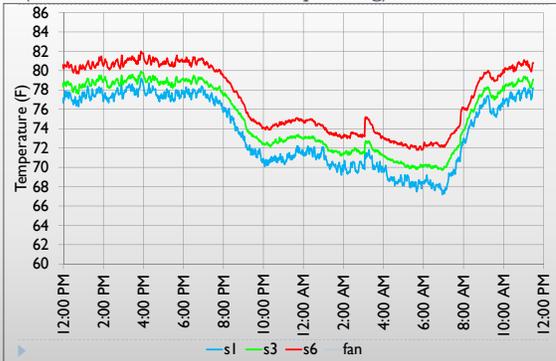
1) Accurately determine how air velocity changes across the profile of a house



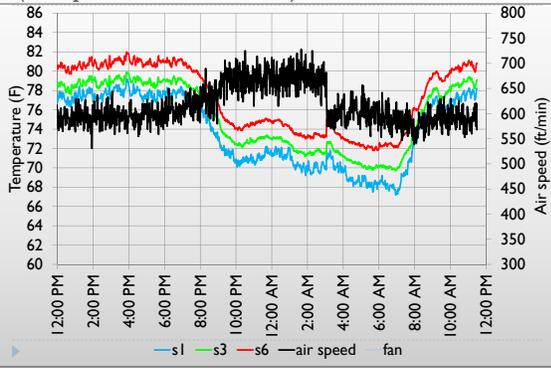
We can study how air velocity changes from floor to ceiling...



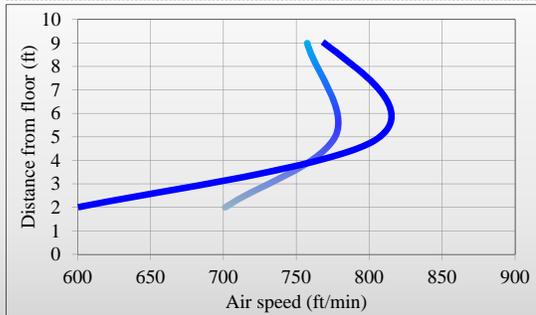
For instance,  
(50' X 560' House - All fans operating)



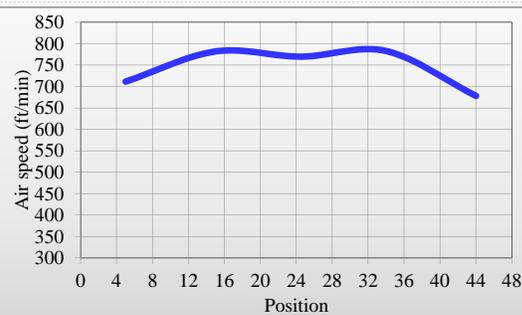
50' X 560' House - All fans operating  
(air speed 18" above floor)



The bigger the birds the lower the air speed at floor level



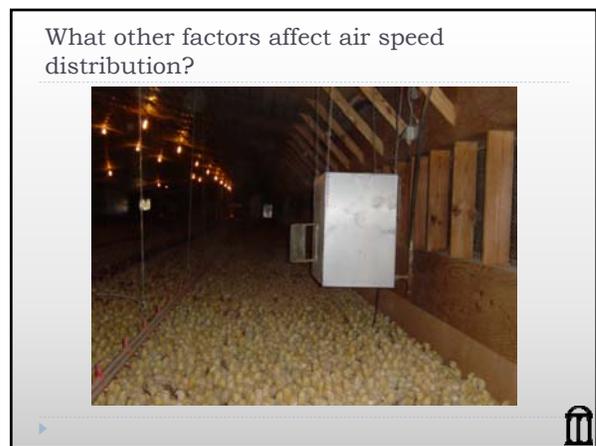
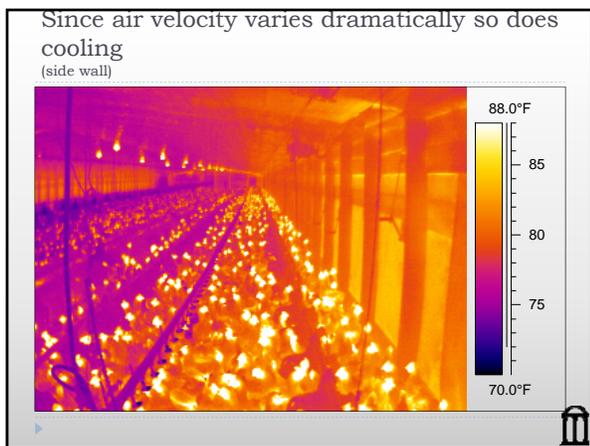
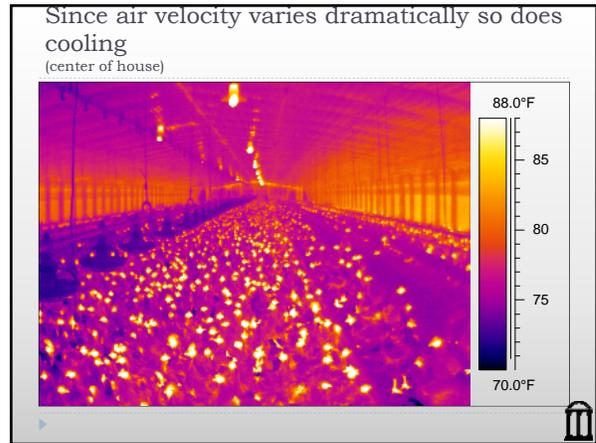
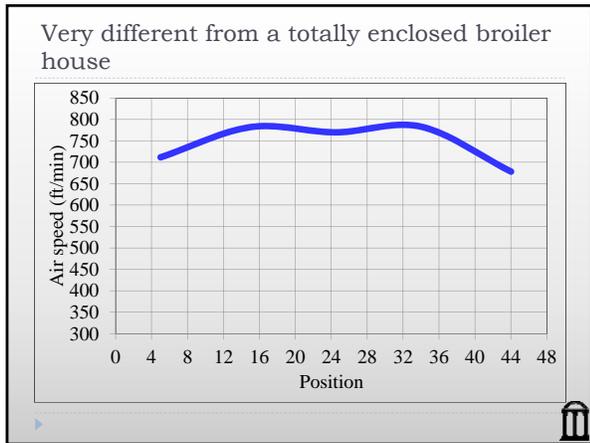
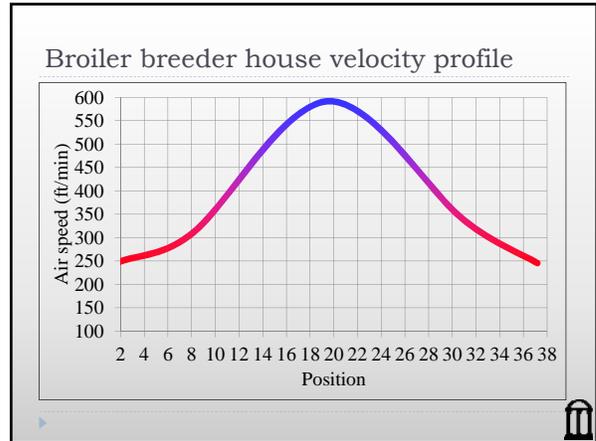
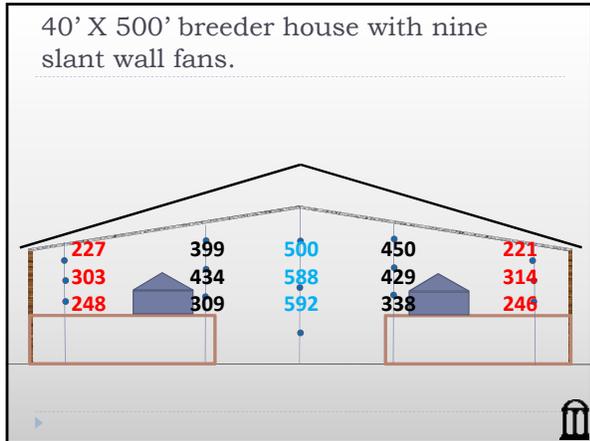
We can also closely examine how air speed varies from side wall to side wall.

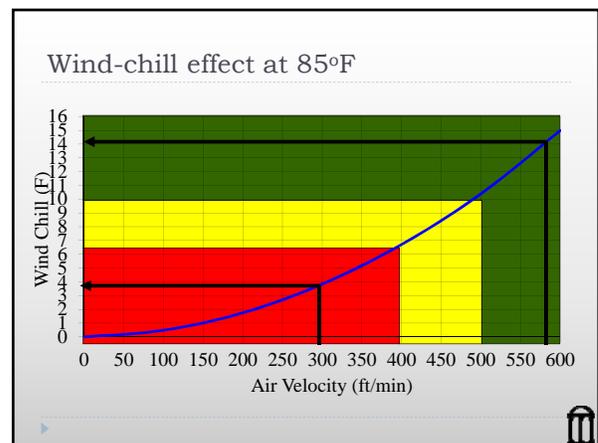
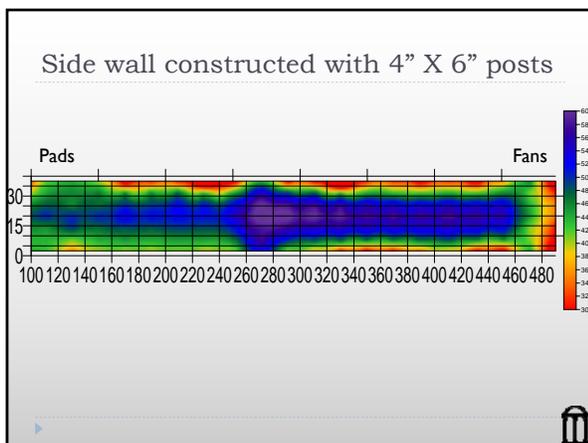
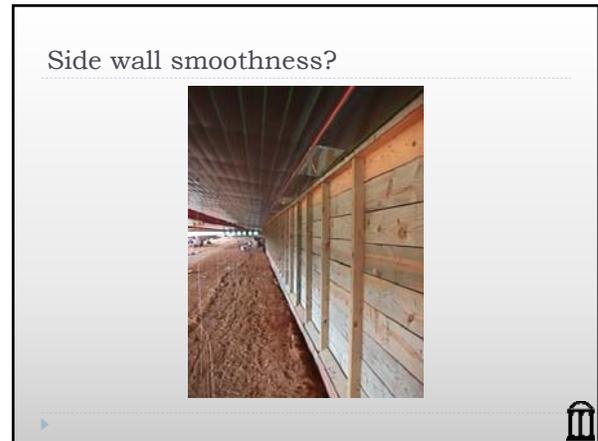
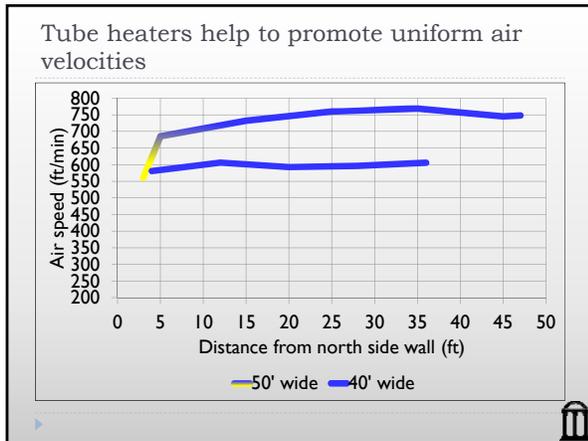
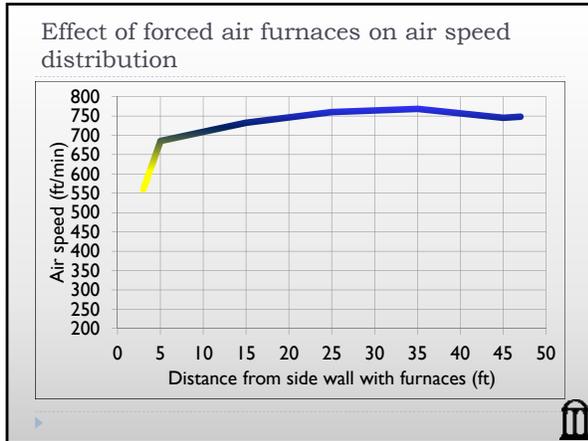


Study what factors affect wall to wall air speed distribution

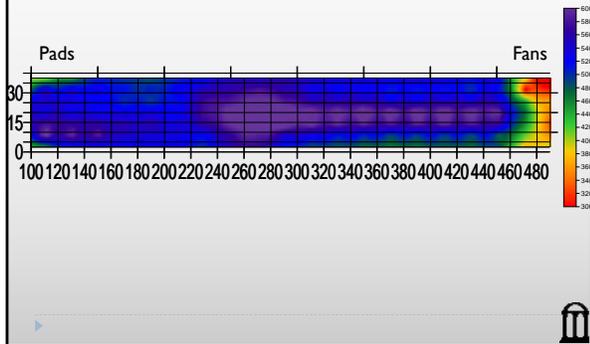
▶ For instance, 40' X 500' breeder house with nine slant wall fans







Compare this to a house with smooth walls

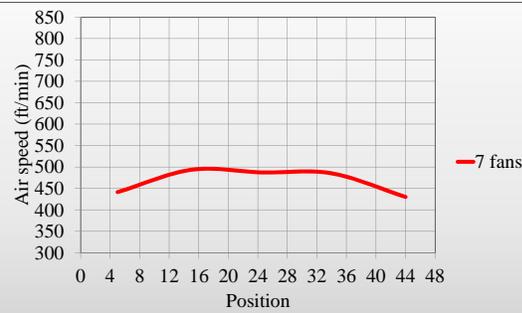


Another thing we have learned...

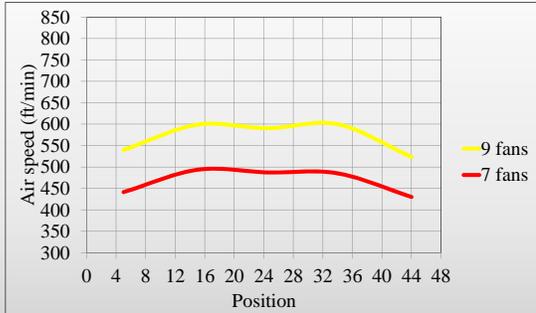
- ▶ Is that as air speed increases the negative effect that a "rough wall" or objects such as furnaces have on air speed uniformity increases



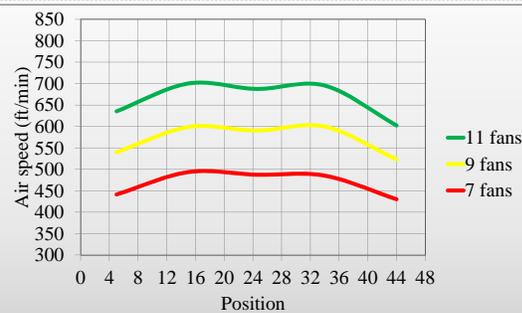
50' X 560' total enclosed broiler house with a smooth side wall



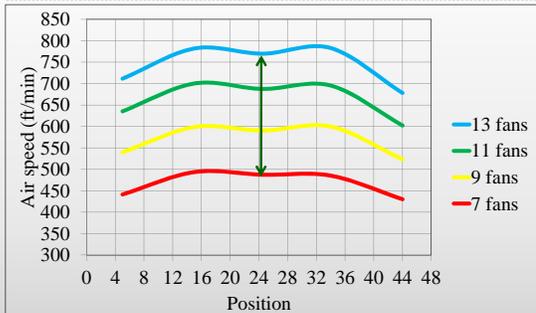
50' X 560' total enclosed broiler house with a smooth side wall

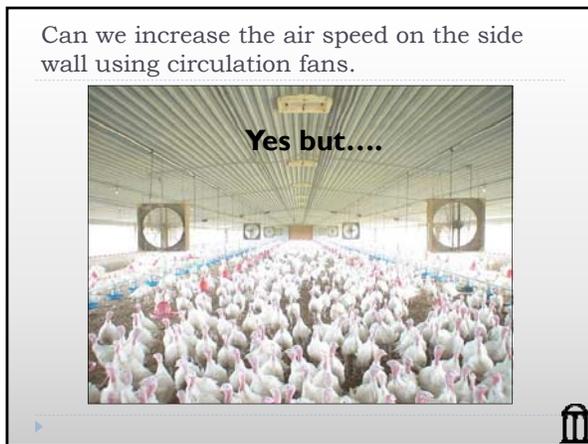
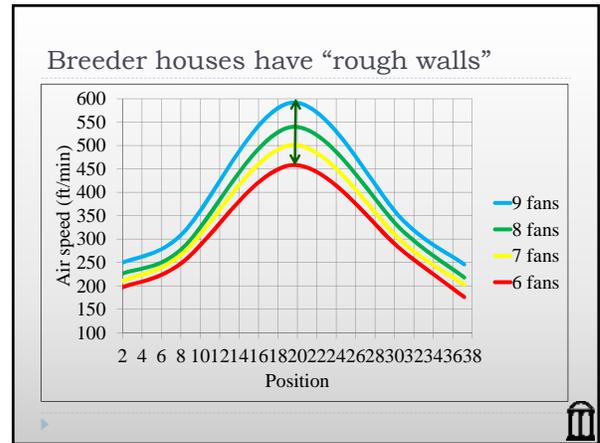
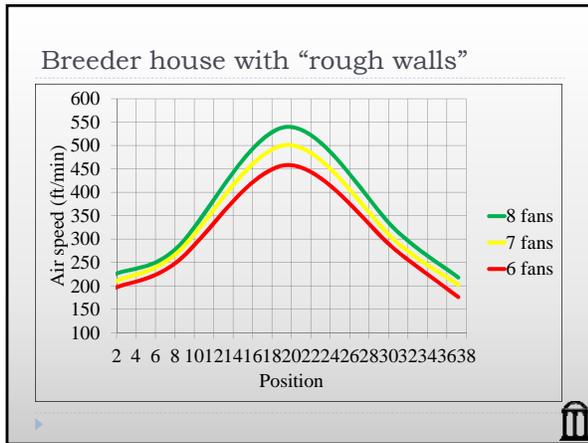
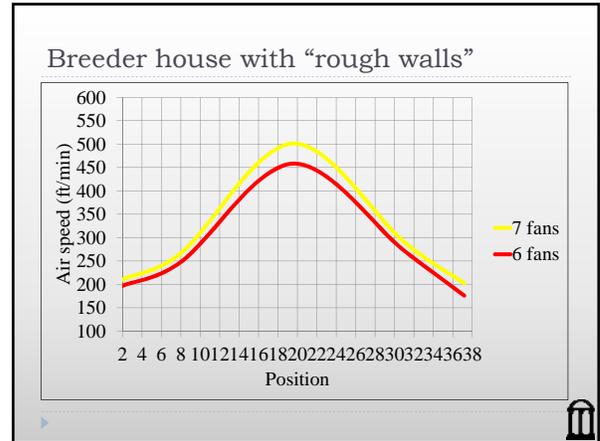
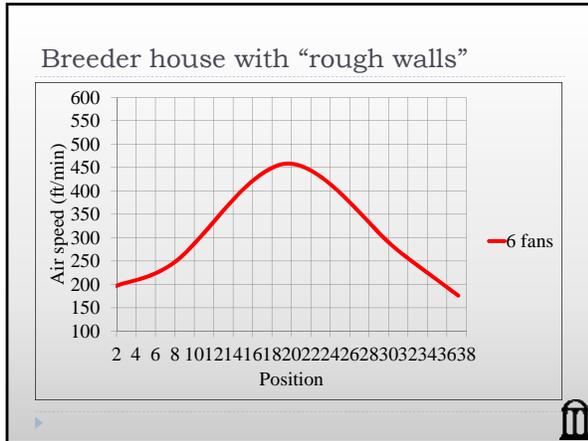


50' X 560' total enclosed broiler house with a smooth side wall



50' X 560' total enclosed broiler house with a smooth side wall





Average air speed of approximately 500 ft/min

Installed circulation fans along the side wall to increase air speed...

Air speed increase near along the side walls but decreased in the center of the house

Air speed only increased in the immediate vicinity of the side wall

To maximize air speed on the side walls keep your walls as smooth as possible.

2) The grid helps us to determine where the best place is to measure average air velocity,

684	789	764	845	705
745	810	805	812	711
705	748	741	692	619

Center line velocity is 15 to 20% higher than the true average

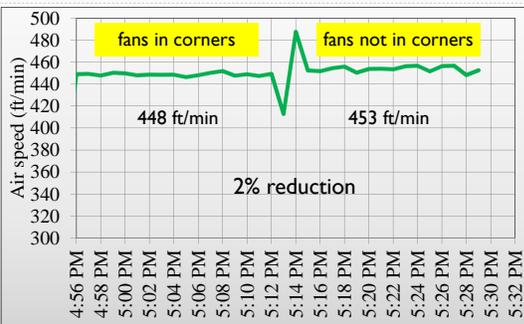
3) Allows us to answer questions about how tunnel fan installation affects fan performance and air distribution



Does placing fans in corners affect their air moving capacity?  
(66' X 600' house with 23, 54" fans)



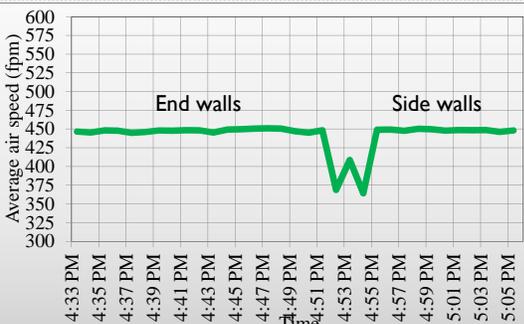
Fans in corners?



How about fans in end wall vs side walls  
(66' X 600' house with 23, 54" fans)

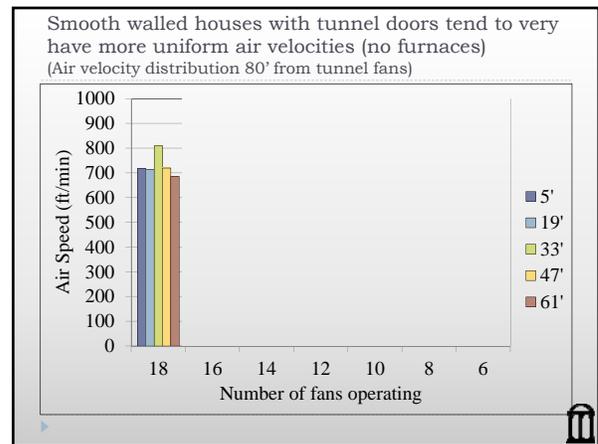
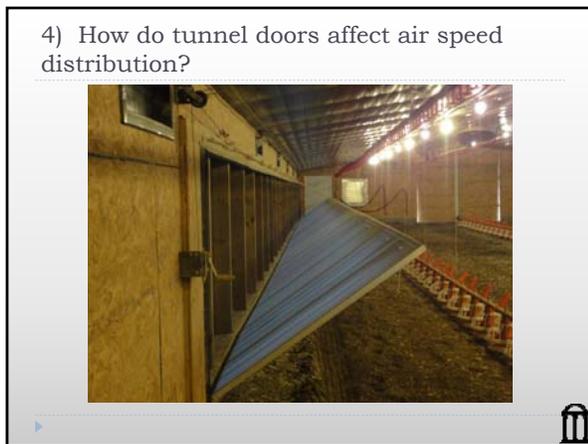
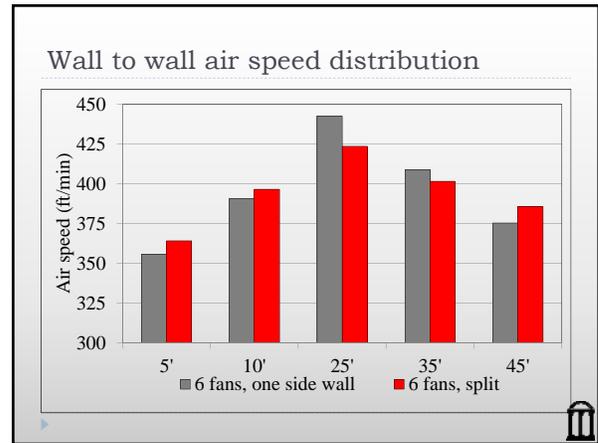
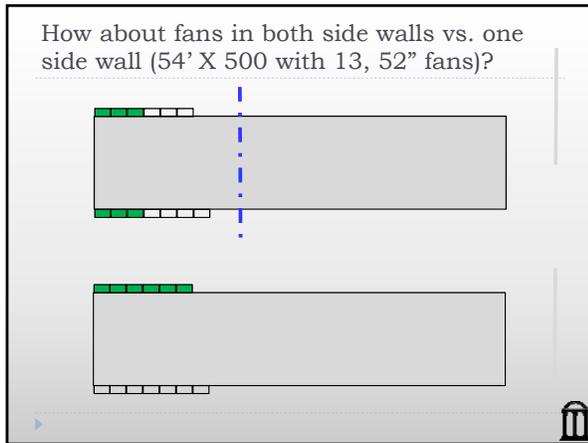
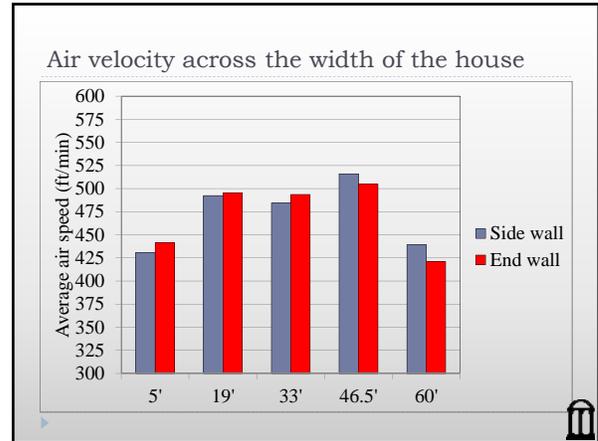
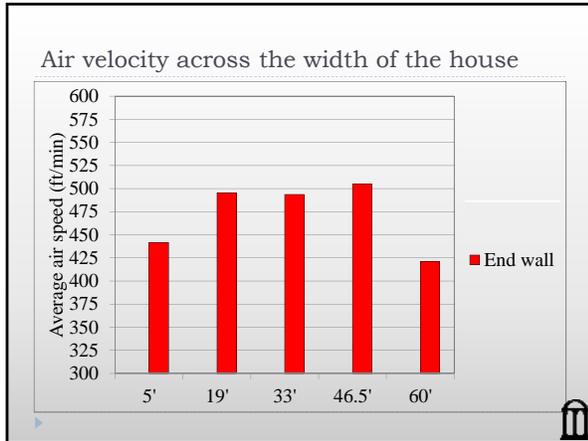


What affect does it have on average air speed (fan capacity)?

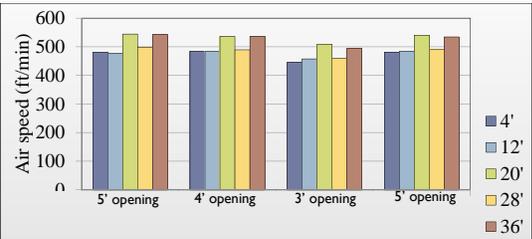


How does it affect wall to wall air speed distribution

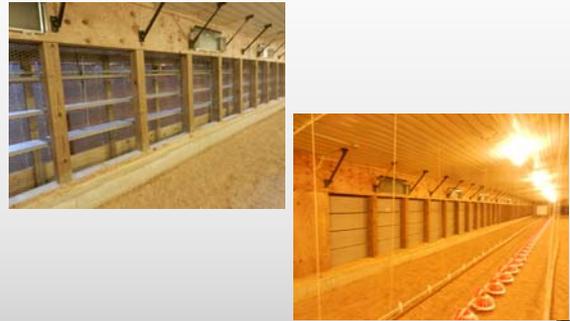




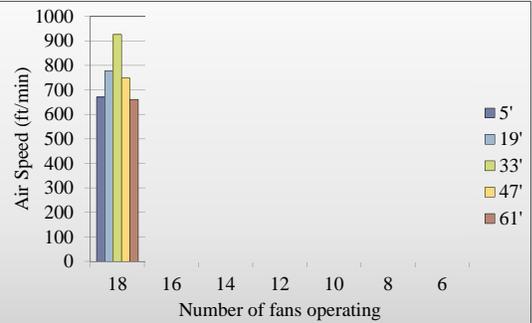
How much the tunnel doors are opened doesn't have much effect on distribution.



Tunnel shutters offered a valuable insight in to the effectiveness of tunnel doors



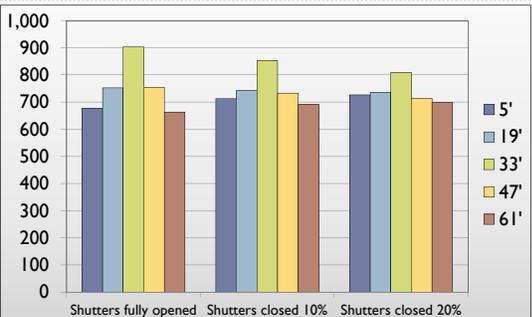
66' X 500' with tunnel "shutters"  
(Air velocity distribution 80' from tunnel fans)



Tunnel shutters in partially closed position



Air velocity profile



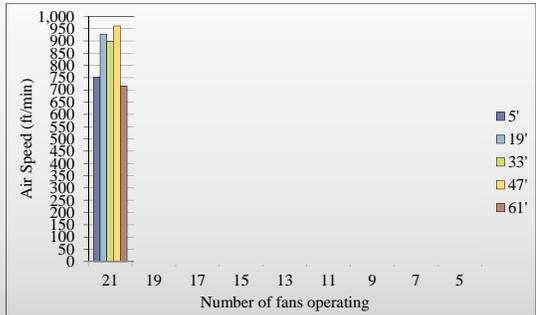
Tunnel door help wall to wall distribution and air movement at the pads.



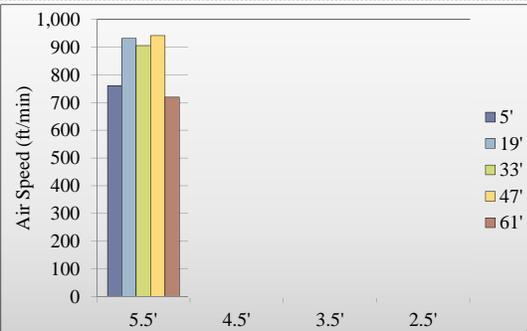
What about closing tunnel curtains



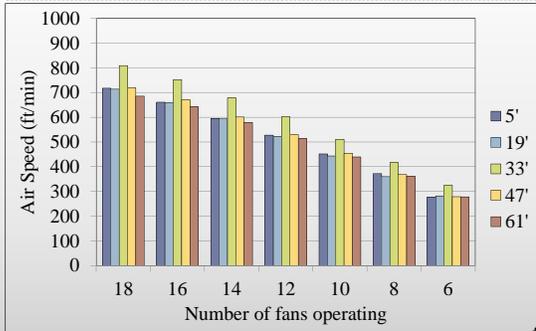
66' X 600' with tunnel curtain  
(6' tall pads with 5.5' tunnel curtain opening)



Closing the tunnel curtain with all fans operating...



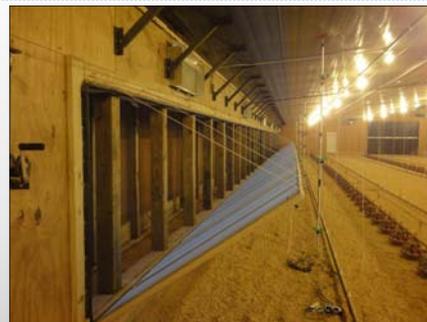
Tunnel door opening does not need to be adjusted to create uniform wall to wall air speeds

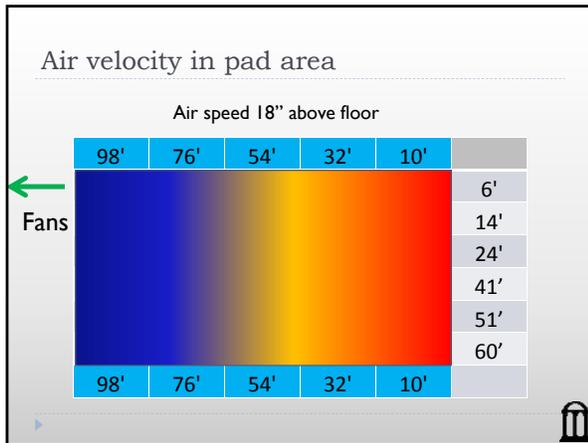


This doesn't mean that tunnel doors solve all our problems.



66' X 600' House  
(100' of 6' tall pads)





60' X 600' House with tunnel doors (sides and ends doors opened)

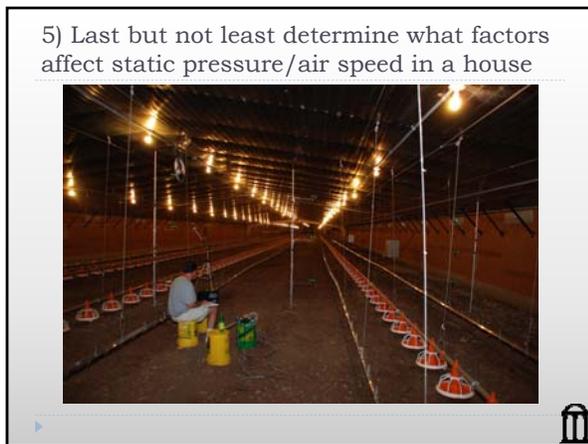
Air speed 18" above floor

		46'	14'	
Fans		323	287	1'
		259	207	14'
		363	61	26'
		363	61	33'
		259	208	45'
		323	287	58'
		46'	14'	

60' X 600' House with tunnel doors (front doors closed)

Air speed 18" above floor

		46'	14'	
Fans		349	329	1'
		240	250	14'
		304	68	26'
		304	68	33'
		240	250	45'
		349	329	58'
		46'	14'	

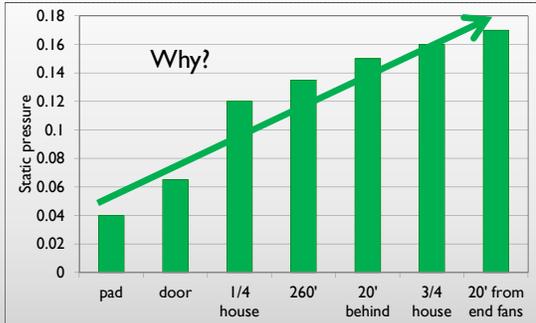


With all the fans operating we measured the static pressure...

- ▶ @ controller = 0.135"
- ▶ @ tunnel fans = 0.17"



Then we measure the pressure all along the entire length of the house



What are we really doing when we measure static pressure in a tunnel house?

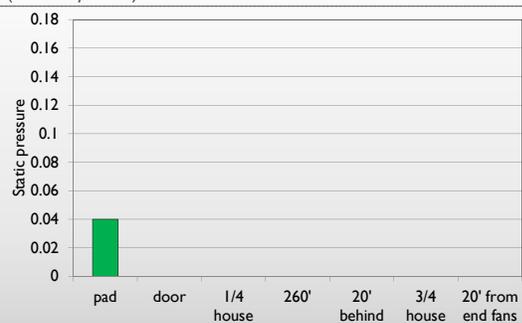
- ▶ We are measuring how much work it takes the fans to move the air from outside to where you are standing inside the house.



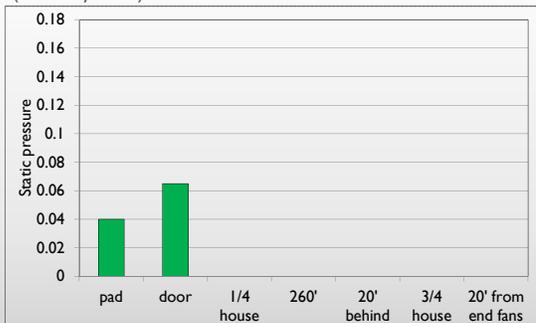
When we measure the static pressure in the center of the house...

- ▶ We are actually measuring the total of the amount of work it takes to...
  - ▶ Pull the air through the pads,
  - ▶ then through the tunnel doors,
  - ▶ into the cross-section of the house,
  - ▶ then down 1/2 way the house.
- ▶ Each action requires work (measured in pressure) of the fans

Static pressure in the 50' X 560' house (700 ft/min)



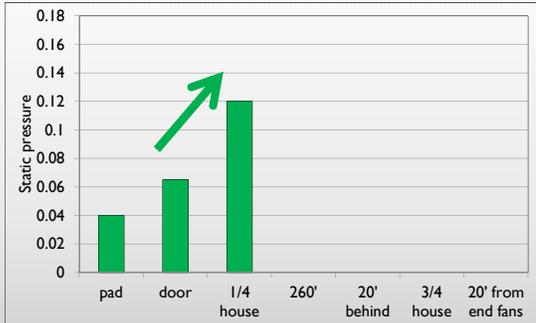
Static pressure in the 50' X 560' house (700 ft/min)



40" tunnel door opening on 5' tall pad



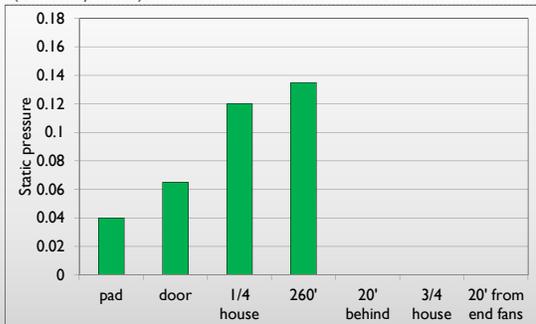
Static pressure in the 50' X 560' house (700 ft/min)



Transition or funnel pressure

- ▶ Pad area is much larger than the cross-sectional area of the house.
- ▶ You are taking air from over 1,000 square feet of pad and cramming it into a 450 square foot pipe

Static pressure in the 50' X 560' house (700 ft/min)



“Pipe flow” pressure

- ▶ When ever a fluid flows down a pipe there is a resistance/friction
- ▶ In water pipes we use the following equation to determine how much work/pressure is required to move water through a pipe:
  - ▶ Loss = PSI Loss Value x Pipe length / 100

PSI loss value table for water flowing through a PVC pipe (per 100')

Flow (gpm)	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"
5	2.5	0.8	0.2	0.1	0	0	0
6	3.4	1.1	0.3	0.1	0	0	0
7	4.6	1.4	0.4	0.2	0	0	0
8	5.9	1.8	0.5	0.2	0	0	0
9	7.3	2.3	0.6	0.3	0.1	0	0
10	8.9	2.7	0.7	0.3	0.1	0	0
11	10.6	3.3	0.9	0.4	0.1	0	0
12	-----	3.8	1.0	0.5	0.1	0	0
13	-----	4.5	1.2	0.6	0.2	0	0
14	-----	5.1	1.4	0.6	0.2	0	0
15	-----	5.8	1.5	0.7	0.2	0.1	0
16	-----	6.5	1.7	0.8	0.3	0.1	0

How much work/pressure does it take...

- ▶ To move water down a 500 long, 1" pvc pipe, at a flow rate of 5 gals/min?

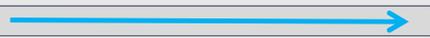


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5	2.5	0.8	0.2	0.1	0	0	0
6	3.4	1.1	0.3	0.1	0	0	0
7	4.6	1.4	0.4	0.2	0	0	0
8	5.9	1.8	0.5	0.2	0	0	0
9	7.3	2.3	0.6	0.3	0.1	0	0
10	8.9	2.7	0.7	0.3	0.1	0	0
11	10.6	3.3	0.9	0.4	0.1	0	0
12	----	3.8	1.0	0.5	0.1	0	0
13	----	4.5	1.2	0.6	0.2	0	0
14	----	5.1	1.4	0.6	0.2	0	0
15	----	5.8	1.5	0.7	0.2	0.1	0
16	----	6.5	1.7	0.8	0.3	0.1	0

"Pipe flow" pressure

- ▶ When every a fluid flows down a pipe there is a resistance/friction
- ▶ Friction:
  - ▶ Loss = PSI Loss Value x Pipe length / 100
  - ▶ = 0.8 X 500/100
  - ▶ = 4 psi



A tunnel-ventilated poultry house is basically a pipe...same laws of physics apply



Pressure "gain" for air flowing in a tunnel-ventilated broiler house per 100'

Air Speed (ft/min)	Pressure Loss
100	0
200	0.001"
300	0.002"
400	0.0035"
500	0.006"
600	0.008"
700	0.012"
800	0.016"

How much work/pressure does it take...

- ▶ To move air down a 500 long house at a flow rate of 500 ft/min?



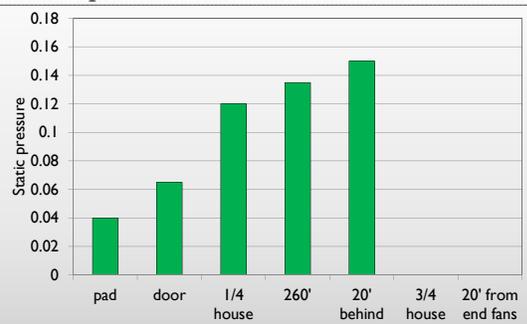
Pressure “gain” for air flowing in a tunnel house

Air Speed (ft/min)	Pressure Loss
100	0
200	0.001”
300	0.002”
400	0.0035”
500	0.006”
600	0.008”
700	0.012”
800	0.016”

Tunnel “pipe flow” pressure

- ▶ When every a fluid flows down a pipe there is a resistance/friction
- ▶ Friction:
  - ▶ Loss = Pressure Loss Value x Pipe length / 100
  - ▶ = 0.006 X 500/100
  - ▶ = 0.03”

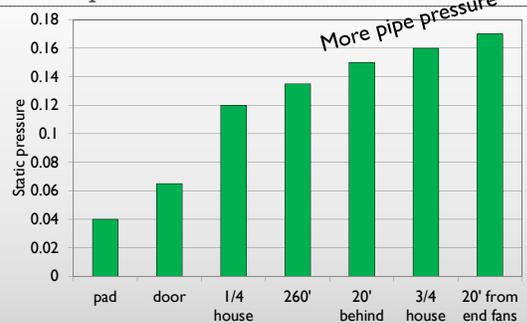
Static pressure



Half house curtain

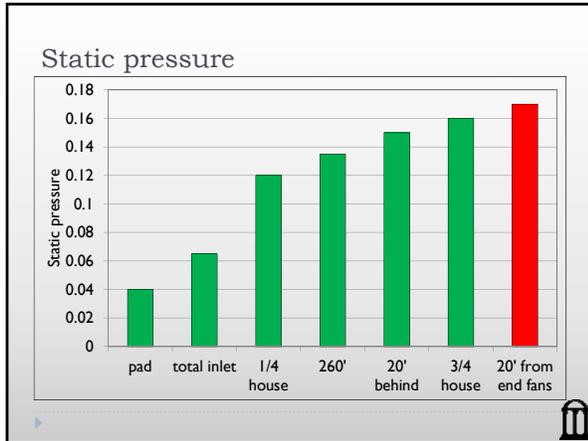


Static pressure



From a fan’s perspective the critical pressure is that measured at the fan





Does this large of a change in pressure from the pads to the fans occur in all houses?

- ▶ No...the large pressure changes primarily occur in high air velocity houses.
- ▶ Due to a law of physics discovered by Daniel Bernoulli in the early 1700's
  - ▶ Pressure increases with the square of velocity
- ▶ More simply put, if you double the velocity of a fluid in a pipe, the pressure/work required to move the fluid through the pipe increases four fold

### PSI loss value table for water flowing through a PVC pipe

Flow (gpm)	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"
5	2.5	0.8	0.2	0.1	0	0	0
6	3.4	1.1	0.3	0.1	0	0	0
7	4.6	1.4	0.4	0.2	0	0	0
8	5.9	1.8	0.5	0.2	0	0	0
9	7.3	2.3	0.6	0.3	0.1	0	0
10	8.9	2.7	0.7	0.3	0.1	0	0
11	10.6	3.3	0.9	0.4	0.1	0	0
12	-----	3.8	1.0	0.5	0.1	0	0
13	-----	4.5	1.2	0.6	0.2	0	0
14	-----	5.1	1.4	0.6	0.2	0	0
15	-----	5.8	1.5	0.7	0.2	0.1	0
16	-----	6.5	1.7	0.8	0.3	0.1	0

### "Pipe flow" pressure

- ▶ When every a fluid flows down a pipe there is a resistance/friction
- ▶ Friction:
  - ▶ Loss = PSI Loss Value x Pipe length / 100
  - ▶ = 2.7 x 500/100
  - ▶ = 14 psi

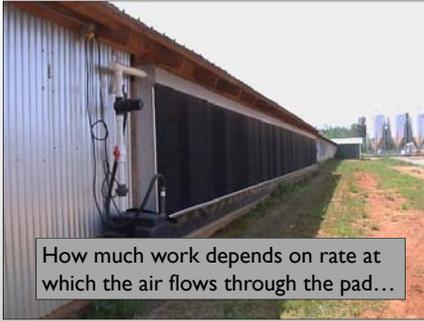
Similar things happen when a fluid flows through fittings...

- ▶ 90 degree elbow - 1" PVC pipe
- ▶ For instance, the pressure required to move water through a single 1" PVC 90 degree elbow at 5 gals/min. is 1.5 psi.
- ▶ Double the flow rate to 10 gals/min. and the pressure required increases four fold to approximately 6 psi.

or water filters...

- ▶ Double the flow rate (5 vs 10 gals/min)...quadruple the pressure.

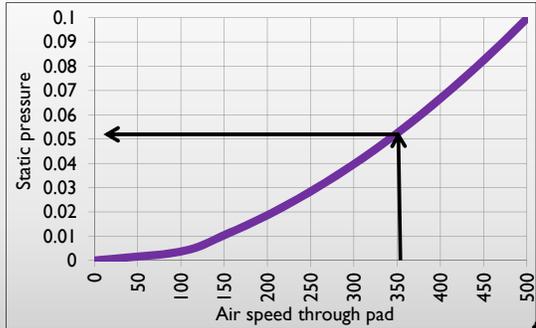
A pad is in a sense a filter....



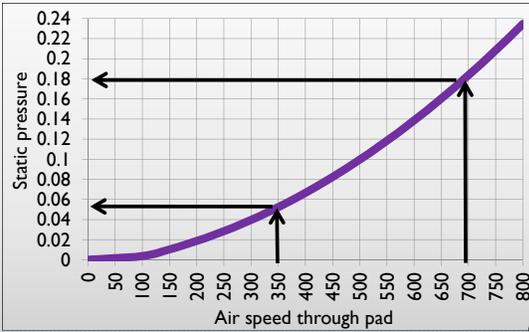
How much work depends on rate at which the air flows through the pad...

Pad pressure curve

(typical air velocity = 350 ft/min)



If we double the air speed through a pad (by installing half as much)



Modern houses...

- ▶ Air speed through pad = 350 ft/min
- ▶ Pad pressure has remained relatively minimal



- ▶ But tunnel air speeds have increased = 600 - 800 ft/min
- ▶ High transition pressure
- ▶ High pipe pressure
- ▶ For example...

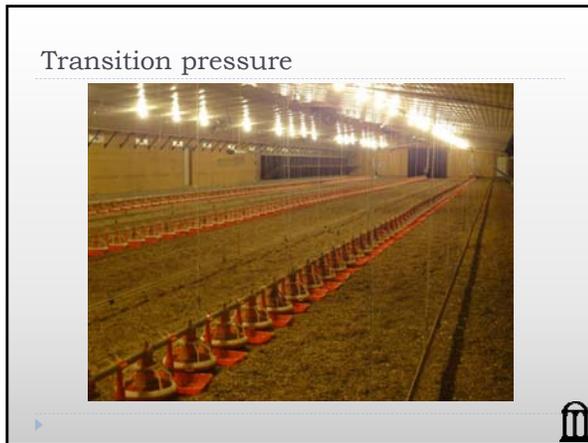
40' X 500' with an air speed of 700 ft/min



Pad pressure

- ▶ 350 ft/min = 0.05"





Transition pressure

Air speed (ft/min)	Pressure gain
100	0.00"
200	0.01"
300	0.013"
400	0.02"
500	0.03"
600	0.045"
700	0.06"
800	0.08"



Pressure loss for air flowing down tunnel house

Air speed (ft/min)	Pressure gain per 100'
100	0
200	0.001"
300	0.002"
400	0.0035"
500	0.006"
600	0.008"
700	0.012"
800	0.016"

Pipe pressure in 500' long house (400' pipe past pads)

▶  $0.012" \times 400/100 = 0.05"$

Total pressure in a 700 ft/min house

Pressure sources	
Pad	0.05"
Transition	0.06"
Pipe	0.05"
Total	0.16"

Tunnel air speed vs. Total static pressure

- ▶ 700 ft/min = 0.16"
- ▶ This is for house without tunnel doors, and clean pads
- ▶ Realistically you would probably need one to two points of pressure to determine the true operating pressure.

Tunnel air speed vs. Total static pressure

- ▶ 400 ft/min = 0.09" - 0.11"
- ▶ 500 ft/min = 0.10" - 0.12"
- ▶ 600 ft/min = 0.13" - 0.15"
- ▶ 700 ft/min = 0.16" - 0.18"
- ▶ 800 ft/min = 0.18" - 0.20"

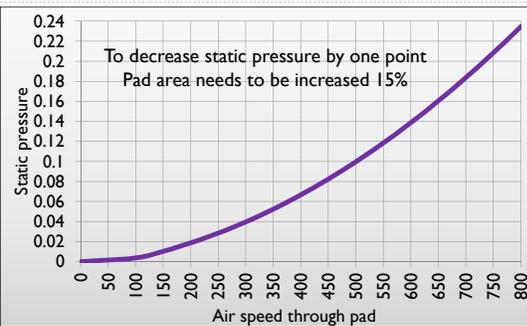
High air speeds = High static pressure



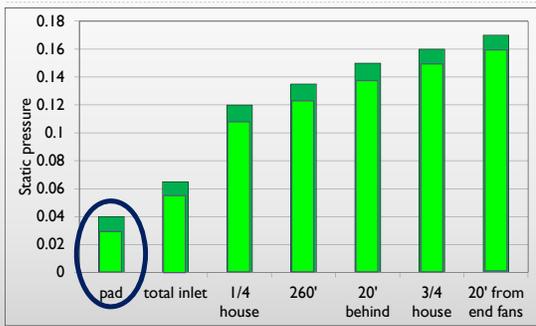
Can't we just add more pad to limit static pressure?



Adding pad will do little good



Static pressure



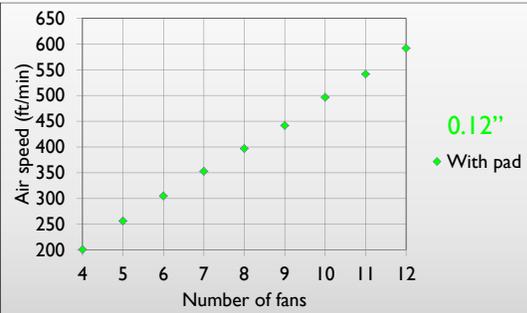
and besides the longer the pad the larger the “dead spot” becomes...



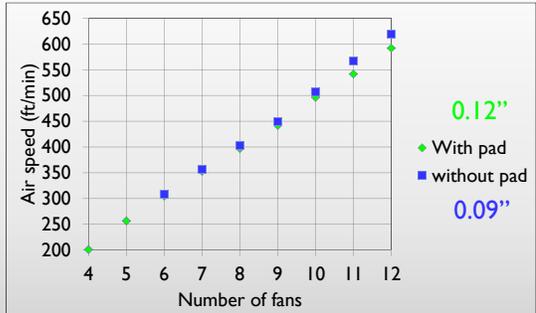
The fact is that the pressure/air speed wouldn't change much even if you removed the pads from a house



40' X 500' house with 600 ft/min air speed



40' X 500' house with 600 ft/min air speed



What affect does tunnel door opening size have on air velocity



Do we really need a 5' tunnel door on a 5' pad?



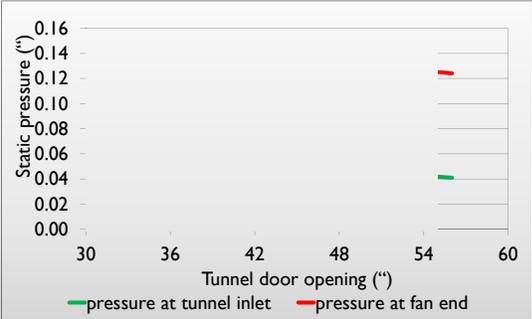
6' opening on a 6' pad?



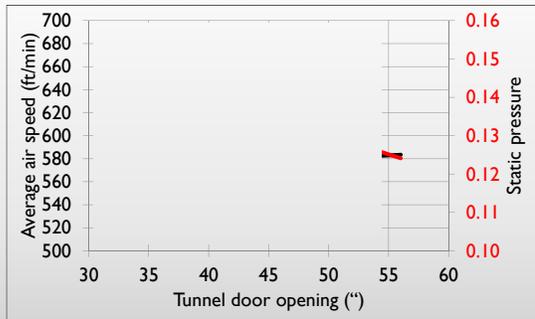
50' X 500' - 600 ft/min  
92' of 5' tall pad



Static pressure as a function of door opening



Average air velocity vs. Tunnel door opening

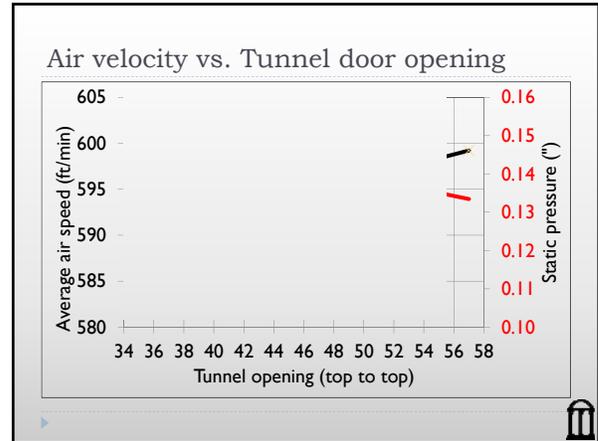
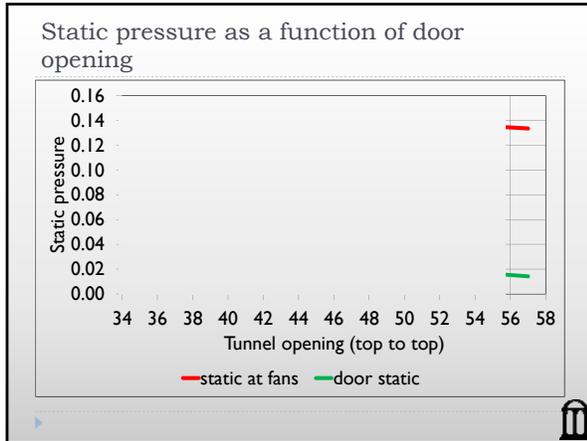


66' X 600' - 600 ft/min  
110' of 6' tall pad

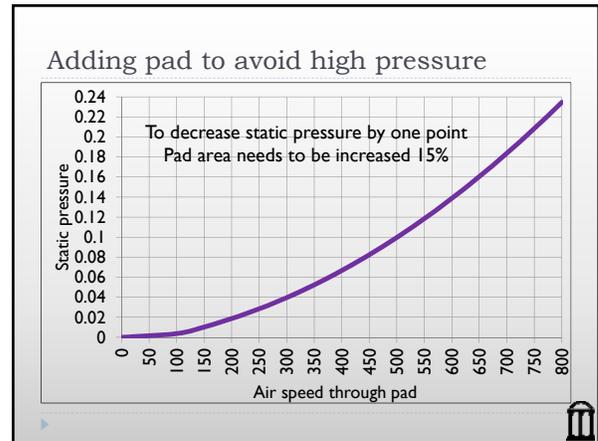


5' tunnel door on a 6' tall pad





- ### Maximizing air speed/cooling in tunnel houses
- ▶ Determine the number of tunnel fans at a proper design static pressure.
    - ▶ 400 ft/min = 0.10"
    - ▶ 500 ft/min = 0.10"
    - ▶ 600 ft/min = 0.15"
    - ▶ 700 ft/min = 0.15"
    - ▶ 800 ft/min = 0.20"
  - ▶ Make sure you install fans that can hold up under high static pressures
  - ▶ Make sure your walls are smooth
    - ▶ No furnaces on the side wall
  - ▶ Install tunnel doors
  - ▶ Keep your pads clean



#### Tunnel Air Speed/Static Pressure Estimating Spreadsheet (V1.2 - Beta)

The University of Georgia Poultry Science - Michael Evers (mpevers@uga.edu)  
 Enter green values in all sections.  
 Use original reading for houses without air distribution.

General Information		Tunnel Fan Information		Tunnel Area to be added	
Item	Value	Number of Fans	Static Pressure (")	Number of Fans	Static Pressure (")
House width	500	8	0.05	8	0.05
House length	100	8	0.05	8	0.05
Celling peak height	12.5	8	0.05	8	0.05
Wind speed	5	8	0.05	8	0.05
Pad length	5	8	0.05	8	0.05
House peak height	1	8	0.05	8	0.05
Pad condition	1	8	0.05	8	0.05
other - clean	1	8	0.05	8	0.05
dry	1	8	0.05	8	0.05
smooth	1	8	0.05	8	0.05
no furn	1	8	0.05	8	0.05
fan condition	1	8	0.05	8	0.05
older good condition	1	8	0.05	8	0.05
new	1	8	0.05	8	0.05
fan condition	1	8	0.05	8	0.05
new	1	8	0.05	8	0.05

Item	Value
Pad static pressure	0.042 inches
Tunnel system static pressure	0.000 inches
Transition pressure	0.004 inches
Pad pressure	0.042 inches
Total tunnel fan pressure	0.042 inches
Fan air moving capacity (avg)	21,000 cfm
Total air moving capacity	171,000 cfm
Average air speed	496 ft/min

Estimated static pressure readings along length of house

Location	Static Pressure (inches)	Average Air Speed (ft/min)
0.042 inches tunnel opening	0.042 inches	496 ft/min
0.042 inches 30' pad level of pad	0.042 inches	496 ft/min
0.042 inches 496 ft/min average air speed	0.042 inches	496 ft/min
0.042 inches pad	0.042 inches	496 ft/min

The University of Georgia

poultryventilation.com