

# HVAC Strategies: Farm Fresh Case Study

Hear Farm Fresh's innovative approach to HVAC design. Learn how a single central air handling system with a unique air distribution system tries to manage the issue of positive or neutral air flow.

Jonathan Perry, Director of Energy and Maintenance, Farm Fresh, LLC



# How fast can a housefly, fly?



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- An average housefly can only fly at speeds of 5 mph (440 fpm). They appear to fly much faster. However, that is generally attributed to the illusion of their motion compared to their size.



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- The Australian Dragonfly has been measured to fly 36 mph or (3,168 fpm)



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- $(5000 \text{ cfm} \times 60 \text{ min/Hr}) \times (41.6 - 20.8 \text{ Btu/lb}) / 14.3 \text{ cu ft/lb} = 436,363 \text{ btu/hr}$  or  
**36 tons of air conditioning**

# Background of New Design

- When our COO, Ron Dennis, took over Farm Fresh in 1997, the style of our store fronts were a long curved vestibule with an inner set of doors.
- One of his early directives was to rip out the inner set of doors along with the inner wall creating a more open feel. It would eliminate the vestibule, which helps maintain the store conditions.
- I was the Director of Energy at the time
- The Director of Energy, the Director of Maintenance, and the VP of Engineering all agreed that removing the inner doors was a bad idea









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- As you can see in the photos, we ripped out all of the inner vestibule doors on almost all of our stores along with all of the inner walls
- We learned that the boss gets what he wants



# Initial testing

- We tested the infiltration at the front of the stores and tried to show how much money it was going to cost the chain



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- We estimated the costs in energy, and how many more maintenance problems would occur, along with how many more associate complaints and customer complaints we would have



# Our early response

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- Where possible we increased outdoor air to our main AHU units to give the store a little more ability to resist the infiltration at the front of the stores (More pressurization)





# Our early response

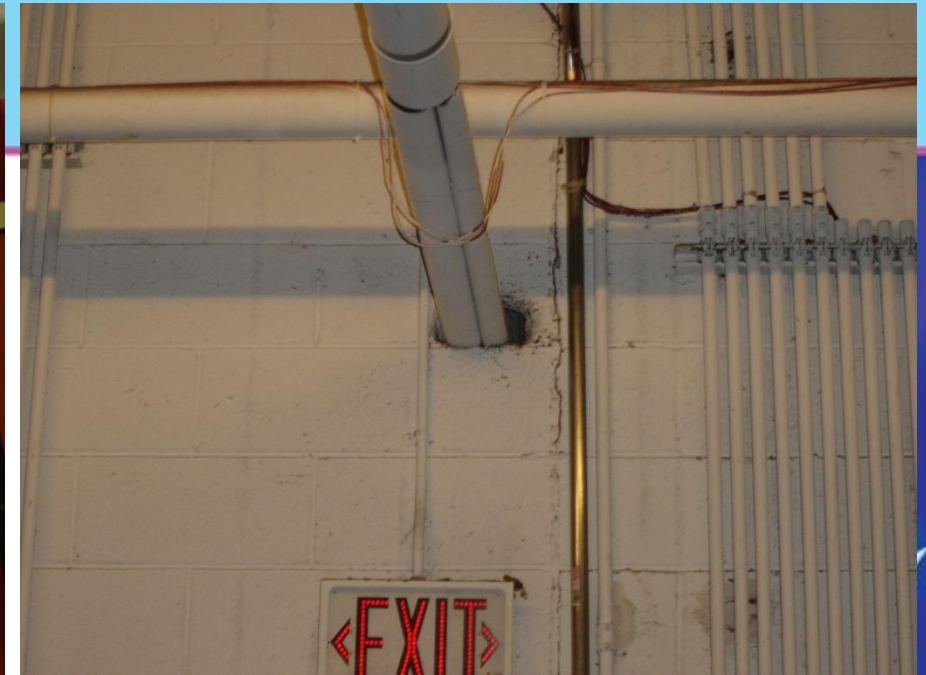
- We did house keeping on the stores. We replaced doors with bad seals, repaired dry wall with holes in walls, sealed up cracks and penetrations



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# After a few years

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- The customers did not complain as loudly as we thought about the store conditions
- The store associates complained loudly and constantly during the peak summer heat and the winter cold
- Our sales continued to grow



# Year 2000

- I became the Director of Energy and Maintenance
- We looked at the store differently when it was not an Energy Department and a Maintenance Department, but an Energy and Maintenance Department
- So, we started studying and really thinking about the building envelop holistically
- I learned tremendously from our HVAC&R technicians by trying to manage both energy and maintenance departments





# 1965 Carrier Handbook of Air Conditioning System Design

- States “Vestibules may decrease the infiltration as much as 30% when the door usage is light. When door usage is heavy, the vestibule is of little value for reducing infiltration

\*See page Chapter 6: Infiltration and ventilation  
page1-91



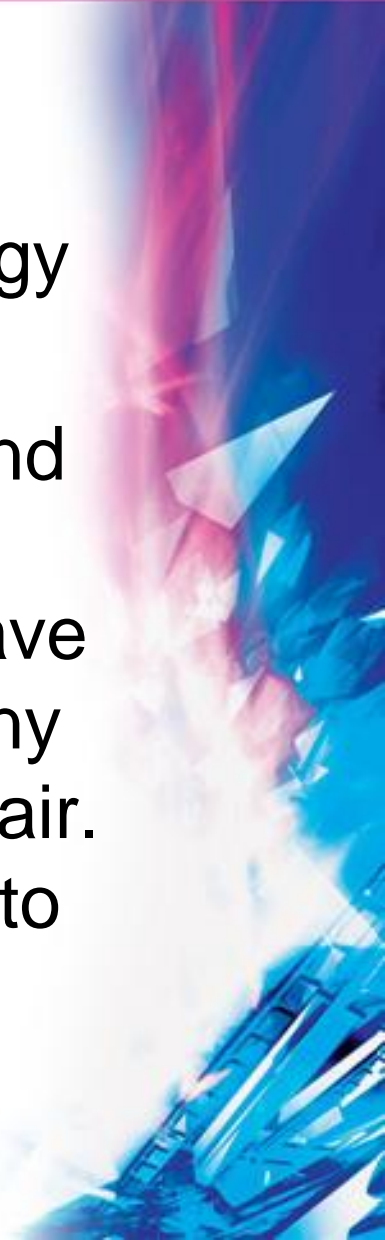
# How often are the front doors open?

- Median \$466,000 sales per week
- \$25 bag of groceries per customer
- Door opens twice per customer
- 168 hours per week
- $=466,000 * 2 / (25 * 168 * 60)$
- 3.7 door openings per minute
- 37,296 openings per week
- *Add employees, cart gathering, vendors, and broken automatic doors and the average is higher*



# Positive Outward Velocity POV

- A Building Design Program for Utility Energy conservation
- This is a paper that was written back around 1985. It discusses the desire to bring in enough outdoor air that the building will have a slightly positive static pressure so that any air coming into the building will be treated air. Some of this air will be lost, but it is better to lose treated air than to gain untreated air.




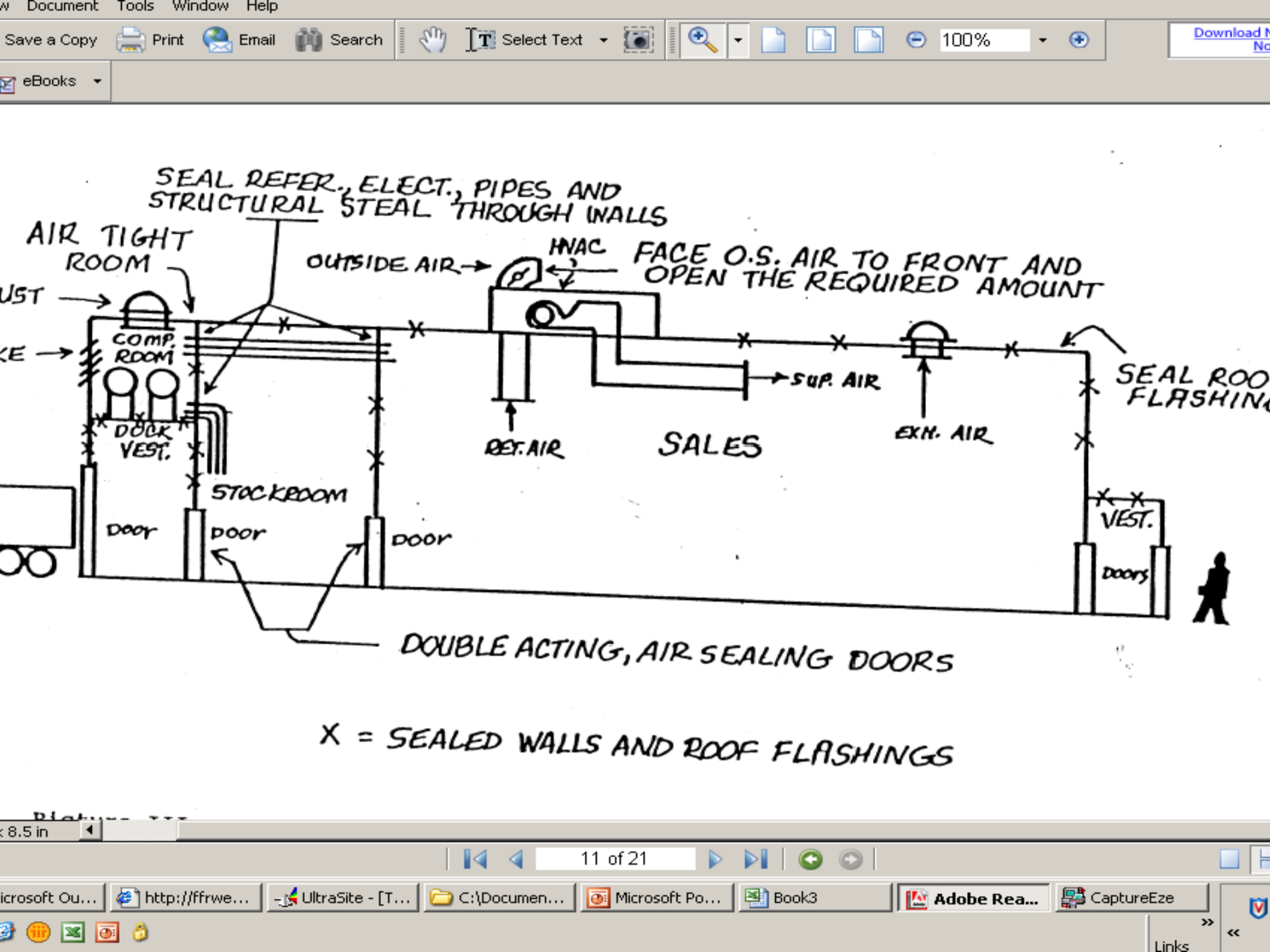
# The Benefits of POV

- Comfort of customers and employees
- Longer product life / less shrink
- More refrigerated food sales
- Reduced defrost time on cases
- Less maintenance down time
- Reduced HVAC energy consumption
- A cleaner store due to less untreated air



# How do you achieve POV?

- First have a vestibule at the front of the store
  - Have a vestibule at the loading dock
  - Make the stock room totally sealed from the main sales floor and the loading dock
  - Face the outdoor air intake the same direction as the door entrance of the store
  - Seal all penetrations, all roof flashings, and have double acting, air sealing doors
  - Bring in enough outdoor air to slightly pressurize the building
- 
- An abstract graphic on the right side of the slide, featuring a blue and white color scheme with a stylized, angular shape that resembles a building or a mechanical component. The graphic is partially obscured by the text of the list.





# Air Entrances

- An entrance way with no door, only an air curtain



# Air Entrances

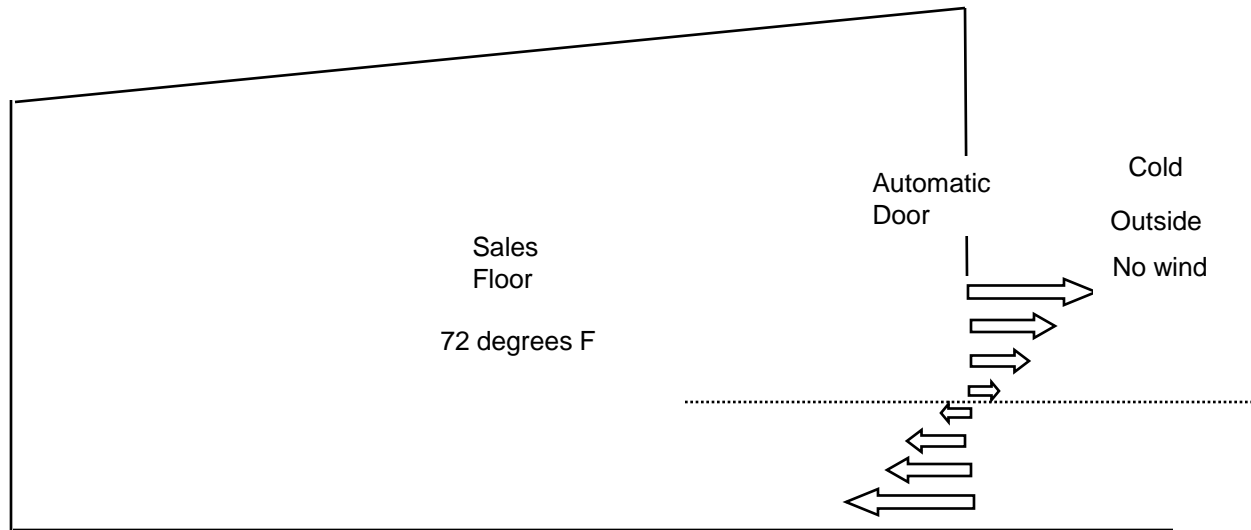
- States that correctly designed and constructed buildings will neutralize the variations to wind pressure and other external forces within pre-described limits
- Again discussed many principles of the POV paper, but does not argue for building pressurization
- Thermal Door Line Tip Over (Cold air rotates out or in the bottom of the door/Warm air leaves or enters the top of the door)





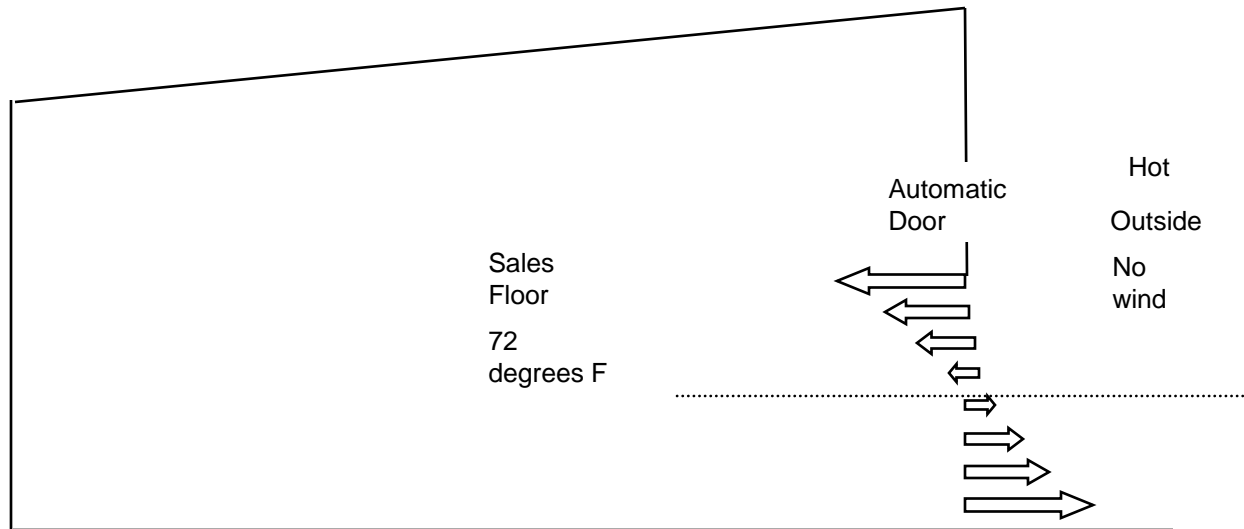
# Thermal Door Tip Over

Winter



# Thermal Door Tip Over

Summer



# How do air entrances “neutralize” the building?

- The main AHU of the neutralized space needs to be sized so that the make-up air volume should exceed mechanical exhaust negatives by  $\frac{1}{3}$ , i.e. exhaust of 1000 cfm = make-up air of 1333 cfm
- Makeup air volume required will vary, but experience tells them it will be  $\frac{1}{10}$  to  $\frac{2}{10}$  of a cfm per square foot of neutralized area



# Cont.

- Requires the HVAC to be designed to maintain a positive pressure
- The sum total of outside air input for the primary neutralized zone must exceed by 33%, the sum total exhaust air form the primary neutralized zone.
- The above percentage is based on practical experience



# Advantages of Air Entrances

- All the same as POV
- Plus 50 % less insect infiltration
- Plus savings in maintenance on automatic doors
- Plus savings on automatic door law suits





# Air Flow Testing Equipment

- Gazillion Typhoon Ultimate Bubble Fountain, floor mount by Fun Rise inc. rated at 5000 bpm continuous usage
- Mini Extreme Bubbles, hand held, by Amazing Bubbles, no dipping required, rated at 300 bpm continuous usage
- Note: bpm (bubbles per minute)





# Air Flow Testing Equipment





# Air Flow Equipment Distributor



335068 030



# Show Video of Positive Pressure Store on a Calm Day

- Show video M2U00169



# Results of Video

- The positively pressurized building on a calm day allows a lot of treated air to leave the building without entirely stopping the infiltration of untreated air





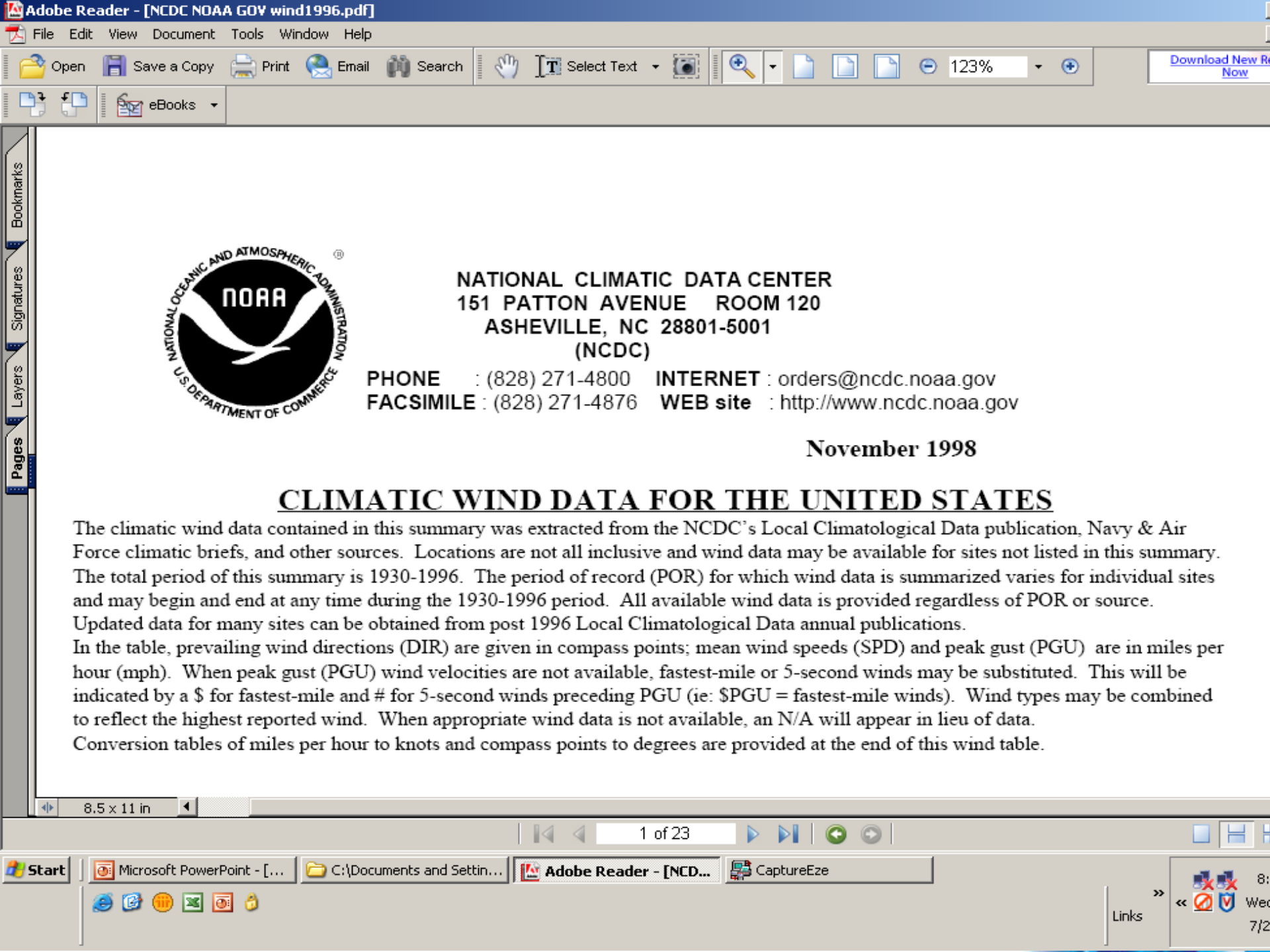
# How is a Positive Building affected by wind?

- Show video MU00214



# ASHRAE Wind Design Criteria

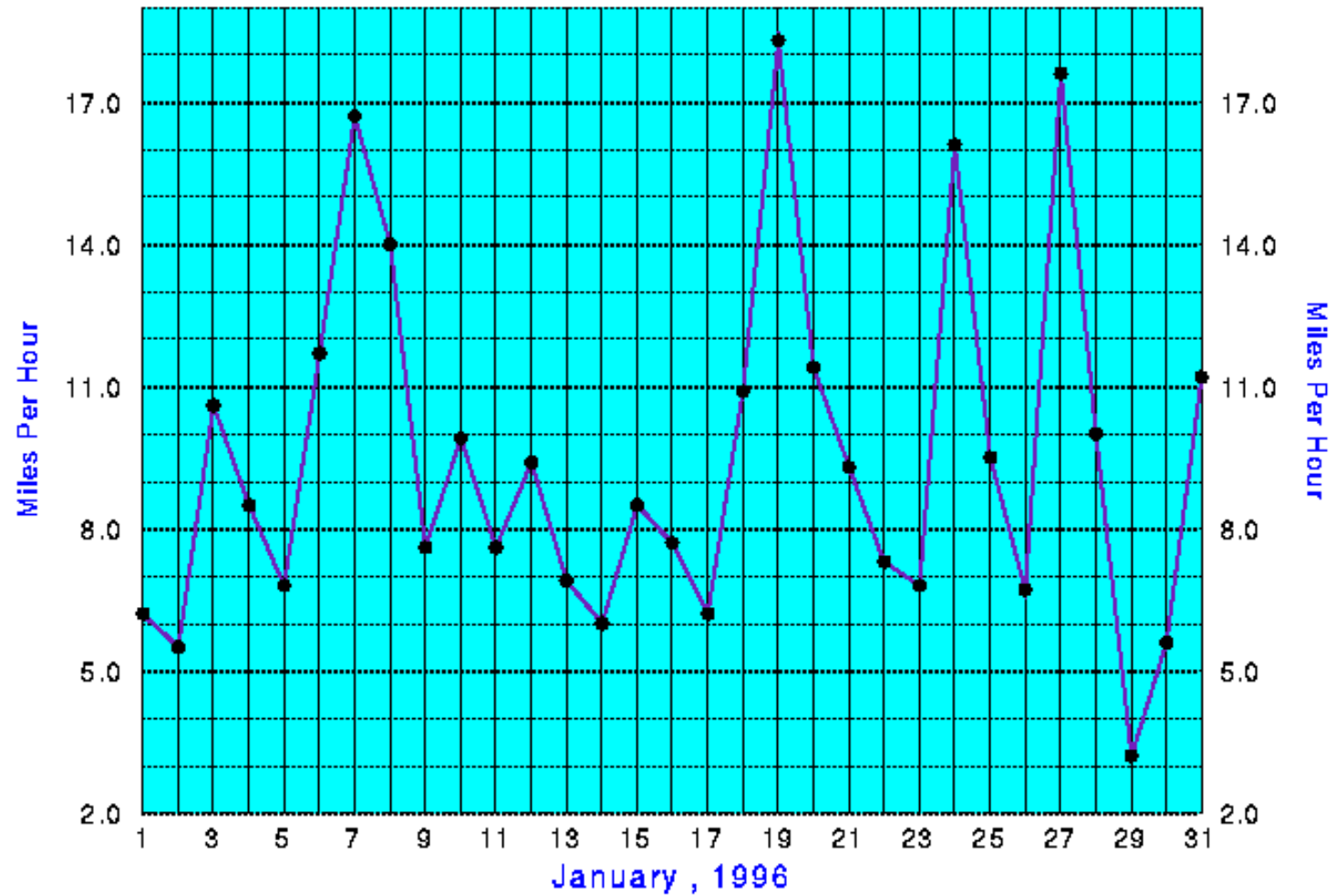
- 1993 Fundamentals Chapter 24
- Prevailing wind direction occurring most frequently with 97.5% dry bulb, winter design temperature. Wind speed is average for those speed values occurring coincidentally with 97.5% dry-bulb winter design
- Norfolk, VA shows Winter NW 10 Knots  
Summer SW note d (99.5% dry bulb winter design temp) 10 knots = 11.5 mph



# NCDC for Selected Cities

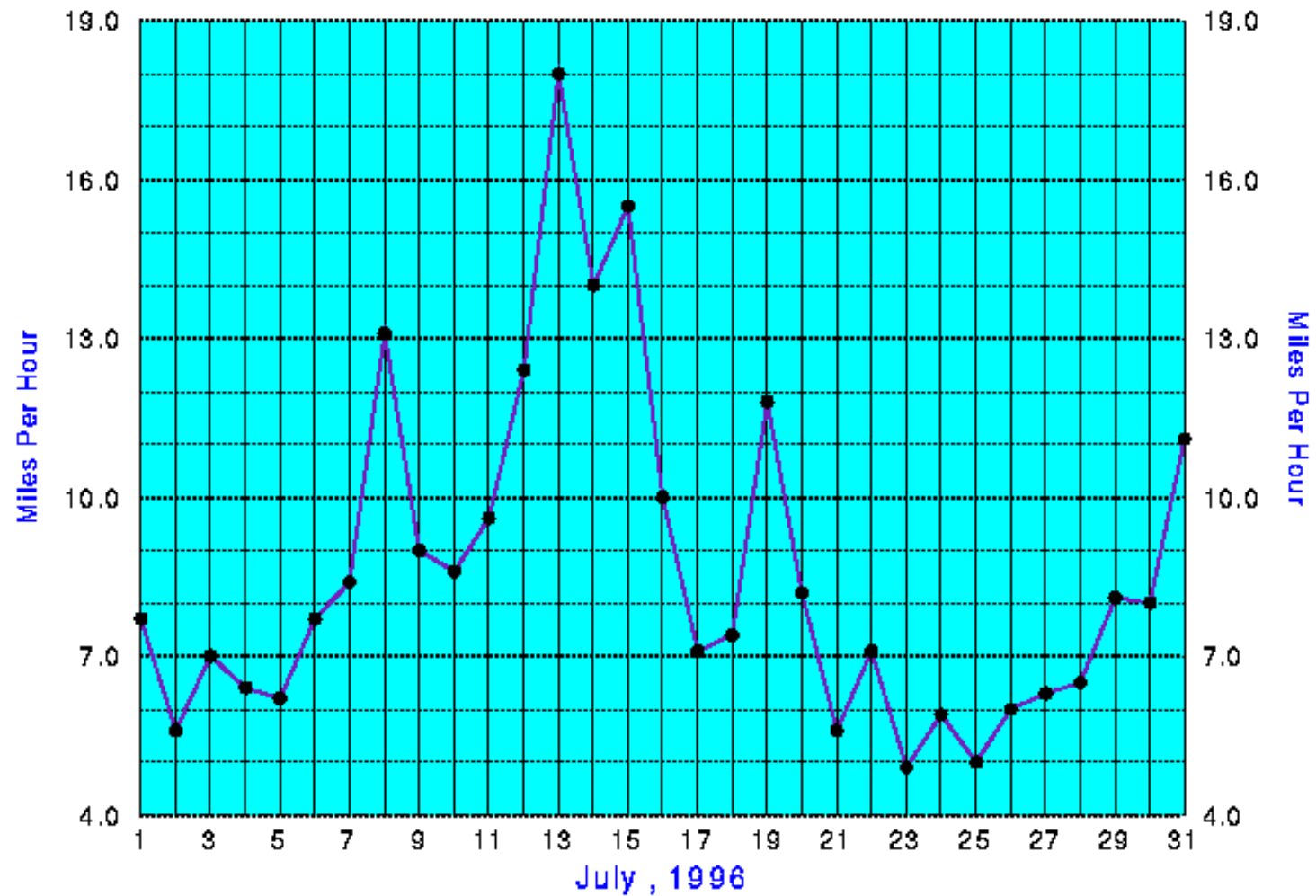
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Denver Colorado	Direction	S	S	S	S	S	S	S	S	S	S	S	S	S
	Speed	10	10	10	10	10	10	9	9	9	10	9	10	10
	PGU	55	52	59	62	60	60	55	52	56	51	49	51	62
Norfolk Virginia	Direction	N	N	NE	S	S	SSW	SW	SW	NE	NE	SW	N	SW
	Speed	11	12	12	12	10	10	9	9	10	10	11	11	11
	PGU	69	56	66	56	66	69	63	63	67	69	55	53	69
Riverside California	Direction	NNW	WNW	WNW	WNW	WNW	WNW	WNW	WNW	WNW	WNW	WNW	NNW	NNW
	Speed	3	3	3	5	5	5	5	5	3	3	3	3	3
	PGU	53	52	55	46	44	45	49	41	45	47	51	56	56
Daytona Florida	Direction	N	N	ESE	ESE	ESE	E	ESE	ESE	ENE	ENE	NW	WNW	ESE
	Speed	9	10	10	10	9	8	7	7	8	9	9	9	9
	PGU	52	58	77	49	69	67	67	68	48	56	47	43	77
Chicago O'Hare	Direction	W	W	W	NE	NE	NE	SW	SW	S	S	S	W	S
	Speed	12	12	12	12	11	9	9	8	9	10	11	11	11
	PGU	58	54	84	69	55	63	54	64	58	57	62	53	84
Cold Bay Alaska	Direction	SSE	SE	SE	SE	NNW	SSE	SSE	SSE	SSE	NNW	NNW	SSE	SSE
	Speed	18	18	17	17	16	16	16	16	17	17	18	18	17
	PGU	85	83	76	85	72	69	58	81	95	87	75	85	95

**(P) Average Daily Wind Speed  
VA NORFOLK INTL ARPT**

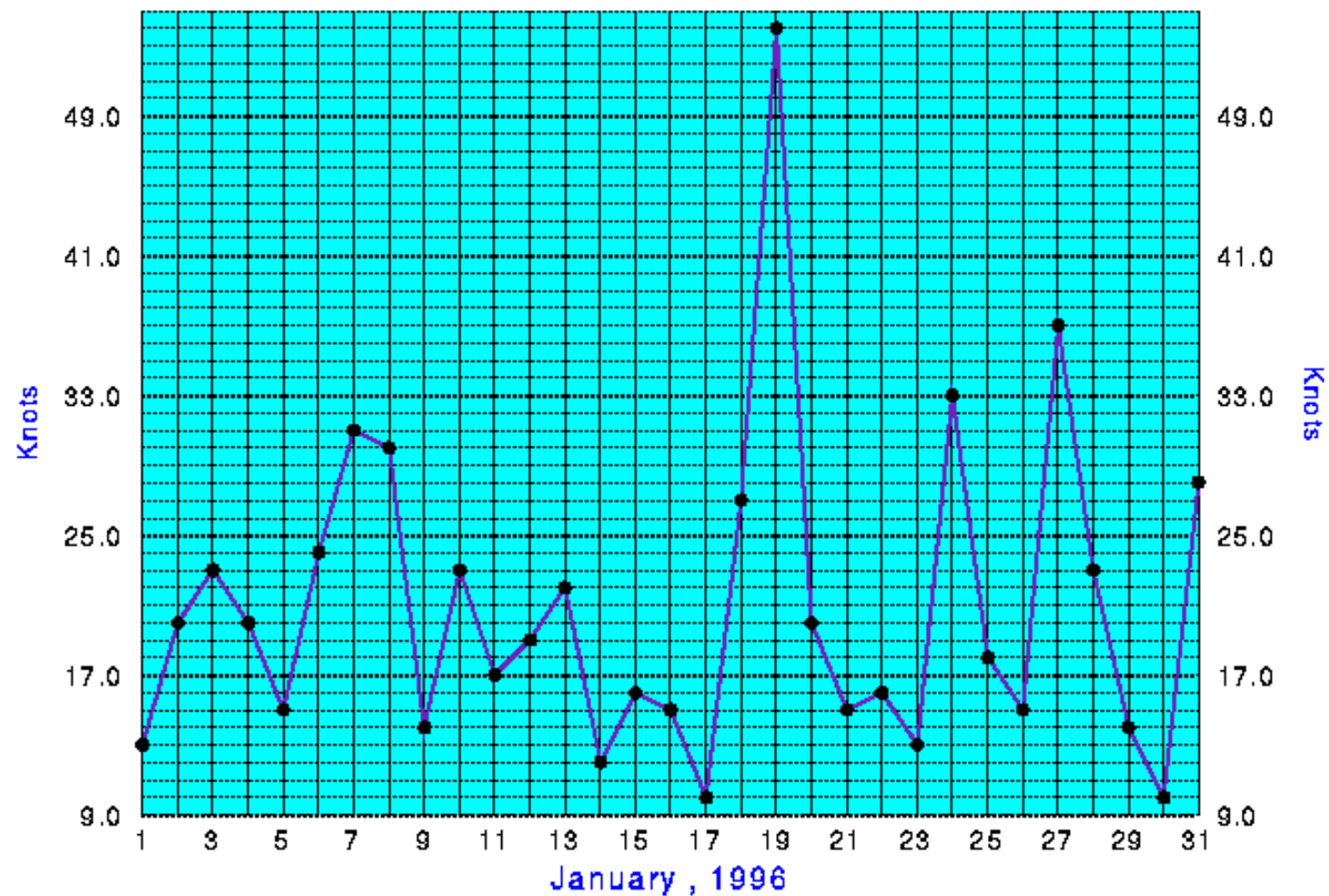




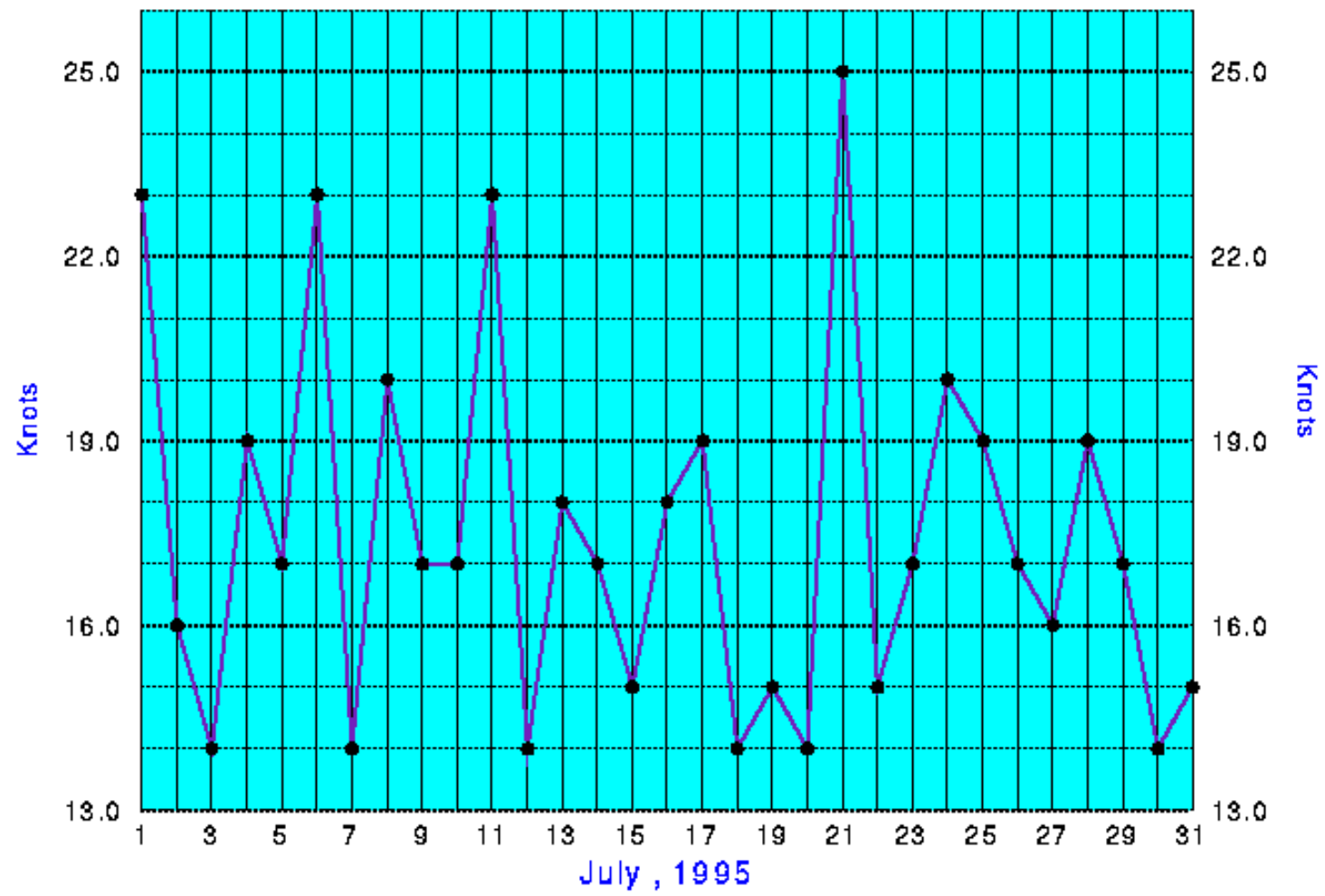
(P) Average Daily Wind Speed  
VA NORFOLK INTL ARPT



(H) Peak Gust Speed  
VA NORFOLK INTL ARPT



(H) Peak Gust Speed  
VA NORFOLK INTL ARPT



# The National Average Wind Speed

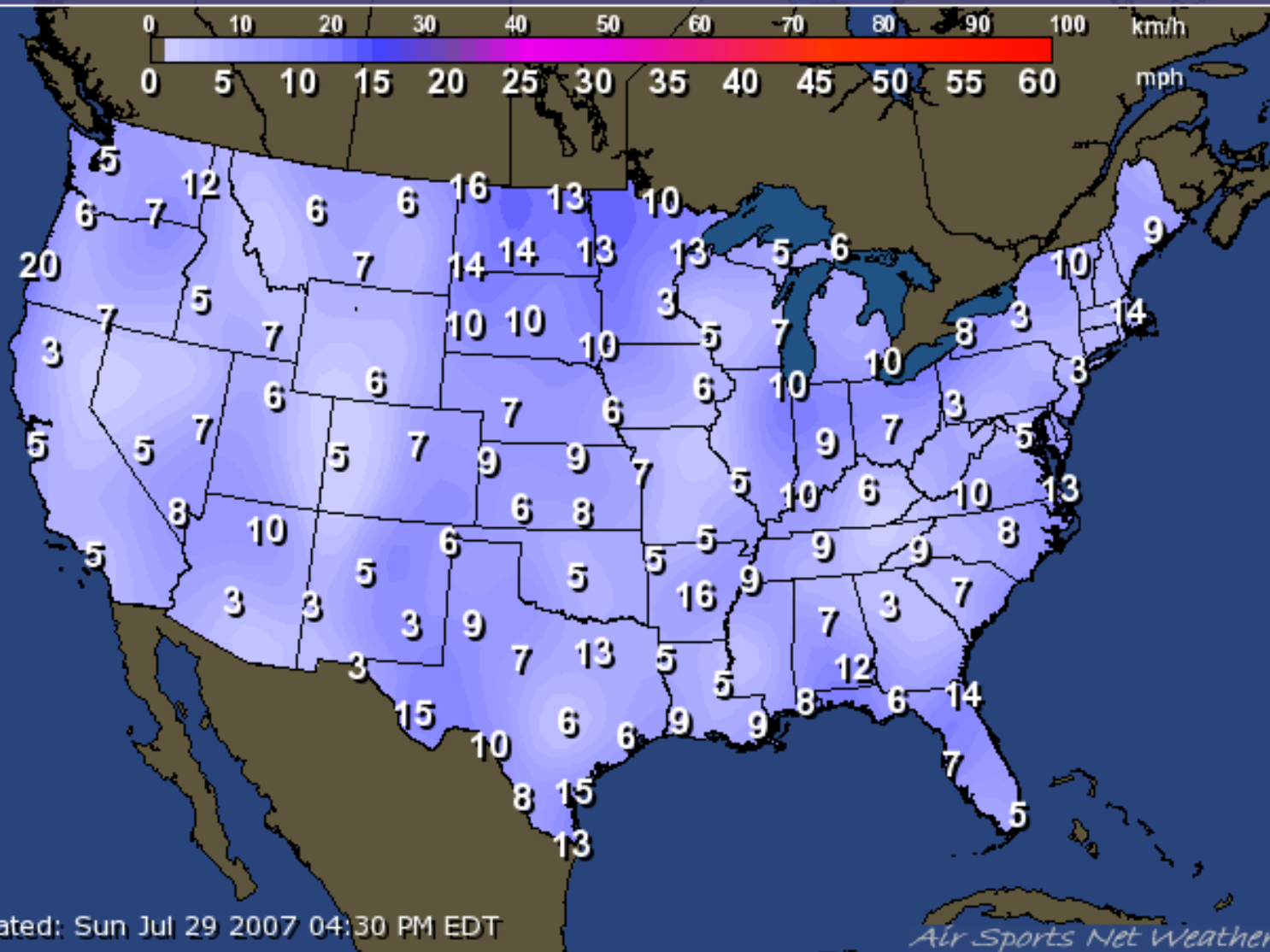
- The average wind speed through out America is about 8 mph. To get an 8 mph average over a 24 hour period the wind needs to travel more than the average for several hours. These higher winds are generally at the warmest times of the day. Grocery stores are usually busiest during these times.



[www.usairnet.com/weather](http://www.usairnet.com/weather)

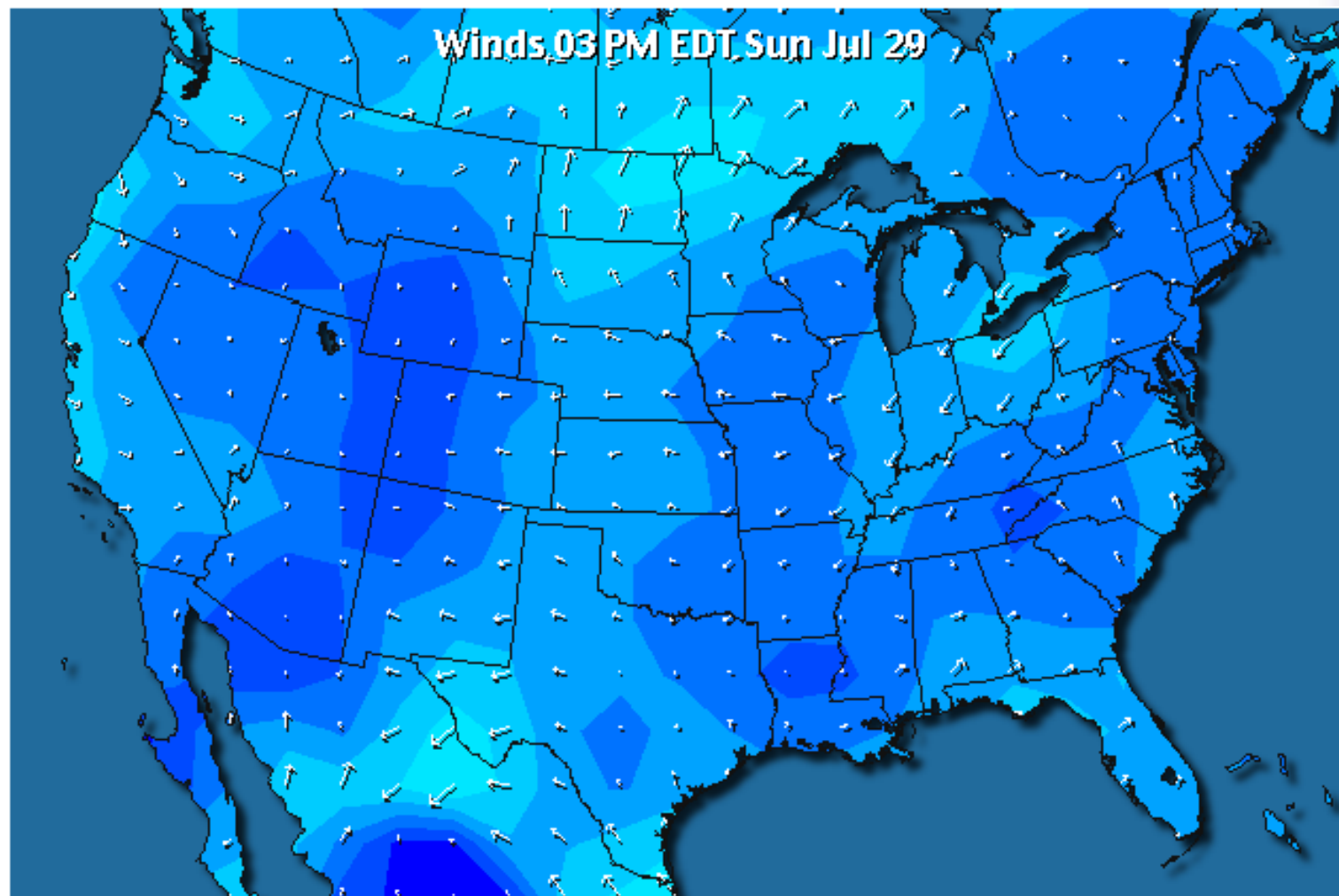
Current Wind Speed

Air Sports Net Weather





# www.wunderground.com



0 2 4 6 8 10 12 14 16 18 20 m/s  
0 5 10 15 20 25 30 35 40 45 mph



# CFM of air entering a door

- Assume 10 miles per hour (mph)
- $(10 \text{ mph}) * (5280 \text{ ft/mile}) / (60 \text{ min/Hour}) = 880 \text{ ft/min}$
- The door opening is 5 ft x 7.5 ft = 37.5 sq ft
- This means  $(880 \text{ ft/min}) * (37.5 \text{ sq ft}) = 33,000 \text{ cfm}$  come through a standard bi-parting automatic door



# Total CFM used in a supermarket

- Most chains design stores between 0.5 and 1.0 cfm per square foot
- This means that the entire building does not move enough air to counter a 10 mph wind entering a standard single bi-parting automatic door.
- Assume  $45,000 \text{ sq ft} * 0.75 \text{ cfm/sq ft} = 33,750 \text{ cfm}$  total cfm moving in the building
- What does that mean if two entrances are open at the same time?

# How much additional outside air is needed to be positive?

- The POV paper recommends 0.05 cfm per square foot or 2,250 cfm for a 45,000 sq ft store
- The Air Entrance recommends 1/10 to 2/10 cfm per square foot or 33% more make-up air than exhaust. So, a 45,000 sq ft store with 5000 cfm would have 450 to 900 cfm by the first method or 1,650 going by exhaust



# How long does it take to catch up from a 10 mph wind gust in a building that is positive?

- Total Exhaust = 6,000 cfm
- Total Makeup = 7,500 cfm
- Pressurizing Air = 1,500 cfm
- 10 mph wind = 33,000 cfm
- The length of time to make neutral is 22 times the length of time the wind blows
- A 35 sq ft hole is opening 3.7 times a minute





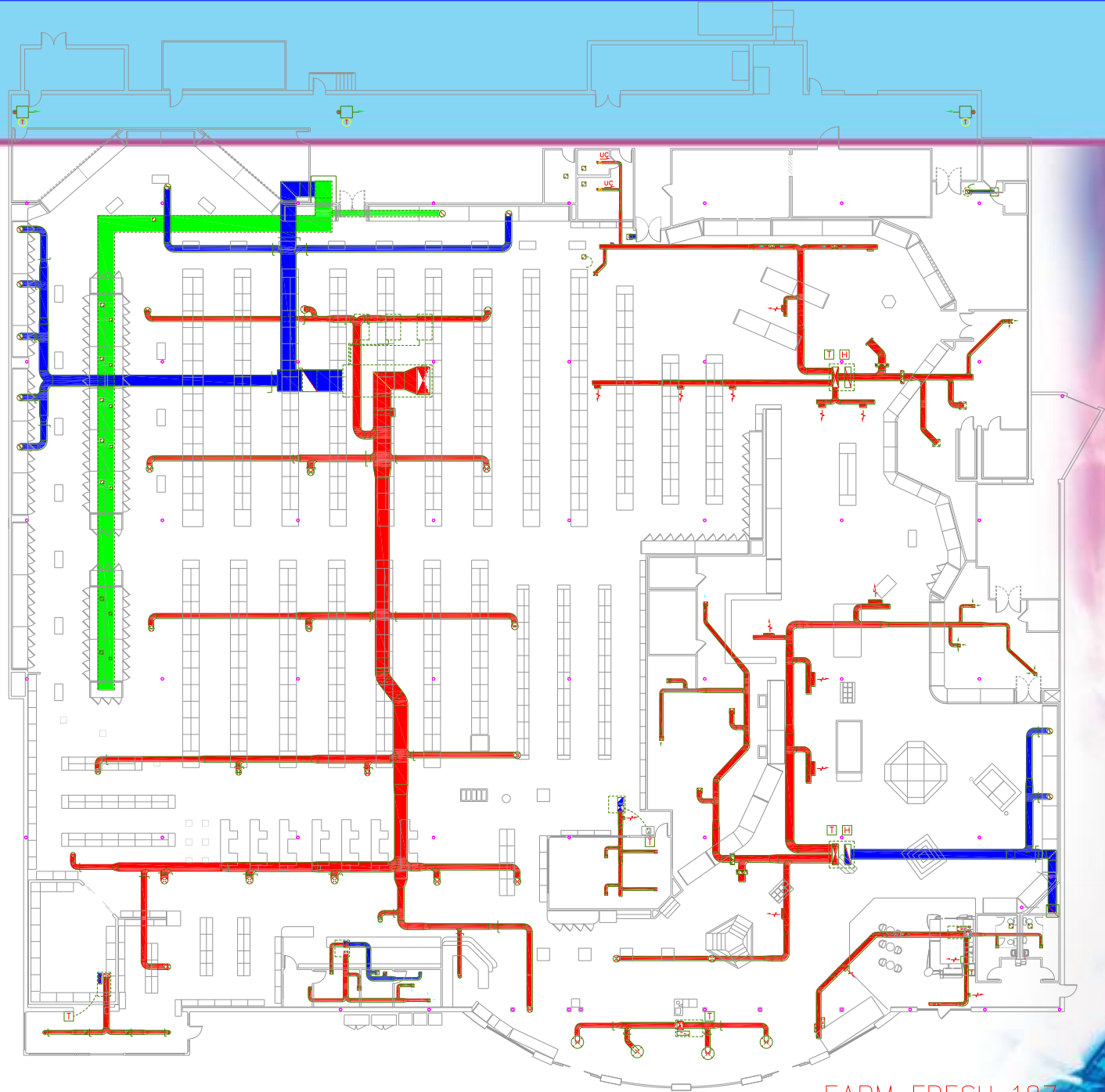
# Farm Fresh HVAC

## Previous Designs

- Under case returns in the cold isle where possible or return air under island frozen food cases
- Return air was returned over the open cases when that was not possible
- Main HVAC AHU would generally be located at the back of the store with short return air ducts and there would be multiple medium sized packaged units
- Supply air would be distributed to the front of the store and it would return to the back of the store
- The front of the store was made with a vestibule





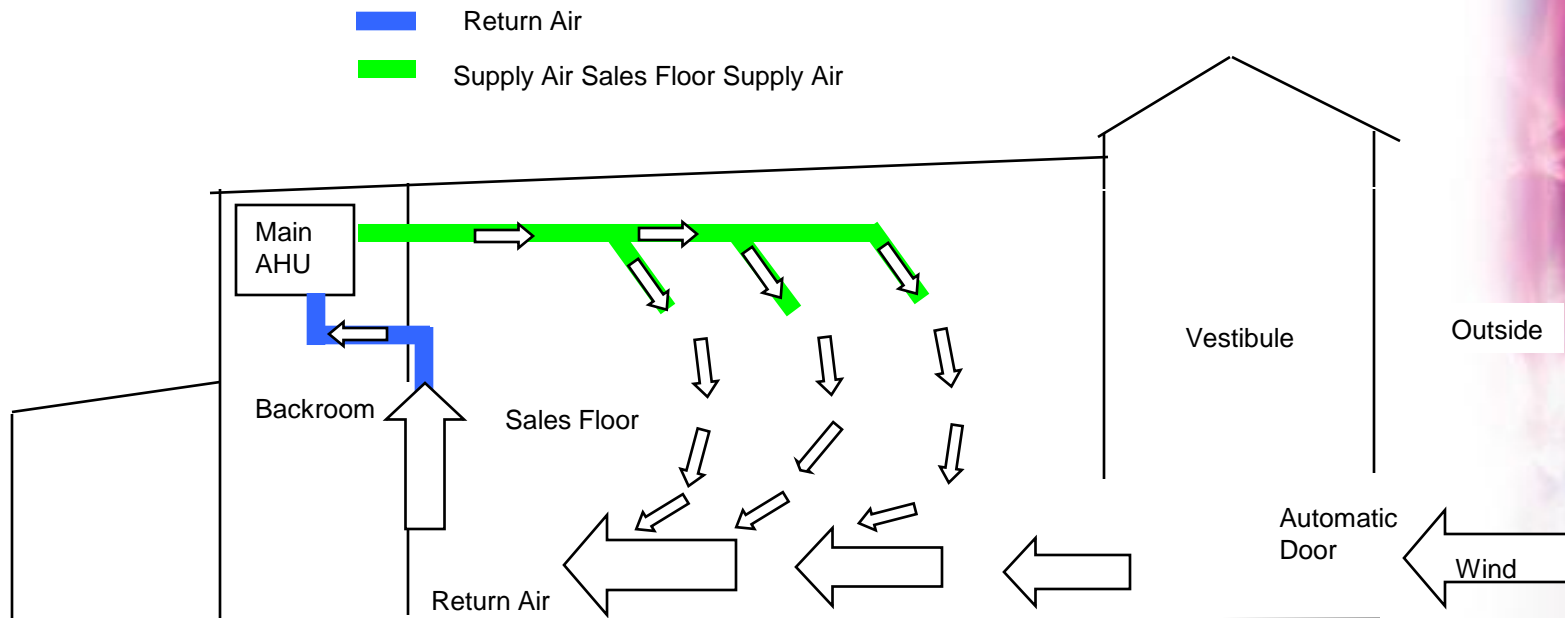


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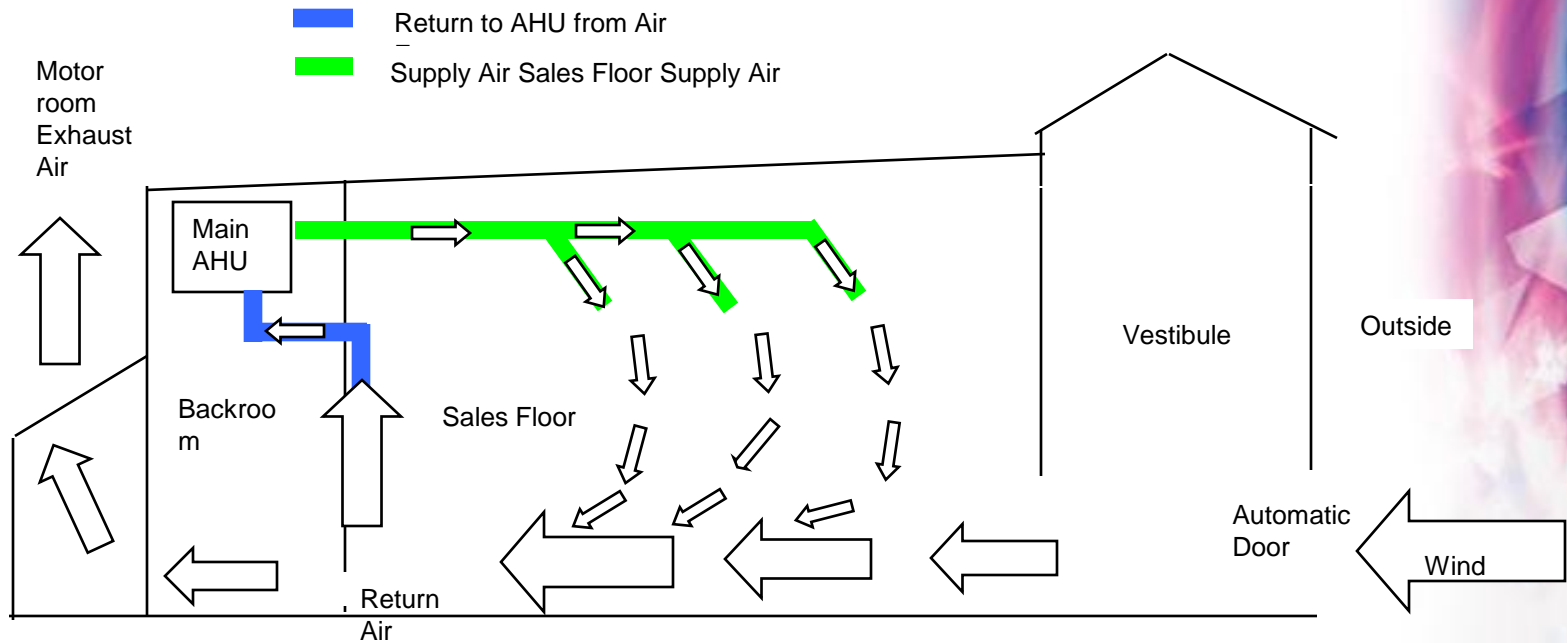
# Previous design cont.

- The motor rooms either mezzanine or rooftop and air cooled
- Makeup air on most exhaust hoods
- Single entrances between the back room and the sales floor. They did not seal and were flimsy.
- Makeup air on the main AHU with little emphasis on the direction that it faced.
- Inconsistent on making the sales floor separate from the backroom and not disciplined on keeping the building structure tight.
- This store actually had roll-in dairy cases. Wind blew through the dairy cooler doors whenever they were open.

# Previous Pattern of Air Flow



# Previous Pattern of Air Flow with Motor room



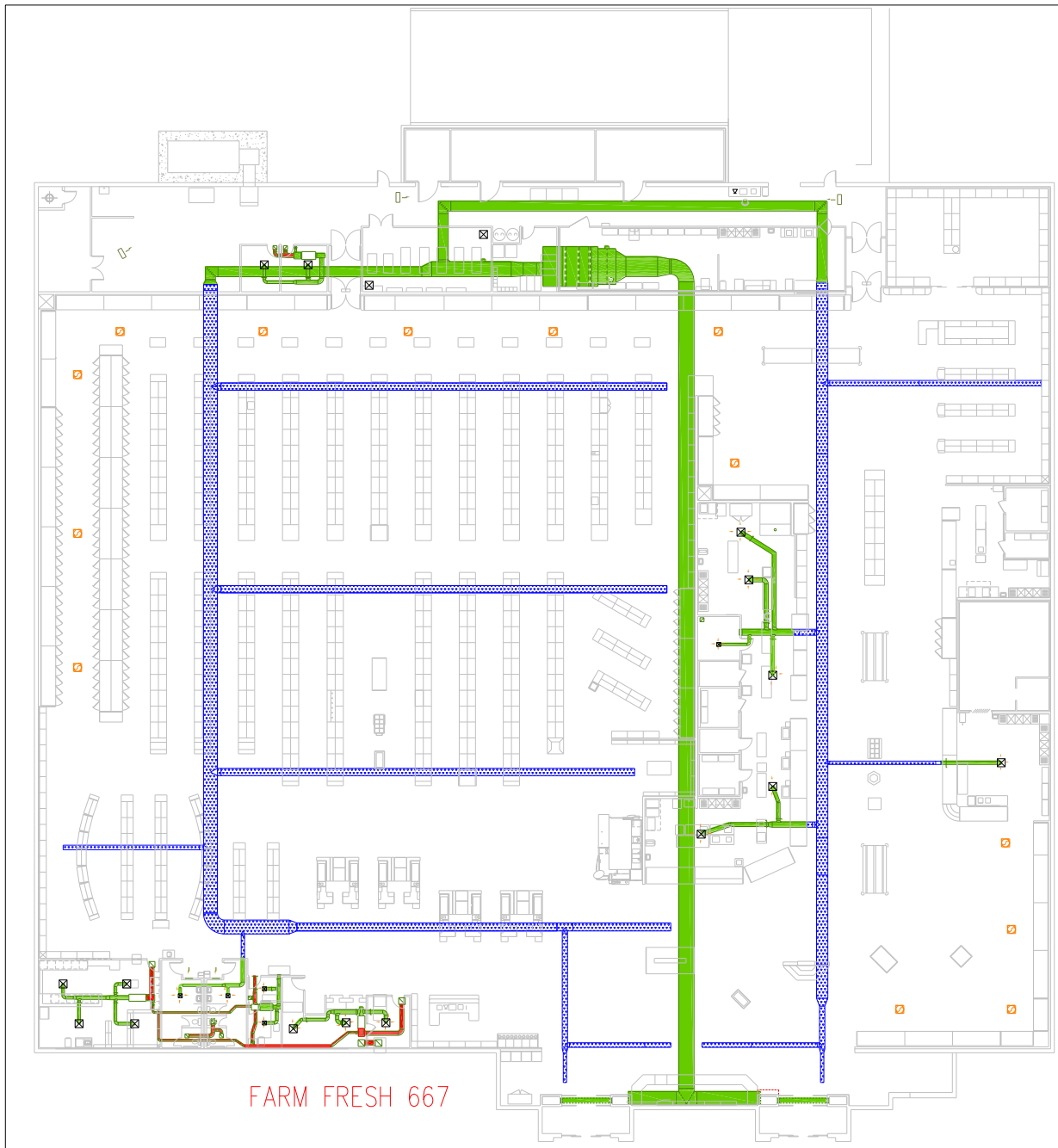
# Farm Fresh New HVAC Design

- One Main AHU
- Reverse Return Air
- Capture Doors
- Targeted Down Blast Fans
- Double air lock on entrances between Sales Floor and Backroom
- No Air Cooled mechanical centers
- Fabric Duct
- No Makeup Air on Hoods / (minimize exhaust)
- Seal all area envelopes completely







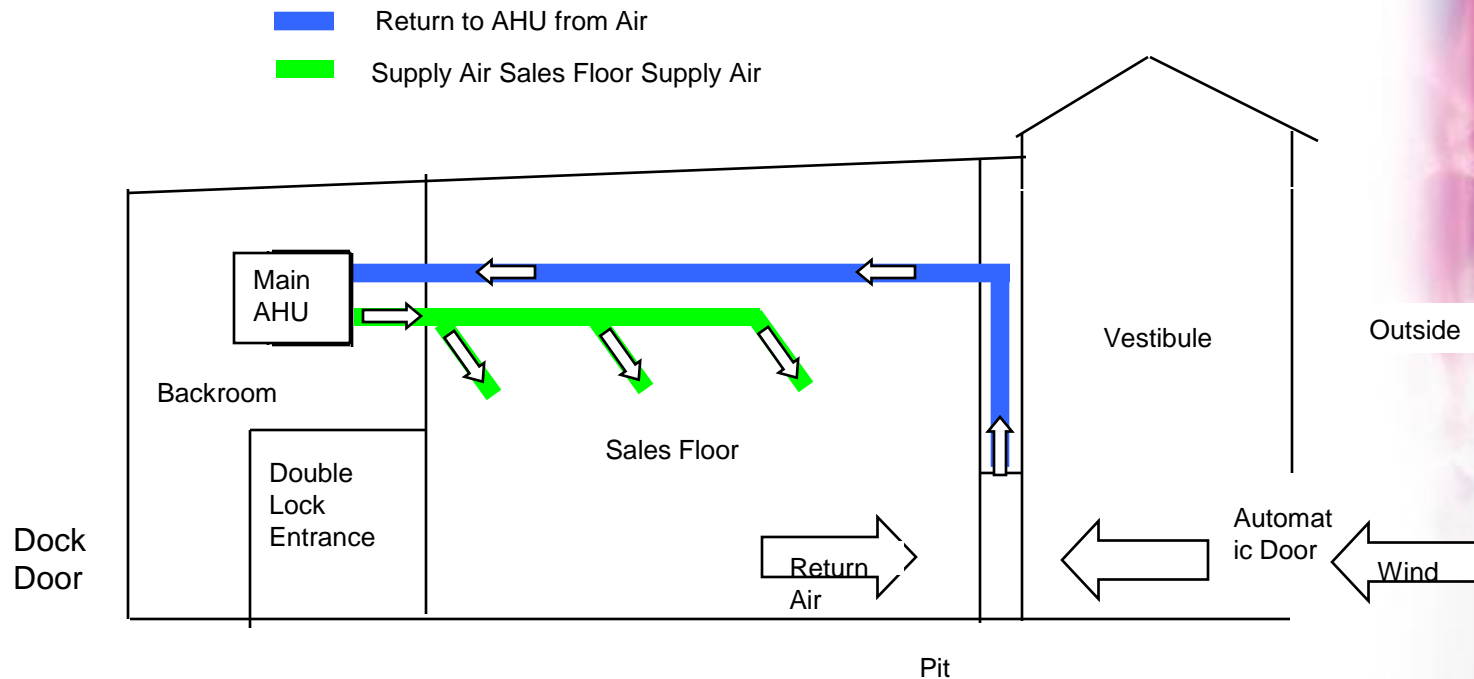


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# Why One Main AHU?

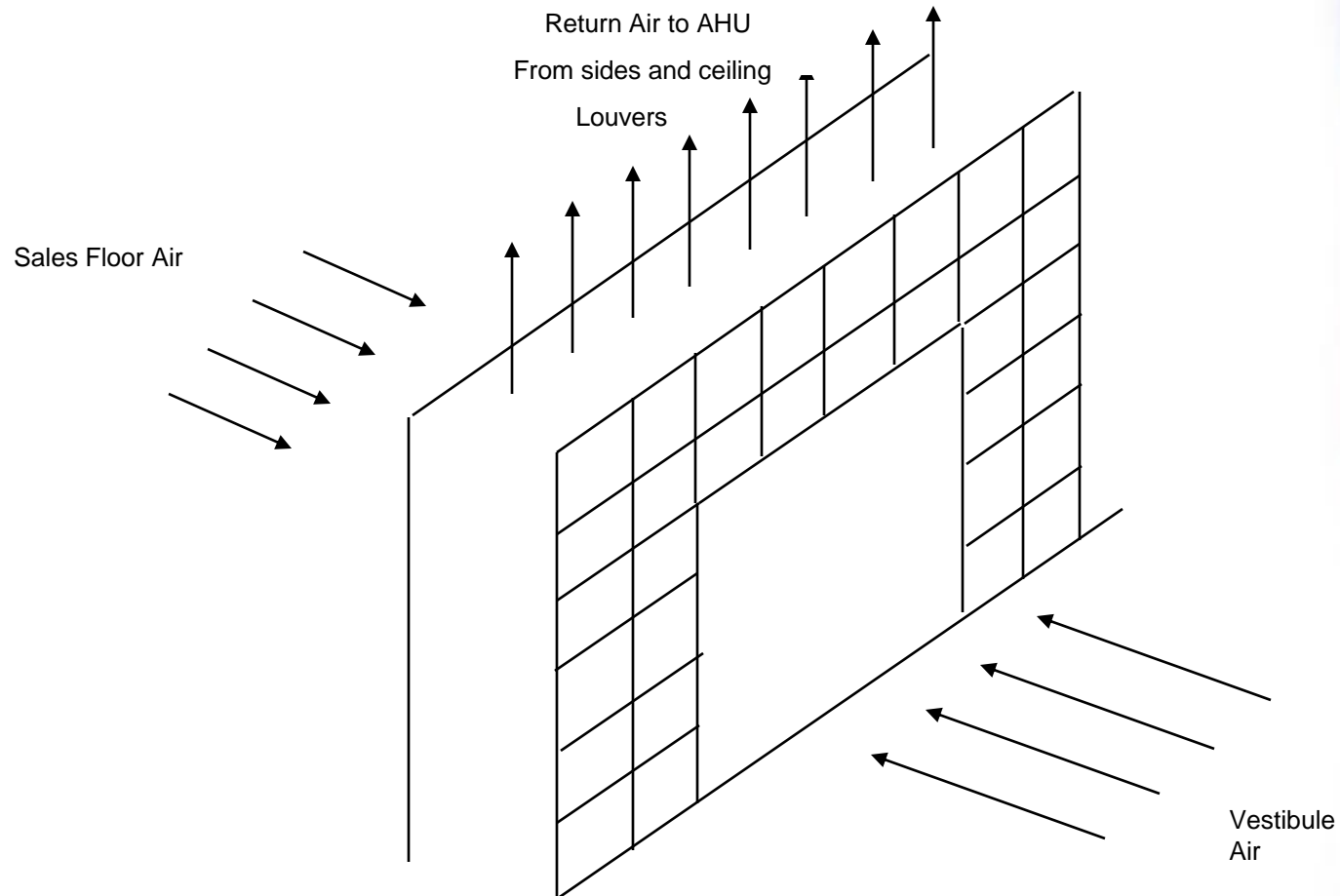
- I believe multiple units operate in heating mode and cooling mode at the same time frequently
- I believe larger motors can be applied and balanced for a more efficient system than package units.
- I believe circulating air and mixing wide ranges of air is more effective than heating and cooling that same air in small local zones for a supermarket
- Less roof top travel / more technician friendly
- Less static pressure than roof top mounted units
- Less concerns on unit insulation
- Not effected by weather
- Standby capacity
- No cranes necessary for compressor replacement

# Basic Layout in Profile





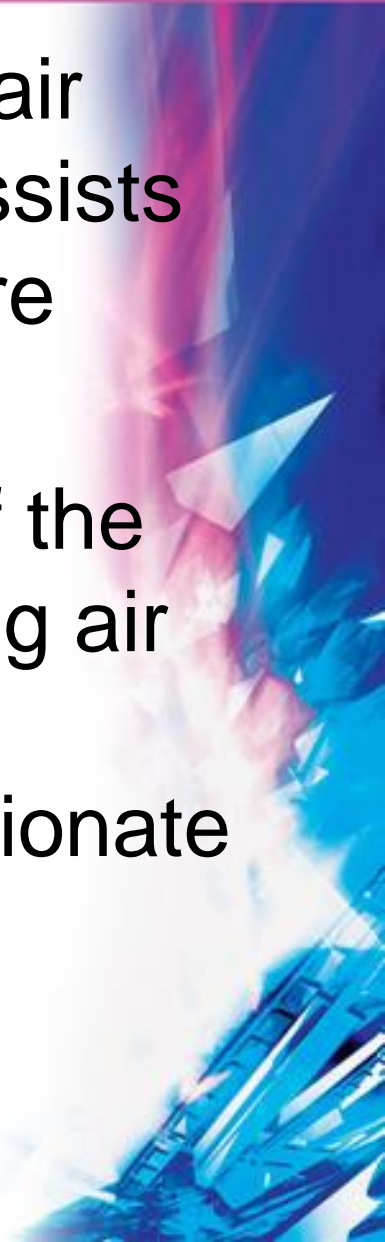
# Capture Door





# Explanation of Reverse Return Air

- In comparing most stores the return air actually sets up an air pattern that assists in pulling outdoor air through the store when the front doors are open
- By reversing this pattern the mass of the store air is colliding with the in coming air at a concentrated point effectively cancelling an infiltrating wind proportionate to each streams kinetic energy



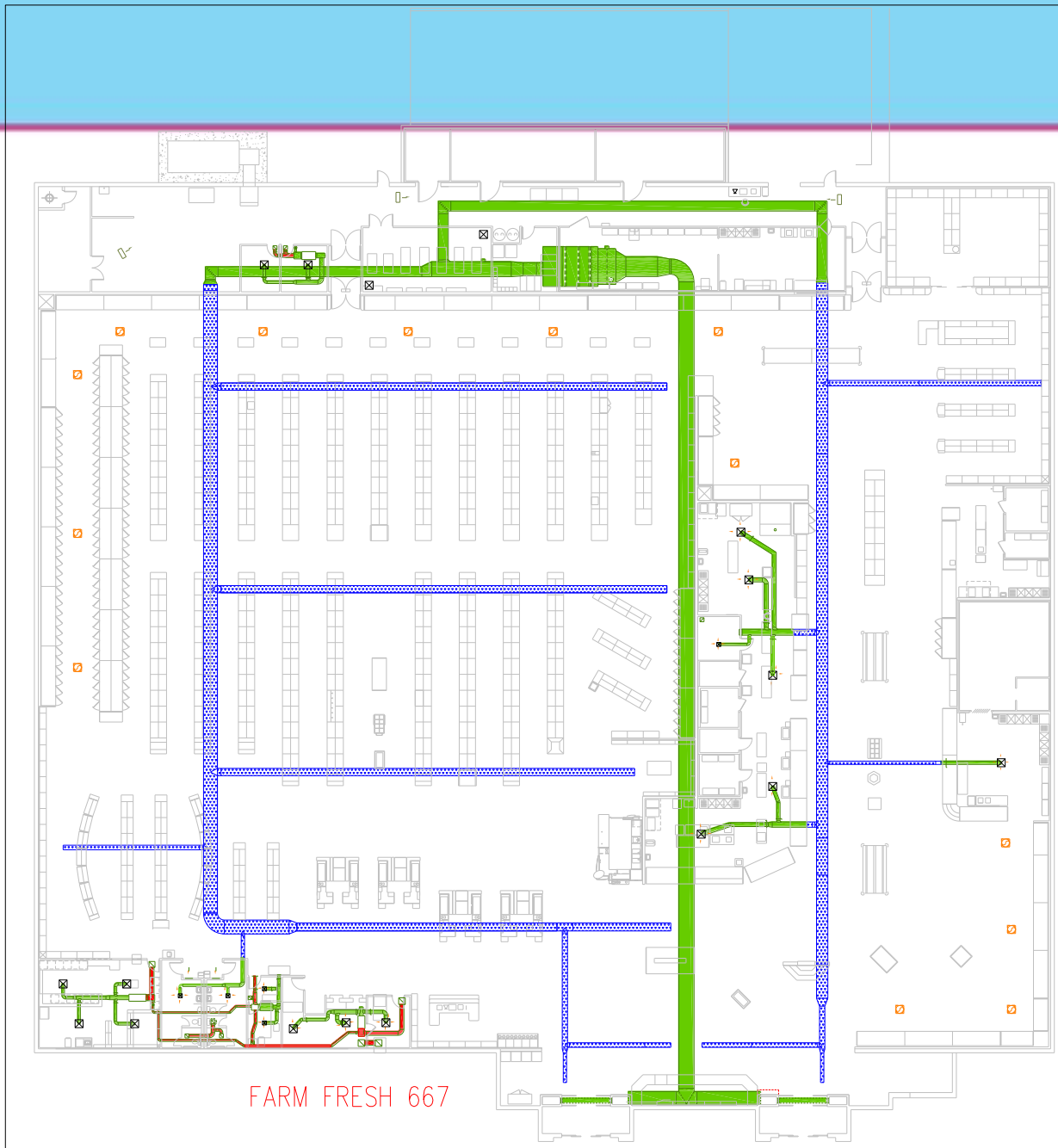






- Show video MU00162 & MU00182





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CUSTOMER SERVICE









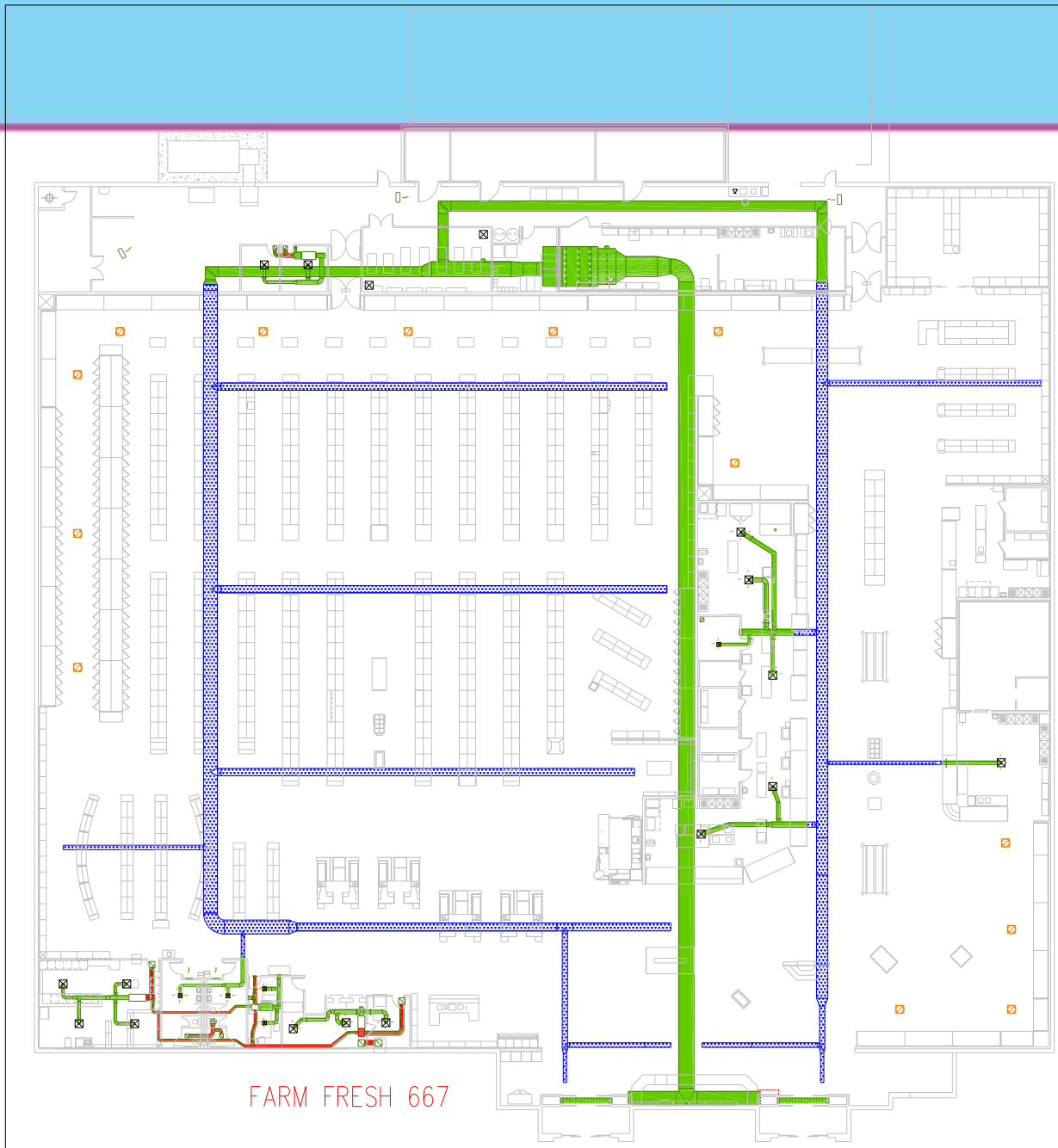












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## Scan Guarantee

We Guarantee  
our Scanning  
Accuracy

to be **100%**

If an item scans  
higher you will  
receive the item

**FREE!**



## Ad Guarantee

If we do not have  
an advertised item  
in stock we will

offer a substitute of  
equal or greater value  
at the same price

offer a rain check  
for your next shopping  
trip for the item

**FREE!**



Maga.

STARBUCKS



## BRANCH HOURS

FULL SERVICE

MONDAY - FRIDAY  
10AM - 7PM

SATURDAY  
10AM - 7PM

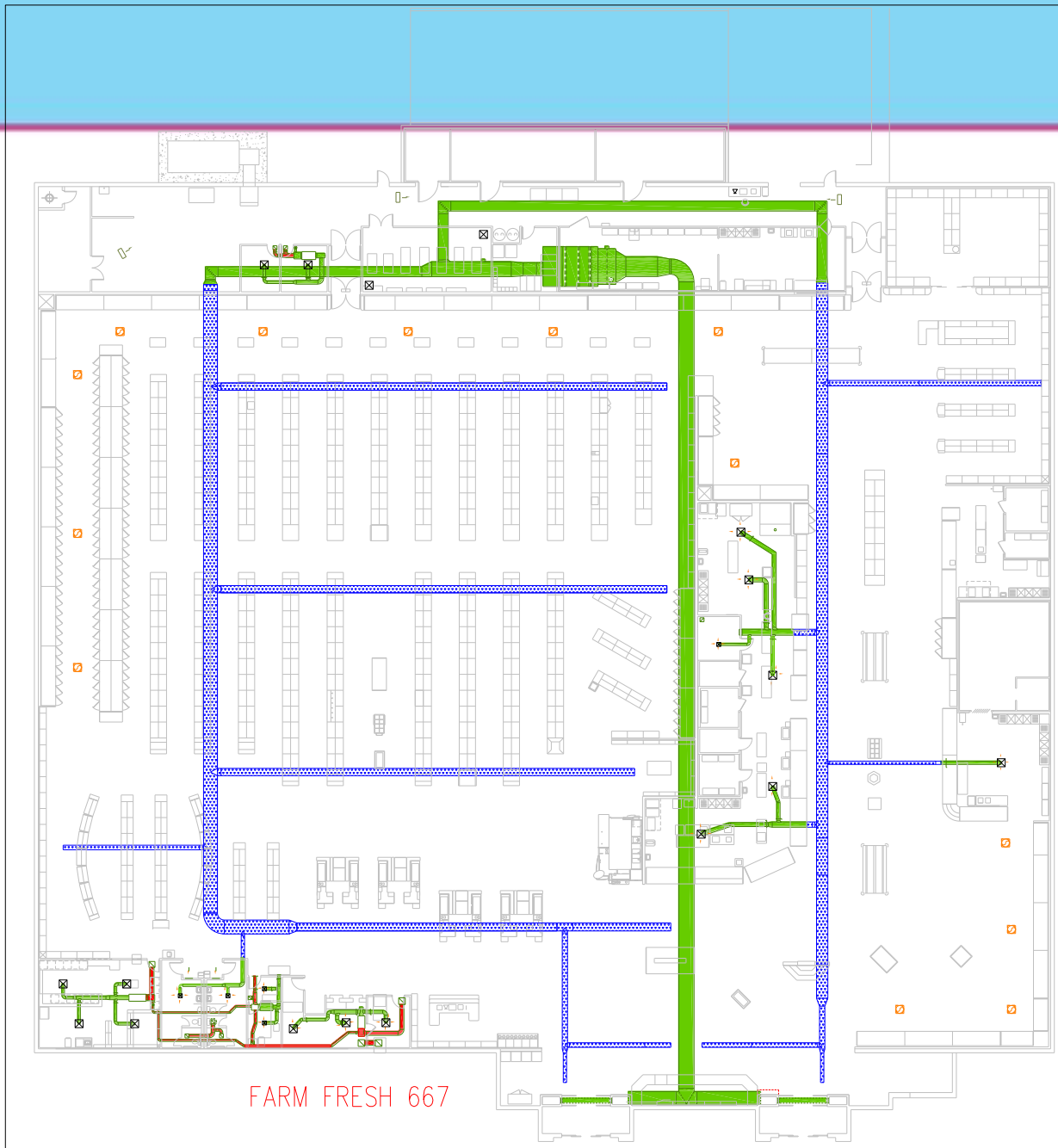




# Down Blast Fans

- These deliver a targeted cone of air of about 1100 cfm to the floor in about an 18" diameter
- They de-stratify the store and keep the store temp uniform
- They can add heat to your cold isles
- Low static pressure compared to using main duct work



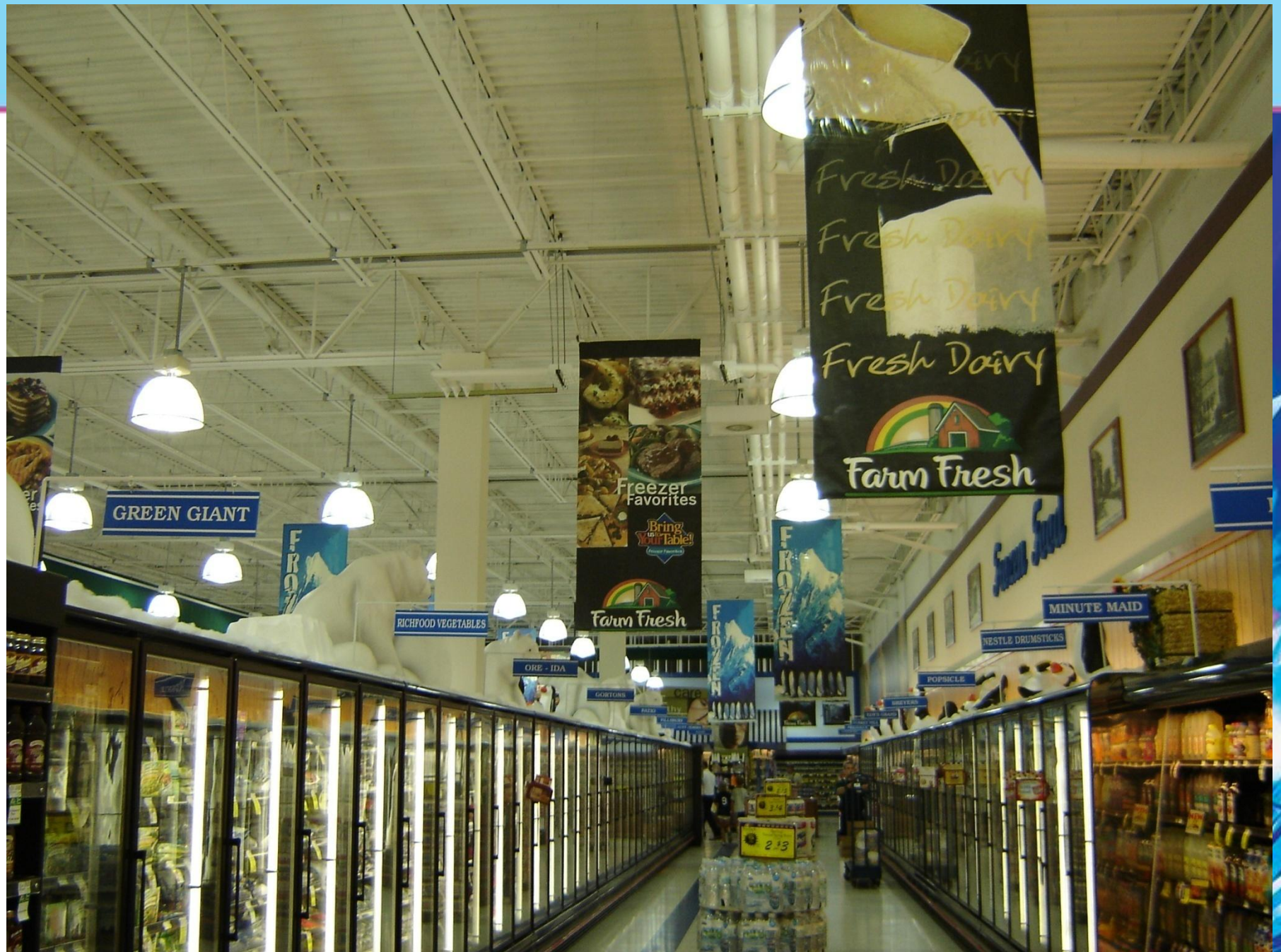


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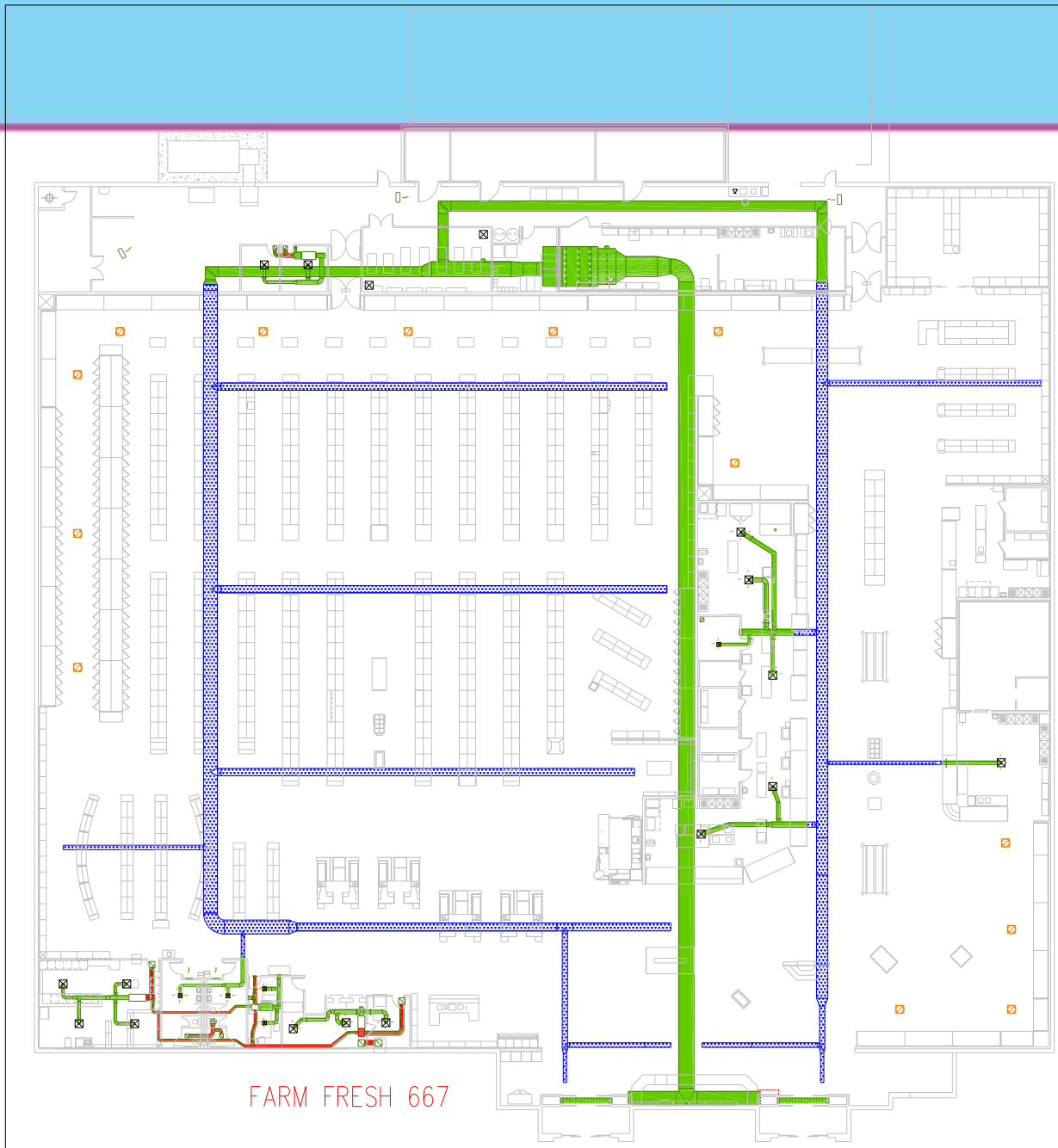












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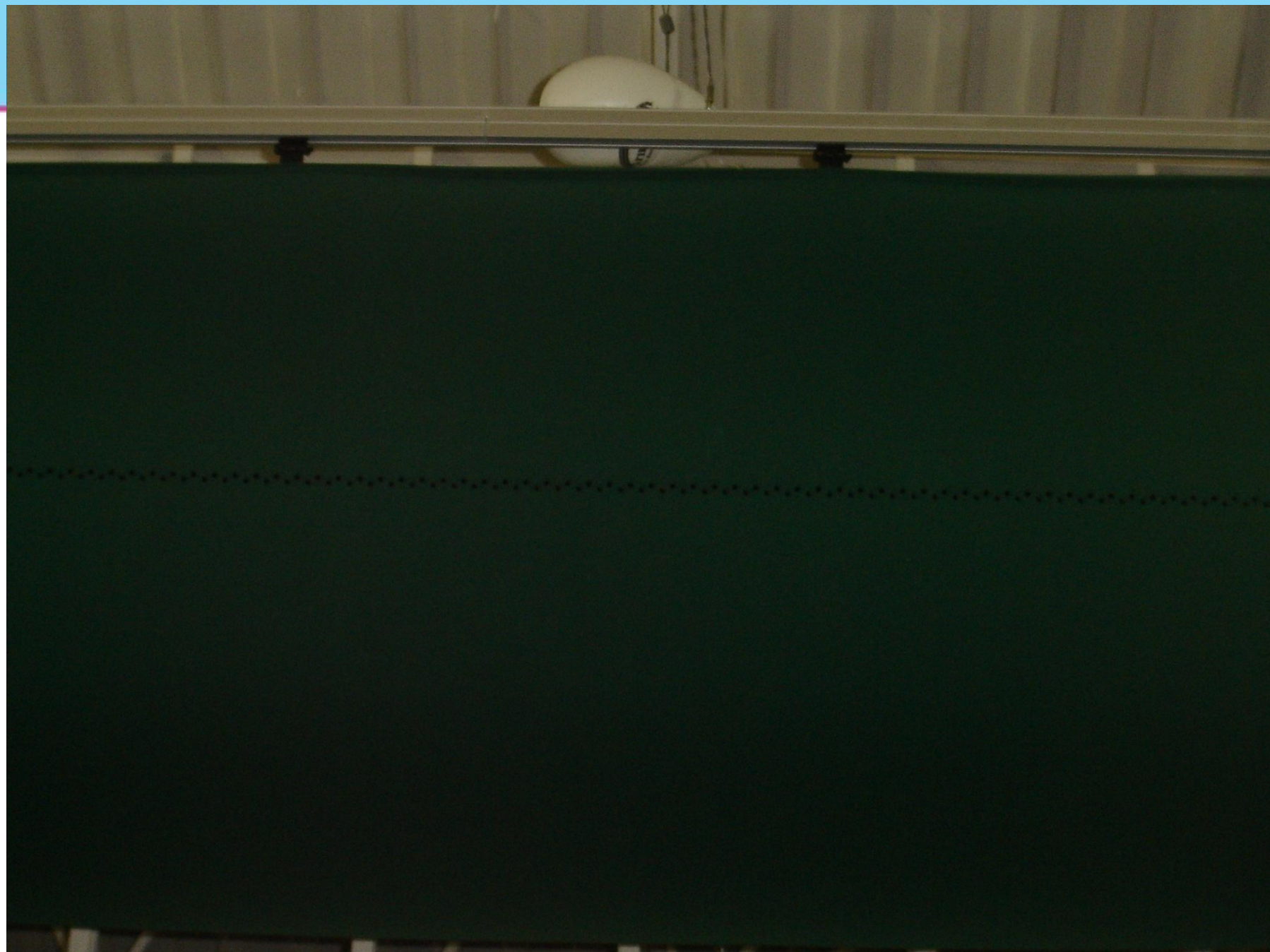
# Air Condition Mechanical Centers

- Reduces the chance of pulling the building into a negative pressure. Some motor rooms exhaust 20,000 cfm of air often robbing treated sales floor air from gaps in doors and pipe penetrations or mechanical doors left open
- Keeps motor rooms comfortable for techs
- Keeps dirt out of high end computer equipment
- Allows leak detection sensors to function better
- Must train techs to treat as a confined space











# Reasons for using Fabric Duct

- Comes essentially balanced as designed
- No dampers to get confused
- More difficult for a technician to tinker with
- Looks cleaner over time in open ceiling
- Takes up less space during construction
- Environmentally friendly
- Installs quickly



# Fabric Duct Lessons

- Use larger holes 1" (small holes can get dirt entrained in them and plug)
- Plan the duct so that you can take it down
- When you need to modify it can be turned around quickly (3 days)













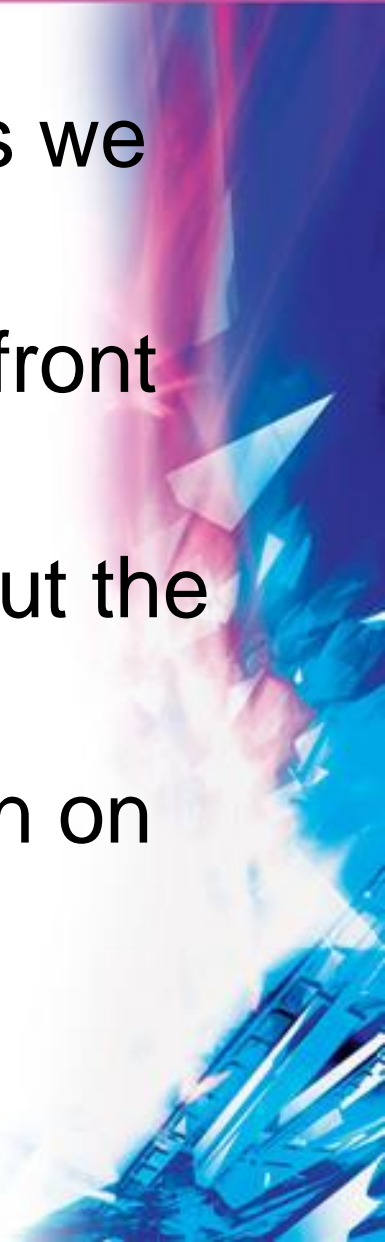
# Seal all penetrations





# How does the system work?

- They are the most comfortable stores we have
- You cannot feel a strong wind at the front of the store
- Our Sanitary inspector is excited about the system for low fly counts
- Energy is below average for our chain on a cost per square foot basis



# Insects facts

- Flies can travel as fast as 5 mph
- When “hunting” flies travel between 0 and 5 feet above ground
- Flies prefer to fly into a slight breeze so they can smell food, but dislike winds stronger than 3 – 4 mph
- Flies will crawl underneath an air curtain by landing on the ground and walking
- I collected 10 fluid ounces of bugs at the base of the filter grille in this system after 1 year of operation
- Show video M2U00139

# Summary

- Buildings should be kept neutral
- Building pressurization costs money when the wind is calm
- Building pressurization cannot offset the average winds in most areas let alone wind gusts
- Return Air should be positioned close to the building entrances
- Reverse return air can offset most winds
- Fan energy is more economical compared to compressor energy when you consider that multiple AC units will often be heating and cooling the same building at the same time. Also more air movement within reason makes the space more comfortable
- Dehumidification heat energy should first be done by fully circulating the heat in the building de-stratifying the space before any auxiliary heat is used.

Questions?





Thank you

