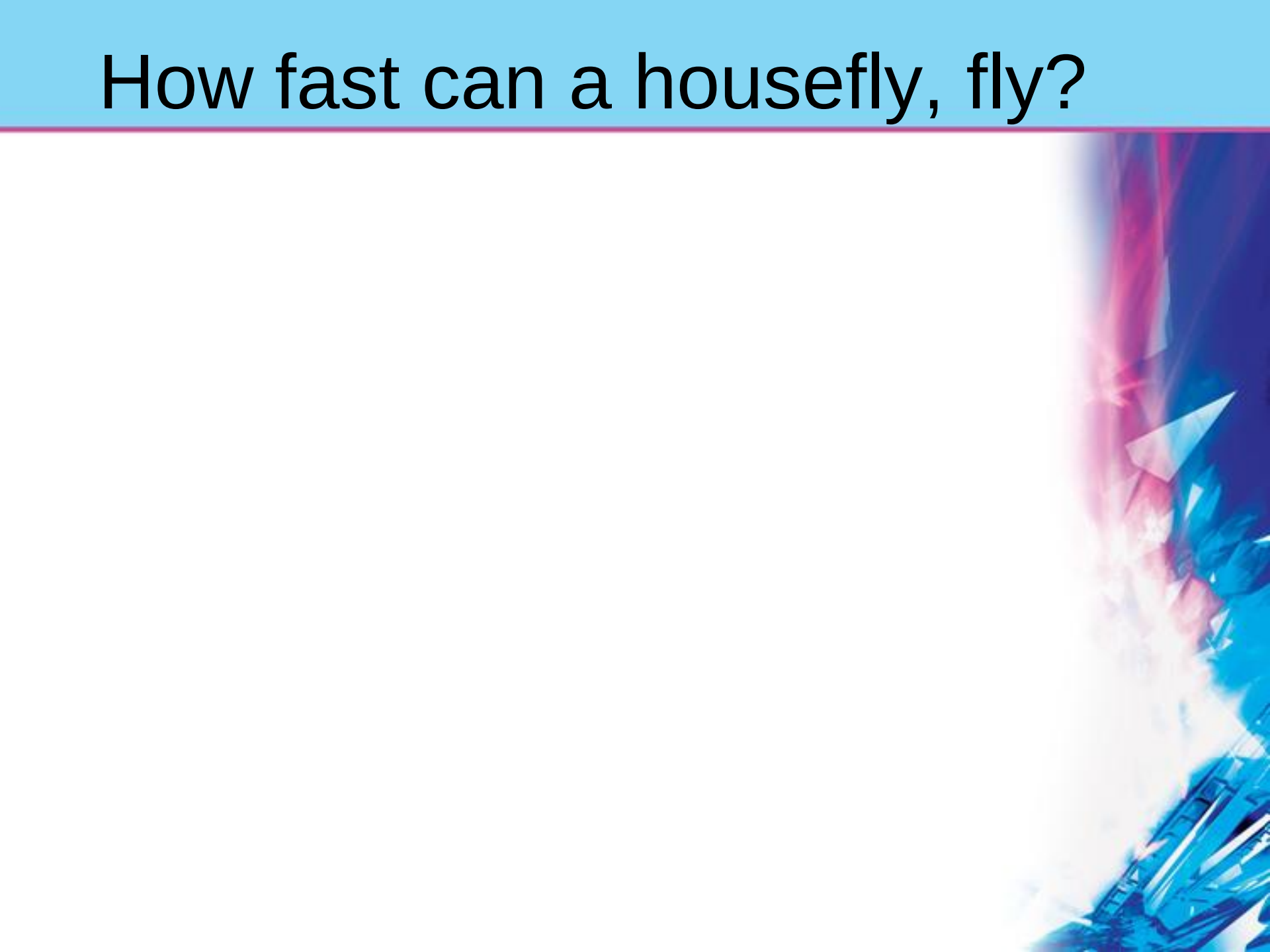
HVAC Strategies: Farm Fresh Case Study

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

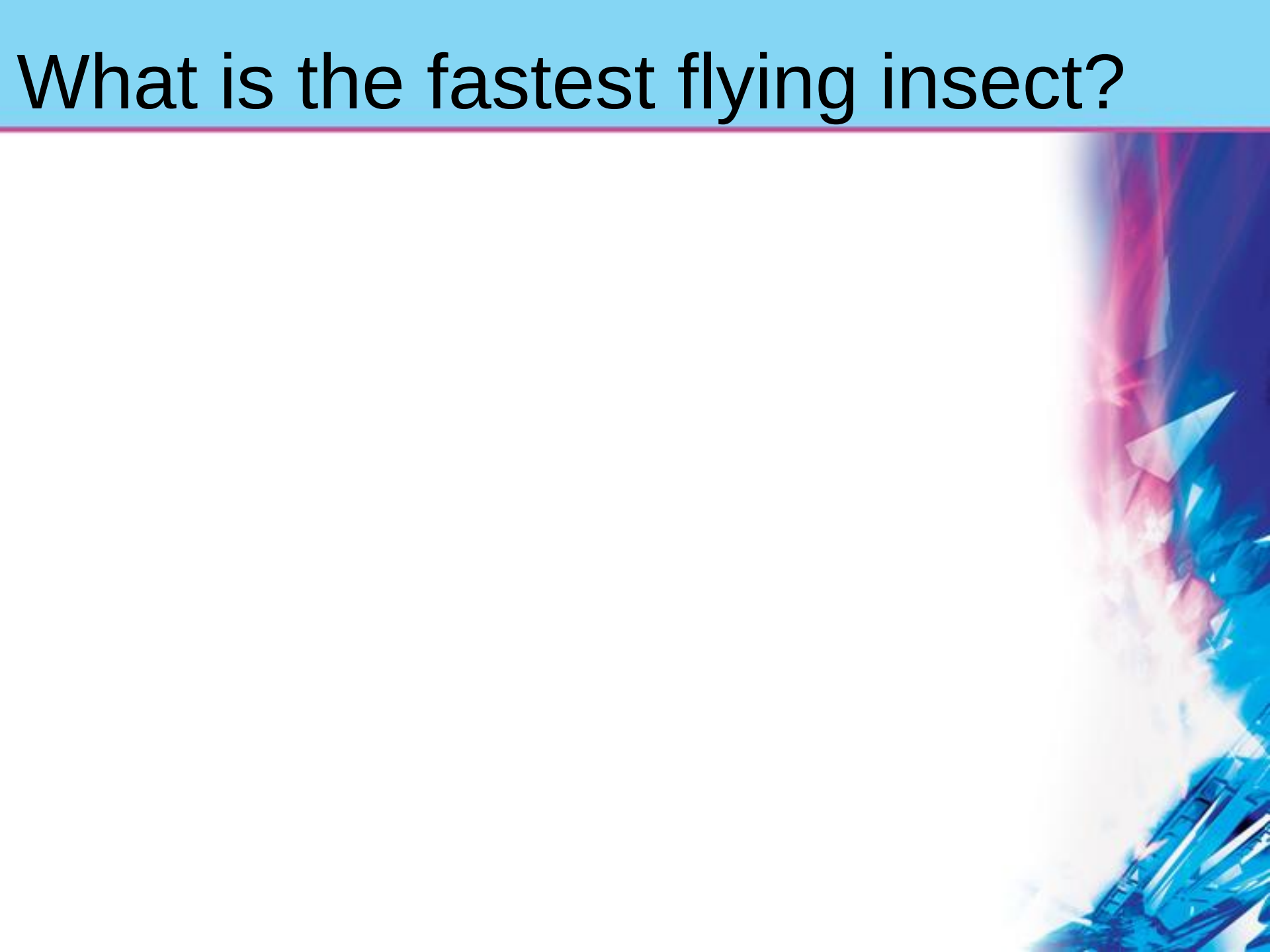
How fast can a housefly, fly?



How fast can a housefly, fly?

- 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.

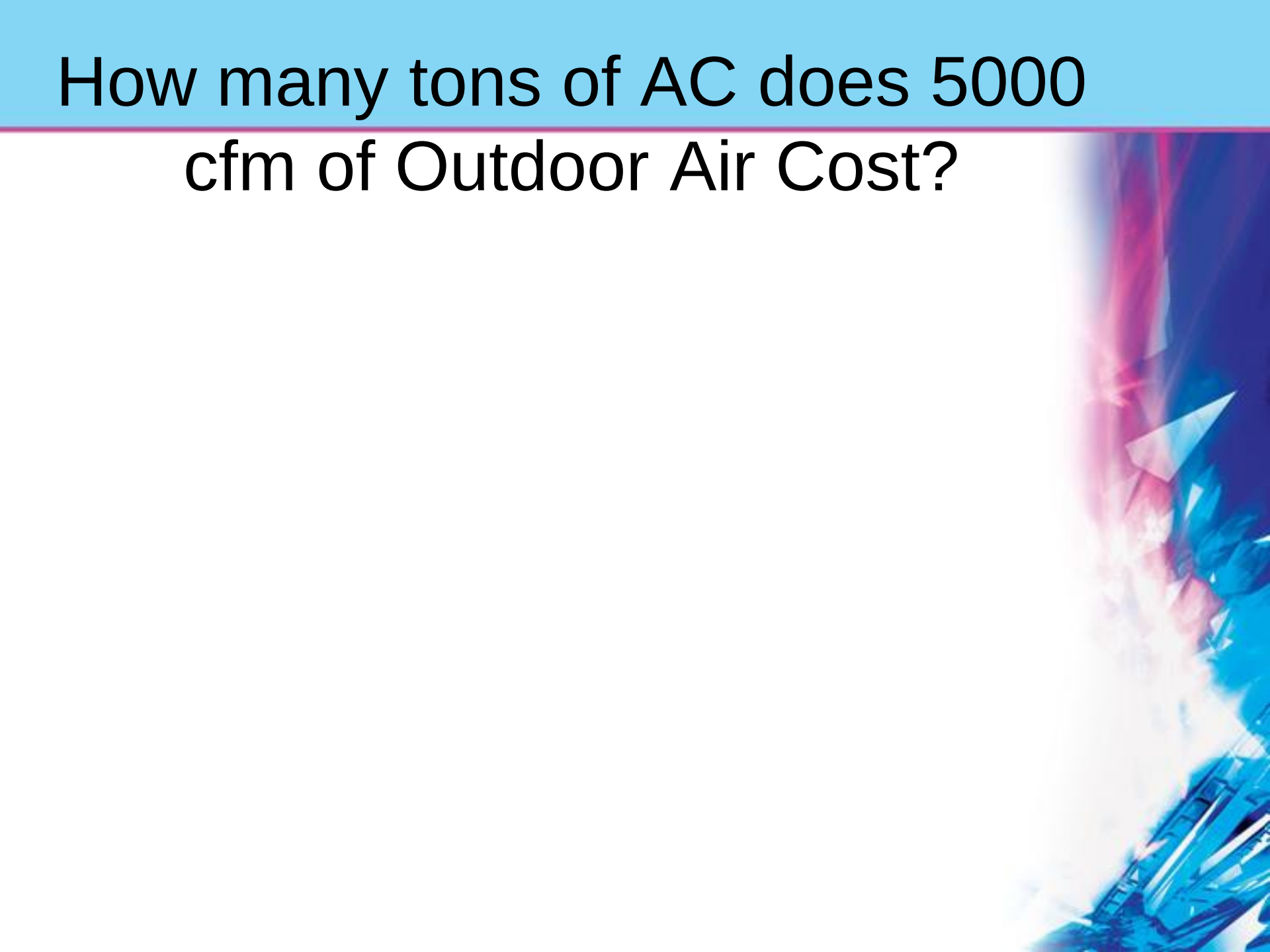
What is the fastest flying insect?



What is the fastest flying insect?

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

How many tons of AC does 5000 cfm of Outdoor Air Cost?



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- (5000 cfm*60 min/Hr)*(41.6-20.8 Btu/lb)/14.3 cu ft/lb = 436,363 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


Coca-Cola
PEPSI
PEPSI
redbox
Food & Pharmacy
STARBUCKS COFFEE

So what happened?


Scan Guarantee
We Guarantee our Scanning Accuracy
to be 100%
If an item scans higher you will receive the item
FREE!
Farm Fresh
Our name says it all.
BEST of Winner
2006
AS ADVERTISED
Farm Fresh
RECIPE OF THE MONTH
FREE - Take Some Home Today!
DONUTS
FRESH EVERYDAY
Value

So what happened?

- 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

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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

- First we had our stores rebalanced

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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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EXIT


OPPING!
AUTOMATIC SL
Welcom
Farm Fres


THANK YOU
FOR SHOPPING
Farm Fresh
EXIT
Farm Fresh
Thank You
For Shopping
With Us Today
Farm Fresh

After a few years

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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

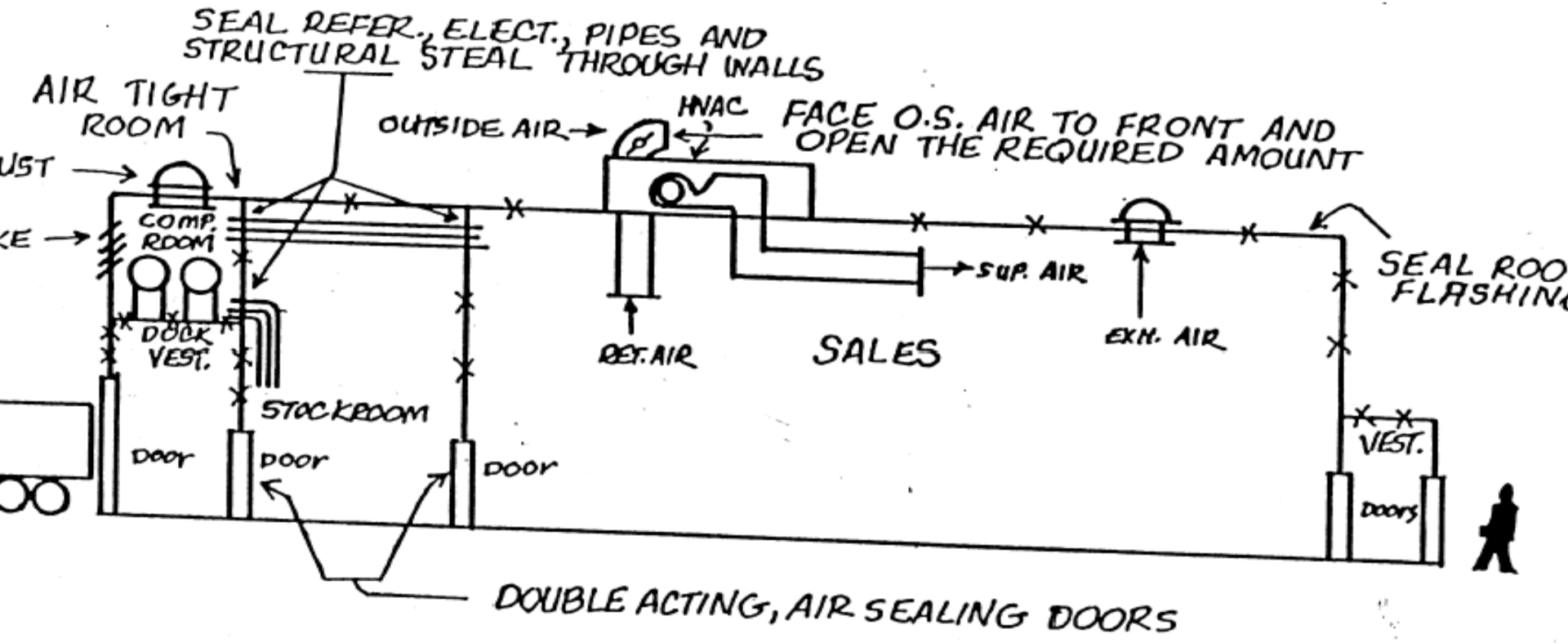
- A Building Design Program for Utility Energy conservation
- This is a paper that was written back around 1985. It discusses the desire to bring in enough outdoor air that the building will have a slightly positive static pressure so that any air coming into the building will be treated air. Some of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



X = SEALED WALLS AND ROOF FLASHINGS

Air Entrances

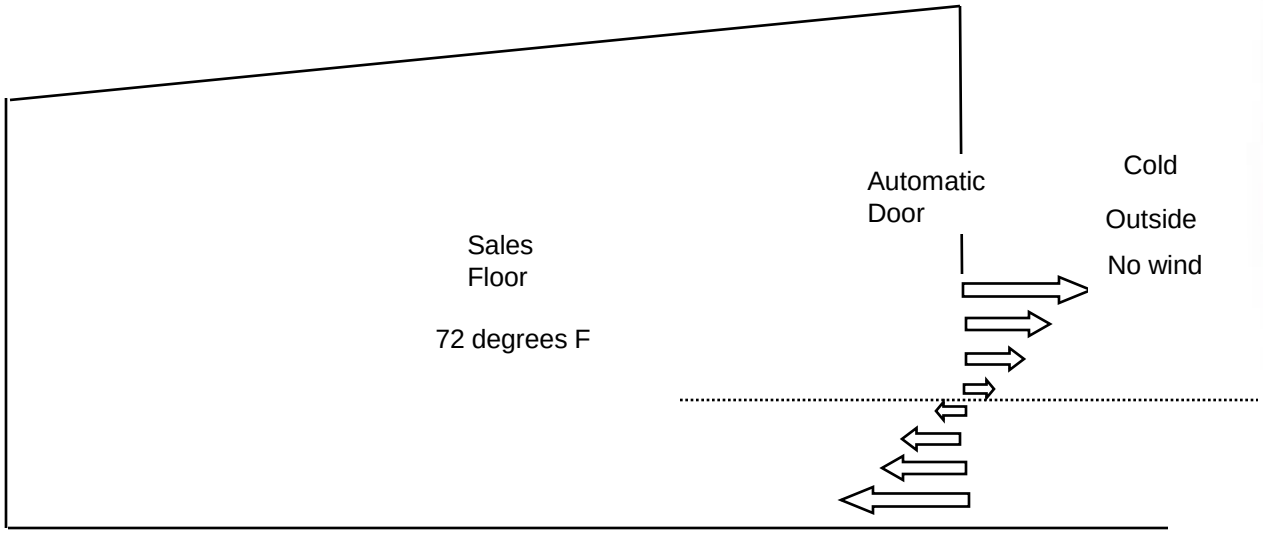
- An entrance way with no door, only an air curtain

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)

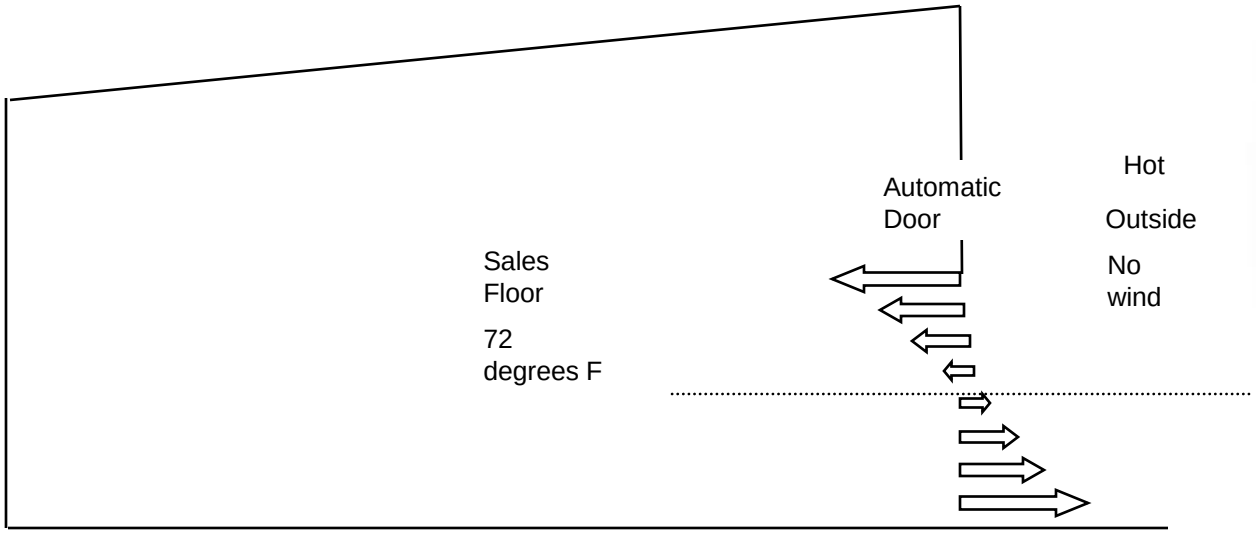
Thermal Door Tip Over

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 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 1/10 to 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 continous usage
- Note: bpm (bubbles per minute)

Air FlowTesting Equipment

Air Flow Equipment Distributor

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

NATIONAL CLIMATIC DATA CENTER
151 PATTON AVENUE ROOM 120
ASHEVILLE, NC 28801-5001
(NCDC)

PHONE : (828) 271-4800 INTERNET : orders@ncdc.noaa.gov
FACSIMILE : (828) 271-4876 WEB site : http://www.ncdc.noaa.gov

November 1998

CLIMATIC WIND DATA FOR THE UNITED STATES

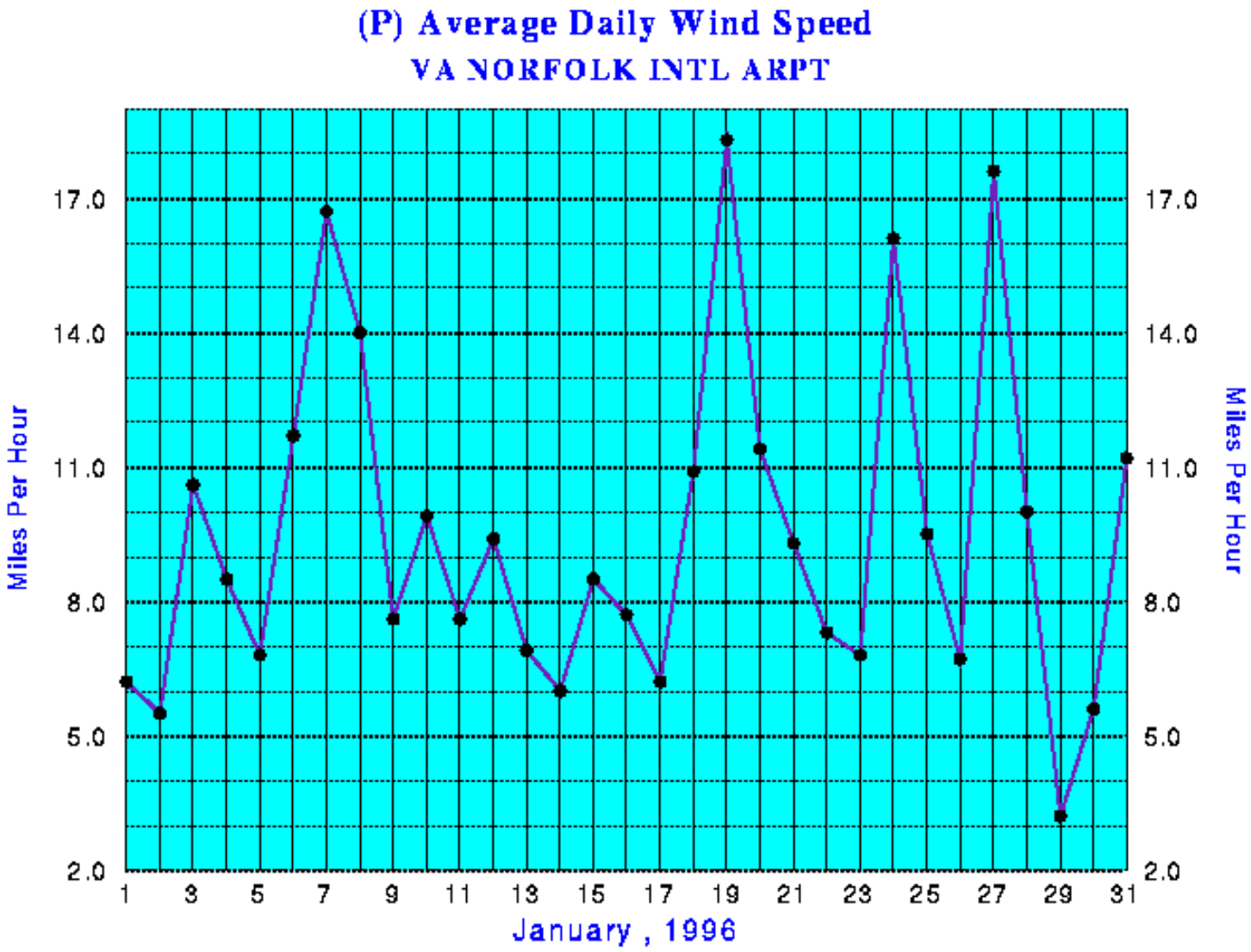
The climatic wind data contained in this summary was extracted from the NCDC's Local Climatological Data publication, Navy & Air Force climatic briefs, and other sources. Locations are not all inclusive and wind data may be available for sites not listed in this summary. The total period of this summary is 1930-1996. The period of record (POR) for which wind data is summarized varies for individual sites and may begin and end at any time during the 1930-1996 period. All available wind data is provided regardless of POR or source. Updated data for many sites can be obtained from post 1996 Local Climatological Data annual publications.

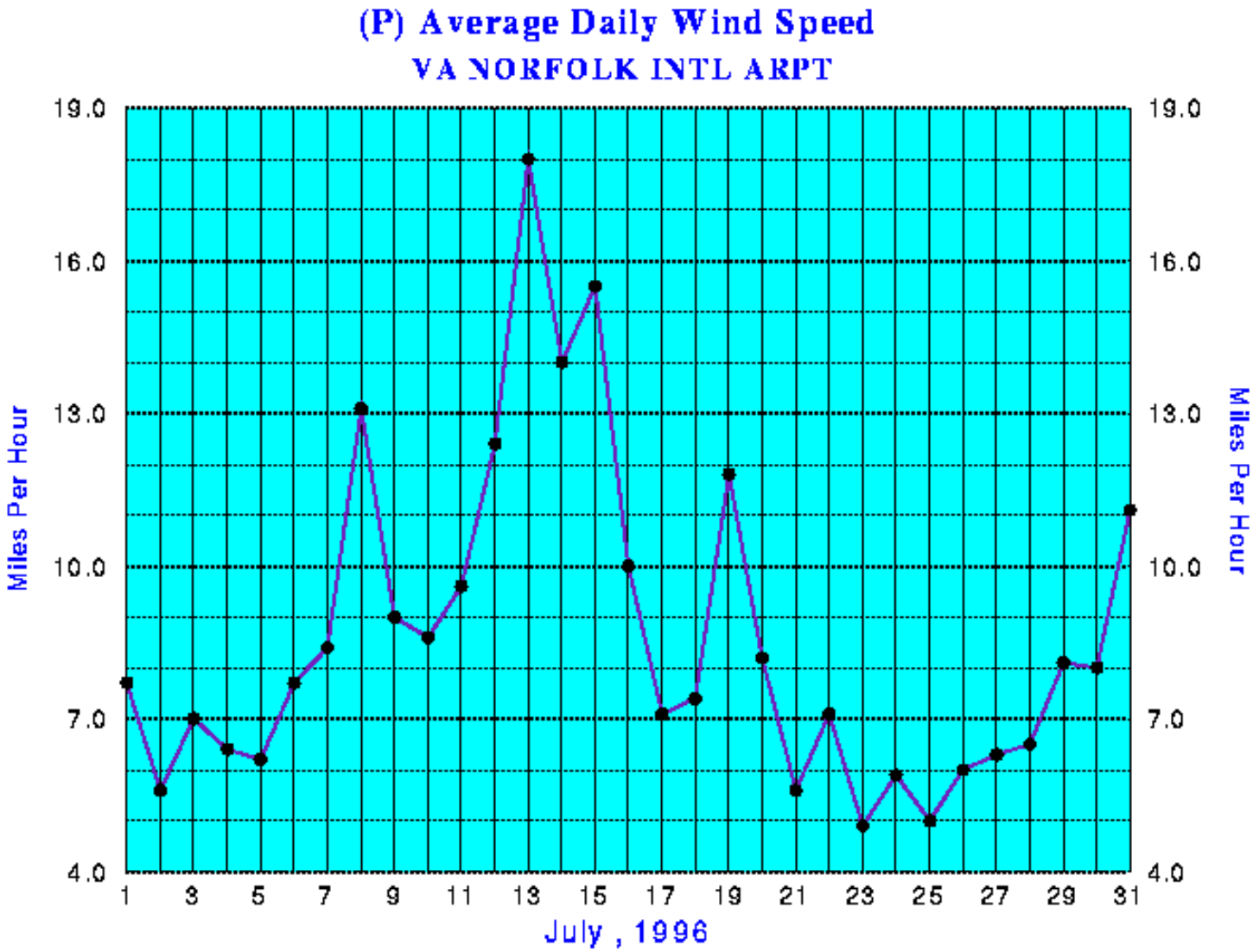
In the table, prevailing wind directions (DIR) are given in compass points; mean wind speeds (SPD) and peak gust (PGU) are in miles per hour (mph). When peak gust (PGU) wind velocities are not available, fastest-mile or 5-second winds may be substituted. This will be indicated by a $ for fastest-mile and # for 5-second winds preceding PGU (ie: $PGU = fastest-mile winds). Wind types may be combined to reflect the highest reported wind. When appropriate wind data is not available, an N/A will appear in lieu of data.

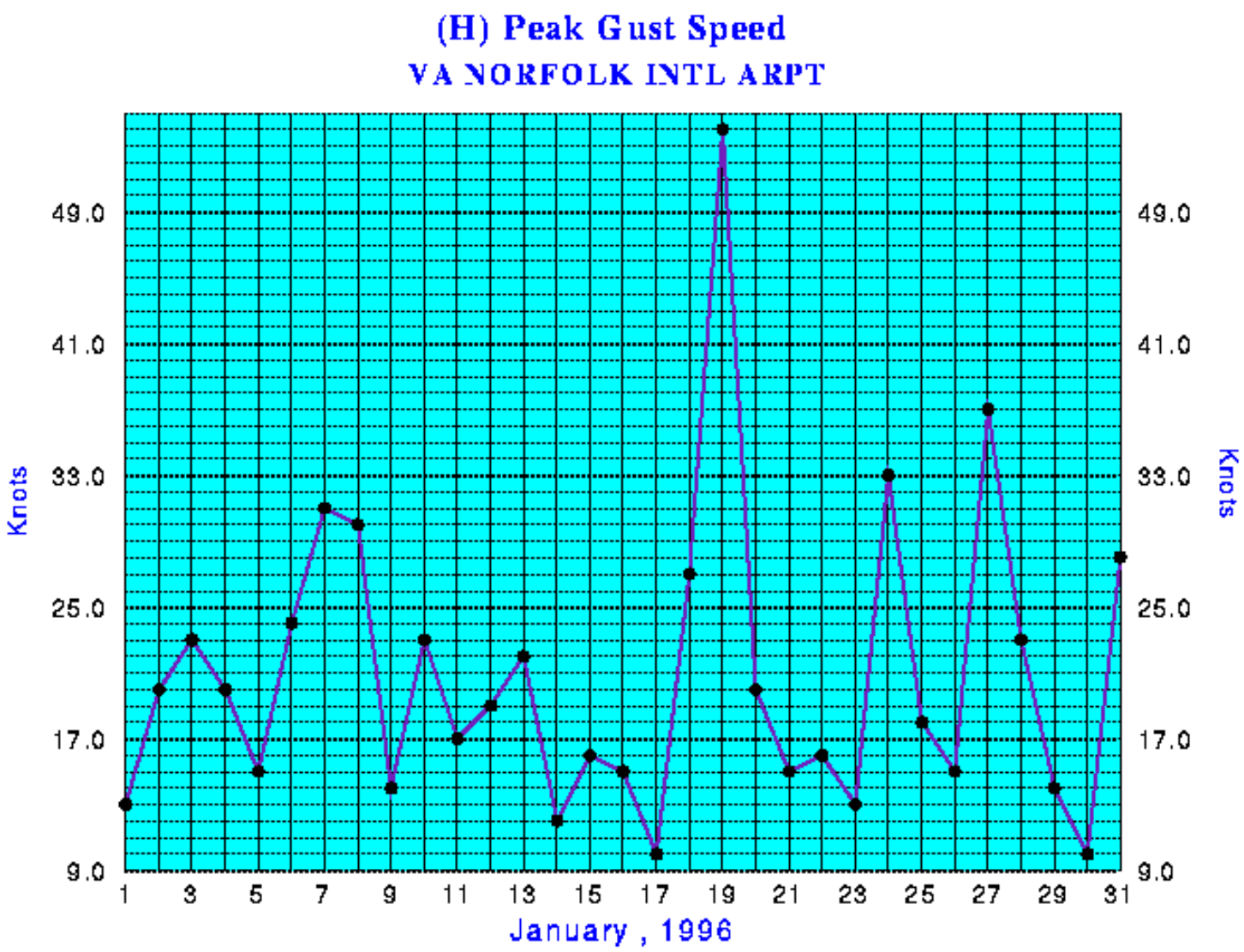
Conversion tables of miles per hour to knots and compass points to degrees are provided at the end of this wind table.

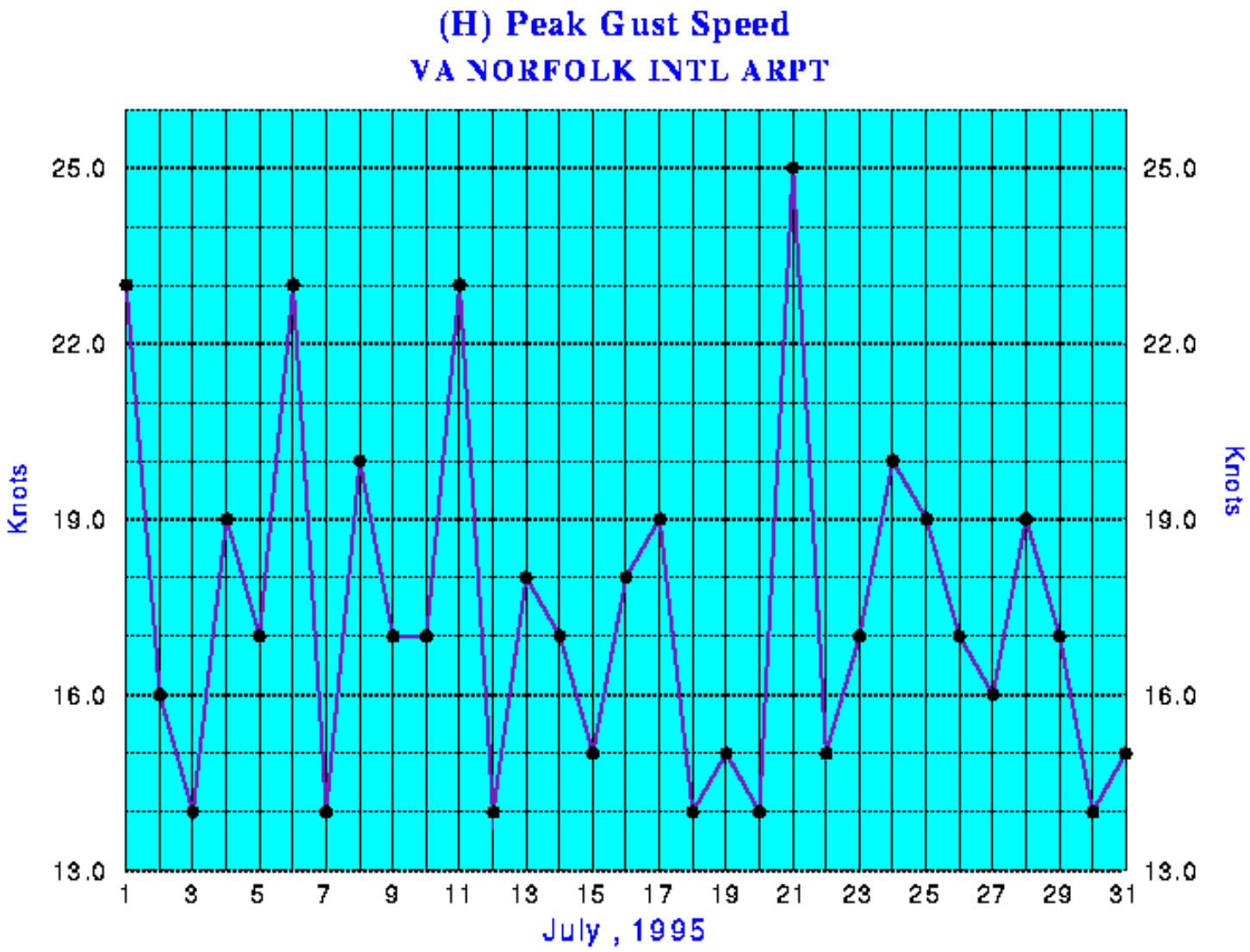
NCDC for Selected Cities

		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
Miles Per Hour
17.0
14.0
11.0
8.0
5.0
2.0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
January , 1996


(P) Average Daily Wind Speed
VA NORFOLK INTL ARPT
Miles Per Hour
19.0
16.0
13.0
10.0
7.0
4.0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
July , 1996


(H) Peak Gust Speed
VA NORFOLK INTL ARPT
Knots
49.0
41.0
33.0
25.0
17.0
9.0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
January , 1996


(H) Peak Gust Speed
VA NORFOLK INTL ARPT
25.0
22.0
19.0
16.0
13.0
Knots
1
3
5
7
9
11
13
15
17
19
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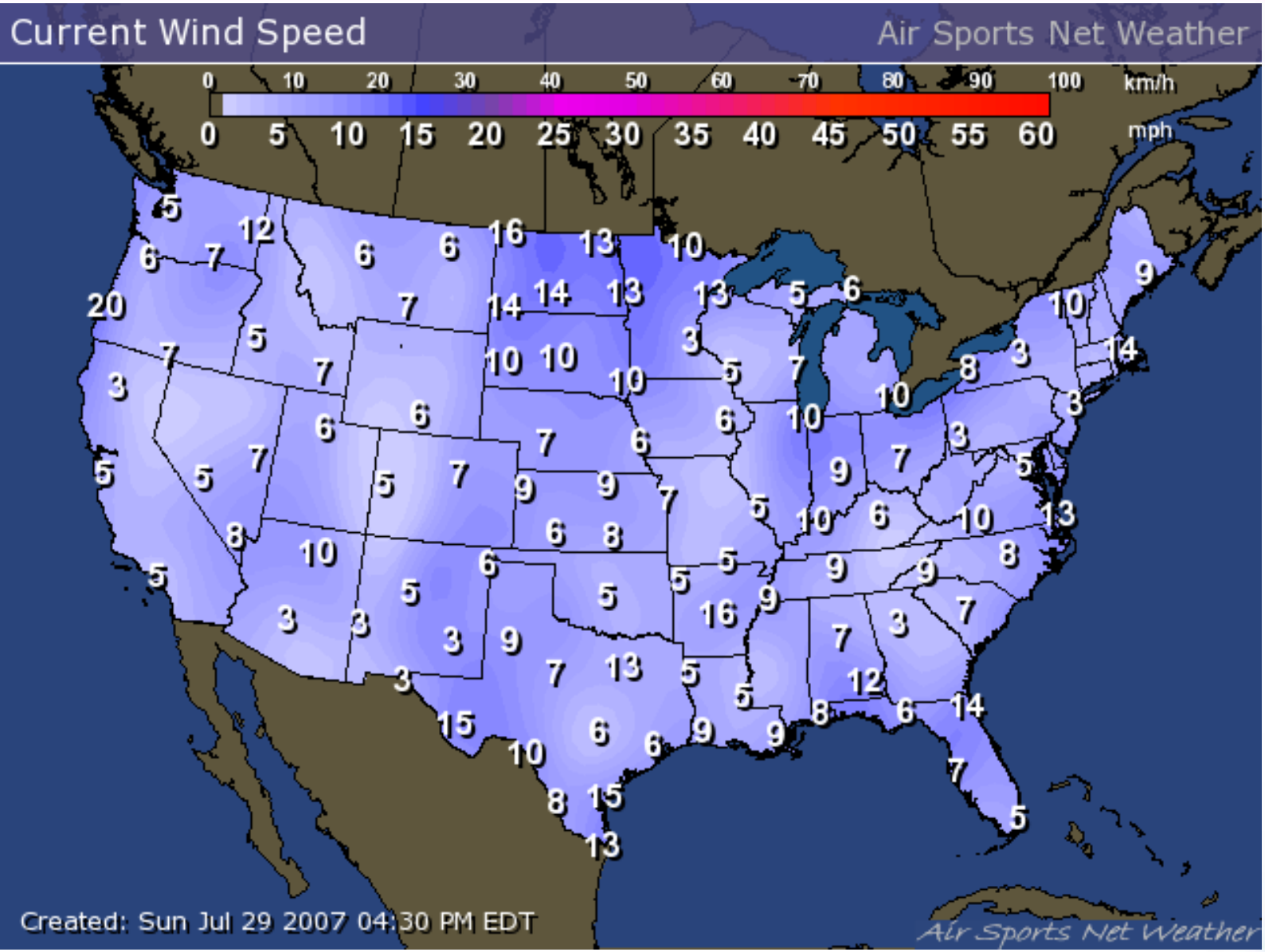
23
25
27
29
31
July , 1995

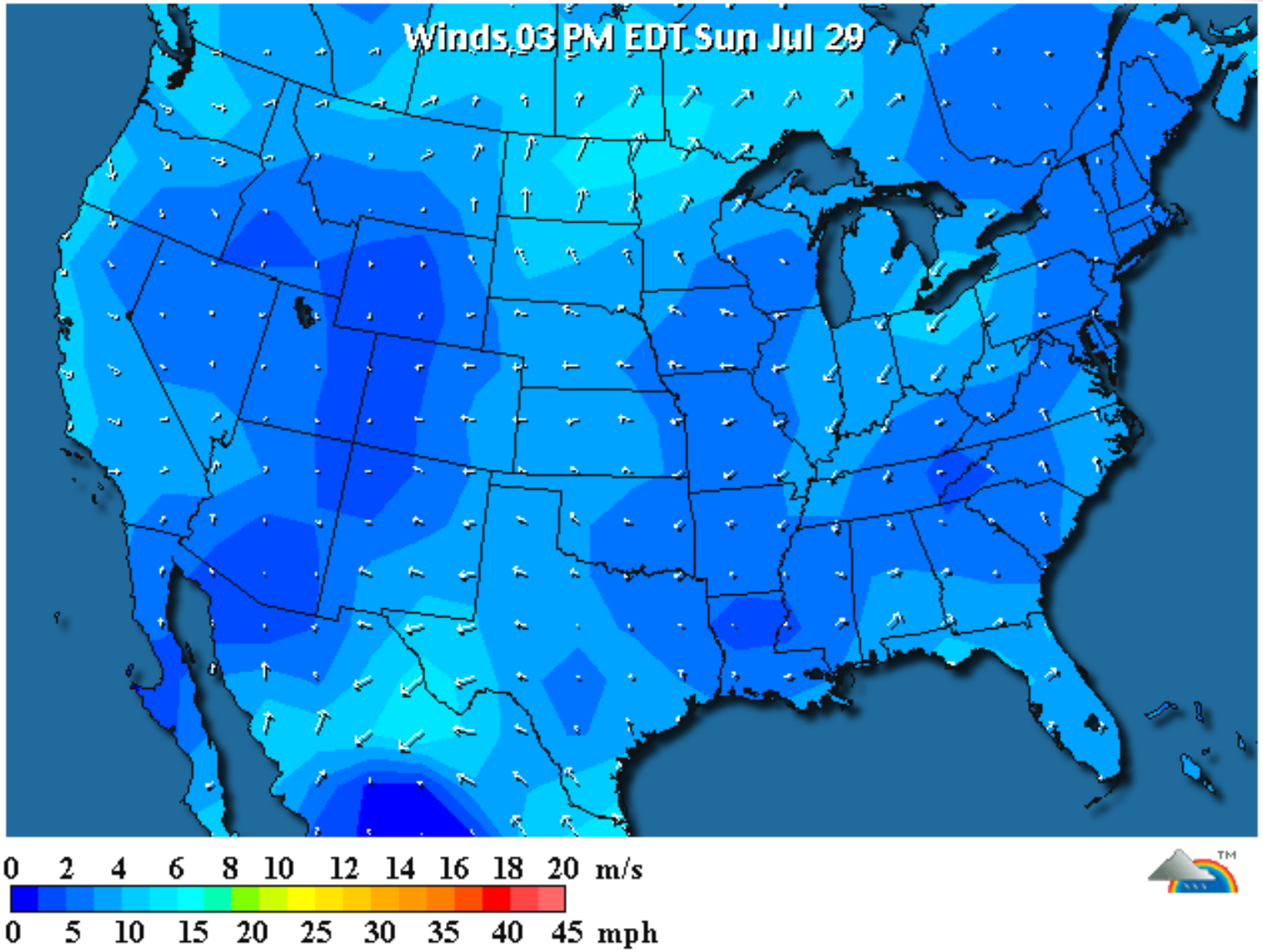
The National Average Wind Speed

- 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



www.wunderground.com



CFM of air entering a door

- Assume 10 miles per hour (mph)
- (10 mph)*(5280 ft/mile)/(60 min/Hour) = 880 ft/min
- The door opening is 5 ft x 7.5 ft = 37.5 sq ft
- This means (880 ft/min)*(37.5 sq ft) = 33,000 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 sq ft * 0.75 cfm/sq ft = 33,750 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

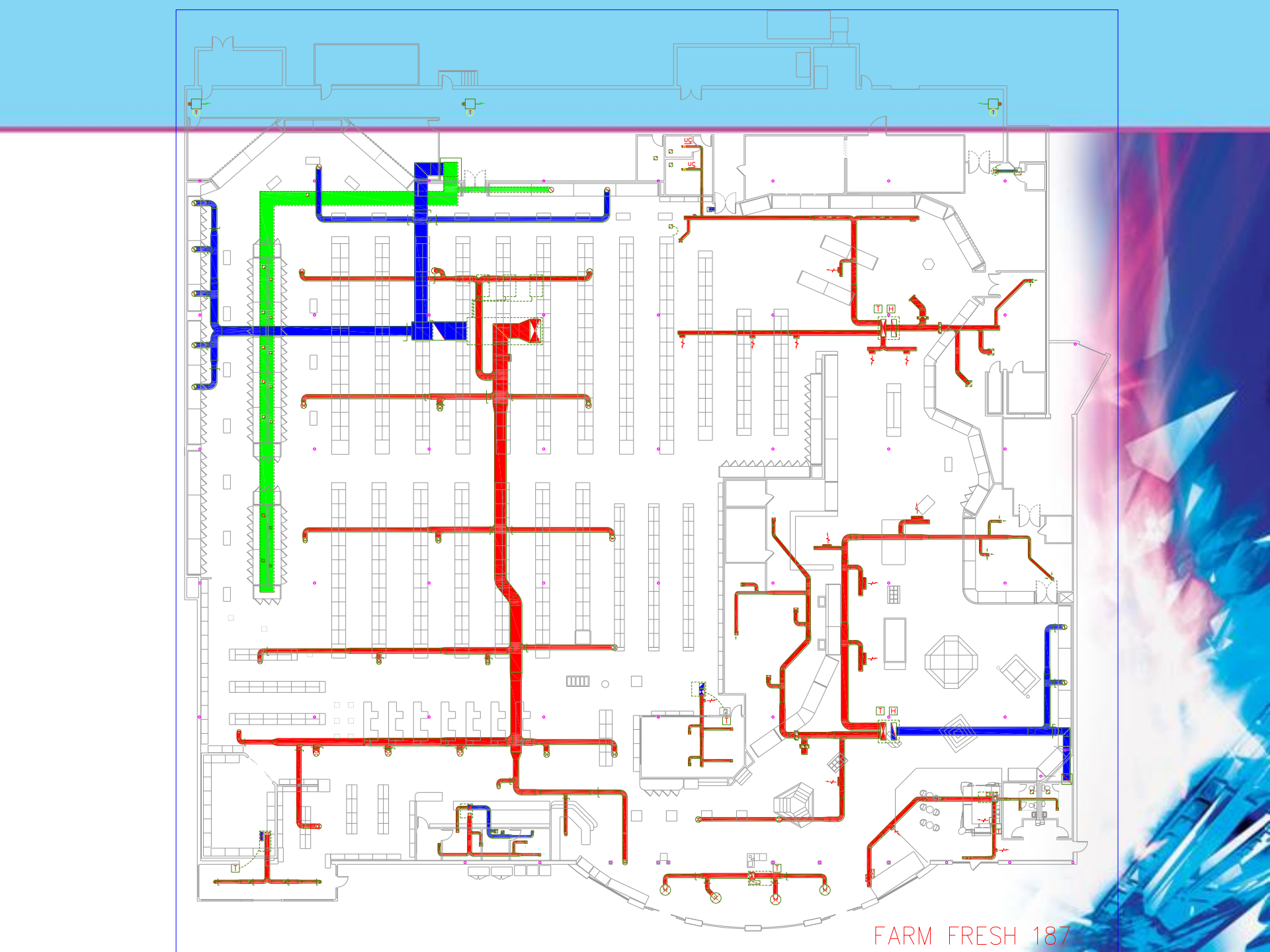
How long does it take to catch up from a 10 mph wind gust in a building that is positive?

- 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

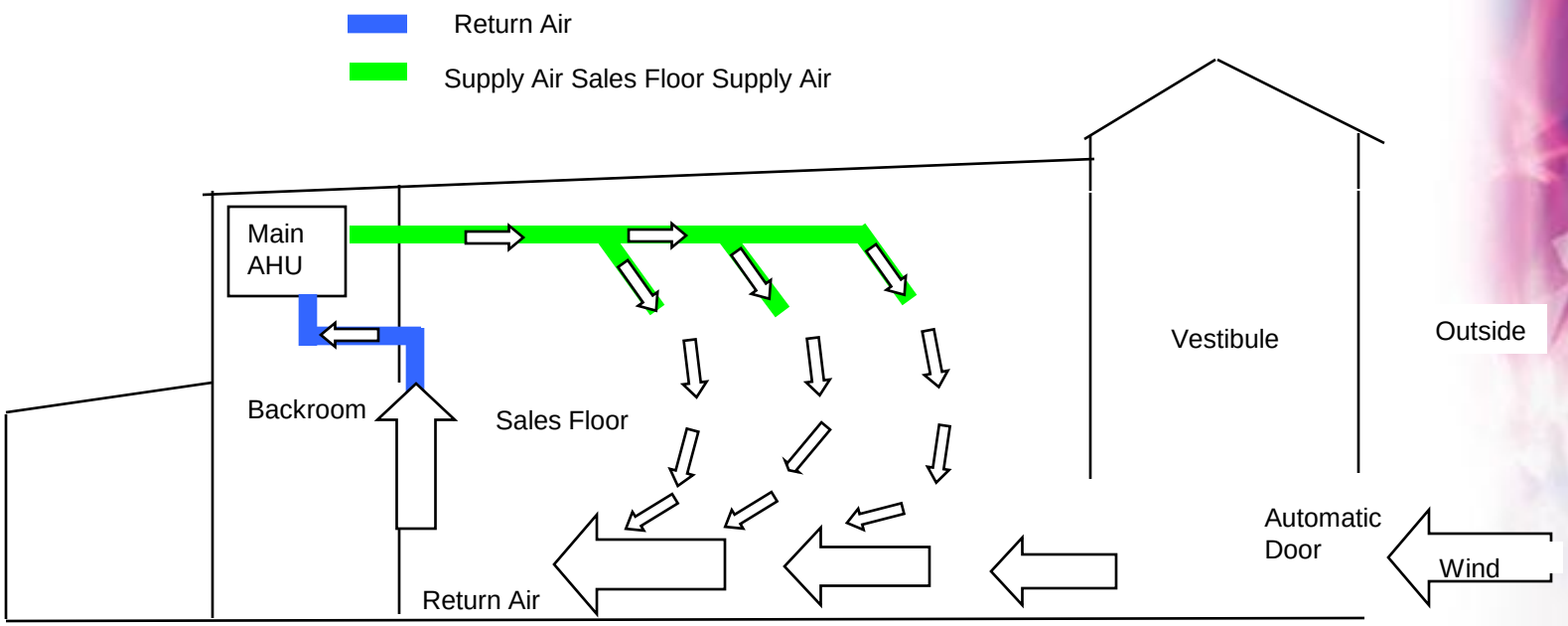
- Under case returns in the cold isle where possible or return air under island frozen food cases
- Return air was returned over the open cases when that was not possible
- Main HVAC AHU would generally be located at the back of the store with short return air ducts and there would be multiple medium 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


FARM FRESH 187

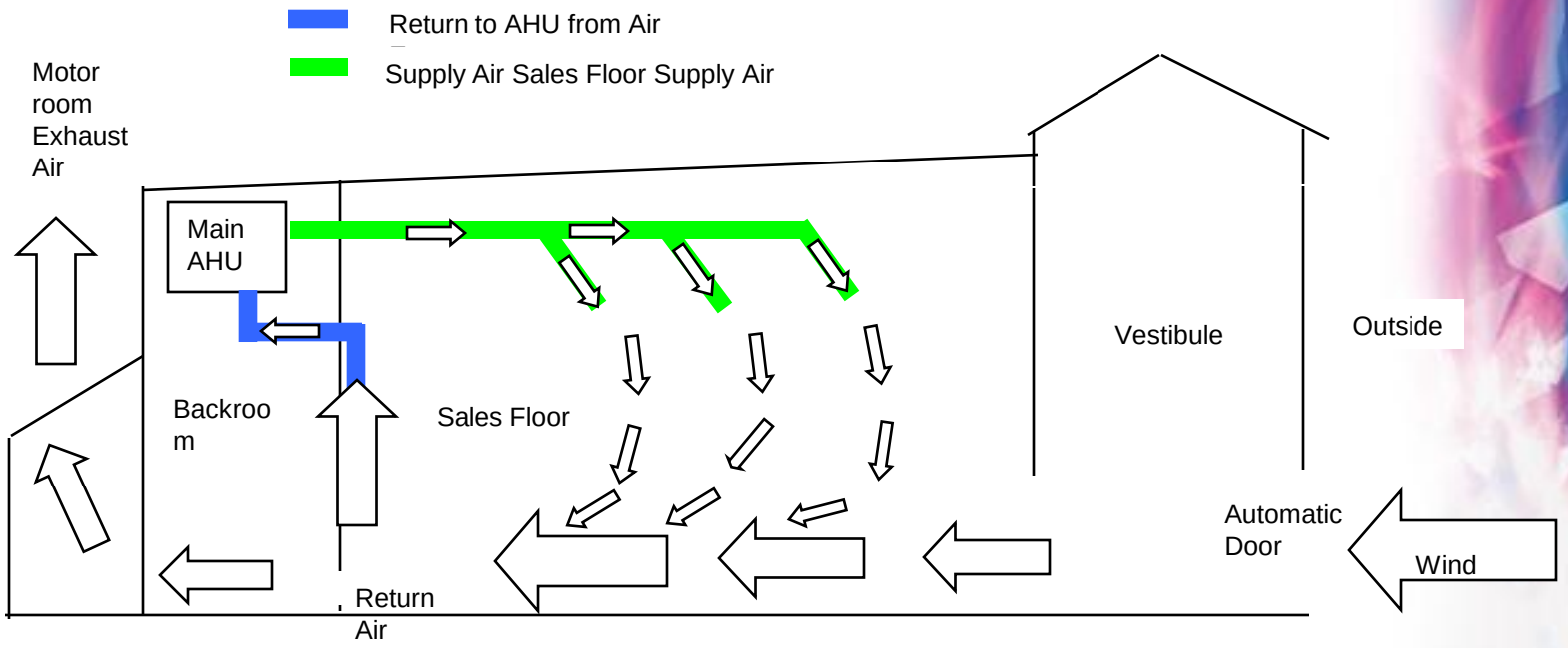
Previous design cont.

- 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 though the dairy cooler doors whenever they were open.

Previous Pattern of Air Flow



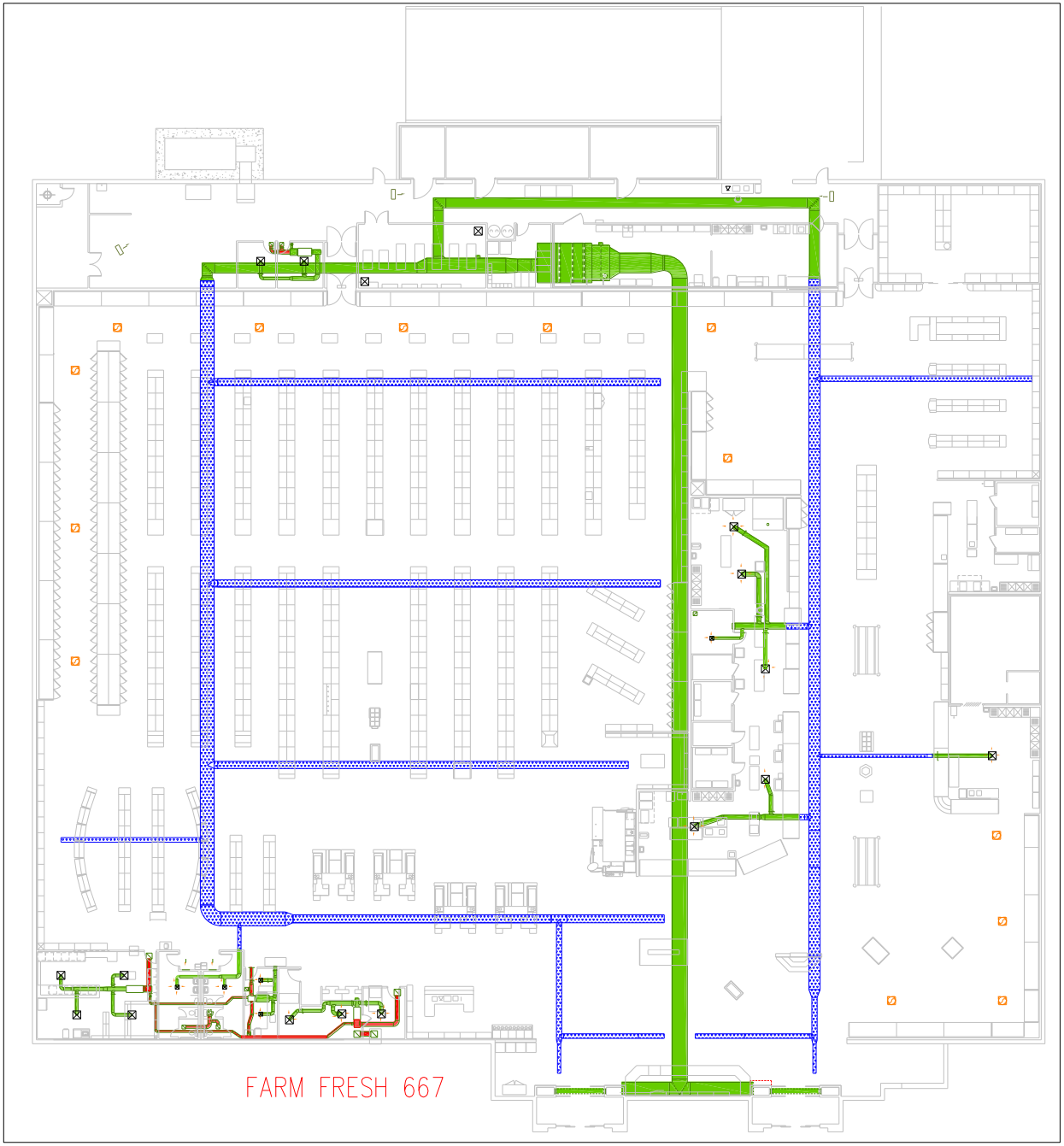
Previous Pattern of Air Flow with Motor room



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 envelops completely

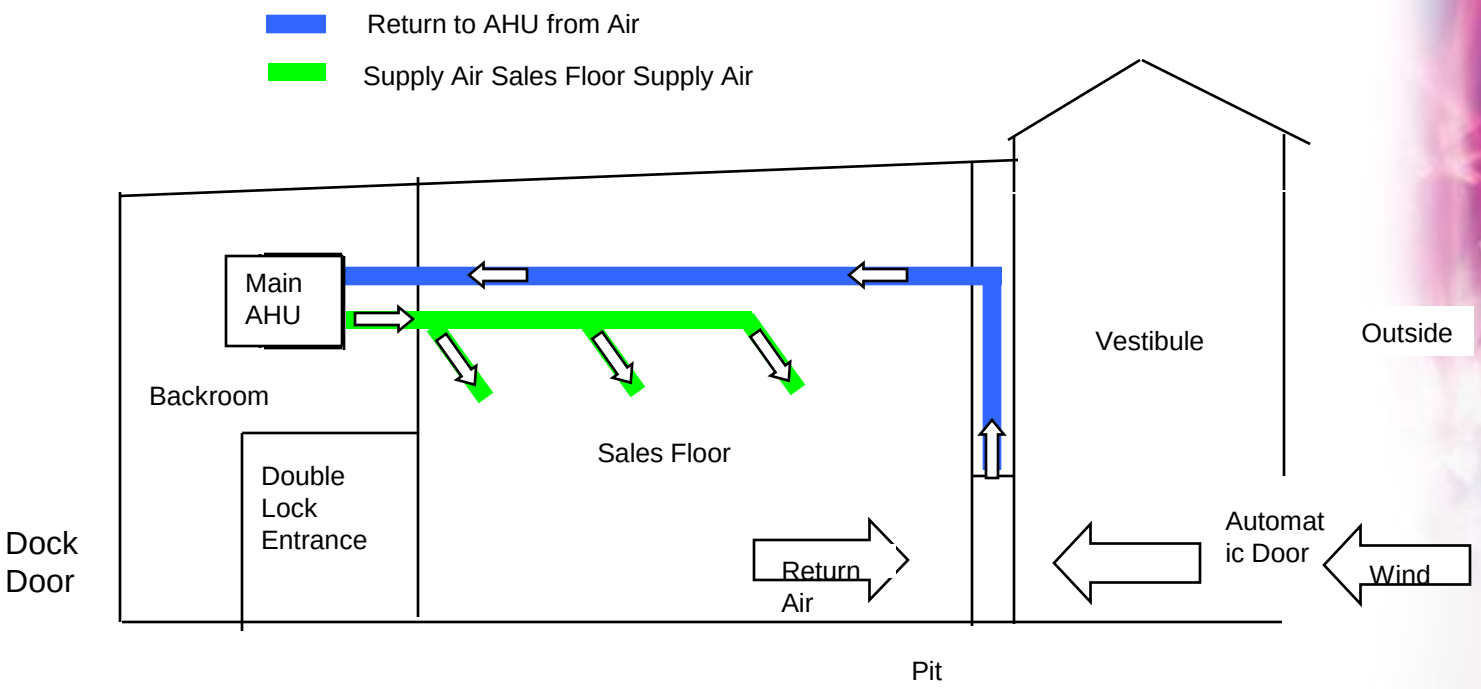

Farm Fresh
Food & Pharmacy
1464


FARM FRESH 667

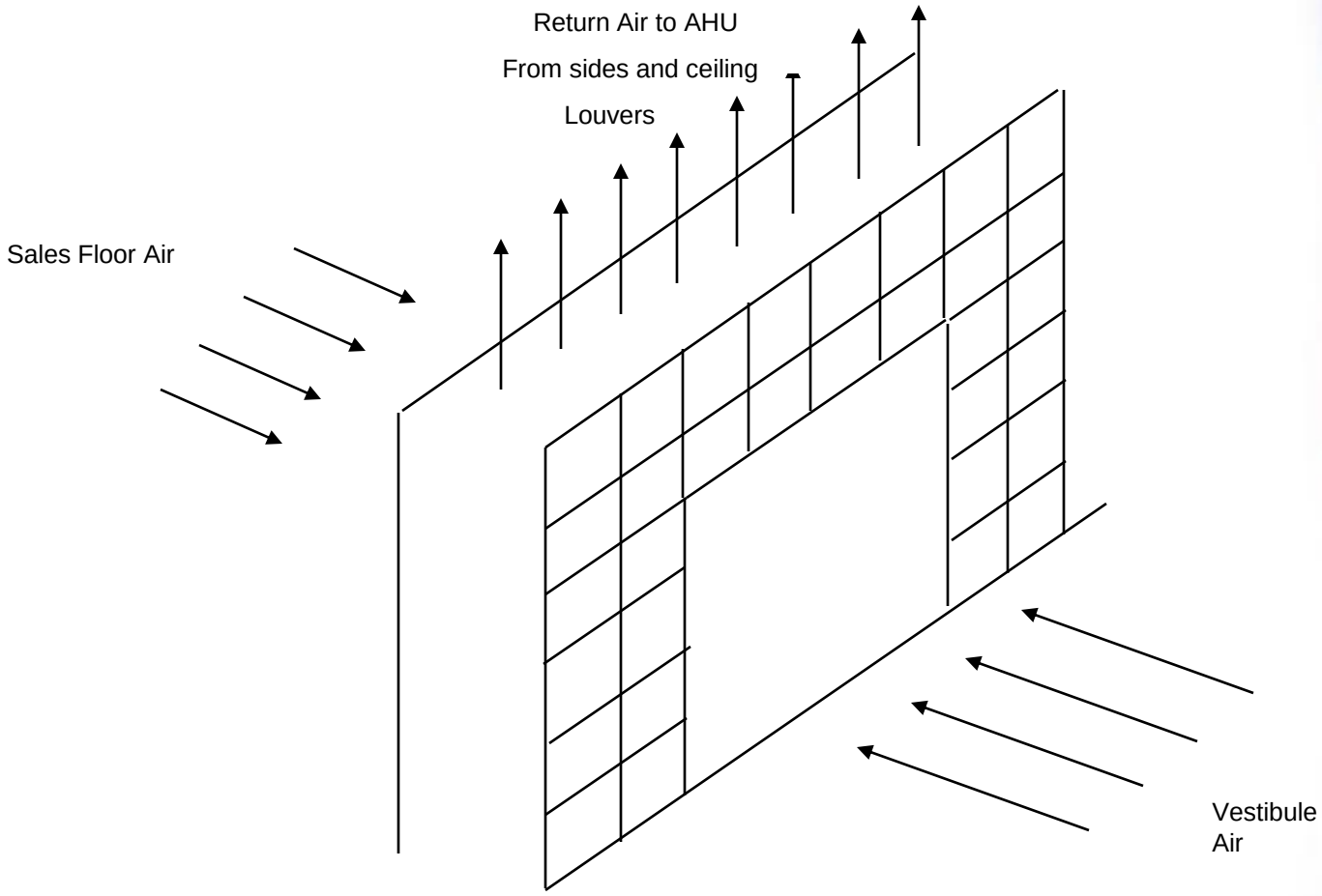
Why One Main AHU?

- 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



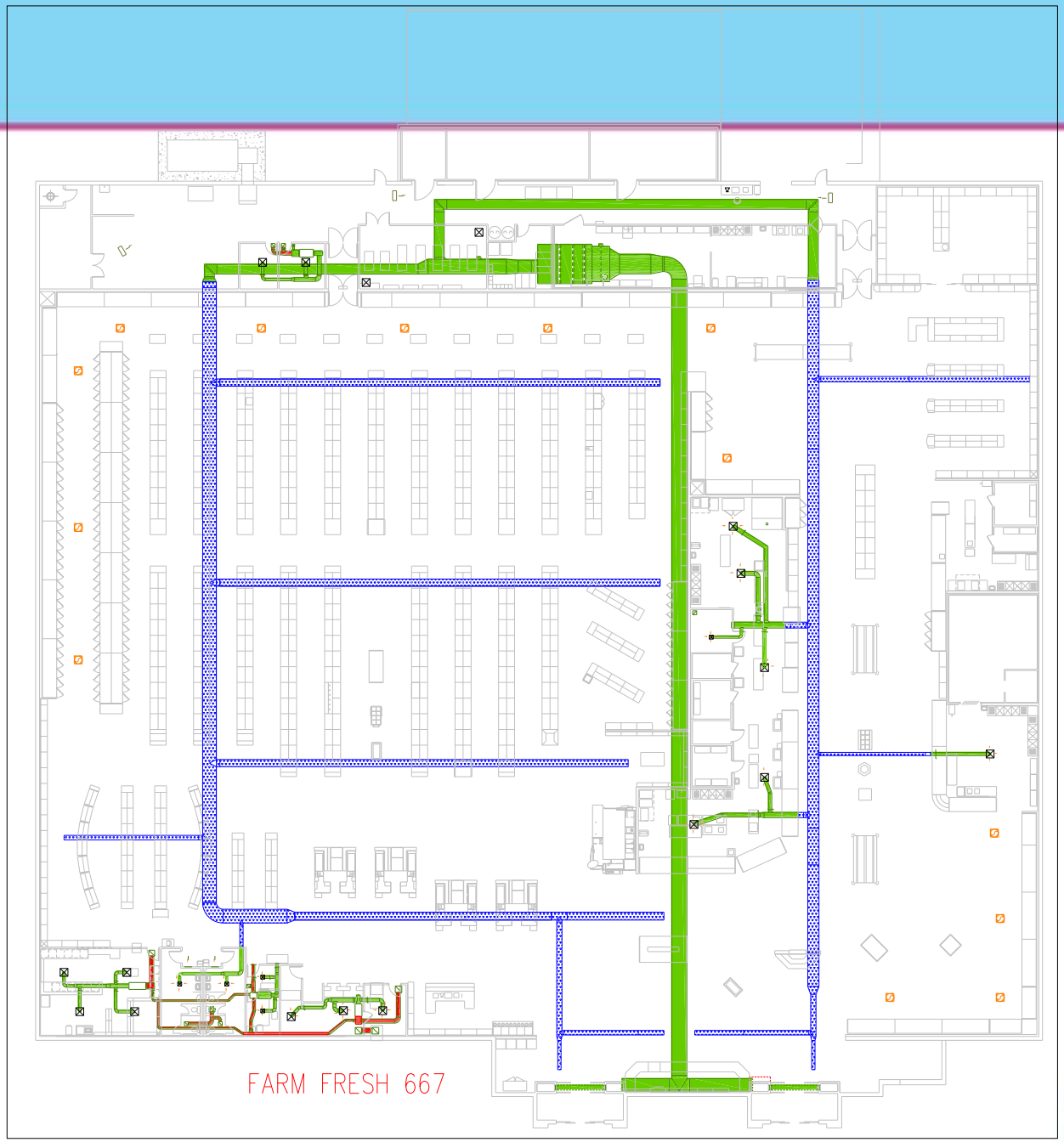
Explanation of Reverse Return Air

- 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


AUTOMATIC
CAUTION
DOOR
Welcome to
Farm Fresh
AUTOMATIC DOOR - STAND CLEAR
Open
6 am
to
Farm Fresh
CONVENIENT SERVICES FOR YOUR EVERY NEED
LOTTO
TICKETMASTER
ATM
Machine
No Soliciting
No Smoking
Salad
Bar


Farm Fresh
EXIT
EXIT
Farm Fresh
Thank You
For Shopping
With Us Today.

- Show video MU00162 & MU00182

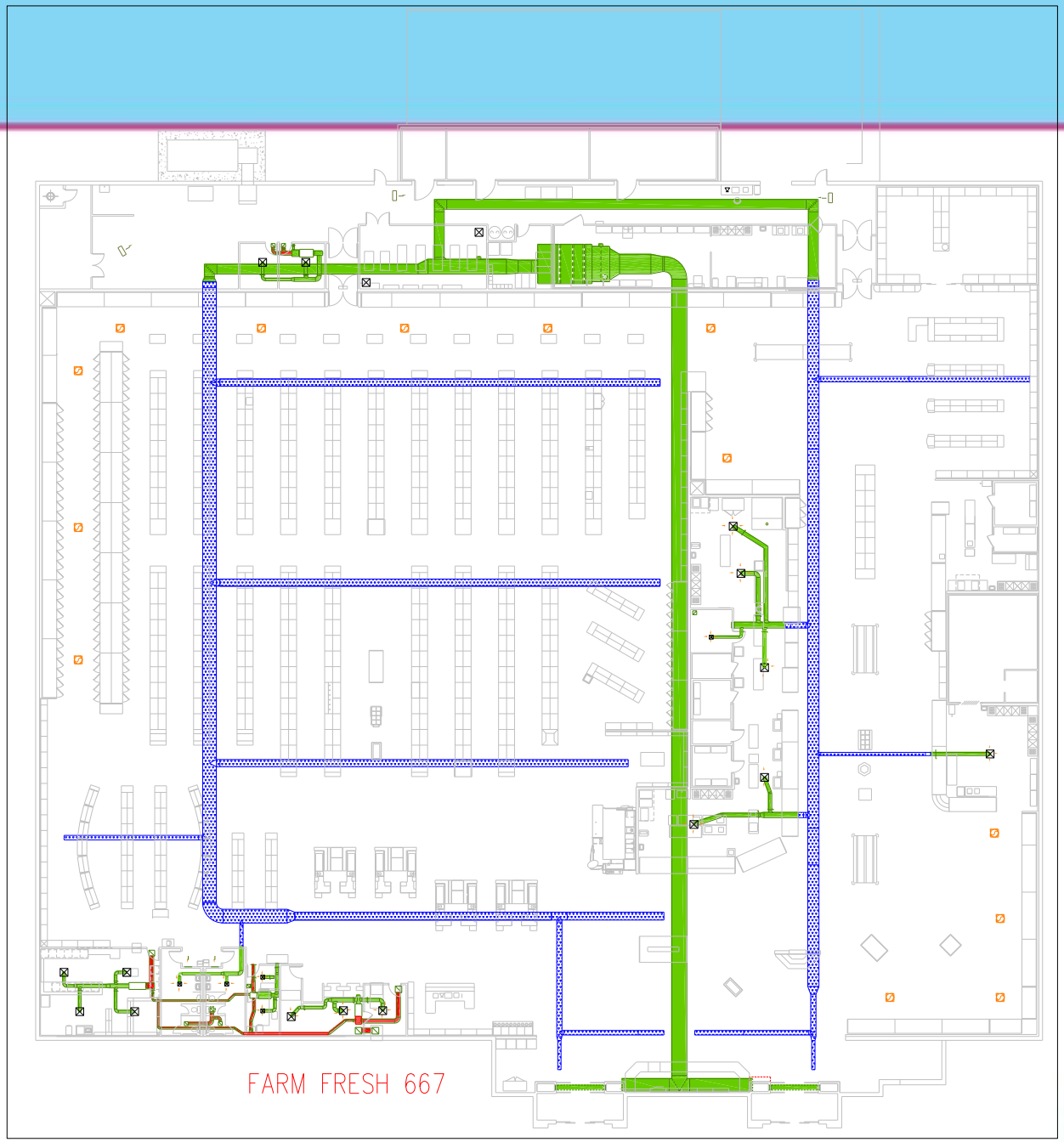

FARM FRESH 667


World Wide Money Transfer
TravelersExpress
MoneyGram
Farm Fresh
CUSTOMER


2 Farm Fresh 2
MIXERS
ROOT BEER
SPORT DRINKS
POWDERED DRINKS
DRINKS
diet PEPSI
2 $5


Ground Beef
USDA Choic
Jimmy Dean
SMITHFIELD
Gold Kist Farms
99¢
SMITHFIELD
Pork
Farm Fresh
USDA A GRADE
Poultry
Farm Fresh
FRESH
NOT


Farm Fresh
QUALITY
Dole


FARM FRESH 667


Salad Bar
Farm Fresh
Boars Head
Artisan Breads
Farm Fresh

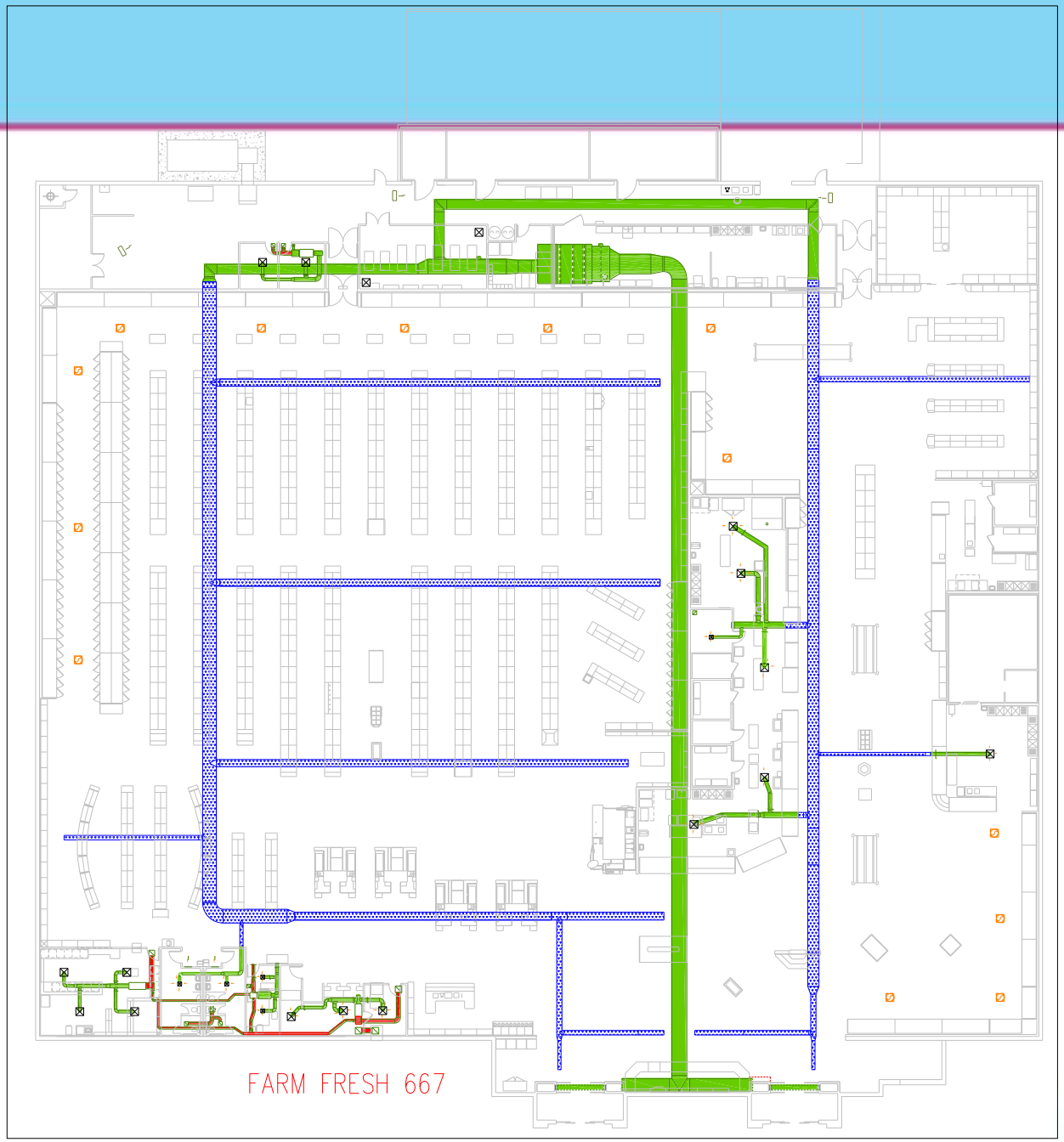

Fresh Dairy
Farm Fresh
YOPLAIT
DANNON
STONYFIELD FARMS
JELL-O

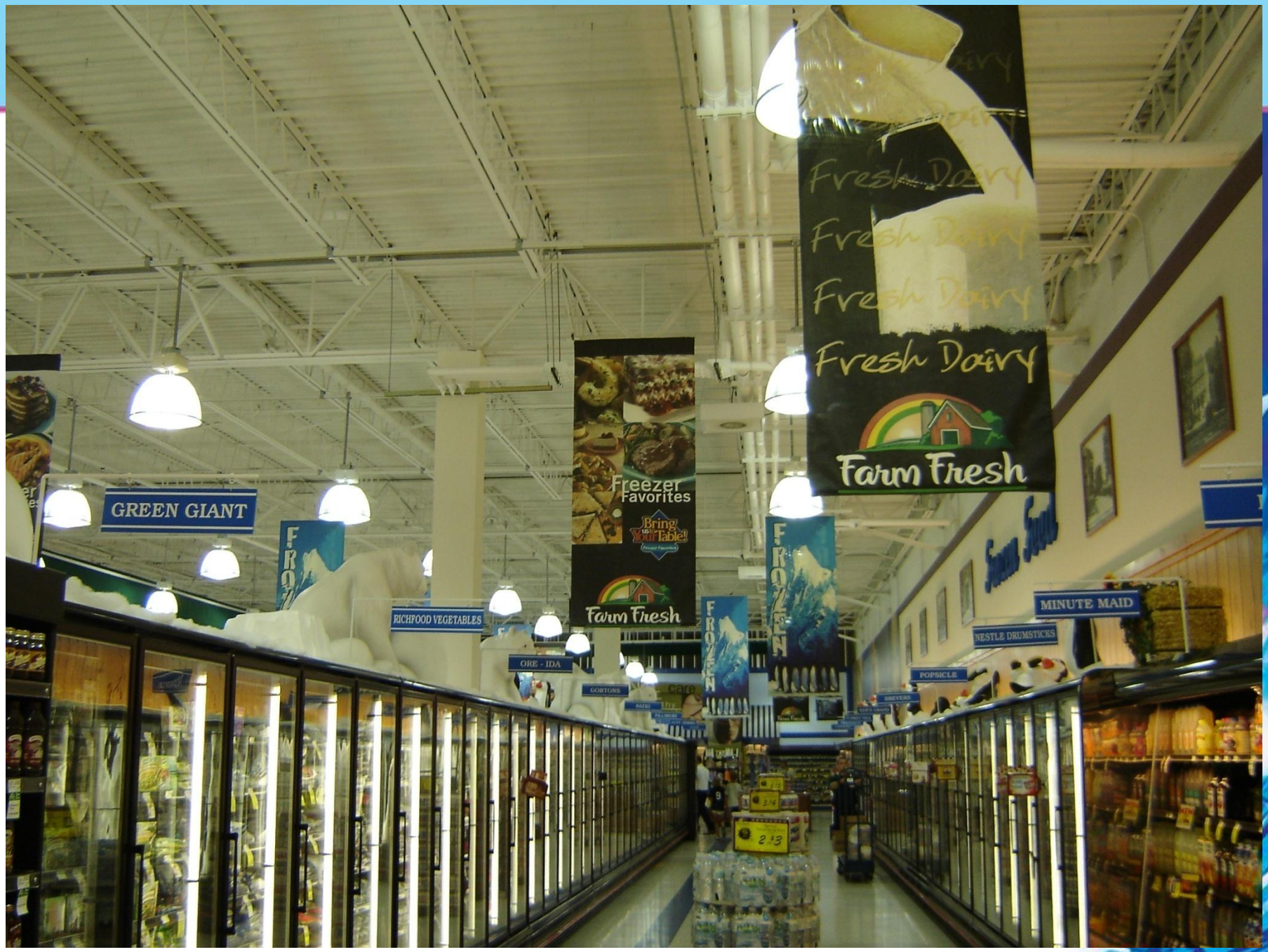

8
ITALIAN BREADS
TOMATO SAUCES
CANNED TOMATOES
OLIVE OILS
7
PASTA
ITALIAN ICE CREAM
OLIVES
COOKWARE
COOKING SAUCES
Farm Fresh

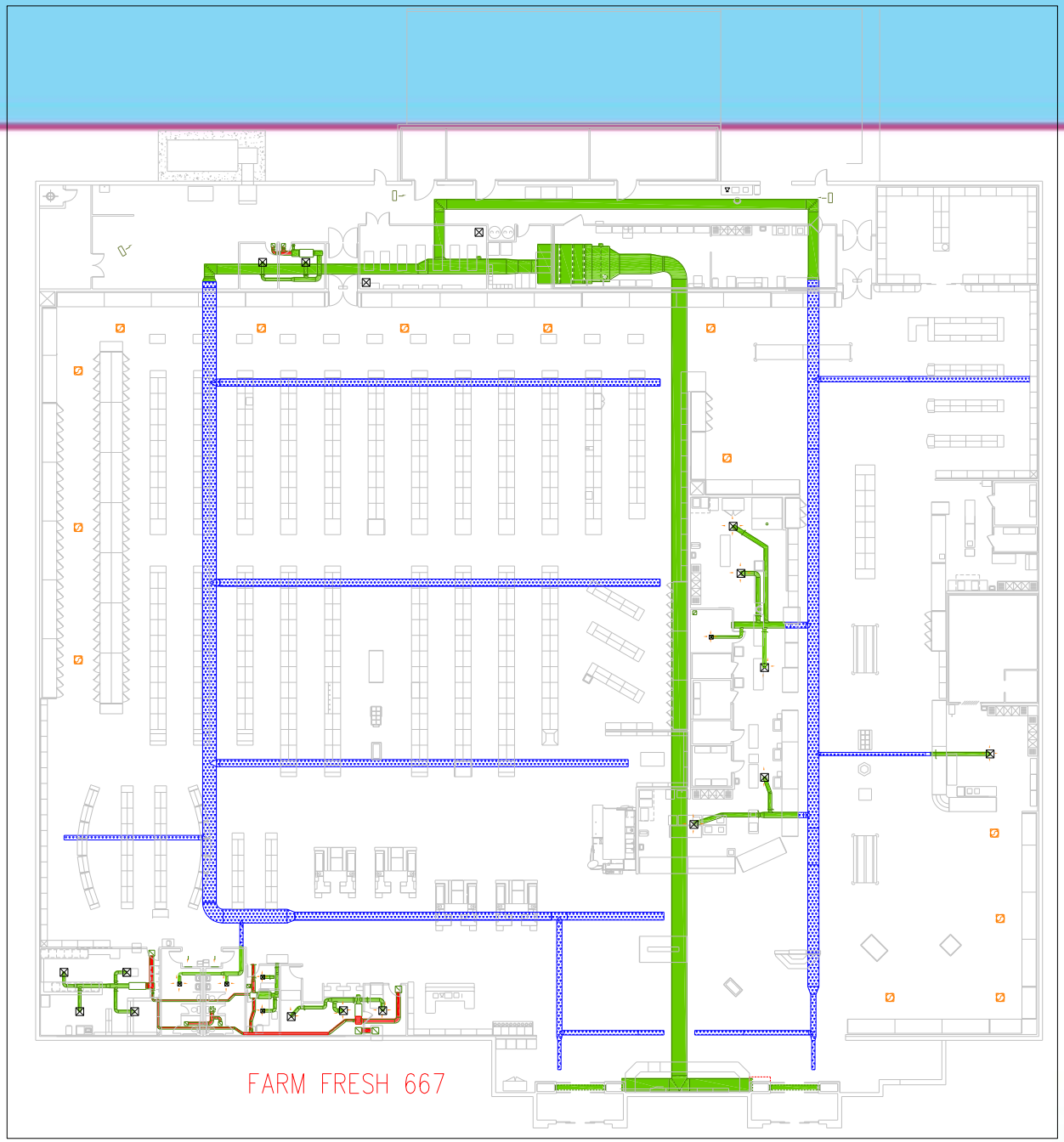

Scan Guarantee
We Guarantee our Scanning Accuracy
to be 100%
If an item scans higher you will receive the item
FREE!
Farm Fresh
Ad Guarantee
FREE!
Farm Fresh
Fresh Flowers
HIGH SCHOOL Spirit Wear
BRANCH HOURS
FULL SERVICE
MONDAY – FRIDAY
10AM – 7PM
SATURDAY

Down Blast Fans

- These deliver a targeted cone of air of about 1100 cfm to the floor in about an 18” diameter
- They de-stratisfy 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


FARM FRESH 667


GREEN GIANT
Freezer Favorites
Bring it to your Table!
Farm Fresh
Fresh Dairy
Farm Fresh
RICHFOOD VEGETABLES
ORE - IDA
GORTONS
FROZEN
MINUTE MAID
NESTLE DRUMSTICKS
POPSICLE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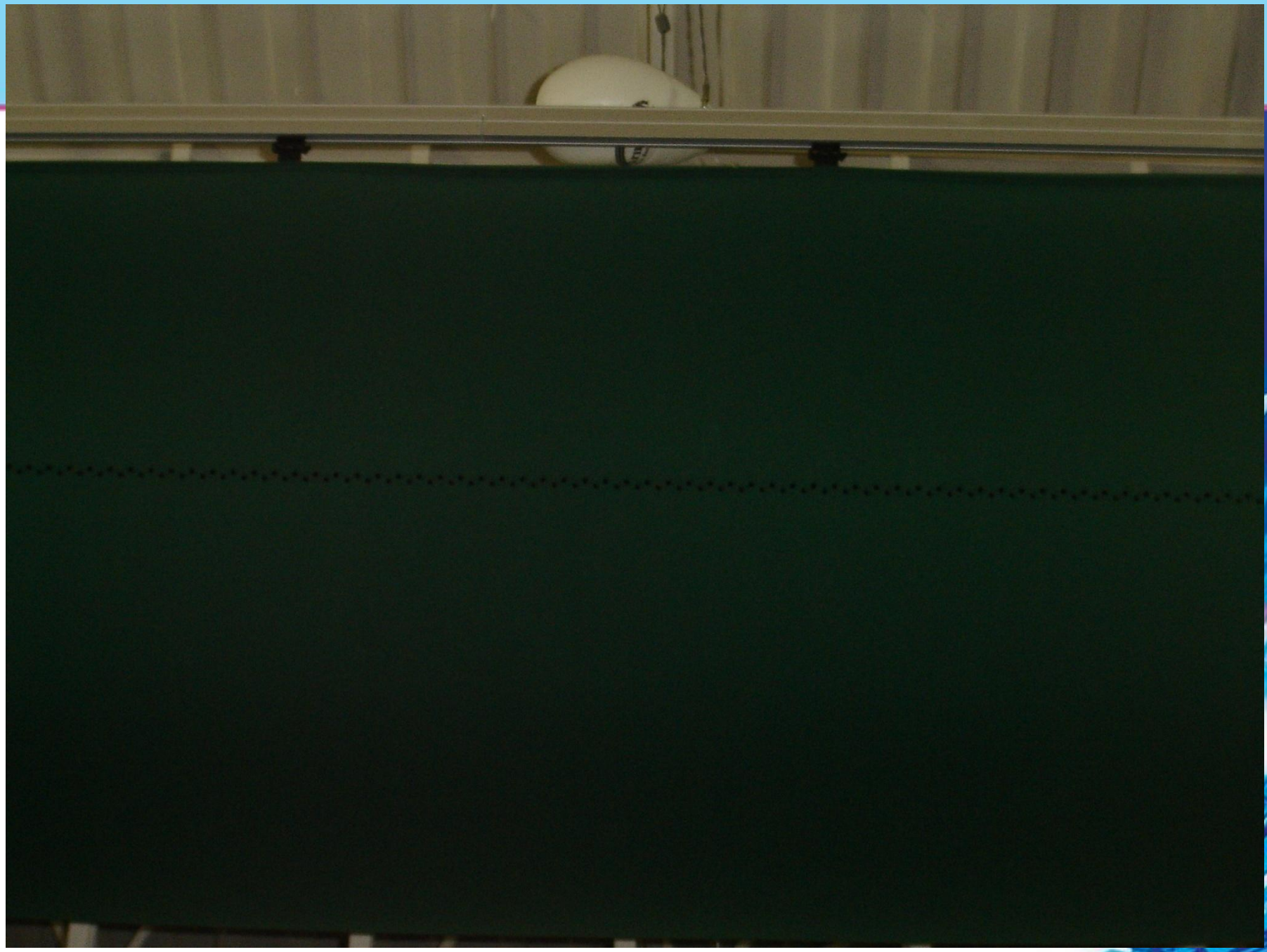
EXIT

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


BOHN



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)


Dole

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

- Flys can travel as fast as 5 mph
- When “hunting” flys travel between 0 and 5 feet above ground
- Flys prefer to fly into a slight breeze so they can smell food, but dislike winds stronger than 3 – 4 mph
- Flys 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