HIGH MERV FILTERS IN CENTRAL AIR HANDLERS: OPPORTUNITIES & CHALLENGES

2019 Nat'l Home Performance Conference

HVAC Strategies 3 3:30 - 5 PM; April 2, 2019

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Filtering Air with Residential Heating & Air Conditioning Systems

Simultaneously…

- ***Significant missed opportunity*** to reduce particles

- ***Major potential liabilities*** (energy use, emissions, energy cost, equipment life, & performance)

Our solutions reduce fine particles by 50-80% while minimizing potential liabilities

ROCIS *(Rock-us) or (Raucous)*

Reducing Outdoor Contaminants in Indoor Spaces

WWW.ROCIS.ORG

WHAT IS ROCIS ?

MISSION

A Southwestern Pennsylvania initiative to reduce the impact of exterior pollution in indoor spaces.

Pittsburgh's Air Quality is Poor[1]

People Most at Risk in the U.S.

…From Year-Round Particle Pollution (Annual $PM_{2.5}$)

- 7th worst city & worst city east of the Rockies
- Allegheny County (Pittsburgh) is 10th worst U.S. county

…From Short-Term Particle Pollution (24-hour PM2.5)

- 10th worst city[1] & worst city east of the Rockies

1. Pittsburgh-New Castle-Weirton (PA-WV-OH)

SOURCE: American Lung Association State of the Air Report 2019
https://www.lung.org/assets/documents/healthy-air/state-of-the-air/sota-2019-full.pdf

ROCIS Monitoring Cohorts

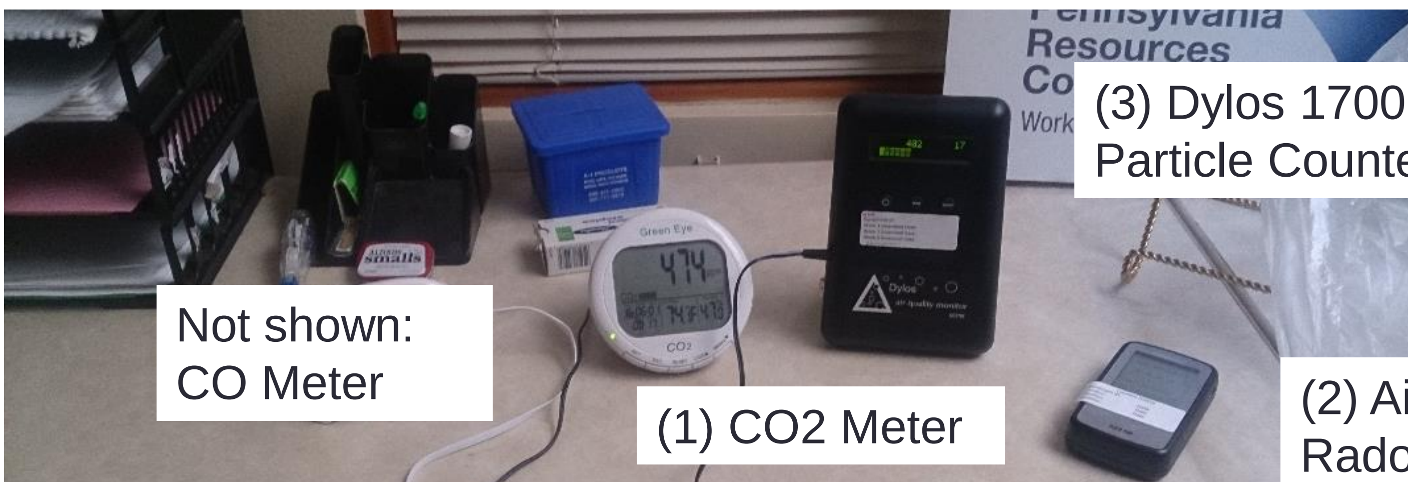
- Initial 3-4 weeks – home or workplace
- Longer term monitoring with interventions
- 250+ participants to date

2 Particle sizes

0.5+ µm

2.5+ µm

Count per 1/100 Ft^3

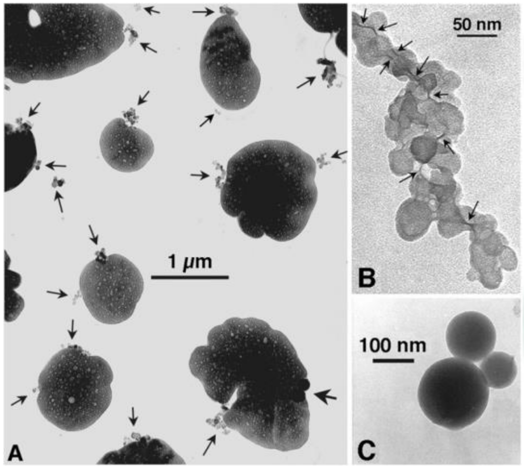


(3) Dylos 1700 Particle Counter

(2) AirThings Radon Monitor

Not shown: CO Meter

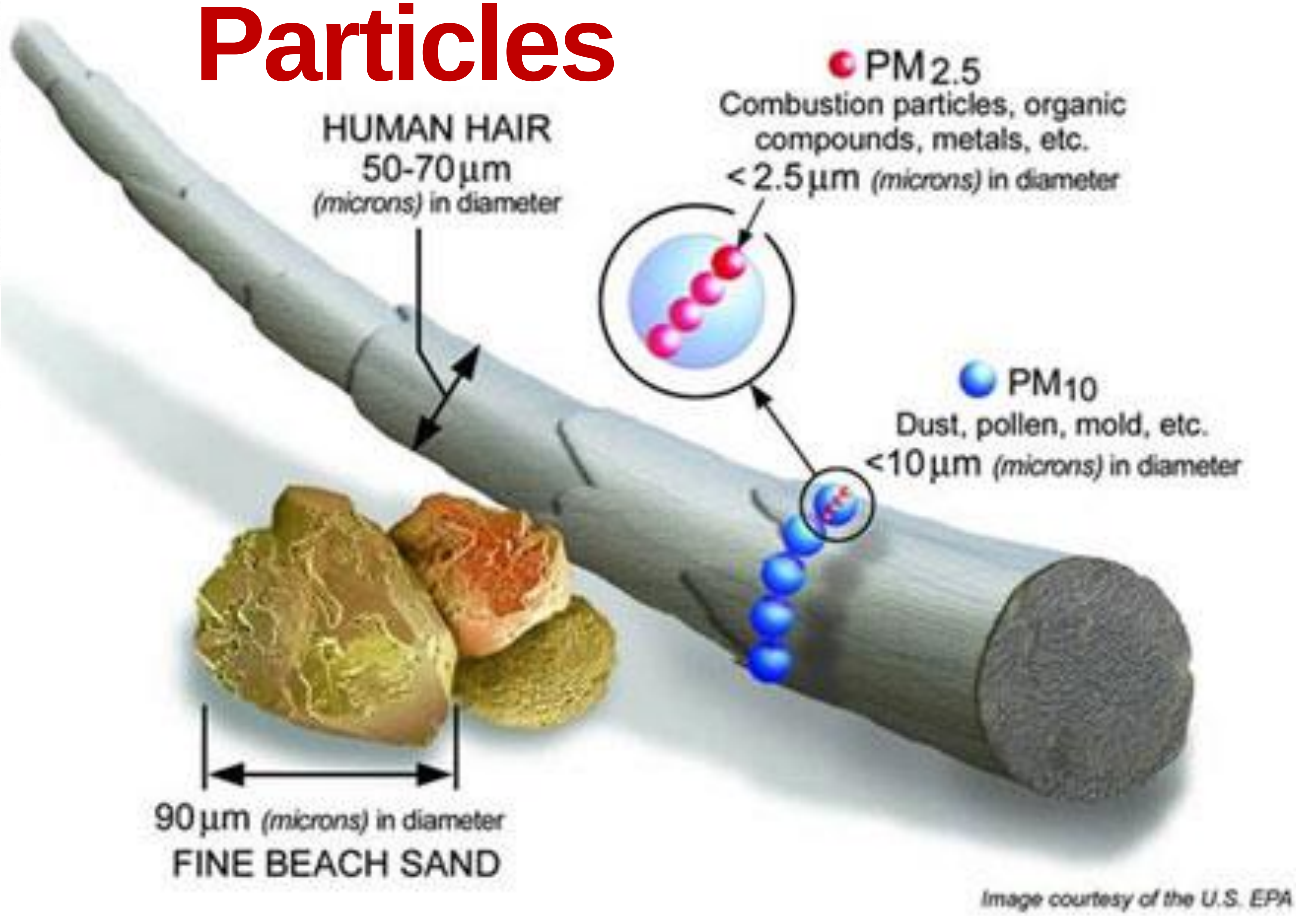
(1) CO2 Meter



OUTDOOR BLACK CARBON

50 nm to 1 μm

Particles



PM_{10}: Particulate matter less than 10 μm in diameter

$PM_{2.5}$: Particulate matter less than 2.5 μm in diameter

ROCIS LCMP Dylos: $PM_{0.5}$+: Particles ***greater than*** 0.5 μm in diameter (1/100 of human hair!)

ROCIS Outdoor Data (70 mile spread) - Readings track

Log scale

V Poor >3000

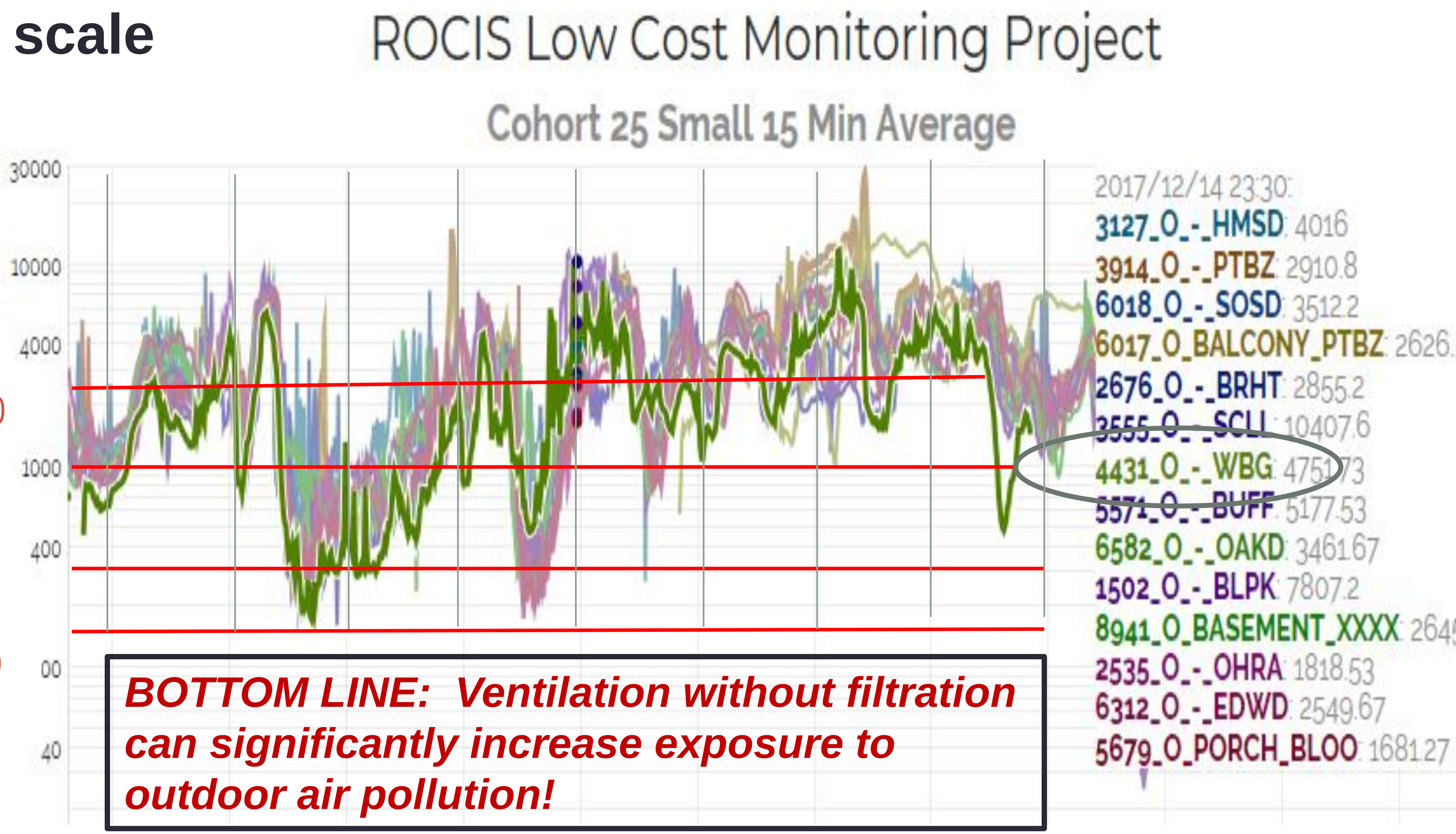
Poor 1050-3000

Fair 300-1049

Good 150-299

V Good 75-149

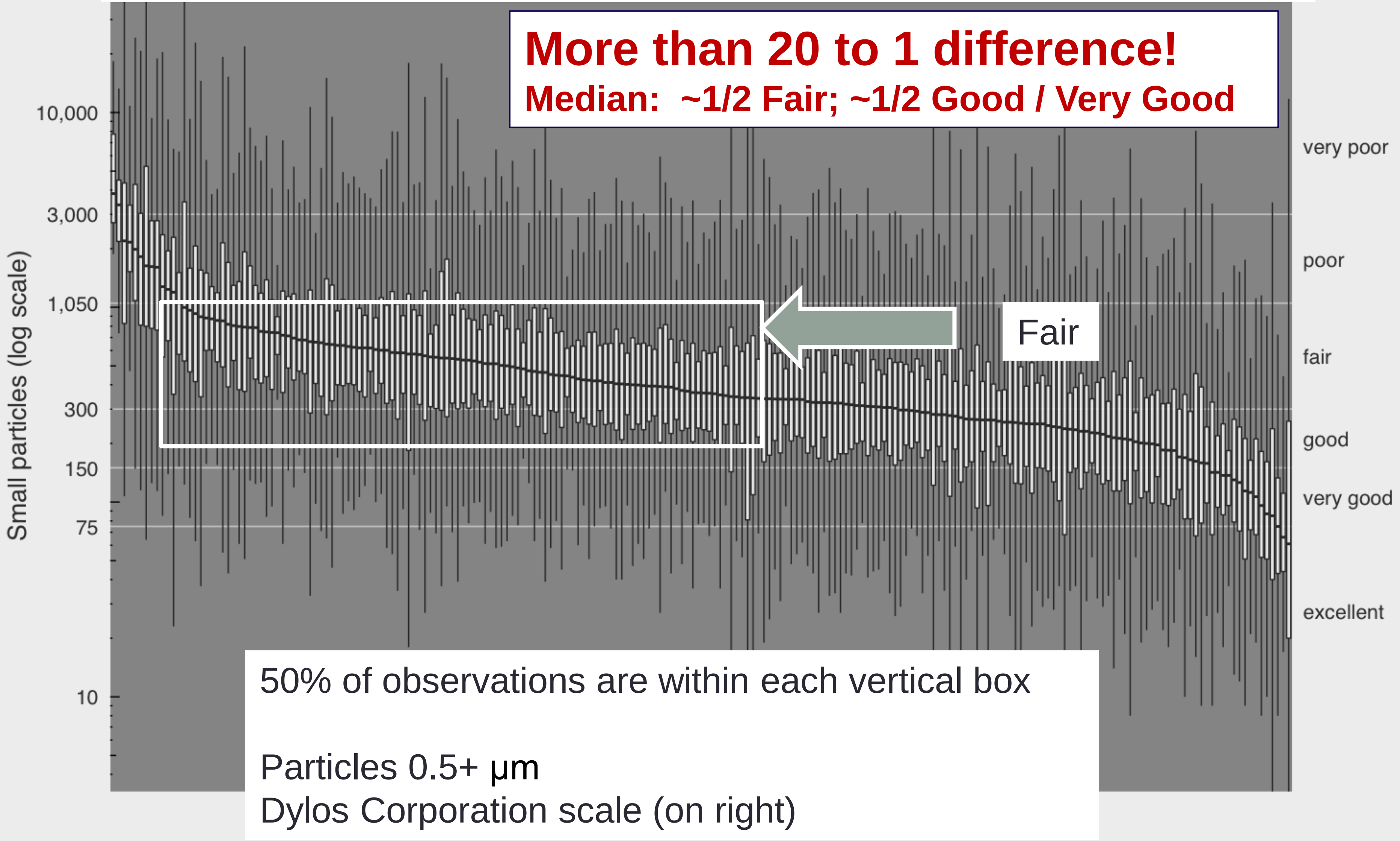
Excellent <75



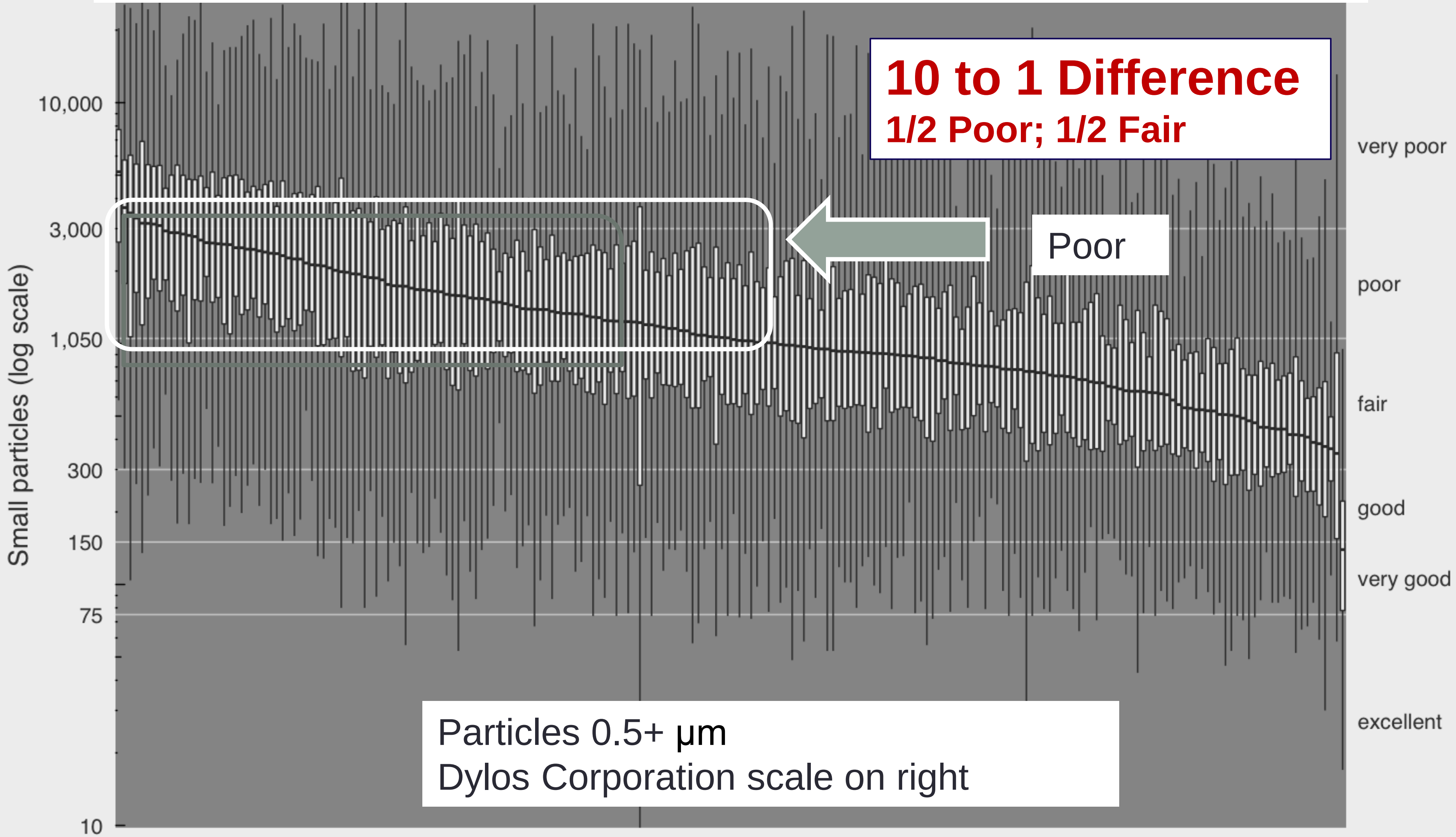
BOTTOM LINE: Ventilation without filtration can significantly increase exposure to outdoor air pollution!

Most sites are Pittsburgh; Green line (Wbg) is 50 miles south
Dylos particles (0.5+ µm)

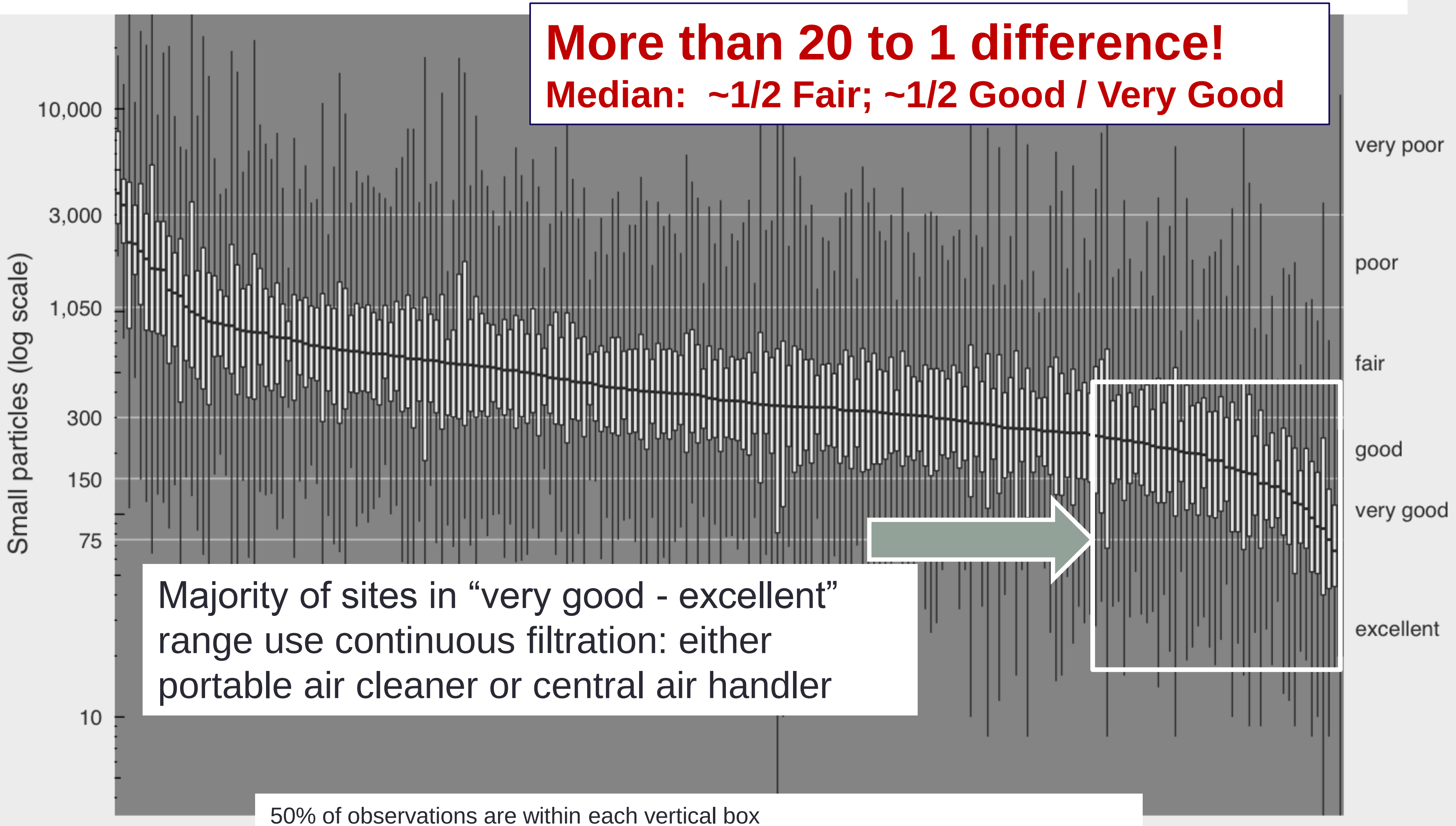
Indoor Particle Distribution – All Sites



Outdoor Particle Distribution – All Sites



Indoor Particle Distribution – All Sites



50% of observations are within each vertical box
Particles 0.5+ µm
Dylos Corporation scale (on right)

ROCIS AIR HANDLER / HIGH MERV FILTER INQUIRY

Typical Air Handler Operation

Inadequate for filtration

Thermostat usually set to “Auto”, not “On”

Average annual runtime ~15%

Call for heat & cool does not align with need for filtration

NOTE: With smart thermostats more control of “on time”

ROCIS High MERV Filter – Air Handler Inquiry

We observed that running an air handler continuously with a high MERV filter substantially dropped particle counts.

But, our question was…

Is there an **easy way** to determine if I can use a high MERV filter with a **longer air handler run-time** without causing problems (energy $, equipment durability, performance)?

ROCIS High MERV Filter – Air Handler Inquiry

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But, our question was…

Is there an **easy way** to determine if I can use a high MERV filter with a **longer air handler run-time** without causing problems (energy $, equipment durability, performance)?

NO !!

Diagnostic Screen is Required

ROCIS Air Handler Inquiry: *Context*

SW Pennsylvania typical housing stock

- Basements
- Mostly gas heat; central AC (oversized)
- Sheet metal ducts in basement
- Supplies & returns to each room

Implications are different w/ attic or crawlspace ducts & homes with central returns

45 DIAGNOSTIC VISITS LATER

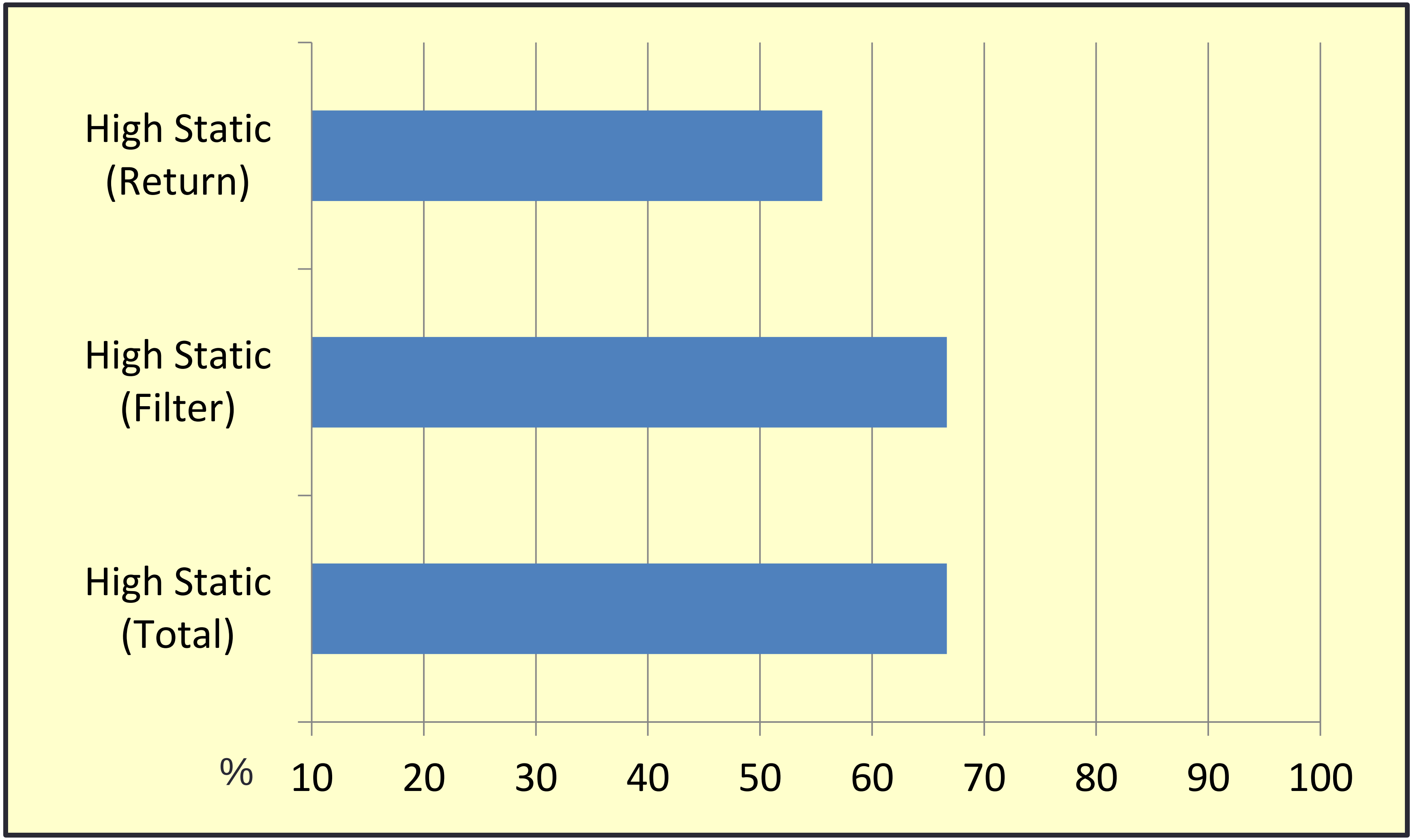
3 Big Issues with 24/7 High MERV Filter

- **Air handler (AHU) energy use /cost** can be high due to 500 to 1,500 watt-draw
  - High cost of running air handler continuously (360 kWh to 1080 kWh/month = ~$500 to $1500/year[1])
- **Wrong blower speed (system air flow)**
  - Seldom set in field
  - Often defaults to high speed, not low, in continuous mode
  - Higher energy cost, less effective filtration
- **Ductwork issues** introduce additional problems
  - Static pressure (TESP) too high
  - Duct leaks (energy waste & pressure-related problems)

[1] **$0.12/kWh**

Problems Identified (%)

45 systems (as found)



ROCIS Air Handler Inquiry

Purpose:

- Fine tune diagnostic assessment to identify appropriate intervention sites
- Explore feasibility of using air handler w/ high MERV filer to reduce particle counts

- 1-minute resolution particle counts for 3+ weeks (0.5+ microns, 2.5+ microns)
- Gain experience w interventions & impact

http://rocis.org/air-handler-inquiry

Filter/AHU Inquiry: *Approach*

- Developed diagnostic protocol
- Over 45+ air handler systems tested to date
- Evaluate opportunity for MERV 13 plus 24/7 operation

Next up:

- Rhett Major, The Energy Doctor
  - Description of the diagnostic visit & intervention

High MERV Filters in Central Air Handlers: Opportunities & Challenges

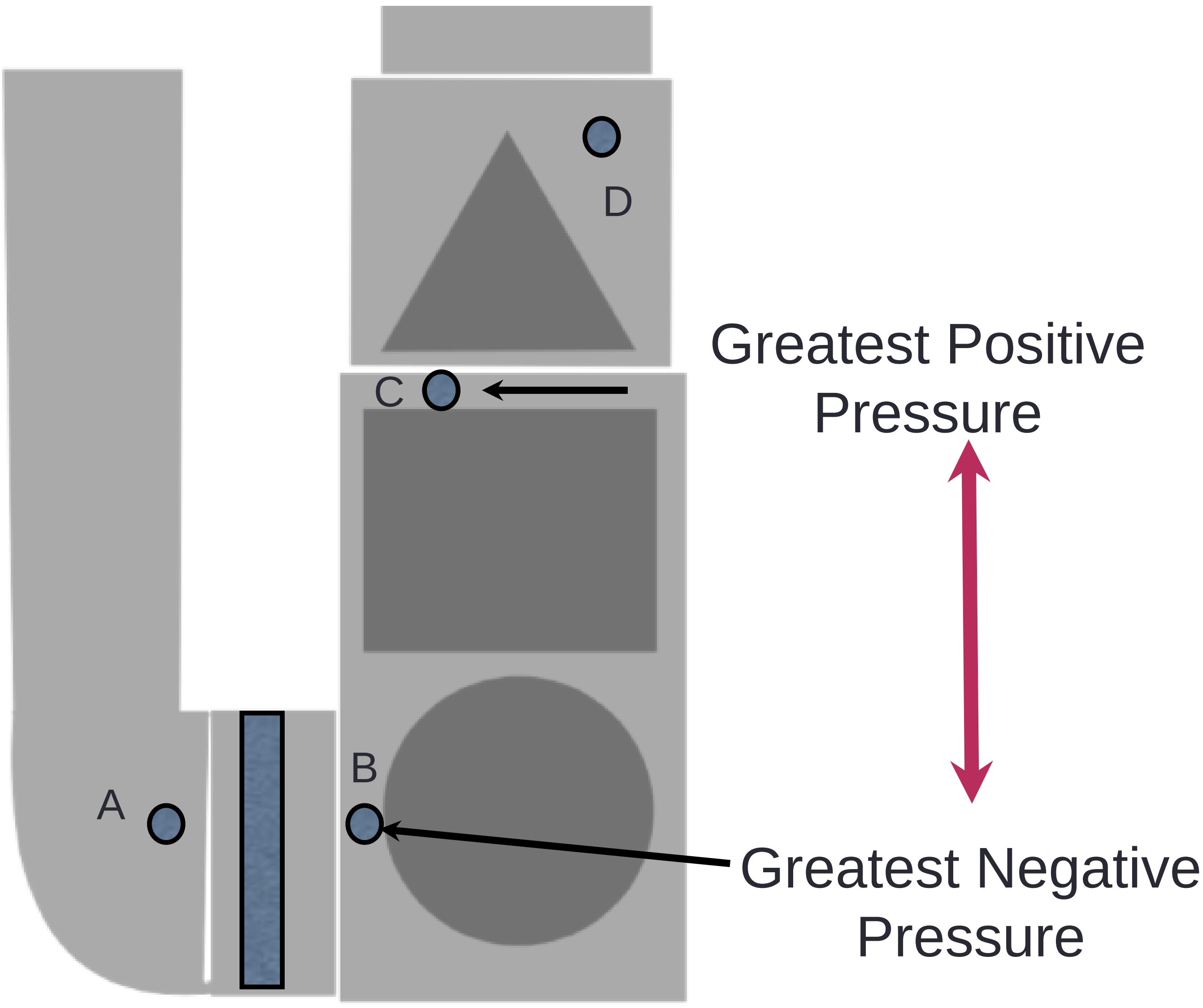
We want cleaner air, but can our systems take the extra restrictions presented by the filter?

1” high MERV filters tend to be very restrictive.

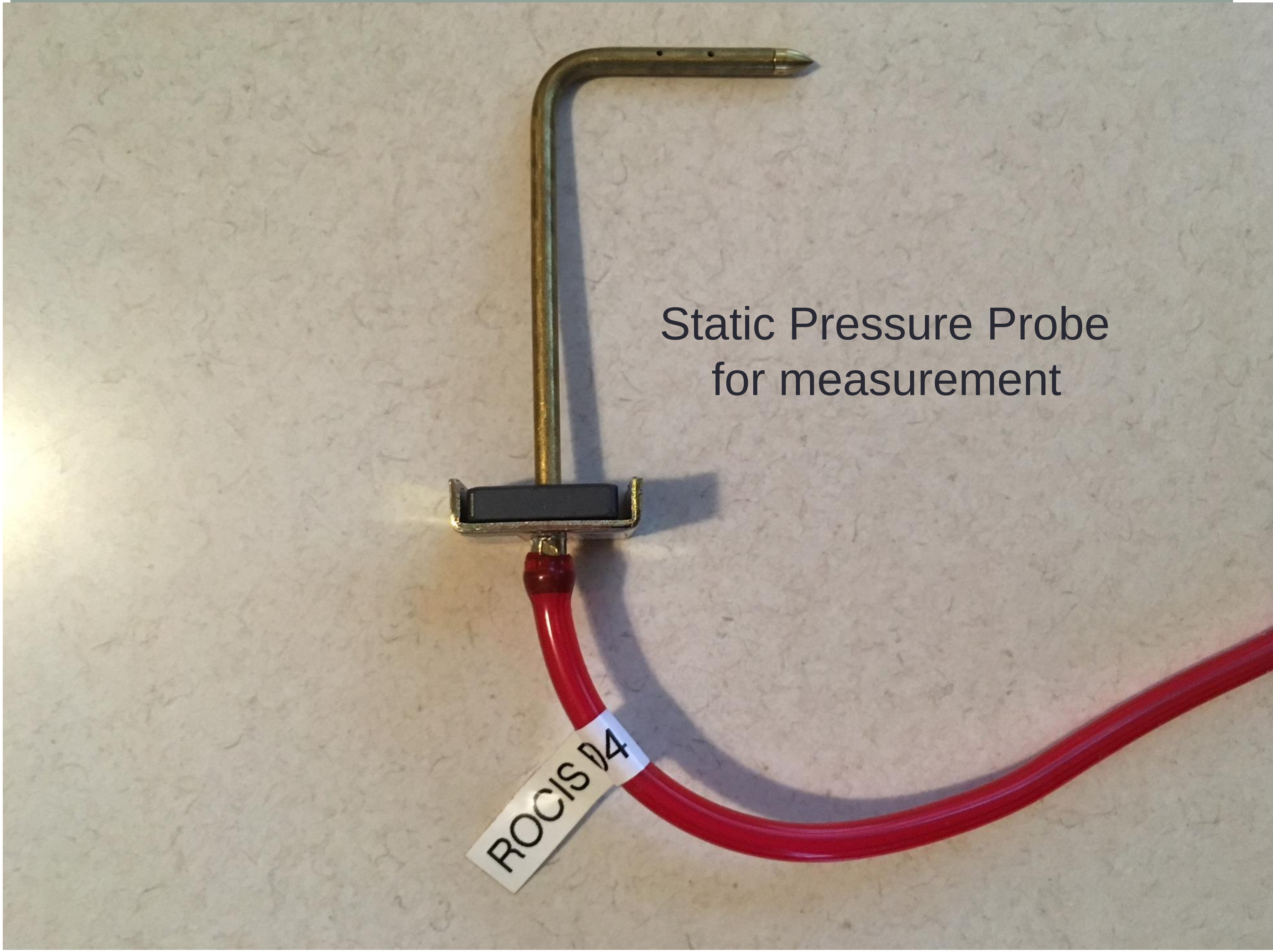
Total External Static Pressure

- TESP -AKA - External Static Pressure
- Combined highest Positive and Negative pressure External to the air handler created by the total resistance in the entire furnace/ AC/ duct system.
- The greater the TESP, the less the airflow.

Test Holes



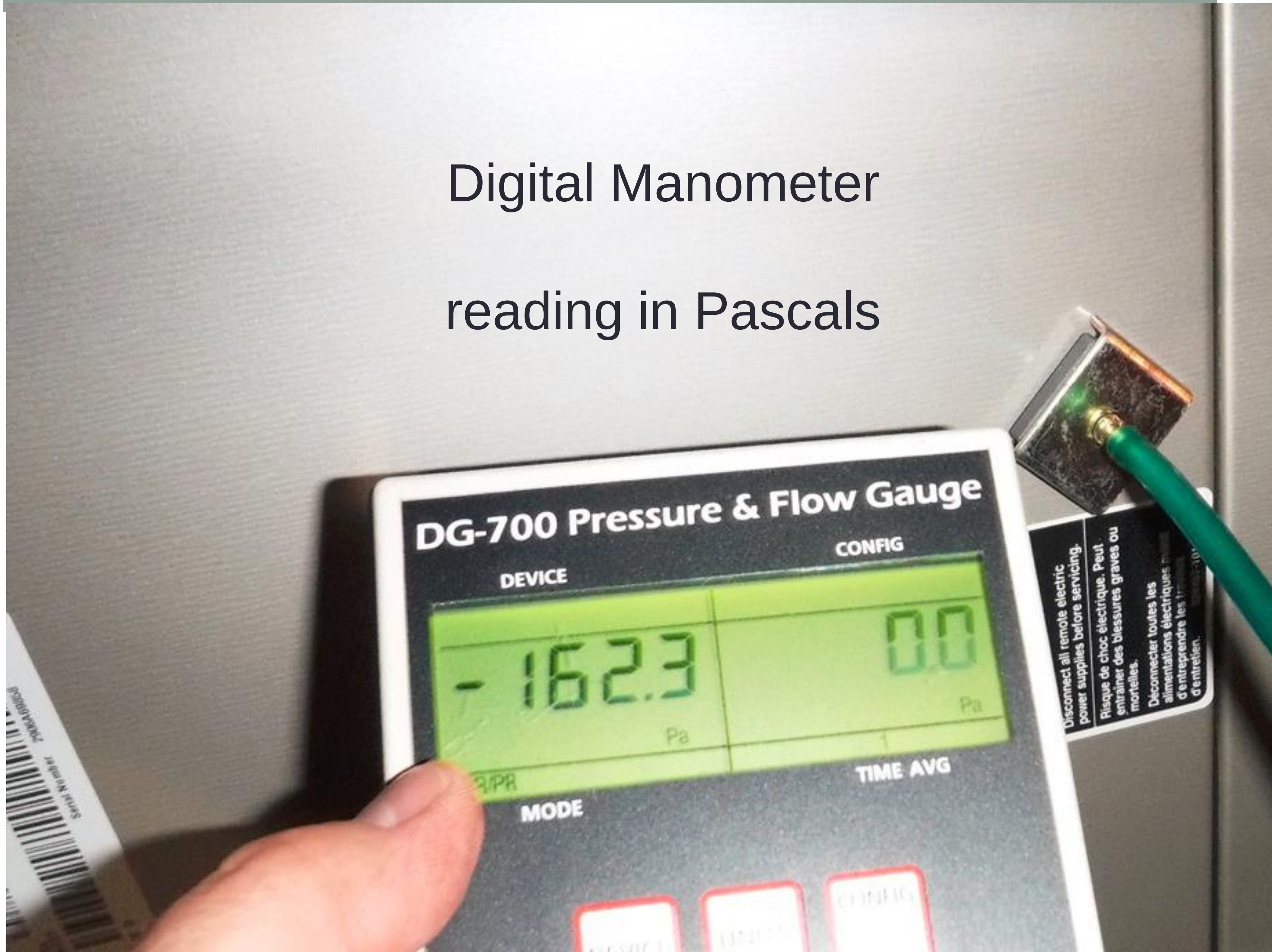
Drill test holes very carefully!



Static Pressure Probe
for measurement

Digital Manometer

reading in Pascals



1-888-728-9288 www.DEAWP.org info@deawp.org

Heating Performance worksheet

Air Handler/ furnace___________________________
Rated Input BTU__________ Output BTU__________
Temperature Rise range ___________________________

1) Drill test holes - 3/8" (carefully located to avoid drilling into components) Check filter for cleanliness - replace if dirty

2) Start up furnace system - set to 85° - Measure spillage stop time __________ seconds
Allow system to run for 5 - 10 minutes - remember to open interior doors after spillage test.
As the system warms up, take static pressure measurements - IWC or Pascals

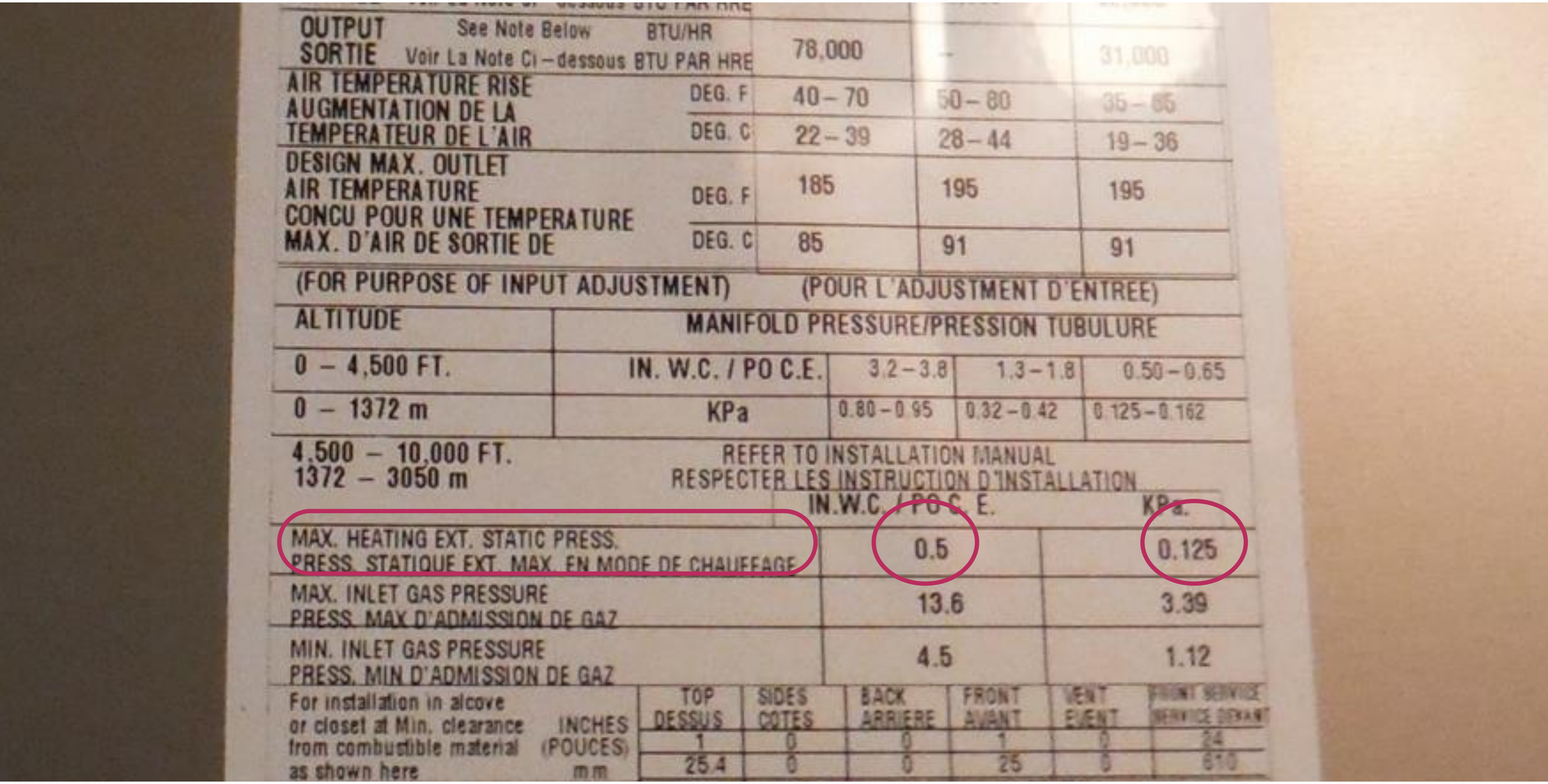
a. Before filter _____________(Return system)
b. After filter _____________
c. Before coil _____________
d. After coil _____________(Supply system)

3) Allowable TESP - from manufacturers nameplate _____________ (IWC x 250 = pascals)
Measured TESP = Absolute value of [b] + [c]. _____________

High TESP pressures indicate many possible problems - isolate where the restrictions are:

4) Ideal Return pressure - 20% of TESP ________ Measured return pressure is = a. ________

I record the static pressure measurements here,
& start doing the calculations



Every furnace or air handler has the maximum static pressure on the manufacturer's label.

I transfer this number to my static pressure test sheets.

Air Handler/ furnace_Trane TUD120R9V5H6 2 Stage
Rated Input BTU 120,000, 78,000
Output BTU 95,000, 62,400
Temperature Rise range 35° - 65°
Filter - Carrier Electronic air cleaner

1) Static pressures: AC speed		Lo Heating speed		High speed		constant speed	
a. Before filter	_-44	Before filter	_-39	Before filter	-48	Before filter	-31
b. After filter	_-68	After filter	_-60	After filter	-61_	After filter	_-49
c. Before coil	_+188	Before coil	+182	Before coil	+189	Before coil	+137
d. After coil	_+46	After coil	_+43	After coil	_+50	After coil	_+35
e. Wattage	_630	wattage	_500	wattage	_610_	wattage	_400
f. CFM	1100	CFM	870	CFM	NM	CFM	740

3) Allowable TESP - from manufacturers nameplate _125__
Measured TESP _256_ __242_ ___250__ ___186__
High TESP pressures indicate many possible problems - isolate where the restrictions are:

4) Ideal Return pressure - 20% of TESP ___-25__
Measured return pressure __-44___ __-39___ ___-48___ ___-31__

High values indicate return restrictions, lower values indicate duct leaks or low fan speed

5) Ideal max filter pressure drop = 20% x TESP __25__
Pressure drop across Filter __24_ __21_ __13___ __18___

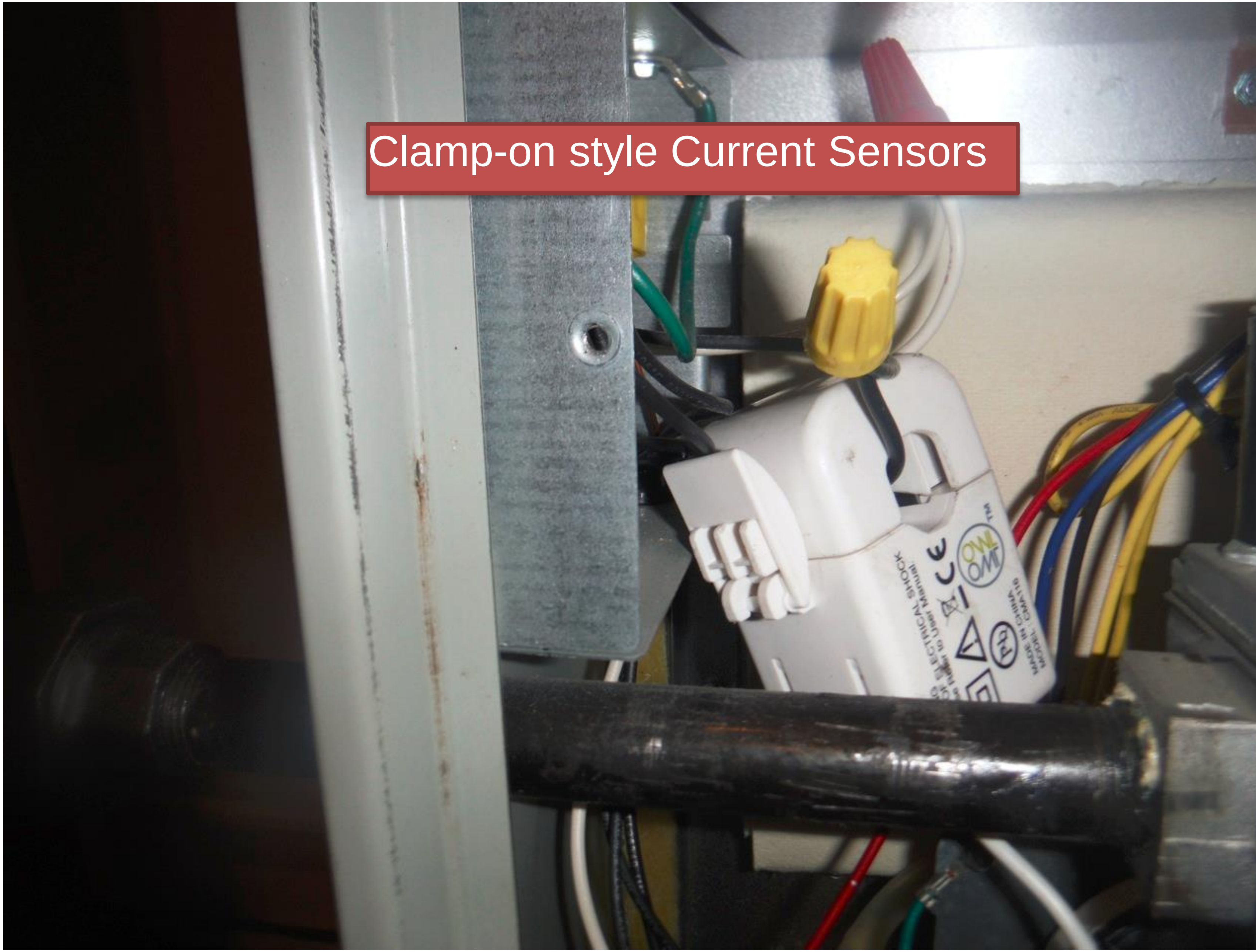
High value indicates problems: Clogged or restrictive of filter - decreases airflow capacity

High Static pressure values indicate problems

Measuring Watt Draw

- Clamp-on style Current Sensors (CT)
- Converts to Wattage
- Wireless monitor display

Clamp-on style Current Sensors



The wireless monitor shows the instantaneous wattage draw for the fan.

(This wattage is high, as it's capturing electric backup heat also.)

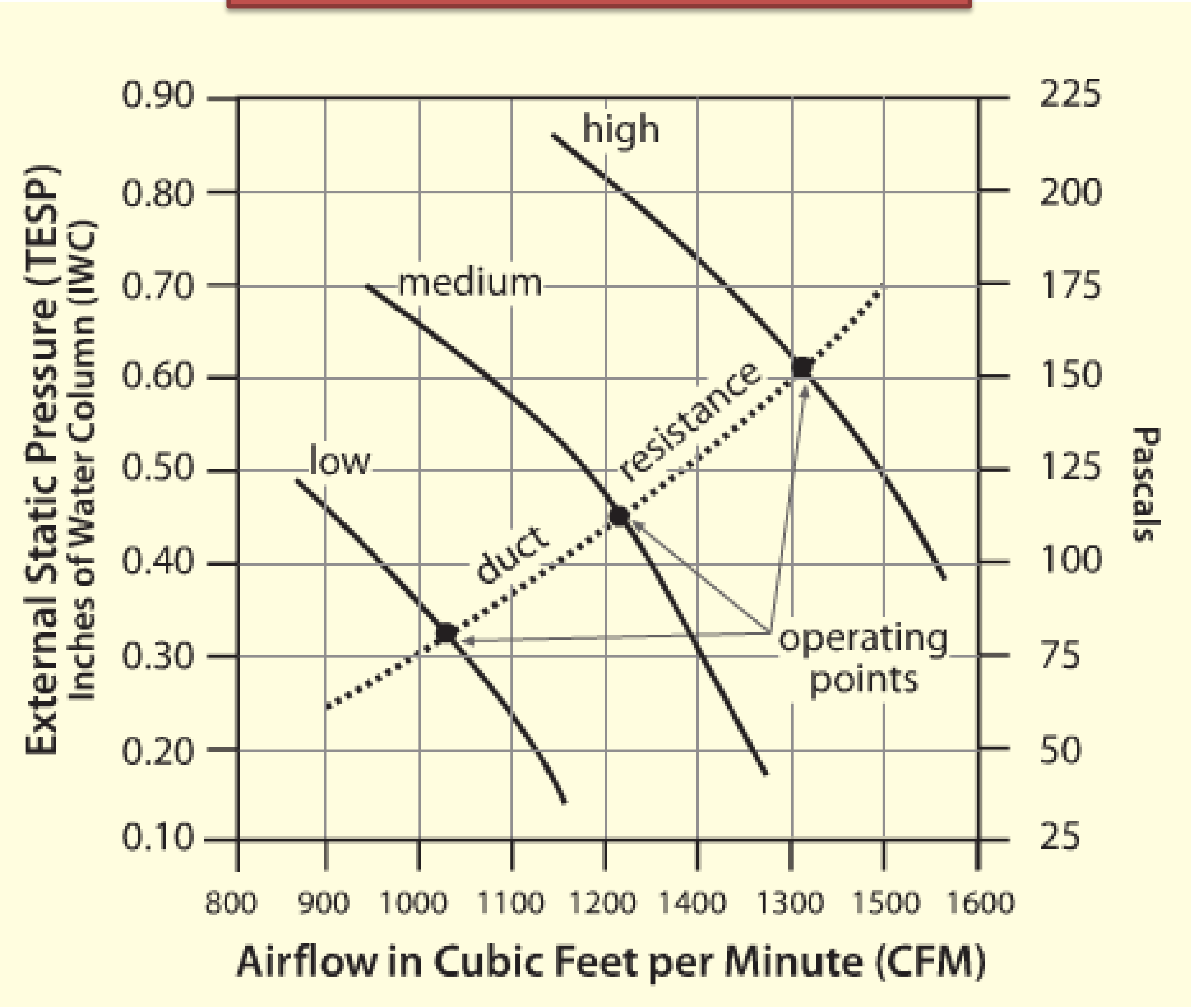
Total External Static Pressure

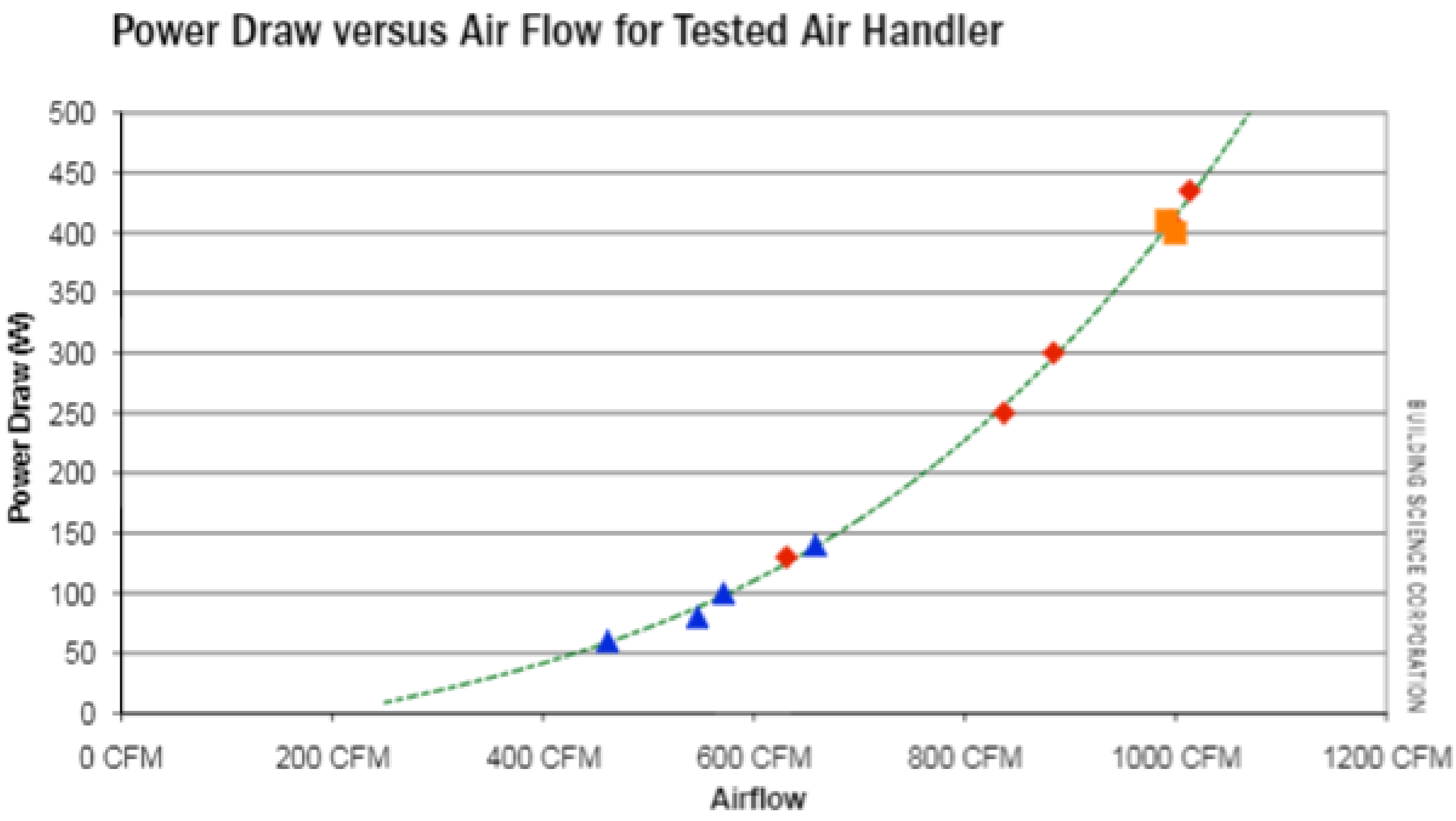
- What can increase TESP?

- **Wrong fan speed**
- **Dirt** - primarily in the filter &/or coil
- **Restrictions** in the ductwork system or filter

- The greater the TESP, the less the airflow with PSC motors, or the higher the wattage draw (with ECMs)

Wrong fan speed



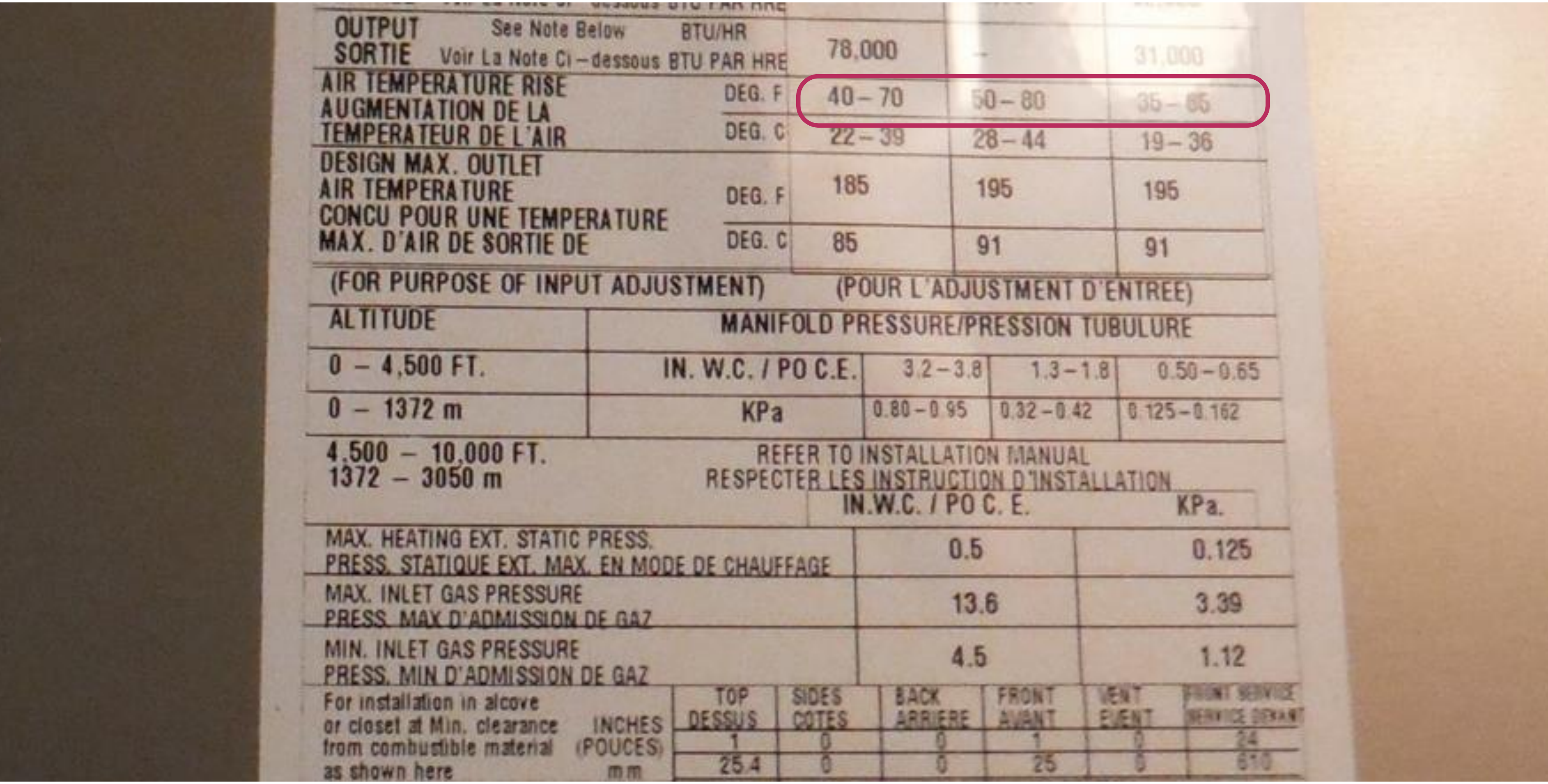


Slide credit: Building Science Corporation

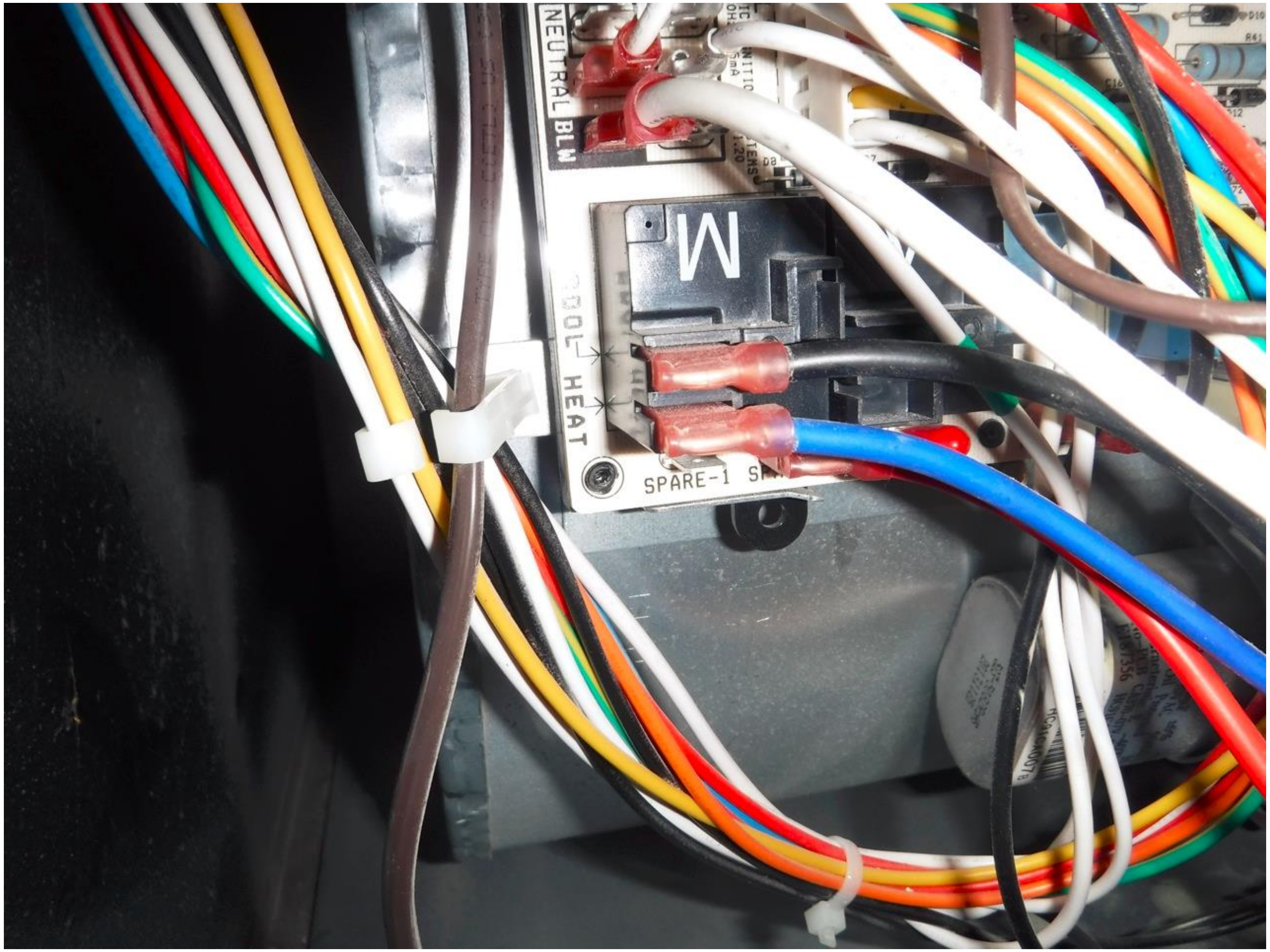
I measure the heat–rise to evaluate appropriateness of fan speed.

Heat Rise/Temp Rise Basics

- The slower the airflow, the greater the heat rise
- The faster the airflow, the lower the heat rise.
- Compare to manufacture’s chart

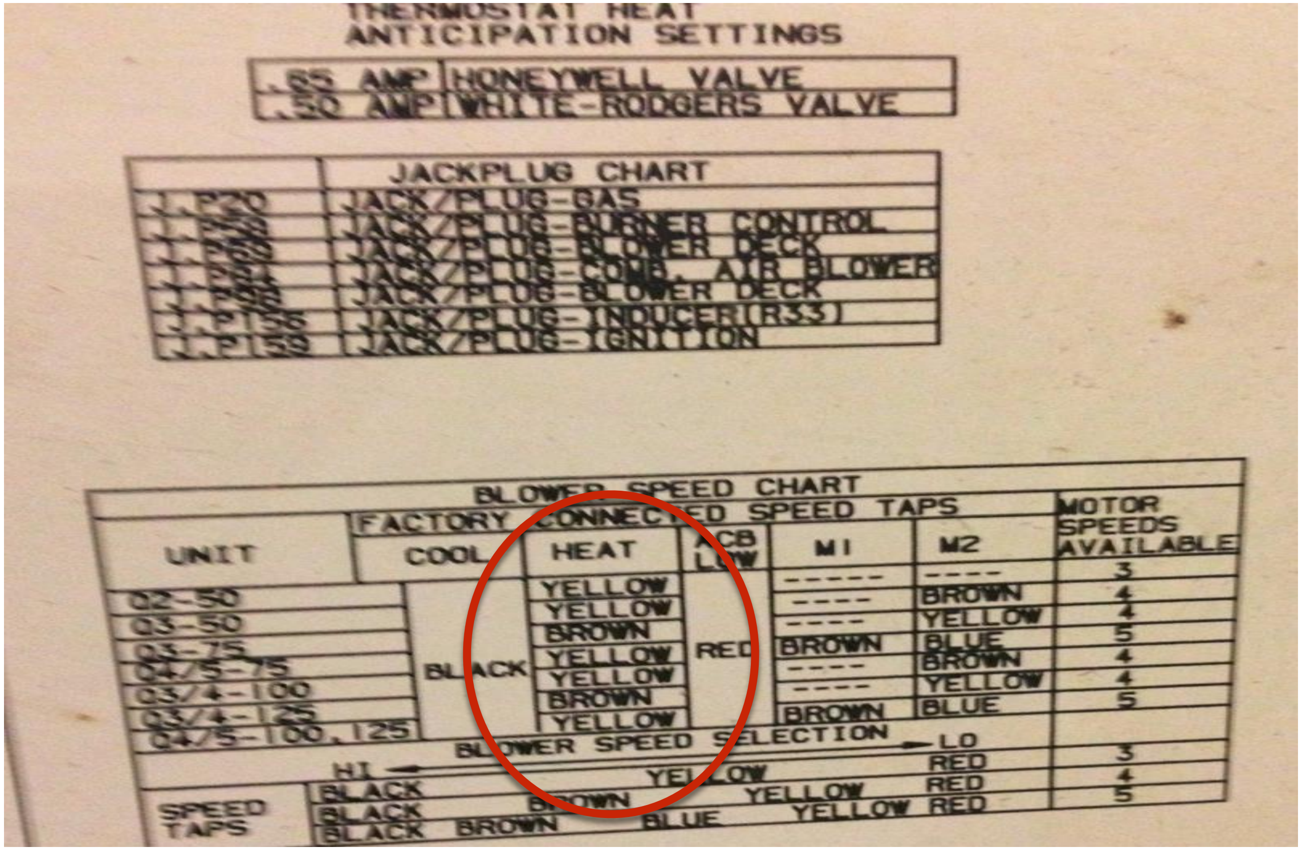

OUTPUT
SORTIE
See Note Below BTU/HR
Voir La Note Ci-dessous BTU PAR HRE
78,000
31,000
AIR TEMPERATURE RISE
AUGMENTATION DE LA
TEMPERATEUR DE L'AIR
DEG. F
40-70
50-80
DEG. C
22-39
28-44
19-36
DESIGN MAX. OUTLET
AIR TEMPERATURE
CONCU POUR UNE TEMPERATURE
MAX. D'AIR DE SORTIE DE
DEG. F
185
195
195
DEG. C
85
91
91
(FOR PURPOSE OF INPUT ADJUSTMENT)
(POUR L'ADJUSTMENT D'ENTREE)
ALTITUDE
MANIFOLD PRESSURE/PRESSION TUBULURE
0 - 4,500 FT.
IN. W.C. / PO C.E.
3.2-3.8
1.3-1.8
0.50-0.65
0 - 1372 m
KPa
0.80-0.95
0.32-0.42
0.125-0.162
4,500 - 10,000 FT.
1372 - 3050 m
REFER TO INSTALLATION MANUAL
RESPECTER LES INSTRUCTION D'INSTALLATION
IN.W.C. / PO C. E.
KPa.
MAX. HEATING EXT. STATIC PRESS.
PRESS. STATIQUE EXT. MAX. EN MODE DE CHAUFFAGE
0.5
0.125
MAX. INLET GAS PRESSURE
PRESS. MAX D'ADMISSION DE GAZ
13.6
3.39
MIN. INLET GAS PRESSURE
PRESS. MIN D'ADMISSION DE GAZ
4.5
1.12
For installation in alcove
or closet at Min. clearance
from combustible material
as shown here
INCHES
(POUCES)
mm
TOP
DESSUS
SIDES
COTES
BACK
ARRIERE
FRONT
AVANT
VENT
EVENT
1
0
0
1
0
24
25.4
0
0
25
0

Adjust Fan Speeds as needed



Not as hard as you think!

Adjusting Fan Speeds



The furnace installation manual usually has a chart to tell you which colors represents which speed.

Some models are a little more complex.
Dip switches need to be adjusted
according to the desired settings

Re-Check Heat-rise/Temp-drop

Example 1

Air Handler/ furnace__NUGE100BG01
Rated Capacity__100,000 / 82,000____
Heat Rise 40° - 70°
4" Merv 13 filter (4 months old)
Ecobee thermostat - _1/2 HP PSC motor

1) Take static pressure measurements - IWC or Pascals

	Heat mode mode		AC/ Circulation Mode
a.	Before filter ____-64______ (Return system)	a.	Before filter __-71______
b.	After filter ____-176_______	b.	After filter ____-188________
c.	Before coil ____+62______	c.	Before coil __+62______
d.	After blower____N/A______ (Supply system)	d.	After blower____N/A________
e.	wattage ____680____	e.	wattage ____840______

2) Allowable Total External Static Pressure - TESP - from manufacturers nameplate
______125________ (IWC x 250 = pascals) ______125_________

Measured TESP = Absolute value of [c] + [d].
______238_____ ______250__

High TESP pressures indicate many possible problems - isolate where the restrictions are:

3) Ideal Return pressures = 20% of TES ______25________ ______25_______
Measured return pressure is = a ______-64_____ ______-71__

High values indicate restrictions in return system, lower values may indicate duct leakage or low fan speed

High TESP

Example 1

4) Ideal max filter pressure drop = 20% x TESP	25	25
Pressure drop across Filter = [b] - [a]	112	117

High value indicates problems such as: Clogged filter or Too restrictive of filter - decreases airflow & cooling capacity

5) Ideal coil pressure drop = 40% of TESP	50	50
Pressure drop across coil = c - b	N/A	N/A

High values may indicate Dirty coil - inspect if possible - decreases airflow & cooling capacity

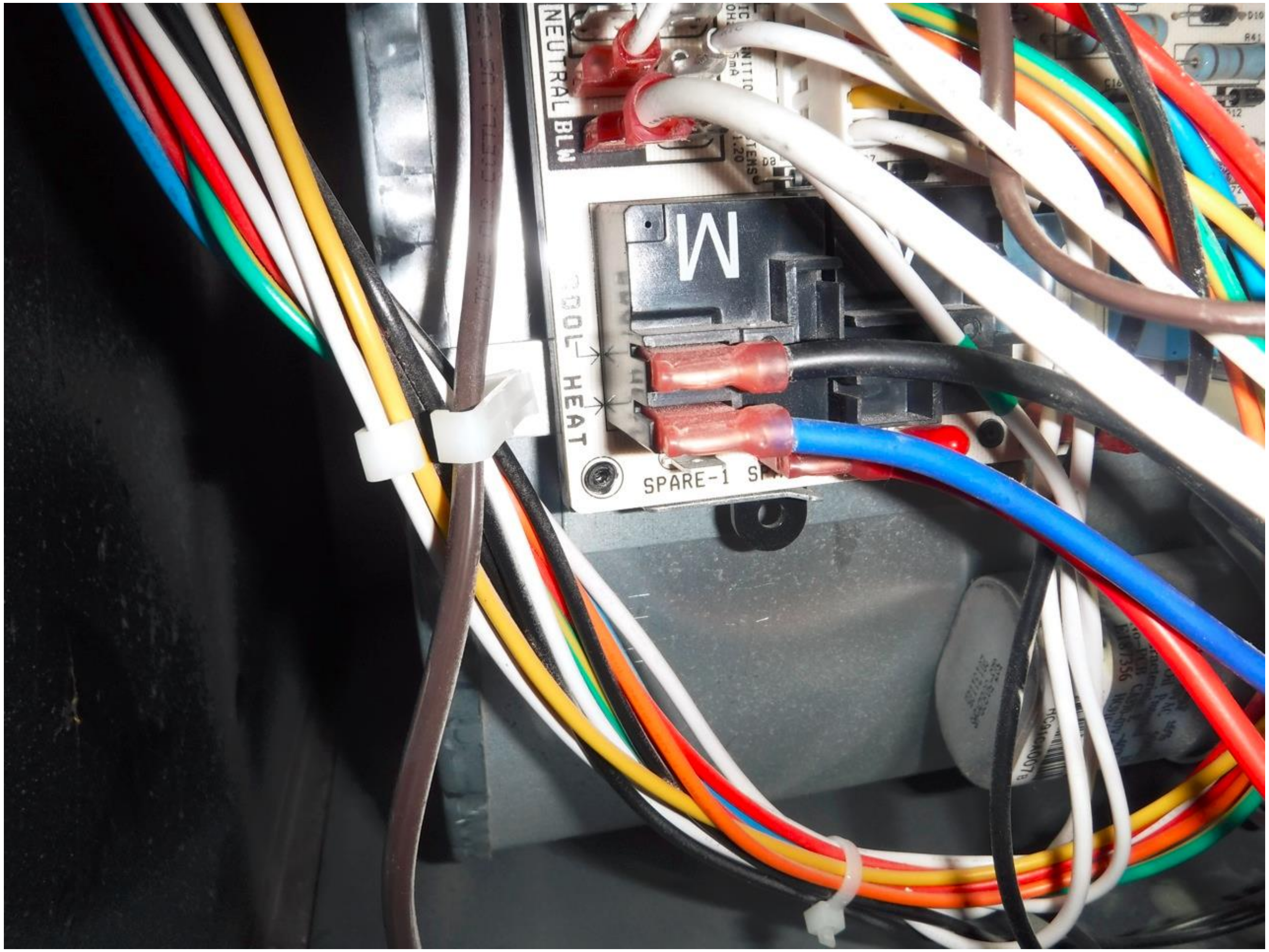
6) Ideal supply duct pressure = 20% of TESP	25	25
Measured supply duct pressure = d.	62	62

High values indicate restrictions in supply system. Lower values could indicate duct leakage or low fan speed)

7) Dry bulb temperature from return hole	72.5	
Dry bulb temp from supply hole	127°	
Heat rise =	54.5	

& Low heat rise

Adjust Fan Speed Down



Example 1 retest

2/8/17 - adjusted
Air Handler/ furnace__NUGE100BG01_1/2 HP
Rated Capacity__100,000 / 82,000____
Heat Rise 40° - 70°
4" Merv 13 filter (4 months old)
Ecobee thermostat - _1/2 HP PSC motor

1) Take static pressure measurements - IWC or Pascals

	Heat mode mode		AC/ Circulation Mode
a. Before filter	-62.5	(Return system)	-63
b. After filter	-165		-165
c. Before coil	+56		+55
d. After blower	N/A	(Supply system)	N/A
e. wattage	550		480

2) Allowable Total External Static Pressure - TESP - from manufacturers nameplate
125 (IWC x 250 = pascals) 125

Measured TESP = Absolute value of [c] + [d].
221 220

High TESP pressures indicate many possible problems - isolate where the restrictions are:

3) Ideal Return pressures = 20% of TES 25 25
Measured return pressure is = a -62.5 -63

High values indicate restrictions in return system, lower values may indicate duct leakage or low fan speed

Lower TESP

Example 1 retest

4) Ideal max filter pressure drop = 20% x TESP	25	25
Pressure drop across Filter = [b] - [a]	-102.5	-102

High value indicates problems such as: Clogged filter or Too restrictive of filter - decreases airflow & cooling capacity

5) Ideal coil pressure drop = 40% of TESP	50	50
Pressure drop across coil = c - b	N/A	N/A

High values may indicate Dirty coil - inspect if possible - decreases airflow & cooling capacity

6) Ideal supply duct pressure = 20% of TESP	25	25
Measured supply duct pressure = d.	56	55

High values indicate restrictions in supply system. Lower values could indicate duct leakage or low fan speed)

7) Dry bulb temperature from return hole	68°	
Dry bulb temp from supply hole	126°	
Heat rise =	58°	

Lower speed = higher heat rise, & lower static pressures

Total External Static Pressure

What else can increase TESP?

- Dirt - primarily in the filter &/or coil
- Restrictions in the ductwork system or filter

A wider filter (4") has about 4 x’s the surface area as the 1“ filter and offers less restriction to the system.

The problem is they are expensive, so people don't change them as often as they should.

Dirty Filters are a big problem

Dirty Coils are a bigger problem

Example 2

Air Handler/ furnace__GMUH150-E5A___3/4 HP
Rated Capacity_150,000 INPUT 120,000 Output_____
HEAT RISE - 50°-80°
Filter - FPR -10 (MERV 12) 1" dirty

1) Take static pressure measurements - IWC or Pascals

	Fan On - Circulation Mode			Heat Mode
a.	Before filter	-50.8 (Return system)	a. Before filter	-47
b.	After filter	-148	b. After filter	-143
c.	Before coil	+115	c. Before coil	+101
d.	After blower	+19 (Supply system)	d. After blower	+18
e.	wattage	750	e. wattage	730
f.	CFM	1050	f. CFM	1000

2) Allowable Total External Static Pressure - TESP - from manufacturers nameplate

	Fan On - Circulation Mode	Heat Mode
(IWC x 250 = pascals)	125	125
	263	244

High TESP pressures indicate many possible problems - isolate where the restrictions are:

	Fan On - Circulation Mode	Heat Mode
3) Ideal Return pressures = 20% of TES	25	25
Measured return pressure is = a	50.8	-47

High values indicate restrictions in return system, lower values may indicate duct leakage or low fan speed

	Fan On - Circulation Mode	Heat Mode
4) Ideal max filter pressure drop = 20% x TESP	25	25
Pressure drop across Filter = [b] - [a]	97.2	

High value indicates problems such as: Clogged filter or Too restrictive of filter - decreases airflow & cooling capacity

Very High TESP

Example 2

decreases airflow & cooling capacity

5) Ideal coil pressure drop = 40% of TESP ______50__________ _______50_______
Pressure drop across coil = c - b ______97______ ______83___

High values may indicate Dirty coil - inspect if possible - decreases airflow & cooling capacity

6) Ideal supply duct pressure = 20% of TESP ______25_________ _______25_________
Measured supply duct pressure = d. ______19___ _______18_____

High values indicate restrictions in supply system. Lower values could indicate duct leakage or low fan speed)

7) Dry bulb temperature from return hole ___NO AC__ _____85°_____
Dry bulb temp from supply hole _______________ ____160°+________
Heat rise = _______________ _____75°+_______

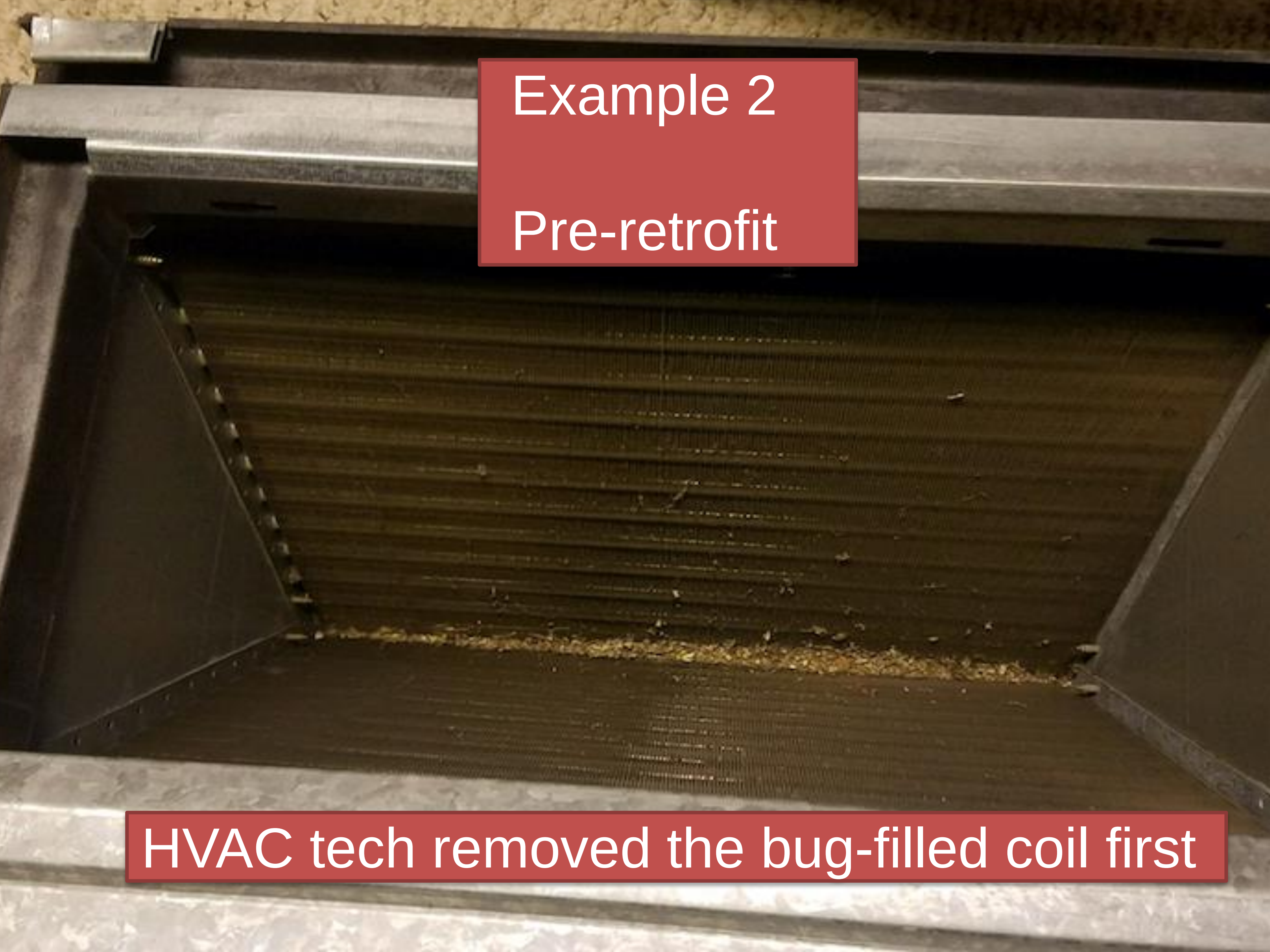
Low speed Wattage _750_ Cost per hour __$0.0975__ per year ___$ 854.1
__1050__ CFM measured w/ TruFlow CFM/ watt ___1.4_____
Heating speed Wattage _730_ Cost per hour _$ $0.0949
__1000___CFM measured w/ TruFlow CFM/ watt __1.37__

This fan speed is too low & should be adjusted up - furnace shut down on high limit
But restrictions in the ductwork prevented proper airflow.

Total External Static Pressure

What else can increase TESP?

- Restrictions in the ductwork system (harder to fix)



Example 2

Pre-retrofit

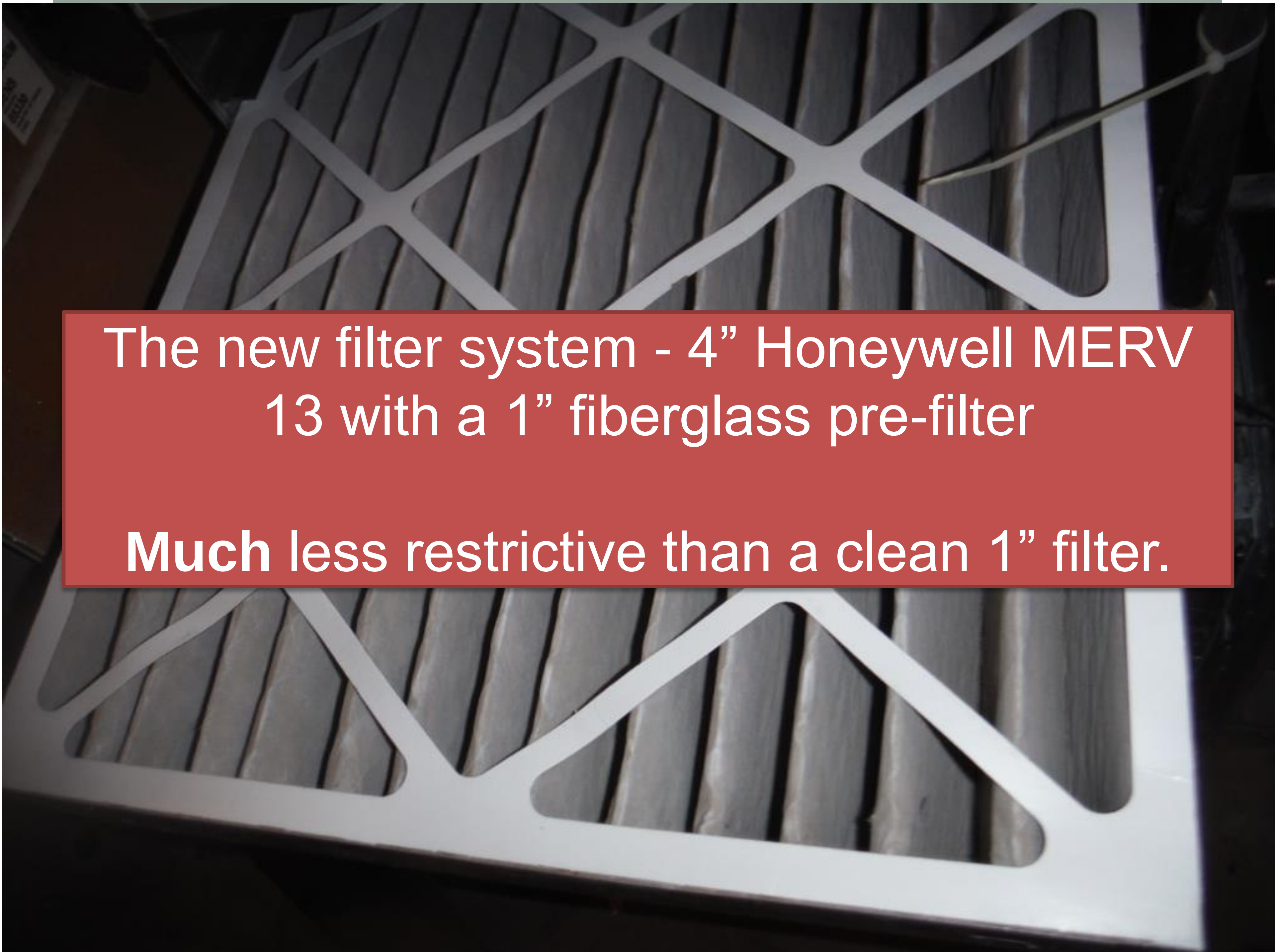
HVAC tech removed the bug-filled coil first

Example 2

Pre-retrofit

Example 2
Post-retrofit

New ductwork & filters
About $500.00
parts & labor



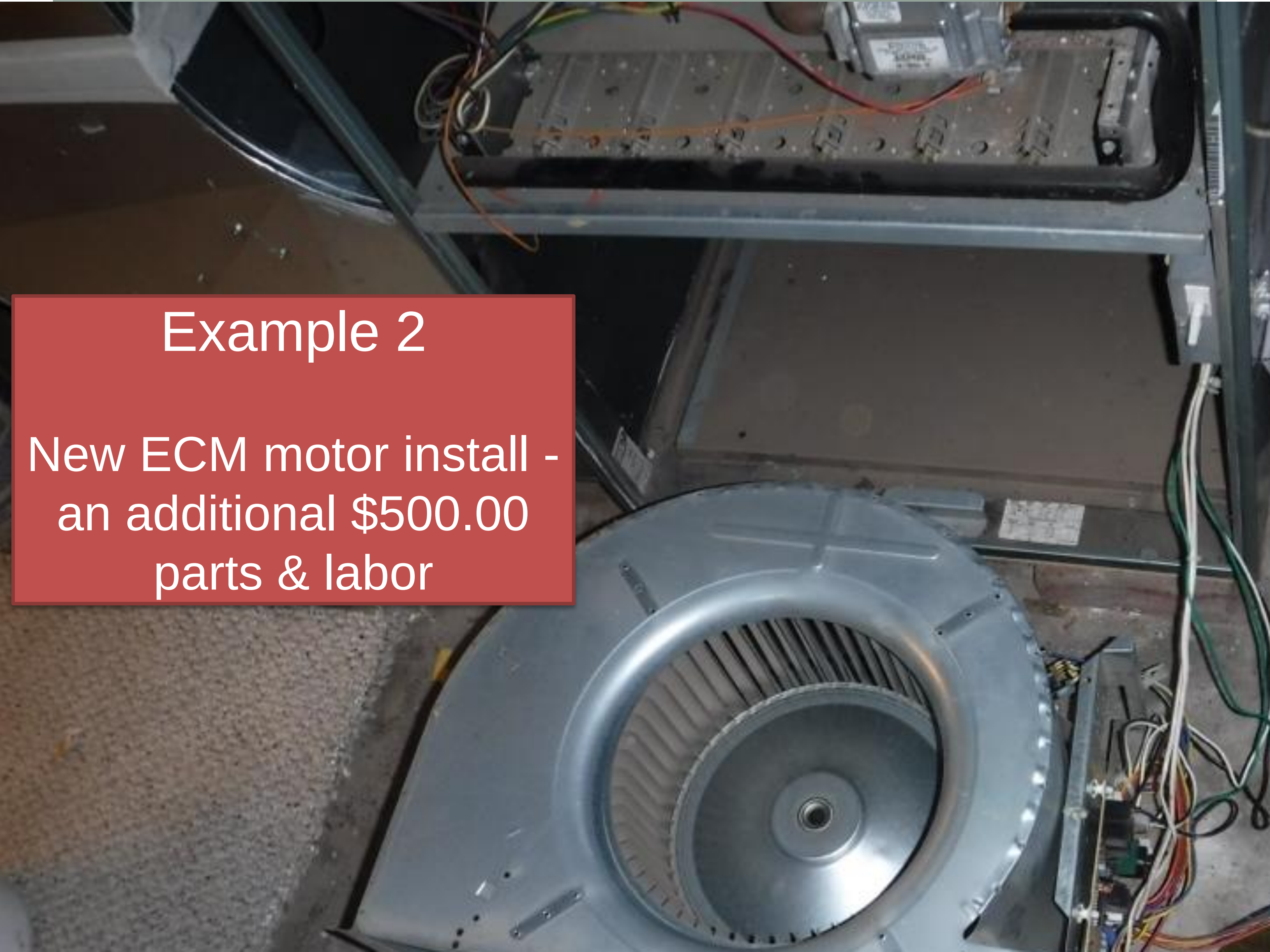
The new filter system - 4” Honeywell MERV 13 with a 1” fiberglass pre-filter
Much less restrictive than a clean 1” filter.

A pre-filter is added to catch the largest "boulders" in older duct systems, and should be changed monthly.

This enables the larger filter to last 6 months or longer

After improving air flow, we are able to change out permanent split capacitor motor (PSC) with an ECM. The drop in wattage (same airflow) is often very significant.

This model allows us to set up a low continuous airflow for filtration, ~400 - 700 CFM, @120 - 180 Watts of power.



Example 2

New ECM motor install - an additional $500.00 parts & labor

HEAT RISE - 50°-80°

Filter - New MERV 13 Horizontal, with pre-filter.

1) Take static pressure measurements - IWC or Pascals

Fan On - Circulation Mode			Heat Mode	
a. Before filter	____-16_____	(Return system)	a. Before filter	____-40_____
b. After filter	____-38_____		b. After filter	____-88_____
c. Before coil	____+15____		c. Before coil	_____+51_____
d. After blower	____+9_____	(Supply system)	d. After blower	____+20_____
e. wattage	____177_____		e. wattage	_____644____
f. CFM	___720_____		f. CFM	_____1230____

2) Allowable Total External Static Pressure - TESP - from manufacturers nameplate

______125_______ (IWC x 250 = pascals) _____125_______

______53_____ ______139_____

High TESP pressures indicate many possible problems - isolate where the restrictions are:

3) Ideal Return pressures = 20% of TES _____25_______ ______25______

Measured return pressure is = a _____-16____ _____-40____

High values indicate restrictions in return system, lower values may indicate duct leakage or low fan speed

4) Ideal max filter pressure drop = 20% x TESP _____25_______ _____25_______

Pressure drop across Filter = [b] - [a] _____22_____ ____48_____

High value indicates problems such as: Clogged filter or Too restrictive of filter - decreases airflow & cooling capacity

Example 2 - post retrofit - TESP nearly cut in half

5) Ideal coil pressure drop = 40% of TESP ______50_________ ______50_______
Pressure drop across coil = c - b ______6_____ _____31___

High values may indicate Dirty coil - inspect if possible - decreases airflow & cooling capacity

6) Ideal supply duct pressure = 20% of TESP _____25________ ______25_________
Measured supply duct pressure = d. _____9___ ______20_____

High values indicate restrictions in supply system. Lower values could indicate duct leakage or low fan speed)

7) Dry bulb temperature from return hole ___NO AC__ ____71°_____
Dry bulb temp from supply hole _______________ ____147°_________
Heat rise = _______________ ______76°_________

Low speed Wattage _177_ Cost per hour __$0.022__ per year ___$193.81
__720__ CFM measured w/ TruFlow CFM/ watt __4.07
Heating speed Wattage _644_ Cost per hour _$ $0.0805
__1230___CFM measured w/ TruFlow CFM/ watt __1.9__

Example 2 - post retrofit

24/7 filtration for less than $200 a year (instead of $854.00 pre-retrofit)

ROCIS Air Handler Retrofit
Post-retrofit (Case w2i9)

STEP 1
Modified larger return drop

(Case w2i9)

ROCIS Air Handler Retrofit

STEP 1
Modified larger return drop

Larger return drop

2-part filter rack (20” x 25”) Horizontal
(4” MERV 13 + 2” pre or post filter)

90° transition designed for better air flow (heel & throat); lower static

RESULTS:

Pressure drop across filter:
Pre: 93 Pa, Post: 16 Pa

Allowable (total system) TESP: 125 Pa

(Case w2i9)

ROCIS Air Handler Retrofit

STEP 2 (not always needed)
New ECM
Labor & materials $500

(Case w2i9)

RESULTS:
In continuous mode:
- 4.27 CFM/watt
- 120 Watts

ECM replacement

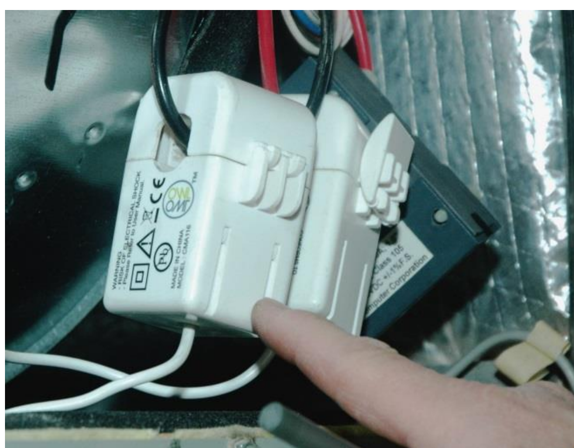
Fan speed adjusted to optimize heating, cooling, & continuous performance.

ROCIS Air Handler Retrofit

STEP 3

Adjust fan speeds to optimize heating, cooling, & continuous performance

Verify system air flows, watt-draw, & static pressure



ROCIS Air Handler Retrofit

STEP 4

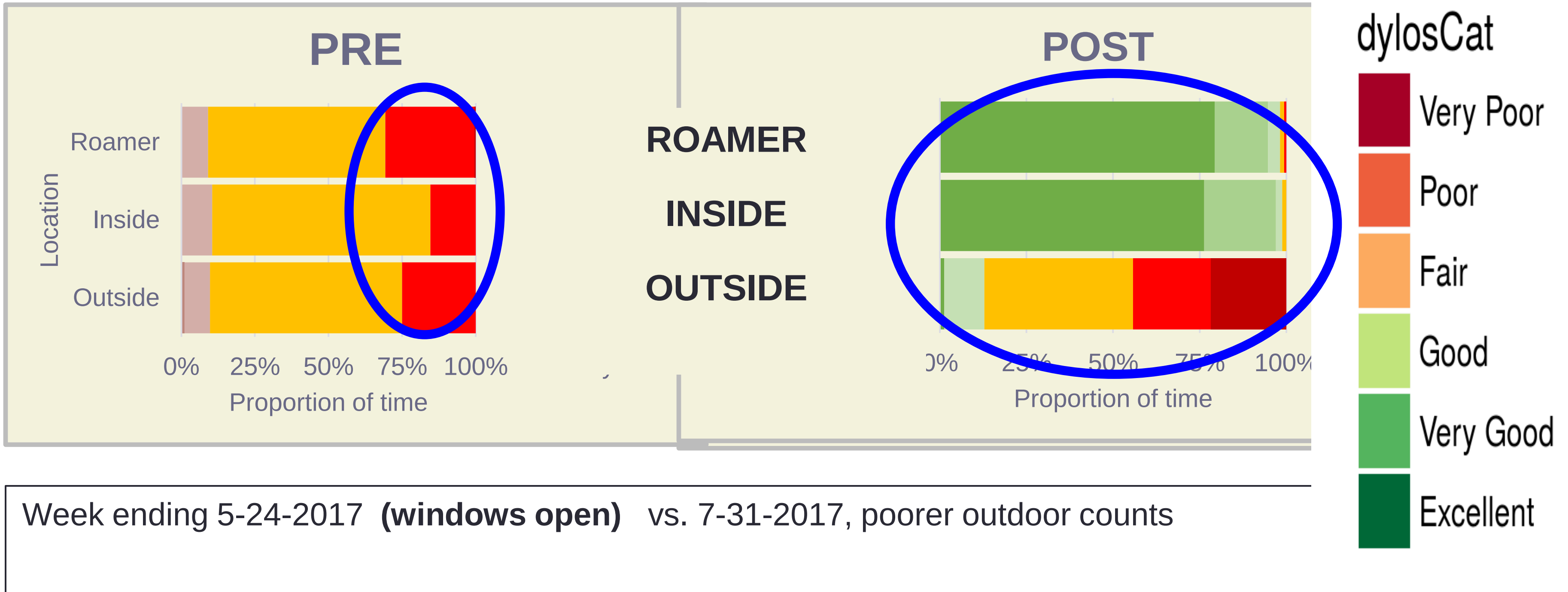
Monitor performance

Monitor inside particles

(0.3, 0.5, 1.0 & 2.5 microns)

Monitor change in static across filter

Case w2i9 Pre & Post – Air Handler Retrofit



Week ending 5-24-2017 **(windows open)** vs. 7-31-2017, poorer outdoor counts

INTERVENTION:

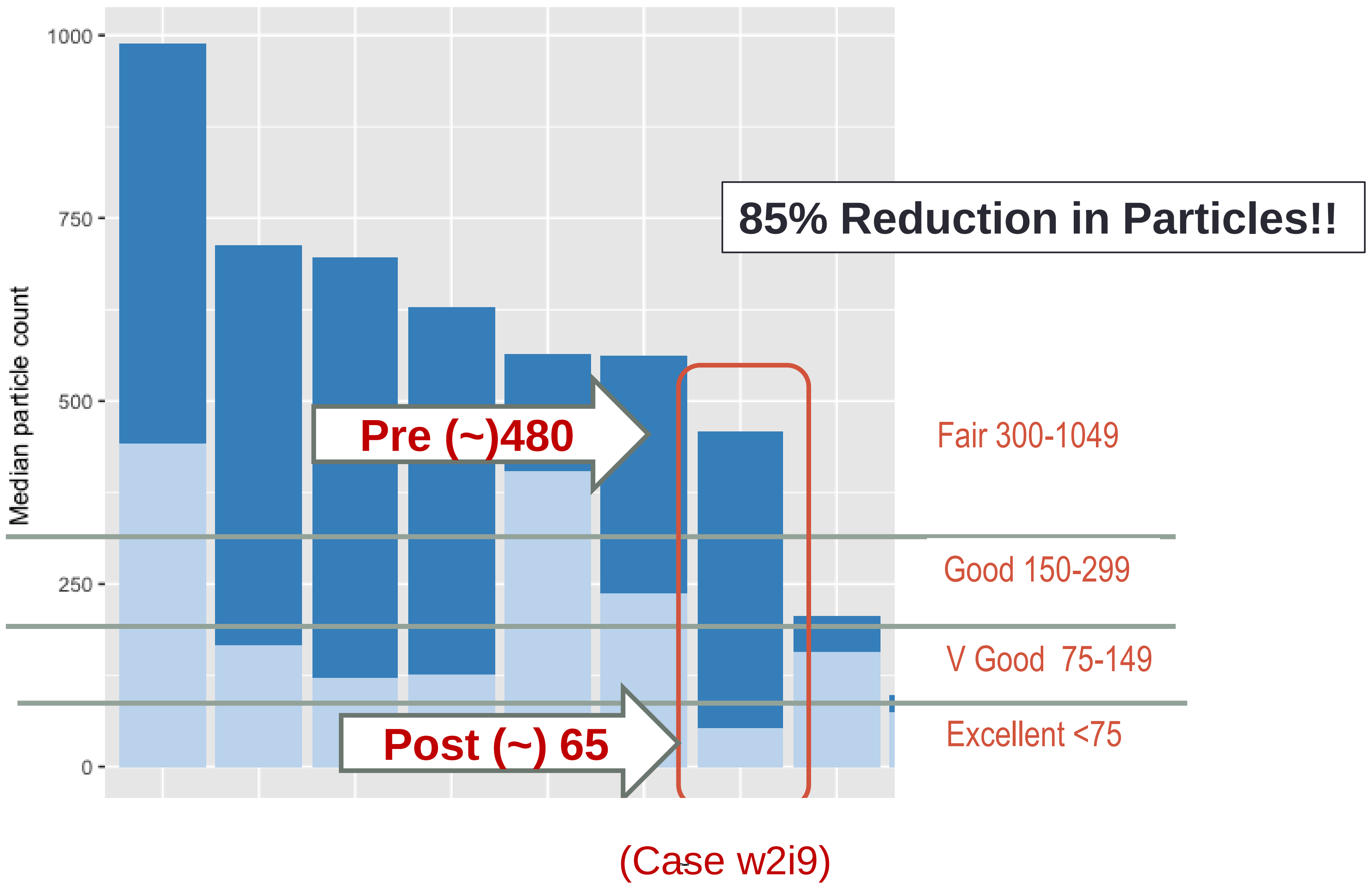
ECM blower (lower air flow & energy cost on continuous setting)

New return (larger 20" x 25" MERV 13 filter & pre-filter)

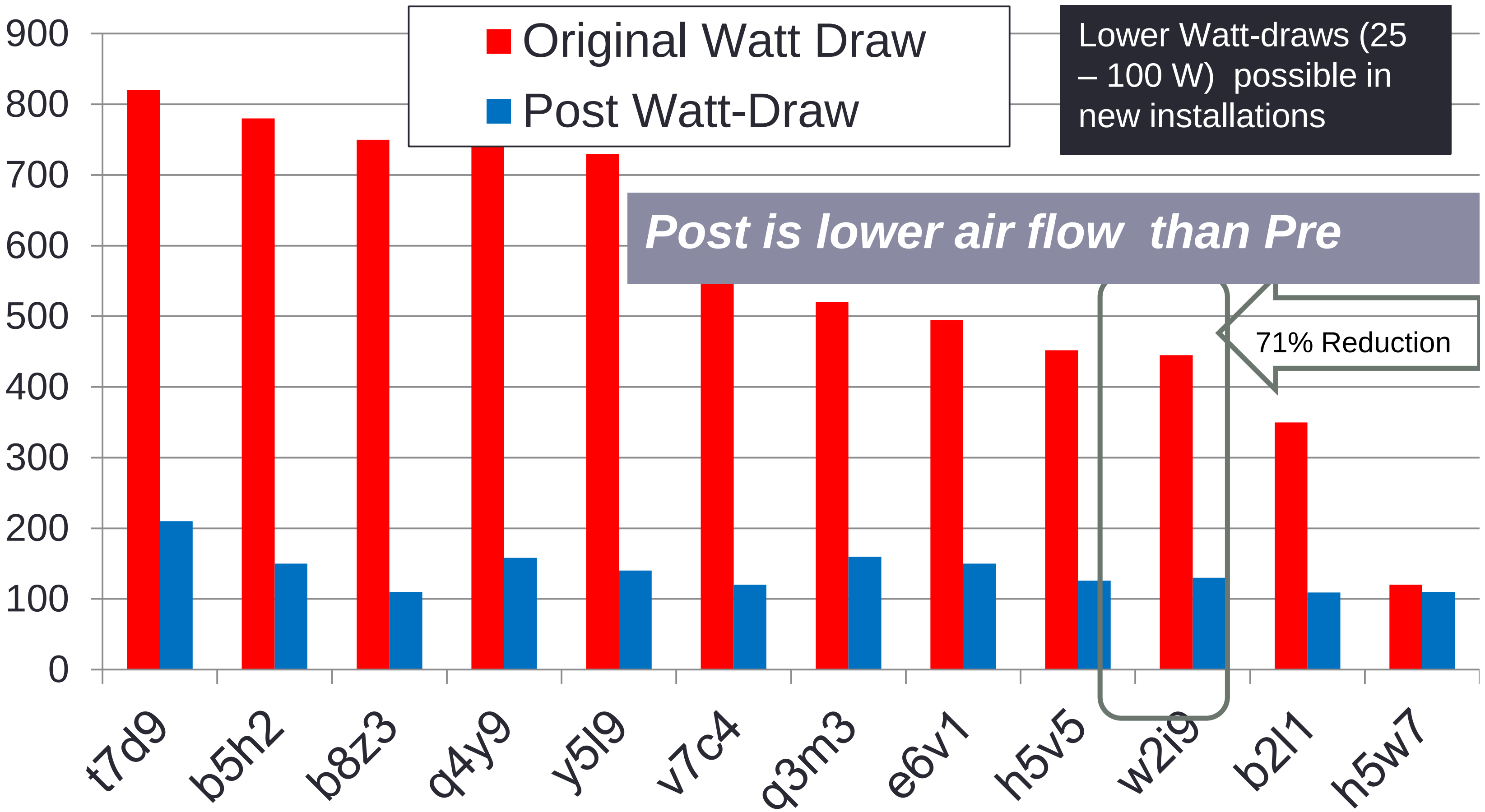
Cost (labor & materials): $1,000

RESULTS: Lower CO_2 in bedroom **24/7 annual operating cost: $131.40**

Selected ROCIS Intervention Homes
Pre-Post Median Particle Count

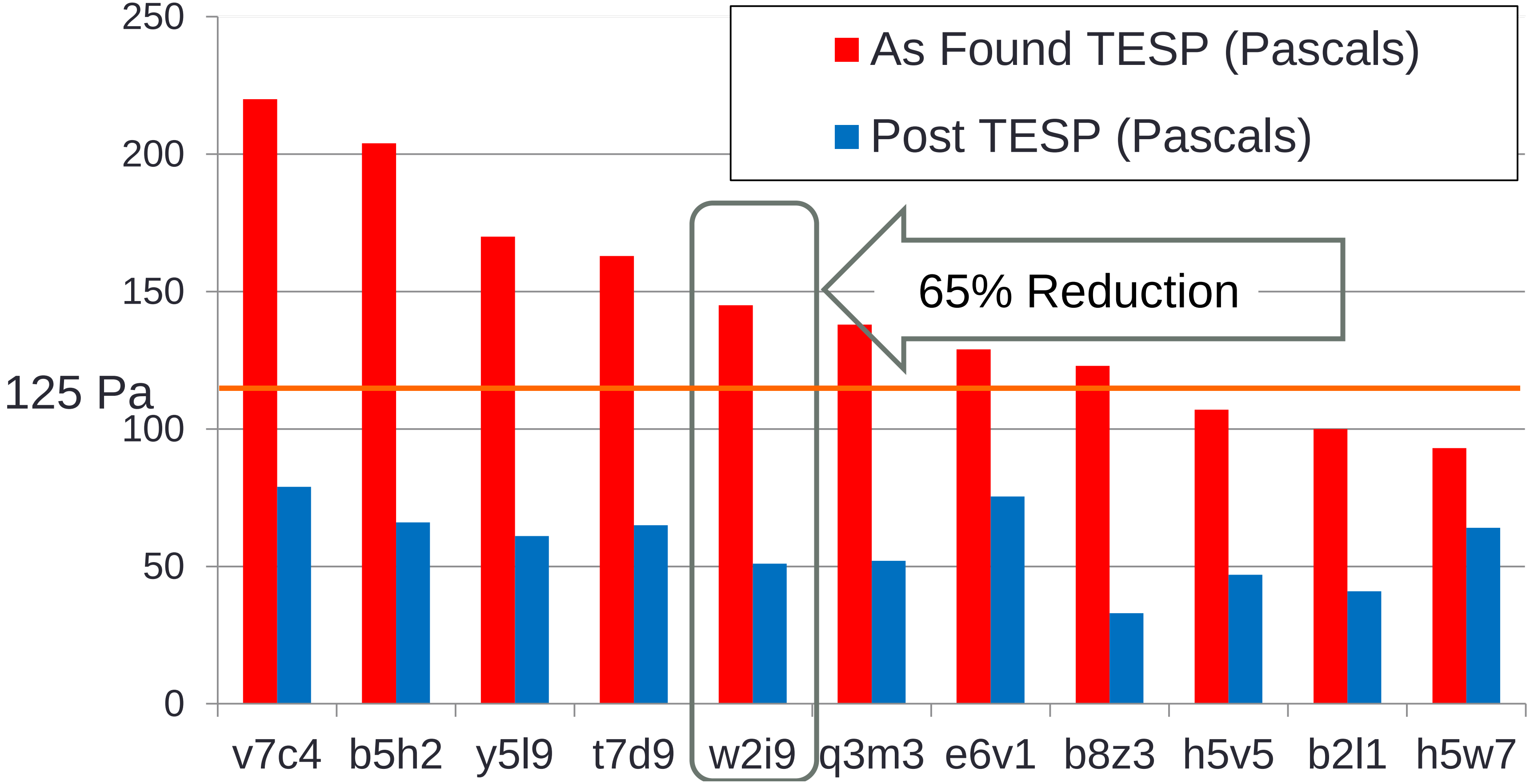


Air Handler Interventions
Pre-Post Continuous Watt-Draw



Use these codes **(w2i9)** to view particle data on ROCIS LMCP Data Explorer
http://rocis.org/rocis-data-explorer

Air Handler Interventions
Pre-Post TESP (Continuous Mode)



Reduction due to: 1) adjusting speed of existing ECM (2 cases);
2) ECM change-out (9 cases).

PSC motors & ECMs are ½ HP w/ nameplate TESP limit of 125 Pascals

Rhett Major

The Energy Doctor

www.energydoc.info

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BACK TO LINDA…
ROCIS AIR HANDLER INQUIRY

Results & Implications

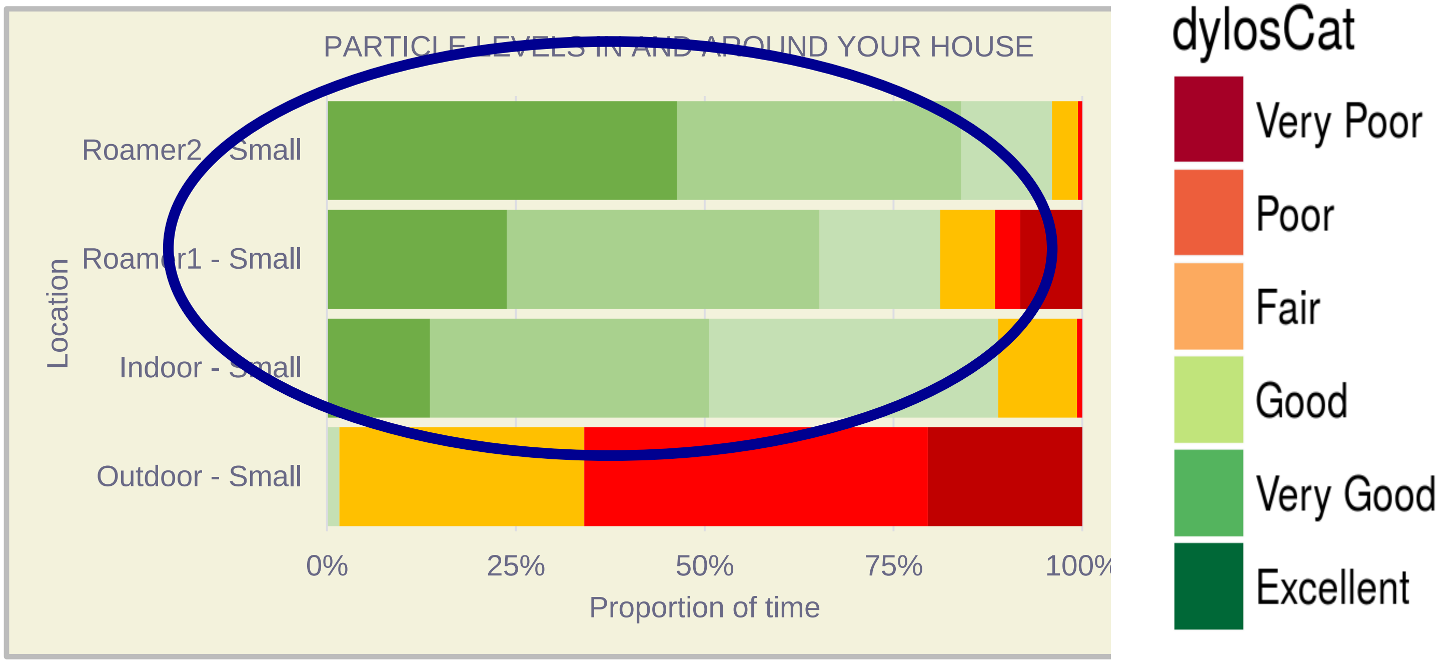
What is going on in this home?

- **ROCIS Data Explorer Participant Example 7**
- Click the link below to see ROCIS team member Don Fugler walk through an example of a participant's home data.
  Plug in the code **w2i9** to the Data Explorer (link above) to further examine this participants home.
  http://rocis.org/rocis-data-explorer-participant-example-7

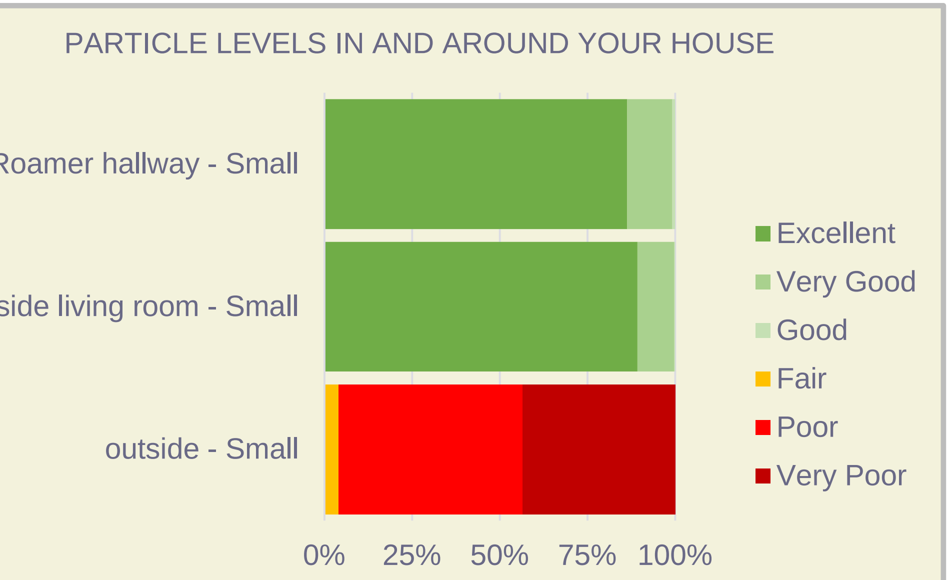
24/7 Filtration/AHU + Portable Air Cleaner

Pre & post:
Used portable
air cleaners

2,240 CFM_{50}



Intervention 07-12-17: ECM, new return drop w horizontal 20”x25” MERV 13 filter w/pre-filter
Results: Continuous Watt draw: pre: 495, post:150; 2.71 CFM/Watt
Pressure drop over filter: 52 PA to 17.5 PA
24/7 annual operating cost: **$164.25**
Recommendations: increase supply-side ductwork; downsize AC when replaced



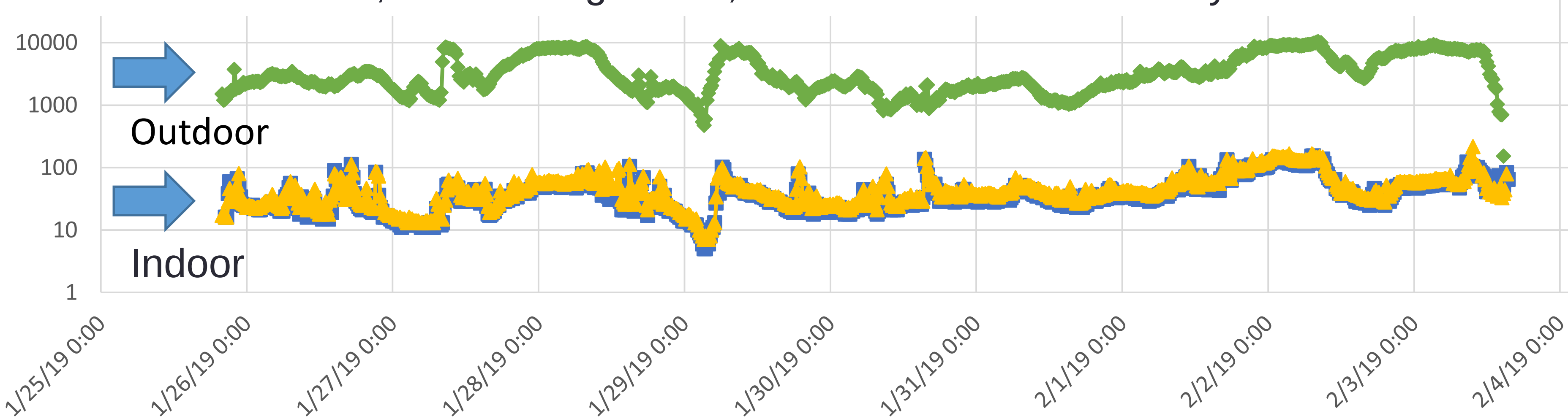
Air Handler 24/7 – MERV 13 Filter

Indoor tracks outdoor
Indoor uniform – 2 locations
Also – 2nd fl portable air cleaner

Continuous Mode: **$12/month**
Post: 110 watts; 500 CFM

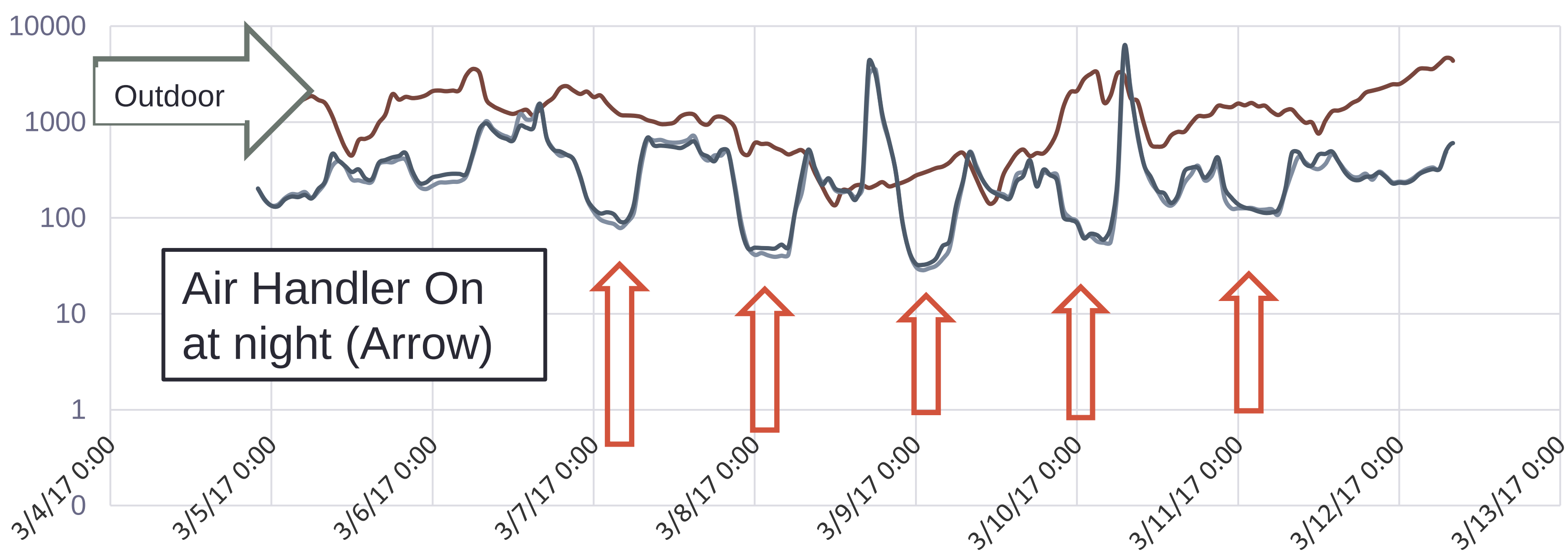
Dylos small (0.5+ microns) (#/1/100 ft^3)

Green – Outdoor; Blue Living Room; Yellow – 2nd Floor Hallway



DYLOS TOTAL PARTICLES

Night-time Air Handler Use



0.5+ µm particles per 1/100 ft^3; 15-minute avg.

Lower particle exposure during periods of greatest occupancy

Intervention (Dec. 16-Mar. 17): ECM, return drop w/ horizontal MERV 12 filter & pre-filter

Results: Continuous Watt-draw: pre 750; post:126; 3.57 CFM/Watt

System much quieter

Annual operating cost (8 hr./day): $44/yr.

This family (b8z3) uses natural ventilation (no AHU/filter) 5+ months/year

What Factors Should Be Considered Prior to Longer Run Time with Higher MERV Filter?

What Factors Should Be Considered Prior to Longer Run Time with Higher MERV Filter?

1) Fan operating cost
2) TESP within name plate
3) Duct system issues, such as leaks, ducts outside conditioned space
4) Face velocity for effective filtration
5) Filter maintenance (when operated 24/7 high MERV 1” filters clog very quickly)

Filter / AHU Inquiry: Questions

- ECM selection for better energy performance
- Filter replacement issues
  ($ & performance, occupant feedback, persistence)
- Selection of appropriate filter(s) (pre/post/larger)
- Bypass (leakage) around filter
- Control strategies
  - Such as EcoBee or Nest thermostat cycling options
  - Integration w/ IAQ sensor(s) - How good is good enough?

    (How important is <1 micron particle sensitivity?)

Are ECMs the Solution?

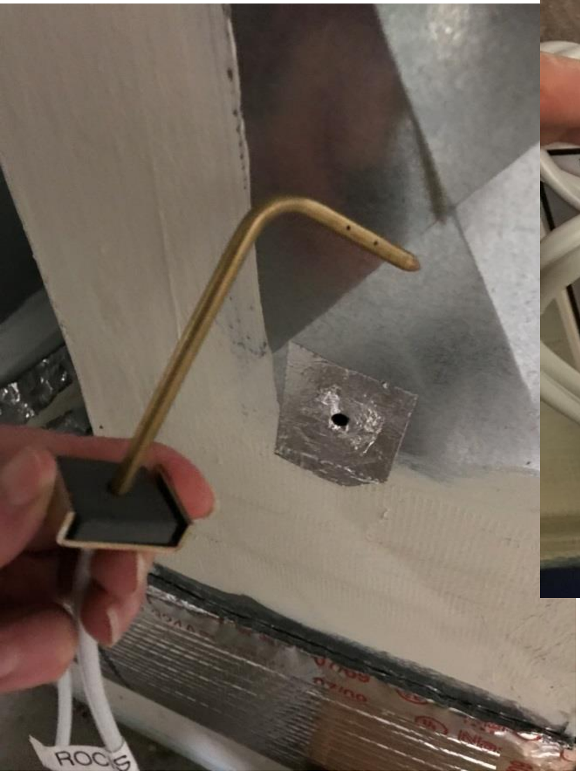
Not by themselves…

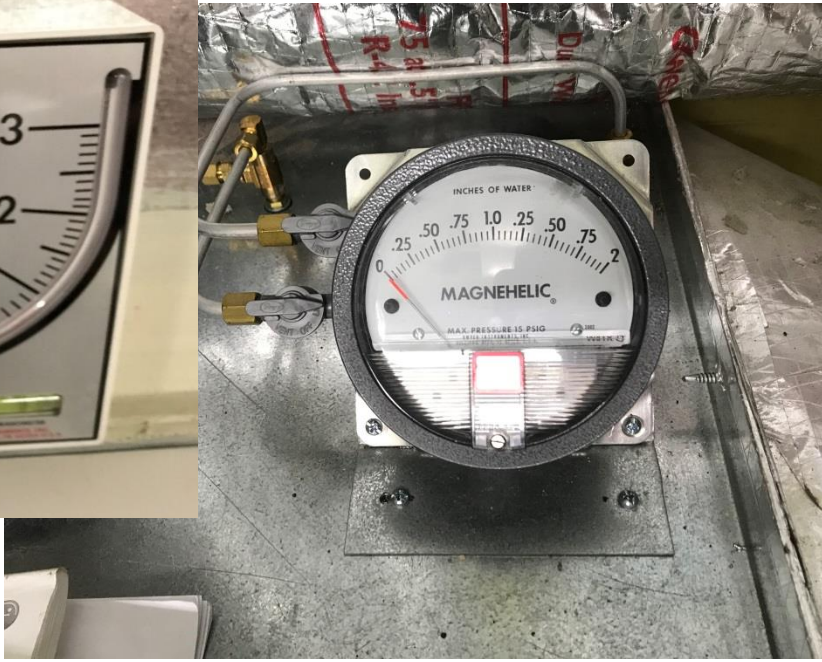
- Even with ECMs, 24/7 operation of central AHU can have a huge adverse impact on energy use & CO_2 emissions
- *Correct blower speed, TESP, & good ducts are essential*
- Must avoid clogged filters & inappropriate filters
- Two of our systems with the highest watt-draw (over 1000) were ¾ HP ECMs with restricted ductwork

Items to Explore
ECM change-out or Keep PSC Motor?

- PSC motor set for 15 minutes/hour at higher flow or continuous at night?
- Same CADR (clean air delivery rate?)
- If so, reduction in particles may be achieved with some PSC motors, at half the intervention cost (just return drop & deeper/larger MERV 13 filter)
- *Question: Same reduction in smaller particles or will higher face velocity affect filter performance?*

When Do Filters Need to Be Replaced?





Occupant feedback tools to measure pressure drop over filter

Install when feasible & train occupants

Jury is out on effectiveness; clear labeling & reminders could increase impact

With our multi-speed ECM no impact on energy use, just air flow & TESP

What are Implications for WAP / HP / Healthy Homes?

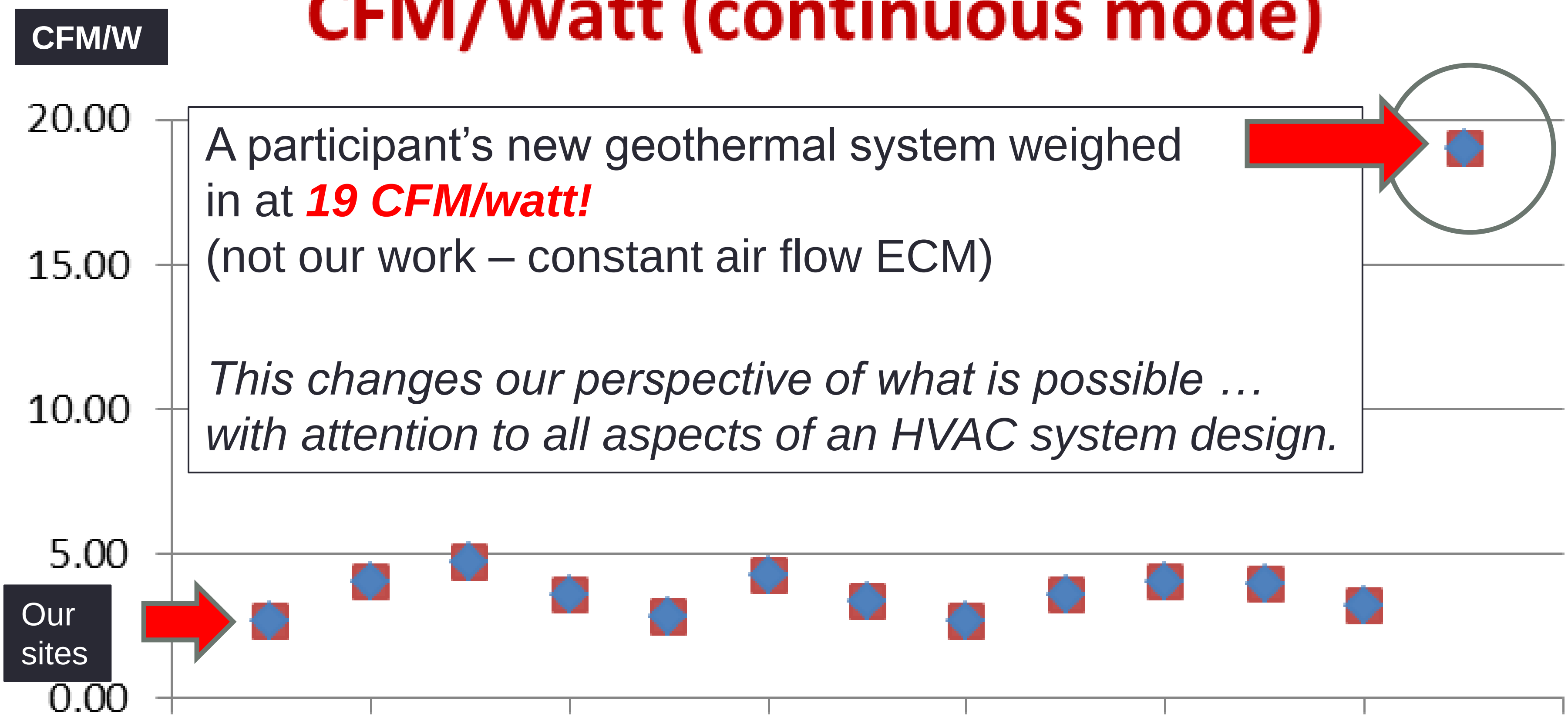
- Integrate diagnostic w/ inspection?
- Integrate as part of healthy home intervention?
- Integrate intervention w/ HVAC upgrade?
- Or at a minimum screen for referral for full diagnostic

Big Opportunity at HVAC replacement

- Downsize HVAC to reduce TESP
- Incorporate return drop modification & option for larger, deeper filter
- Set blower speeds for optimal performance
- Address duct system shortcomings

- To ponder…
  - Could potential filtration health & comfort benefits add impetus to getting HVAC systems designed & installed correctly?

What is Your Frame of Reference?? CFM/Watt (continuous mode)



It should be easier to achieve significantly better performance (CFM/watt in new HVAC installation

Intervention Summary

- These interventions can be effective; but household & HVAC **screening is essential**
- The **tighter** the house/building, the **greater** the **impact** of filtration…
- But, the tighter the building, the more critical it is to **control indoor sources**
- One option - shift focus from building exposure to **human exposure,** e.g., air quality in bedrooms **while people are sleeping**

Bottom Line!

Integrated solutions are needed to enhance health, resilience, energy efficiency, comfort, & durability (engagement, building tightness, source control, O&M)

Ideally, improve outdoor air quality!

Thanks to Phil Johnson &

The Heinz Endowments for supporting the

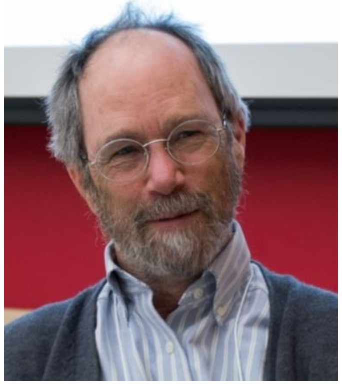
ROCIS initiative

(Reducing Outdoor Contaminants in Indoor Spaces)

and

Our 250+ Project Participants!

The ROCIS Team



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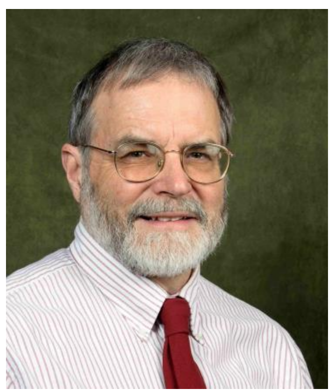

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Questions?

http://ROCIS.org/

- White papers & presentations
- Access to resources & research results
  - LCMP http://rocis.org/rocis-low-cost-monitoring-project
  - ROCIS Brief - Ducted Range Hood (Tom Phillips)
    - http://rocis.org/kitchen-range-hoods
  - Air Handler Inquiry http://rocis.org/air-handler-inquiry
  - ROCIS Data http://rocis.org/rocis-data
- Stay Tuned…
  - ROCIS Brief - Portable Air Cleaners
  - Video Shorts - Telling the Story

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