PARTICLE FILTRATION WITH CENTRAL AIR HANDLERS: FOLLY OR OPPORTUNITY?

TRACK: HVAC STRATEGIES, Breakout 3,
Tuesday, April 12, 2022, 11:30 - 12:30

PRESENTERS

Rhett Major, Principal
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www.ROCIS.org

LEARNING OBJECTIVES

At the completion of this session, attendees will :

1) Recognize the potential health benefits of substantially reducing exposure to particles (.1 to 5 microns), & the role of filtration in addressing particles generated inside & outside of a home

2) Be able to describe the interactions that can result from the use of higher MERV filters, & longer air handler run-times, as well as specific strategies to minimize adverse impacts

3) Be able to list 5 things to consider to determine the appropriateness of using a higher MERV filter, & operating an air handler system 50% or more of the time

FILTERING AIR WITH HOME HEATING & AIR CONDITIONING SYSTEMS

Significant missed opportunity to reduce particles

However: *Major liabilities* (energy use, emissions, energy cost, equipment life, & performance)

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

NHPC '22
NASHVILLE

TIME FOR A ROCIS VIDEO

Most of our exposure to outdoor pollution happens INSIDE buildings

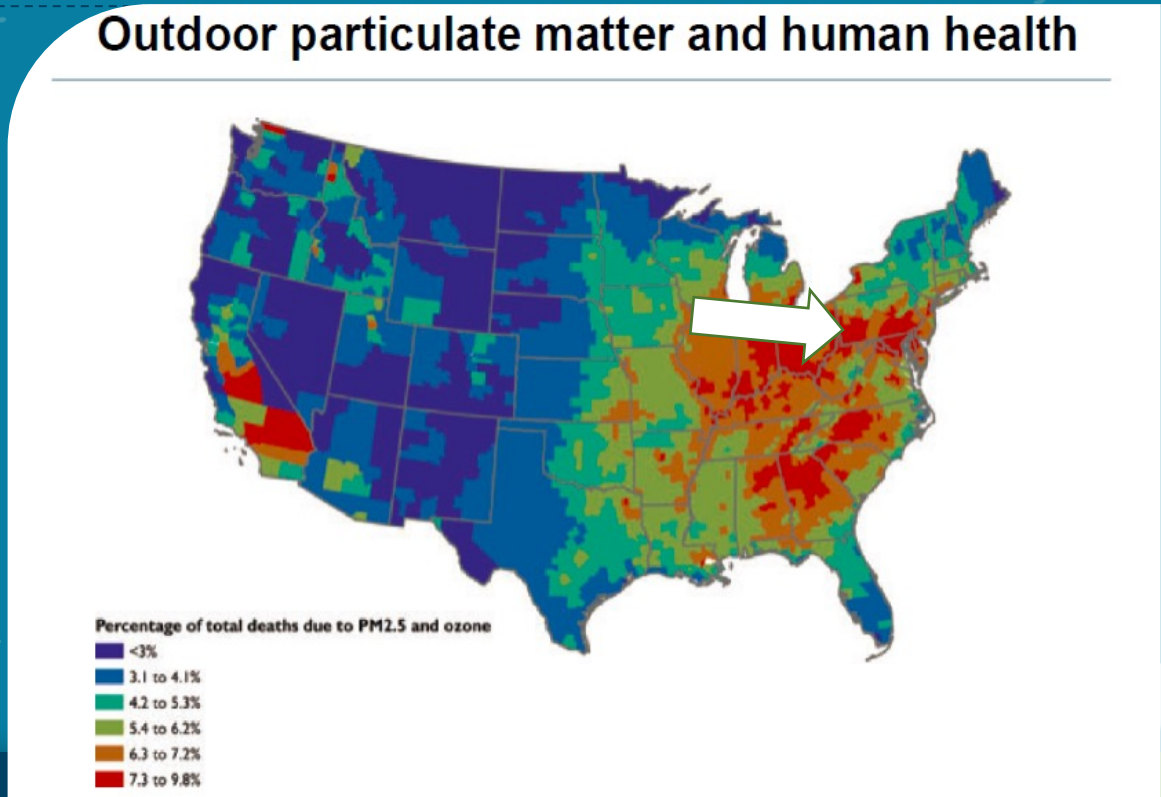
https://iaqscience.lbl.gov/health-effects-outdoor-air-particles

Outdoor Particles (PM) & Human Health

"Our best estimates of the US mortality burden associated with total $PM_{2.5}$ exposure in 2012

from ~230,000 to ~300,000 deaths."

Azimi, P., & Stephens, B. (2020). *Journal of Exposure Science & Environmental Epidemiology*.



Climate and Environment

Deadly air pollutant 'disproportionately and systematically' harms Americans of color, study finds

Black, Latino and Asian Americans face higher levels of exposure to fine particulate matter from traffic, construction and other sources

By **Juliet Eilperin** and **Darryl Fears**

Add to list

April 28, 2021 at 2:00 p.m. EDT

Interstate 15 carries heavy traffic between Southern California and Las Vegas. (David McNew/Getty Images)

The study found that Black people are exposed to 21 percent more fine-particle pollution compared to average Americans, while exposure was 18 percent greater for Asian Americans and 11 percent more for Hispanics. White Americans, by contrast, have 8 percent less pollution exposure than the average.

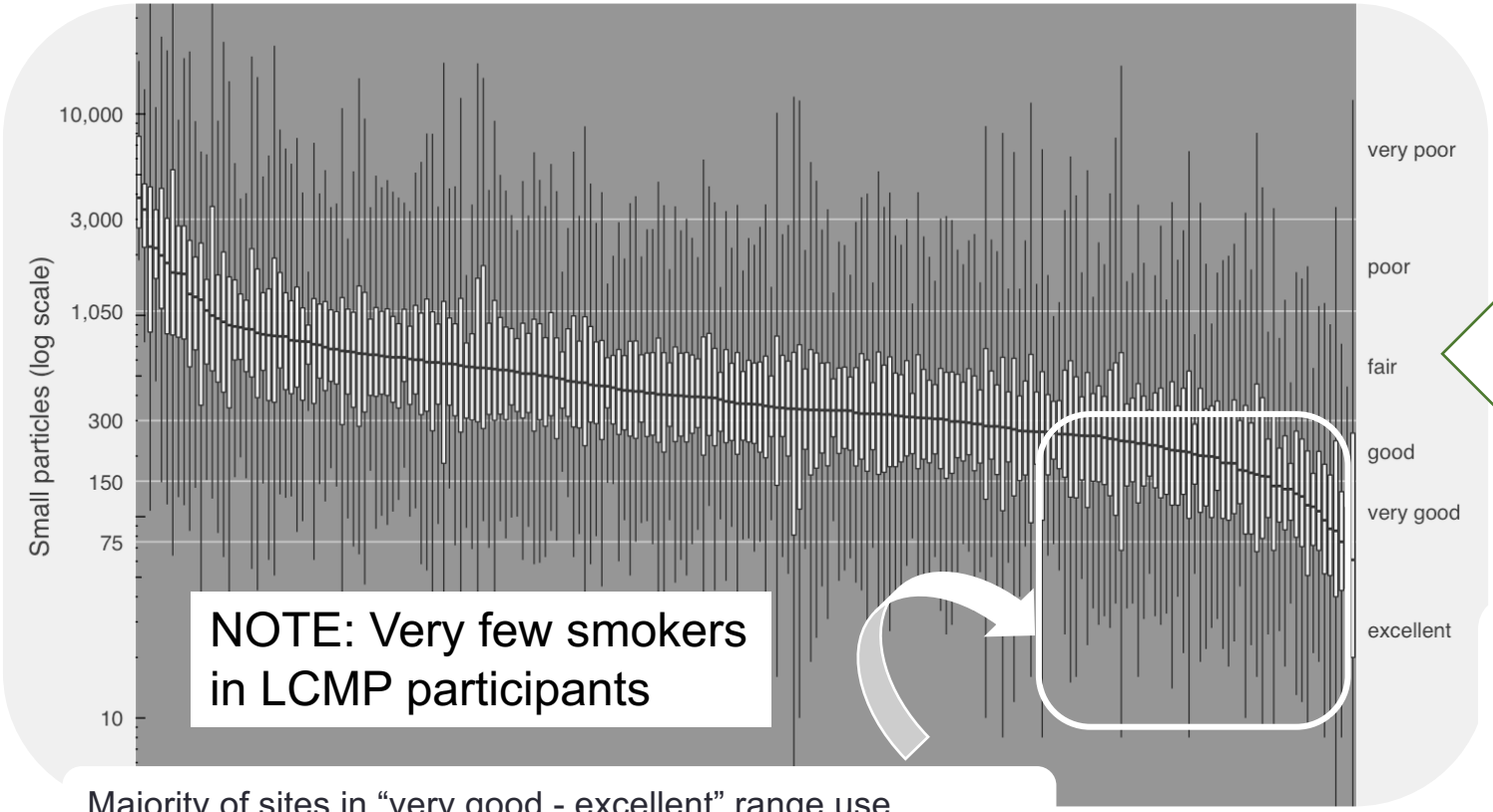
Jun 12, 2020

Environmental injustice in Pittsburgh: Poor, minority neighborhoods see higher rates of deaths from air pollution

"Systemic racism is not limited to one system."

Kristina Marusic

INDOOR PARTICLE DISTRIBUTION: ALL SITES



More than 20 to 1 difference!
Median:
~2/3 Fair
~1/3 Good / Very Good

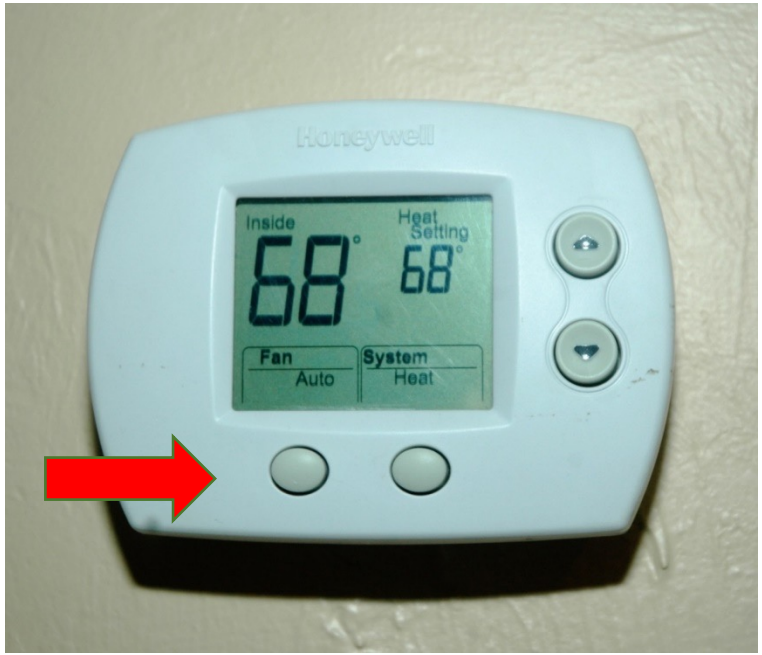
LCMP ROCIS DATA:
50% of observations are within each vertical box
Particles 0.5+ µm (Dylos small)
Dylos Corporation scale (on right)

Majority of sites in “very good - excellent” range use ***continuous filtration:*** either portable or central air handler

Filtration only works when it is ON!

AIR HANDLER OPERATION

- Thermostat usually set to “Auto”, not “On”
- Average annual run-time is ~15%
- Inadequate for filtration
- Call for heat & cool does not align with need for filtration
- With smart thermostats more control of “on time”



High MERV Filter - Air Handler (Filter/AHU) Inquiry

Initial Question…

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 ($, equipment durability, performance, or GHG emissions)?

NO !!

Diagnostic Screen is Required

NHPC '22
NASHVILLE

Filter/AHU Inquiry: *Approach*

Developed diagnostic protocol

Over 60+ 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

SPECIAL THANKS TO:

Scott Pigg - Slipstream

Mark Jerome - CLEAResult

Bill Graber - TEC

Steve Rogers - TEC

Building Science Corporation

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

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1” high MERV filters tend to be very restrictive.

TOTAL EXTERNAL STATIC PRESSURE

TESP - AKA - External Static Pressure

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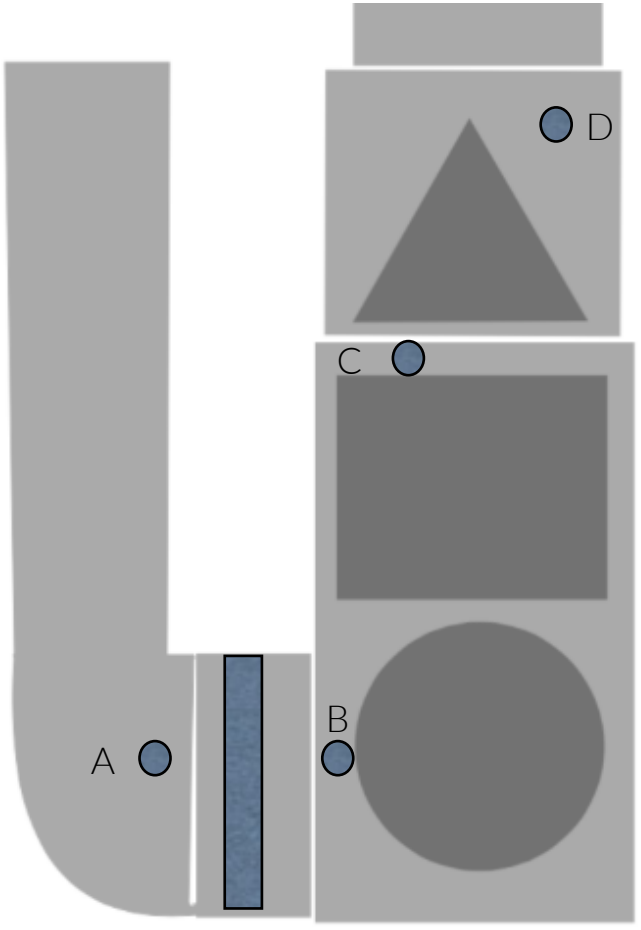
The greater the TESP, the more restricted the airflow.

Test Holes



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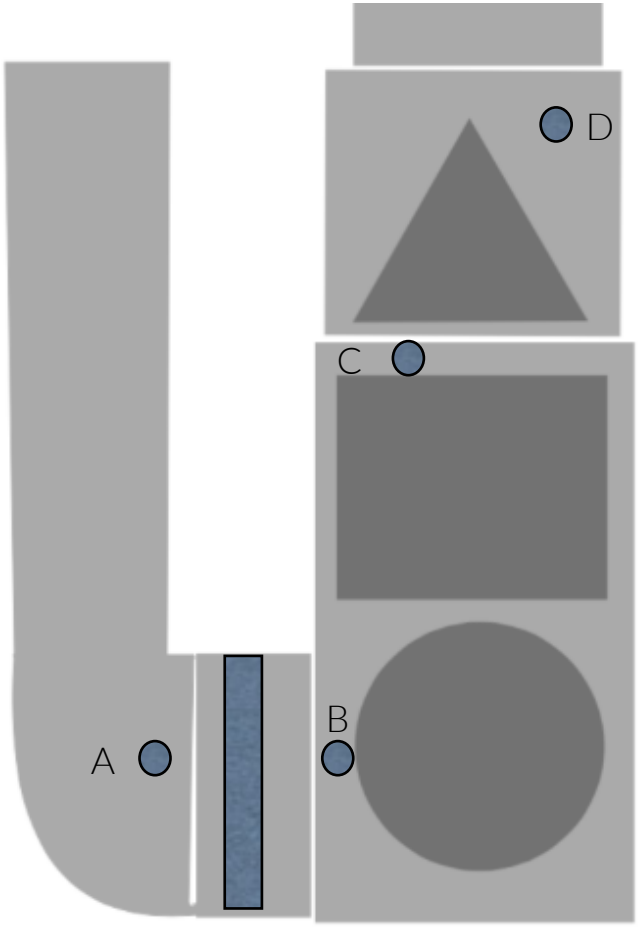
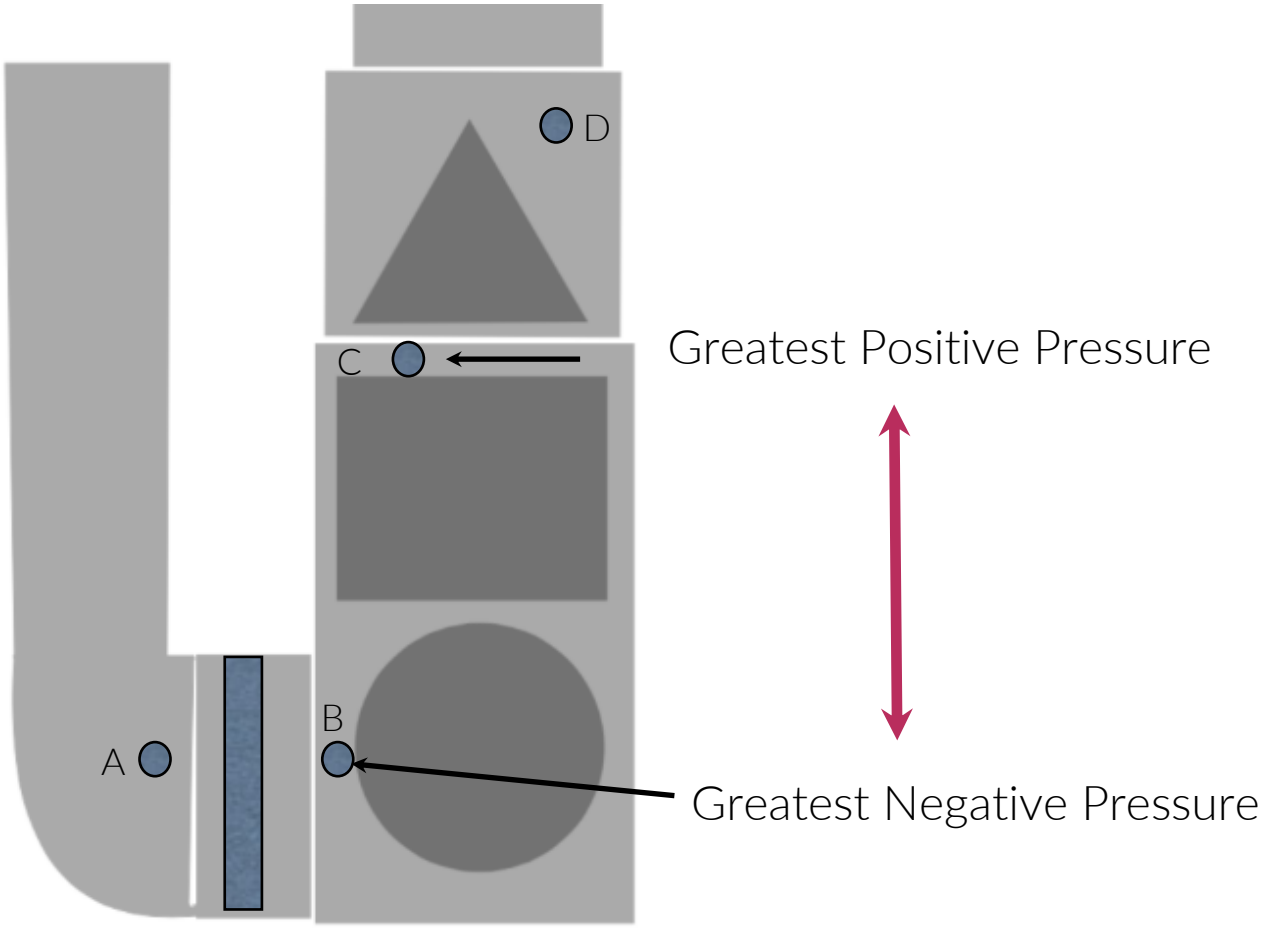


Drill test holes very carefully!

Test Holes



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MEASURING EXTERNAL STATIC PRESSURE & OEM FAN TABLE

Equipment Needed

- Standard Manometer/Magnehelic or Digital
- 1 or 2 Static Pressure Probes
- Tubing

- Other equipment
  - Drill with ¼ inch bit
  - Step Drill bit

Measure Static Pressure with manometer

- **Drill ¼ inch ports, insert static tip**

Return Plenum

After Filter

Before Coil

Supply Plenum

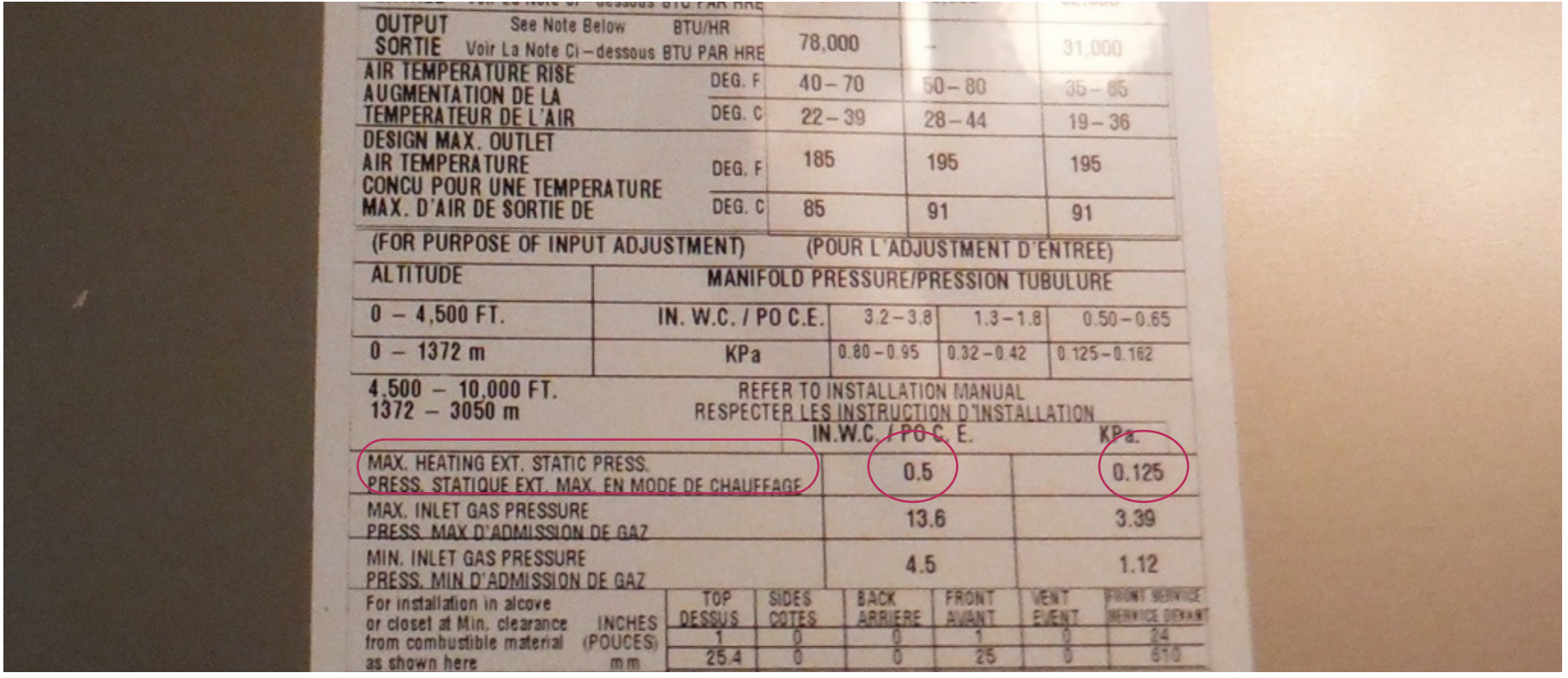
OUTPUT / SORTIE — See Note Below / Voir La Note Ci-dessous	BTU/HR / BTU PAR HRE	78,000	–	31,000
AIR TEMPERATURE RISE / AUGMENTATION DE LA TEMPERATEUR DE L'AIR	DEG. F	40 – 70	50 – 80	35 – 85
	DEG. C	22 – 39	28 – 44	19 – 36
DESIGN MAX. OUTLET AIR TEMPERATURE / CONCU POUR UNE TEMPERATURE MAX. D'AIR DE SORTIE 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		TOP / DESSUS	SIDES / COTES	BACK / ARRIERE	FRONT / AVANT	VENT / EVENT	FRONT SERVICE / SERVICE DEVANT
	INCHES (POUCES)	1	0	0	1	0	24
	mm	25.4	0	0	25	0	610



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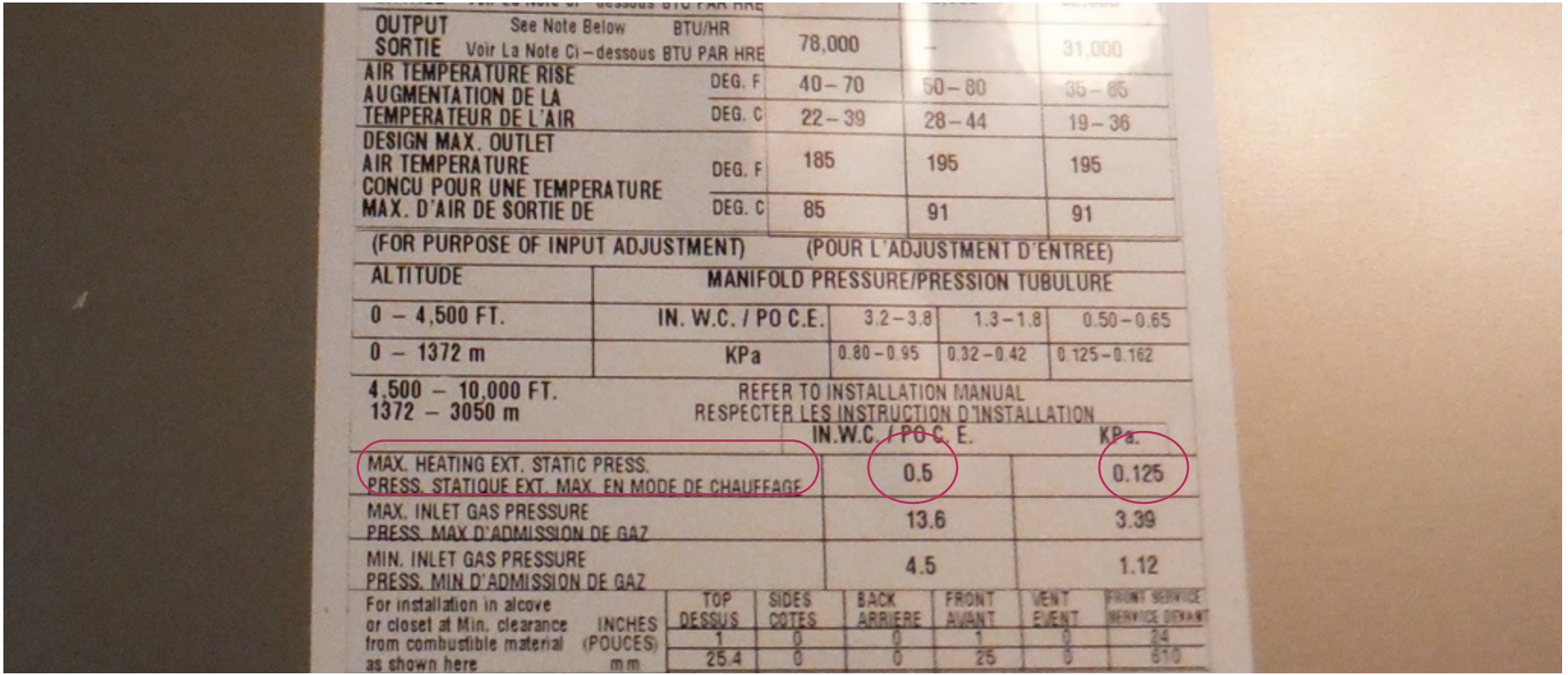

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Every furnace or air handler has the maximum static pressure on the manufacturers label.
I transfer this number to my static pressure test sheets.

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. _____**

Diagnostic Energy Auditors, Western Pennsylvania

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I record the static pressure measurements from these 4 locations here, & start doing the calculations

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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

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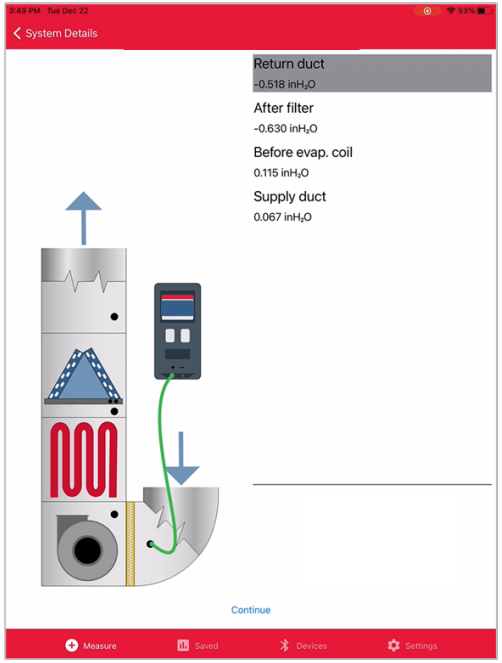
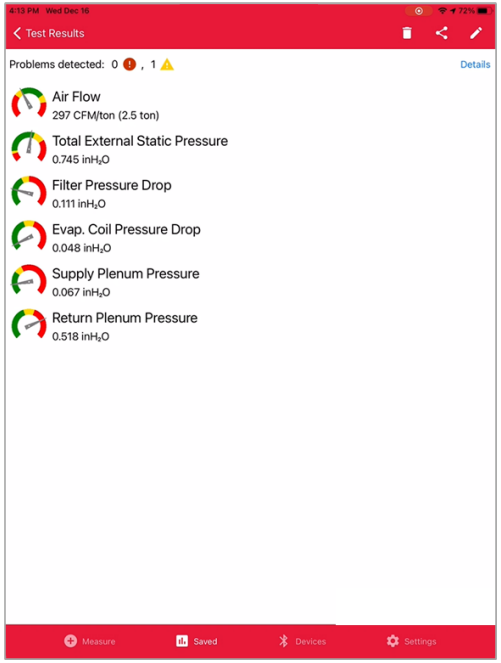
TRUEFLOW PRESSURE AND FLOW ANALYSIS

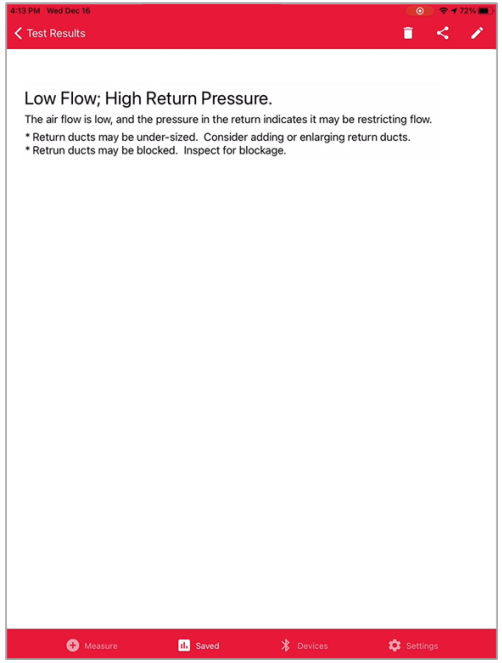
Measure Pressures & Flow



Results – Issue Detected



Details, Possible Actions



TRUEFLOW®

Why Should I Care About Static Pressure?

- *High static pressure* may cause:

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- *High static pressure* **may cause:**
  - High amp draw on ECM and variable speed motors

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Why Should I Care About Static Pressure?

- *High static pressure* **may cause:**
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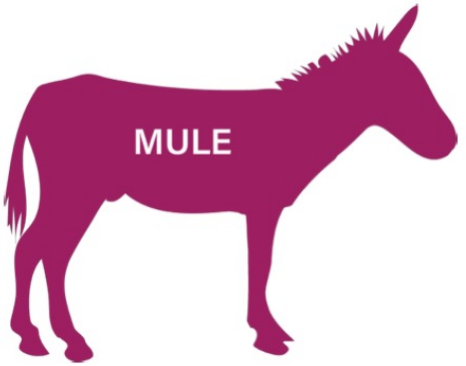
  - High energy usage
  - Blower motor and/or compressor failure

Three types of blowers

PSC

ECM
Constant-Airflow

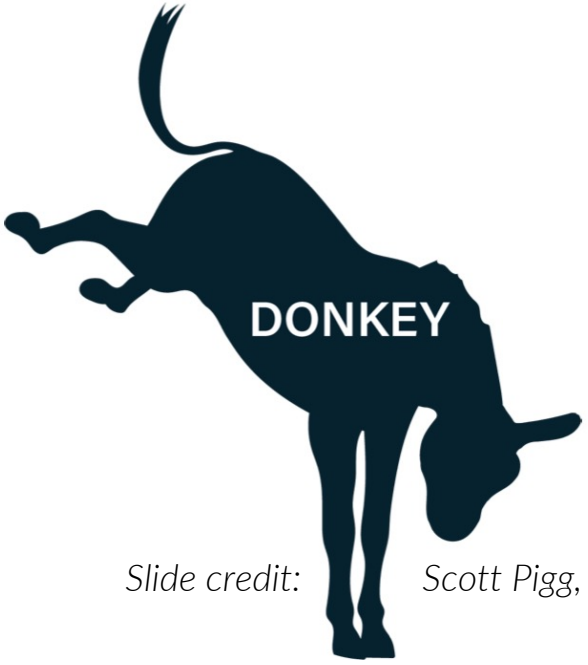


ECM
Constant-Torque

Slide credit: Scott Pigg, Slipstream

Permanent-split Capacitor (PSC)

- Widely used for furnace blowers
- AC induction motor
- Runs at constant speed; 3-4 selections
- Limited airflow range
- Not very efficient (60-65%)
- Low cost
- Commodity replacement



Slide credit: *Scott Pigg, Slipstream*

Electronically-commutated Motor (ECM), *Constant Airflow*

Aka "brushless permanent magnet (BPM)"

- Introduced in late 1980s for high-end, "variable-speed" furnaces
- DC motor
- Maintains constant airflow
- Wide airflow range
- More efficient
- Has start/stop ramping
- High cost
- Mfr specific

Slide credit: Scott Pigg, Slipstream

Airflow Control Tips
For Constant Volume ECM™

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  while delivering the correct airflow.

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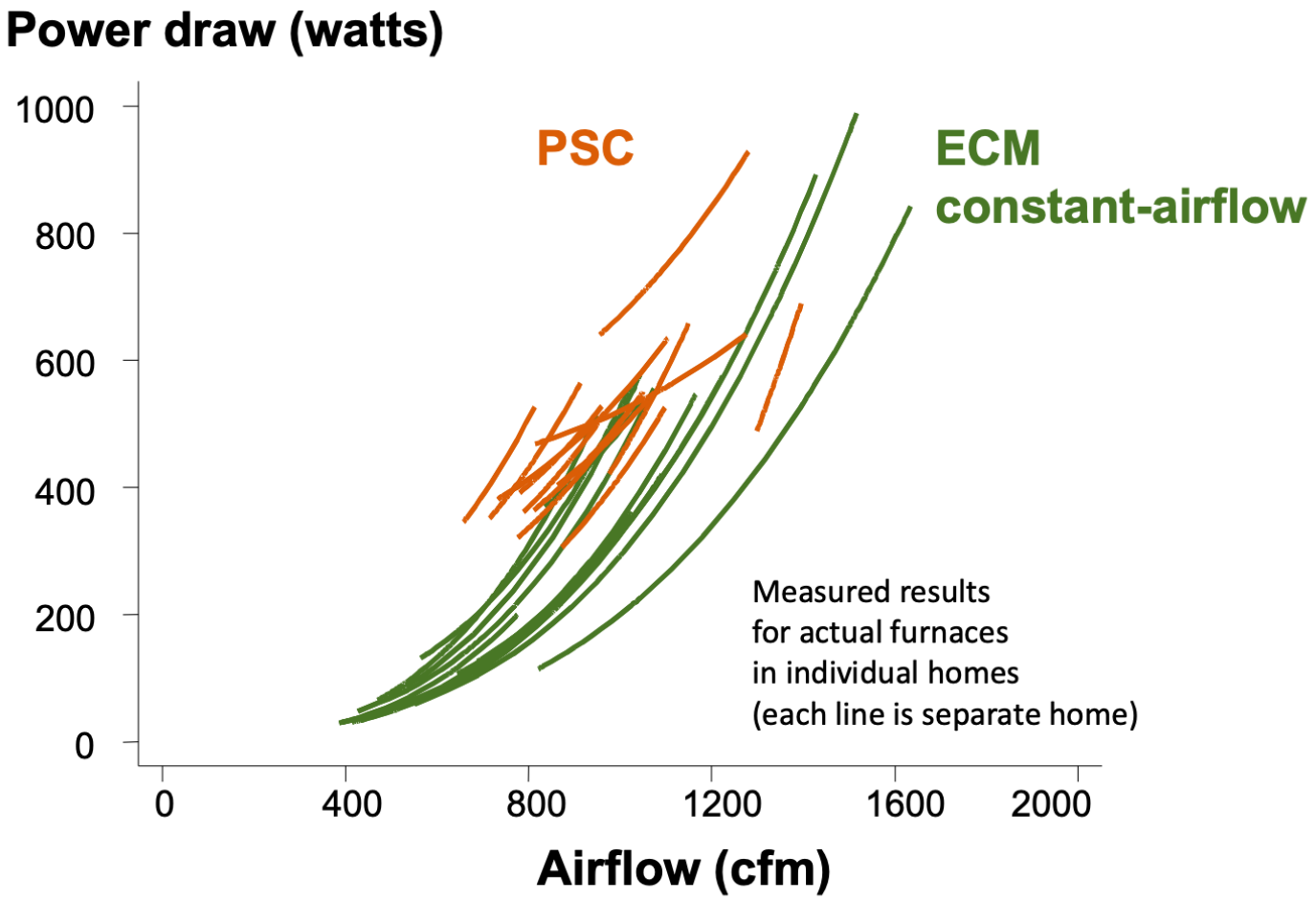
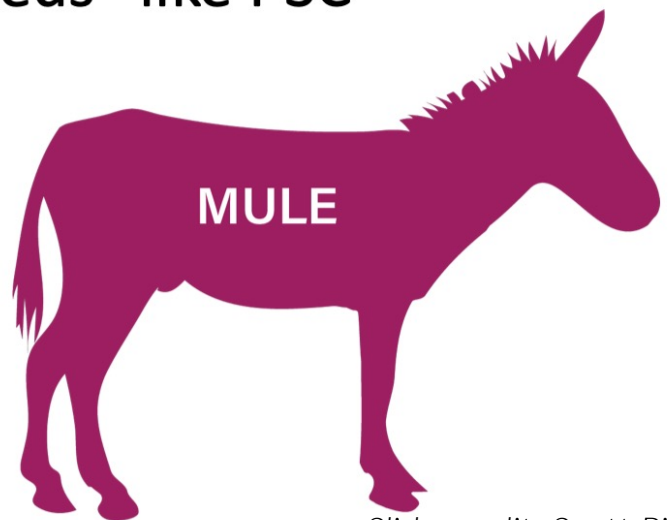
This is a measurement - not a setting!


Power draw (watts)
1000
800
600
400
200
0
PSC
ECM
constant-airflow
Measured results
for actual furnaces
in individual homes
(each line is separate home)
0
400
800
1200
1600
2000
Airflow (cfm)

Electronically-commutated Motor (ECM)
Constant Torque

Original trade name "X13"

- Introduced around 2006
- ECM efficiency
- Maintains constant torque (not airflow)
- Limited to discrete "speeds" like PSC
- Has start/stop ramping
- Middle cost
- Can be retrofit



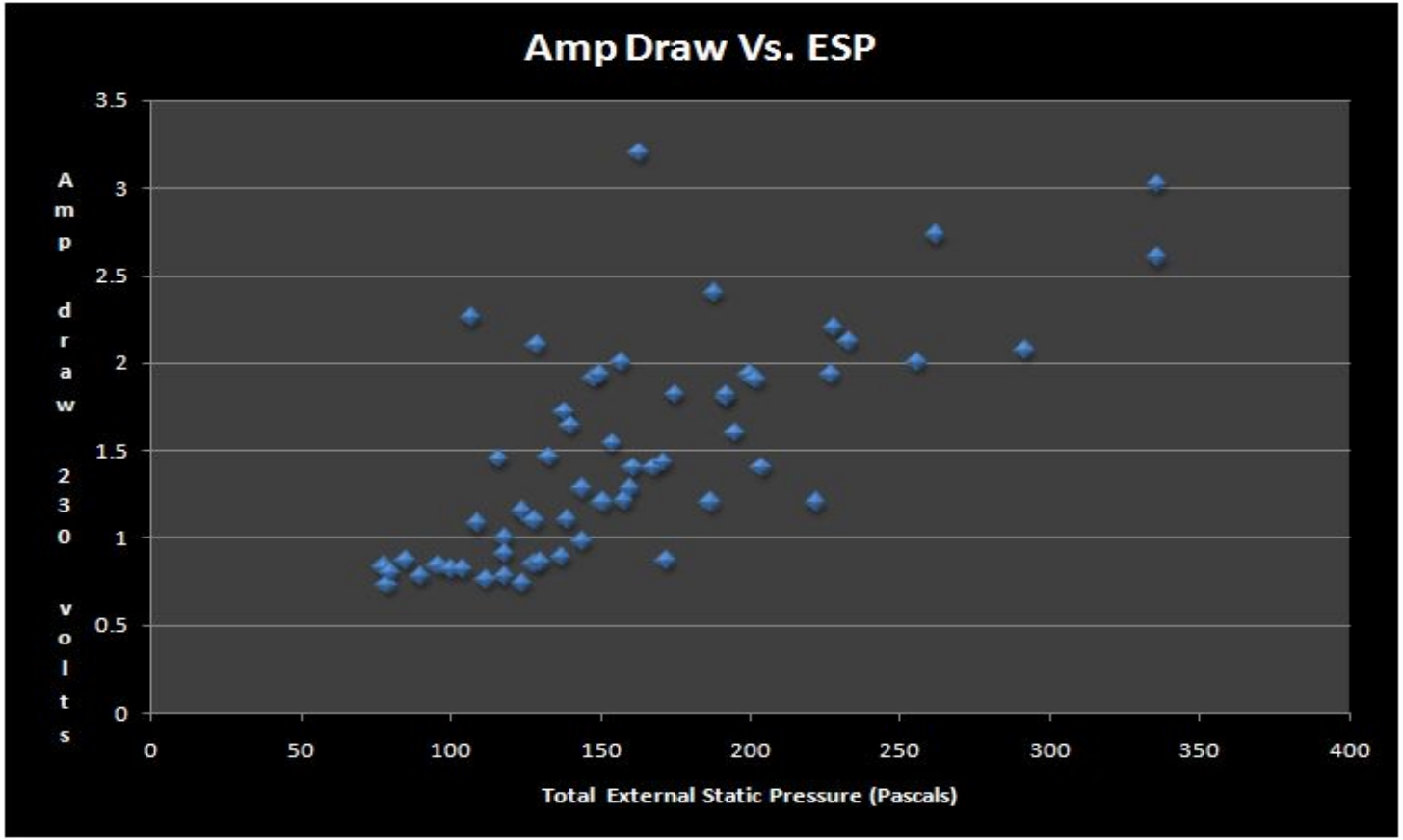
Slide credit: Scott Pigg, Slipstream

Response to flow resistance (static pressure)

As static pressure goes up, …	Airflow…	Power Draw…
	…goes down	…goes down
	…goes down, (but not as much)	…stays about the same
	…stays about the same	…goes up

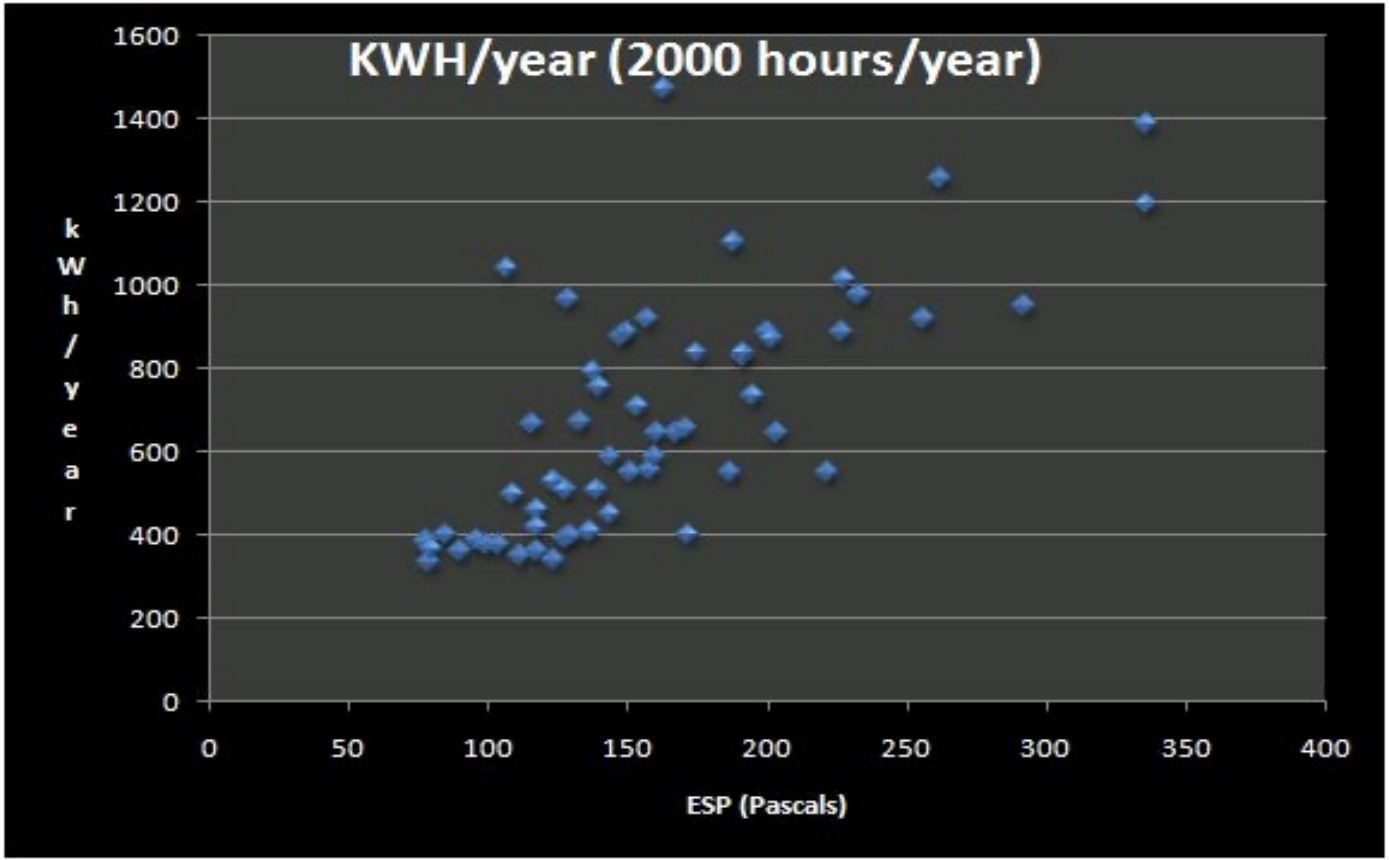
Slide credit: Scott Pigg, Slipstream

AMP DRAW VS. EXTERNAL STATIC PRESSURE - ECM / VARIABLE SPEED



Slide credit:
Mark Jerome - CLEAResult

KWH/YEAR VS. EXTERNAL STATIC PRESSURE - ECM / VARIABLE SPEED



Slide credit:
Mark Jerome - CLEAResult

MEASURING WATT DRAW

- Clamp-on style Current Transformer (CT) (OWL, Energy Detective, Sense)

MEASURING WATT DRAW

- Clamp-on style Current Transformer (CT) (OWL, Energy Detective, Sense)
- Converts magnetic field to Wattage

MEASURING WATT DRAW

- Clamp-on style Current Transformer (CT) (OWL, Energy Detective, Sense)
- Converts magnetic field to Wattage
- Wireless monitor display

Clamp-on style Current Sensor (CT)

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

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?

Total External Static Pressure

- What can increase TESP?
- Wrong fan speed

Total External Static Pressure

- What can increase TESP?

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

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

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**

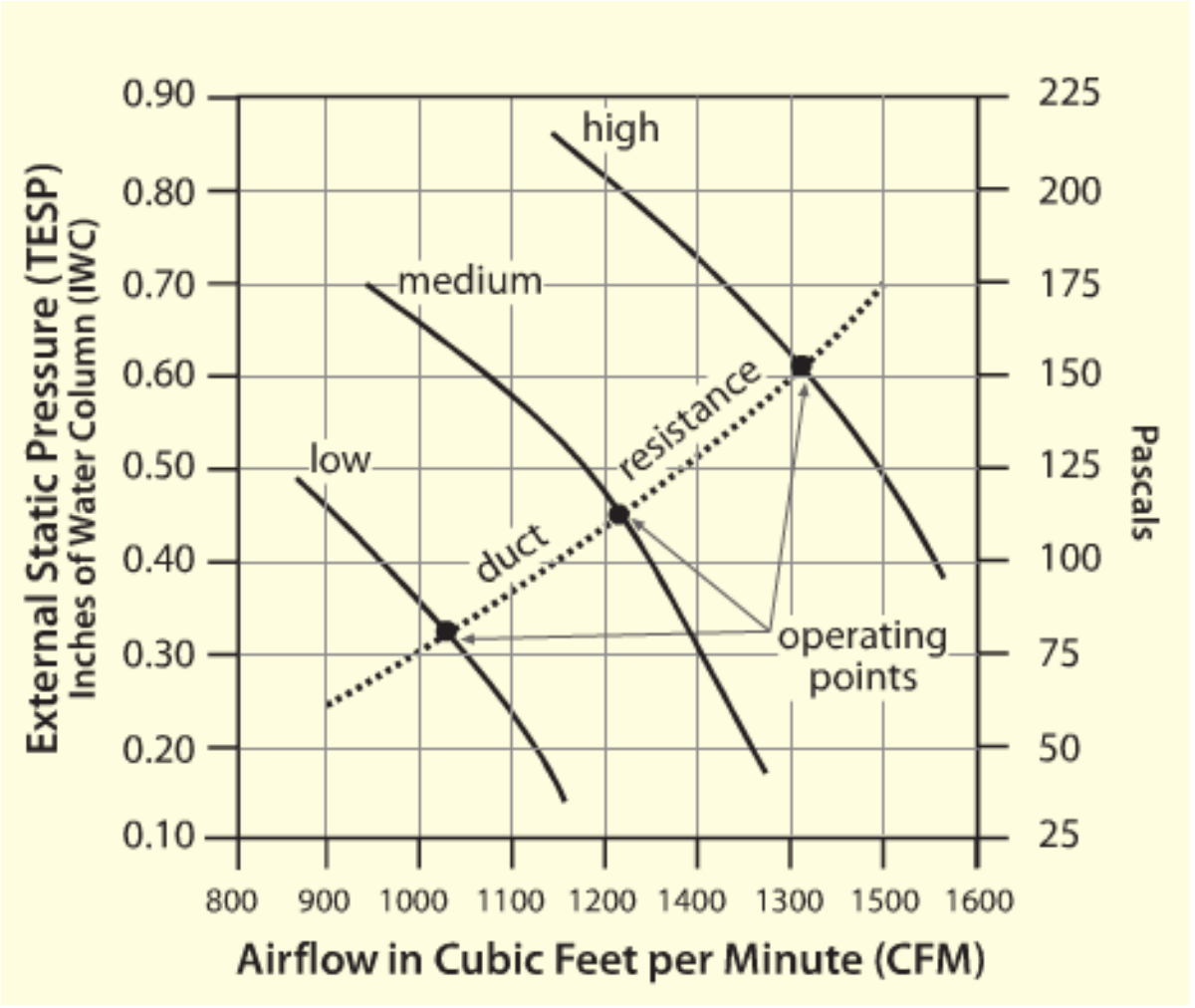
- The greater the TESP, the less the airflow with PSC motors, or the higher the wattage draw (with ECM)

Permanent-split Capacitor (PSC)

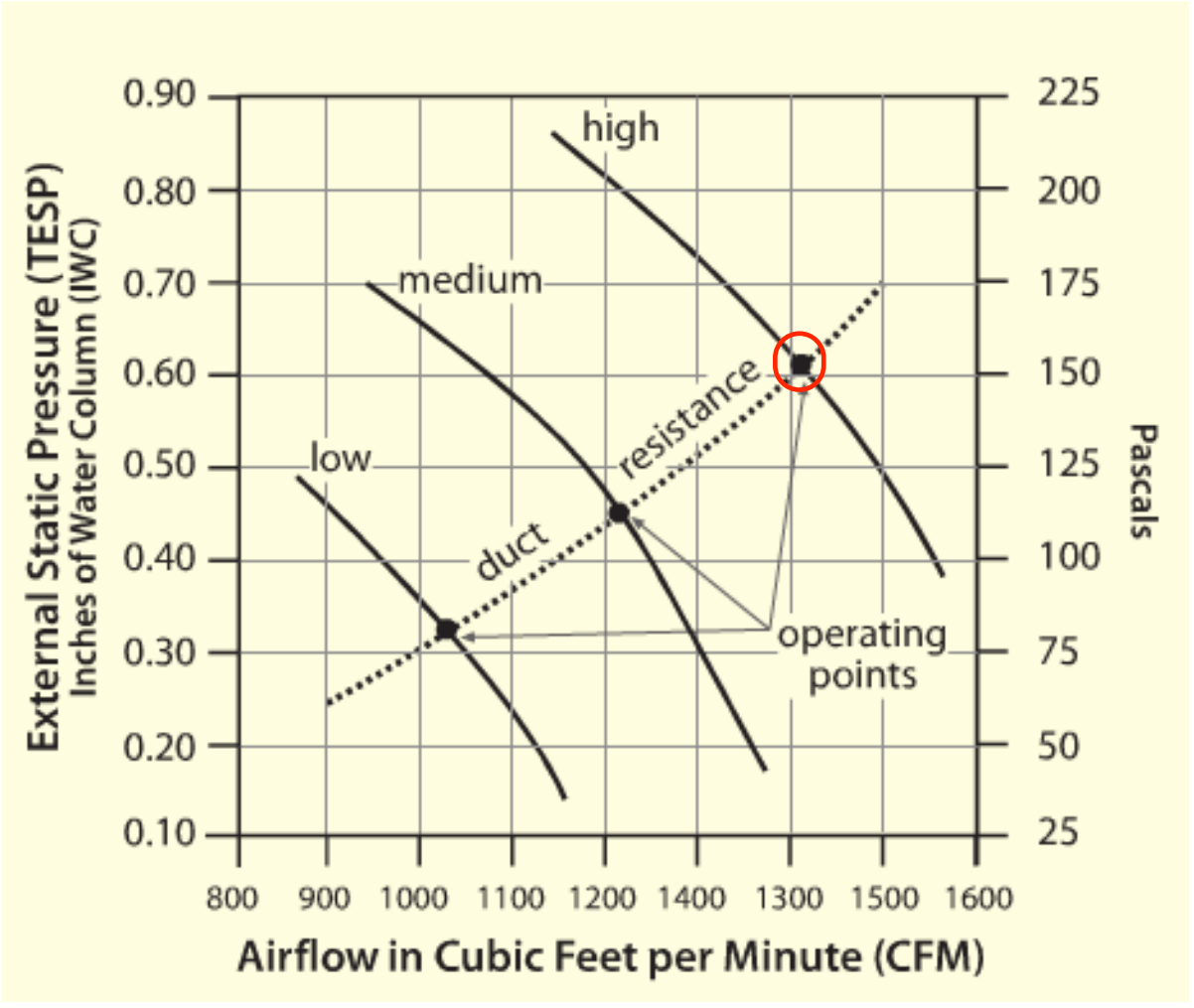
- Widely used for furnace blowers
- AC induction motor
- Runs at constant speed; 3-4 selections
- Limited airflow range
- Not very efficient (60-65%)
- Low cost
- Commodity replacement

Slide credit: Scott Pigg, Slipstream

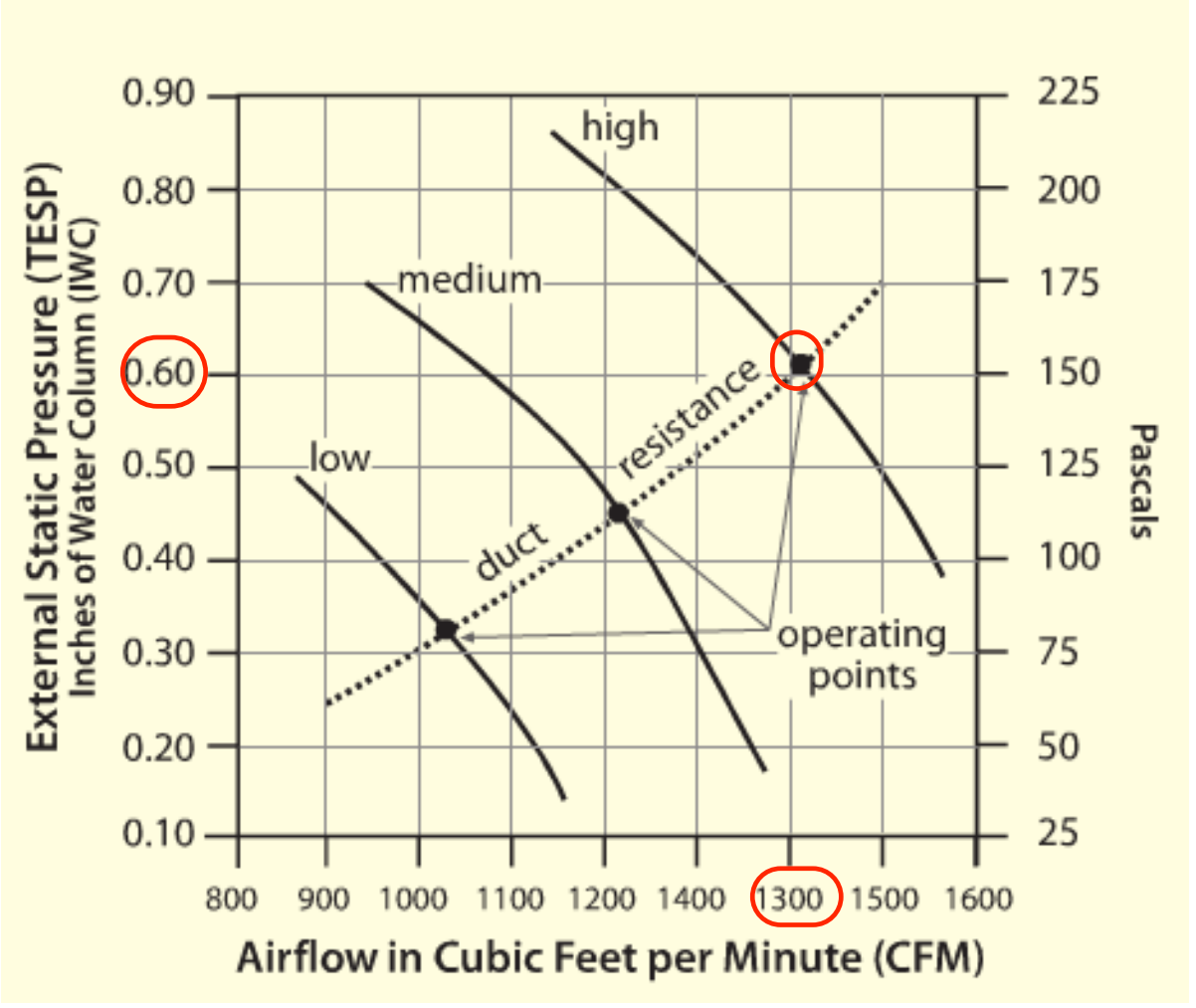
Wrong fan speed - PSC



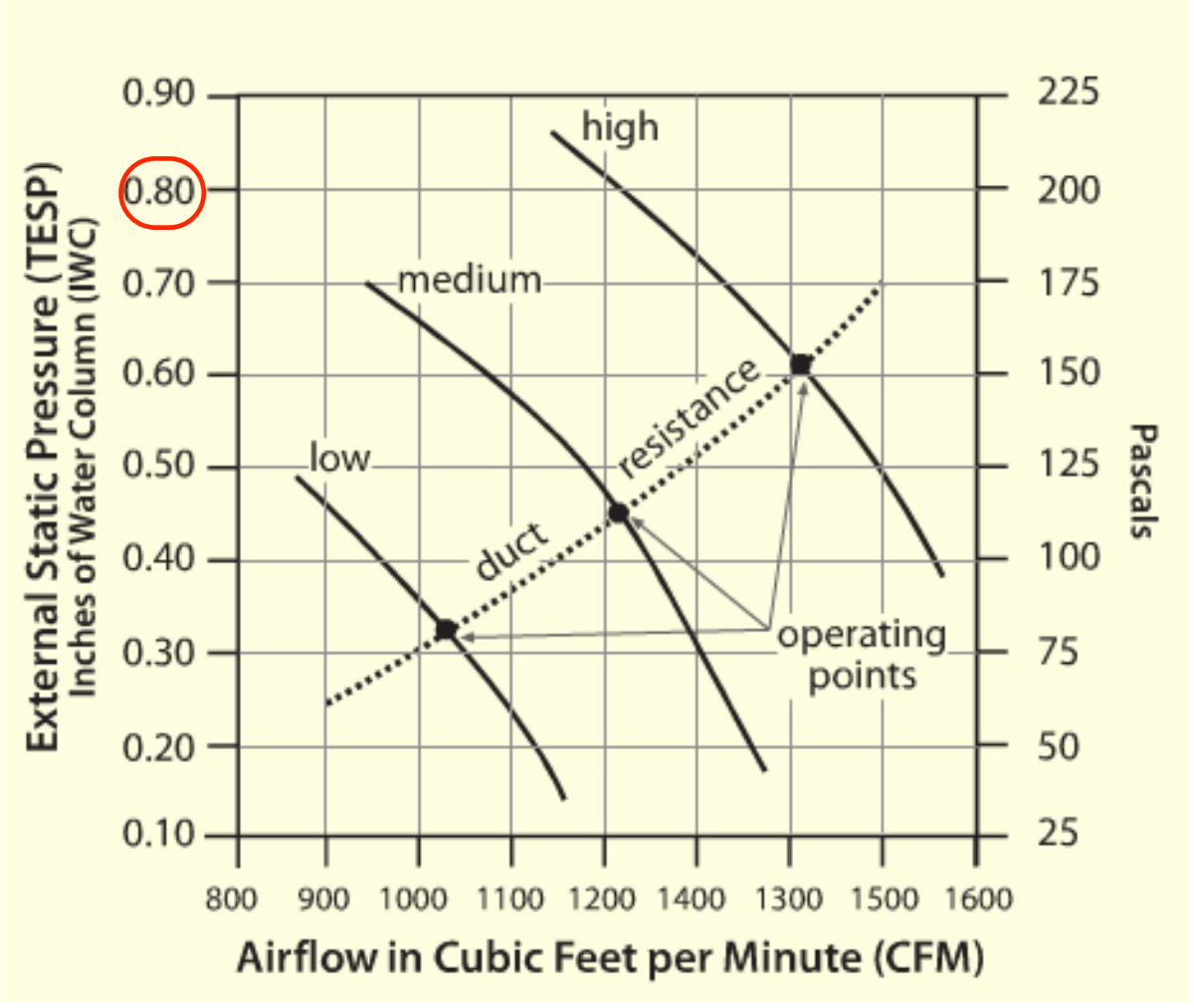
Wrong fan speed - PSC



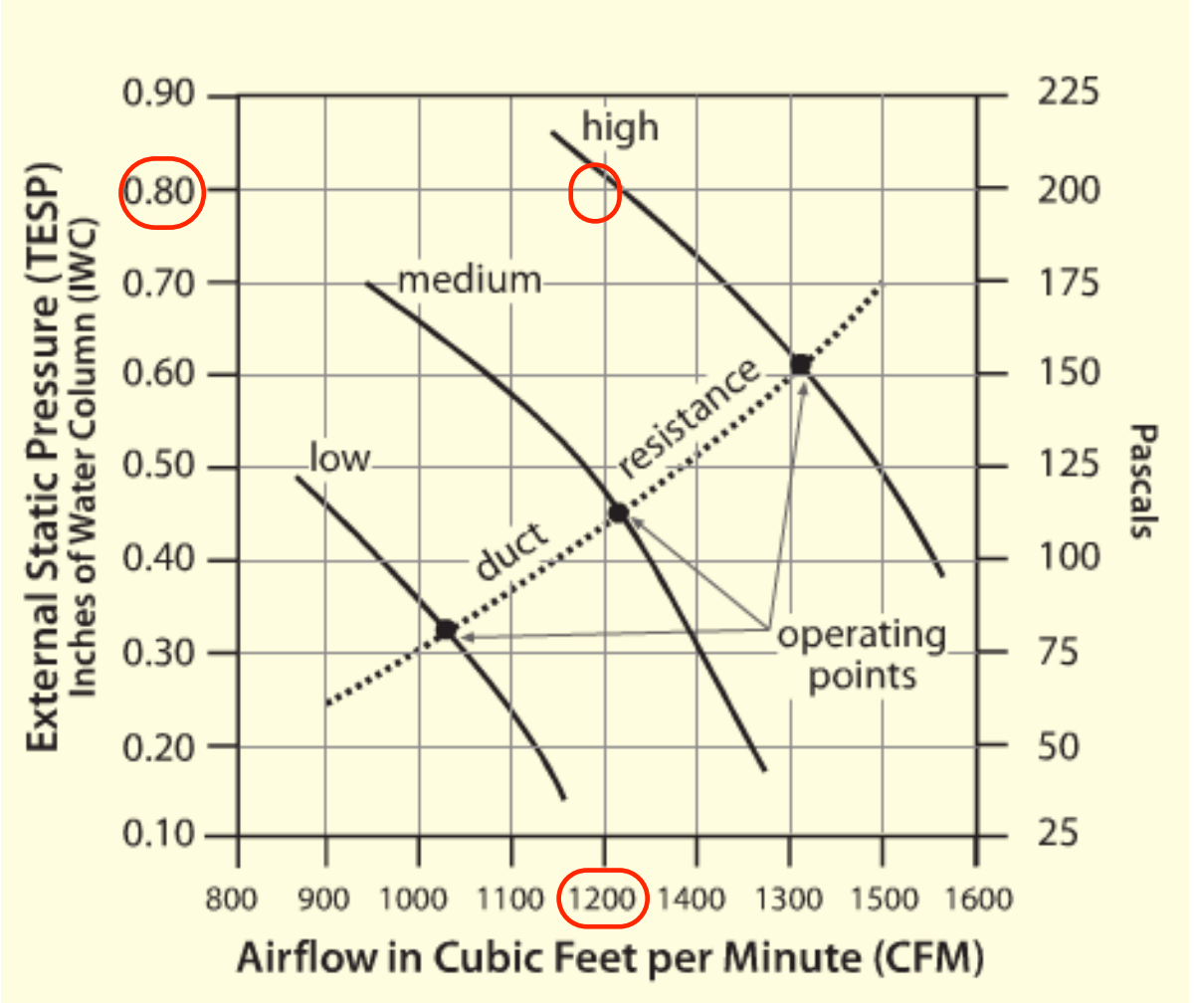
Wrong fan speed - PSC



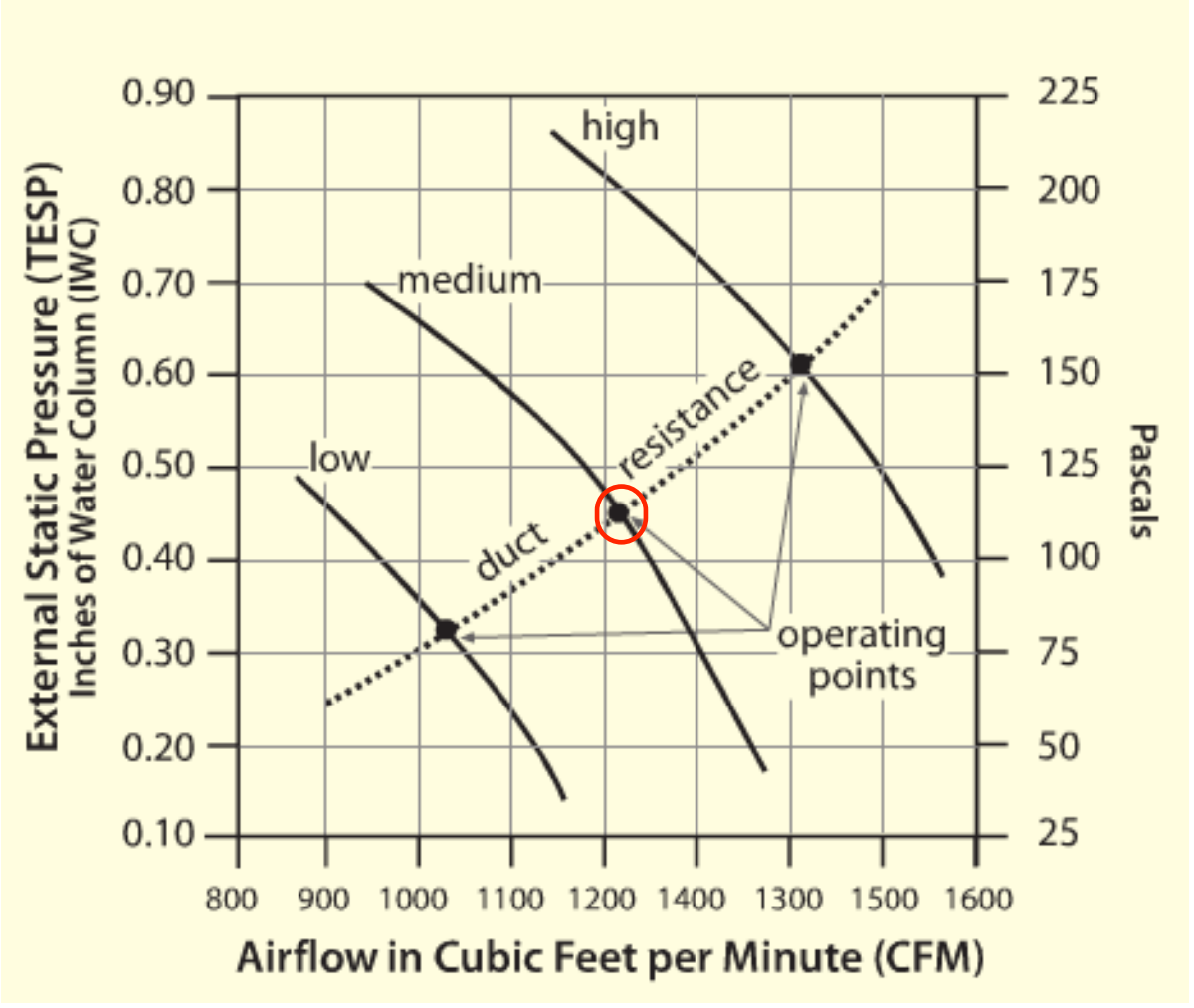
Wrong fan speed - PSC



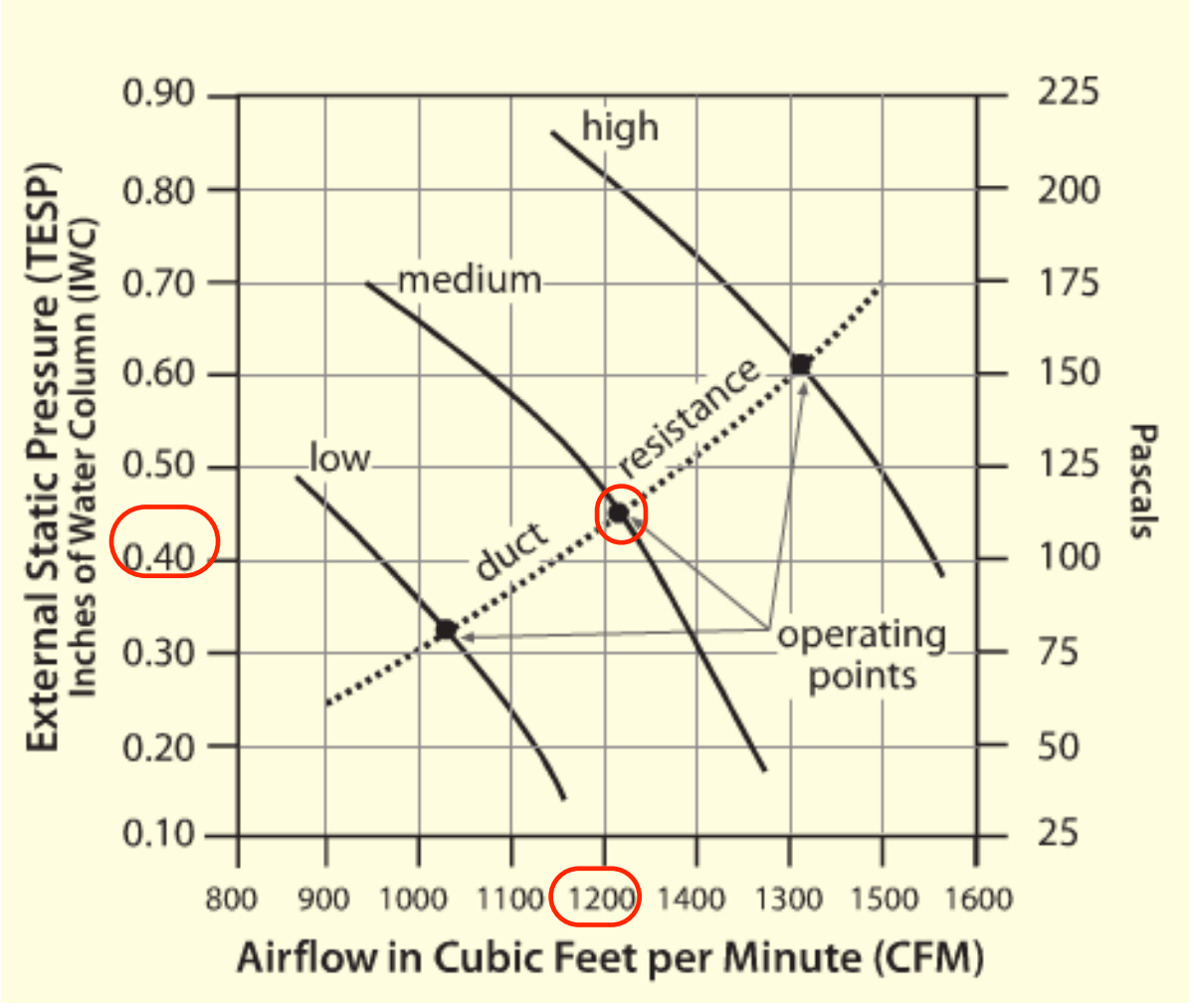
Wrong fan speed - PSC



Right fan speed - PSC



Right fan speed - PSC



Electronically-commutated Motor (ECM), *Constant Airflow*

Aka "brushless permanent magnet (BPM)"

- Introduced in late 1980s for high-end, "variable-speed" furnaces
- DC motor
- Maintains constant airflow
- Wide airflow range
- More efficient
- Has start/stop ramping
- High cost
- Mfr specific

Slide credit: Scott Pigg, Slipstream

*UH2B080A9V3V FURNACE HEATING AIRFLOW (CFM) AND POWER (WATTS) VS. EXTERNAL STATIC PRESSURE WITH FILTER									
1st Stage Capacity = 50,440 2nd Stage Capacity = 77,600									
	AIRFLOW SETTING	DIP SWITCH SETTING			EXTERNAL STATIC PRESSURE				
		SW 7	SW 8		0.1	0.3	0.5	0.7	0.9
HEATING 1ST STAGE	LOW	ON	ON	CFM TEMP. RISE WATTS	800 56 105	800 56 140	800 56 180	800 56 220	800 56 265
	MEDIUM LOW	OFF	ON	CFM TEMP. RISE WATTS	860 52 115	880 51 165	890 50 215	920 48 265	910 49 320
	NORMAL **	ON	OFF	CFM TEMP. RISE WATTS	960 46 150	990 45 200	1000 44 230	1020 44 310	1010 44 350
	HIGH	OFF	OFF	CFM TEMP. RISE WATTS	1080 41 195	1110 40 255	1120 40 315	1120 40 365	1080 41 390
HEATING 2ND STAGE	LOW	ON	ON	CFM TEMP. RISE WATTS	1100 62 205	1100 62 260	1120 61 320	1120 61 370	1090 63 400
	MEDIUM LOW	OFF	ON	CFM TEMP. RISE WATTS	1210 57 265	1240 55 340	1260 54 410	1260 54 470	1130 61 430
	NORMAL **	ON	OFF	CFM TEMP. RISE WATTS	1360 50 365	1390 49 445	1400 49 500	1360 50 535	1210 57 475
	HIGH	OFF	OFF	CFM TEMP. RISE WATTS	1360 50 355	1390 49 450	1400 49 520	1350 51 535	1180 58 465

NOTES:
* First letter may be "A" or "T"
** Factory setting

Static Pressure - effect on ECM

	EXTERNAL STATIC PRESSURE				
	0.1	0.3	0.5	0.7	0.9
CFM	800	800	800	800	800
TEMP. RISE	56	56	56	56	56
WATTS	105	140	180	220	265
CFM	860	880	890	920	910
TEMP. RISE	52	51	50	48	49
WATTS	115	165	215	265	320
CFM	960	990	1000	1020	1010
TEMP. RISE	46	45	44	44	44
WATTS	150	200	230	310	350
CFM	1080	1110	1120	1120	1080
TEMP. RISE	41	40	40	40	41
WATTS	195	255	315	365	390

Static Pressure - effect on ECM

	EXTERNAL STATIC PRESSURE				
	0.1	0.3	0.5	0.7	0.9
CFM	800	800	800	800	800
TEMP. RISE	56	56	56	56	56
WATTS	105	140	180	220	265
CFM	860	880	890	920	910
TEMP. RISE	52	51	50	48	49
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CFM	800	800	800	800	800
TEMP. RISE	56	56	56	56	56
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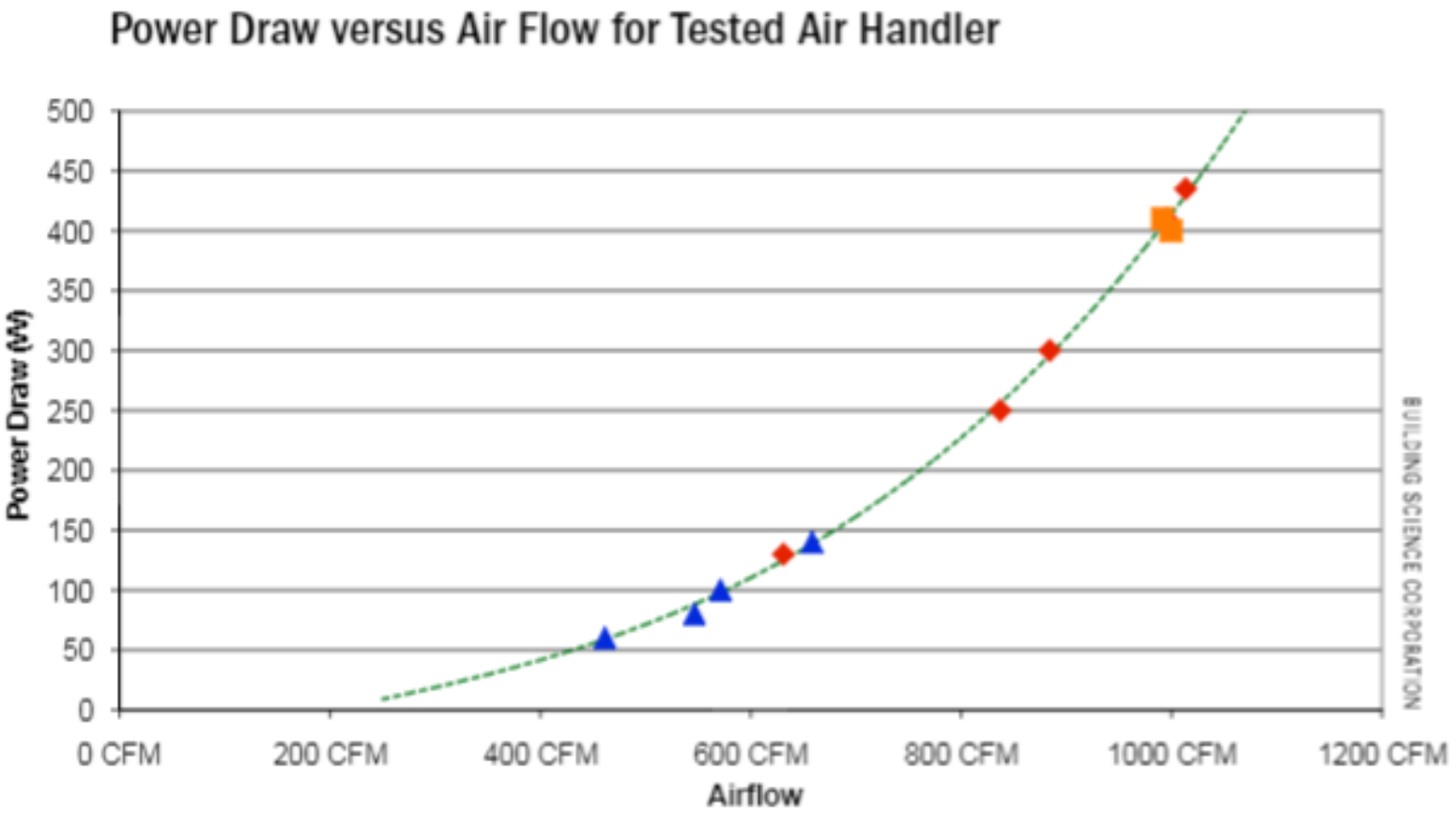


Slide credit: Building Science Corporation

CHECK HEAT-RISE - TO EVALUATE APPROPRIATENESS OF FAN SPEED.

OUTPUT SORTIE — See Note Below / Voir La Note Ci-dessous	BTU/HR / BTU PAR HRE	78,000	–	31,000
AIR TEMPERATURE RISE / AUGMENTATION DE LA TEMPERATEUR DE L'AIR	DEG. F	40 – 70	50 – 80	35 – 65
	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		TOP DESSUS	SIDES COTES	BACK ARRIERE	FRONT AVANT	VENT EVENT	FRONT SERVICE SERVICE DEVANT
	INCHES (POUCES)	1	0	0	1	0	24
	mm	25.4	0	0	25	0	610

DOWNFLOW W/O COIL USE SUB – BASE / DEBIT DESCENDANT SANS SERPENTIN, UTILISER LA BASE — KGASB0201ALL

TYPE FSP CATEGORY IV DIRECT VENT FORCED AIR FURNACE.
TYPE FSP CATEGORIE IV. GENERATEUR D'AIR CHAUD A EVACUATION DIRECTE ET A AIR FORCE.

FACTORY AUTHORIZED GAS CONVERSION KITS
ENSEMBLES DE CONVERSION AU GAZ AUTORIES PAR L'USINE

NATURAL GAS TO PROPANE	KGANP5201VSP
PROPANE TO NATURAL GAS	KGAPN4401VSP

APPROVED FOR BUILDING CONSTRUCTED ON SITE (BATIMENT CONSTRUIT SUR PLACE)

NOTE. This Furnace is approved for altitudes up to 4500 ft. above sea level. Refer to installation instructions for adjustments

HEAT RISE/TEMP RISE BASICS

- The slower the airflow (thru the heat exchanger) the greater the heat rise.

HEAT RISE/TEMP RISE BASICS

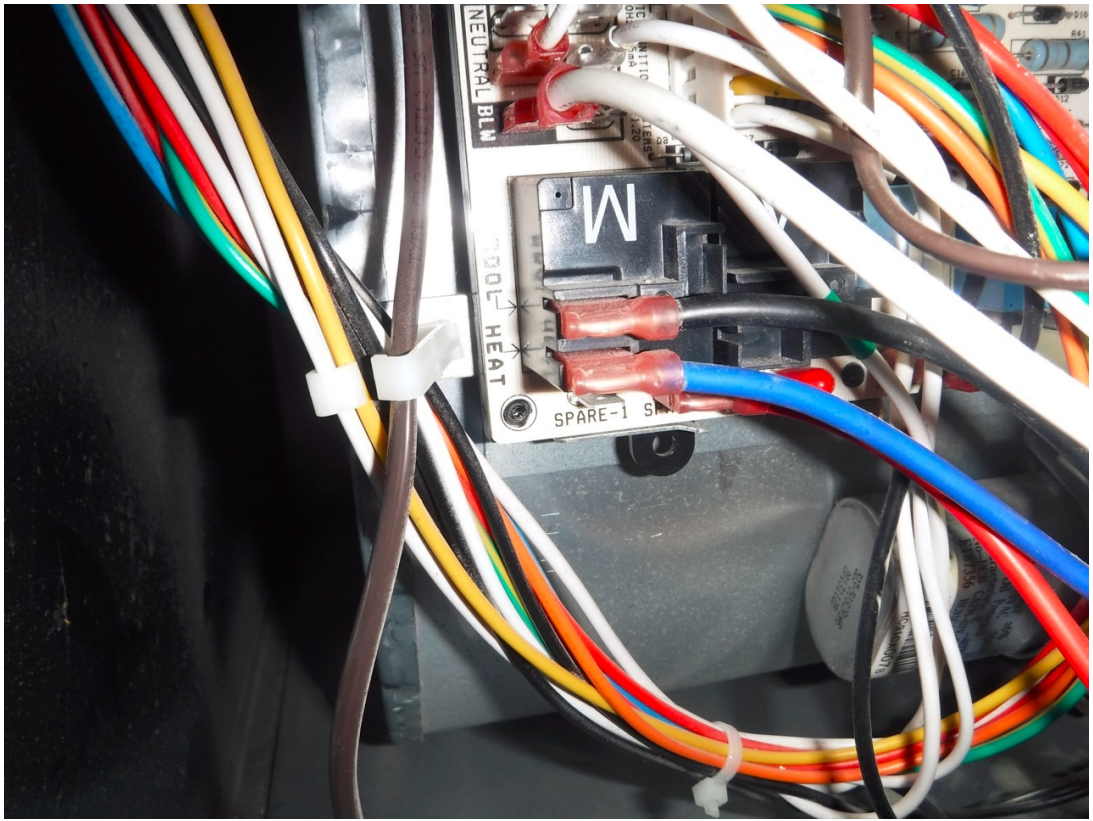
- The slower the airflow (thru the heat exchanger) the greater the heat rise.

- The faster the airflow, the lower the heat rise.

HEAT RISE/TEMP RISE BASICS

- The slower the airflow (thru the heat exchanger) the greater the heat rise.
- The faster the airflow, the lower the heat rise.
- Compare this heat-rise to Manufacture's spec on furnace.

ADJUST FAN SPEEDS AS NEEDED



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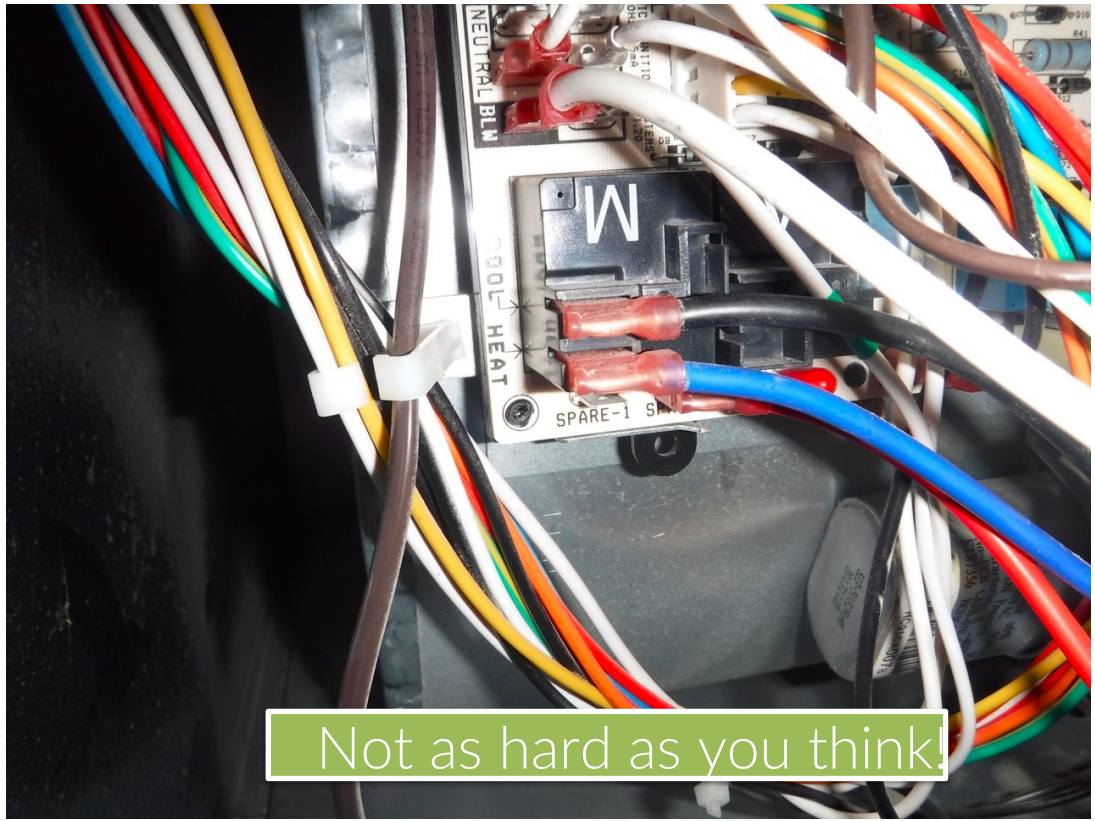
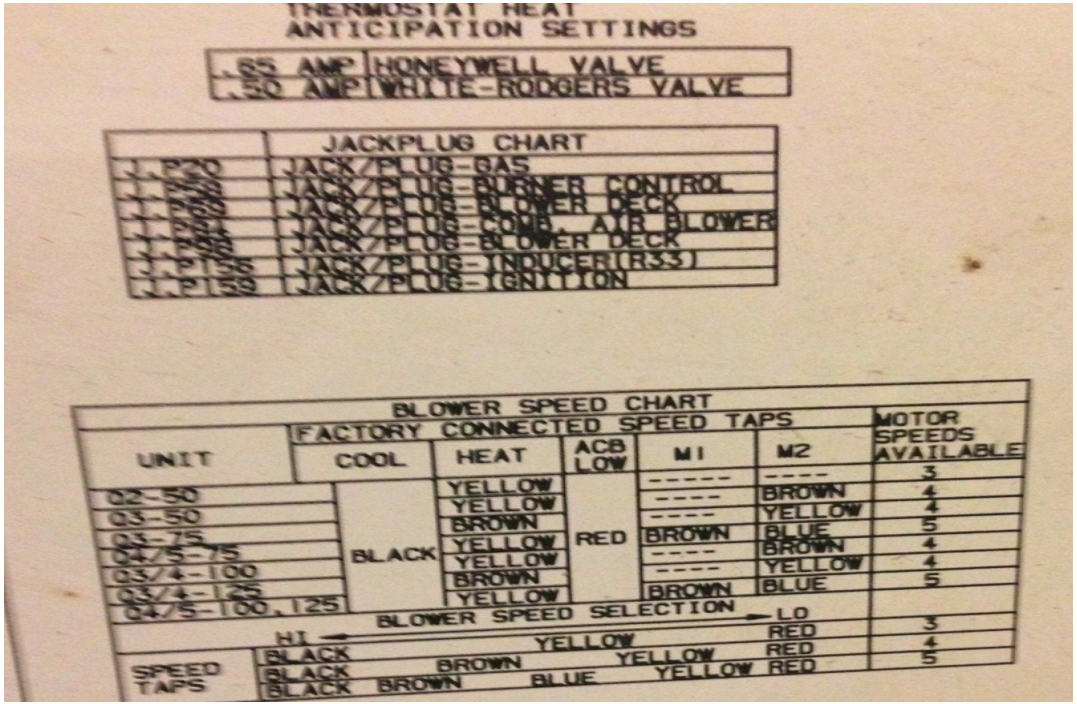


ADJUSTING FAN SPEEDS



THERMOSTAT HEAT ANTICIPATION SETTINGS

.65 AMP	HONEYWELL VALVE
.50 AMP	WHITE-RODGERS VALVE

	JACKPLUG CHART
J.P20	JACK/PLUG-GAS
J.P58	JACK/PLUG-BURNER CONTROL
J.P69	JACK/PLUG-BLOWER DECK
J.P84	JACK/PLUG-COMB. AIR BLOWER
J.P88	JACK/PLUG-BLOWER DECK
J.P156	JACK/PLUG-INDUCER(R33)
J.P159	JACK/PLUG-IGNITION

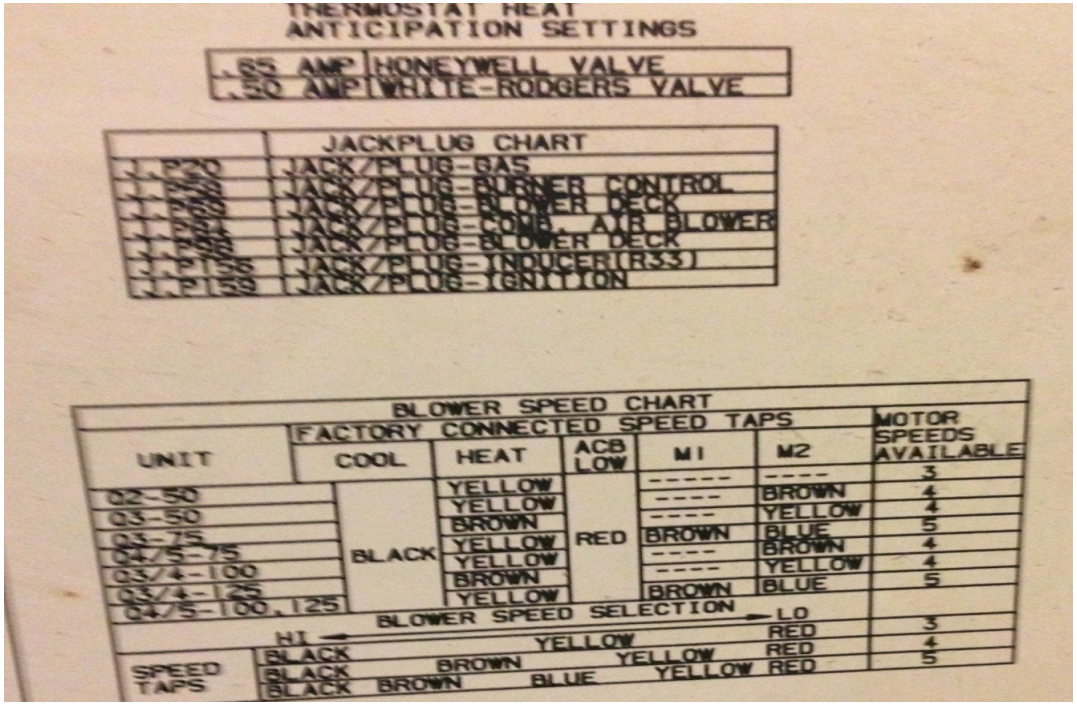
BLOWER SPEED CHART

UNIT	FACTORY CONNECTED SPEED TAPS					MOTOR SPEEDS AVAILABLE
	COOL	HEAT	ACB LOW	M1	M2	
02-50	BLACK	YELLOW	RED	-----	----	3
03-50		YELLOW		----	BROWN	4
03-75		BROWN		----	YELLOW	4
04/5-75		YELLOW		BROWN	BLUE	5
03/4-100		YELLOW		----	BROWN	4
03/4-125		BROWN		----	YELLOW	4
04/5-100,125		YELLOW		BROWN	BLUE	5

BLOWER SPEED SELECTION → LO

SPEED TAPS	HI				LO	
	BLACK		YELLOW		RED	3
	BLACK	BROWN		YELLOW	RED	4
	BLACK	BROWN	BLUE	YELLOW	RED	5

ADJUSTING FAN SPEEDS



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BLOWER SPEED CHART

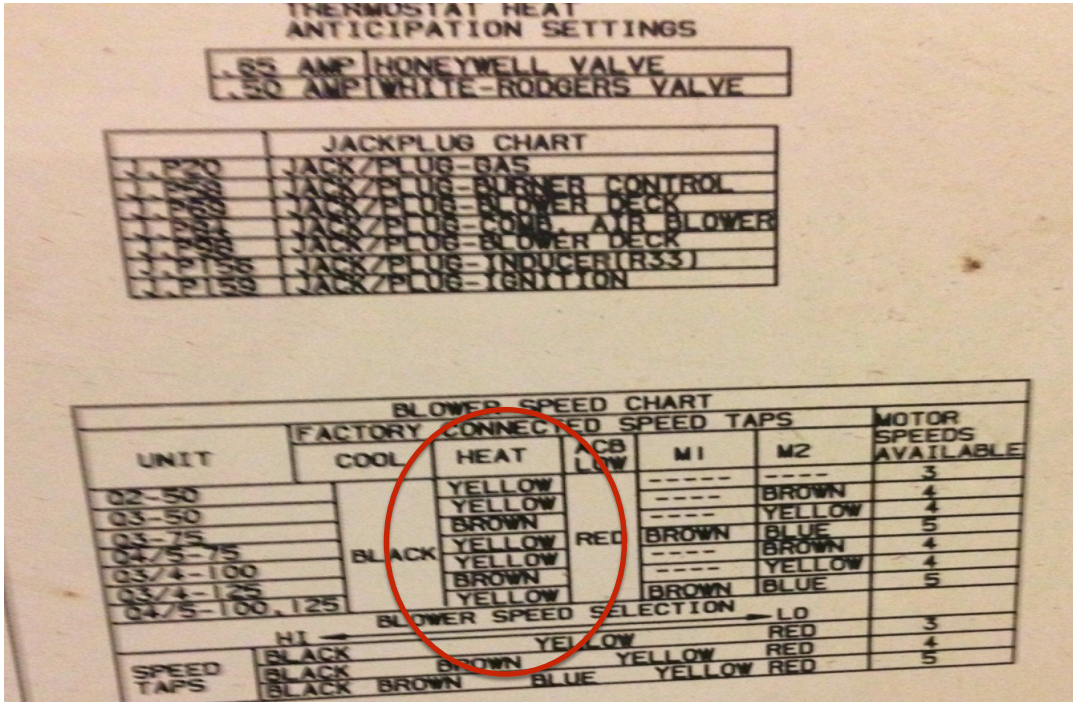
UNIT	FACTORY CONNECTED SPEED TAPS					MOTOR SPEEDS AVAILABLE
	COOL	HEAT	ACB LOW	M1	M2	
02-50	BLACK	YELLOW	RED	-----	----	3
03-50		YELLOW		----	BROWN	4
03-75		BROWN		----	YELLOW	4
04/5-75		YELLOW		BROWN	BLUE	5
03/4-100		YELLOW		----	BROWN	4
03/4-125		BROWN		----	YELLOW	4
04/5-100,125		YELLOW		BROWN	BLUE	5

BLOWER SPEED SELECTION → LO

SPEED TAPS	HI →			LO
	BLACK	YELLOW		RED 3
	BLACK	BROWN	YELLOW	RED 4
	BLACK	BROWN	BLUE	YELLOW RED 5

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

ADJUSTING FAN SPEEDS



THERMOSTAT HEAT ANTICIPATION SETTINGS

.65 AMP	HONEYWELL VALVE
.50 AMP	WHITE-RODGERS VALVE

	JACKPLUG CHART
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J.P58	JACK/PLUG-BURNER CONTROL
J.P69	JACK/PLUG-BLOWER DECK
J.P84	JACK/PLUG-COMB. AIR BLOWER
J.P88	JACK/PLUG-BLOWER DECK
J.P156	JACK/PLUG-INDUCER(R33)
J.P159	JACK/PLUG-IGNITION

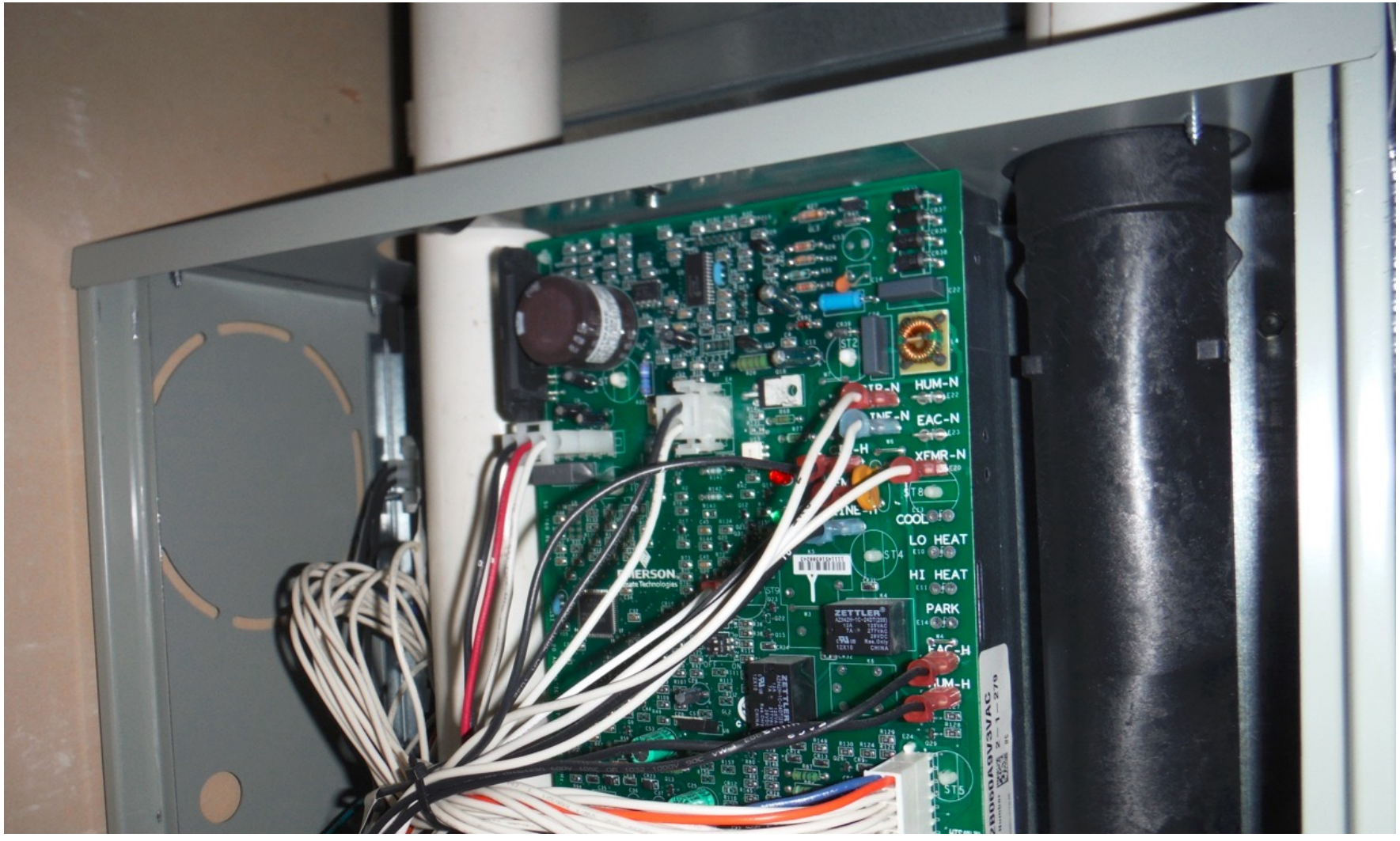
BLOWER SPEED CHART

UNIT	FACTORY CONNECTED SPEED TAPS COOL	HEAT	ACB LOW	M1	M2	MOTOR SPEEDS AVAILABLE
02-50	BLACK	YELLOW	RED	-----	----	3
03-50		YELLOW		----	BROWN	4
03-75		BROWN		----	YELLOW	4
04/5-75		YELLOW		BROWN	BLUE	5
03/4-100		YELLOW		----	BROWN	4
03/4-125		BROWN		----	YELLOW	4
04/5-100,125		YELLOW		BROWN	BLUE	5

BLOWER SPEED SELECTION → LO

SPEED TAPS	HI →			LO
	BLACK	YELLOW	RED	3
	BLACK	BROWN	YELLOW RED	4
	BLACK	BROWN BLUE	YELLOW RED	5

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


HUM-N
EAC-N
XFMR-N
COOL
LO HEAT
HI HEAT
PARK
ZETTLER

Some models are a little more complex,
they have tiny dip switches that 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)	Before filter	-71
b.	After filter	-176	After filter	-188
c.	Before coil	+62	Before coil	+62
d.	After blower	N/A (Supply system)	After blower	N/A
e.	wattage	680	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

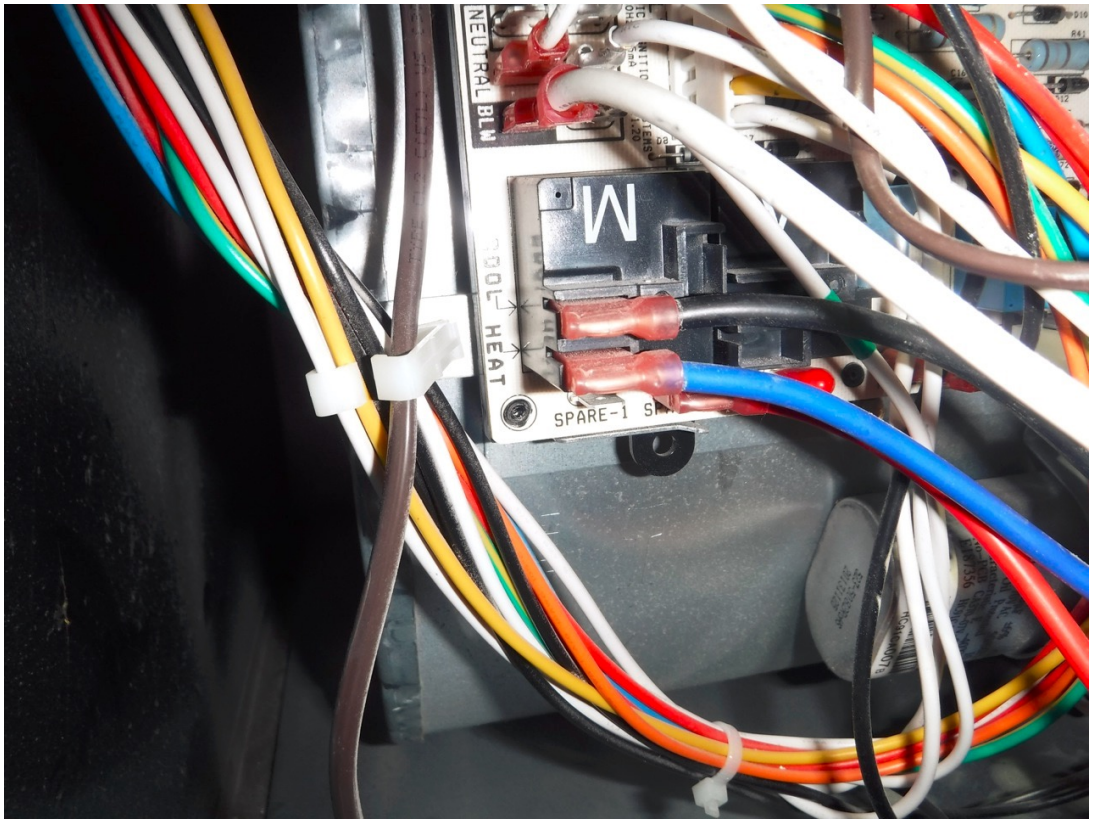
6) Ideal supply duct pressure = 20% of TESP	25	25
Measured supply duct pressure = d.	62	62

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)	Before filter	-63
b.	After filter	-165	After filter	-165
c.	Before coil	+56	Before coil	+55
d.	After blower	N/A (Supply system)	After blower	N/A
e.	wattage	550	wattage	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, and lower static pressures

WHAT ELSE CAN INCREASE TESP?

Dirt - primarily in the filter &/or coil

These 1” filters are often the culprit - they offer too much restriction when clean, and way too much restriction when dirty (which they often are).

A wider filter (4") has about four times the surface area as the 1“ filter, and offers less restriction to the system.

The problem is they are expensive, so people don't want to change them as often as they ought to be changed.

Tests for Pressure Drop and Efficiency on Air Filters

Filter	Depth	300 fpm	400 fpm	500 fpm	Ambient Particles	Particles After Filter	% Particle Drop
Precisionaire Easy Flow	1"	.10"	.12"	.14"			
True Blue Fiberglass	1"	.10"	.11"	.13"			
Filtrete 300	1"	.19"	.21"	.24"	1567000	1468000	6.32%
Filtrete 600	1"	.21"	.24"	.26"	1168000	943000	19.26%
Filtrete 1000	1"	.22"	.24"	.27"	740000	549000	25.81%
Filtrete 1250	1"	.22"	.24"	.27"	831000	716000	13.84%
Filtrete 1700	1"	.25"	.27"	.31"	767000	493000	35.72%
MERV 7	1"	.17"	.19"	.22"	940000	890000	5.32%
MERV 7	2"	.14"	.16"	.18"			
MERV 7	4"	.10"	.13"	.14"			
Carbon	2"	.14"	.16"	.18"	992000	948000	4.44%
MERV 11	1"	.26"	.28"	.31"	972000	865000	11.01%
MERV 11	2"	.20"	.23"	.25"	945000	821000	13.12%
MERV 12	2"	.23"	.24"	.26"	701000	452000	35.52%
Polyester	1"	.14"	.15"	.16"	1333000	1303000	2.25%
Polyester	2"	.30"	.33"	.37"	1322000	1303000	1.44%
Ring Panel	2"	.27"	.30"	.34"	1304000	1240000	4.91%
					1304000	135400	-3.83%
MERV 13	2"	.35"	.38"	.42"	168000	647000	39.42%
MERV 14	2"	.39"	.44"	.48"	1021000	508000	50.24%
MERV 14	4"	.29"	.36"	.40"	935000	455000	51.34%

Tests for Pressure Drop and Efficiency on Air Filters

Filter	Depth	300 fpm	400 fpm	500 fpm	Ambient Particles	Particles After Filter	% Particle Drop
Precisionaire Easy Flow	1"	.10"	.12"	.14"			
True Blue Fiberglass	1"	.10"	.11"	.13"			
Filtrete 300	1"	.19"	.21"	.24"	1567000	1468000	6.32%
Filtrete 600	1"	.21"	.24"	.26"	1168000	943000	19.26%
Filtrete 1000	1"	.22"	.24"	.27"	740000	549000	25.81%
Filtrete 1250	1"	.22"	.24"	.27"	831000	716000	13.84%
Filtrete 1700	1"	.25"	.27"	.31"	767000	493000	35.72%
MERV 7	1"	.17"	.19"	.22"	940000	890000	5.32%
MERV 7	2"	.14"	.16"	.18"			
MERV 7	4"	.10"	.13"	.14"			
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Dirty Filters are a big problem

TOTAL EXTERNAL STATIC PRESSURE

- What else can increase TESP?
- **Restrictions** in the ductwork system (harder to fix)


Example 2
Pre-retrofit
CLEAN FILTER
MONTHLY

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)	Before filter	-47
b.	After filter	-148	After filter	-143
c.	Before coil	+115	Before coil	+101
d.	After blower	+19 (Supply system)	After blower	+18
e.	wattage	750	wattage	730
f.	CFM	1050	CFM	1000

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

125	(IWC x 250 = pascals)	125
263		244

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	50.8	-47

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]	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

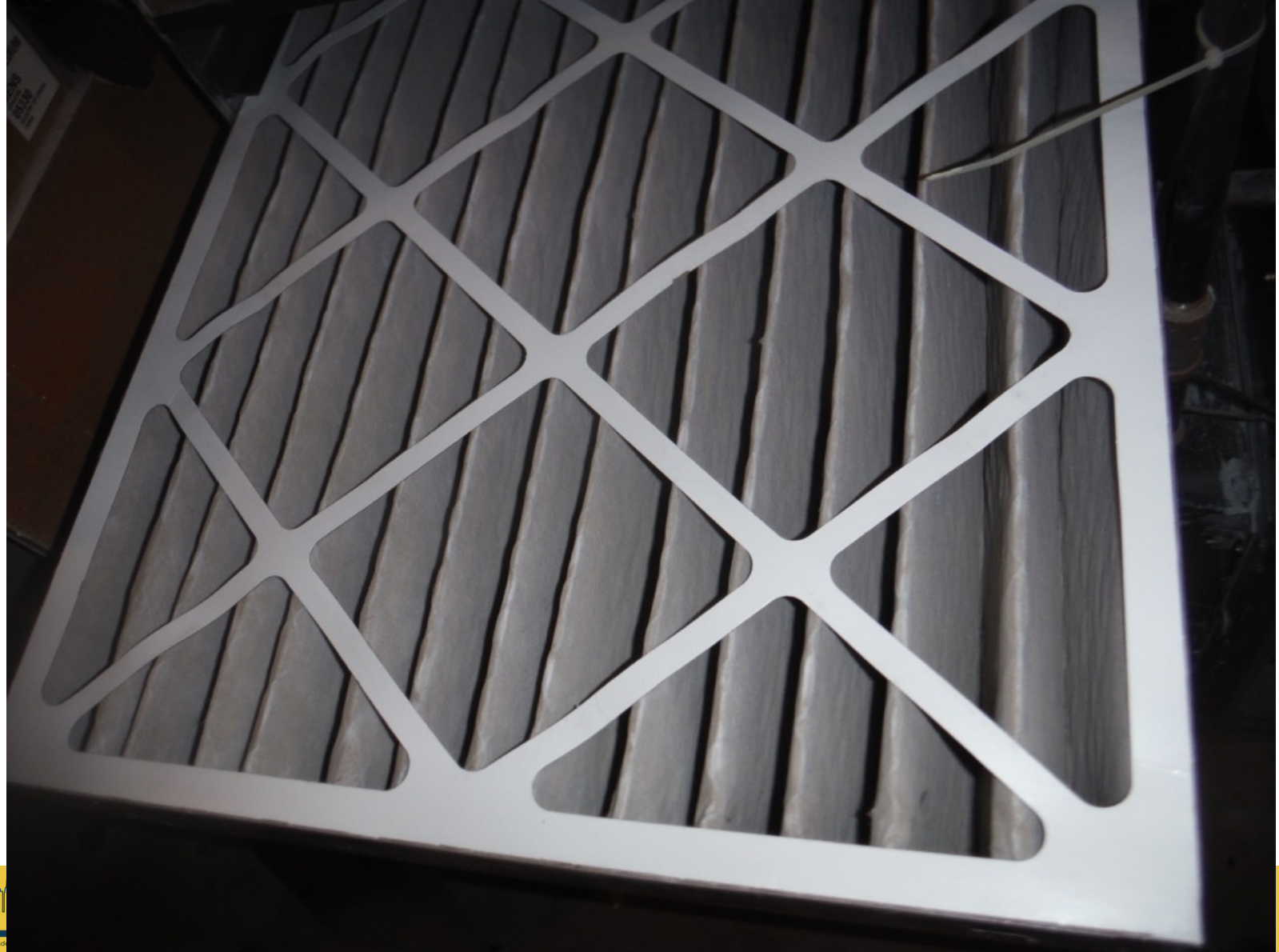
- What else can increase TESP?
- **Restrictions** in the ductwork system (harder to fix)


Dirty Coils are a bigger problem


Example 2
Pre-retrofit
HVAC tech removed the dirty coil first


Example 2
Pre-retrofit
CLEAN FILTER
MONTHLY


Example 2
Post-retrofit
New ductwork & filters
About $500.00
(parts and labor)



The new filter system - 4” Honeywell MERV 13 with a 1” fiberglass pre-filter

Much less restrictive than a clean 1” filter.


The pre-filter is there to catch the largest “boulders”,
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 the inefficient permanent split capacitor motor (PSC) with a replacement ECM (Constant Torque). The drop in wattage (same airflow) is often very significant.

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


Example 2
New ECM motor install- an additional $500.00 parts and labor

Air Handler/ furnace__GMUH150-E5A___3/4 HP ECM
Rated Capacity_150,000 INPUT 120,000 Output_____
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)	Before filter	-40
b.	After filter	-38	After filter	-88
c.	Before coil	+15	Before coil	+51
d.	After blower	+9 (Supply system)	After blower	+20
e.	wattage	177	wattage	644
f.	CFM	720	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

Example 2 - post retrofit

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__

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


Example 3


Example 3
What the heck?

Example 3

Air Handler/ furnace__N9SE0601714A1___
Rated Input BTU__60,000___ Output BTU__58,000____
Temperature Rise range ___40-70_____
Filter Used _ High Merv 1" filter Filtrete 2200_ Medium High speed

1)Take static pressure measurements - IWC or Pascals

Continuous mode		AC mode		
a. Before filter	-28	a. Before filter	-36	(Return System)
b. After filter	-92	b. After filter	-115	
c. Before coil	+46	c. Before coil	+59	
d. After coil	+27	d. After coil	+28	(Supply system)

2) Allowable TESP - ____125 pa_____ (IWC x 250 = pascals)
Measured TESP = Absolute value of [b] + [c].
____138_____ _____174_____
High TESP pressures indicate many possible problems - isolate where the restrictions are:

3) Ideal Return pressure - 20% of TESP __25___
Measured return pressure is = a.
____23_____ _____36_____
High values indicate return restrictions, lower values indicate duct leaks or low fan speed

4) Ideal max filter pressure drop = 20% x TESP __25___

Example 3

5) Ideal coil pressure drop = 40% of TESP __50__
Pressure drop across coil = c - d
____25_____ _____31_____
High values may indicate Dirty coil - inspect if possible

6) Ideal supply duct pressure = 20% of TESP ___25___
Measured supply duct pressure = d.
____21_____ _____28_____
High values indicate restrictions in supply system. Lower values could indicate duct leakage or low fan speed)

Cooling speed Wattage ___590____ Cost per hour ___$.0755___ Cost per year___661.65_____

Circulation speed Wattage ___520_____ Cost per hour __$.0665__ Cost per year____$583.07____

Cooling Measured / calculated CFM ____1110_____ method ___Static pressure charts

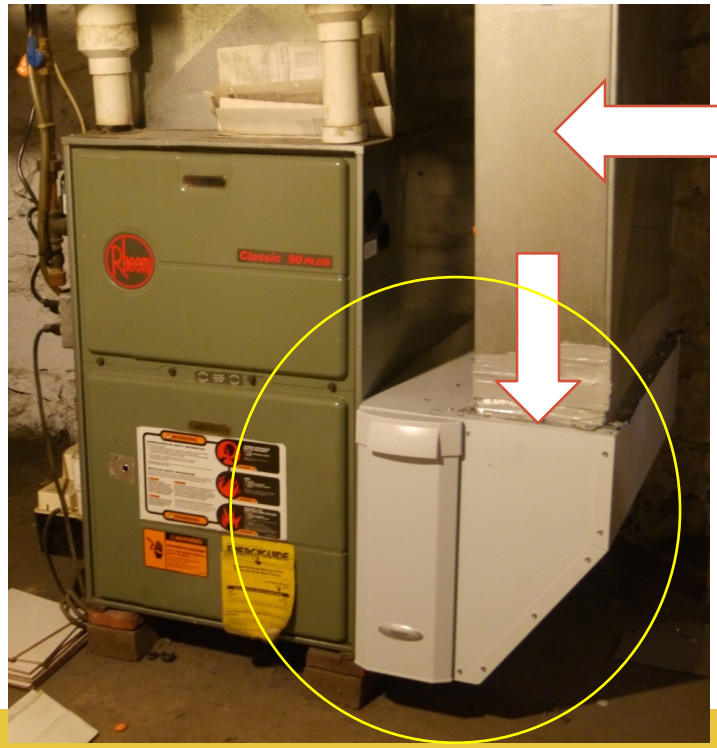
Removing Mastic from old ductwork


Learning as I go


Replaced PSC motor with ECM

LESSONS LEARNED: AN EARLY CHANGE-OUT

In search of an easy fix…. Don't do this!!!



Not Effective!

1) Return drop restricted due to size (8" x 25")
2) Poor design at throat w hard 90 degree angle

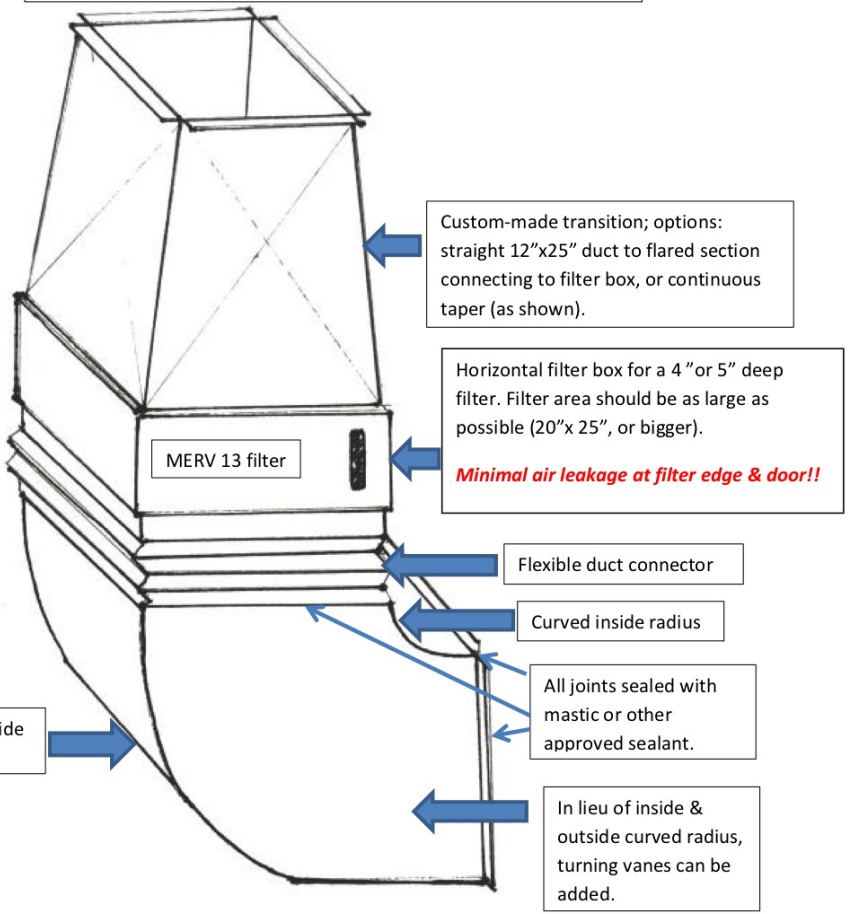
3) Filter still only 16" x 25"

Too much airflow (system oversized) for this return drop

Basement Return Drop Modification

This modification allows for:

1) a larger & deeper MERV 13 filter; 2) more even flow/loading over the full filter; and 3) lower static pressure across both the filter & return side of the ductwork.




Example 3
90 degree transition designed for better air flow; lower static (with turning vanes)


Larger return drop
2-part filter rack (20” x 25”) Horizontal (4” MERV 13 + 1” pre or post filter)


026
02
Azure Digi-M
NARS Azure
Programming Tool
BROAD-OCEAN
S1
S2
Fan speed adjusted to optimize heating, cooling, & continuous performance.

Much Better Performance!

Example 3

Much Better Performance!

Example 3

RESULTS:

5 yr. old home
Significant comfort improvement!

About $1000 investment

Much Better Performance!

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About $1000 investment

In continuous mode:

➢3.38 CFM/watt
➢TESP Pre: 138, Post: 52

Much Better Performance!

Example 3

RESULTS:

5 yr. old home
Significant comfort improvement!

About $1000 investment

In continuous mode:

- ➢3.38 CFM/watt
- ➢TESP Pre: 138, Post: 52
- ➢360 Watts (reduction)

Much Better Performance!

Example 3

RESULTS:

5 yr. old home
Significant comfort improvement!

About $1000 investment

In continuous mode:

- 3.38 CFM/watt
- TESP Pre: 138, Post: 52
- 360 Watts (reduction)
- $142/ yr. elec. use ($583.00 Pre)

Much Better Performance!

Example 3

RESULTS:

5 yr. old home
Significant comfort improvement!

About $1000 investment

In continuous mode:

- 3.38 CFM/watt
- TESP Pre: 138, Post: 52
- 360 Watts (reduction)
- $142/ yr. elec. use ($583.00 Pre)
- $441/yr savings

Example : Air Handler Retrofit 2.0

Larger return drop

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

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

RESULTS:

In continuous mode:

- 4.27 CFM/watt
- 120 Watts

- Pressure drop across filter Pre: 93 Pa, Post: 16 Pa
- Allowable TESP: 125 Pa (total system)

ECM replacement

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

Opportunities at Changeout time

Opportunities at Changeout time

New Furnace

Opportunities at Changeout time

New Furnace

Adding AC

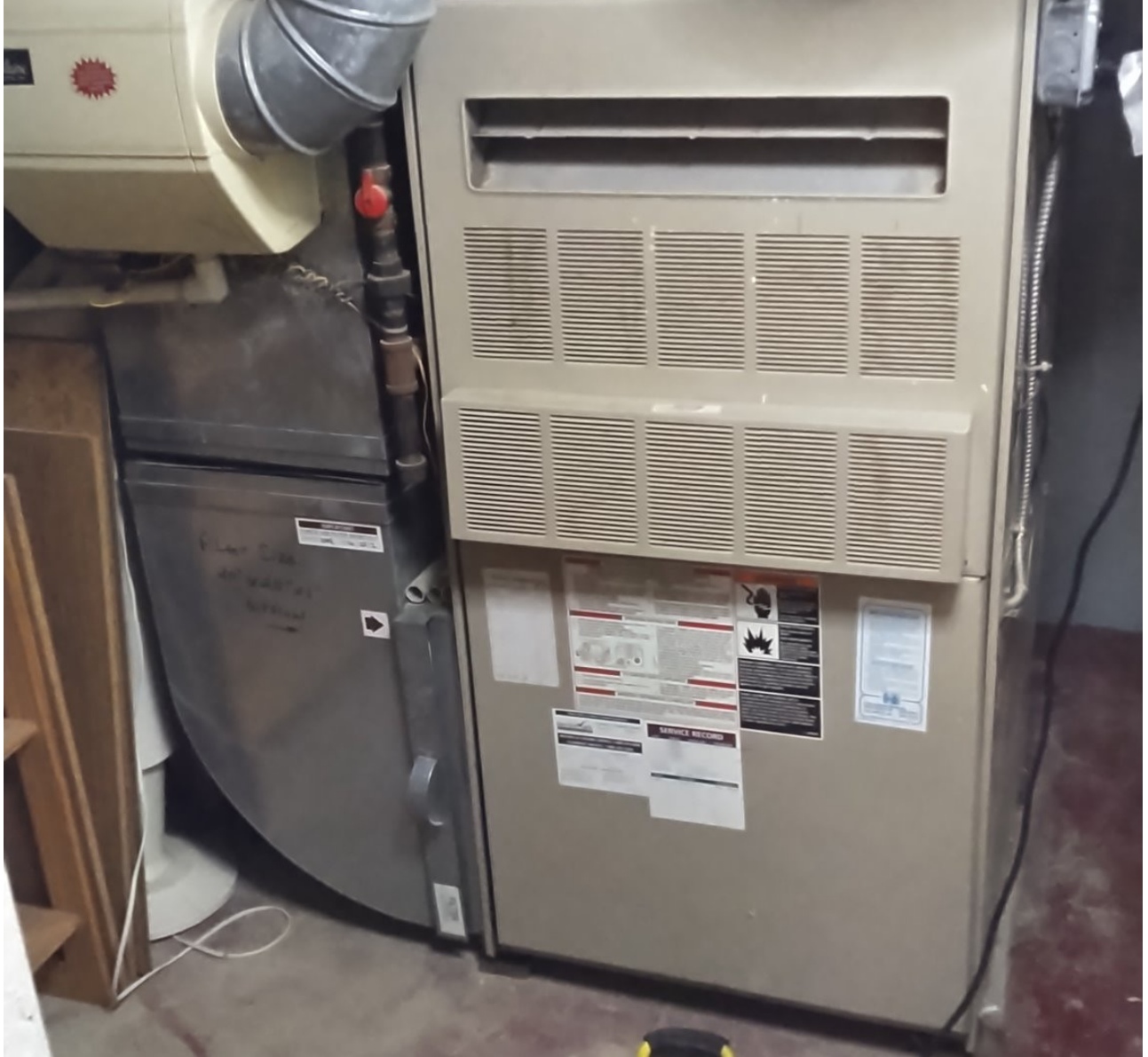
Opportunities at Changeout time

Downsize Furnace

Opportunities at Changeout time

Downsize Furnace

Change Return Drop & Filter


SERVICE RECORD


Air Flow
X 4670
ENERGYGUIDE
95.1


Example 4
Comfortmaker
WARNING
AVERTISSEMENT
3M
16x25x1
Filtrete
10. 1. 2020 10:10

Example 4

1) Static pressures: AC speed		H		Fan only speed		Adjusted fan speed	
a. Before filter	-61	Before filter	-56	Before filter	-61	Before filter	-52
b. After filter	-160	After filter	-115	After filter	-160	After filter	-117
c. Before coil	+66	Before coil	+57.5	Before coil	+66	Before coil	58
d. After coil	+38	After coil	+37	After coil	+38	After coil	32
e. Wattage	340	wattage	223	wattage	340	wattage	189
f. CFM	1300	CFM	925	CFM	1300	CFM	920

3) Allowable TESP - from manufacturers nameplate 125

Measured TESP 226 172.5 226 175

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

4) Ideal Return pressure - 20% of TESP -25

Measured return pressure -61 -56 -61 -52

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 99 59 99 65

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

6) Ideal coil pressure drop = 40% of TESP 50

Pressure drop across coil 28 19.5 28 26

High values may indicate Dirty coil - inspect if possible

Example 4

1) Static pressures: AC speed		H		Fan only speed		Adjusted fan speed	
a. Before filter	-61	Before filter	-56	Before filter	-61	Before filter	-52
b. After filter	-160	After filter	-115	After filter	-160	After filter	-117
c. Before coil	+66	Before coil	+57.5	Before coil	+66	Before coil	58
d. After coil	+38	After coil	+37	After coil	+38	After coil	32
e. Wattage	340	wattage	223	wattage	340	wattage	189
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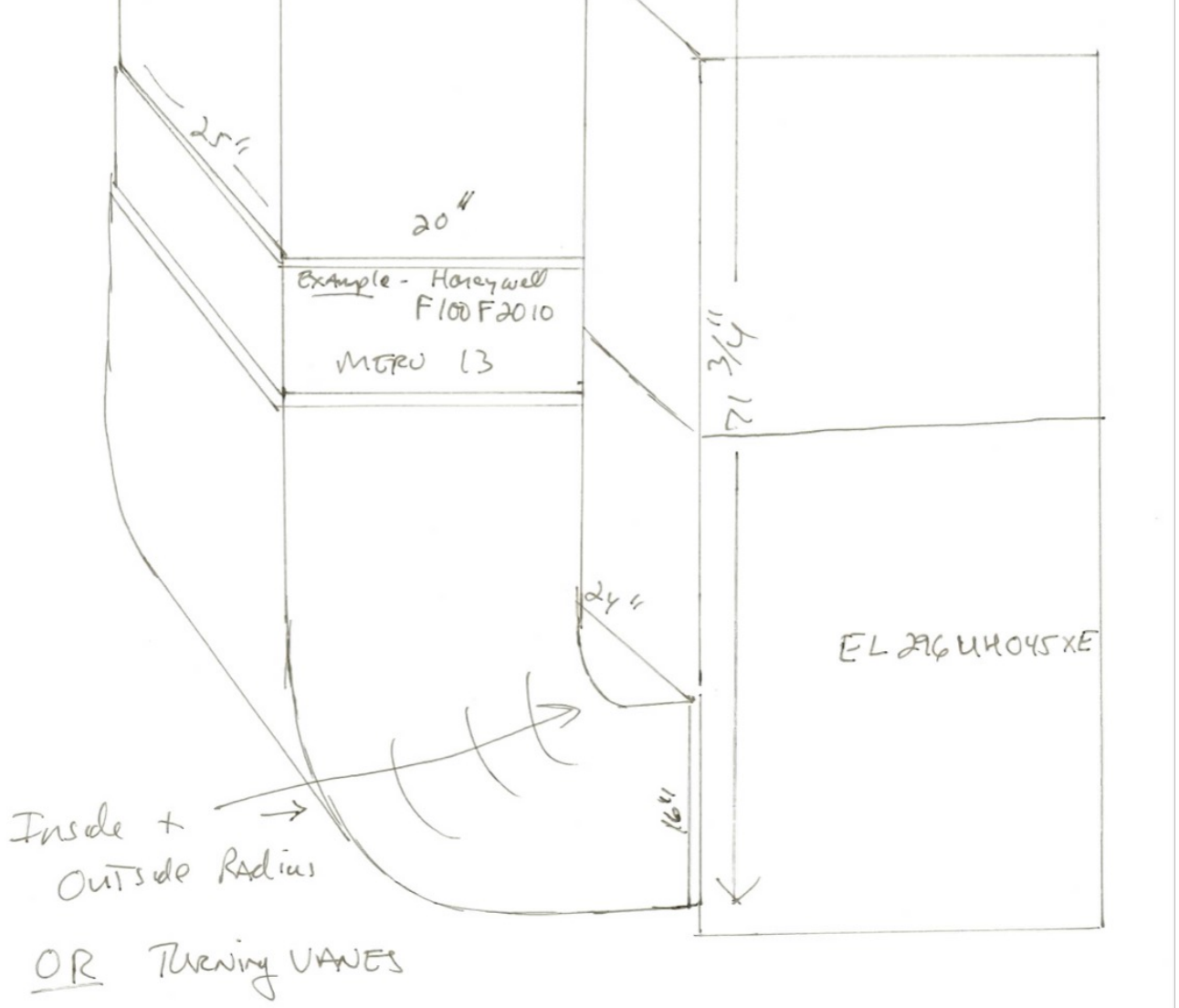
Flue gas
Nat. Gas
4.
3069 ppm CO
5.
20.
6.
---- ppm CO-HF
7.
0.0 % ExAir
Print
Start
10. 1.2020 10:45


25"
20"
Example - Honeywell
F100F2010
MERV 13
71 3/4"
24"
EL296UH045XE
16"
Inside +
Outside Radius
OR Turning VANES


INSTALLATION INSTRUCTIONS

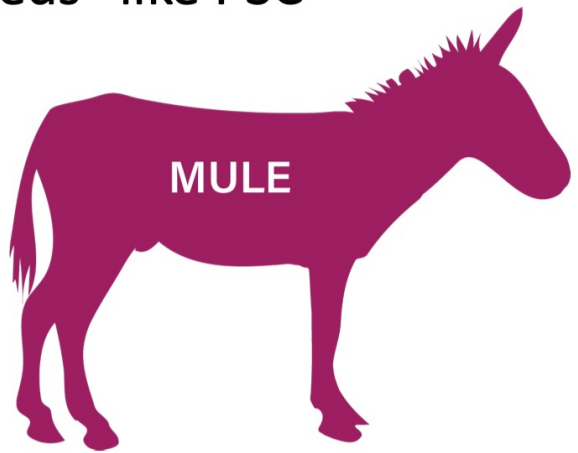

Use Genuine Healthy Climate
Replacement Filters
Air Flow
Model HCF20-11
20" x 25" x 5"
X6673
MERV
11
Air Flow

Constant Torque ECM

Electronically-commutated Motor (ECM)
Constant Torque

Original trade name “X13”

- Introduced around 2006
- ECM efficiency
- Maintains constant torque (not airflow)
- Limited to discrete “speeds” like PSC
- Has start/stop ramping
- Middle cost
- Can be retrofit



Slide credit: Scott Pigg, Slipstream

Measured TESP ___NA___ _____ _____ _____

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

4) Ideal Return pressure - 20% of TESP ___-25__
Measured return pressure __-16____ _-21___ ___-25_____ ___-16___

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 __16__ __22__ _____27___ ___16___

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

6) Ideal coil pressure drop = 40% of TESP ___50___
Pressure drop across coil __NA____ _____ _____ _____

High values may indicate Dirty coil - inspect if possible

7) Ideal supply duct pressure = 20% of TESP ___25___
Measured supply duct pressure __+20__ _+25__ ___+33__ ____+19___

High values indicate restrictions in supply system.

8) Dry bulb temperature from return hole _____ ___68___ __68___
Dry bulb temp from supply hole _____ __104____ __98____
Heat rise = _____ __42°___ ___30°__

AC speed Wattage _260__ Cost per hour $0.0286
___770___ CFM measured w/ TruFlow CFM/ watt __2.96__
Low fire Wattage _352_ Cost per hour _$0.038_
__870__ CFM measured w/ TruFlow CFM/ watt __2.47____
Hi -Heating Wattage _495_ Cost per hour _$0.054
__1080___CFM measured w/ TruFlow CFM/ watt ___2.18__

Measured TESP __NA___ _____ _____ _____

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

4) Ideal Return pressure - 20% of TESP ___-25__
Measured return pressure __-16____ _-21___ ___-25_____ ___-16___

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 __16__ __22__ _____27___ ___16___

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

6) Ideal coil pressure drop = 40% of TESP ___50___
Pressure drop across coil __NA____ _____ _____ _____

High values may indicate Dirty coil - inspect if possible

7) Ideal supply duct pressure = 20% of TESP ___25___
Measured supply duct pressure __+20__ _+25__ ___+33__ ____+19___

High values indicate restrictions in supply system.

8) Dry bulb temperature from return hole _____ ___68___ __68___
Dry bulb temp from supply hole _____ __104____ __98____
Heat rise = _____ __42°___ ___30°__

AC speed Wattage _260__ Cost per hour $0.0286
___770___ CFM measured w/ TruFlow CFM/ watt __2.96__
Low fire Wattage _352_ Cost per hour _$0.038_
__870__ CFM measured w/ TruFlow CFM/ watt __2.47____
Hi -Heating Wattage _495_ Cost per hour _$0.054
__1080___CFM measured w/ TruFlow CFM/ watt ___2.18__

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Hi -Heating Wattage _495_ Cost per hour _$0.054
__1080___CFM measured w/ TruFlow CFM/ watt ___2.18__
Constant speed Wattage _260_ Cost per hour $0.0286 Cost per Year 24/7/365 _$250.54
Cost at 30 min/hr $125.26
__770__ CFM measured w/ TruFlow CFM/ watt ___2.96_____

Brand new Carrier system

INITIALLY:

- 1” filter & return drop too restrictive
- Airflows not adjusted properly
- TESP too high in Stages 2 & 3, & AC

INTERVENTION:

- Carrier tech adjusted airflows
- ROCIS installed new return drop w larger deeper MERV 13 Aprilaire filter

POST:

- Fan only: 42 watts, 317 CFM, TESP 49 Pa
- Stage 2 & AC: 193 watts, 670 CFM; TESP 94 Pa
- Stage 3: 310 watts, 720 CFM, TESP 114 PA

FAN ONLY PERFORMANCE:

7.54 CFM/Watt

24/7 operation: $53/year

TESP System Limit: 125 Pa

Rhett Major
The Energy Doctor
www.energydoc.info
TheEnergyDoctor@Comcast.net

BIG ISSUES WITH 24/7 HIGH MERV FILTER

Air handler (AHU) energy use 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])

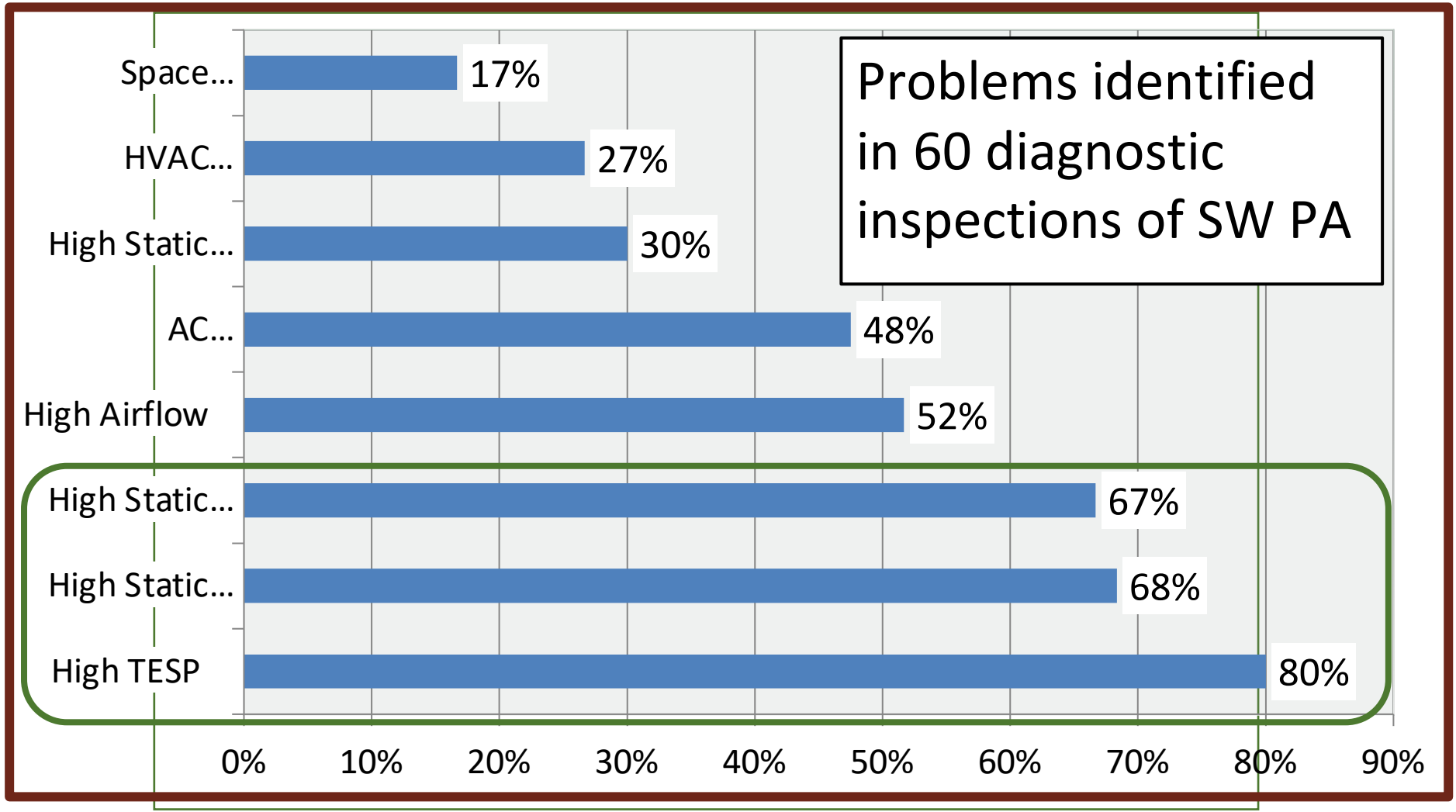
Wrong blower speed

- 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 too high (can lead to equipment failure)
- Duct leaks (energy waste & pressure-related problems)

[1] $0.12/kWh


Problems identified in 60 diagnostic inspections of SW PA
Space...
17%
HVAC...
27%
High Static...
30%
AC...
48%
High Airflow
52%
High Static...
67%
High Static...
68%
High TESP
80%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%

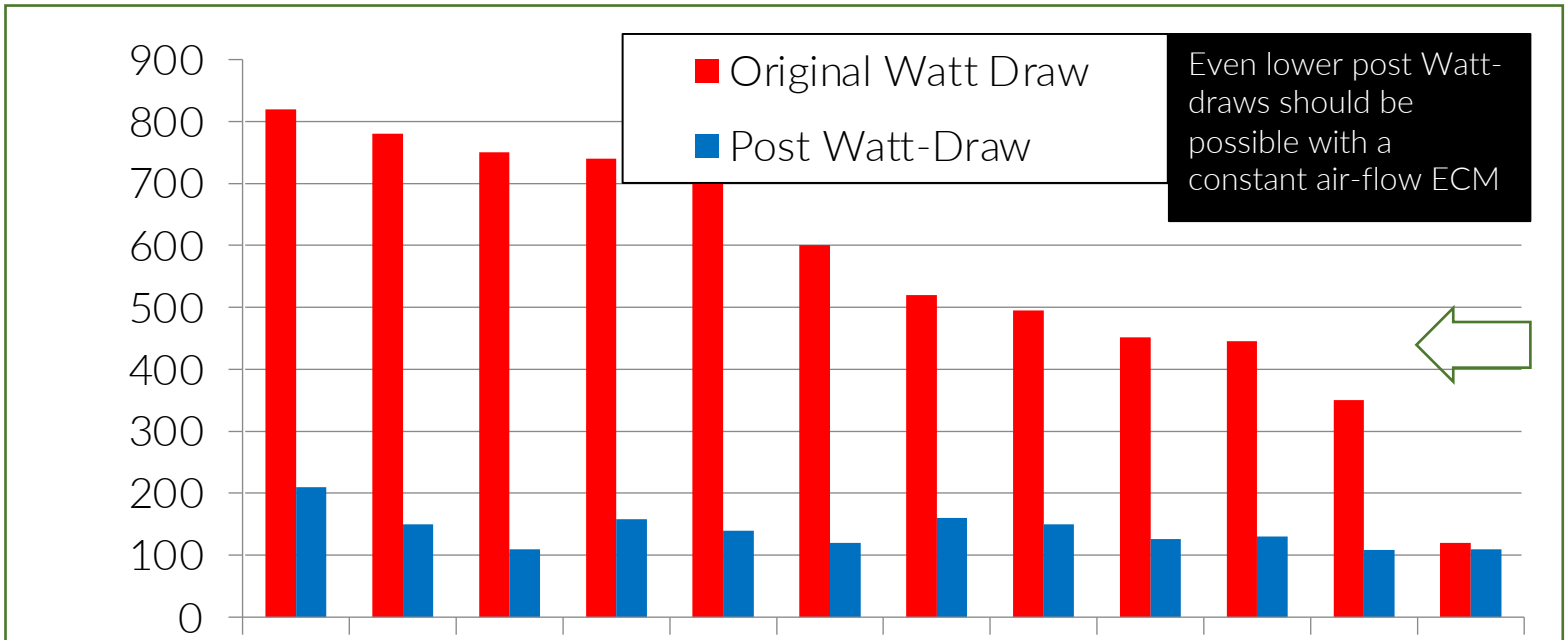
ROCIS 24/7 Air Handler Checklist

Air Handler Inquiry | ROCIS.org

Guidance is specific to our typical residential basement HVAC systems

Air Handler Interventions

Pre-Post Continuous Watt-Draw



FILTER ESSENTIALS

Deep filter (we prefer 4")
Large filter (surface area)
Low resistance filter (check label on filter)
Minimize filter bypasses

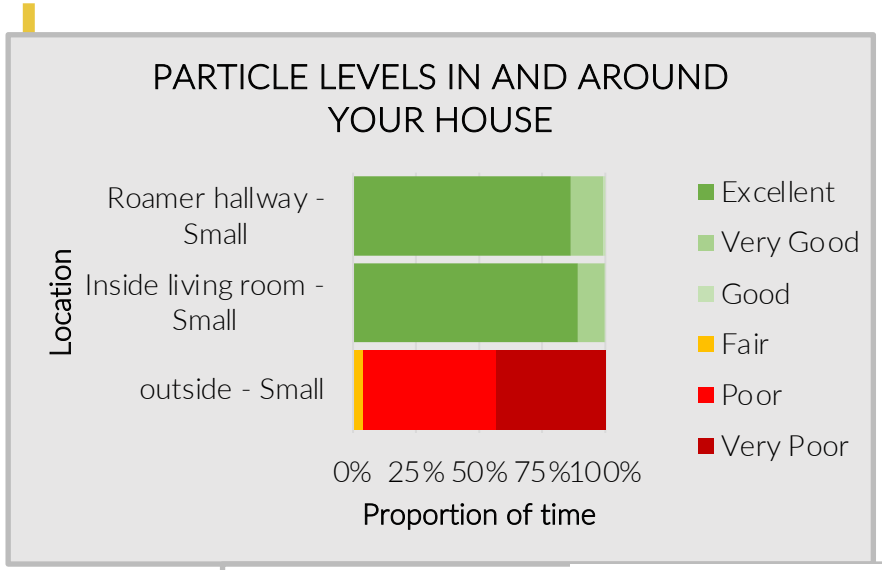
MERV 13 to reduce 0.3 to 0.5 µm particles (MERV is like R-Value; *performance depends on installation/operation)*

Adequate run/on time (if system passes diagnostic screening)

Performance Tested Comfort Systems (PTCS)

Great program in the Pacific NW that addresses system sizing, air flow, & static pressure:

https://ptcs.bpa.gov/

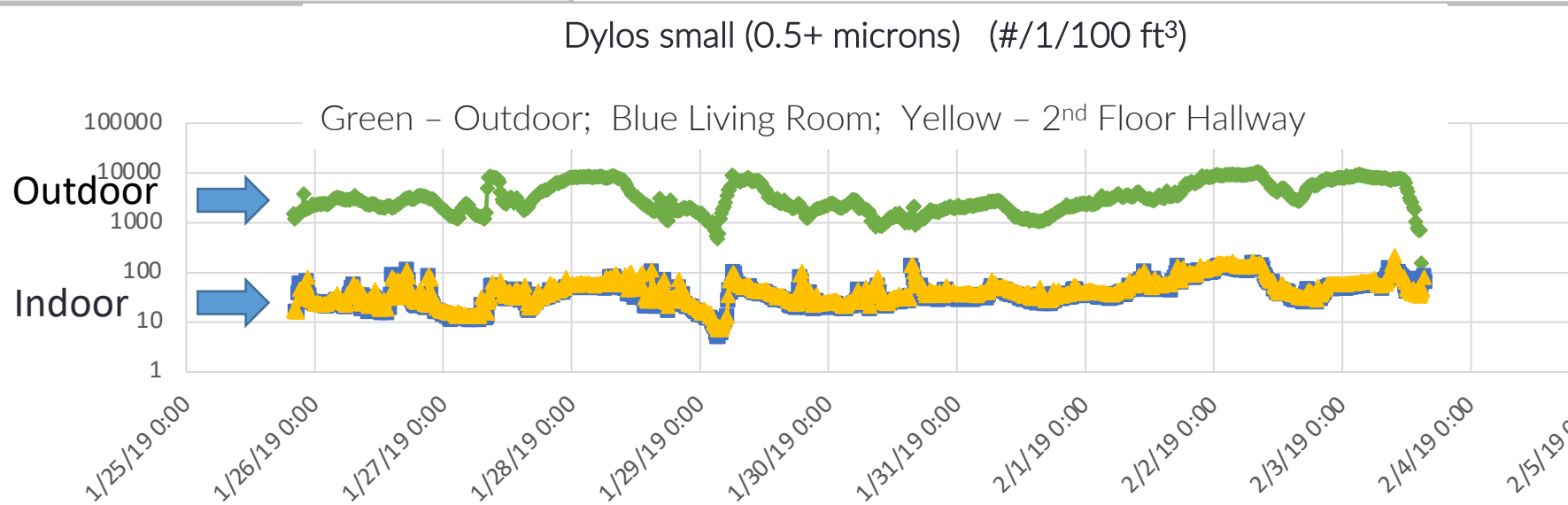


LCMP Top Performer

Air Handler 24/7 – MERV 13 Filter

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

Continuous Mode: **$12/month**
Post: 110 watts; 500 CFM
Pre-Post: 400 watt reduction



Filter Bypass:
Relatively Common in Homes

Photo credit: Brent Stephens

Even small leaks (bypasses) can make a big difference

One change – we now use manufactured filter boxes for a better seal around the filter

4 CHALLENGES

1) No option for AHU upgrade
2) How to determine optimal fan run-time
3) Don’t miss the boat – at point of replacement
4) Clarify the value proposition

FAN/FILTER INTERVENTION: LOW COST, MERV 13

4” MERV 13 filter ($35) on 20” x 20” box fan (~$20)

Box fan in room or in window

UL-rated fan with overheat protection

FAN/FILTER OPTIONS
20” BOX FAN W HIGH MERV FILTERS

Use multiple filters for better air flow (2 in V, or 4 in box)

Known as the Corsi-Rosenthal Cube
https://m.box.com/shared_item/https%3A%2F%2Fucdavis.box.com%2Fs%2Fkgo937lk0d02g0k2bxvpxxqbfatd7czu

Image Credit: Comparetto Comfort Solutions

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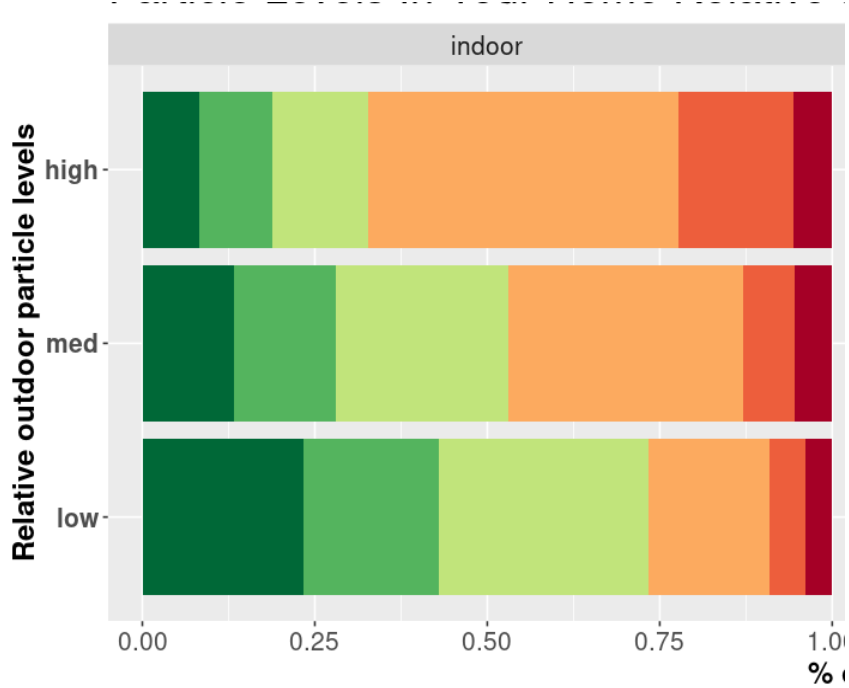
PARTICLE LEVELS INSIDE
RELATIVE TO OUTSIDE

Shorter fan run-time needed when outdoor air is best



Indoor when Outdoor air is worst (25%)

Indoor when Outdoor air is best (25%)

ROCIS LMCP Data Explorer http://rocis.org/rocis-data-explorer

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RELATIVE TO OUTSIDE

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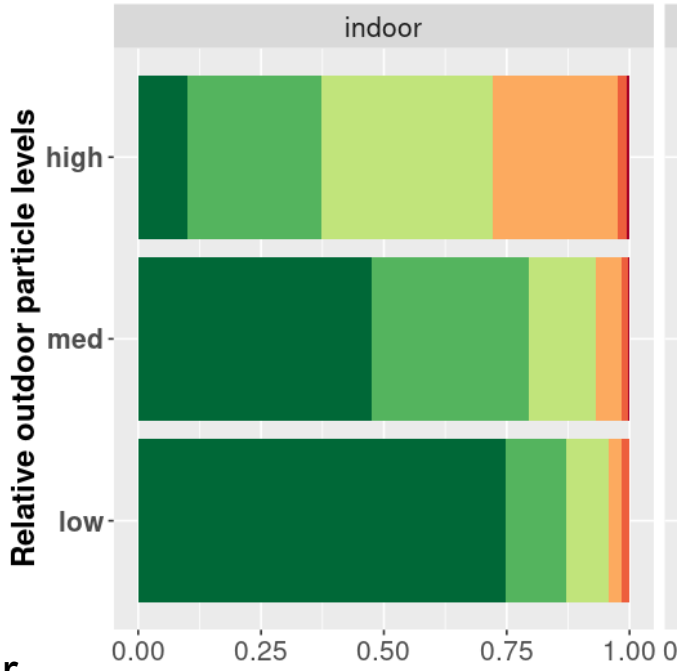

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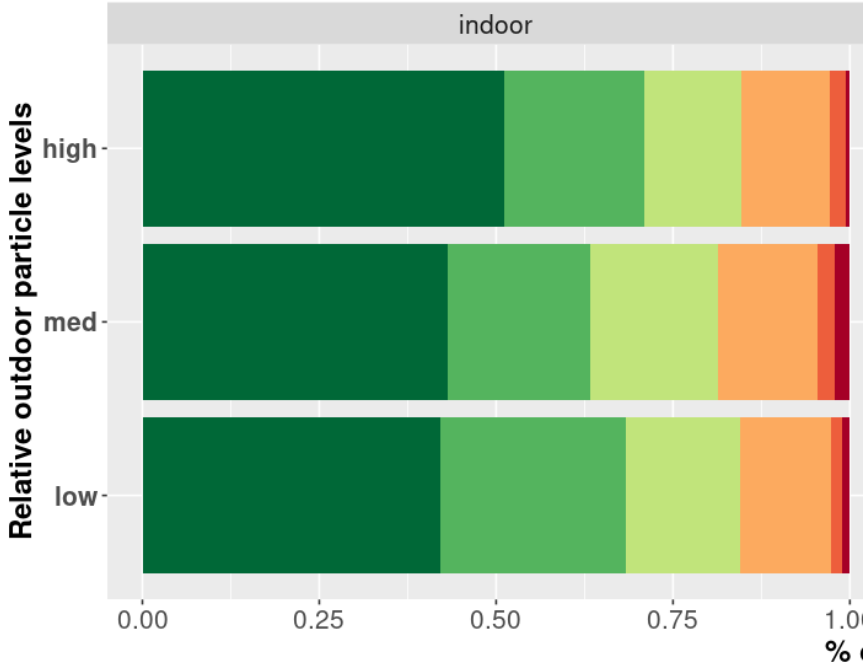
PARTICLE LEVELS INSIDE
RELATIVE TO OUTSIDE (24/7 AHU OPERATION)

Shorter fan run-time needed when outdoor air is best



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4 CHALLENGES

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BIG OPPORTUNITY

AT HVAC SYSTEM REPLACEMENT

Downsize HVAC to reduce static pressure!!

Incorporate return drop modification & option for larger, deeper filter

Set blower speeds for optimal performance

Address duct system shortcomings

To ponder…

- How can potential filtration health & comfort benefits add impetus to getting HVAC systems designed & installed correctly?

4 CHALLENGES

1) No option for AHU upgrade
2) How to determine optimal fan run-time
3) Don’t miss the boat – at point of replacement
4) Clarify the value proposition

QUESTIONS / COMMENTS?

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