A Review of Air Flow Measurements

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- ***ForTheHome***
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- Manometers
- Temperature Measurement
- Thermal Imaging Cameras
- Vacuum Measurement & Kits

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SYSTEM / InDuct AIRFLOW MEASUREMENTS

- Temperature rise
- True Flow Grid
- Static pressure drop
- Pitot tube
- Averaging Pitot tube (AmpliFlow®)
- Hot wire anemometer
- Rotating Mini-Vane
- DuctBlaster® Pressure Matching Method

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SUPPLY AND RETURN AIRFLOW MEASUREMENTS

- Large vane anemometer
- Small Vane anemometer
- FlowBlaster®
- Flow hood & ***new SmartHood***
- FlowFinder® Powered flow hood
- Exhaust Fan Flow meter
- Garbage bag and stop watch
- Large Vane Anemometer and "mini-hood"

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Anemometer:

An instrument for measuring wind speed

ANN-NIH-MOM-MITTER

from the Greek anemos = wind

or wind meters

The AIR facts….

- Even though you cannot see it
  - Air has mass
    - Standard Air Conditions: 70 F, 0% rH, Sea Level
    - Standard air weighs 0.075 lb/ft^3
  - Air takes up space
  - Air density changes with Temperature, Altitude, Humidity

We condition pounds of air, NOT CFM’s.

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In Duct Measurements

- Temperature Rise Method
  - Heat Flow Equation
- Pitot Tube
  - Tube in a tube: need a manometer
- Thermal Anemometer (Hot Wire)
  - WindChill effect – lick your fingertip
- Wilson Flow Grid (TrueFlow grid)
  - Pitot Array
- Static pressure drop across coils, filters, heat exchangers
  - (***Provided there is a CFM look up chart***)
- Rotating Mini-vane

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Supply & return measurements

- FlowBlaster® / FlowFInder / SmartHood
- Flow Hood / Capture hood
- Exhaust fan flow meter
  - Within it's range & return only…
- Rotating Large vane *

  MUCH TOUGHER to do…
- Pitot Tube *
  - Traverse and average
- Thermal Anemometer * (Hot Wire)
  - Traverse and average

* ***MUST HAVE OPEN AREA ON SUPPLIES***

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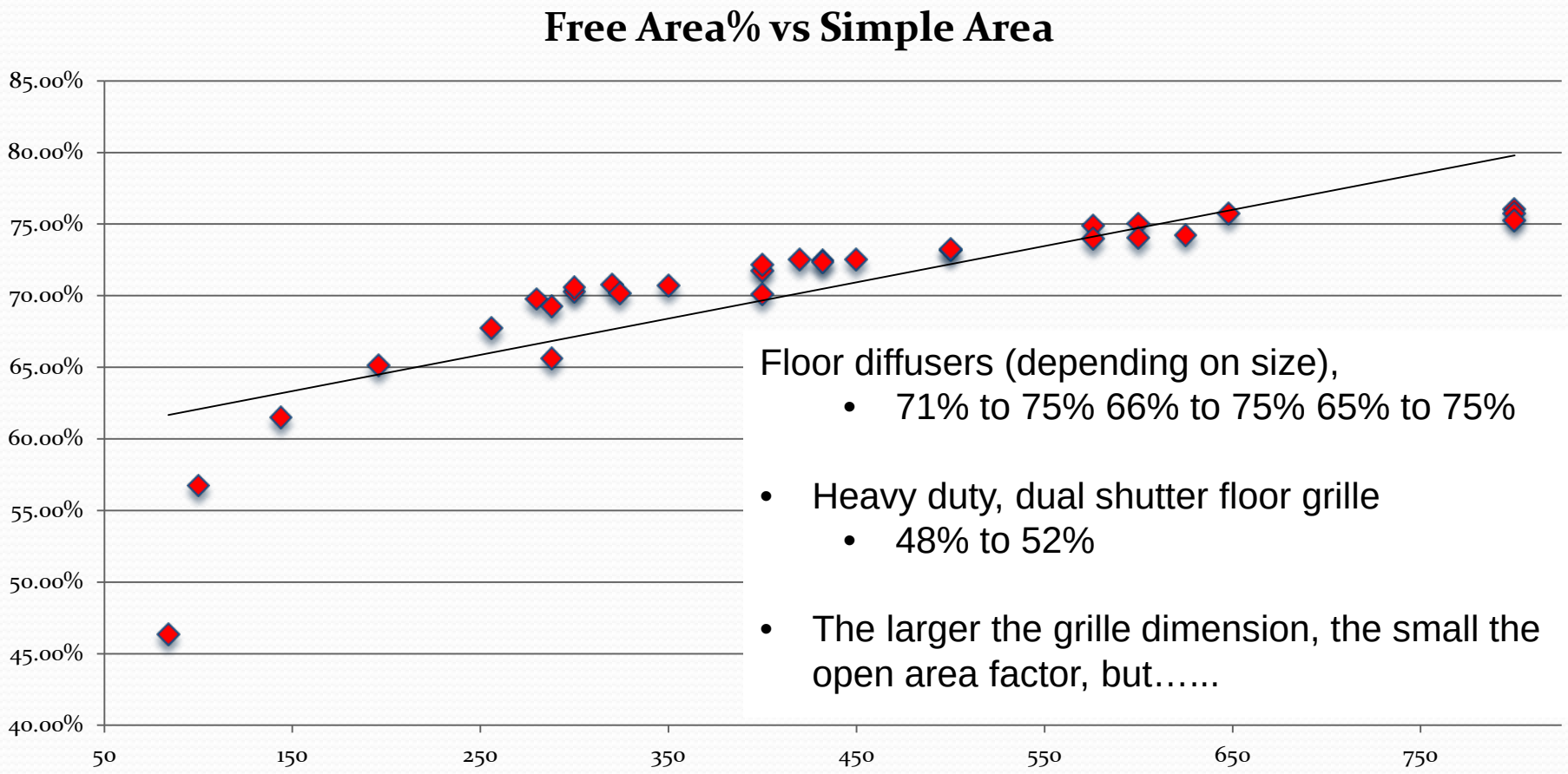
Rule 412: Open Area on Supplies



Floor diffusers (depending on size),

- 71% to 75% 66% to 75% 65% to 75%

- Heavy duty, dual shutter floor grille
  - 48% to 52%

- The larger the grille dimension, the small the open area factor, but…...

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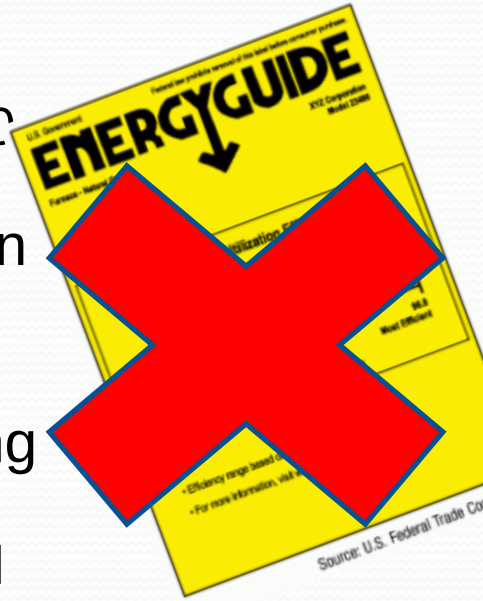
Temperature Rise Method

- CFM = (BTUh OUT) / (1.08 x ΔT)
  - ***1.08 factor is density dependent!***
- Use on natural gas, oil, propane and electric furnaces
  - CAUTION: variations in fuel and motor heat make this an estimation
  - Allow appliance to reach steady state efficiency. (10 minutes or stable stack temperature)
- BTUh OUT = BTUH INPUT x SSE (for combustion systems)
- DO NOT USE the YELLOW STICKER! AFUE
- Measure the temperature rise OF THE AIR moving across the heat exchanger.
  - Out of the line of sight of the heat exchanger (avoid radiant effect)
  - Close bypass humidifier, if present



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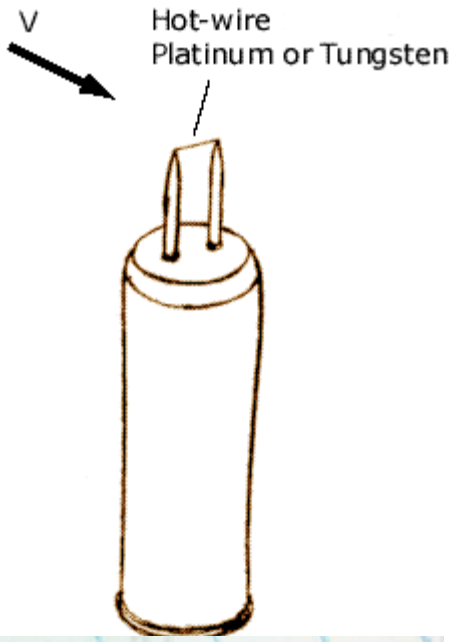
Hot Wire

- How it works
  - Wind-chill of a heated bead is proportional to the air velocity
- Benefits
  - Broad range, easy to use
- Limitations
  - Denser air has more mass
    - Carries away more heat at a given velocity
  - Subject to contamination
  - Intercepts a small area
- Applications
  - In duct measurements



Price range $250-$600

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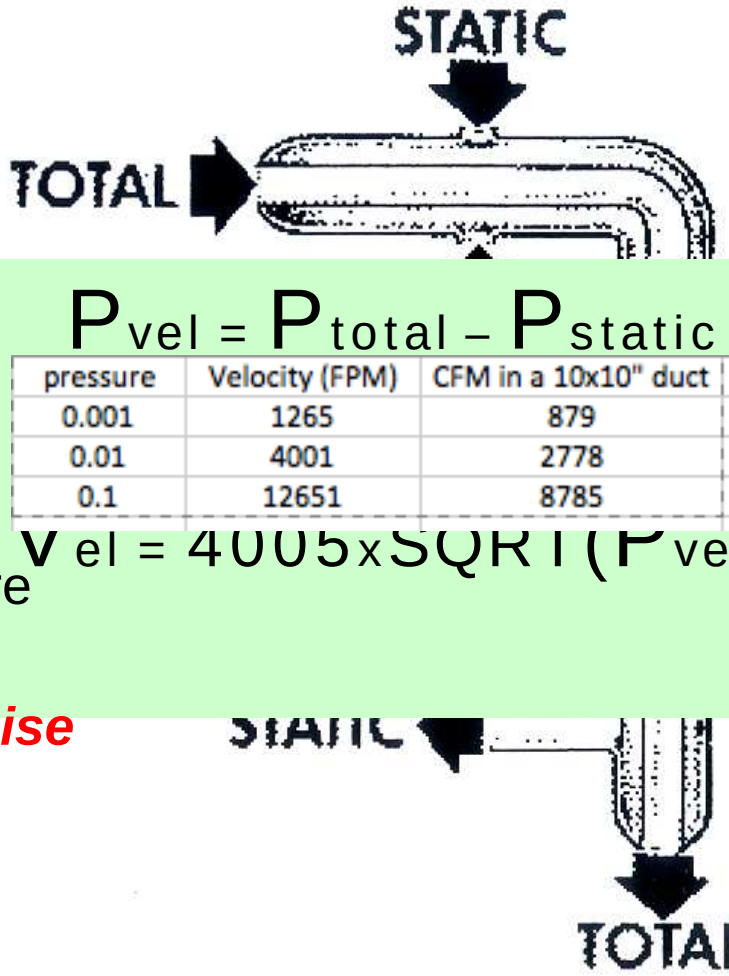
Pitot Tube

- How it works
  - Air pushes/pulls sensor diaphragm
- Benefits
  - Easy to use, cost effective
- Limitations
  - Denser air has more mass, thus more pressure at a given velocity
  - “Lower velocity” limits only with ***precise*** manometer with calculation
  - Small intercept area
- Applications
  - In duct measurement



$$P_{vel} = P_{total} - P_{static}$$

pressure	Velocity (FPM)	CFM in a 10x10" duct
0.001	1265	879
0.01	4001	2778
0.1	12651	8785

$$V_{el} = 4005 \times SQRT(P_{vel})$$

Price range $50 -$150 plus manometer $550 to $850

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In-Duct Measurements- Probe* placement

Look for:

ASHRAE: Straight sections of duct 7-10 duct diameters away from turns and fittings.

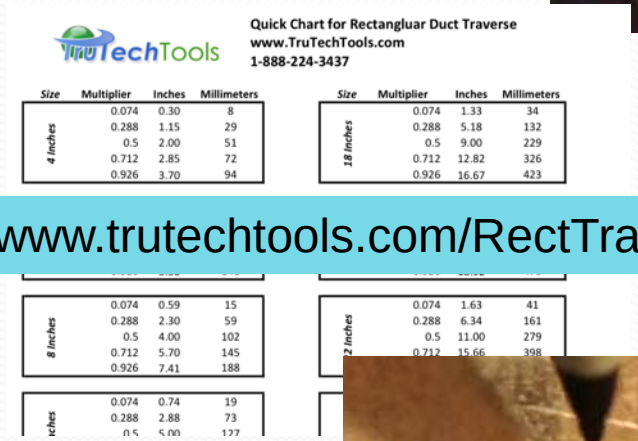
MINIMUM 3 Duct Diameters

Good location on a traditionally ducted system

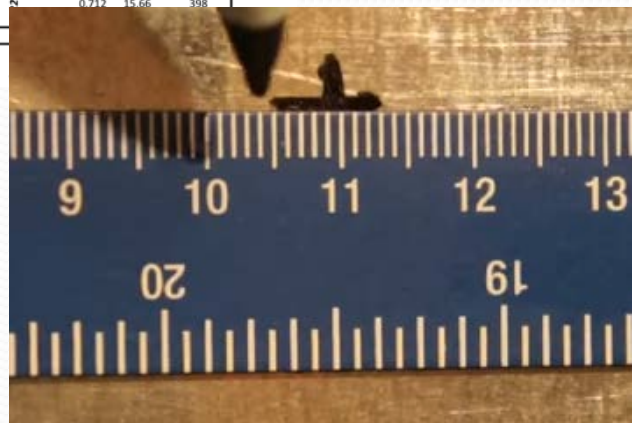
**** Pitot tube, Hot Wire or mini-vane***

Doing a Traverse

- Two Types
  - Timed Average (Sweep)
  - Point Average
- Timed Average
  - Faster
  - Depends on your consistency
- Point Average
  - Conventional
  - Determine target points
  - Hitting target points
- Can do traverse with both rotating vane or Hot-wire anemometers



www.trutechtools.com/RectTraverse



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TrueFlow® Plate (Pitot Array) or Flow Grid

- How it works
  - Like multiple Pitot Tubes yielding an average velocity sampled over large area
- Benefits
  - Fast to set up, adjustable
  - Central return or in filter slot
- Limitations
  - Same as those of a Pitot tube
  - Very close to “run conditions” (NSOP)
  - Needs digital manometer
- Applications
  - System airflow

Cost ~ $825 + $850-$1250 = $1675 - $2075

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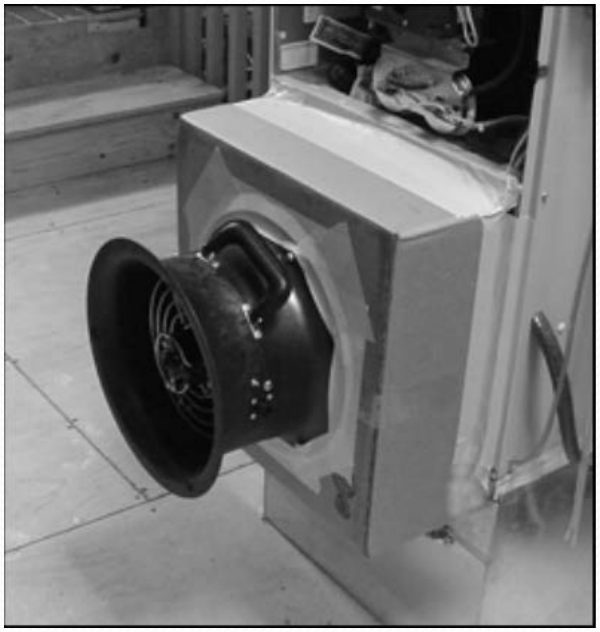
DuctBlaster® Pressure Matching

- How it works
  - Matches normal system pressure with DuctBlaster® which then measures the actual flow at that pressure
- Benefits
  - Accuracy of DuctBlaster®
  - May already be a tool you have
- Limitations
  - Fitting to the air handler cabinet
  - Multi-step process
- Applications
  - System airflow



Cost ~ $2000

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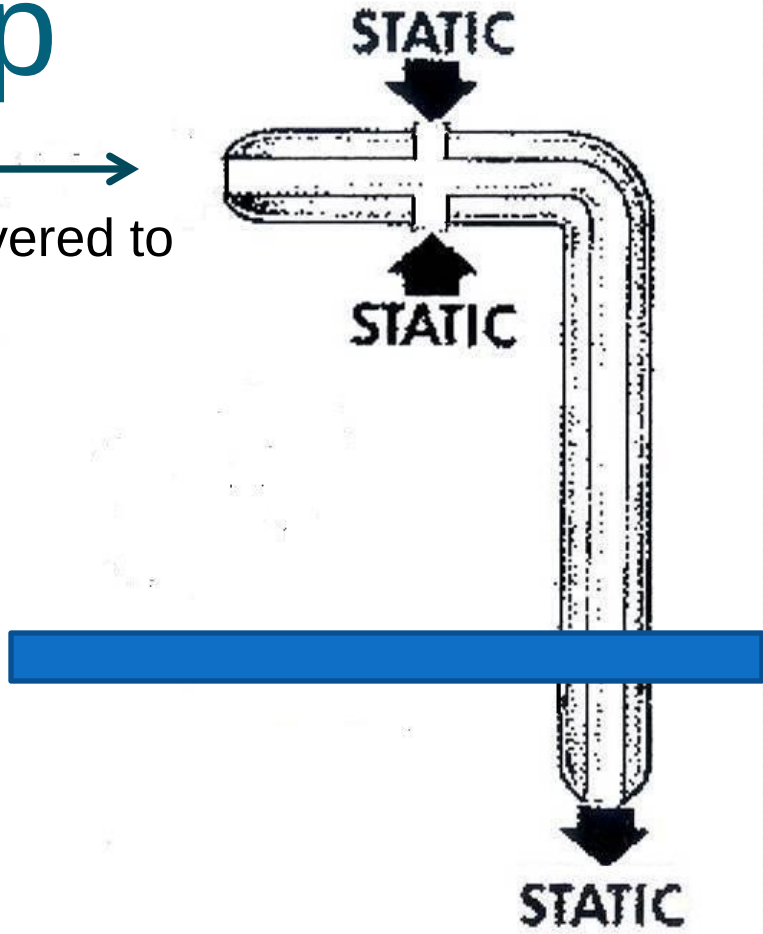
Static Pressure Tip

- How it works
  - Static or balloon pressure of air is delivered to a pressure sensor
- Benefits
  - Easy to use, cost effective
- Limitations
  - Air Density correction considerations
  - ***Does <u>not</u> directly equate to airflow***
- Applications
  - In duct measurement



Price $ 20 each, usually need 2

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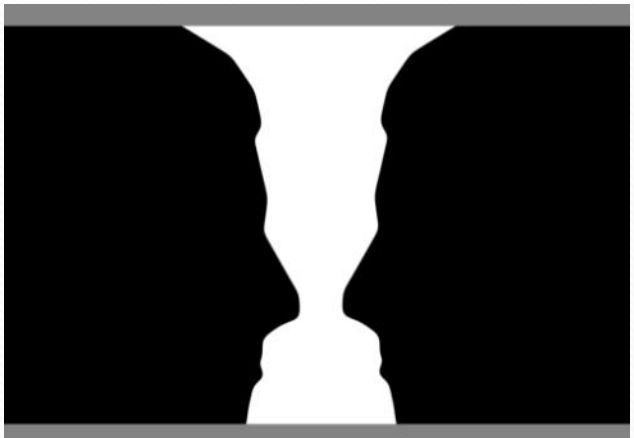
Total External Static Pressure

- Manufacturer profiles each heat exchanger or evaporator coil
- By measuring across system components (coil or HX)
  - CFM
  - Pressure drop
- Creates a table of CFM at ESP for various configurations
- The industry standard for TESP in equipment design is ½”wc, ranges from 0.3-1.0” H2O are possible
- ECM motors make it a new ballgame



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2.5B Coil Specifications: Airflow Pressure Drop

TABLE 1
AIRFLOW PRESSURE DROP

Coil Model Number	Approx. Design Airflow CFM [L/s] Range	Face Area Sq. Ft. [m²]	Fins/In. Rows Deep	Static Pressure Drop Through Wet Cooling Coil [kPa] (Inches W.C.) CFM [L/s]													
				600 [283]	700 [330]	800 [378]	900 [425]	1000 [472]	1100 [519]	1200 [566]	1300 [614]	1400 [661]	1500 [708]	1600 [755]	1700 [802]	1800 [850]	1900 [897]
HIGH EFFICIENCY COOLING COILS																	
3624	825 / 1175 [389 / 555]	9.98 [0.93]	14/3	—	—	0.07 [0.02]	0.09 [0.02]	0.11 [0.03]	0.14 [0.04]	0.16 [0.04]	—	—	—	—	—	—	—

NOTE: Represents Coil-Only Airflow Ratings.

[ ] Designates Metric Conversion

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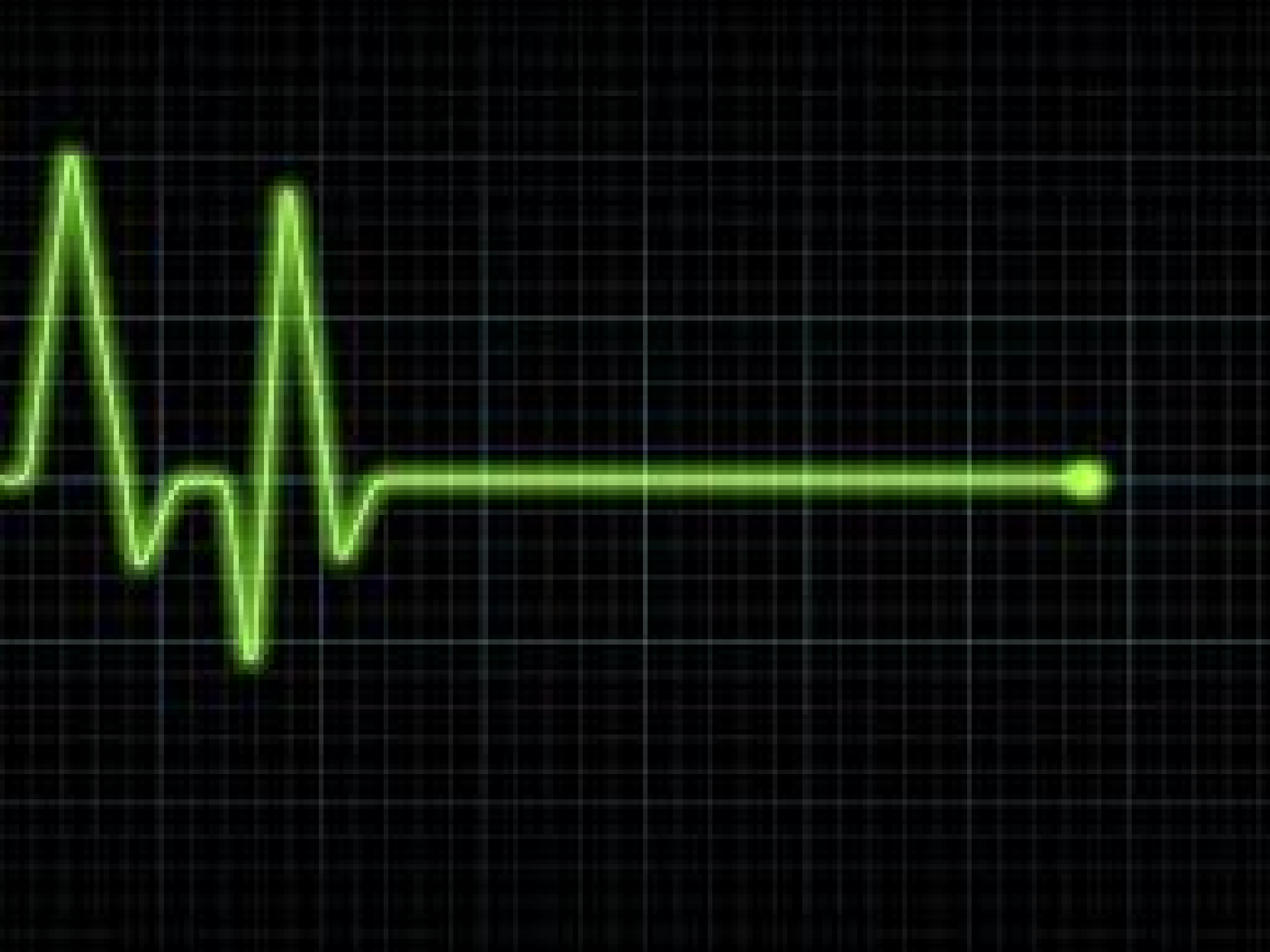
Motor types and Static Pressure

- Two types of residential blower motors
  - Permanent Split Capacitor (***PSC***)
  - Airflow *decreases* as the static pressure *increases*.
- Electronically Commutated Motor (***ECM***) motors
  - Auto-adjust RPM and *power* to keep *programmed* airflow
  - Airflow varies little as static pressure changes
  - Actually senses the resistance to airflow
  - Has a programmed speed limit
  - However, if resistance is high, *power consumption is high*
- Static pressure measurements on ECM system…
  - Checks efficiency and within design, not CFM
  - Very little change in the CFM with static pressure
- An X-13 motor is a hybrid: multiple taps programmed by MFR



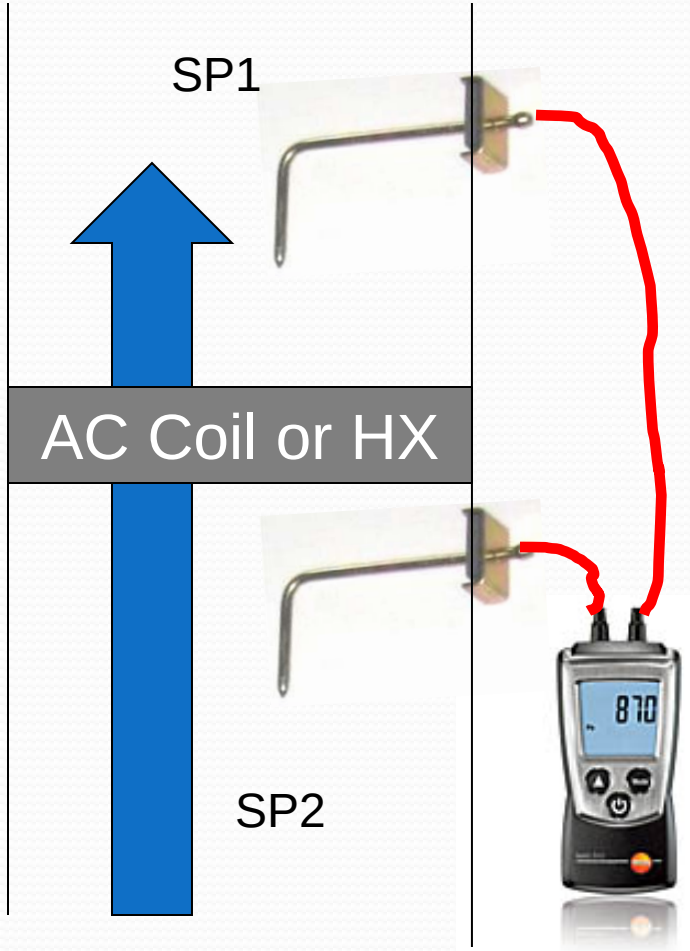
MODEL RGRL-	BLOWER SIZE [mm]	MOTOR H.P. [W]	BLOWER SPEED	CFM [L/s] AIR DELIVERY EXTERNAL STATIC PRESSURE INCHES WATER COLUMN [kPa]						
				0.1 [.02]	0.2 [.05]	0.3 [.07]	0.4 [.10]	0.5 [.12]	0.6 [.15]	0.7 [.17]
04*M	11 x 7 [279 x 178]	1/2 [373]	LOW	805 [380]	780 [368]	760 [358]	720 [340]	685 [323]	645 [304]	605 [285]
			MED-LO	920 [434]	885 [417]	850 [401]	810 [382]	775 [365]	730 [344]	690 [325]
			MED-HI	1140 [538]	1110 [524]	1085 [512]	1045 [493]	1010 [476]	950 [448]	890 [420]
			HIGH	1360 [642]	1320 [623]	1280 [604]	1235 [583]	1195 [564]	1140 [538]	1080 [500]

*E=Standard
*N=NO_x Models
***Where the maximum airflow is above 1800 CFM or more, both sides or 1 side and the bottom must be used for return air to maximize airflow.
NOTE: CFM values represent furnace-only airflow ratings.

[ ] Designates Metric Conversions

Static Pressure Drop

- How it works
  - Need mfr table of Pressure Profiles
- Benefits
  - Low cost
  - Easy to set up and use
    - Need a digital manometer, too
- Limitations
  - Results depend on the equipment mfr. tables
  - The “known resistance” often changes
    - “wet coil” how wet is wet, dirty coils
  - Velocity drag at walls of duct
  - Air density correction
  - CAREFUL DRILLING INTO THINGS!
- Applications
  - In duct measurement



Price ~ $ 15 x2
PLUS a manometer $89- $250
TOTAL $119 to $280

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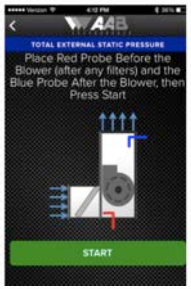
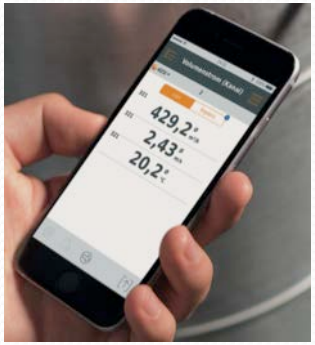
Manometers for Static Pressure





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Rule # 315: Standard charts

- The ***use of standardized tables or charts should be avoided*** at all costs as they do not provide even a reasonable estimation of airflow.
- Coil designs very in rows, and fin spacing and only the manufacturer's chart will account for these design variables.

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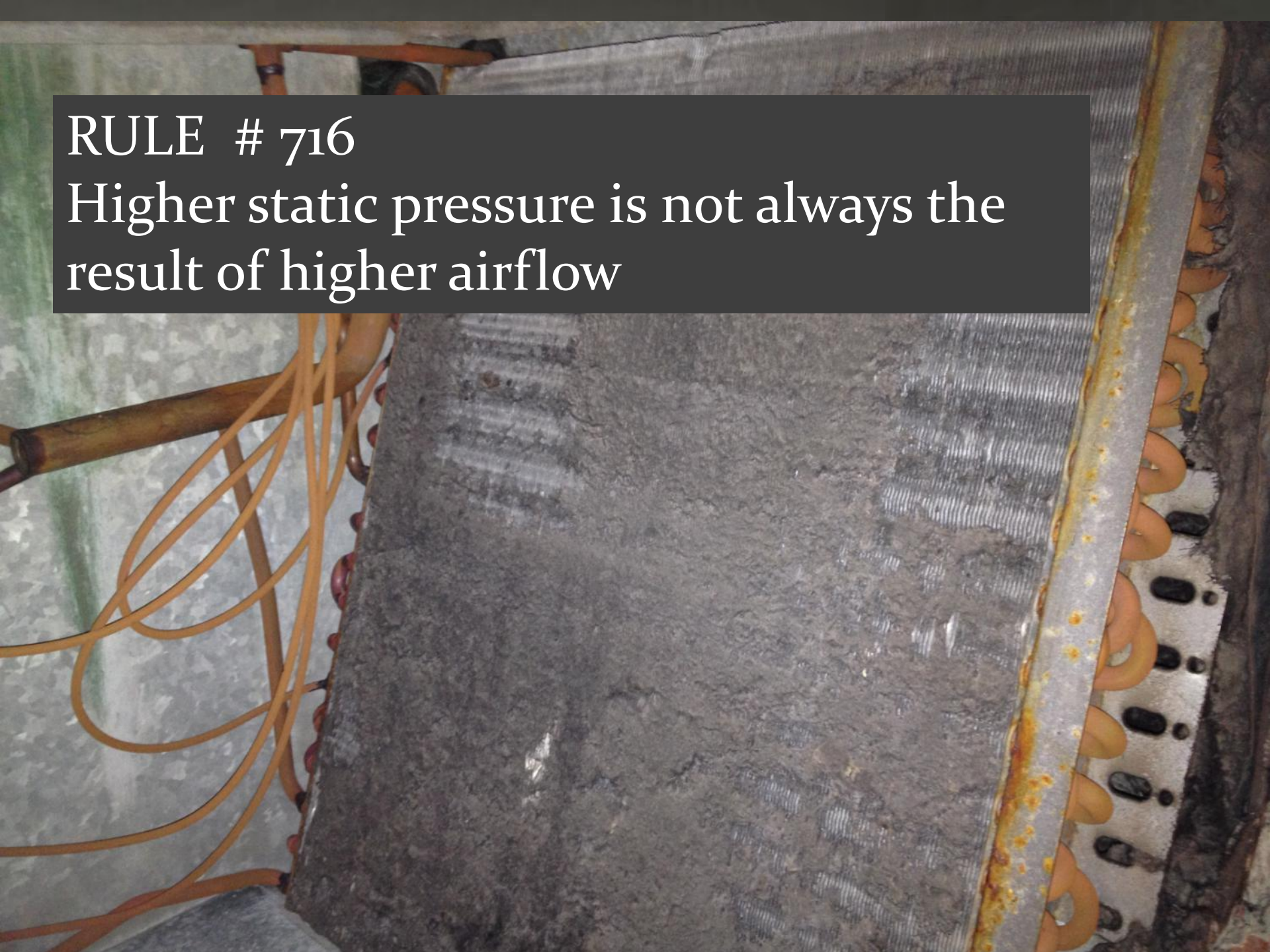
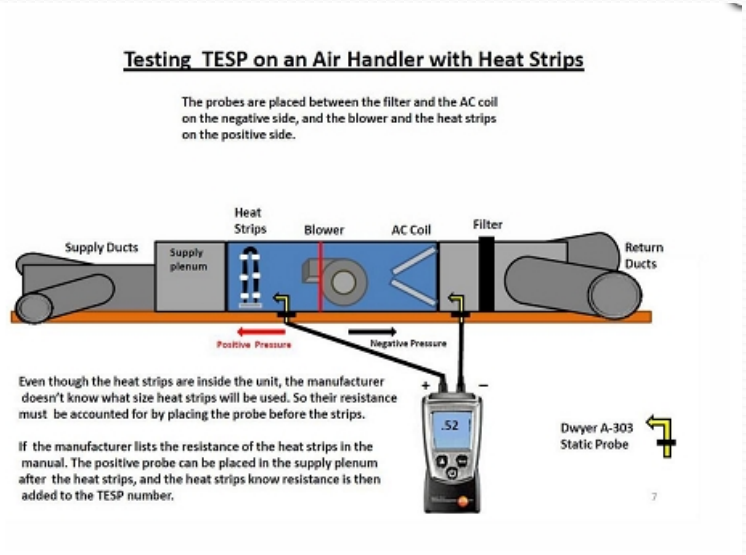


RULE # 716

Higher static pressure is not always the result of higher airflow

RESOURCES

- Free guide to testing TESP
  - www.bit.ly/TTT-ESP



- 20 Minute video lesson
  - www.bit.ly/ESP-VIDEO

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Vane Anemometer

- How it works
  - Propeller rotates proportional to the speed of the air
- Benefits
  - No need for density correction
  - Averages over large or “large” small area
  - Minimally invasive
- Limitations
  - Not for very low flow
  - Turbulence
  - Angular of probe during test (10% off angle, 1% error)
  - Friction of propeller bearings & propeller bypass
- Large Vane Applications:
  - Supplies & returns
  - Especially flex duct systems
- Mini-Vane Applications:
  - In duct on hard duct systems

Price range $99- $500

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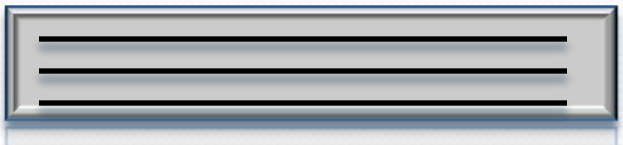
Stub Box Sweep/Traverse



- Pluses
  - Area is known
  - No grilles
  - More consistent

- Need to check
  - Back pressure
  - Proper dimensions
  - Application beyond floor registers

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Mini-mini vane!

- How it works
  - Propeller rotates proportional to the speed of the air
- Benefits
  - No need for density correction
  - Minimally invasive
  - Easy calculations and reporting and emailing
- Limitations
  - Not for very low flow
  - Turbulence
  - Angular of probe during test (10% off angle, 1% error)
  - Friction of propeller bearings
  - May be awkward to use
- Large Vane Applications:
  - Supplies & returns
  - Especially flex duct systems

Price ~$50

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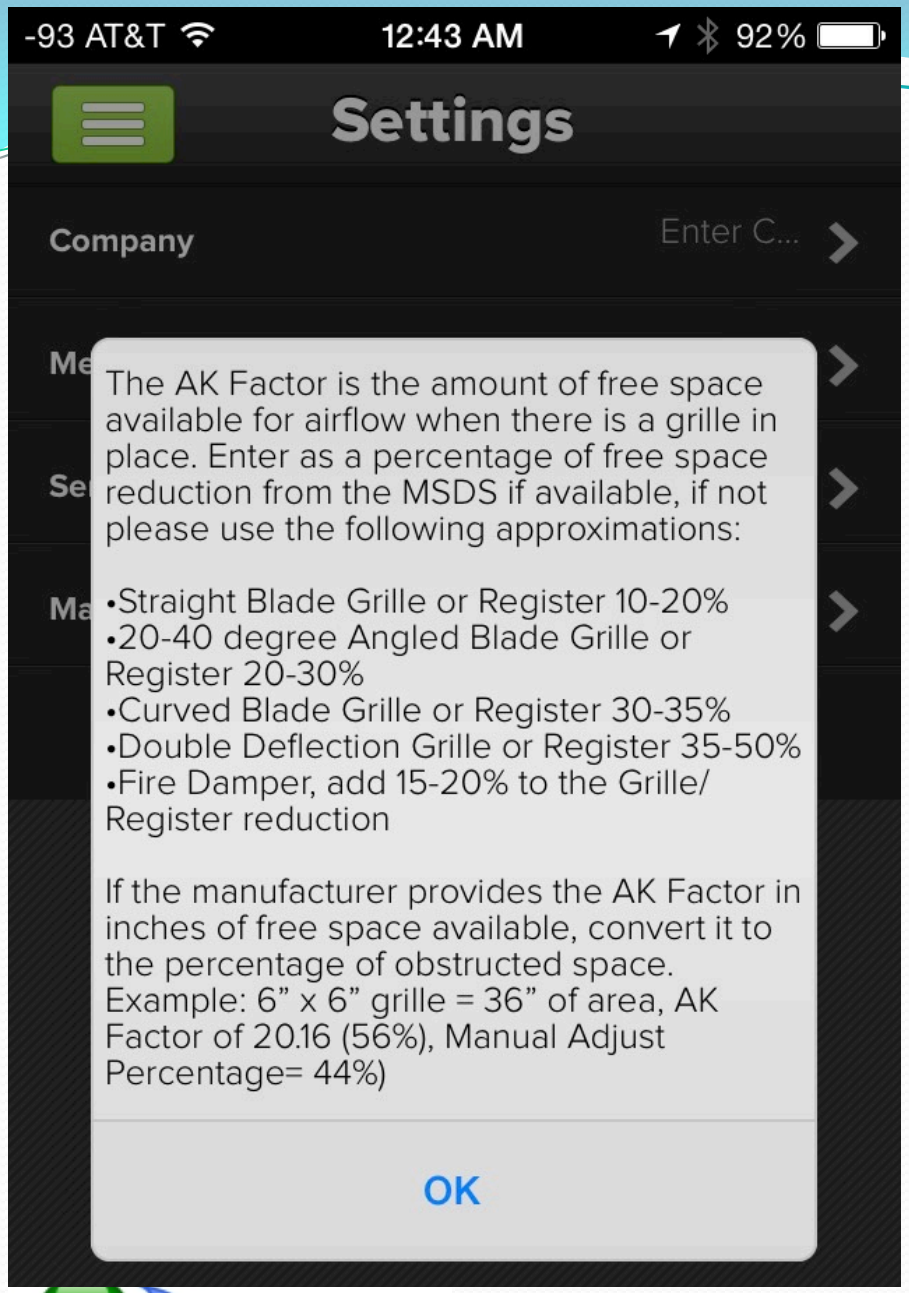

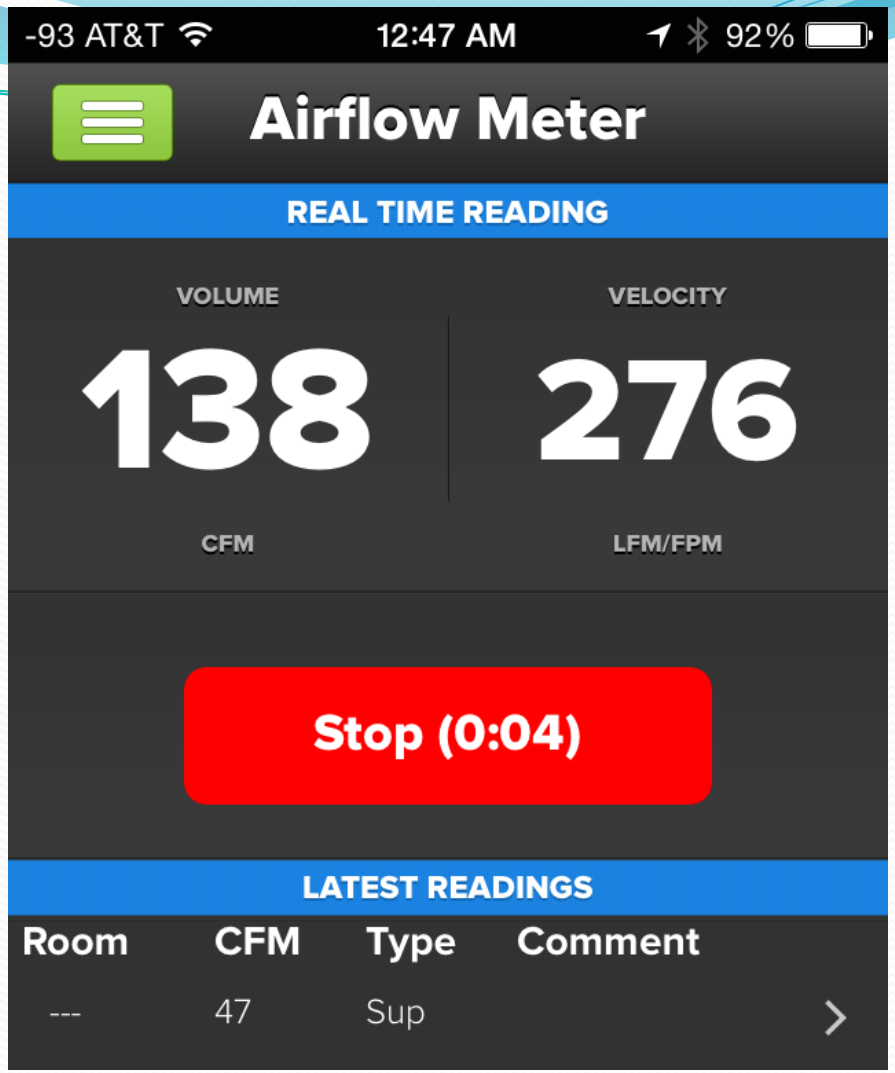

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Rule 724: Scoops, mini-hoods & funnels

- Not to be used at volume flows above about 50 CFM
- Due to back pressure

Exhaust Fan Flow Meter

- *Used for exhaust fan flow*
- *Need precision digital manometer*
  - *Pascal read out*
- *Measuring range 10 to 124 CFM*
- *Display on DG700 or DM32 gives readings*
  - *Or Sticker /chart on EFFM*
- *Placed over a fan grill, air is drawn through the calibrated opening.*
- *Opening adjusted to minimize back pressure while maximizing accuracy*

Cost $135 + Precision Digital manometer ($525 to $1250)

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Capture Devices

- Plastic Bag & stop watch
  - Cheap! Accurate? Repeatable?
- Flow hoods
  - With Pitot array
  - With Hot Wire array
- Benefits
  - Fast to set up and use
  - Captures all of the air, if done correctly
  - Snapshots
  - Multifunction meters
  - 2 ranges : 500 & 2500 CFM
- Limitations
  - Accuracy is mass dependent/corrected
  - Back pressure compensation (SmartHood!)

$10 to $1500 to $3500

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The PVCD

- The polymeric volumetric capture device
- AKA The garbage bag
- Works by timing how long it takes to fill a known volume with air
- Use “pressure spike” inside bag to indicate full

Truly capturing it.

Garbage bag formula:

$$\frac{\text{(bag size in gallons)} \times 0.156 \text{ ft}^3/\text{gallon} \times 60 \text{ sec/minute}}{\text{seconds to fill bag}} = \_\_\_\_\_ \text{ CFM}$$

Example:

$$\frac{55 \text{ gallon} \times 0.156 \text{ ft}^3/\text{gallon} \times 60 \text{ sec/minute}}{4 \text{ seconds to fill}} = 129 \text{ CFM}$$

Garbage Bag Flow

AirProbe

- How it works
  - An averaging Pitot Tube
- Benefits
  - Easy to use, cost effective
- Limitations
  - MUST be exact size of duct
  - Offline calculation or table required
  - “Lower velocity” limits only with precise manometer with calculation
  - 1” diameter hole to drill and plug
- Applications
  - In duct measurement

Price range $100 plus manometer $200, about $300 total

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SIZING THE PRESSURE TRANSMITTER

- CFM- Cubic feet per minute (customer furnished)
- A- Area square feet (customer furnished)
- V- Velocity feet per minute (customer furnished)
- ΔP- Differential pressure in WC"
- Use formula B to calculate the ΔP for transmitter

$$V(FPM) = \frac{CFM}{A}$$

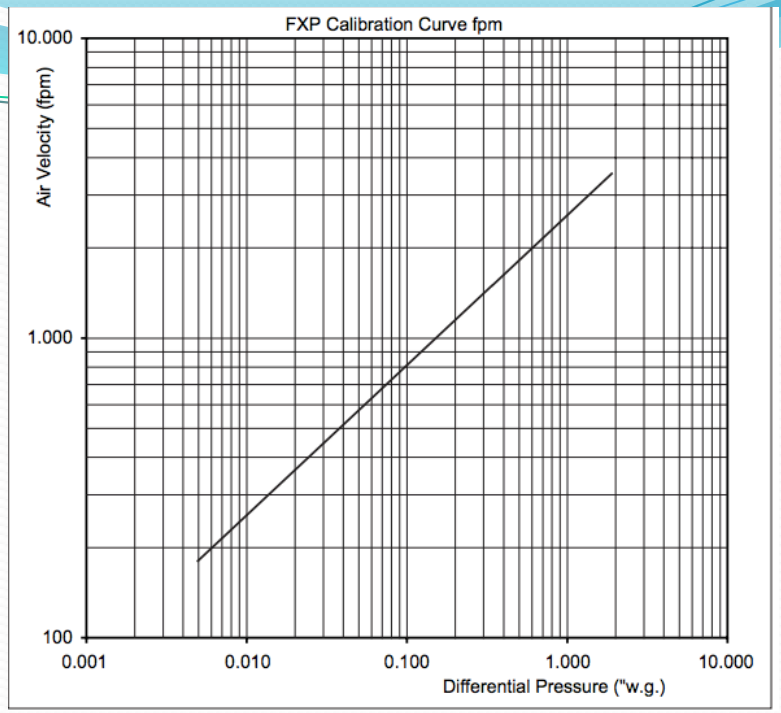
$$V = Kv * \sqrt{\Delta P}$$

Formula A

$$\Delta P = \left[\frac{V}{Kv}\right]^2$$

Formula B

FXP Calibration Chart					
Size	**Kv**	**Size**	**Kv**	**Size**	**Kv**
4"	2225	7"	2450	12"	2500
5"	2325	8"	2480	14"	2525
6"	2400	10"	2490	16"	2550
18" and up			2550		



CFM = 800
Area = 1 sq ft
Vel = 800 FPM

$dP = (Vel / Kv)^2$

dP = 0.102 IWC

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FLOWBLASTER®

Auto compensates for Back pressure

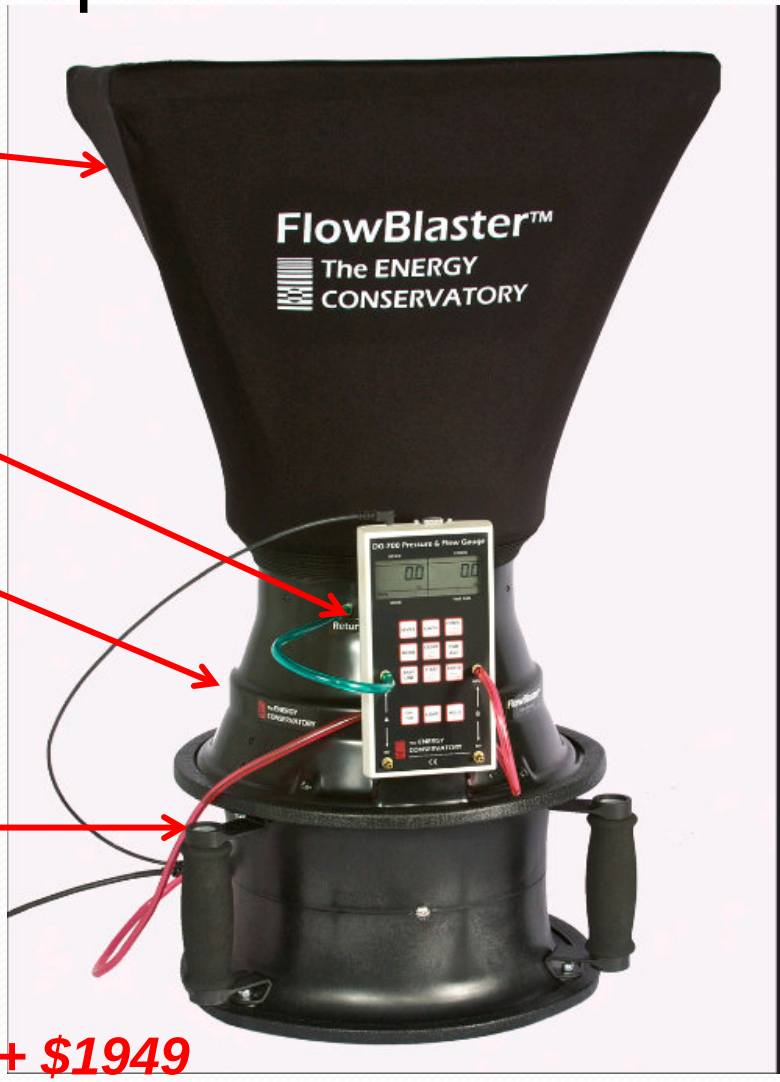
A powered flow hood!

Grill skirt

Digital Manometer

Fan controller

Measurement Array



NOT SHOWN
Waist carried Battery pack

Compensating Fan (DuctBlaster®)

Attaches to a DuctBlaster® COST = ~ $1100 + $1949

Powered Flow Hood
Flow Finder MK2

- Internal fan and sensor compensates for back pressure
- Up to 500 CFM supply or return
- Ultimate accuracy
- Single piece
- Lightweight (5 lbs)

COST = $3395

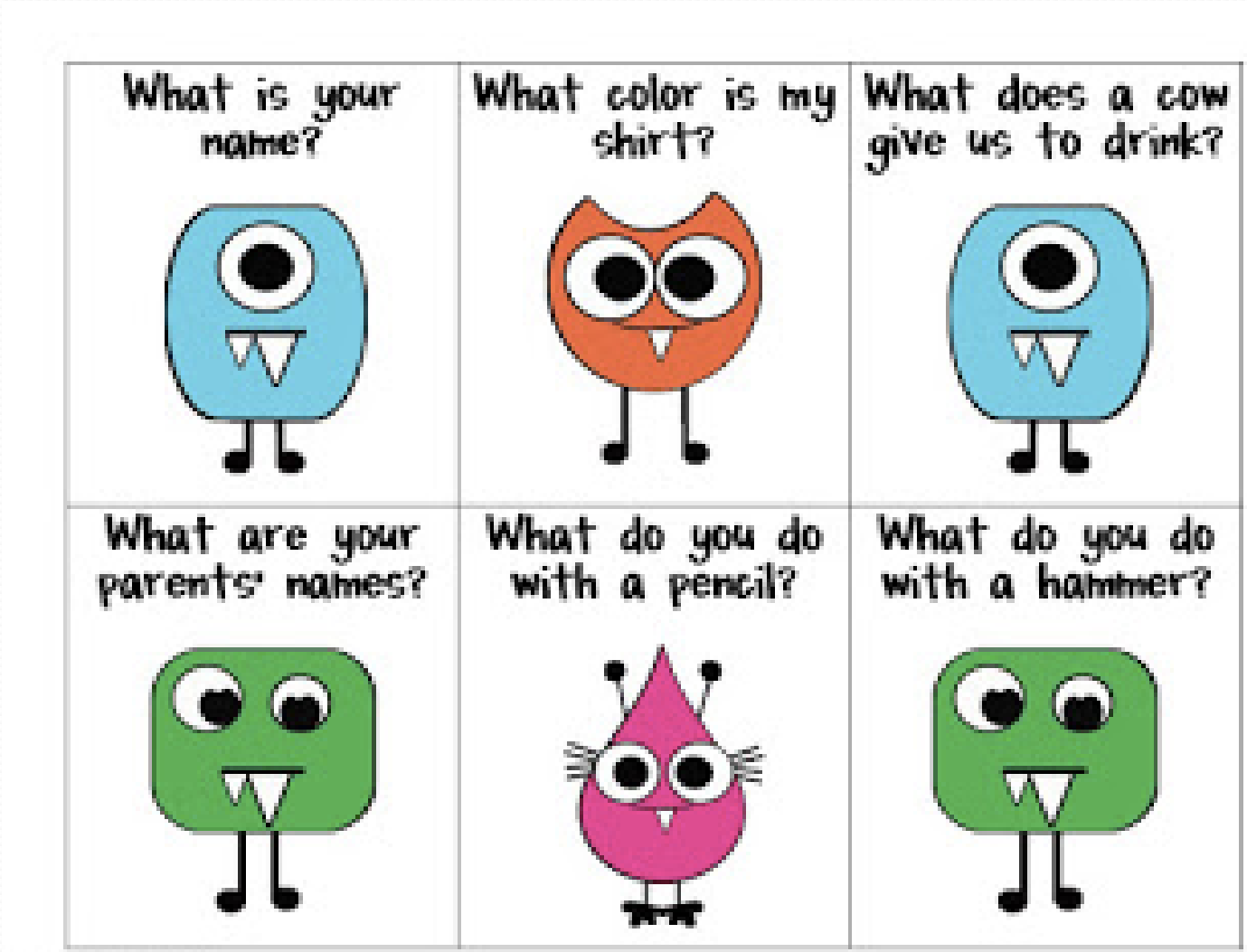
retrotec
airflow systems since 1980 www.retrotec.com

Dwyer®

SmartHood

Look Ma! No Displays!

QUESTIONS ???


What is your name?
What color is my shirt?
What does a cow give us to drink?
What are your parents' names?
What do you do with a pencil?
What do you do with a hammer?

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