Air Flow Measurements

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TruTech Tools, LTD

Part 2 in the TruTech Tools

AC System Performance Series

AC System Performance Series

- Part 1: The Big Picture
- Part 2: Airflow
- Part 3: Refrigerant Charge – July 5, 2 PM EST
  - Determine, measure and set proper refrigerant charge, evacuation process all critical to get highest efficiency.
- Part 4: Capacity Testing - July 12, 2 PM EST
  - Equipment is sold on cooling tons, learn the proper tools and techniques to measure it.

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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 weighs 0.075 lb/ft^3
  - Air takes up space

- We are not conditioning CFM's of air but rather pounds of it!

What's a CFM?

- C = Cubic
- F = Feet
- M = per Minute
- It's a volume flow rate
- How much air per minute
- CFM = Velocity x Area

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Calculating CFM

- First: an accurate air velocity (speed) measurement is required (FPM)
- Multiply air speed by the cross sectional area to get the CFM
- If the air velocity measurement is incorrect, the CFM will also be incorrect!!

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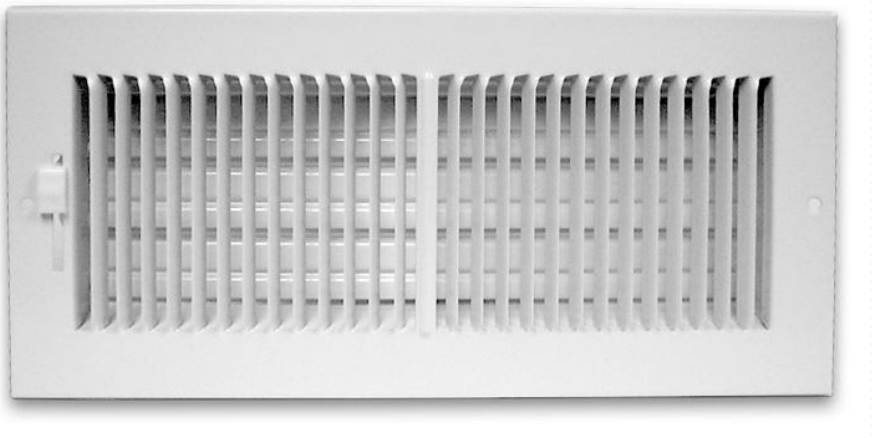
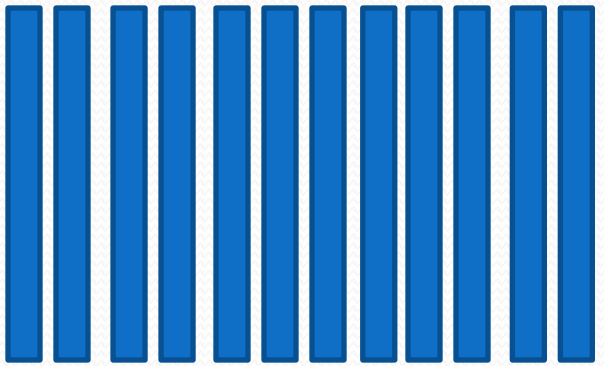
Anemometers on Supplies: K Factor

TOTAL AREA = 4 x 10 = 40 sq in
0.28 sq ft



K Factor =0 .75



OPEN AREA = Total Area x K Factor
OPEN AREA = 40 x 0.75 = 30 sq in
= 0.21 sq ft

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CFM = Open Area x Velocity

- OPEN AREA = 30 sq in
- = 0.21 sq ft
- Velocity = 200 feet per minute (FPM)

- Volume Flow = 0.21 x 200 = 42 CFM

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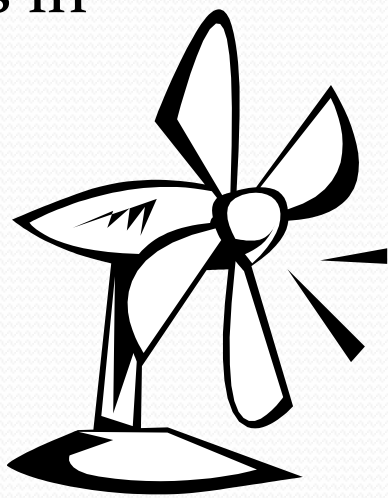
Specific Volume

As air is heated or humidified, its specific volume increases and its density decreases

Airflow

- One of the two adjustable parameters on a refrigeration system
- Airflow is critical to proper operation
- Must be set before charge is set measured or adjusted!!!
- System capacity is directly affected by changes in airflow.



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Energy Star on Air Flow

70% of systems have improper airflow

Considering an ENERGY STAR CAC/ASHP Specification for 2006

Appropriate Accuracy is key to useful measurements

- Reasons **FOR** taking measurements
  - I can prove the system operates as the manufacturer intended
  - I know where to start troubleshooting
  - I can eliminate “false causes”
  - I have a “paper trail” of my work
  - I can get better factory support when needed
  - It helps me sleep well at night

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Achieving accurate measurements:

It's not any one thing.

- There may be error inherent in the
  - Measurement process
  - Positioning of the instrument probe
  - Calculation errors
  - Not factoring in air density
  - Improper techniques and practice
  - Limitations of measurement device or devices
    - Resolution

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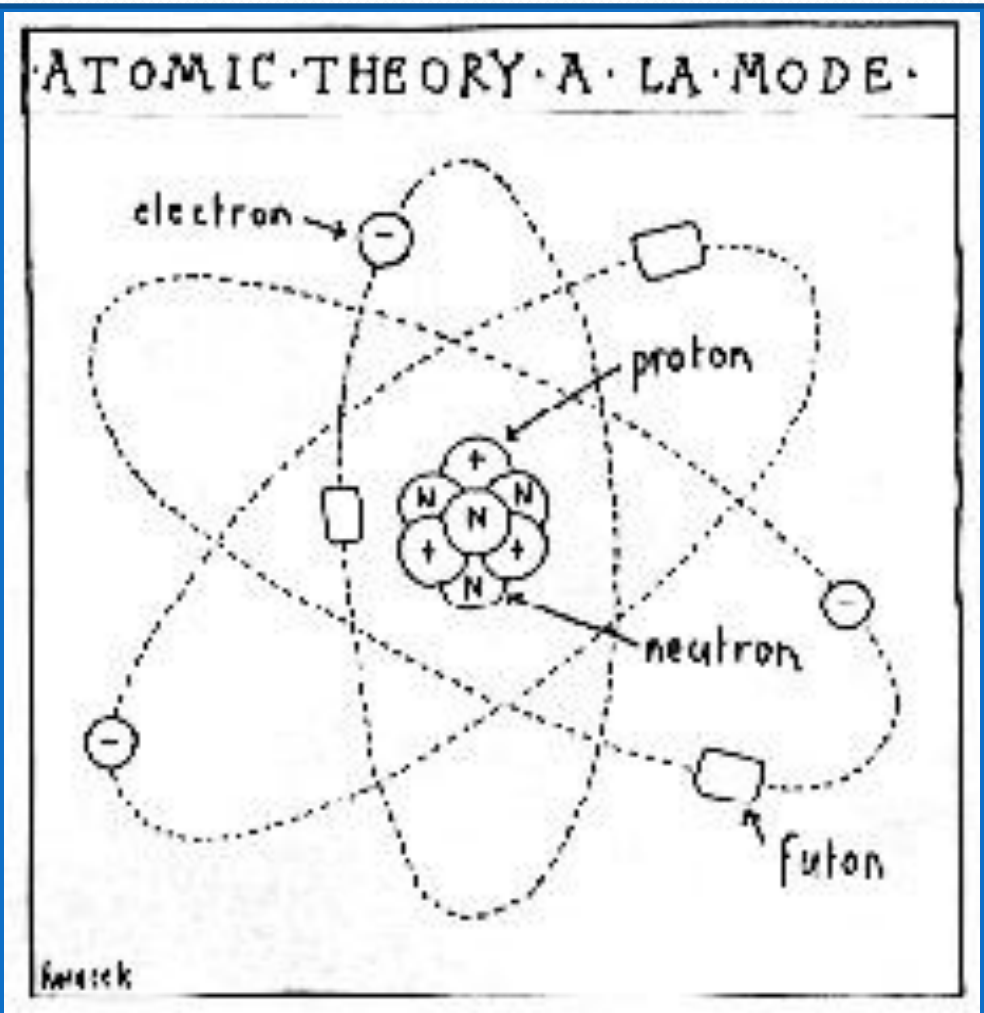
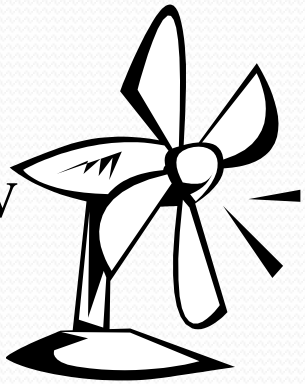
REMEMBER
There are no theories in HVAC/R!



Airflow

- Airflow must ALWAYS be set at the appliance first!
  - Airflow is critical to system performance
  - Refrigerant charging requires proper airflow
  - Set to a nominal 400 CFM/Ton for A/C
  - Set to 450 CFM/Ton for heat pumps
  - Middle of temperature rise range for furnaces

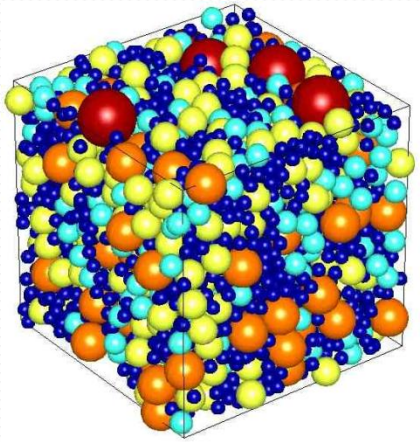
    Always refer to manufacturer's specific instructions



After the airflow has been set at the appliance NEVER adjust it to change system characteristics!

Issues affecting accuracy

- Density Correction
  - Density error of +/- 10%
  - Airflow accuracy of +/- 5%
- Proper measurement technique
- Accurate sensors



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Why density really matters

If the air density is low, more CFM is required to keep the mass flow rate the same!!!

If air density is not considered, many systems will have very low airflow.

The beauty of the fan

The volume of air will not be effected in a given system because a fan will move the same amount of air regardless of the air density. In other words, if a fan will move 3,000 cfm at 70°F it will also move 3,000 cfm at 250°F

Photo: GREENHECK FANS

If fans move a constant CFM independent of air density…..

They can measure airflow independent of air density too!!!

Many ways …

- **Indirect measurements**
  - **Windchill**
    - **Your hand, Lick your finger, Hotwire anemometer**
  - **Temperature rise with known heat input**
  - **Static Pressure**
    - **Pressure drop over known restriction**
  - **Pitot Static**
    - **Tubes, arrays, grids**
  - **Capture devices**
    - **Hoods, bags**
    - **Powered capture device FlowBlaster®**
- **Direct measurements**
  - **Rotating vane**

Measuring techniques In Duct Systems

- Temperature Rise Method
- Pitot Tube
- Thermal Anemometer (Hot Wire)
- Wilson Flow Grid (TrueFlow grid)
- Pressure drops across coils filters and heat exchangers
  - (Provided there is a CFM look up chart)
- Mini-Vane Anemometer

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Measuring techniques at terminals

- Flow Hood/Capture Hood
- Pitot Tube
  - Traverse and average
- Thermal Anemometer (Hot Wire)
  - Traverse and average
- Rotating vane
- FlowBlaster®

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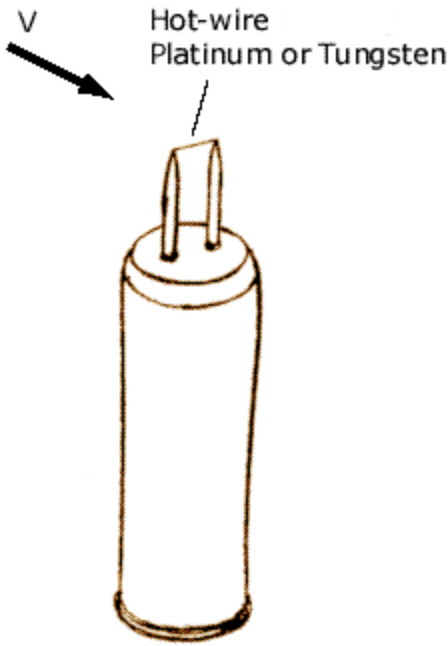
Hot Wire

- How it works
  - Windchill 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



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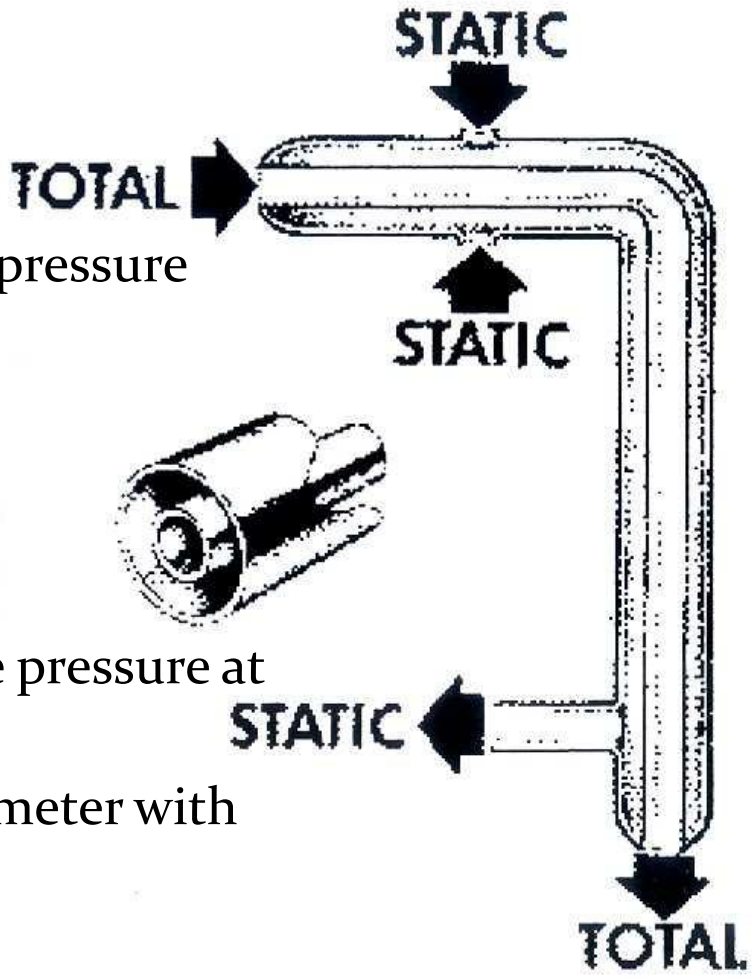
Pitot Tube

- How it works
  - Impact pressure of air is sensed on a pressure sensor
- Benefits
  - Easy to use, cost effective
- Limitations
  - Denser air has more mass, thus more pressure at a given velocity
  - Low velocity only with precise manometer with calculation
- Applications
  - In duct measurement



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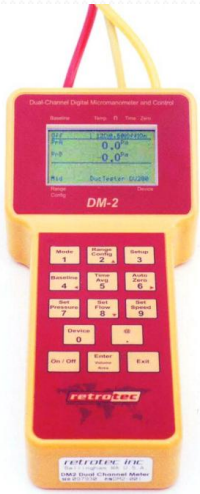
TrueFlow® Plate Pitot Array or Flow Grid

- How it works
  - Like a 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
  - Not exactly the same as “run conditions”
  - Needs digital manometer
- Applications
  - System airflow

Cost approx $800 + $750



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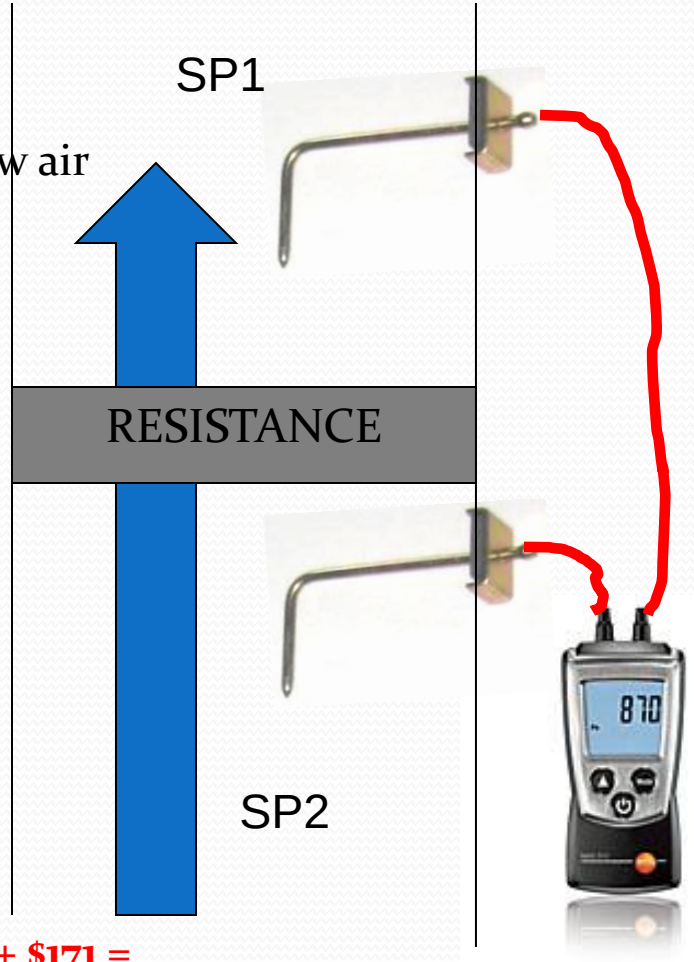
Static Pressure Drop

- How it works
  - The Static pressure “half” of a Pitot tube
  - Need to measurements of static pressure over a know air flow resistance
- 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
  - CAREFUL DRILLING INTO THINGS!
- Applications
  - In duct measurement
- COST
  - **Static Pressure Tips and Host + Manometer = $43 + $171 = $214**



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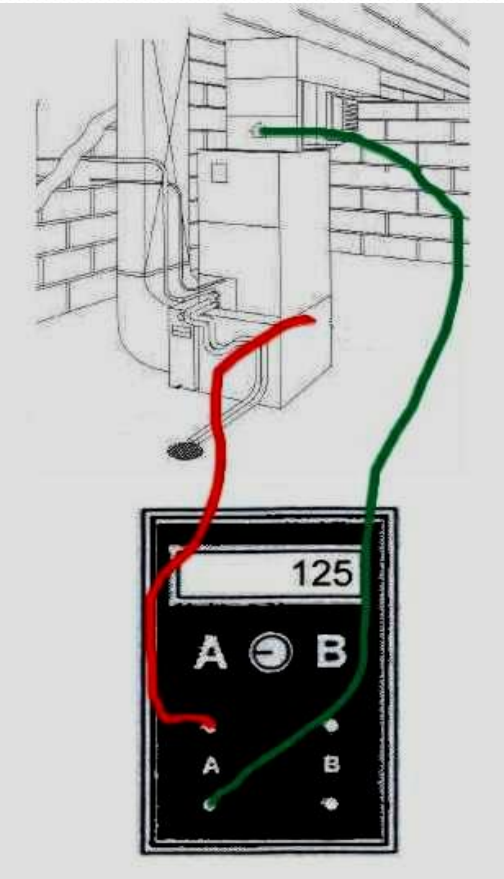
Measuring Total External Static Pressure

- External Static Pressure (ESP) is the resistance (supply and return) the fan must operate against
- The greater the pressure, the less the flow



Pocket Manometer

Differential pressure manometer for pressure measurements in the range 0 to 40" wc. Readings can be displayed in Pascal over the whole measurement range.

Set / measure, airflow, air velocity, static pressure, draft, room depressurization, fuel pressure, check pressure switches

Air velocity measurement with Pitot tube (Pitot tube extra)

Switchable units: hPa, mbar, Pa mmH2O, mmHg, inH2O, inHg, psi, m/s, fpm

Total External Static Pressure

- Airflow in CFM is measured by the manufacturer
- Pressure drop across the heat exchanger or evaporator coil is measured.
- If a pressure drop and a CFM are known, a new CFM can be calculated at any measured pressure drop.
- Can only be used as an estimating tool for airflow without manufacturer's literature.
- 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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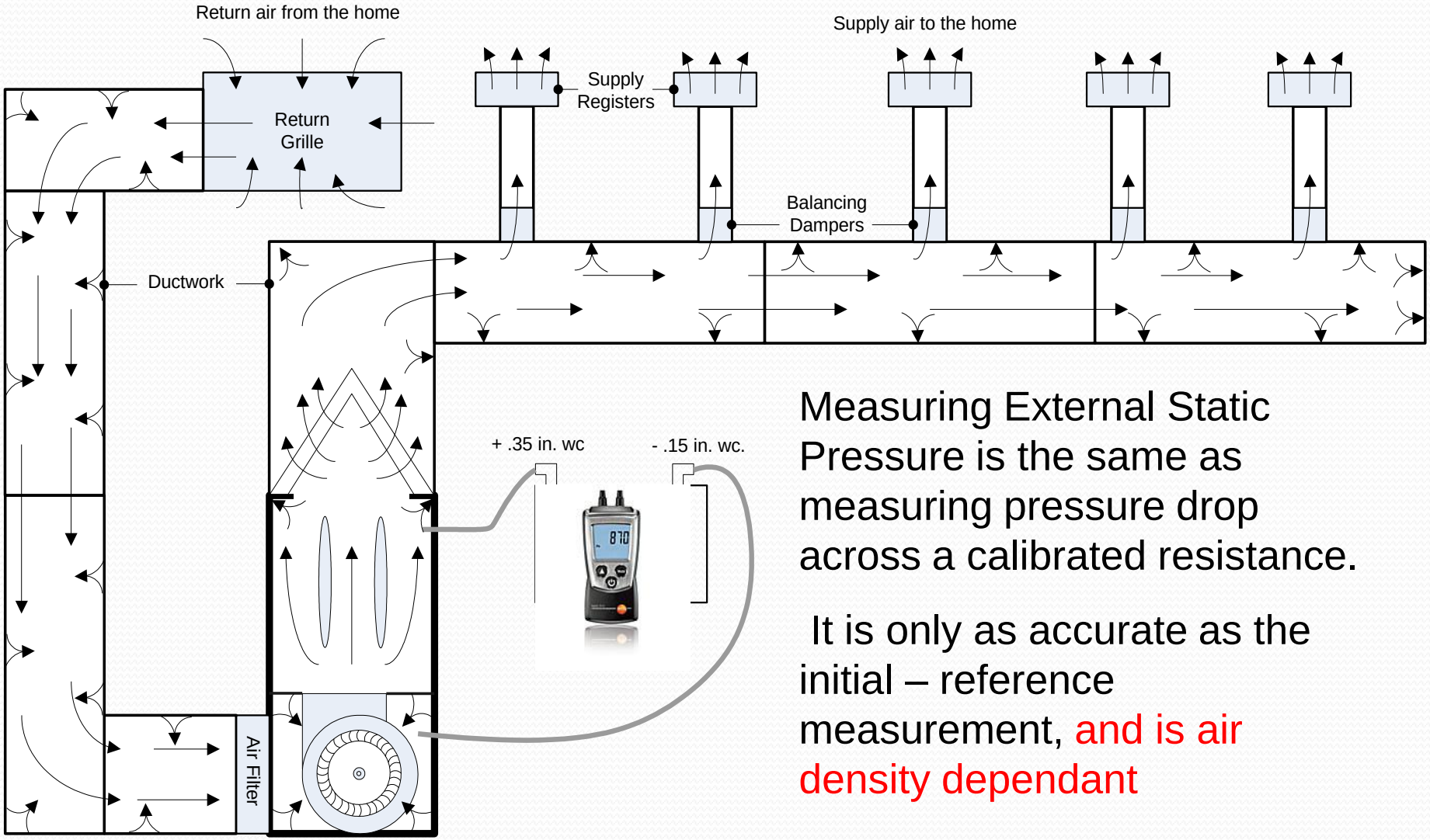
AIRFLOW PERFORMANCE DATA

Model Cabinet Size	Electric Heaters	Blower Motor		CFM WATTS RPM	External Static Pressure - In. W.C.								
		Speed	Volts*		.10	.20	.30	.40	.50	.60	.70	.80	.90
-21	None	Low	230		1009 [126] 559	1011 [144] 608	1010 [162] 656	1008 [180] 701	1004 [199] 747	1000 [219] 790	997 [239] 833	997 [260] 874	999 [282] 915
	4 (Max.)	Low	230		987 [127] 575	985 [148] 633	982 [168] 688	978 [189] 738	974 [210] 788	970 [232] 833	967 [255] 879	965 [278] 922	966 [303] 965
	None	Low	208		993 [117] 550	990 [133] 600	988 [150] 649	987 [169] 695	986 [189] 741	986 [209] 785	986 [231] 830	986 [251] 870	986 [272] 911
	4 (Max.)	Low	208		981 [122] 559	974 [140] 621	969 [161] 681	967 [183] 734	965 [205] 788	964 [229] 835	963 [252] 883	962 [274] 928	959 [295] 968
	None	High	230		1196 [193] 638	1199 [216] 681	1201 [240] 725	1203 [265] 766	1205 [290] 807	1206 [316] 846	1208 [341] 885	1209 [366] 923	1210 [390 961
	4 (Max.)	High	230		1185 [208] 665	1169 [222] 709	1166 [246] 755	1172 [276] 802	1181 [309] 850	1190 [343] 895	1192 [373] 940	1184 [396] 977	116 [40 10
	None	High	208		1171 [181] 626	1171 [201] 672	1174 [224] 717	1179 [249] 761	1184 [275] 805	1189 [301] 845	1193 [327] 886	1195 [351] 922	11 [3 9
	4 (Max.)	High	208		1153 [191] 647	1146 [210] 696	1149 [235] 745	1156 [265] 793	1164 [296] 842	1171 [327] 887	1173 [355] 932	1165 [377] 971	1 [
	None	Low	230		1423 [221] 573	1422 [245] 615	1419 [271] 657	1415 [298] 699	1410 [326] 740	1406 [355] 781	1401 [386] 820	1397 [417] 860	
	5 (Max.)	Low	230		1420 [242]	1416 [272]	1413 [306]	1411 [342]	1408 [381] 812	1404 [421] 860	1400 [460] 908	1395 [498] 950	

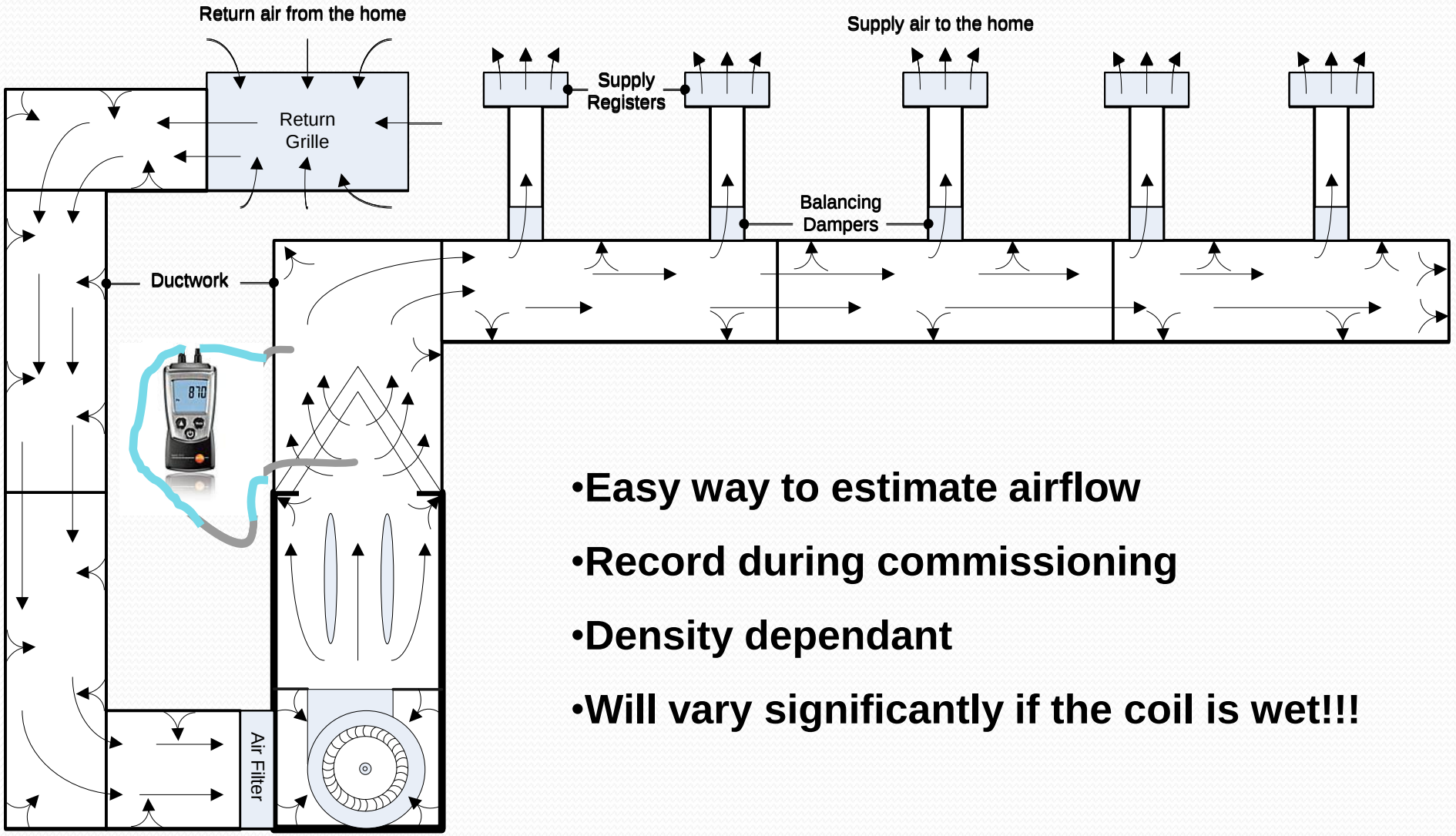
ESP – External Static Pressure



Measuring External Static Pressure is the same as measuring pressure drop across a calibrated resistance.

It is only as accurate as the initial – reference measurement, and is air density dependant

Pressure Drop Across the Evaporator Coil



- Easy way to estimate airflow
- Record during commissioning
- Density dependant
- Will vary significantly if the coil is wet!!!

Large static pressure drops across system components like

- Coils
- Filters
- Secondary heat exchangers

Indicate excess restrictions normally due to dirt!

Where to take measurements?

- **Gas furnace and split AC:**
  - Measure before blower to after furnace
- **Package unit (gas or electric):**
  - Measure from return plenum to supply plenum
- **Split Heat Pump:**
  - Measure before coil to after blower (whole indoor unit, including strips

Interpreting in the Field ESP Tests

- Most gas furnaces are designed to operate around 0.5 IWC (125 Pa (Pascals))
- Very hard to get exact air flow even if fan curve is known
- The good news is that the **test can tell you the extent of the problem and on which side (return or supply) the problem is**

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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
  - Turbulence
  - Angular orientation during test
    - Small error: 10% off angle, 1% error
  - Friction of propeller
  - Impact of air-rotation when too close to a fan output
- Large Vane Applications:
  - Supplies & returns
  - Especially flex duct systems
- Mini-Vane Applications:
  - In duct on hard duct systems

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MEASURING AIR VELOCITY FOR BALANCING

- Air balancing is accomplished by measuring the velocity of the air leaving each register
- Face velocity should be 400-600 FPM
  - Air velocities over 700 FPM are noisy
- If the duct system is designed properly, equal velocity balancing of the system will assure proper air delivery to the space.
- If a mini-vane is used to measure air quantity in the duct the K-factor can be calculated and CFM measured at the registers with the large vane.
- Cost about $460

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Proportional Balance the System

Starting with the register with the highest airflow work room by room to proportional balance the system

Face velocities should typically be 450 to 750 FPM

Return opening 500-600 FPM

Scoops, mini-hoods and funnels

- Not to be used at volume flows above about 75 CFM
- Due to back pressure

Where to Make IN Duct Measurements

Look for:

•Straight sections of duct 2-3 duct diameters away from turns and fittings.

Ideal location on a traditionally ducted system

Mini Vane

- Non-invasive measurement
- Excellent repeatability
- Forgiving to operator error
  - 10% change in yaw or pitch yields error of less than 1%
- **Cost About $630**

Measure Air Velocity and CFM

Mini Vane

- *Airflow in under 3 minutes*
- *Full duct traverse assures accuracy (timed or point)*
- *Large(small probe) is not affected by stray eddy currents*
- *Ultra low mass rotating vane*
- *Precision jewel bearings for low breakaway torque*
  - *the thrust of a fruit fly*
- *Excellent durability and chemical and kid resistance.*
- ***No air density correction required.***

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Capture Devices

- Plastic Bag & stop watch
  - Cheap! Accurate? Repeatable?
- Flow hoods
  - Pitot array
  - Hot Wire measurement
- Benefits
  - Fast to set up and use
- Limitations
  - Accuracy is mass dependent

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Flow Hoods

Pitot static array

Fast, one person snapshot operation

Multi-functional

- Detachable digital manometer: Pitot, airflow, temperature, velocity matrix, or relative humidity probes.

Back pressure compensated

Multiple hood sizes/models available

- 500 & 2500 CFM

$1600 (low flow) $3000 (wide range)

FLOWBLASTER®

Auto compensates for Back pressure

A powered flow hood!

Grill skirt

Digital Manometer

Fan controller

Measurement Array

Compensating Fan (DuctBlaster®)

(Battery pack)

Attaches to a DuctBlaster®

COST = ~ $1100 + $1875 = $2975

Powered Flow Hood

$150 accessory for on ANY brand of Duct Leakage Tester

Up to 650 CFM supply or return flows

(Zip poles not included - ~$30)

Still usable as a Pressure pan

Duct Leakage tester needed

(cost $1895)

Pressure Pans for use as Powered Flow Hood
#PP105

retrotec
airflow systems since 1980 www.retrotec.com

Thank you!

More info: 888-224-3437
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The A/C System Performance Series

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