In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1 hours** of credit toward **Building Officials and Residential Contractors** continuing education requirements."

For additional continuing education approvals, please see your credit tracking card.

Quality Install Testing Procedures for Forced Air Systems

Duluth Energy Design 2014

Quality Installation: Outcomes

- Installation practices have links to:

✓Comfort

✓Humidity Levels (dehumidification)

✓Efficiency / Reduced Consumption

✓Indoor Air Quality

✓Increased Equipment Reliability

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Why Test?

- SEER reduced when airflow not correct
- High Static = more power draw on *ECMs
- ECMs start to draw more power at .8” wc
- Must know system performance to consider ECM upgrade
- Furnace temperature rise

*ECM = Electronic Commutating Motor

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Why Test?

- Coils, filters, registers and
- Ductwork (flexible ducting, elbows, transitions) all add to Total External Static Pressure (TESP)
- High static pressure makes more noise
- Flow directly effects comfort
- No test is just a guess

AFFORDABLE ENERGY SOLUTIONS.COM

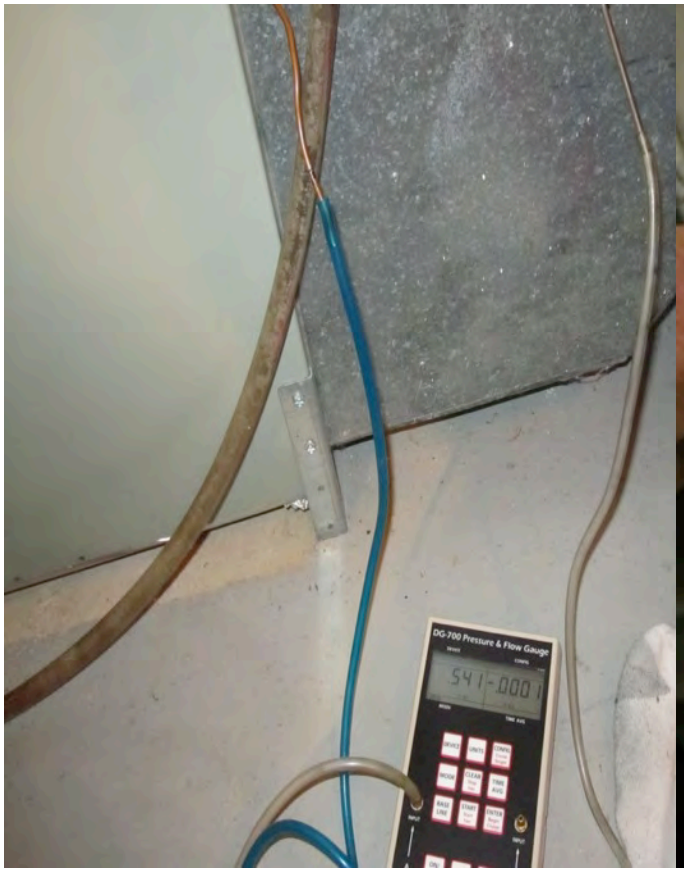
TOTAL HOME PERFORMANCE

Causes: Dirty Air Filters

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Causes: Clean Air Filters



.541” w.c. Drop on New Filter!

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Causes: Dirty Blowers

AFFORDABLE ENERGY SOLUTIONS.COM

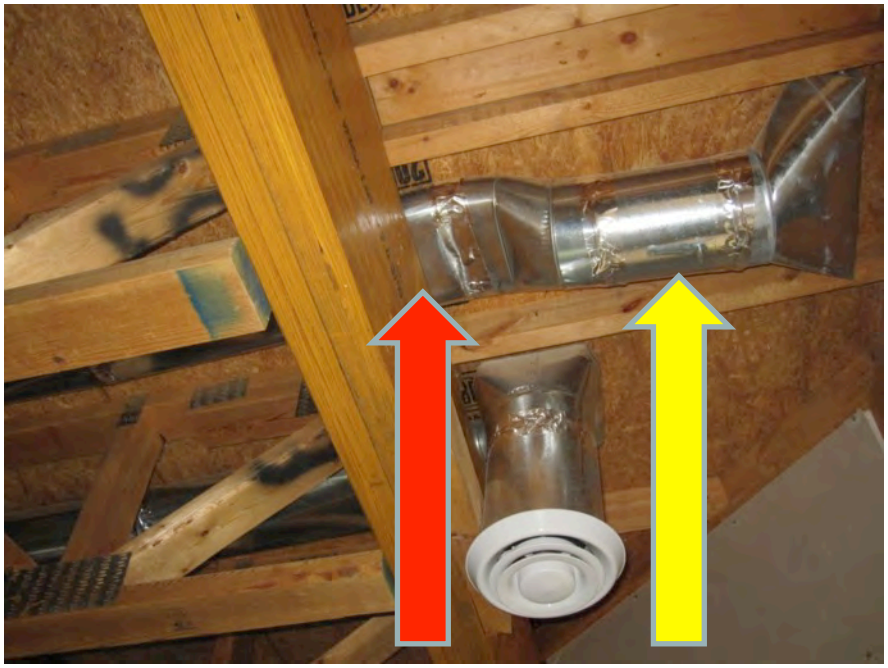
TOTAL HOME PERFORMANCE

Causes: Dirty Evaporator Coils

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Causes: Poor Duct Design

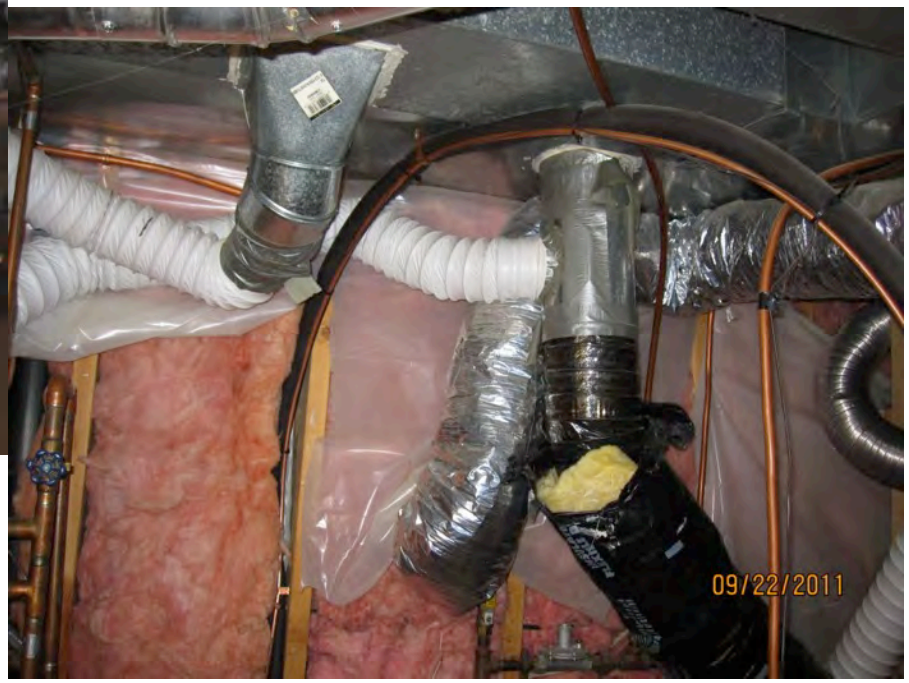


Red arrow to yellow arrow equals XX linear feet (equivalent)

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Causes: Poor Duct Design



AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Causes: Poor Duct Design

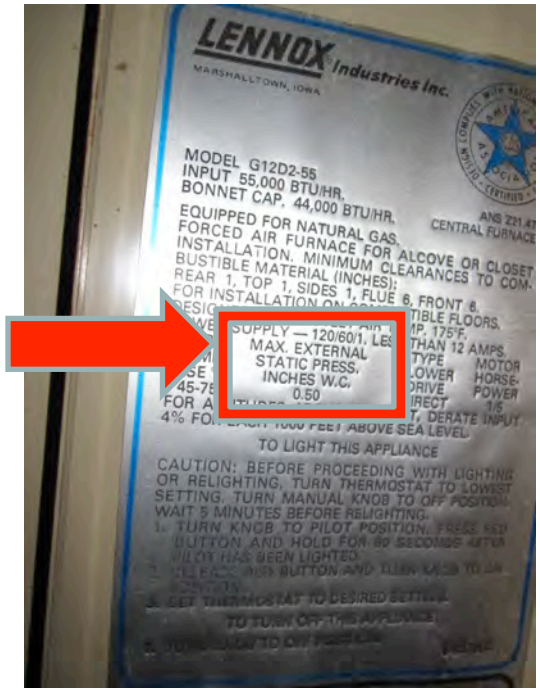
AFFORDABLE ENERGY SOLUTIONS.COM

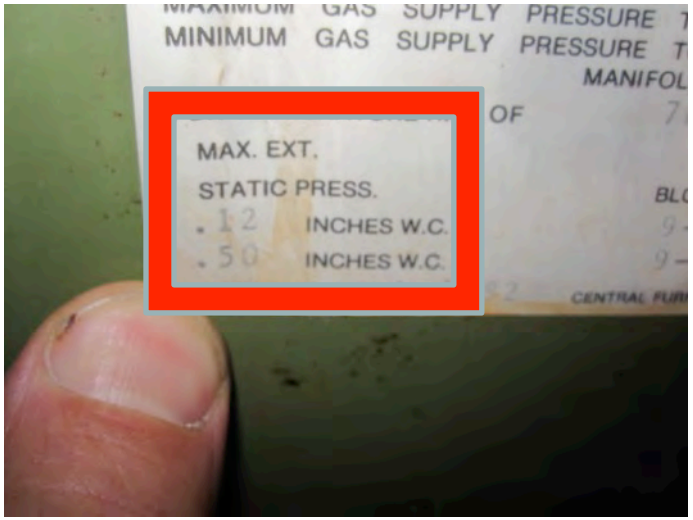
TOTAL HOME PERFORMANCE

Two Main Tests

- Total External Static Pressure
  - Good for diagnosing system
- Air Flow CFM
  - Verify actual air flow

What is Rated TESP?

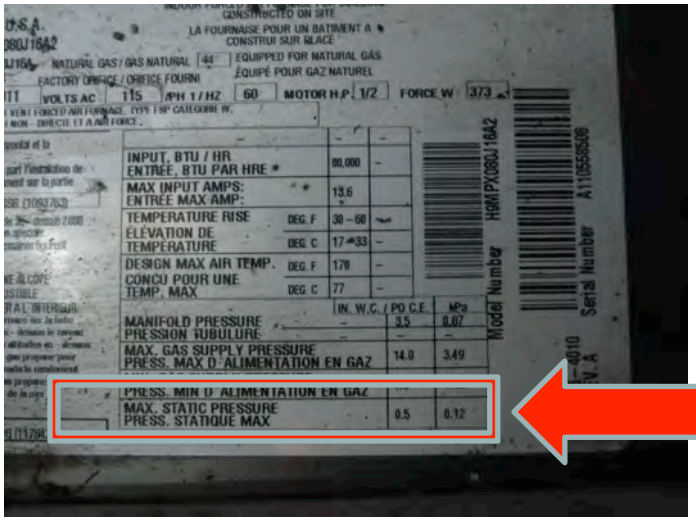


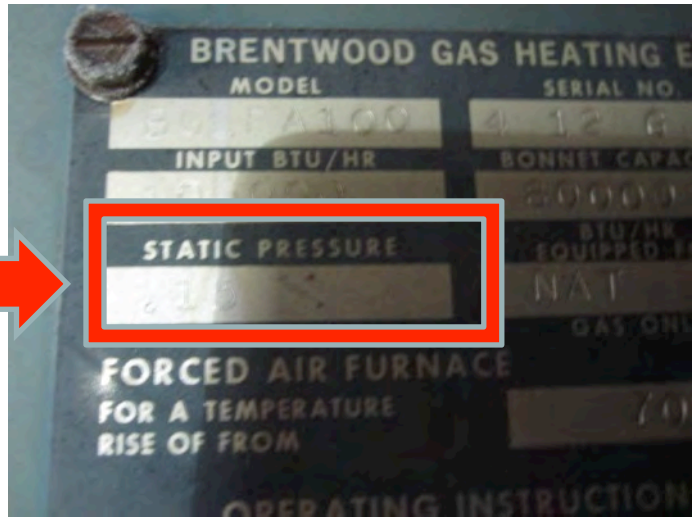


AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

What is Rated TESP?

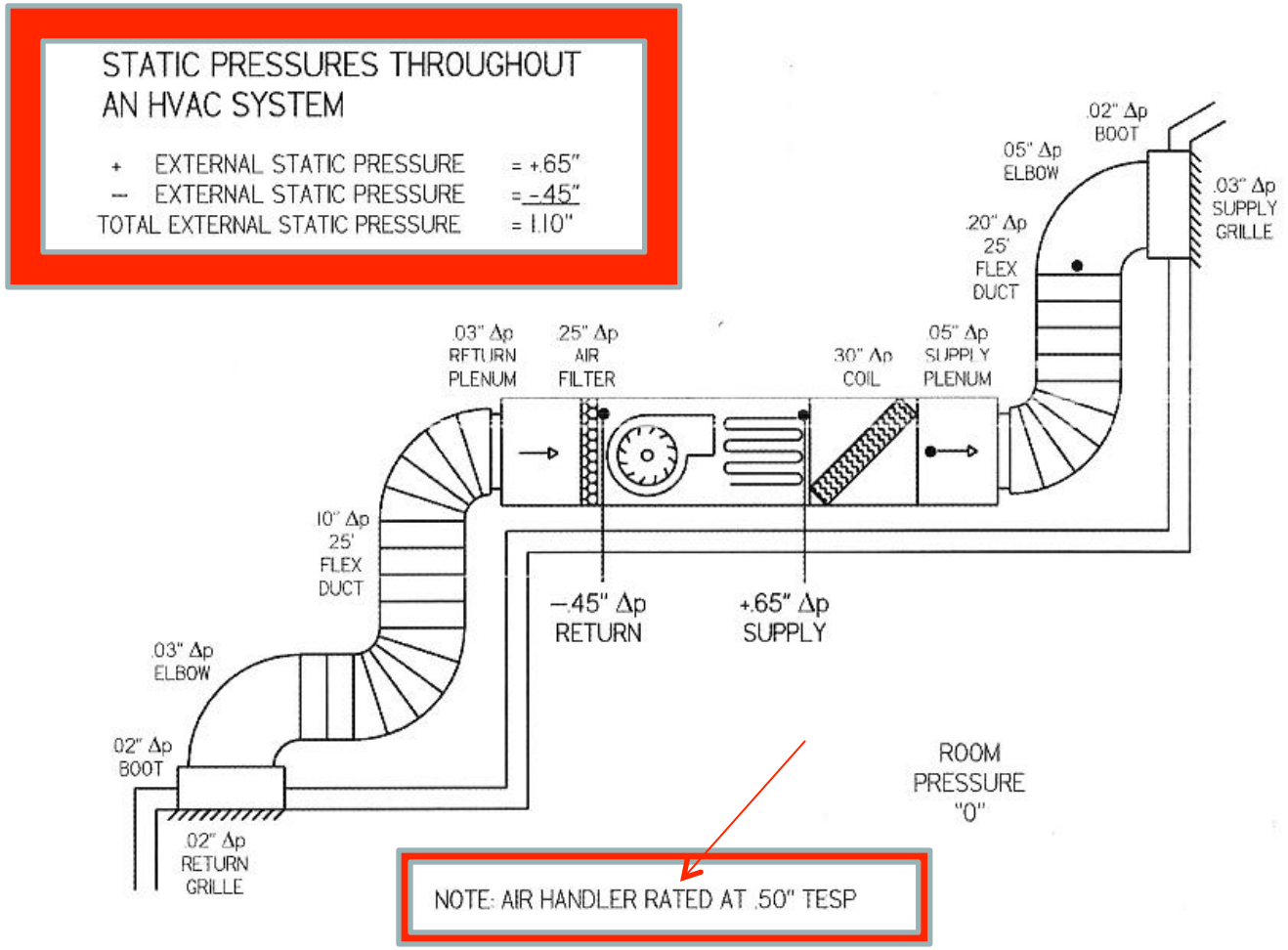




AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

What is TESP?

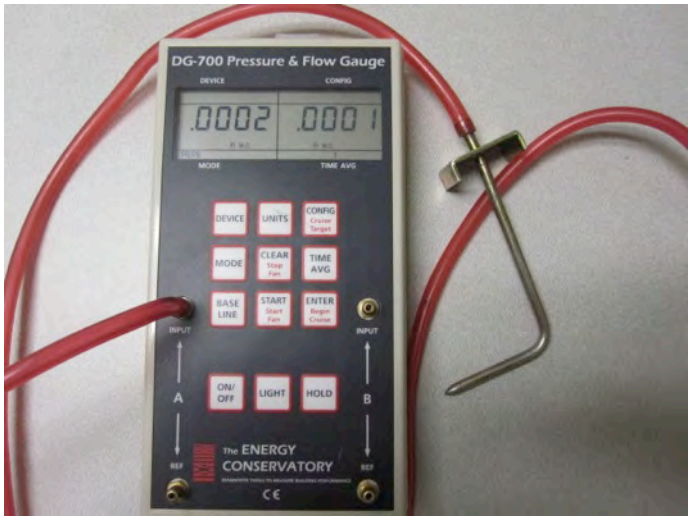


All components add resistance. Too much can restrict flow.

Diagram courtesy of
National Comfort Institute

Testing TESP

Static Pressure Tube and Manometer

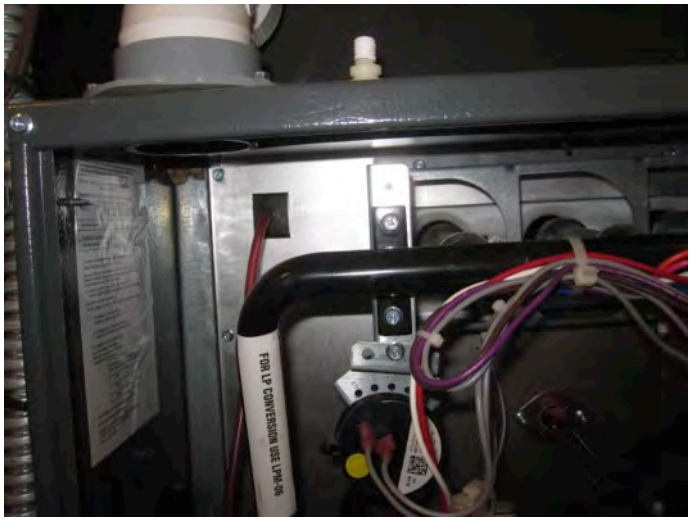


AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Location of test holes

Before AC coil, top of heat exchanger



AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Location of test holes

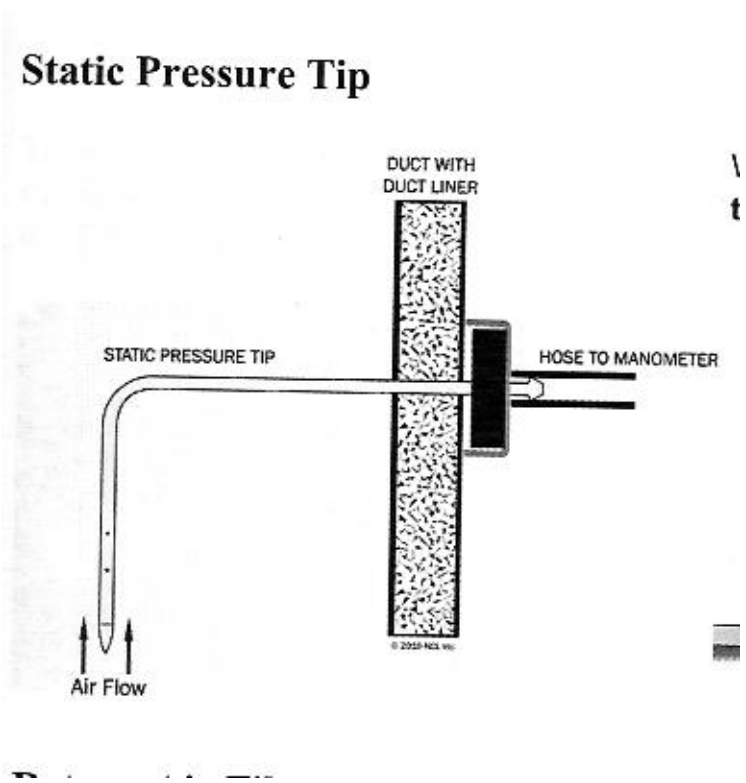
After filter, blower compartment

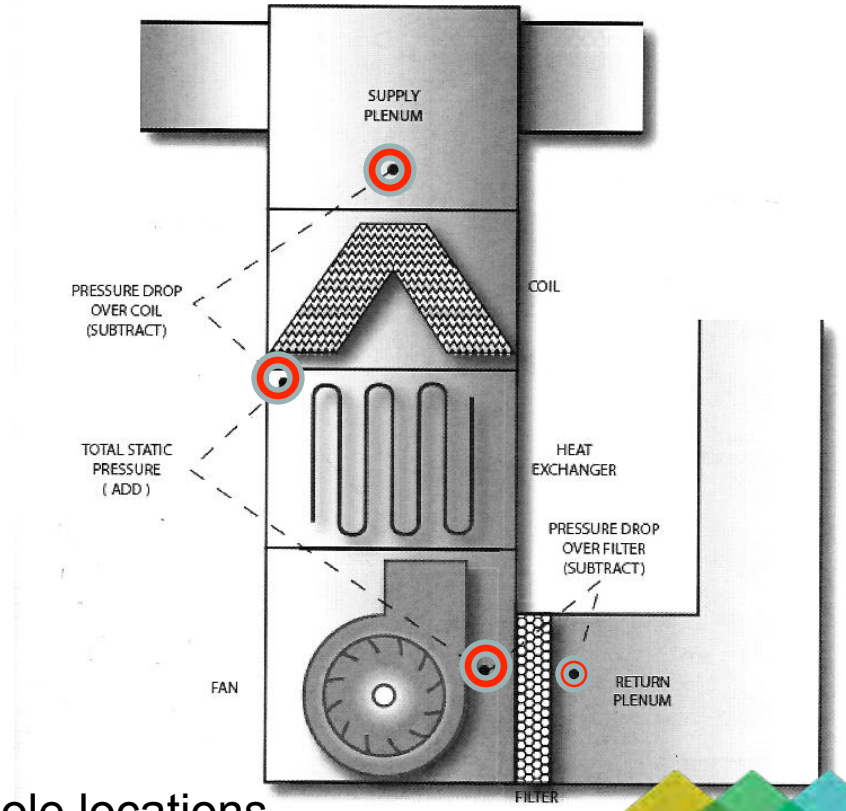
AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Testing TESP

Pitot Tube and Manometer





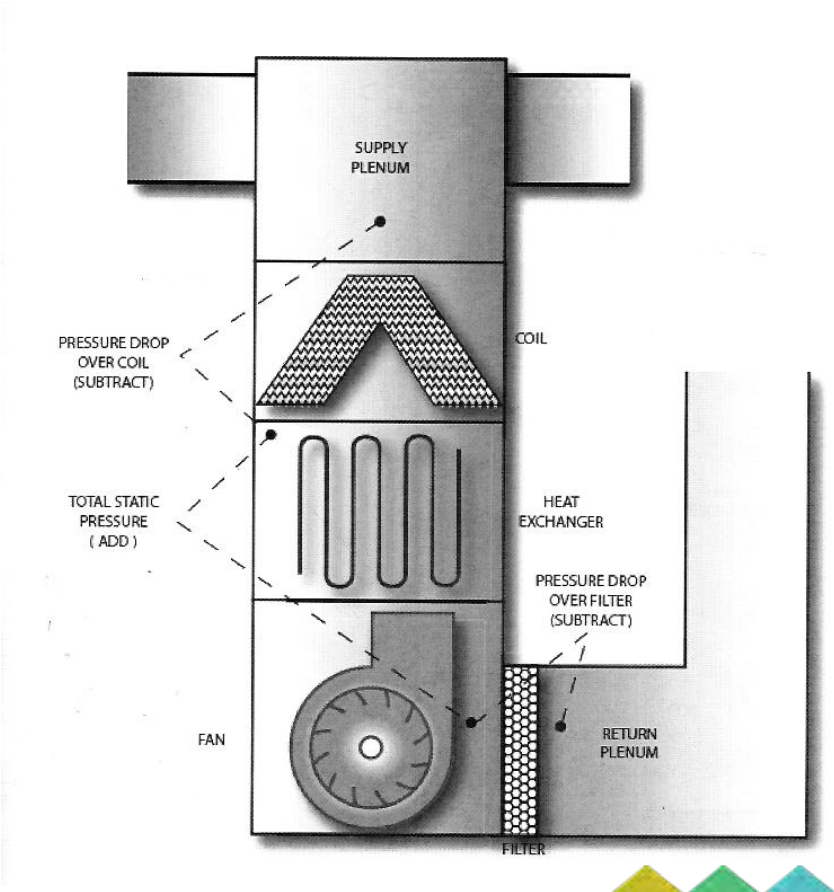
Test hole locations

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Testing TESP

- TESP = top of heat exchanger to bottom of blower (after filter)
- Pressure Drop = change over a distance (AC coil, filter, etc.
- Check rating (includes coil? Filter?)

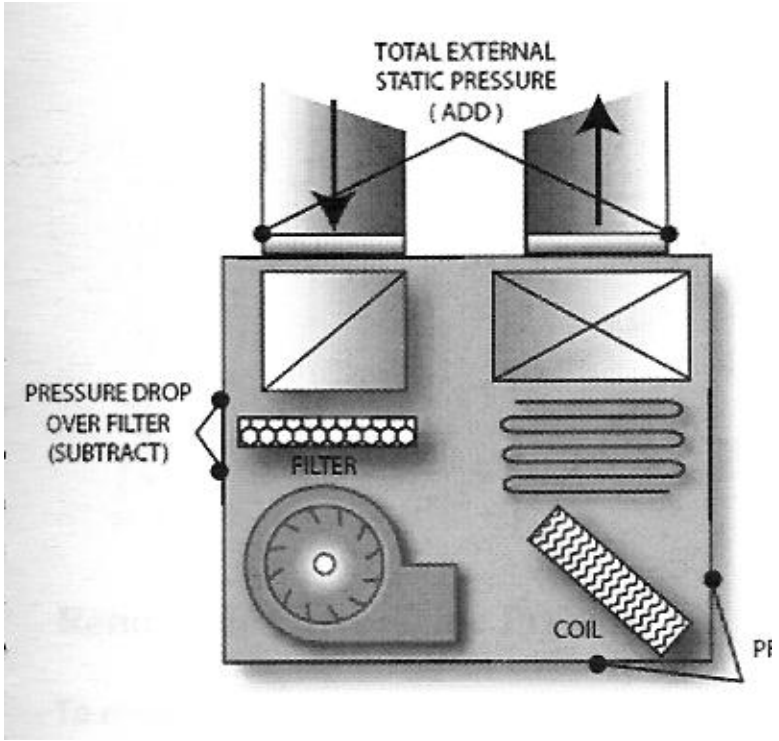


AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Testing TESP Rooftop units

- TESP = Supply and return
- Pressure Drop = change over a distance (AC coil, filter, etc.
- Rated TESP, *coil included* in *<u>package units.</u>*



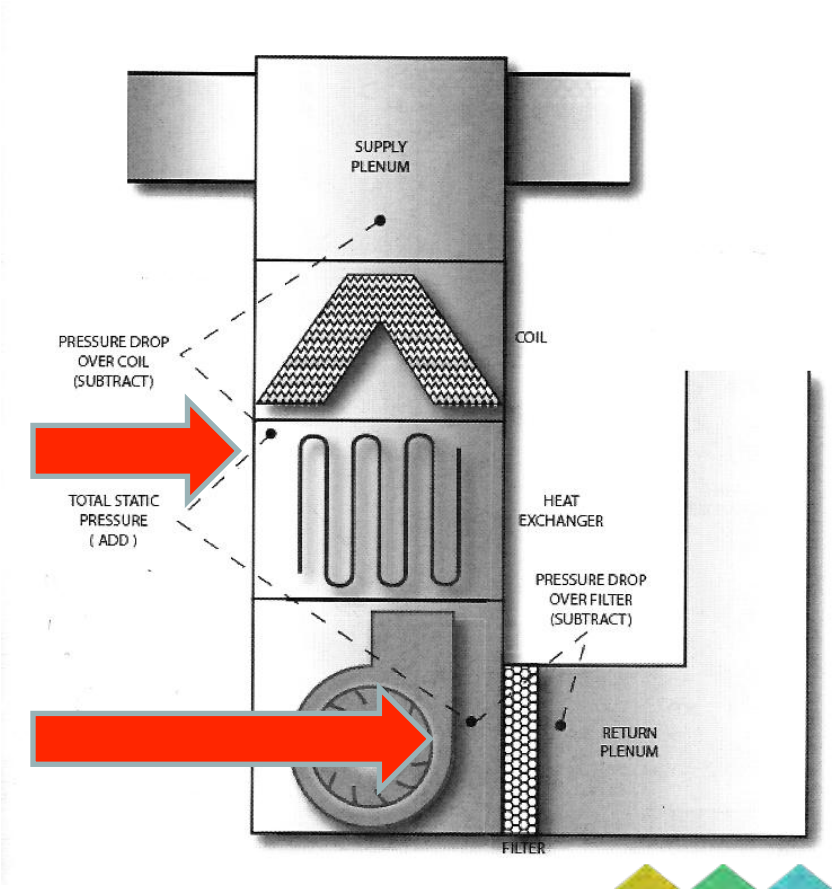
AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Testing TESP

- TESP = Add two numbers together

Add these two readings together

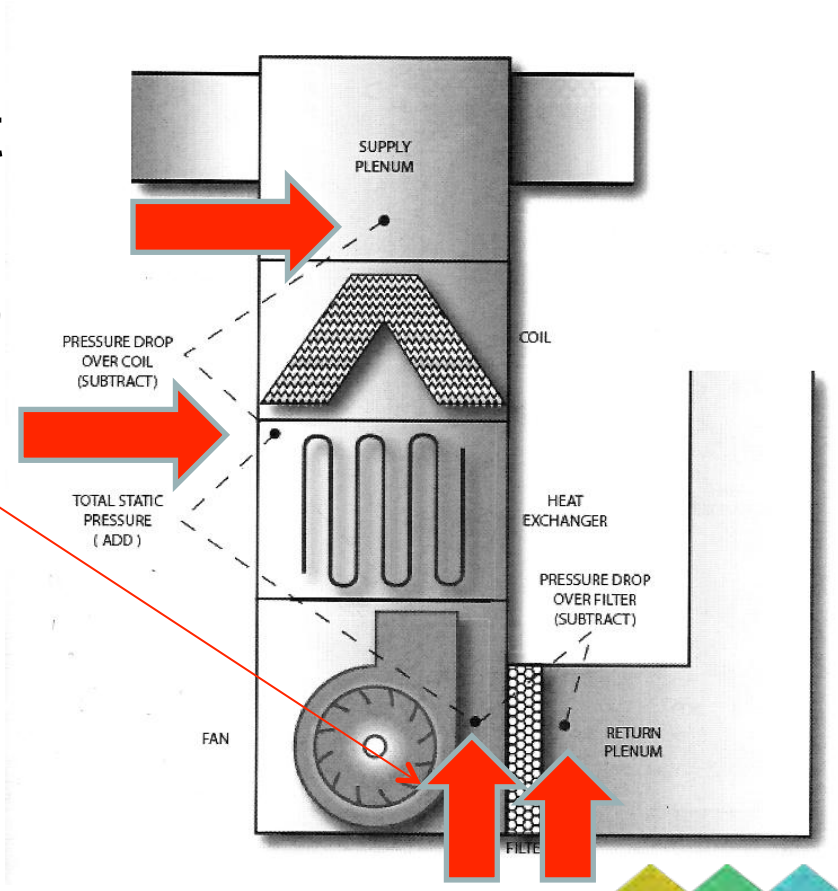


AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Testing TESP

Subtract These Two Readings



- Pressure Drop = subtract numbers (ignore ± sign)

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

TESP Results

- Think Golf and Blood Pressure
- Lower is better
- High numbers indicate a problem
- And a need for….more work on your game or on the forced air system

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Testing Air Flow (CFM)

- Static Pressure affects air flow
- Air flow determines efficiency
- Need air flow to set refrigerant charge
- Need 400~ cfm per ton of cooling
- Need to know # of tons

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Measuring Air Flow

True Flow Meter®

Energy Conservatory.com

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

True Flow Meter®

- Energy Conservatory, MN Manufacturer
- Advantages: very accurate, fairly easy to set up
- Disadvantages: Additional equipment cost, needs filter slot that fits plates, results can be effected by poor duct design

True Flow Meter®

- Install in filter slot
- Generally fits all sizes and configurations possible
- Flow plate automatically averages flow rates
- Need manometer (pressure gauge) to make readings

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Testing Air Flow

Hot Wire or Mini-Vane Anenometer

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Testing Air Flow

Hotwire or Mini-Vane Anenometer

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Hot Wire or Mini Vane

- Advantages: Fast and east to use, accurate (when compared to True Flow meter)
- Disadvantages: Additional Equipment cost, need linear section of duct

Hot Wire or Mini Vane

- Drill holes in duct
- Take readings
- Meter automatically calculates averages of flow rates
- Test time: about 5+ minutes

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Fan Curve Tables

- Advantages: Low cost, Quick and easy (if table available), good for troubleshooting
- Disadvantages: Fan tables sometimes not available (can use generic), duct configurations may cause turbulence

Fan Curve method

- Take readings
- Know fan speed setting, rated TESP
- Match readings off fan table to find CFM
- Read the fine print

Fan Curve Table

BLOWER PERFORMANCE DATA

GMH95

BLOWER PERFORMANCE
(CFM & Temperature Rise vs. External Static Pressure)

Model / Heating Speed As Shipped	Motor Speed	Tons AC at 0.5" ESP	EXTERNAL STATIC PRESSURE (Inches Water Column)												
			0.1		0.2		0.3		0.4		0.5		0.6	0.7	0.8
			CFM	RISE	CFM	RISE	CFM	RISE	CFM	RISE	CFM	RISE	CFM	CFM	CFM
GMH950453BX* (MED-HI)	HIGH	3.0	1352	29	1318	30	1260	31	1202	33	1128	35	1044	955	853
	MED	2.5	1214	32	1172	34	1123	35	1064	37	1012	39	938	859	741
	MED-LO	2.0	997	40	994	40	960	41	923	43	884	45	817	741	611
	LOW	1.5	757	52	753	52	734	54	704	56	674	59	620	524	438
GMH950703BX* (MED-HI)	HIGH	3.0	1449	41	1409	42	1326	45	1273	47	1201	49	1194	1106	1018
	MED	2.5	1192	50	1172	51	1141	52	1094	54	1046	57	973	904	793
	MED-LO	2.0	981	61	962	62	943	63	917	65	888	67	830	784	665
	LOW	1.5	750	79	730	81	714	83	692	86	657	90	620	570	502
GMH950704CX* (MED-HI)	HIGH	4.0	2069	29	1965	30	1871	32	1756	34	1661	36	1548	1416	1275
	MED	3.5	1752	34	1724	34	1667	36	1603	37	1488	40	1402	1280	1062
	MED-LO	3.0	1437	41	1437	41	1417	42	1369	43	1320	45	1256	1140	984
	LOW	2.5	1184	50	1177	50	1161	51	1132	52	1095	54	1047	928	837
GMH950904CX* (MED-HI)	HIGH	4.0	1970	40	1874	342	1757	45	1667	48	1566	51	1431	1334	1182
	MED	3.5	1713	46	1650	48	1572	50	1510	52	1418	56	1313	1211	1079
	MED-LO	3.0	1439	55	1412	56	1370	58	1327	60	1260	63	1189	1079	956
	LOW	2.5	1183	67	1155	69	1122	74	1108	72	1062	75	1011	931	816
GMH950905CX* (MED-HI)	HIGH	5.0	2058	39	1997	40	1928	42	1852	43	1777	45	1682	1600	1487
	MED	4.0	1718	47	1685	48	1632	49	1586	51	1520	53	1458	1369	1281
	MED-LO	3.5	1502	54	1464	55	1429	56	1380	58	1319	61	1272	1209	1137
	LOW	3.0	1305	62	1277	63	1253	64	1212	66	1175	69	1127	1081	1010
GMH950905DX* (MED-HI)	HIGH	5.0	2147	37	2114	37	2057	39	2030	39	1978	40	1889	1784	1713
	MED	4.0	1675	47	1686	47	1640	48	1623	49	1557	51	1501	1455	1360
	MED-LO	3.5	1489	53	1470	54	1436	55	1409	56	1361	58	1318	1248	1130
	LOW	3.0	1307	61	1265	63	1234	64	1203	66	1168	68	1098	1093	991
GMH951155DX* (MED-HI)	HIGH	5.0	2134	46	2103	47	2029	48	1941	51	1906	51	1818	1753	1625
	MED	4.0	1678	58	1643	60	1643	60	1577	62	1527	64	1489	1423	1339
	MED-LO	3.5	1453	68	1440	68	1426	69	1363	72	1349	73	1314	1253	1205
	LOW	3.0	1259	78	1239	79	1220	80	1181	83	1159	85	1118	1082	1016

The fine Print

1. CFM in chart is without filters(s). Filters do not ship with this furnace, but must be provided by the installer. If the furnace requires two return filters, this chart assumes both filters are installed.
2. All furnaces ship as high speed cooling and medium-speed heating. Installer must adjust blower cooling & heating speed as needed.
3. For most jobs, about 400 CFM per ton when cooling is desirable.
4. INSTALLATION IS TO BE ADJUSTED TO OBTAIN TEMPERATURE RISE WITHIN THE RANGE SPECIFIED ON THE RATING PLATE.
5. The chart is for information only. For satisfactory operation, external static pressure must not exceed value shown on rating plate. The shaded area indicates ranges in excess of maximum external static pressure allowed when heating. The data for 0.6" w.c. to 0.8" w.c. is shown for air conditioning purposes only.
6. The above chart is for U.S. furnaces installed at 0-2000 feet. At higher altitudes, a properly de-rated unit will have approximately the same temperature rise at a particular CFM, while the ESP at that CFM will be lower.

The actual Fine Print

1. CFM in chart is *without* filter(s). Filters do not ship with this furnace but must be provided by the installer. If the furnace requires two return filters, this chart assumes both filters are installed.

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

The actual Fine Print

5. The chart is for information only. For satisfactory operation, external static pressure must not exceed value shown on rating plate.

i.e. have to actually test TESP to know if it exceeds rated value

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Possible Solutions

- Less restrictive filters
- Regular filter changes, maintenance
- Curved ductwork, turning vanes
- Registers with more open free air space

Possible Solutions

- Add more return air
- Add more supply air
- Add better filtration
- Clean blower wheel
- Clean evaporator coil

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Possible Solutions

- Smooth ductwork, not flex duct
- Proper sizing / design of ductwork
- Sealing ductwork

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

How Much Air Flow is Needed?

Depends on furnace type

- Rules of thumb per 10,000 BTU:
  - Atmospheric draft: 100 cfm
  - Induced draft: 130 cfm
  - Condensing: 150 cfm

Example: 80,000 BTU induced draft furnace

Needs (80/10) x 130 = 1040 cfm

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

How Much Air Flow is Needed?

For air conditioning

- Rules of thumb 400 per ton of cooling
- Can use 350 – 450 cfm
- Lower for better de-humidification

Example: 2 ton AC unit

Needs 2 x 400 = 800 cfm

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Practical Applications

How Much Airflow Is Required?

CFM = Btu(output)/1.08 X ΔT

80K Furnace 92% Temp Rise 35-65

73,600 / 1.08 X 55 = 1247 CFM!

2 Ton AC = 800 CFM

1.08 = 60 min (hours to min) X .75 (average density) X .24 (specific heat)

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Practical Applications

Replacing Old 70% 100K with
New 95% 80K Furnace

What will be the effect
on static pressure?

$$SP2 = SP1 \times (CFM2/CFM1)^2$$

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Practical Applications

$SP2 = SP1 \times (CFM2/CFM1)^2$

Original Furnace has .6 TESP and 1000 CFM

New Furnace is 76,000 output/1.08 X 55 (59) = 1288 CFM

$SP2 = .6 \times (1200/1000)^2$

$SP2 = .6 \times 1.44 = .86$ TESP

SP2 = .86! 30% INCREASE!

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Practical Applications

What size filter do I Need?

CFM/Face Velocity = Area in SQ FT

Face Velocity around 300 FPM, 400 MAX

1200/300 = 4 Sq FT of Surface Area

20x25 inch filter has 3.47 Sq Ft

16x20 inch filter has 2.22 Sq Ft

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Practical Applications

What is my actual furnace Btu output?

Btu = CFM X 1.08 X Temperature Rise

Btu = 600 X 1.08 X 55 = 59,400

Compare to Name Plate Rating

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Potential Problems Found

Restrictive filter (up to 50% drop in flow)

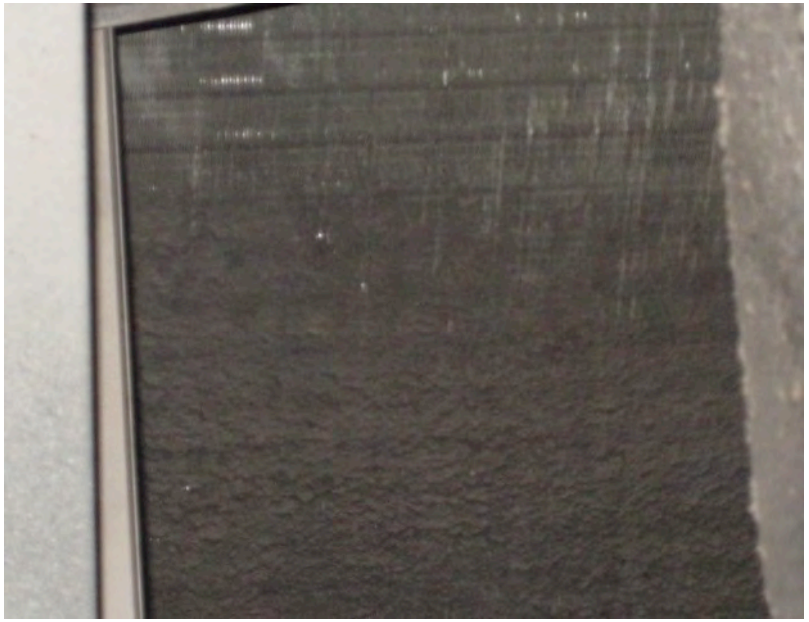
Restrictive designer registers

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Potential Problems Found

Dirty AC Coils



Owner did not know this coil existed

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Potential Problems Found

Undersized Supply ducts

Undersized Ductwork

Plenum

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Challenges

- Additional testing often means more cost
- Alterations to ductwork can add cost to proposal
- “Low Bid” vs. most responsible bid
- Customer education
- Contractor education

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Benefits

- Energy Savings (that is expected and predicted)
- Increased Comfort
- Better customer service
- Longer Equipment Life
- Utility Rebates for Energy Savings

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

“My office doesn’t get any heat….”

AFFORDABLE ENERGY SOLUTIONS.COM

TOTAL HOME PERFORMANCE

Thank You

Bruce Stahlberg, CEM
Affordable Energy Solutions, Inc.
Minneapolis, MN

Steve Hokanson
Total Home Performance LLC
Jordan, MN