Check, Test & Start-up

Instructor: Josh Goodman
Josh.goodman@carrierenterprise.com

Carrier

CE

bryant
Heating & Cooling Systems

AGENDA

- Tools/Startup
- Airflow calculation
  - Elec. Heat method
  - Clocking the gas meter
  - Static pressure
- Basic Refrigeration
- Total System Capacity

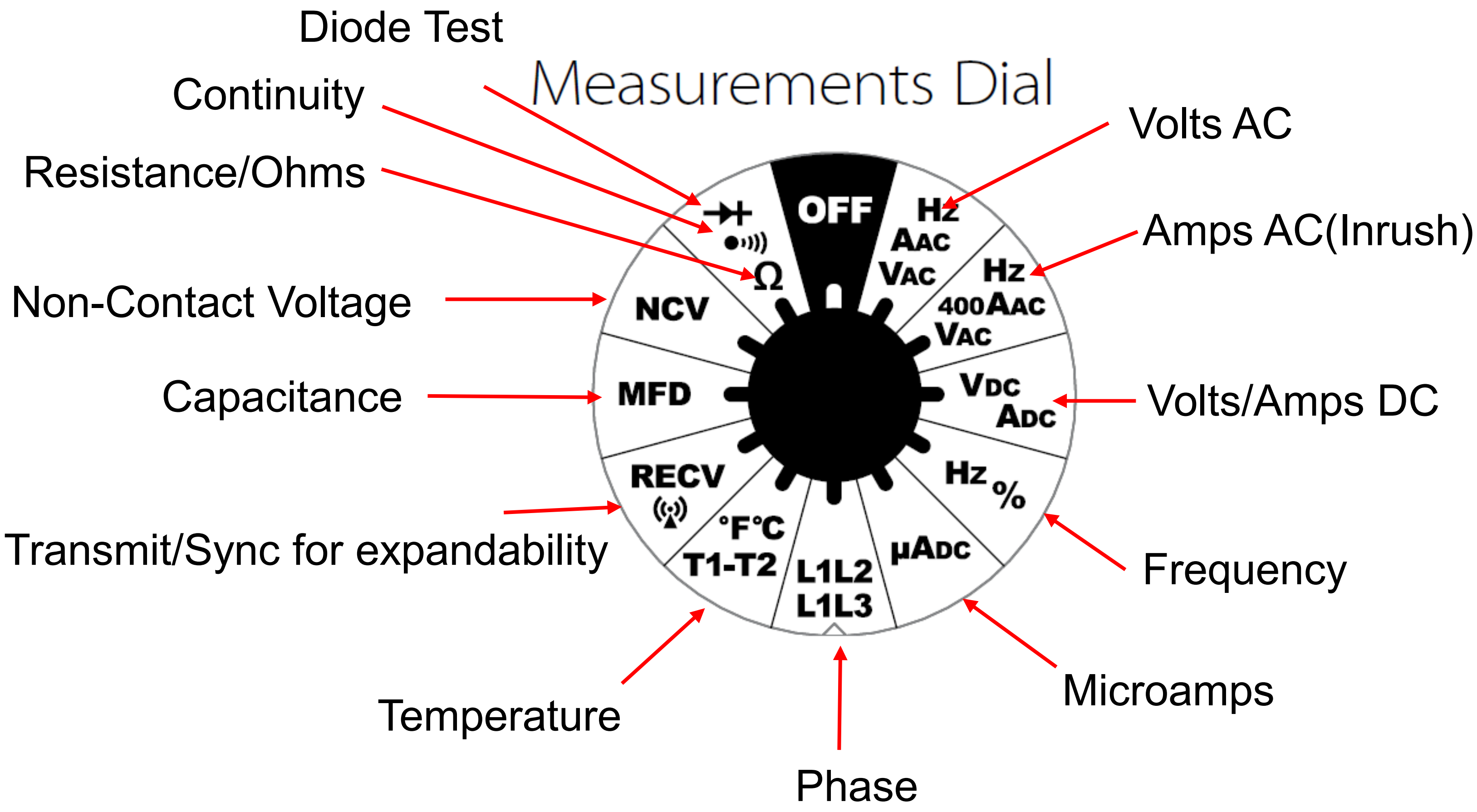
TOOLS

- Tool bag
- Gloves
- Safety glasses
- Nut drivers (¼, 5/16, 3/8)
- Pocket Thermometers
- Screw drivers(Philips and regular)
- 2-10” adjustable wrenches
- Open ended wrench (3/8, 1/2, 5/8)
- Electrician/Lineman's Pliers
- Channel locks
- Side cutters
- Wire stripper
- Box cutter
- Allen wrenches (folding)
- Refrigeration wrench and attachment
- Refrigeration Cap Key’s
- Brush
- Spray bottle
- Water hose and nozzle
- Torpedo level
- PVC cutters
- Tube cutters
- Flaring kit
- Tube benders
- Electronic Leak detector
- Psychrometer
- Torch
- Vacuum Pump
- Refrigerant Gauges
- And many others

VOLT/AMP METERS

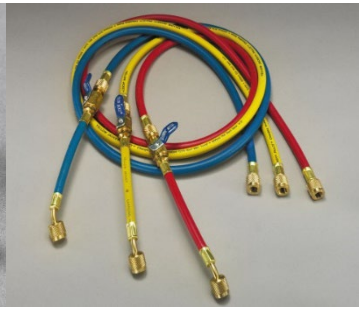
Volts AC/DC
Inrush current
Temperature F/C
Capacitance
Duty cycle %
400 amps AC
Microamps DC
Frequency via leads and clamp
50 Mega Ohm with 0.1 resolution
Continuity
Diode test
Hi-voltage Warning

VOLT/AMP METERS



REFRIGERANT GAUGES AND HOSES

- Analogy vs Digital



NITROGEN

Always use nitrogen when brazing. Just 1-2 lbs moving thru the tubes while brazing
Pressure test systems to 400 psig
Pressure test Ductless systems to 500 psig

NOT USING NITROGEN

TORCHES


BERNZOMATIC
MAP/PRO
BERNZOMATIC


TurboTorch
EXTREME
AIR/ACETYLENE KIT
ENSEMBLE AIR/ACETYLÈNE
CONJUNTO DE AIRE/ACETILENO
X-5MC


TRADE PRO
Oxyacetylene Outfit
TRADE PRO

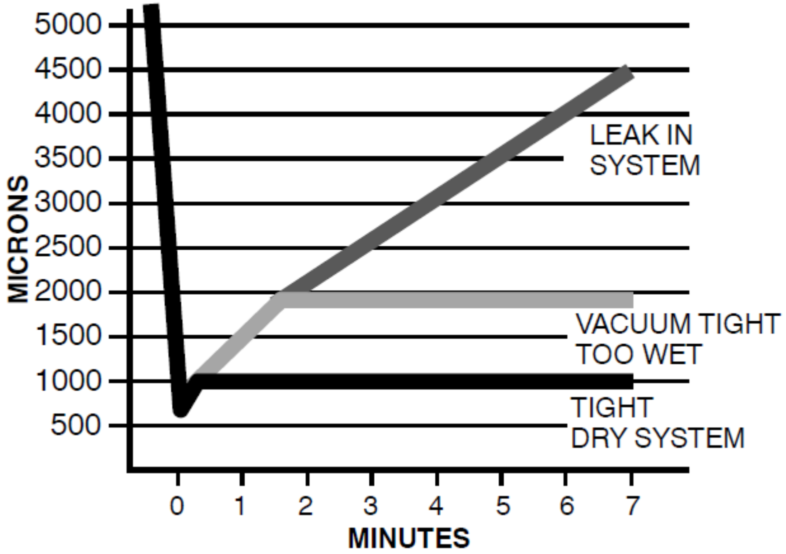
VACUUM PUMPS/RECOVERY

Visit Yellowjacket.com or the manufacture of your vacuum pumps website for videos and tips

VACUUM

Deep Vacuum Method

The deep vacuum method requires a vacuum pump capable of pulling a vacuum of 500 microns and a vacuum gage capable of accurately measuring this vacuum depth. The deep vacuum method is the most positive way of assuring a system is free of air and liquid water. A tight dry system will hold a vacuum of 1000 microns after approximately 7 minutes. (See Fig. 8.)



A95424

Fig. 8 – Deep Vacuum Graph

AIRFLOW MEASUREMENT

An accurate airflow measurement must be performed before the system can be properly charged with refrigerant or before any attempt is made to measure performance.

400 CFM/Ton Cooling +/- 50 cfm

MEASUREMENT METHODS

- Temperature Rise
  - Air Handler electric resistance heat
  - Clocking a gas meter
    Natural gas furnaces
- Total Static Pressure

THE PERFECT SERVICE VISIT

- Upon arrival meet & greet the homeowner
  - Ask discover questions
  - Why am I here? Any unusual sounds or operation?
- Place the thermostat in the Emergency heat position
- Go to the indoor unit, operate the system for 10 mins.
- Measure the supply voltage, Aux heat amp draw, and measure the temp split of the Aux heat only. Inspect the coil, filter, drain pans and see what type of metering device the indoor unit has.

AIRFLOW MEASUREMENT

Electric heat air flow formula

Formula:

$$\text{CFM} = \frac{\text{Voltage x Amperage x 3.414}}{\text{1.08 x Temperature Rise } (\triangle T)}$$

This is the easy way to do it on your calculator

You do not have to worry about all those extra numbers after the decimal point like when using the above equation.

Volts x Amps x 3.414 / 1.08 / Delta T(temp rise) = CFM

Write it down, save it, memorize it, store it, print it, keep it, add it to your toolbox!!! Make money $$$ with it!!!

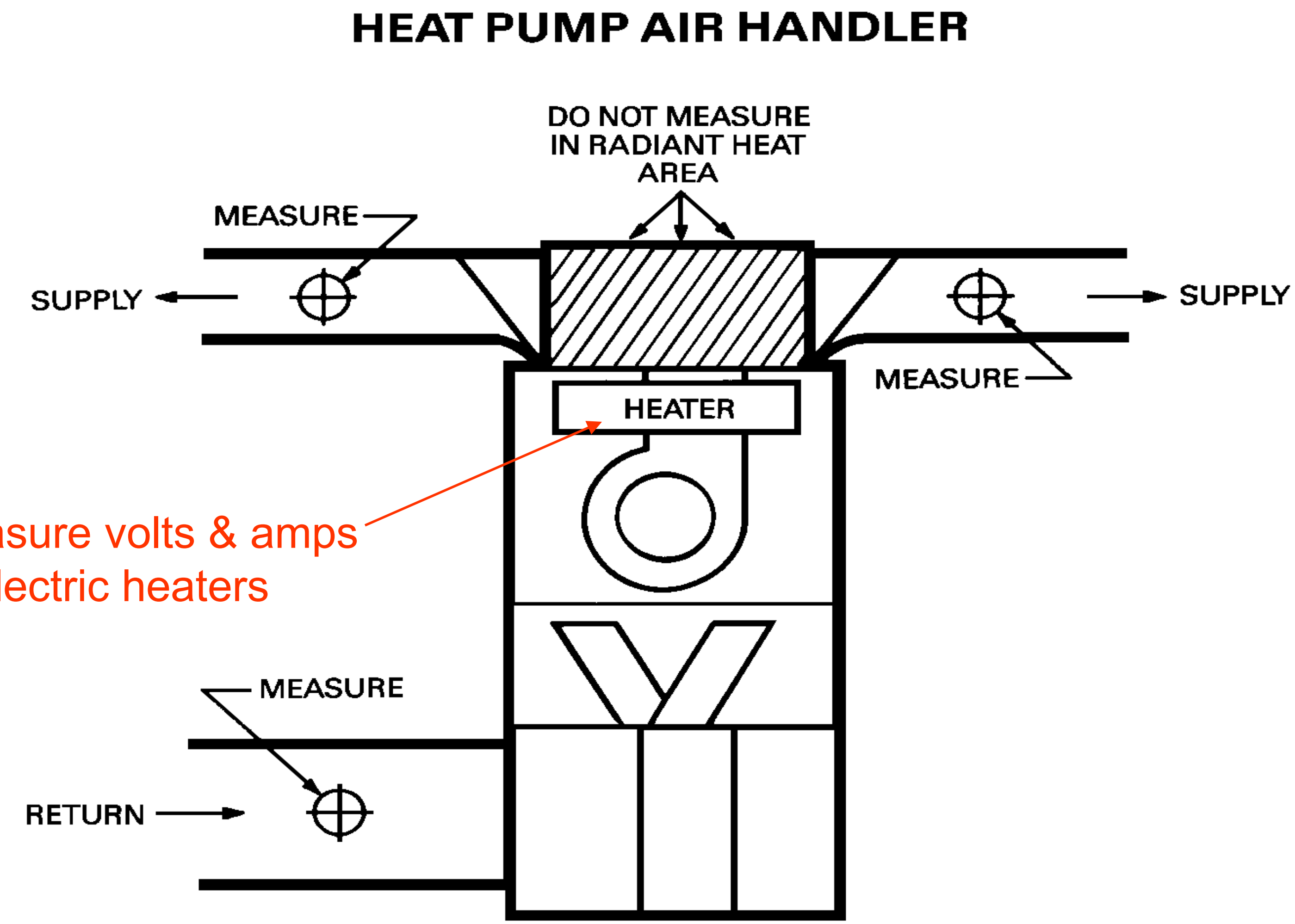
ELECTRIC HEAT METHOD

VOLTS X AMPERES = WATTS

1 WATT = 3.414 BTU's

VOLTS X AMPS X 3.414 = BTUH (OUTPUT)

TAKING TEMPERATURES



Measure volts & amps of electric heaters

MEASUREMENTS

- Service Tip
  - On average we should see
  - approx. 20 amps per 5 Kw of elec. heat.
  - 10 amps per 2.5 Kw of elec. Heat.
    - 1ph

Electric Heat Method

Formula:

$$CFM = \frac{\text{Voltage x Amperage x 3.414}}{\text{1.08 x Temperature Rise } (\triangle T)}$$

Air Handler Supply Voltage: 244 Volts

Air Handler Section Amperage: 38 Amps

Supply Air Temp: 105F

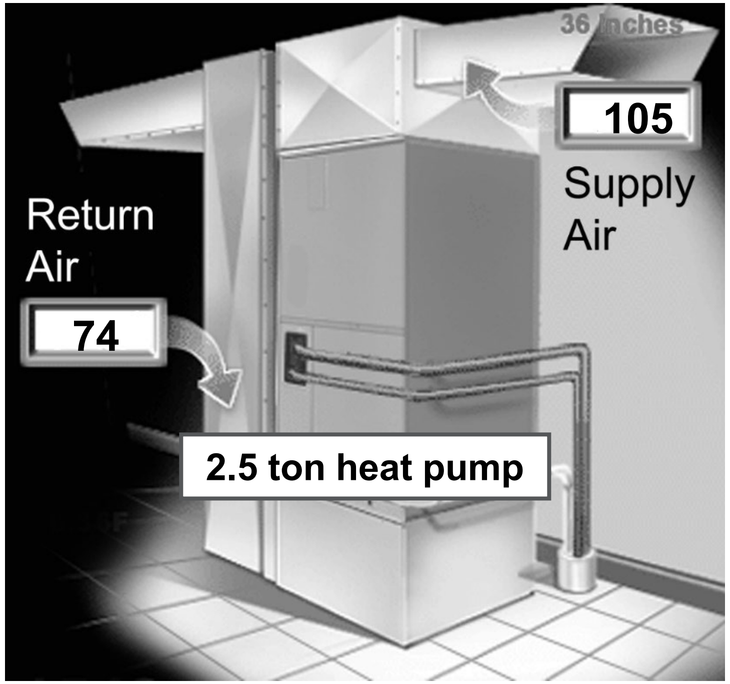
Return Air Temp: 74F

1. **244 Volts x 38 Amps x 3.414=**
   31,654 BTUH Output

2. **105F - 74F = 31F (△T)**

3. $$\frac{31654}{1.08 \times 31}$$

4. $$\frac{31654}{33.48} = 945 \text{ CFM}$$



Voltage = 244 Volts
Amperage draw = 38 Amps

Example 1

Electric Heat Method

Volts x Amps = Watts

244 volts x 38 amps = 9,272 watts

WATTS X 3.414 = BTUH (OUTPUT)

9,272 x 3.414 = 31,654 BTUH

$$\text{CFM} = \frac{\text{BTUH (OUTPUT)}}{1.08 \times \text{Delta T}}$$

$$\text{CFM} = \frac{31{,}654}{1.08 \times 31^\circ}$$

$$\text{CFM} = \frac{31{,}654}{33.48}$$

CFM = 945

Electric Heat Method

Formula:

$$CFM = \frac{\text{Voltage} \times \text{Amperage} \times 3.414}{1.08 \times \text{Temperature Rise } (\triangle T)}$$

Air Handler Supply Voltage: 238 Volts

Air Handler Section Amperage: 58 Amps

Supply Air Temp: 108F

Return Air Temp: 68F

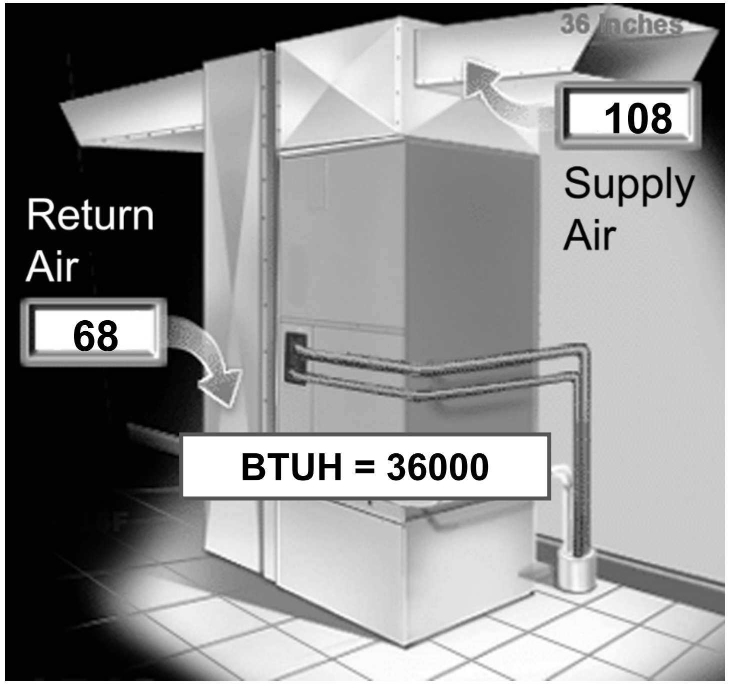
1. 238 Volts x 58 Amps x 3.414=
   47,127 BTUH Output

2. 108F - 68F = 40F ($\triangle$T)

3. $$\frac{47{,}127}{1.08 \times 40}$$

4. $$\frac{47{,}127}{43.2} = 1090 \text{ CFM}$$

Example:



Voltage = 238 Volts
Amperage draw = 58 Amps

Example 2

Electric Heat Method

Volts x Amps = Watts

238 volts x 58 amps = 13,804 watts

WATTS X 3.414 = BTUH (OUTPUT)

13,804 x 3.414 = 47,127 BTUH

$$CFM = \frac{BTUH\ (OUTPUT)}{1.08 \times Delta\ T}$$

$$CFM = \frac{47{,}127}{1.08 \times 40°}$$

$$CFM = \frac{47{,}127}{43.2}$$

CFM = 1090

Airflow Measurement

CFM Formula

$$CFM = \frac{BTUH\ (Output)}{1.08 \times TEMP\ DIFFERENCE}$$

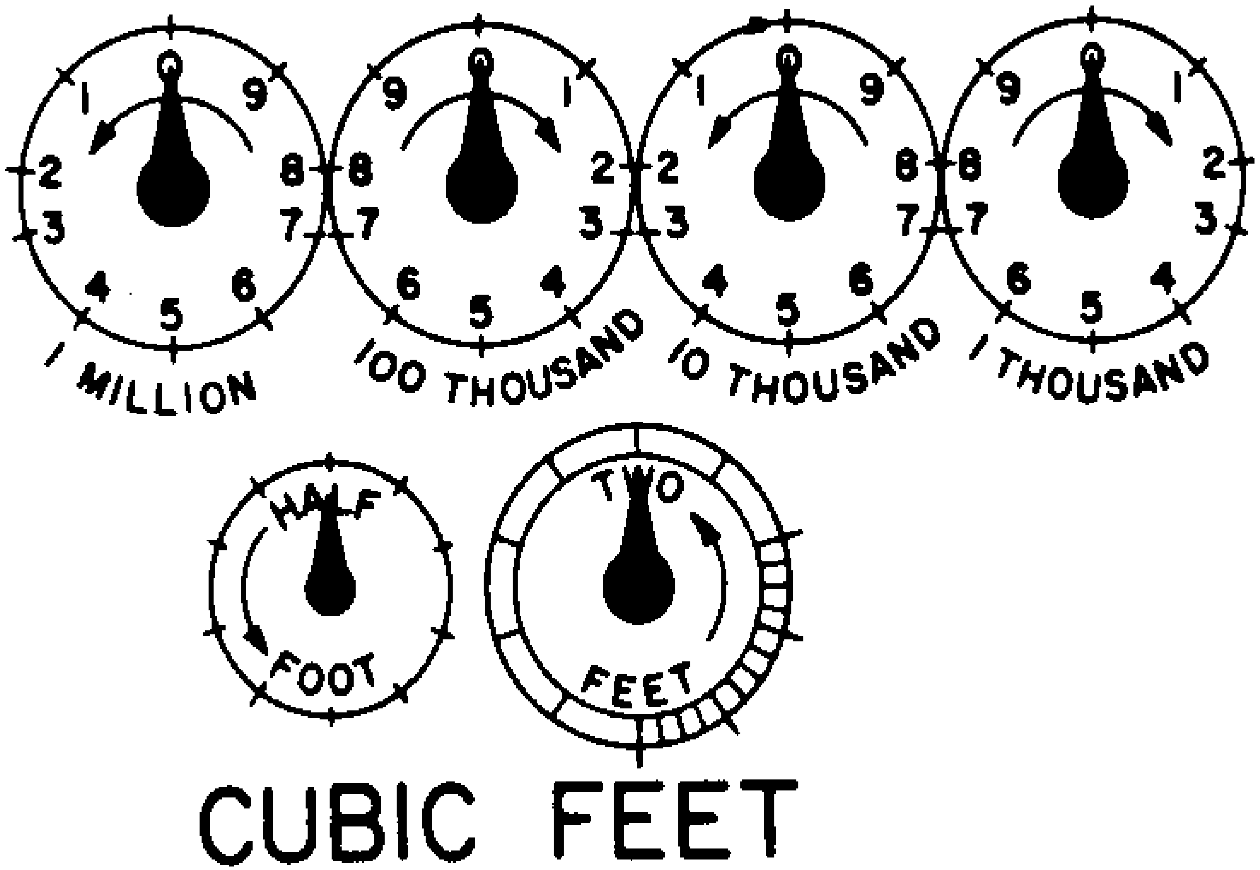
The easiest way to verify output of a Gas Furnace is to verify input.

MEASUREMENT METHODS

- Natural gas furnaces
  - Clock the gas meter

  or
  - Measure Manifold pressure
- Oil and LP furnaces
  - LP furnace, you need to verify manifold gas pressure
  - Oil furnace, check nozzle and pump pressure see charts.

Gas Furnace Input



Gas Furnace Input

- Make sure no other appliances are on during the test.
- Set the thermostat to heat mode and 90 degrees.
- Record the seconds required to consume 1 cubic foot of gas on the meter
- The furnace must run for 15 mins on high stage
- Determine temperature rise between the supply and return air.

BTU'S PER A CUBIC FOOT OF NATURAL GAS

The BTU content per a cubic foot of natural gas fluctuates daily

For todays examples we will use 1050 per a cu. Ft.

Virginia Heat Content of Natural Gas Deliveries to Consumers (BTU per Cubic Foot)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	1,038	1,032	1,033	1,028	1,030	1,039	1,043	1,038	1,043	1,042	1,046	1,045
2014	1,044	1,040	1,039	1,041	1,038	1,040	1,041	1,040	1,038	1,046	1,055	1,054
2015	1,056	1,053	1,051	1,045	1,055	1,055	1,056	1,054	1,055	1,053	1,051	1,057
2016	1,055	1,055	1,056	1,052	1,054	1,052	1,054	1,054	1,053	1,052	1,055	1,054
2017	1,057	1,052	1,057	1,055	1,051	1,052	1,051	1,051	1,050	1,051	1,052	1,057
2018	1,053	1,049	1,056	1,050	1,048	1,051	1,046	1,050	1,049	1,050	1,056	1,061
2019	1,055	1,056	1,057	1,053	1,049	1,048	1,049	1,050	1,046	1,051	1,050	1,053
2020	1,052	1,052	1,051	1,047	1,046	1,049	1,045	1,046	1,051	1,047		

Maryland Heat Content of Natural Gas Deliveries to Consumers (BTU per Cubic Foot)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	1,041	1,037	1,032	1,027	1,037	1,042	1,060	1,056	1,062	1,059	1,061	1,059
2014	1,053	1,048	1,045	1,049	1,047	1,052	1,051	1,051	1,049	1,052	1,057	1,057
2015	1,059	1,061	1,058	1,051	1,058	1,057	1,055	1,049	1,050	1,053	1,049	1,050
2016	1,061	1,055	1,050	1,048	1,047	1,046	1,052	1,051	1,046	1,042	1,045	1,050
2017	1,054	1,056	1,055	1,043	1,046	1,041	1,044	1,047	1,045	1,042	1,038	1,048
2018	1,051	1,043	1,052	1,045	1,041	1,038	1,040	1,034	1,035	1,035	1,045	1,042
2019	1,050	1,050	1,050	1,045	1,039	1,036	1,039	1,040	1,036	1,036	1,045	1,048
2020	1,047	1,045	1,041	1,038	1,035	1,036	1,040	1,038	1,036	1,034		

This information was found on EIA.gov
US Energy Information Administration
Or
Cematraining.com

Gas Furnace Input

The Ultimate GOAL Example

How long does it take to consume 1 cubic foot of gas in seconds

60 Minutes in an hour, and 60 seconds in a minute = 3600 seconds in an hour

3600 / seconds = cubic feet of gas per an hour

=

Cubic feet per an hour X 1050(specific heat content per a cubic foot **AVG**)

=

BTUH input

Gas Furnace Input

The Ultimate GOAL Example

How long does it take to consume 1 cubic foot of gas in seconds

60 Minutes in an hour, and 60 seconds in a minute = 3600 seconds in an hour

3600 **/** **38** seconds = **95** cubic feet

=

95 X 1050(avg)

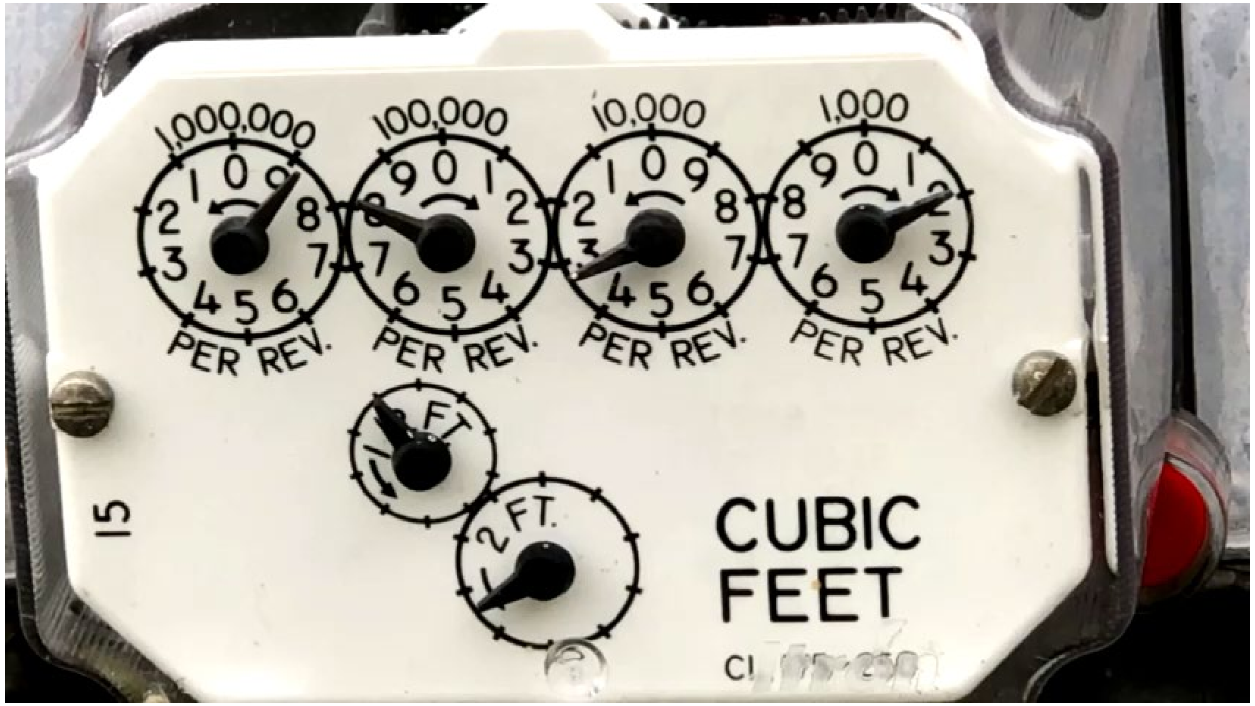
=

99,750 BTUH input

Excludes Dry wells, always contact the supplier for the daily heat content

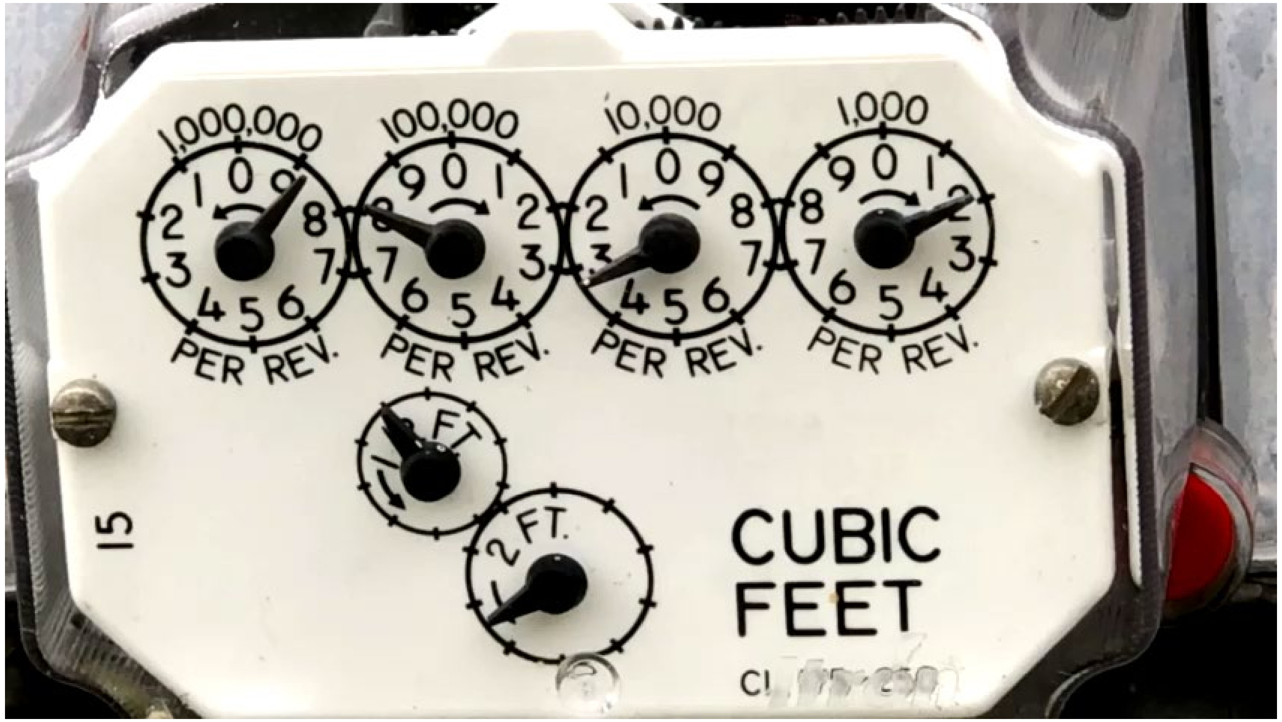
CLOCKING THE GAS METER

CLOCKING THE GAS METER



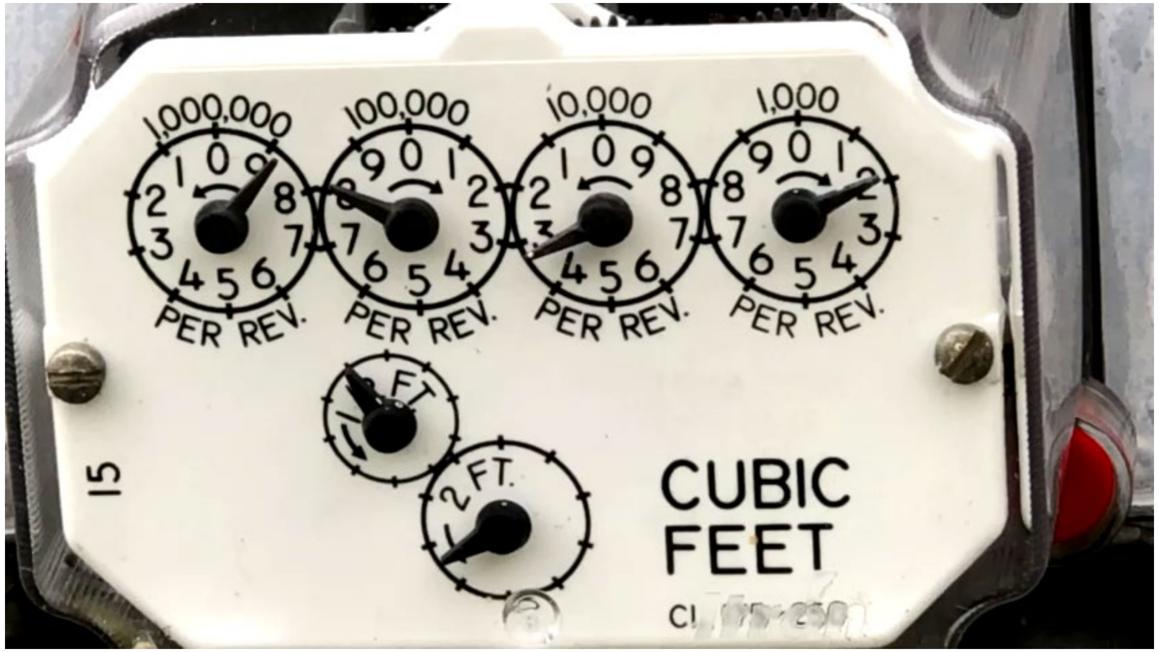
It takes 57 seconds to consume 1 cubic foot of gas

CLOCKING THE GAS METER



It takes 42 seconds to consume 1 cubic foot of gas

CLOCKING THE GAS METER



We clocked the meter, and it takes 32 seconds to consume 1 cubic foot of gas

3600 / 32 sec = 112.5 cubic feet consumed per an hour

112.5 X 1050 (avg BTU content per a cu. ft.) = 118,125 BTUH input

Airflow Calculation 80% Furnace

Formula:

$$CFM = \frac{\text{BTUH OUTPUT}}{1.08 \times \text{Temperature Rise } (\triangle T)}$$

BTUH: 96,000 tag says Output

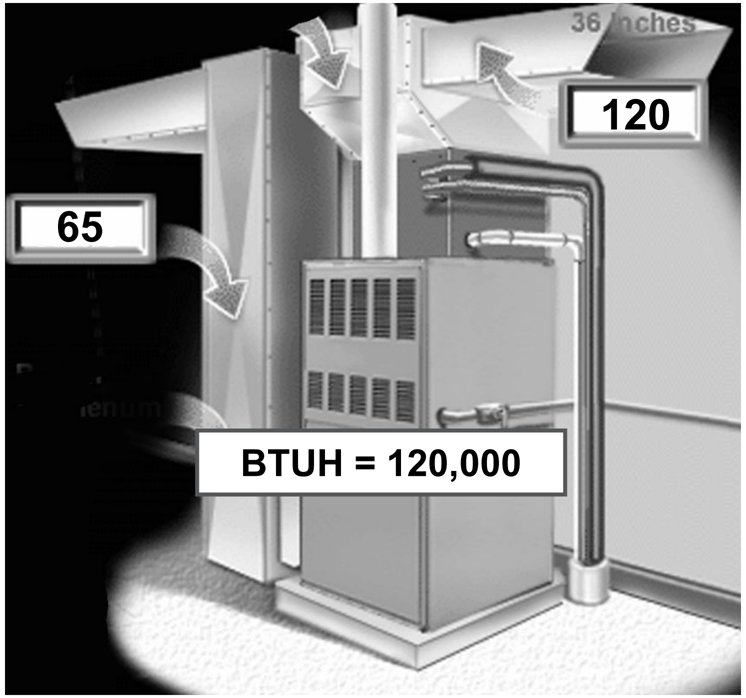
Supply Air Temp: 120F

Return Air Temp: 65F

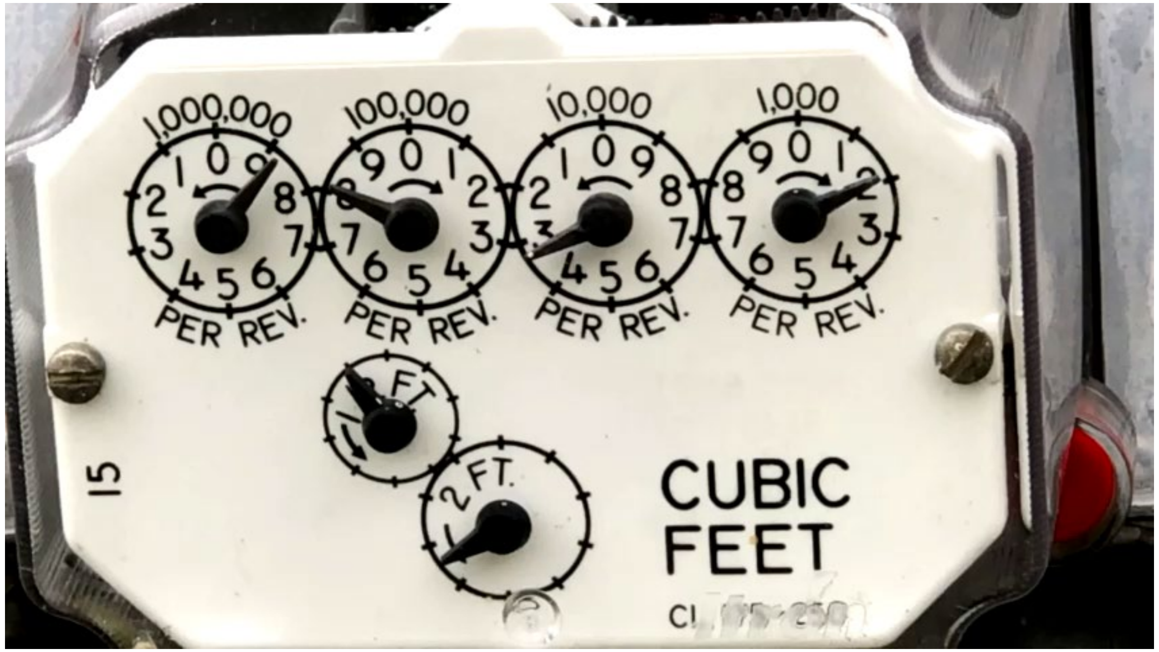
1. 120F - 65F = 55F (△T)

2. $\frac{96{,}000}{1.08 \times 55}$

3. $\frac{96{,}000}{59.4}$ = 1616 CFM



CLOCKING THE GAS METER



We clocked the meter, and it takes 46 seconds to consume 1 cubic foot of gas

3600 / 46 sec = 78 cubic feet consumed per an hour

78 X 1050 (avg BTU content per a cu. ft.) = 81,900 BTUH input

Airflow Calculation 90%

Formula:

$$CFM = \frac{\text{BTUH OUTPUT}}{1.08 \times \text{Temperature Rise } (\triangle T)}$$

BTUH: 72,000 tag says Output

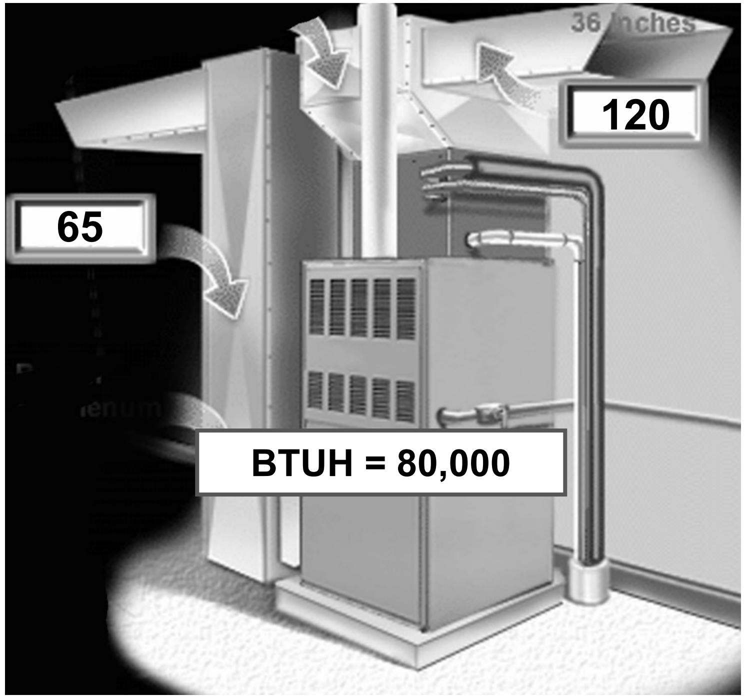
Supply Air Temp: 120F

Return Air Temp: 65F

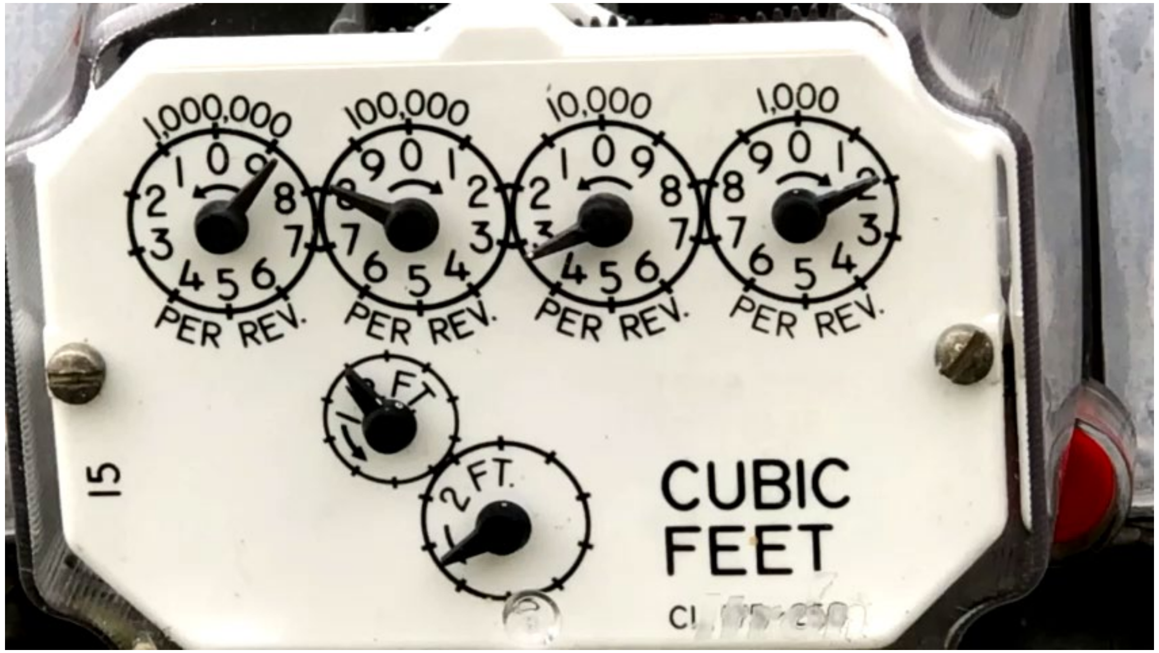
1. 120F - 65F = 55F ($\triangle$T)

2. $$\frac{72{,}000}{1.08 \times 55}$$

3. $$\frac{72{,}000}{59} = 1220 \text{ CFM}$$



CLOCKING THE GAS METER



We clocked the meter, and it takes 62 seconds to consume 1 cubic foot of gas

3600 / 62 sec = 58 cubic feet consumed per an hour

58 X 1050 (avg BTU content per a cu. ft.) = 60,900 BTUH input

Airflow Calculation 96%

Formula:

$$CFM = \frac{\text{BTUH OUTPUT}}{1.08 \times \text{Temperature Rise } (\triangle T)}$$

BTUH: 57,600 tag says Output

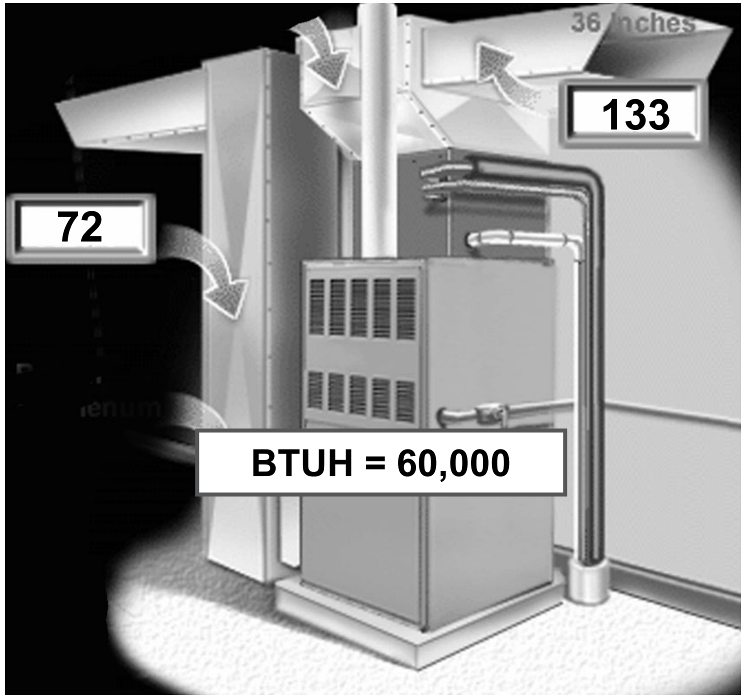
Supply Air Temp: 133F

Return Air Temp: 72F

1. 133F - 72F = 61F (△T)

2. $\frac{57{,}600}{1.08 \times 61}$

3. $\frac{57{,}600}{65.88}$ = 874 CFM



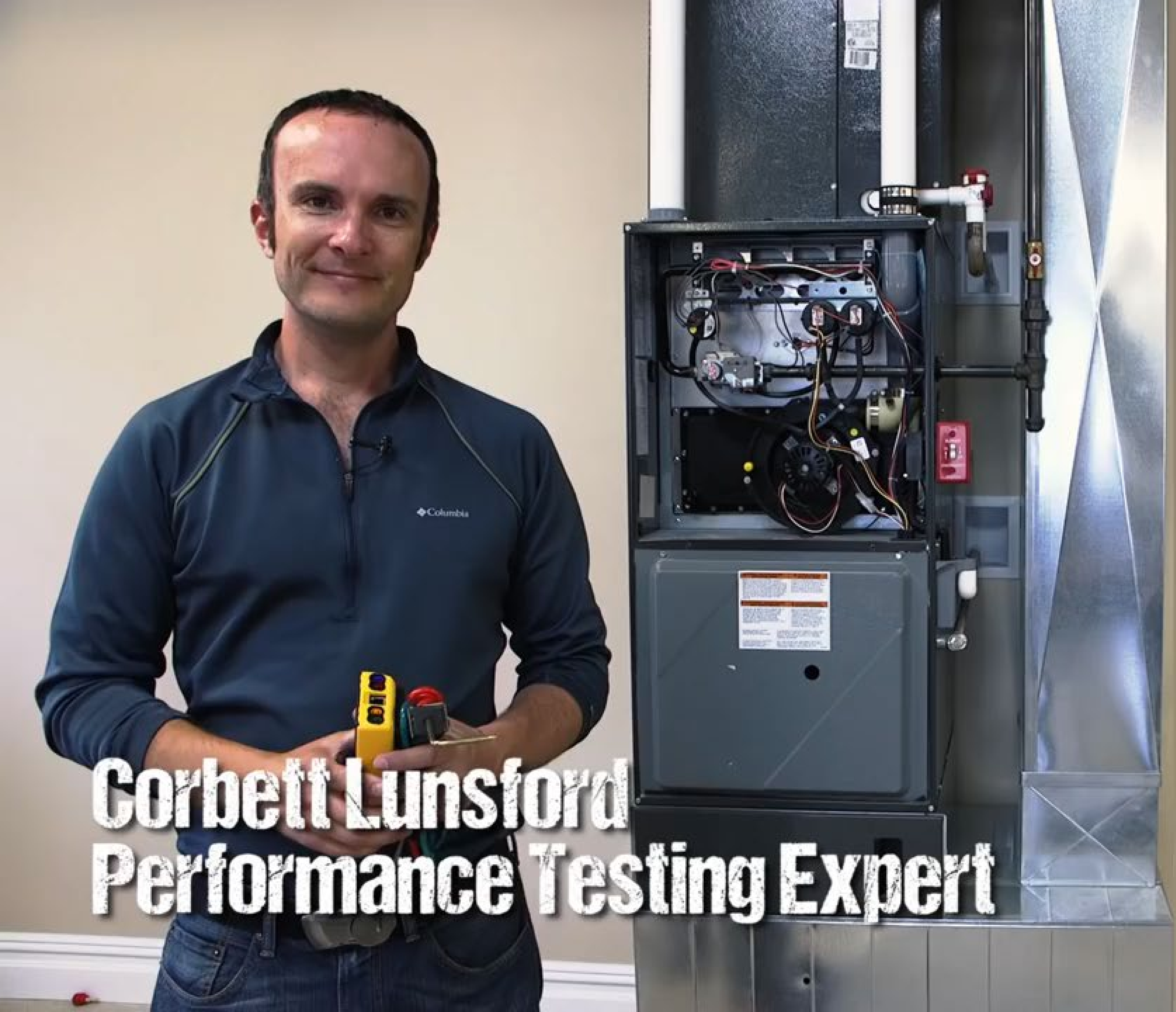
THE BLOWER / STATIC PRESSURE

- Provides the pressure difference to force the air into the duct system, through the grilles and registers, and into the room

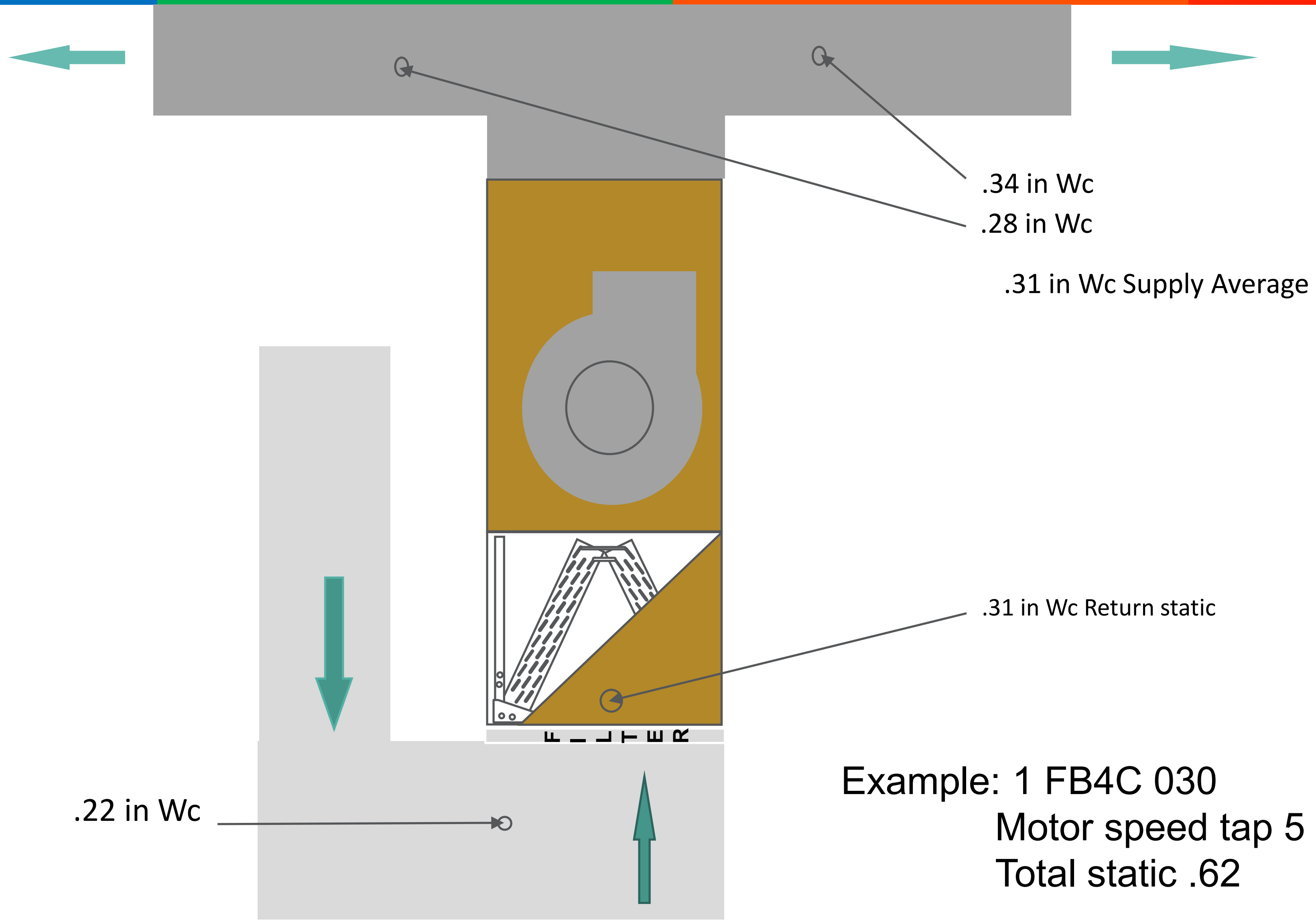
- Typically, 400 cfm of air must be moved per minute per ton of air conditioning

- Pressure in the ductwork is measured in inches of water column (in. W.C)

- Air pressure in the ductwork is measured with a manometer the Building Performance Workshop



AIR HANDLER /INCHES WC



Example: 1 FB4C 030
Motor speed tap 5
Total static .62

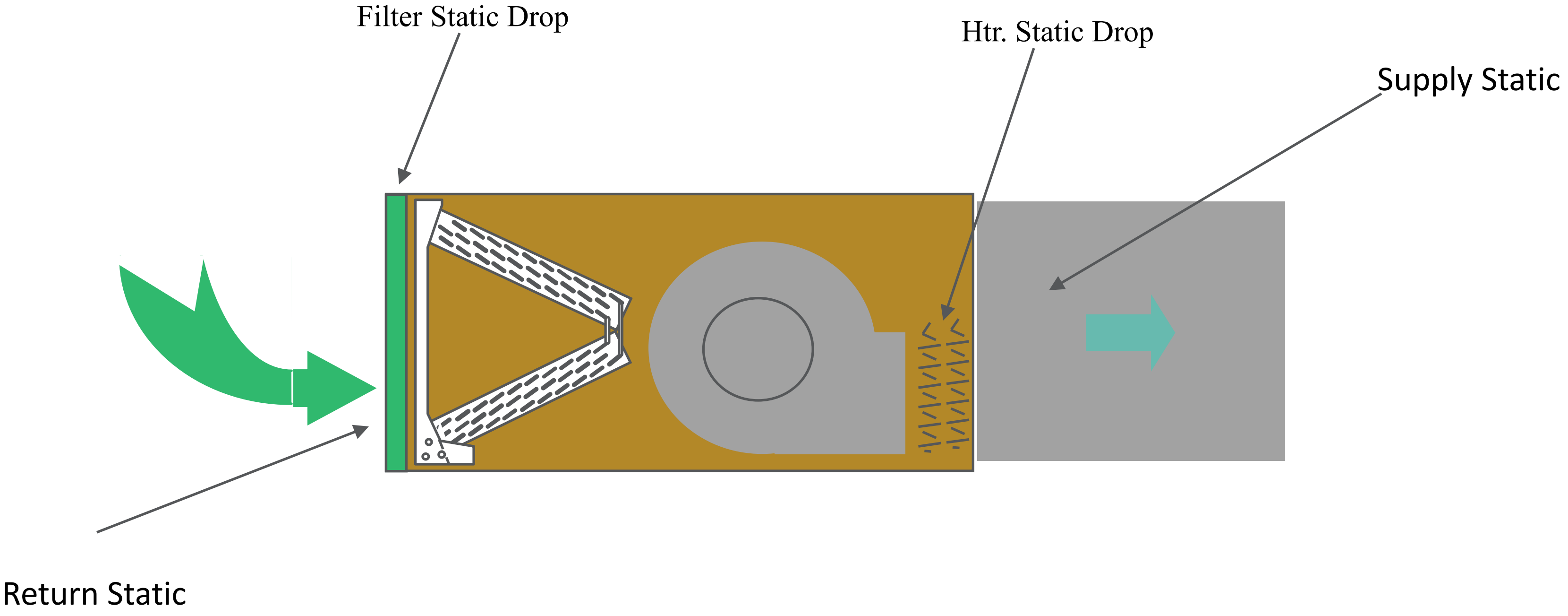
BLOWER PERFORMANCE DATA

PERFORMANCE DATA

FB4C AIRFLOW PERFORMANCE (CFM)

MODEL & SIZE	BLOWER SPEED	0.10	0.20	0.30	0.40	0.50	0.60
FB4C 018	Tap 5	767	739	702	669	620	565
	Tap 4	614	569	534	486	436	398
	Tap 3	701	660	616	581	537	499
	Tap 2	614	569	534	486	436	398
	Tap 1	410	350	304	261	228	203
FB4C 024 & 025	Tap 5	969	936	892	835	763	676
	Tap 4	826	795	766	743	706	660
	Tap 3	826	795	766	743	706	660
	Tap 2	701	660	616	581	537	499
	Tap 1	617	592	552	507	472	420
FB4C 030	Tap 5	1108	1090	1065	1034	1009	974
	Tap 4	1026	1000	969	938	899	865
	Tap 3	1026	1000	969	938	899	865
	Tap 2	909	873	842	799	762	724
	Tap 1	825	795	757	722	674	634

Air Handler

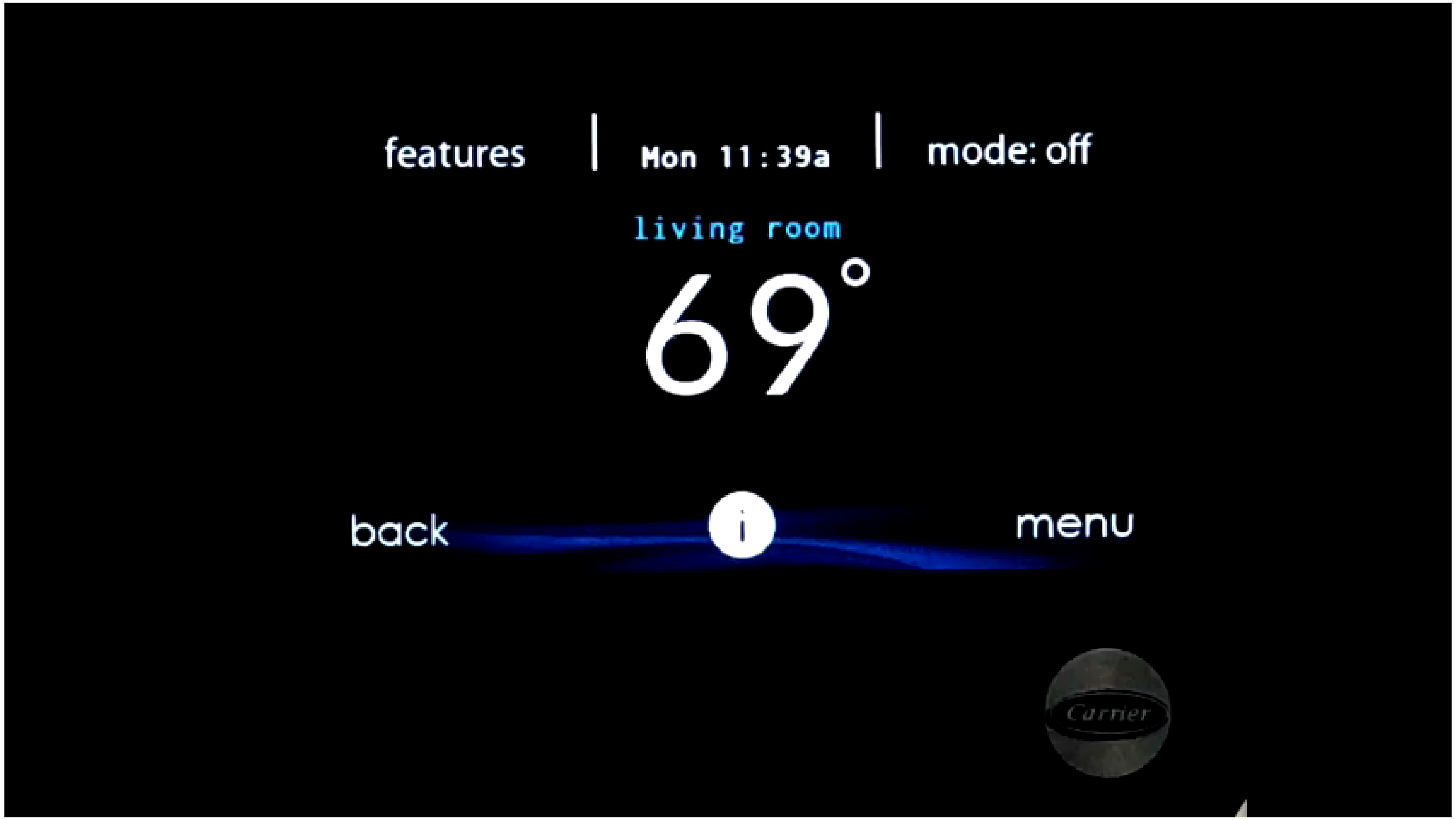


Example: FE4A

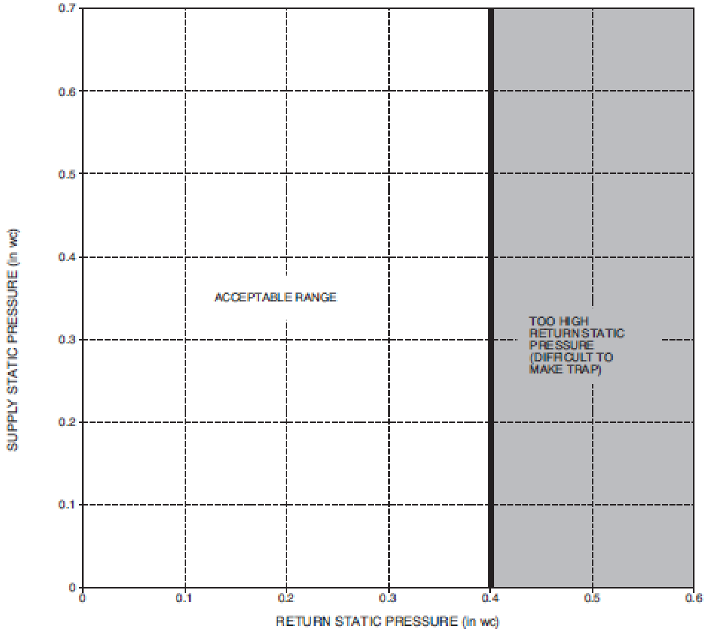
UI Calculated CFM 906

Total static .84

Airflow Verification test



BLOWER PERFORMANCE DATA



For satisfactory operation (specifically making dry secondary trap), subject fan coils must be installed with duct systems which fall within the "Acceptable Range" illustrated above.

MINIMUM RPM TABLE

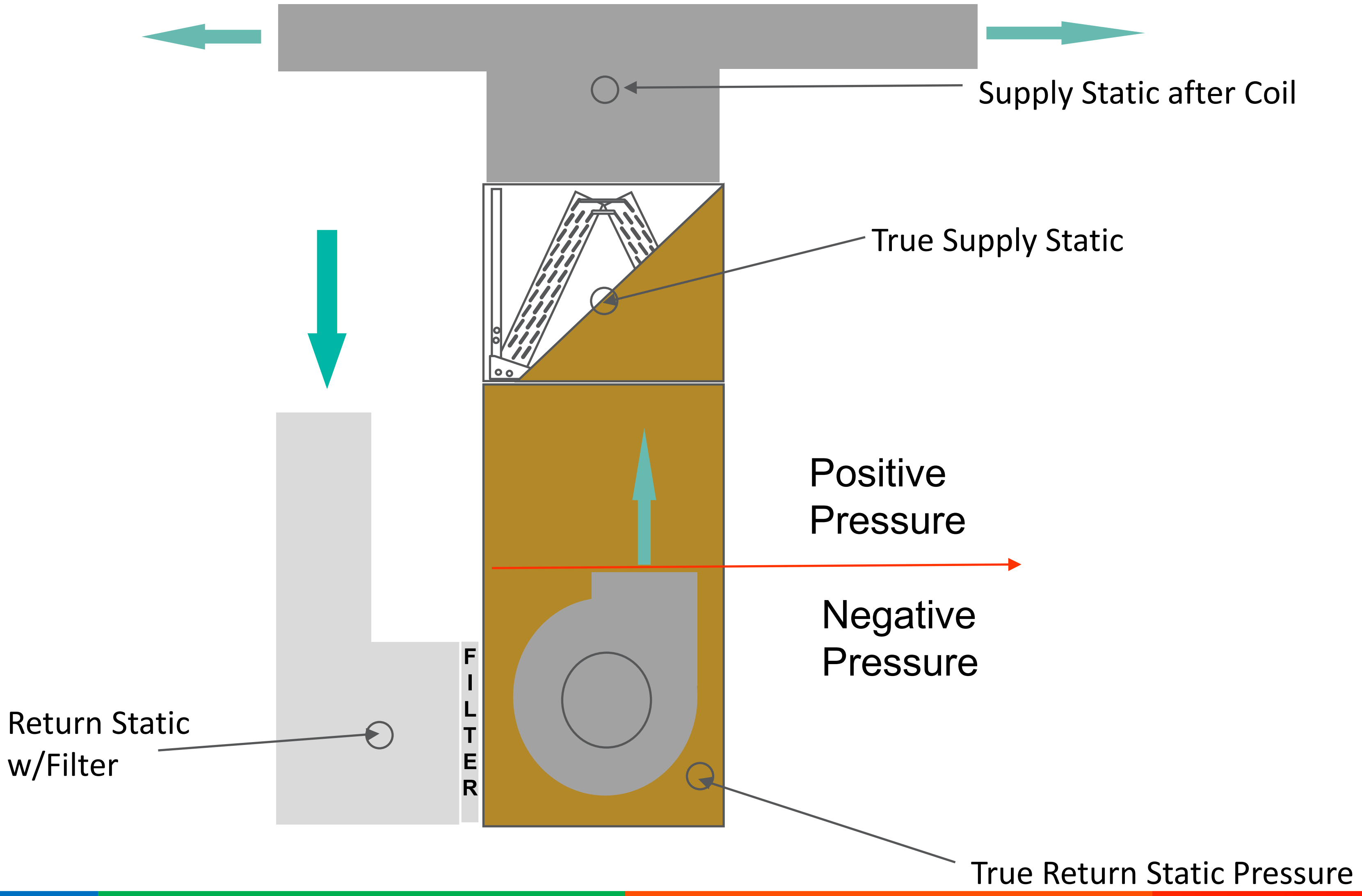
MODEL	SYSTEM SIZES	CFM RANGE	MIN RPM
FE4ANF002	018, 024, 030, 036	150 - 1200	300
FE4AN(B,F)003	024, 030, 036, 042	200 - 1400	285
FE4AN(B,F)005	030, 036, 042, 048	250 - 1600	275
FE4ANB006	036, 042, 048, 060	500 - 2000	275
FE5ANB004	024, 030, 036, 042	500 - 1400	275

MAXIMUM STATIC TABLE

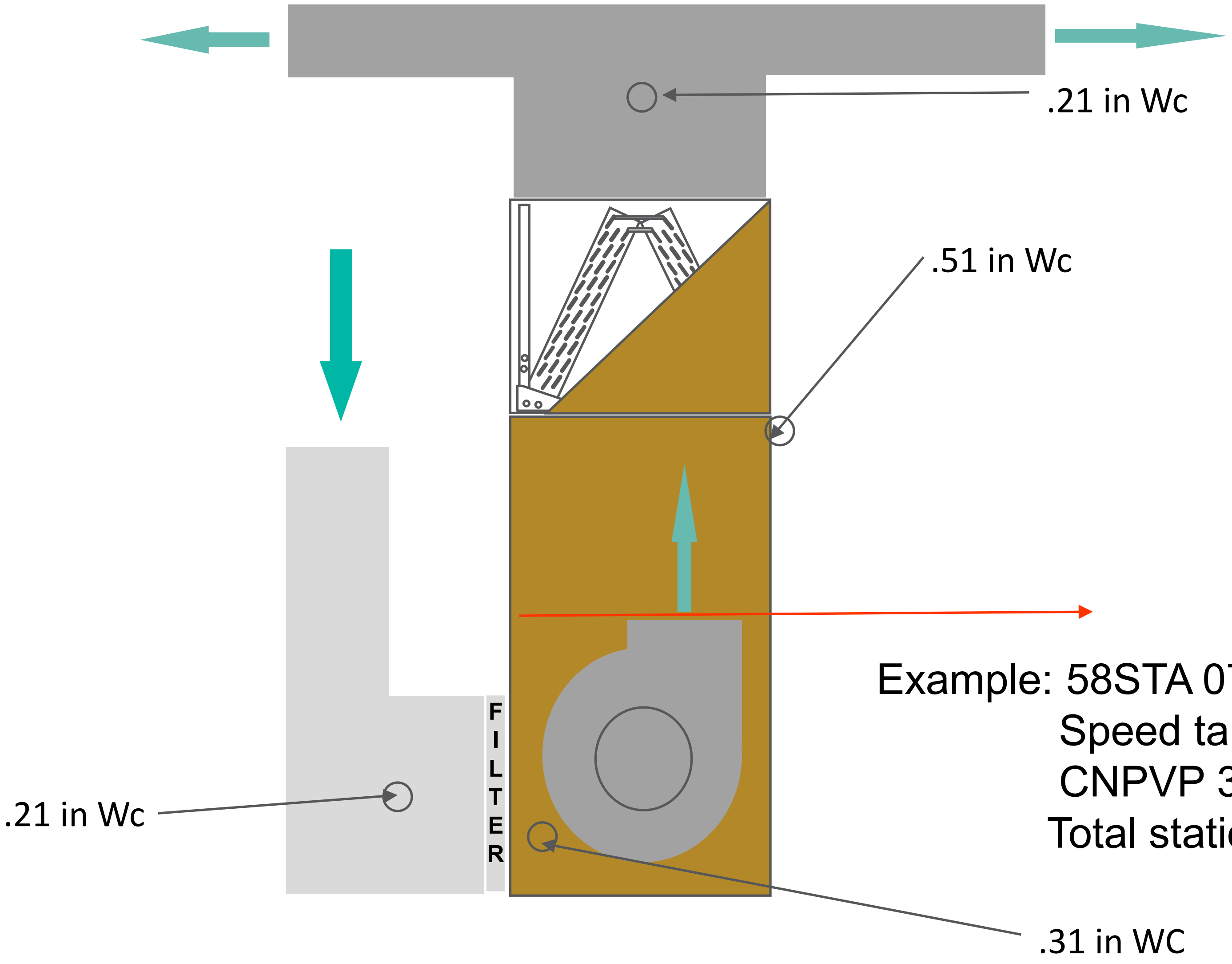
MODEL	AIRFLOW DELIVERY	AVAILABLE STATIC PRESSURE
FE4ANF002	525 CFM	1.00 in wc
	700 CFM	1.00 in wc
	875 CFM	1.00 in wc
	1050 CFM	0.80 in wc
	1200 CFM	0.60 in wc
FE4AN(B,F)003	700 CFM	1.00 in wc
	875 CFM	1.00 in wc
	1050 CFM	1.00 in wc
	1225 CFM	1.00 in wc
	1400 CFM	0.80 in wc
FE4AN(B,F)005	875 CFM	1.00 in wc
	1050 CFM	1.00 in wc
	1225 CFM	1.00 in wc
	1400 CFM	1.00 in wc
	1600 CFM	0.50 in wc

Plexi-glass can be used as a tool for troubleshooting condensate concerns

GAS FURNACE /INCHES WC



GAS FURNACE /INCHES WC



Example: 58STA 070-12
Speed tap HI
CNPVP 3014
Total static .82

BLOWER PERFORMANCE DATA

AIR DELIVERY – CFM (With Filter)

FURNACE SIZE	RETURN–AIR INLET	SPEED	EXTERNAL STATIC PRESSURE (In. W.C.)									
			0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
045–08	Bottom or Side(s)	High	1035	995	945	895	835	770	675	565	390	195
		Med–High	865	830	790	745	690	625	545	440	250	195
		Med–Low	760	720	680	635	580	520	445	345	220	195
045–12	Bottom or Side(s)	High	1440	1375	1305	1240	1160	1070	975	870	730	560
		Med–High	1360	1300	1240	1175	1115	1040	950	850	725	575
		Med–Low	1250	1210	1160	1100	1040	965	885	790	670	520
070–08	Bottom or Side(s)	High	1030	1005	965	925	870	810	740	645	465	280
		Med–High	835	815	790	755	710	660	590	480	325	205
		Med–Low	725	700	675	635	595	545	460	350	250	––
070–12	Bottom or Side(s)	High	1425	1375	1320	1265	1200	1125	1035	940	830	655
		Med–High	1320	1280	1240	1205	1140	1075	995	905	790	620
		Med–Low	1200	1175	1145	1105	1050	990	920	840	725	555
070–16	Bottom or Side(s)	High	1755	1700	1635	1570	1505	1435	1350	1260	1160	1055
		Med–High	1550	1520	1475	1430	1375	1310	1240	1155	1070	970
		Med–Low	1355	1340	1310	1280	1240	1190	1125	1060	975	890
090–14	Bottom or Side(s)	High	1605	1570	1535	1465	1385	1285	1175	1055	895	645
		Med–High	1470	1445	1410	1380	1300	1220	1115	990	830	600
		Med–Low	1310	1295	1265	1230	1195	1120	1025	915	710	565
090–16	Bottom or Side(s)	High	1940	1880	1805	1720	1635	1540	1425	1290	1090	830
		Med–High	1740	1700	1650	1590	1525	1440	1335	1195	1010	820
		Med–Low	1505	1505	1480	1440	1375	1300	1190	1045	890	740

AIRFLOW

Knowing the true airflow and static pressure is the key to resolving comfort complaints and possible equipment related concerns

A few tips to remember

Always take measurements at the system not the grills

Always take temperatures at the unit with the same probe

Your return static should always be below your supply static

The lower the static, the lower the wattage of the motor

A noisy supply or return are easy signs of an airflow issue

Return static should never be over -.4 in Wc

When looking at temperature splits unit give a design temperature range to operate in 35-65, 40-70 and etc. When running on the high end of the temp split. You might get periodic calls from time to time of a furnace locking out on Code 13 or 33.

THE PERFECT SERVICE VISIT

- Upon arrival meet & greet the homeowner
  - Ask discover questions
  - Why am I here? Any unusual sounds or operation?
- Place the thermostat in the Emergency heat position
- Go to the indoor unit, operate the system for 10 mins.
- Measure the supply voltage, Aux heat amp draw, and measure the temp split of the Aux heat only. Inspect the coil, filter, drain pans and see what type of metering device the indoor unit has.
- **Calculate CFM, make any adjustments needed to meet target airflow, 400 cfm +/- 50 cfm per a ton before proceeding**
- **CFM Validated**

THE PERFECT SERVICE VISIT

- Upon arrival meet & greet the homeowner
  - Ask discover questions
  - Why am I here? Any unusual sounds or operation?
- Place the thermostat in the Emergency heat position
- Go to the indoor unit, operate the system for 10 mins.
- Measure the supply voltage, Aux heat amp draw, and measure the temp split of the Aux heat only. Inspect the coil, filter, drain pans and see what type of metering device the indoor unit has.
- Calculate CFM, make any adjustments needed to meet target airflow, 400 cfm +/- 50 cfm per a ton before proceeding
- CFM Validated
- **Place the unit in cooling mode and measure your return DB and WB temperatures**

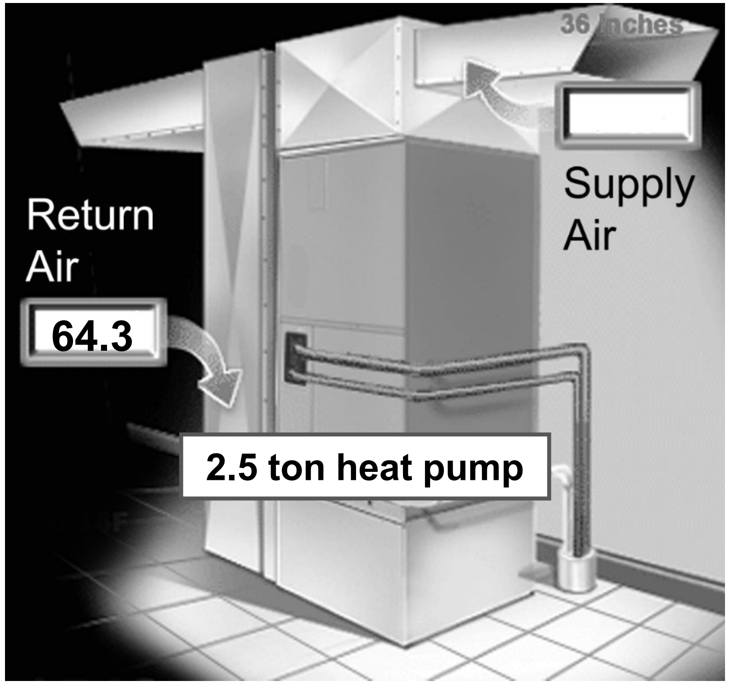
Refrigerant Charging

Air Handler Supply

CFM: 945

Supply Air Temp: DB WBF

Return Air Temp: DB 64.3 WBF



Example 1

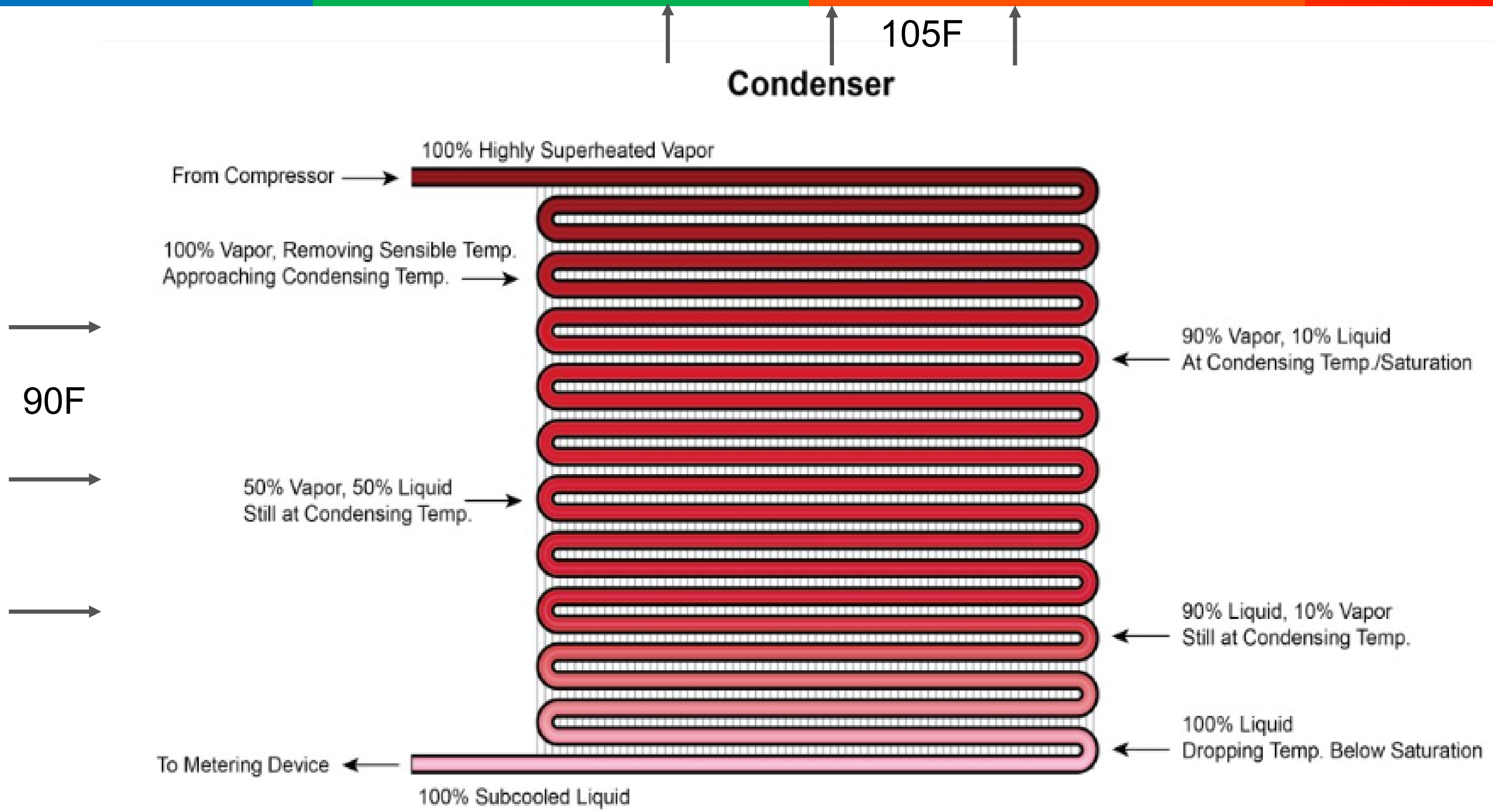
THE PERFECT SERVICE VISIT

- Upon arrival meet & greet the homeowner
  - Ask discover questions
  - Why am I here? Any unusual sounds or operation?
- Place the thermostat in the Emergency heat position
- Go to the indoor unit, operate the system for 10 mins.
- Measure the supply voltage, Aux heat amp draw, and measure the temp split of the Aux heat only. Inspect the coil, filter, drain pans and see what type of metering device.
- Calculate CFM, make any adjustments needed to meet target airflow, 400 cfm +/- 50 cfm per a ton before proceeding
- CFM Validated
- Place the unit in cooling mode and measure your return DB and WB temperature
- **Allow the unit to run in cooling for 15 mins, every system, every type of metering device and measure the Hi and Low pressures and the Liquid and Vapor line temperatures.**

BASIC REFRIGERATION

- Before we go on, now let's look at the refrigerant cycle operation

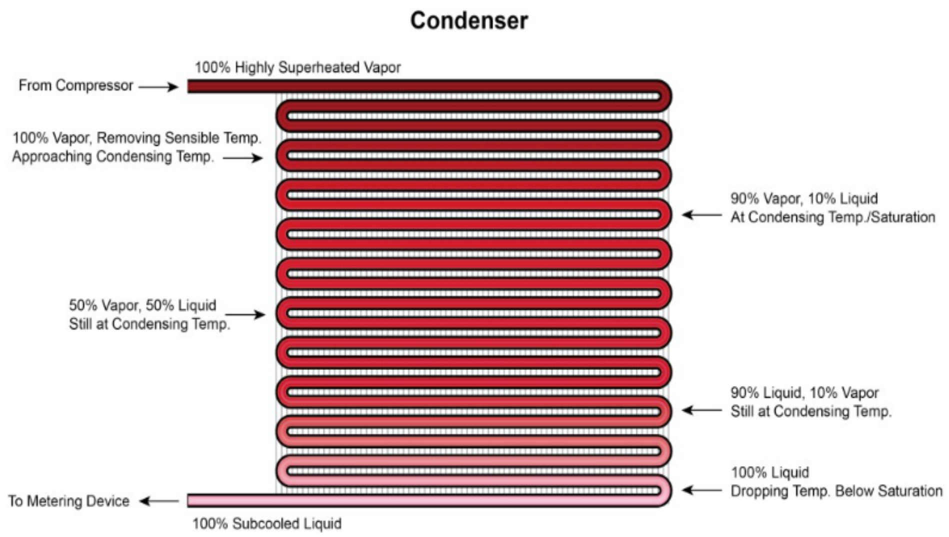
Condenser


105F
Condenser
90F
100% Highly Superheated Vapor
From Compressor
100% Vapor, Removing Sensible Temp.
Approaching Condensing Temp.
90% Vapor, 10% Liquid
At Condensing Temp./Saturation
50% Vapor, 50% Liquid
Still at Condensing Temp.
90% Liquid, 10% Vapor
Still at Condensing Temp.
100% Liquid
Dropping Temp. Below Saturation
To Metering Device
100% Subcooled Liquid

Condenser

The condenser has three jobs:

1. **De-superheat the refrigerant** (Drop the temperature down to the condensing temperature)
2. **Condense (saturate) the refrigerant** (Reject heat until all the refrigerant turns to liquid)
3. **Subcool the refrigerant** (Drop the temperature of the refrigerant below the condensing / saturation temperature)

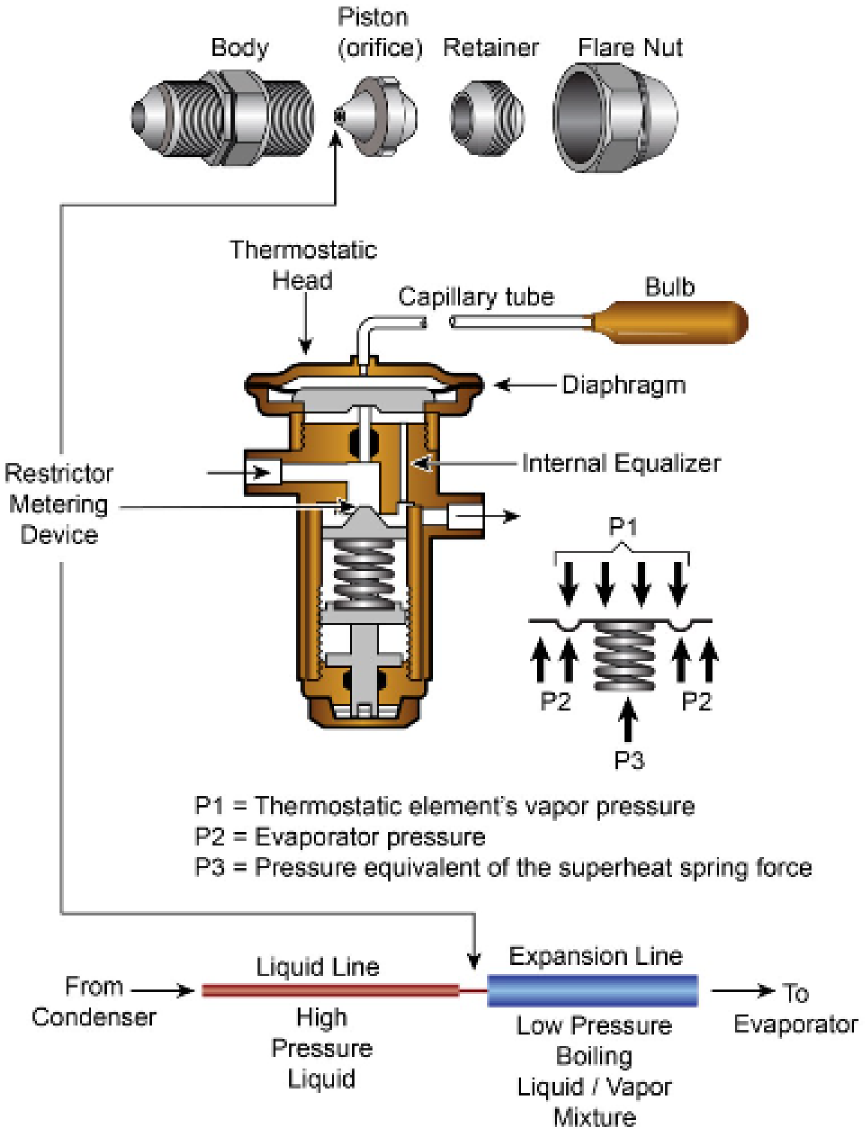


Condenser

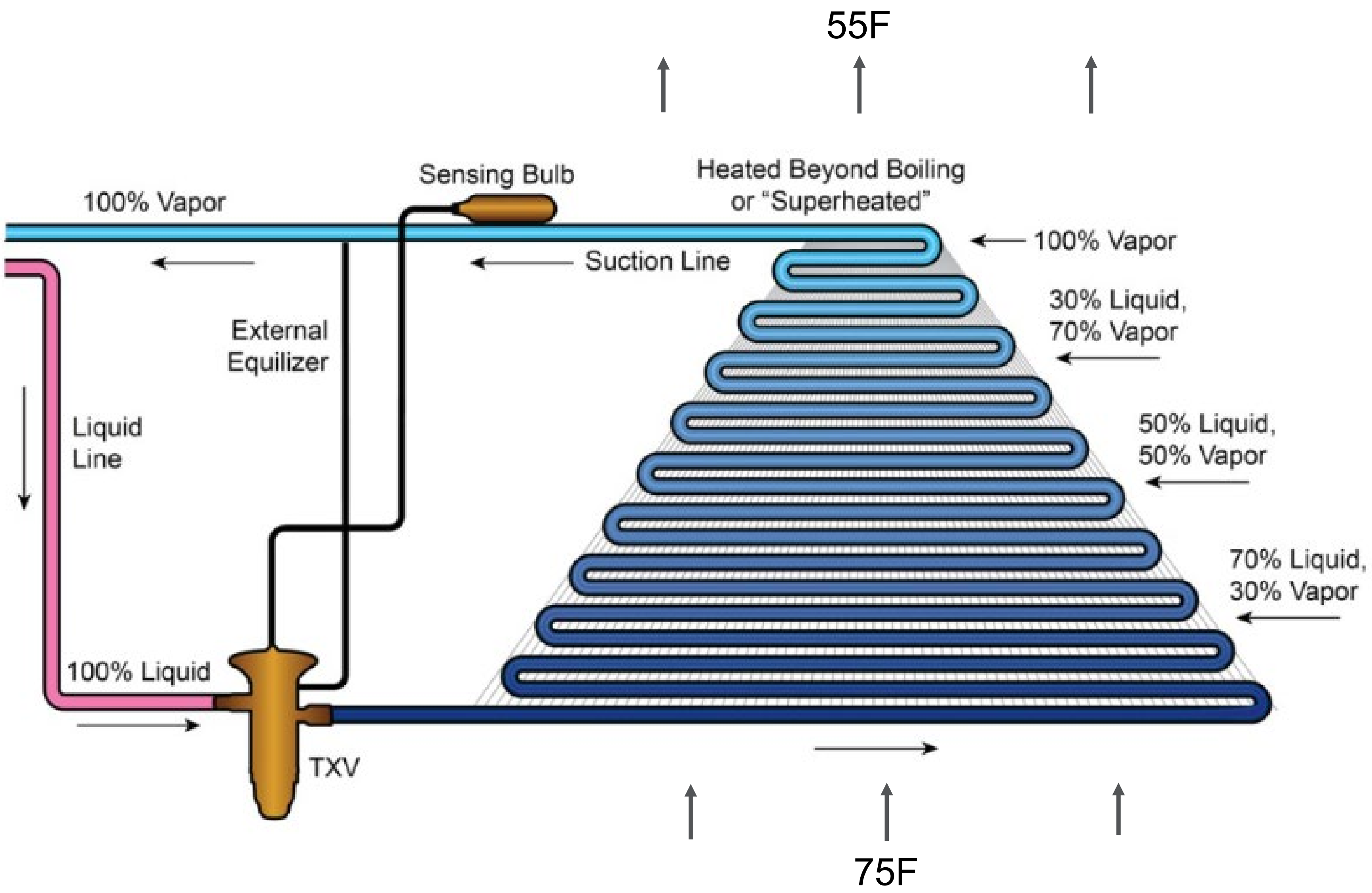
Different equipment efficiencies will have different target **Condensing Temperature Over Ambient** (CTOA) readings. Keep in mind that these date ranges don't guarantee the SEER but rather give the date ranges that these efficiencies will be most likely.

6 – 10 SEER Equipment (Older than 1991) = 30° CTOA
10 -12 SEER Equipment (1992 – 2005) = 25° CTOA
13 – 15 SEER Equipment (2006 – Present) = 20° CTOA
16 SEER+ Equipment (2006 – Present) = 15° CTOA

Metering Device



Evaporator


55F
Sensing Bulb
Heated Beyond Boiling
or "Superheated"
100% Vapor
Suspension Line
100% Vapor
30% Liquid,
70% Vapor
External
Equilizer
Liquid
Line
50% Liquid,
50% Vapor
70% Liquid,
30% Vapor
100% Liquid
TXV
75F

Evaporator

The evaporator is also known as the cooling coil, because the **purpose of the evaporator is to absorb heat**. It accomplishes this through the refrigerant changing from liquid to vapor (boiling). This boiling process begins as soon as the refrigerant leaves the metering device, and it continues until the refrigerant has absorbed enough heat to completely finish the change from liquid to vapor. **As long as the refrigerant is boiling it will remain at a constant temperature; this temperature is referred to as *saturation temperature* or *evaporator temperature***. As soon as the refrigerant is done boiling, the temperature starts to rise. This temperature increase is known as *superheat.*

Evaporator

A good rule of thumb for suction pressure is 40° saturation below indoor ambient +/- 5° *(Return temperature measured at the evaporator coil).*

This temperature differential is often called an evaporator split or design temperature difference (DTD)

This 40° rule only works at 400 CFM per ton, when a system is designed for 350 CFM per ton the DTD will be closer to 38° – 40° +/- 5°

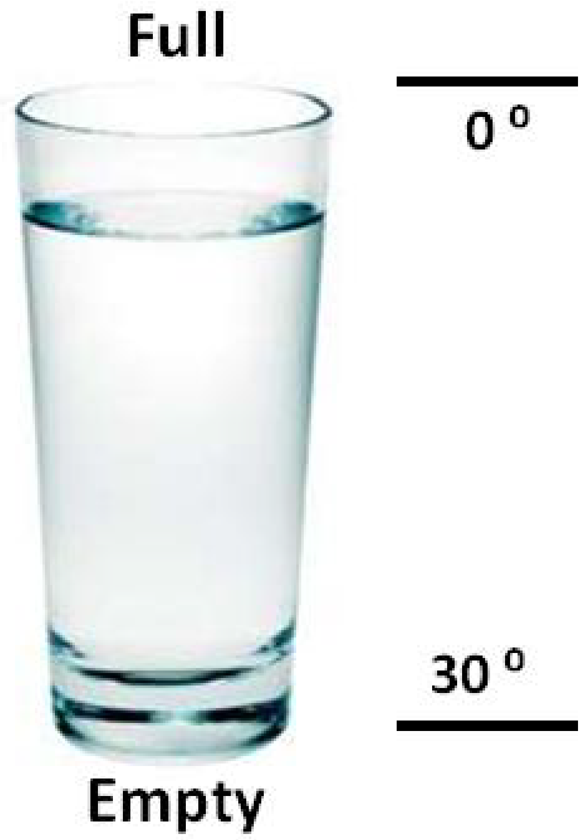
CHARGING

- There are 3 ways of charging a system
  - Weight
  - Pistons(charged by superheat)
    - Superheat- The amount of heat **ADDED** to the refrigerant past it's "evaporating temperature"
    - Low pressure side of the system (VAPOR LINE)
  - TXV's(charged by subcooling)
    - Subcooling- The amount of heat **REMOVED** from the refrigerant below it's "condensing temperature"
    - High pressure side of the system (LIQUID LINE)
  - We use our gauges to find the "evaporating" and "condensing" temperatures and a thermometer to measure the temperature of the refrigerant

CHARGING BY WEIGHT

- Unit is factory charged for 15ft of lineset. Adjust charge by adding or removing 0.6 oz/ft of 3/8 liquid line above or below 15ft respectively. For standard refrigerant line lengths (80 ft or less), allow system to operate in cooling mode at least 15 minutes.

SUPERHEAT CHARGING



<u>SuperHeat (PISTION):</u>
The **SMALLER** the number, the more **LIQUID** there is in **EVAPORATOR COIL.**

SUPERHEAT CHARGING

Determining how much superheat is needed

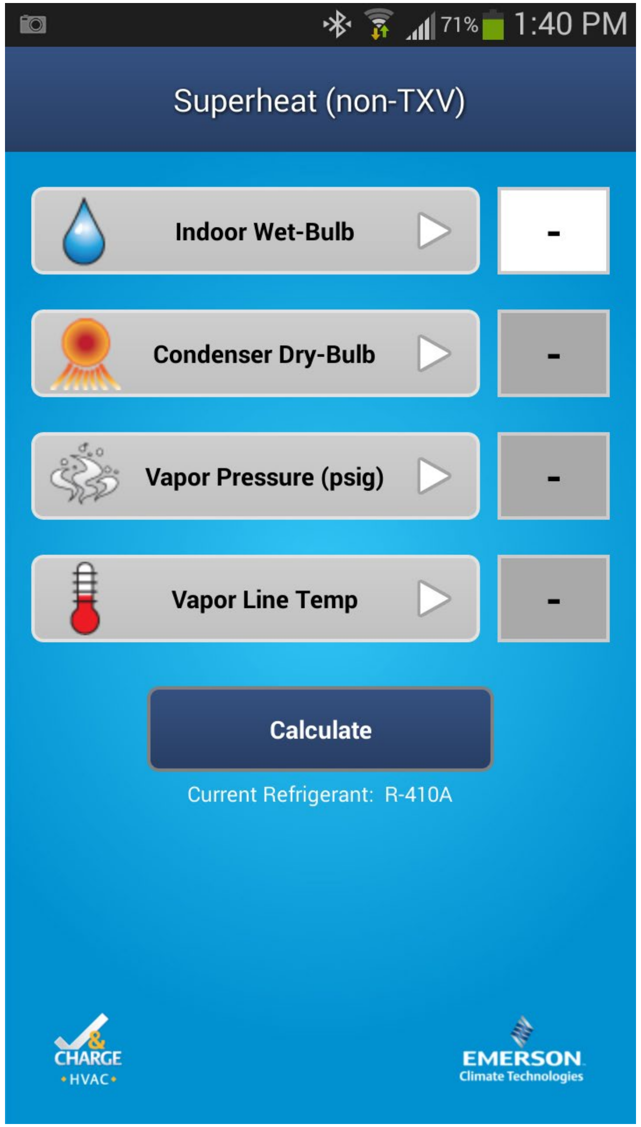
There in no magic number

Measure the outdoor air temperature dry bulb

Measure indoor temperature wet and dry bulb

Use units charging chart or slide calculator to determine super heat required for the above parameters

SUPERHEAT CHARGING



SUPERHEAT CHARGING

Used to find required superheat to charge too.

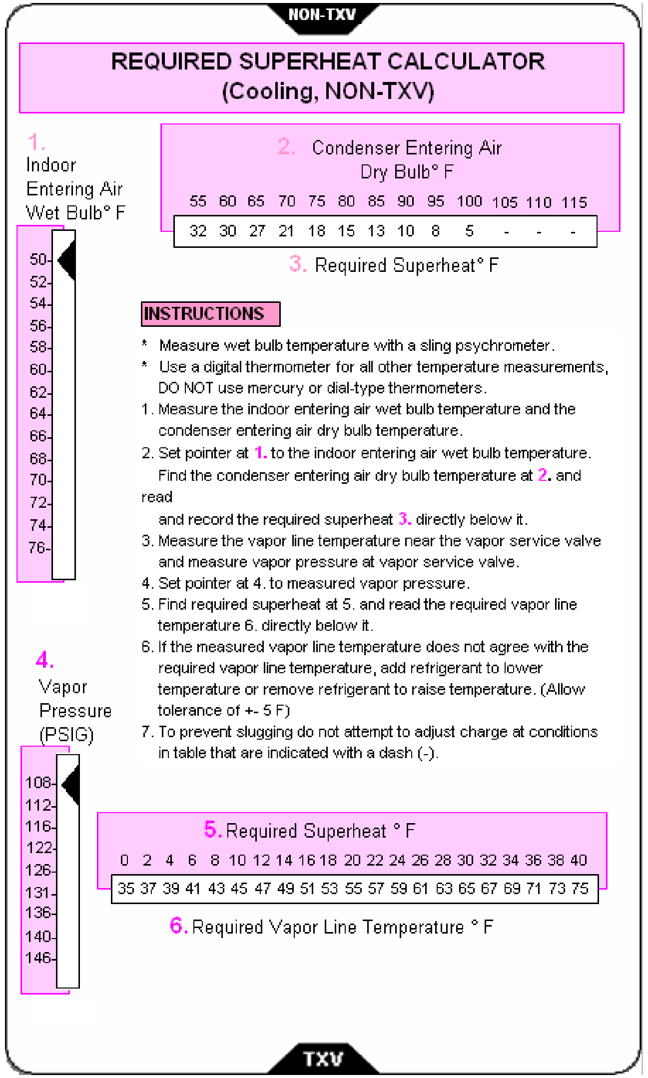
The chart on the inside of the unit panel ALWAYS trumps any slide chart OR phone app!

Table 4—Superheat Charging

OUTDOOR TEMP (°F)	EVAPORATOR ENTERING AIR TEMPERATURE (°F WB)													
	50	52	54	56	58	60	62	64	66	68	70	72	74	76
55	9	12	14	17	20	23	26	29	32	35	37	40	42	45
60	7	10	12	15	18	21	24	27	30	33	35	38	40	43
65	—	6	10	13	16	19	21	24	27	30	33	36	38	41
70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30	33	36	39
75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28	31	34	37
80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	25	28	31	35
85	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22	26	30	33
90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20	24	27	31
95	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18	22	25	29
100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15	20	23	27
105	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13	17	22	26
110	—	—	—	—	—	—	—	—	—	6	11	15	20	25
115	—	—	—	—	—	—	—	—	—	—	8	14	18	23

Where a dash (—) appears, do not attempt to charge system under these conditions or refrigerant slugging may occur. Charge must be weighed in.
NOTE: Superheat °F is at low-side service port.

Chart inside the unit



SUPERHEAT CHARGING

Outdoor dry bulb temperature 85 degrees F

Indoor wet bulb 68 degrees F

Required super heat is ? 19 Degrees F

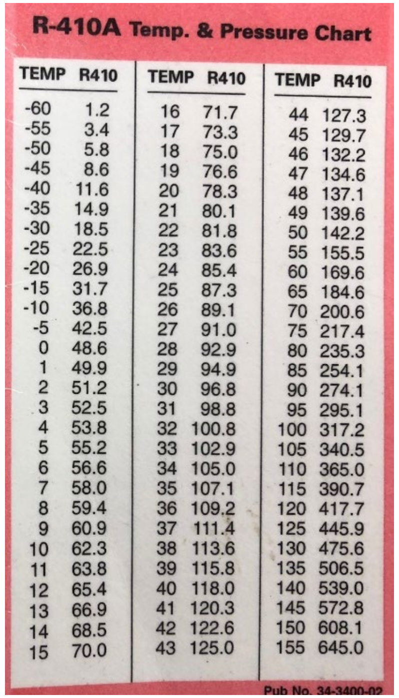
Table 4—Superheat Charging

OUTDOOR TEMP (°F)	EVAPORATOR ENTERING AIR TEMPERATURE (°F WB)													
	50	52	54	56	58	60	62	64	66	68	70	72	74	76
55	9	12	14	17	20	23	26	29	32	35	37	40	42	45
60	7	10	12	15	18	21	24	27	30	33	35	38	40	43
65	—	6	10	13	16	19	21	24	27	30	33	36	38	41
70	—	—	7	10	13	16	19	21	24	27	30	33	36	39
75	—	—	—	6	9	12	15	18	21	24	28	31	34	37
80	—	—	—	—	5	8	12	15	18	21	25	28	31	35
85	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	11	15	19	22	26	30	33
90	—	—	—	—	—	—	5	9	13	16	20	24	27	31
95	—	—	—	—	—	—	—	6	10	14	18	22	25	29
100	—	—	—	—	—	—	—	—	8	12	15	20	23	27
105	—	—	—	—	—	—	—	—	5	9	13	17	22	26
110	—	—	—	—	—	—	—	—	—	6	11	15	20	25
115	—	—	—	—	—	—	—	—	—	—	8	14	18	23

Where a dash (—) appears, do not attempt to charge system under these conditions or refrigerant slugging may occur. Charge must be weighed in.
NOTE: Superheat °F is at low-side service port.

SUPERHEAT CHARGING

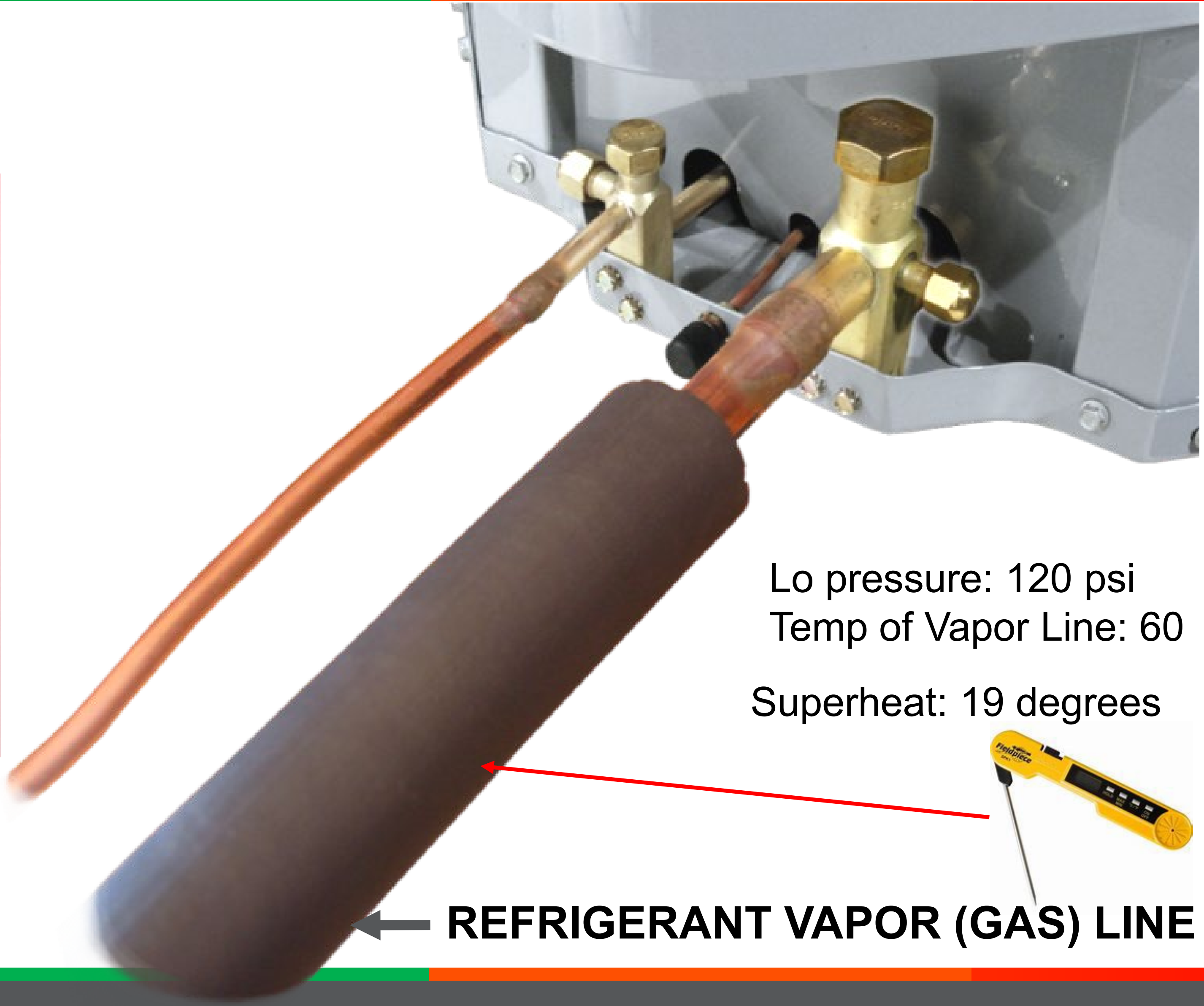
Example 1



R-410A Temp. & Pressure Chart

TEMP	R410	TEMP	R410	TEMP	R410
-60	1.2	16	71.7	44	127.3
-55	3.4	17	73.3	45	129.7
-50	5.8	18	75.0	46	132.2
-45	8.6	19	76.6	47	134.6
-40	11.6	20	78.3	48	137.1
-35	14.9	21	80.1	49	139.6
-30	18.5	22	81.8	50	142.2
-25	22.5	23	83.6	55	155.5
-20	26.9	24	85.4	60	169.6
-15	31.7	25	87.3	65	184.6
-10	36.8	26	89.1	70	200.6
-5	42.5	27	91.0	75	217.4
0	48.6	28	92.9	80	235.3
1	49.9	29	94.9	85	254.1
2	51.2	30	96.8	90	274.1
3	52.5	31	98.8	95	295.1
4	53.8	32	100.8	100	317.2
5	55.2	33	102.9	105	340.5
6	56.6	34	105.0	110	365.0
7	58.0	35	107.1	115	390.7
8	59.4	36	109.2	120	417.7
9	60.9	37	111.4	125	445.9
10	62.3	38	113.6	130	475.6
11	63.8	39	115.8	135	506.5
12	65.4	40	118.0	140	539.0
13	66.9	41	120.3	145	572.8
14	68.5	42	122.6	150	608.1
15	70.0	43	125.0	155	645.0

Pub No. 34-3400-02



Lo pressure: 120 psi

Temp of Vapor Line: 60

Superheat: 19 degrees

REFRIGERANT VAPOR (GAS) LINE

SUPERHEAT CHARGING

Outdoor dry bulb temperature 75 degrees F

Indoor wet bulb 66 degrees F

Required super heat is ? 21 Degrees F

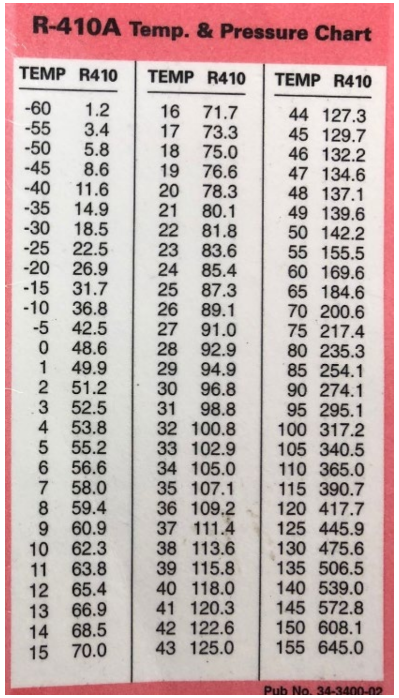
Table 4—Superheat Charging

OUTDOOR TEMP (°F)	EVAPORATOR ENTERING AIR TEMPERATURE (°F WB)													
	50	52	54	56	58	60	62	64	66	68	70	72	74	76
55	9	12	14	17	20	23	26	29	32	35	37	40	42	45
60	7	10	12	15	18	21	24	27	30	33	35	38	40	43
65	—	6	10	13	16	19	21	24	27	30	33	36	38	41
70	—	—	7	10	13	16	19	21	24	27	30	33	36	39
75				6	9	12	15	18	21	24	28	31	34	37
80	—	—	—	—	5	8	12	15	18	21	25	28	31	35
85	—	—	—	—	—	—	8	11	15	19	22	26	30	33
90	—	—	—	—	—	—	5	9	13	16	20	24	27	31
95	—	—	—	—	—	—	—	6	10	14	18	22	25	29
100	—	—	—	—	—	—	—	—	8	12	15	20	23	27
105	—	—	—	—	—	—	—	—	5	9	13	17	22	26
110	—	—	—	—	—	—	—	—	—	6	11	15	20	25
115	—	—	—	—	—	—	—	—	—	—	8	14	18	23

Where a dash (—) appears, do not attempt to charge system under these conditions or refrigerant slugging may occur. Charge must be weighed in.
NOTE: Superheat °F is at low-side service port.

SUPERHEAT CHARGING

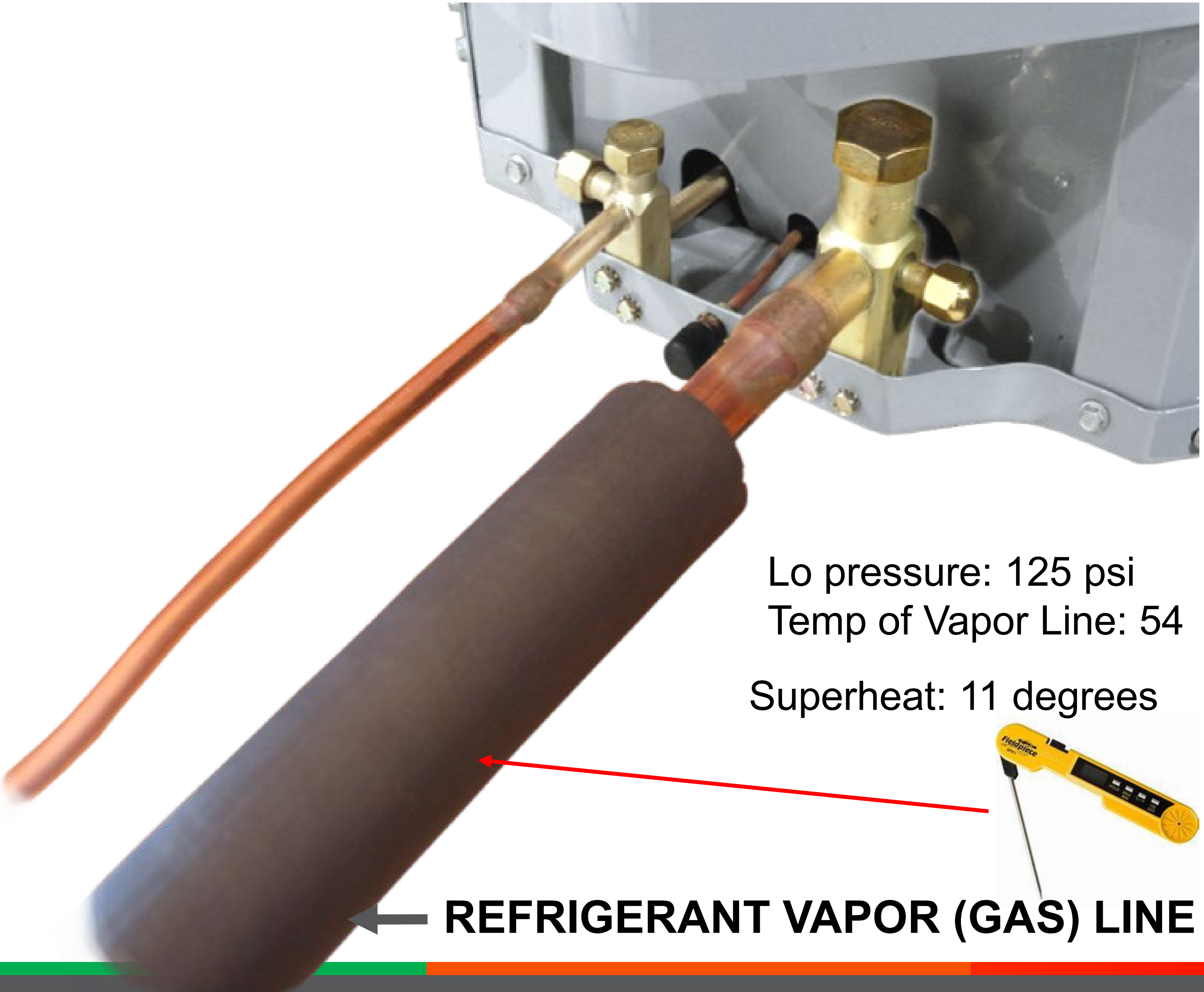
Example 2



R-410A Temp. & Pressure Chart

TEMP	R410	TEMP	R410	TEMP	R410
-60	1.2	16	71.7	44	127.3
-55	3.4	17	73.3	45	129.7
-50	5.8	18	75.0	46	132.2
-45	8.6	19	76.6	47	134.6
-40	11.6	20	78.3	48	137.1
-35	14.9	21	80.1	49	139.6
-30	18.5	22	81.8	50	142.2
-25	22.5	23	83.6	55	155.5
-20	26.9	24	85.4	60	169.6
-15	31.7	25	87.3	65	184.6
-10	36.8	26	89.1	70	200.6
-5	42.5	27	91.0	75	217.4
0	48.6	28	92.9	80	235.3
1	49.9	29	94.9	85	254.1
2	51.2	30	96.8	90	274.1
3	52.5	31	98.8	95	295.1
4	53.8	32	100.8	100	317.2
5	55.2	33	102.9	105	340.5
6	56.6	34	105.0	110	365.0
7	58.0	35	107.1	115	390.7
8	59.4	36	109.2	120	417.7
9	60.9	37	111.4	125	445.9
10	62.3	38	113.6	130	475.6
11	63.8	39	115.8	135	506.5
12	65.4	40	118.0	140	539.0
13	66.9	41	120.3	145	572.8
14	68.5	42	122.6	150	608.1
15	70.0	43	125.0	155	645.0

Pub No. 34-3400-02



Lo pressure: 125 psi

Temp of Vapor Line: 54

Superheat: 11 degrees

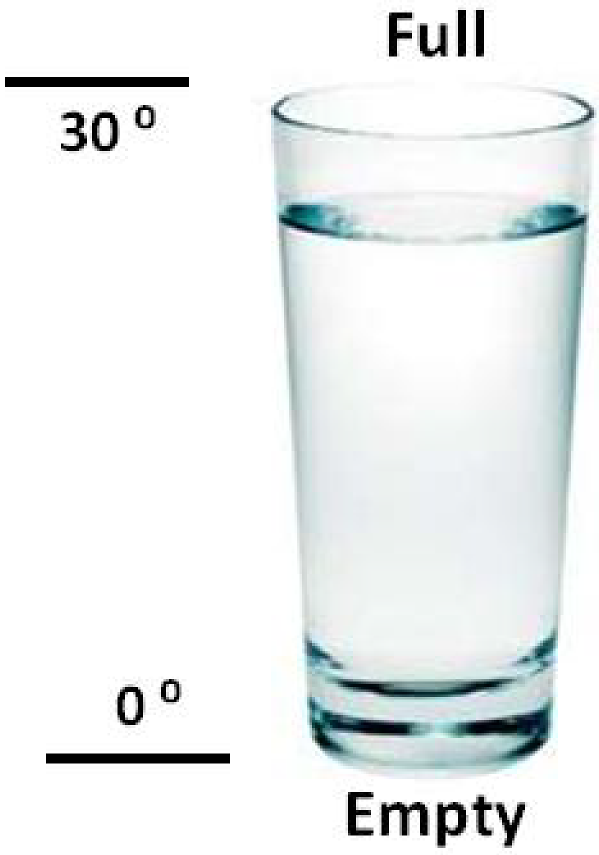
REFRIGERANT VAPOR (GAS) LINE

SUPERHEAT CHARGING

- If superheat is **above** target superheat **add** refrigerant
- If superheat is **below** target superheat **remove** refrigerant

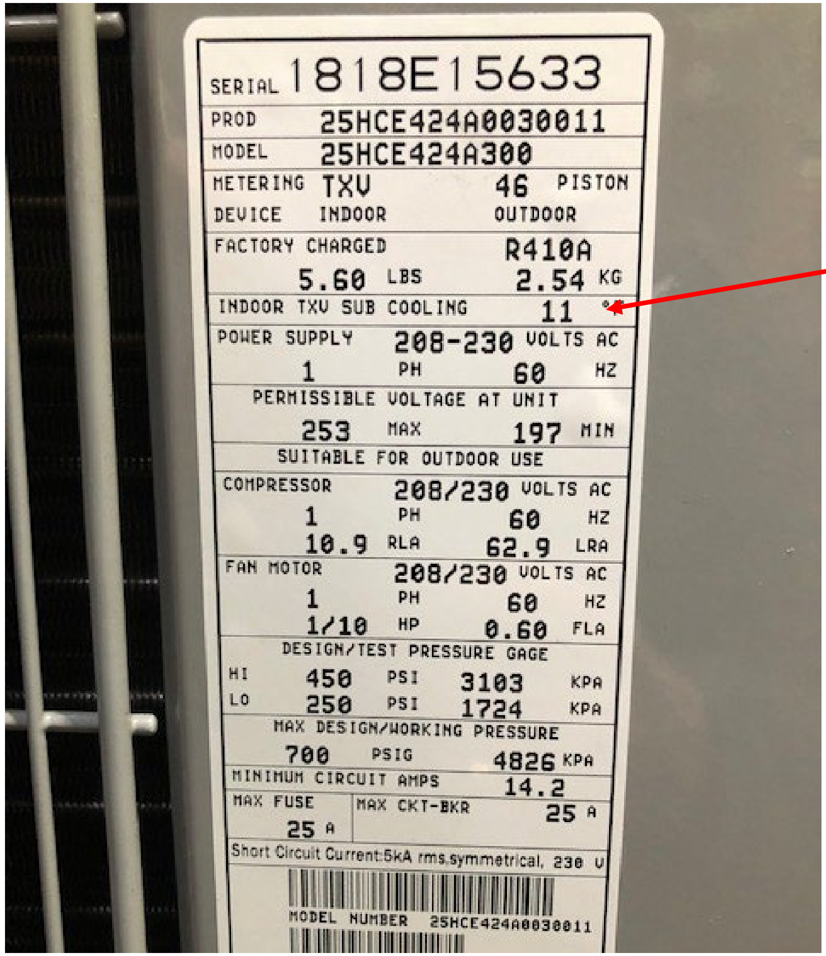
SUBCOOLING EXPLAINED

<u>SubCooling (TXV):</u>
The **BIGGER** the number, the more **LIQUID** there is in the **CONDENSING COIL**.



TXV Charging

What is our target subcooling?



Tip: : Every unit has a +/- of 3 degrees

Short line sets should favor the low end

Long line sets should favor the hi end

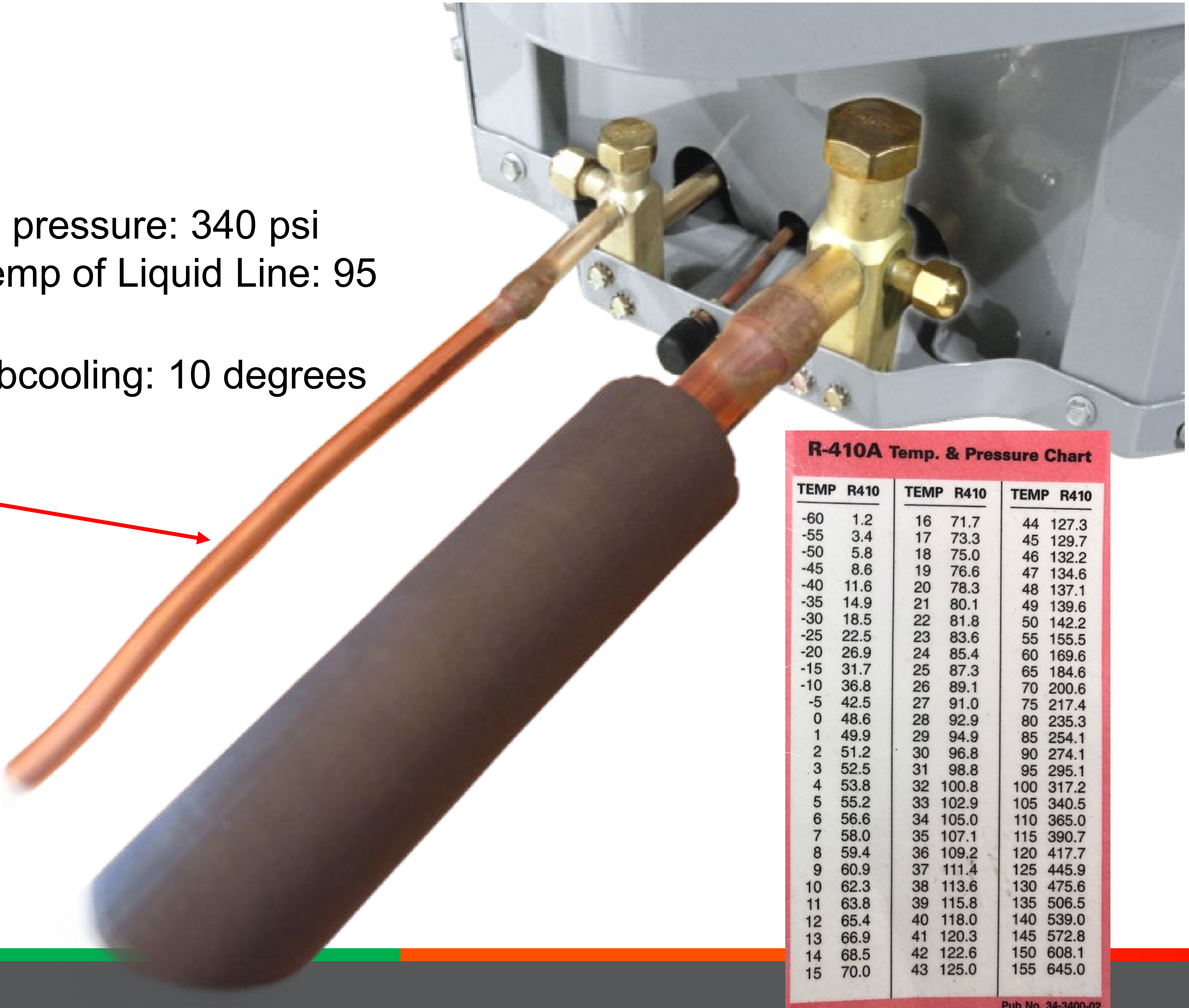
ALL system's need to run 15 mins no matter what SEER

TXV Charging

Example 1

Hi pressure: 340 psi
Temp of Liquid Line: 95

Subcooling: 10 degrees



LIQUID REFRIGERANT LINE

R-410A Temp. & Pressure Chart

TEMP	R410	TEMP	R410	TEMP	R410
-60	1.2	16	71.7	44	127.3
-55	3.4	17	73.3	45	129.7
-50	5.8	18	75.0	46	132.2
-45	8.6	19	76.6	47	134.6
-40	11.6	20	78.3	48	137.1
-35	14.9	21	80.1	49	139.6
-30	18.5	22	81.8	50	142.2
-25	22.5	23	83.6	55	155.5
-20	26.9	24	85.4	60	169.6
-15	31.7	25	87.3	65	184.6
-10	36.8	26	89.1	70	200.6
-5	42.5	27	91.0	75	217.4
0	48.6	28	92.9	80	235.3
1	49.9	29	94.9	85	254.1
2	51.2	30	96.8	90	274.1
3	52.5	31	98.8	95	295.1
4	53.8	32	100.8	100	317.2
5	55.2	33	102.9	105	340.5
6	56.6	34	105.0	110	365.0
7	58.0	35	107.1	115	390.7
8	59.4	36	109.2	120	417.7
9	60.9	37	111.4	125	445.9
10	62.3	38	113.6	130	475.6
11	63.8	39	115.8	135	506.5
12	65.4	40	118.0	140	539.0
13	66.9	41	120.3	145	572.8
14	68.5	42	122.6	150	608.1
15	70.0	43	125.0	155	645.0

Pub No. 34-3400-02

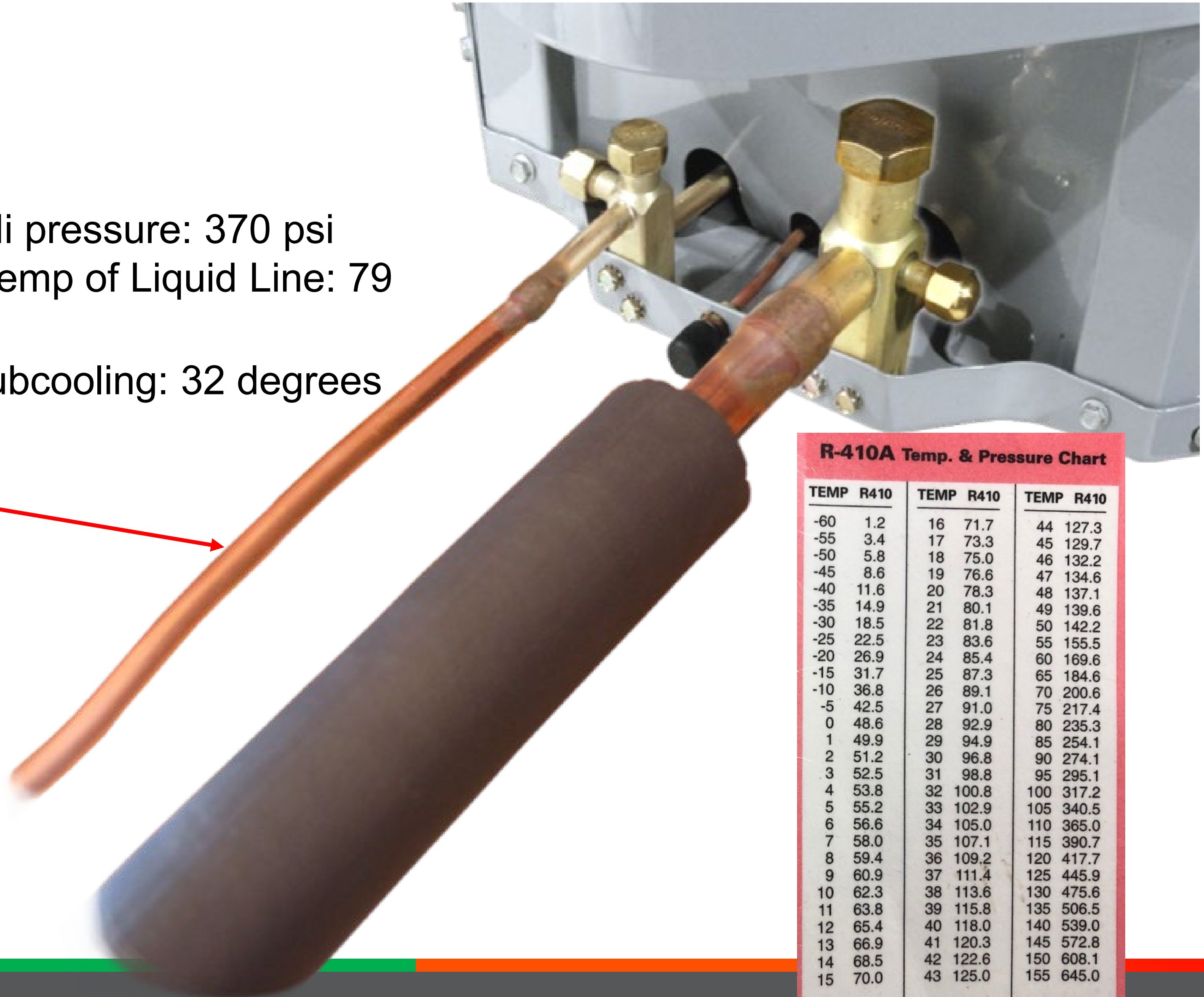
TXV Charging

Example 2

Hi pressure: 370 psi
Temp of Liquid Line: 79

Subcooling: 32 degrees

LIQUID REFRIGERANT LINE



R-410A Temp. & Pressure Chart

TEMP	R410	TEMP	R410	TEMP	R410
-60	1.2	16	71.7	44	127.3
-55	3.4	17	73.3	45	129.7
-50	5.8	18	75.0	46	132.2
-45	8.6	19	76.6	47	134.6
-40	11.6	20	78.3	48	137.1
-35	14.9	21	80.1	49	139.6
-30	18.5	22	81.8	50	142.2
-25	22.5	23	83.6	55	155.5
-20	26.9	24	85.4	60	169.6
-15	31.7	25	87.3	65	184.6
-10	36.8	26	89.1	70	200.6
-5	42.5	27	91.0	75	217.4
0	48.6	28	92.9	80	235.3
1	49.9	29	94.9	85	254.1
2	51.2	30	96.8	90	274.1
3	52.5	31	98.8	95	295.1
4	53.8	32	100.8	100	317.2
5	55.2	33	102.9	105	340.5
6	56.6	34	105.0	110	365.0
7	58.0	35	107.1	115	390.7
8	59.4	36	109.2	120	417.7
9	60.9	37	111.4	125	445.9
10	62.3	38	113.6	130	475.6
11	63.8	39	115.8	135	506.5
12	65.4	40	118.0	140	539.0
13	66.9	41	120.3	145	572.8
14	68.5	42	122.6	150	608.1
15	70.0	43	125.0	155	645.0

Pub No. 34-3400-02

TXV Charging

- If subcooling is **above** target subcooling **remove** refrigerant
- If subcooling is **below** target subcooling **add** refrigerant

- NOW is the TXV working?

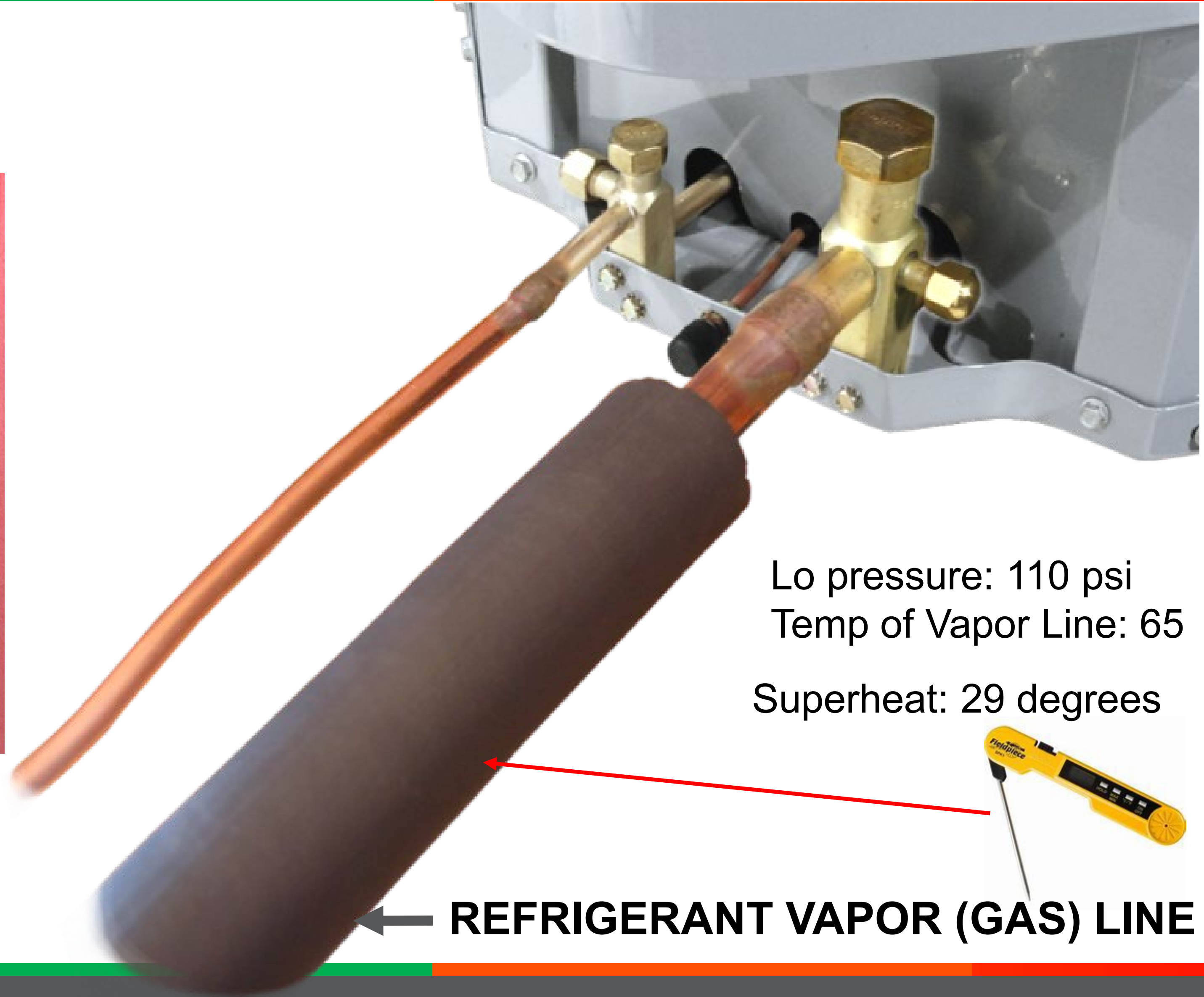
IS THE TXV WORKING?

Example 1

R-410A Temp. & Pressure Chart

TEMP	R410	TEMP	R410	TEMP	R410
-60	1.2	16	71.7	44	127.3
-55	3.4	17	73.3	45	129.7
-50	5.8	18	75.0	46	132.2
-45	8.6	19	76.6	47	134.6
-40	11.6	20	78.3	48	137.1
-35	14.9	21	80.1	49	139.6
-30	18.5	22	81.8	50	142.2
-25	22.5	23	83.6	55	155.5
-20	26.9	24	85.4	60	169.6
-15	31.7	25	87.3	65	184.6
-10	36.8	26	89.1	70	200.6
-5	42.5	27	91.0	75	217.4
0	48.6	28	92.9	80	235.3
1	49.9	29	94.9	85	254.1
2	51.2	30	96.8	90	274.1
3	52.5	31	98.8	95	295.1
4	53.8	32	100.8	100	317.2
5	55.2	33	102.9	105	340.5
6	56.6	34	105.0	110	365.0
7	58.0	35	107.1	115	390.7
8	59.4	36	109.2	120	417.7
9	60.9	37	111.4	125	445.9
10	62.3	38	113.6	130	475.6
11	63.8	39	115.8	135	506.5
12	65.4	40	118.0	140	539.0
13	66.9	41	120.3	145	572.8
14	68.5	42	122.6	150	608.1
15	70.0	43	125.0	155	645.0

Pub No. 34-3400-02



Lo pressure: 110 psi
Temp of Vapor Line: 65

Superheat: 29 degrees

REFRIGERANT VAPOR (GAS) LINE

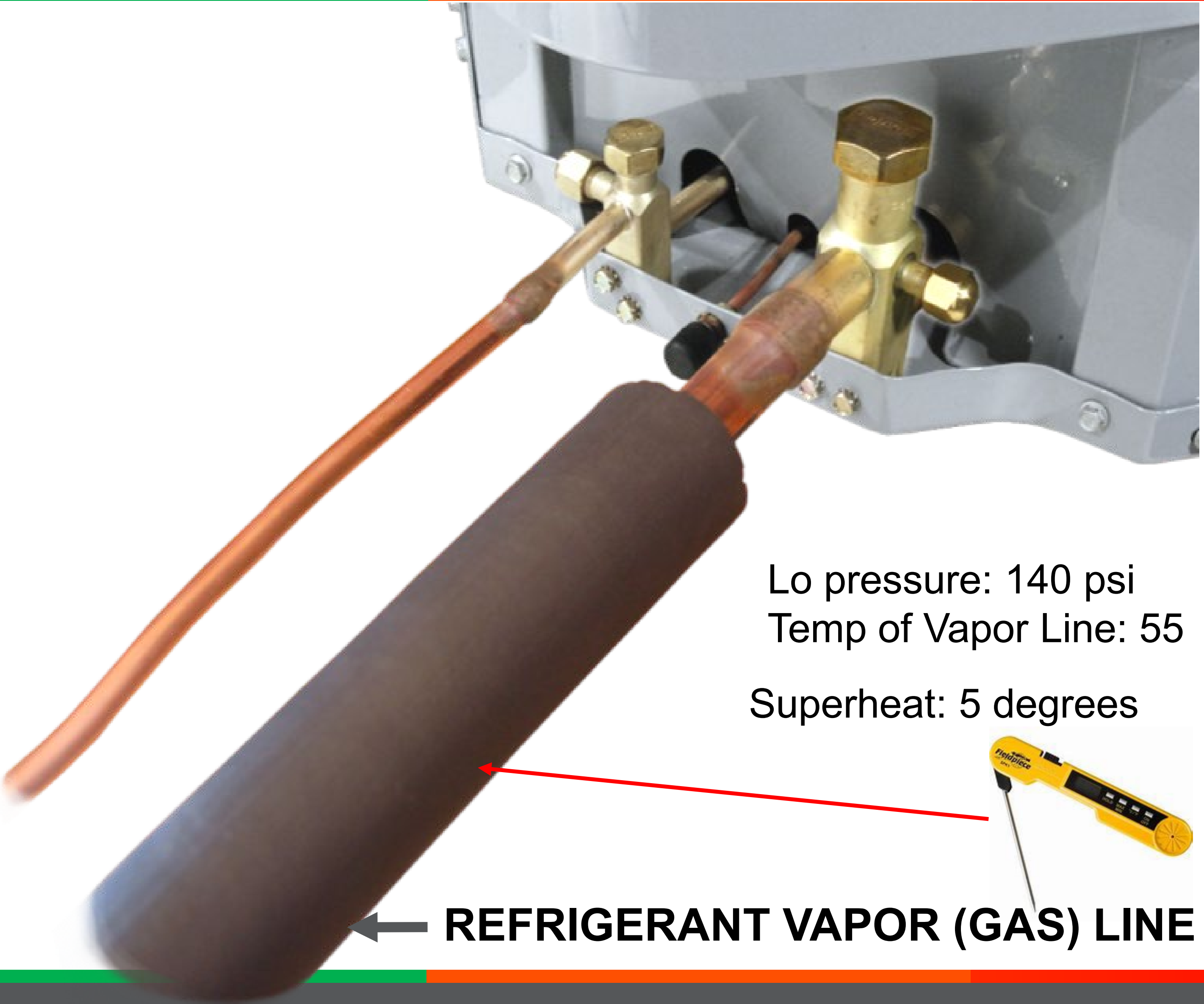
IS THE TXV WORKING?

Example 2

R-410A Temp. & Pressure Chart

TEMP	R410	TEMP	R410	TEMP	R410
-60	1.2	16	71.7	44	127.3
-55	3.4	17	73.3	45	129.7
-50	5.8	18	75.0	46	132.2
-45	8.6	19	76.6	47	134.6
-40	11.6	20	78.3	48	137.1
-35	14.9	21	80.1	49	139.6
-30	18.5	22	81.8	50	142.2
-25	22.5	23	83.6	55	155.5
-20	26.9	24	85.4	60	169.6
-15	31.7	25	87.3	65	184.6
-10	36.8	26	89.1	70	200.6
-5	42.5	27	91.0	75	217.4
0	48.6	28	92.9	80	235.3
1	49.9	29	94.9	85	254.1
2	51.2	30	96.8	90	274.1
3	52.5	31	98.8	95	295.1
4	53.8	32	100.8	100	317.2
5	55.2	33	102.9	105	340.5
6	56.6	34	105.0	110	365.0
7	58.0	35	107.1	115	390.7
8	59.4	36	109.2	120	417.7
9	60.9	37	111.4	125	445.9
10	62.3	38	113.6	130	475.6
11	63.8	39	115.8	135	506.5
12	65.4	40	118.0	140	539.0
13	66.9	41	120.3	145	572.8
14	68.5	42	122.6	150	608.1
15	70.0	43	125.0	155	645.0

Pub No. 34-3400-02



Lo pressure: 140 psi
Temp of Vapor Line: 55

Superheat: 5 degrees

REFRIGERANT VAPOR (GAS) LINE

IS THE TXV WORKING?

- TXV's are typically designed for 15 degrees of superheat during normal conditions
  - If low superheat, 2-10 degrees you could have
    - Low airflow
    - Low Load(home is cool, 70 degrees or below)
    - Dirty filter
  - If hi superheat, 15-25 degrees you could have
    - Hi airflow
    - Hi Load (home is warm, 80 degrees or higher)
- If the subcooling is correct and superheat is above 30 degrees, the TXV has most likely failed

THE PERFECT SERVICE VISIT

- Upon arrival meet & greet the homeowner
- Place the thermostat in the Emergency heat position
- Go to the indoor unit, operate the system for 10 mins.
- Measure the supply voltage, Aux heat amp draw, and measure the temp split of the Aux heat only. Inspect the coil, filter, drain pans and see what type of metering device.
- Calculate CFM, make any adjustments needed to meet target airflow, 400 cfm +/- 50 cfm per a ton before proceeding
- CFM Validated
- Place the unit in cooling mode and measure your return DB and WB temperature
- Allow the unit to run in cooling for 15 mins, every system, every type of metering device and measure the Hi and Low pressures and the Liquid and Vapor line temperatures.
- **Charge Validated**

Capacity Measurement

Total Capacity Formula

Capacity = CFM X 4.5 X Delta H

We now know the CFM
All we need is the entering and leaving wet bulb temperatures
Place the unit in cooling and allow to operate for 15 mins if not already running

Write it down, save it, memorize it, store it, print it, keep it,
add it to your toolbox!!! Make money $$$ with it!!!

CE

THE PERFECT SERVICE VISIT

- Upon arrival meet & greet the homeowner
- Place the thermostat in the Emergency heat position
- Go to the indoor unit, operate the system for 10 mins.
- Measure the supply voltage, Aux heat amp draw, and measure the temp split of the Aux heat only. Inspect the coil, filter, drain pans and see what type of metering device.
- Calculate CFM, make any adjustments needed to meet target airflow, 400 cfm +/- 50 cfm per a ton before proceeding
- CFM Validated
- Place the unit in cooling mode and measure your return DB and WB temperature
- Allow the unit to run in cooling for 15 mins, every system, every type of metering device and measure the Hi and Low pressures and the Liquid and Vapor line temperatures.
- Charge Validated
- **Measure WB and Dry bulb temperatures at the indoor unit**

Electric Heat Method(recap)

Formula:

$$\text{CFM} = \frac{\text{Voltage x Amperage x 3.414}}{\text{1.08 x Temperature Rise } (\triangle T)}$$

Air Handler Supply Voltage: 244 Volts

Air Handler Section Amperage: 38 Amps

Supply Air Temp: 105F

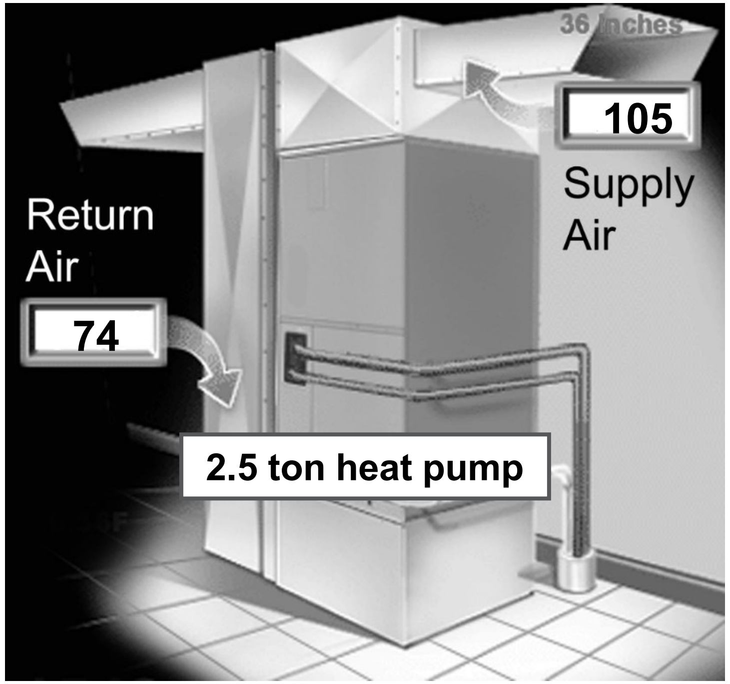
Return Air Temp: 74F

1. 244 Volts x 38 Amps x 3.414=
   31,654 BTUH Output

2. 105F - 74F = 31F (△T)

3. $\frac{31654}{1.08 \times 31}$

4. $\frac{31654}{33.48}$ = 945 CFM



Cooling Mode

Voltage = 244 Volts
Amperage draw = 38 Amps

Example 1

Capacity Measurement

Formula:

Total Capacity = CFM X 4.5 X Delta H

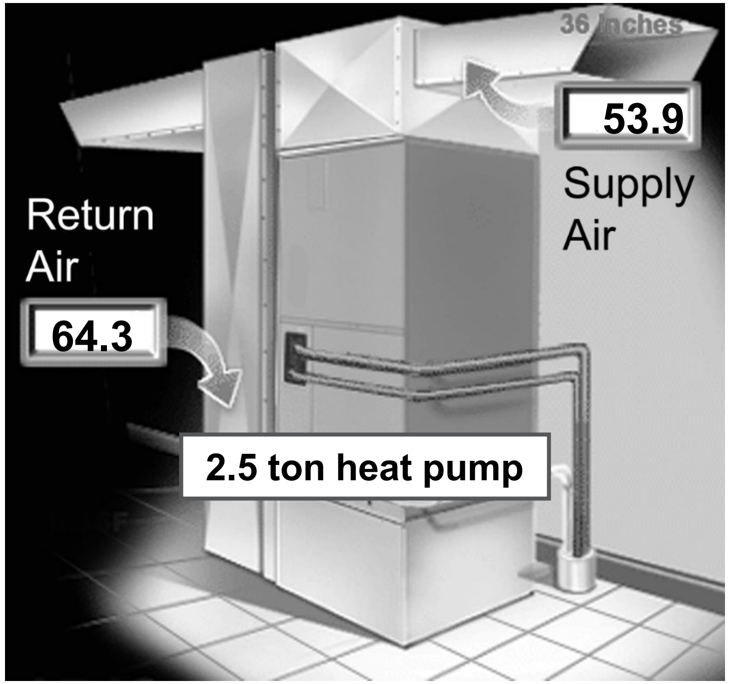
Air Handler Supply

CFM: 945

Supply Air Temp: 54 DB 53.9 WBF

Return Air Temp: 74 DB 64.3 WBF

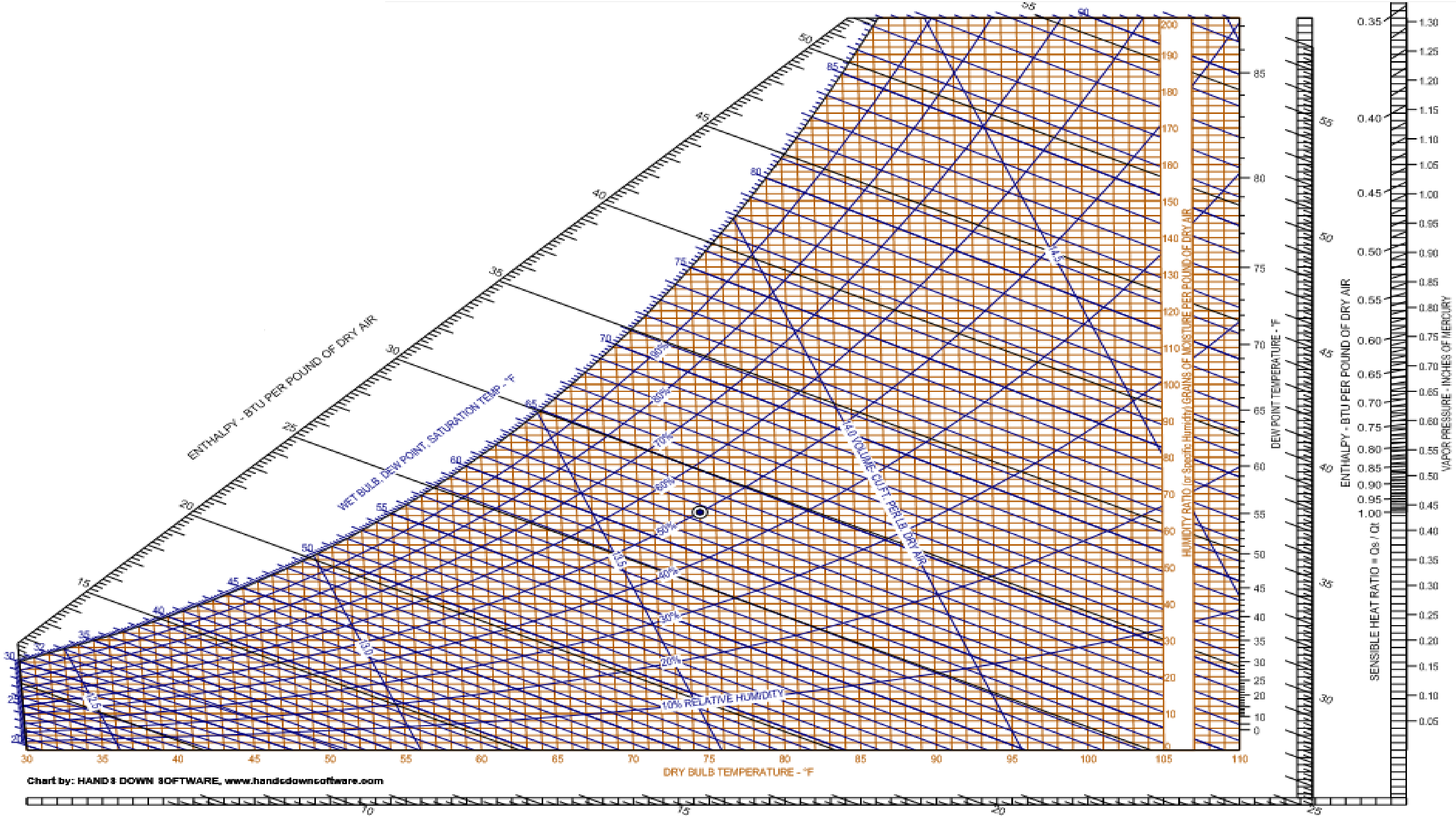
1. **Check chart convert WB to Heat**
2. **RA(H) – SA(H) = (△H)**
3. **cfm X 4.5 X (△H)**
4. **TOTAL BTU's produced**



Cooling Mode

Example 1

Psychrometric Chart



Capacity Measurement

Can be found on the internet

Cooling Mode

WET BULB TEMPER-ATURE	.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
51	20.86	20.92	20.98	21.04	21.09	21.15	21.21	21.26	21.32	21.38
52	21.44	21.49	21.55	21.60	21.66	21.72	21.78	21.83	21.89	21.95
53	22.02	22.06	22.12	22.18	22.24	22.30	22.36	22.43	22.49	22.55
54	22.62	22.68	22.74	22.80	22.86	22.92	22.98	23.04	23.11	23.16
55	23.22	23.28	23.34	23.40	23.46	23.52	23.58	23.64	23.71	23.77
56	23.84	23.90	23.96	24.03	23.09	24.15	24.21	24.28	24.34	24.40
57	24.48	24.53	24.59	24.66	24.72	24.79	24.85	24.92	24.99	25.05
58	25.12	25.18	25.25	25.32	25.38	25.45	25.51	25.58	25.65	25.71
59	25.78	25.85	25.91	25.99	26.06	26.12	26.19	26.26	26.33	26.39
60	26.46	26.53	56.60	26.67	26.74	26.81	26.88	26.94	27.01	27.08
61	27.15	27.21	27.28	27.35	27.42	27.48	27.55	27.62	27.69	27.76
62	27.85	27.92	28.00	28.07	28.14	28.21	28.29	28.36	28.43	28.50
63	28.57	28.65	28.72	28.79	28.86	28.94	29.01	29.08	29.16	29.23
64	29.31	29.38	29.45	29.53	29.60	29.68	29.76	29.83	29.91	29.98
65	30.06	30.13	30.21	30.29	30.37	30.45	30.52	30.60	38.68	30.76
66	30.83	30.92	31.00	31.07	31.15	31.23	31.31	31.39	31.47	31.54
67	31.62	31.70	31.77	31.85	31.93	32.01	32.09	32.17	32.25	32.33
68	32.42	32.51	32.59	32.67	32.76	32.84	32.92	33.01	33.09	33.17
69	33.25	33.34	33.42	33.50	33.59	33.67	33.75	33.84	33.92	34.01
70	34.09	34.17	34.26	34.34	34.43	34.51	34.60	34.69	34.77	34.86
71	34.95	25.04	35.13	35.22	35.31	35.40	35.48	35.57	35.66	35.74
72	35.83	35.92	36.01	36.10	36.19	36.27	36.37	36.46	36.55	36.65
73	36.74	36.83	36.92	37.02	37.11	37.21	37.30	37.39	37.48	37.57
74	37.66	37.76	37.85	37.94	38.04	38.14	38.23	38.33	38.43	38.52
75	38.61	38.71	38.80	38.90	39.00	39.09	39.19	39.28	39.37	39.47
76	39.57	39.67	39.77	39.87	39.97	40.07	34.17	40.27	40.37	40.47
77	40.57	40.68	40.78	40.88	40.98	40.08	41.18	41.28	41.38	41.48
78	41.58	41.69	41.79	41.89	42.00	42.10	42.20	42.31	42.41	42.52
79	42.62	42.73	42.83	42.94	43.05	43.15	43.26	43.37	43.48	43.59
80	43.69	43.81	43.91	44.02	44.13	44.24	44.36	44.46	44.57	44.68
81	44.78	44.89	45.00	45.11	45.23	45.34	45.45	45.57	45.68	45.80
82	45.90	46.02	46.13	4.24	46.35	46.47	46.58	46.69	46.71	46.82
83	47.04	47.16	47.28	47.40	47.52	47.63	47.75	47.87	48.00	48.10
84	48.22	48.34	48.46	48.58	48.70	48.82	48.94	49.06	49.19	49.31
85	49.43	49.56	49.68	49.70	49.92	50.05	50.17	50.29	50.41	50.54

ENTHALPY CHART
WET BULB TO ENTHALPY CONVERSION
Wet bulb temperature in tenths of a degree Fahrenheit

Measure any wet bulb temperature. Select the temperature from the left column, then the tenth of a degree from the columns to the right. This will be the heat content of one pound of air at the corresponding wet temperature. To determine enthalpy change, also known as ΔHT, locate the enthalpy of two wet bulb bulb readings subtract the enthalpy values.

Capacity Measurement

Formula:

Total Capacity = CFM X 4.5 X Delta H

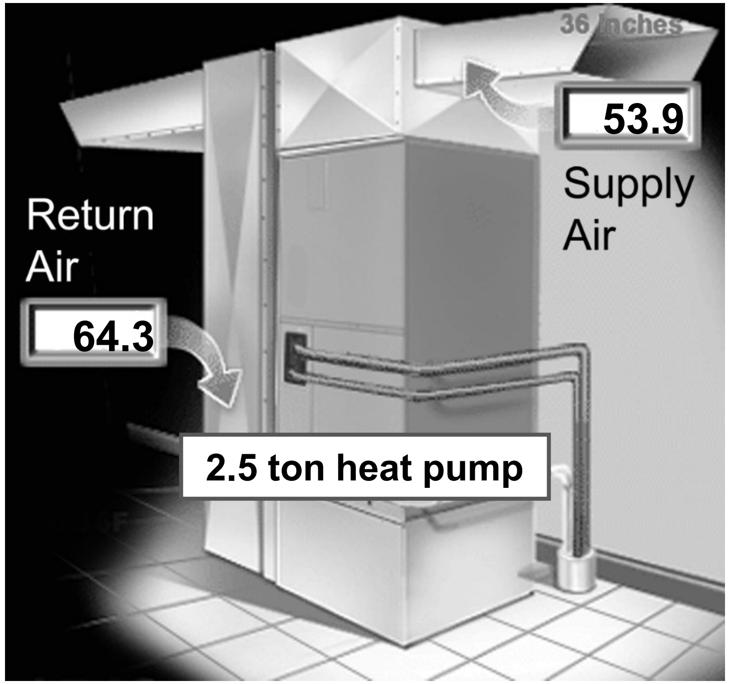
Air Handler Supply

CFM: 945

Supply Air Temp: 54 DB 53.9 WBF

Return Air Temp: 74 DB 64.3 WBF

1. **Check chart convert WB to Heat**
2. **29.53 – 22.55 = 6.98 (△H)**
3. **945 X 4.5 X 6.98**
4. **29,682 TOTAL BTU's produced**



Example 1

Cooling Mode

Capacity Measurement

Formula:

Sensible Capacity = CFM X 1.08 X Delta T

Air Handler Supply

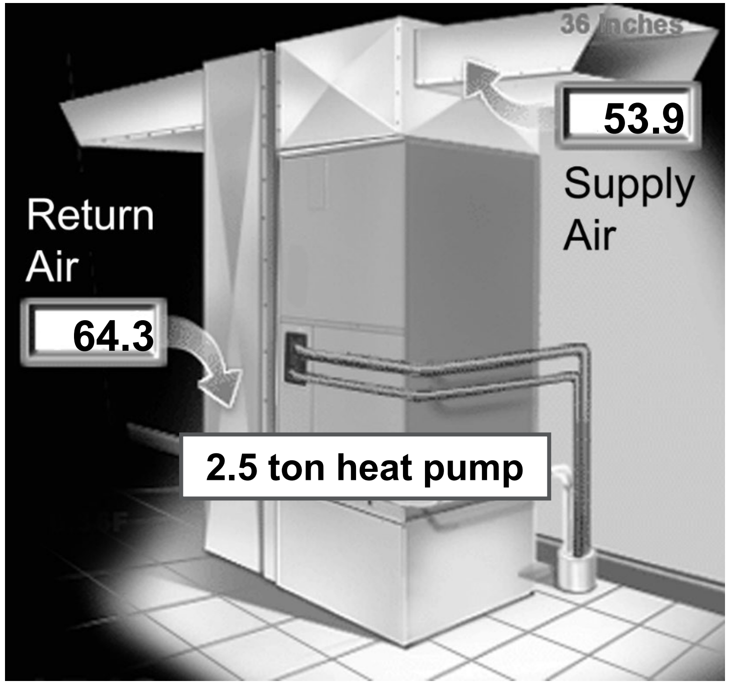
CFM: 945

Supply Air Temp: 55 DB 53.9 WBF

Return Air Temp: 74 DB 64.3 WBF

1. **74 – 55 = 19 (△T)**
2. **945 X 1.08 X 19**
3. **19,391 SENSINBLE BTU's produced**

Cooling Mode



Example 1

Capacity Measurement

Example 1:

We measured 244 volts power supply
We measured 38 amps on the Elec. Heat
We measured a 31 degree Elec. heat temp split
We measured the WB and DB temps in cooling mode

We had 29,862 BTU's of Total capacity
We had 19,391 BTU's of Sensible cooling

Capacity Measurement

EVAPORATOR AIR		CONDENSER ENTERING AIR TEMPERATURES °F (°C)											
		75 (23.9)			85 (29.4)			95 (35)			105 (40.6)		
CFM	EWB °F (°C)	Capacity MBtuh Total	Capacity MBtuh Sens‡	Total Syst. KW**	Capacity MBtuh Total	Capacity MBtuh Sens‡	Total Syst. KW**	Capacity MBtuh Total	Capacity MBtuh Sens‡	Total Syst. KW**	Capacity MBtuh Total	Capacity MBtuh Sens‡	Total Syst. KW**
25HCE430—30 Outdoor Section With FB4CNP030L Indoor Section													
875	72 (22.2)	33.97	17.32	1.97	32.47	16.75	2.17	30.87	16.16	2.40	29.15	15.54	2.67
	67 (19.4)	30.80	21.30	1.97	29.42	20.72	2.17	27.96	20.13	2.40	26.39	19.50	2.67
	63 (17.2)††	28.51	20.46	1.97	27.22	19.89	2.17	25.86	19.29	2.41	24.39	18.66	2.67
	62 (16.7)	27.99	25.15	1.97	26.74	24.55	2.17	25.44	23.90	2.41	24.07	23.17	2.67
	57 (13.9)	27.05	27.05	1.97	26.06	26.06	2.18	25.01	25.01	2.41	23.88	23.88	2.67
1050	72 (22.2)	34.85	18.48	2.00	33.25	17.90	2.21	31.57	17.30	2.44	29.76	16.66	2.71
	67 (19.4)	31.61	23.17	2.01	30.15	22.59	2.21	28.60	21.97	2.44	26.95	21.32	2.71
	63 (17.2)††	29.28	22.21	2.01	27.91	21.62	2.21	26.47	21.00	2.45	24.94	20.34	2.71
	62 (16.7)	28.88	27.53	2.01	27.62	27.37	2.21	26.36	26.36	2.45	25.12	25.12	2.71
	57 (13.9)	28.55	28.55	2.01	27.48	27.48	2.21	26.33	26.33	2.45	25.09	25.09	2.71
1125	72 (22.2)	35.15	18.97	2.02	33.53	18.39	2.23	31.81	17.78	2.46	29.96	17.13	2.73
	67 (19.4)	31.89	23.96	2.02	30.38	23.37	2.23	28.82	22.74	2.46	27.14	22.07	2.73
	63 (17.2)††	29.55	22.94	2.03	28.15	22.34	2.23	26.69	21.71	2.46	25.12	21.03	2.73
	62 (16.7)	29.18	29.18	2.03	28.02	28.02	2.23	26.83	26.83	2.46	25.55	25.55	2.73
	57 (13.9)	29.10	29.10	2.03	27.98	27.98	2.23	26.80	26.80	2.46	25.52	25.52	2.73

This is the Kw rating for the unit which means the unit running should consume 2.21 Kw
2.21 X 1000 = 2210 watts
2210 / your input voltage
2210 / 239 volts = 9.2 total system amps

Electric Heat Method(recap)

Formula:

$$CFM = \frac{\text{Voltage x Amperage x 3.414}}{\text{1.08 x Temperature Rise } (\triangle T)}$$

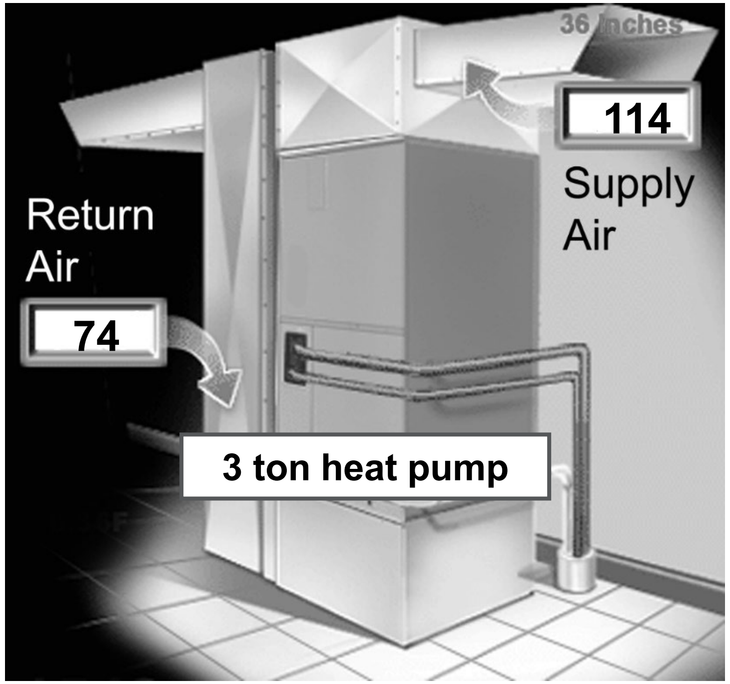
Air Handler Supply Voltage: 238 Volts

Air Handler Section Amperage: 58 Amps

Supply Air Temp: 114F

Return Air Temp: 74F

1. 238 Volts x 58 Amps x 3.414=
   47,127 BTUH Output
2. 114F - 74F = 40F ($\triangle$T)
3. $$\frac{47{,}127}{1.08 \times 40}$$
4. $$\frac{47{,}127}{43.2} = 1090 \text{ CFM}$$



Cooling Mode

Voltage = 238 Volts
Amperage draw = 58 Amps

Example 2

Capacity Measurement

Cooling Mode

Formula:

Total Capacity = CFM X 4.5 X Delta H

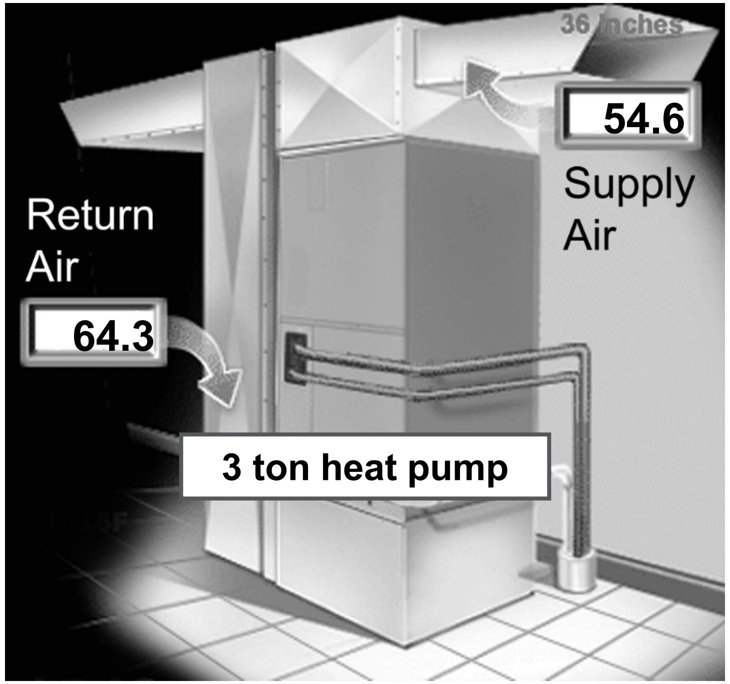
Air Handler Supply

CFM: 1090

Supply Air Temp: 55 DB 54.6 WBF

Return Air Temp: 74 DB 64.3 WBF

1. **Check chart convert WB to Heat**



Example 2

Capacity Measurement

Can be found on the internet

Cooling Mode

WET BULB TEMPER-ATURE	.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
51	20.86	20.92	20.98	21.04	21.09	21.15	21.21	21.26	21.32	21.38
52	21.44	21.49	21.55	21.60	21.66	21.72	21.78	21.83	21.89	21.95
53	22.02	22.06	22.12	22.09	22.24	22.30	22.36	22.43	22.49	22.55
54	22.62	22.68	22.74	22.80	22.86	22.92	22.98	23.04	23.11	23.16
55	23.22	23.28	23.34	23.40	23.46	23.52	23.58	23.64	23.71	23.77
56	23.84	23.90	23.96	24.03	23.09	24.15	24.21	24.28	24.34	24.40
57	24.48	24.53	24.59	24.66	24.72	24.79	24.85	24.92	24.99	25.05
58	25.12	25.18	25.25	25.32	25.38	25.45	25.51	25.58	25.65	25.71
59	25.78	25.85	25.91	25.99	26.06	26.12	26.19	26.26	26.33	26.39
60	26.46	26.53	56.60	26.67	26.74	26.81	26.88	26.94	27.01	27.08
61	27.15	27.21	27.28	27.35	27.42	27.48	27.55	27.62	27.69	27.76
62	27.85	27.92	28.00	28.07	28.14	28.21	28.29	28.36	28.43	28.50
63	28.57	28.65	28.72	28.79	28.86	28.94	29.01	29.08	29.16	29.23
64	29.31	29.38	29.45	29.53	29.60	29.68	29.76	29.83	29.91	29.98
65	30.06	30.13	30.21	30.29	30.37	30.45	30.52	30.60	38.68	30.76
66	30.83	30.92	31.00	31.07	31.15	31.23	31.31	31.39	31.47	31.54
67	31.62	31.70	31.77	31.85	31.93	32.01	32.09	32.17	32.25	32.33
68	32.42	32.51	32.59	32.67	32.76	32.84	32.92	33.01	33.09	33.17
69	33.25	33.34	33.42	33.50	33.59	33.67	33.75	33.84	33.92	34.01
70	34.09	34.17	34.26	34.34	34.43	34.51	34.60	34.69	34.77	34.86
71	34.95	25.04	35.13	35.22	35.31	35.40	35.48	35.57	35.66	35.74
72	35.83	35.92	36.01	36.10	36.19	36.27	36.37	36.46	36.55	36.65
73	36.74	36.83	36.92	37.02	37.11	37.21	37.30	37.39	37.48	37.57
74	37.66	37.76	37.85	37.94	38.04	38.14	38.23	38.33	38.43	38.52
75	38.61	38.71	38.80	38.90	39.00	39.09	39.19	39.28	39.37	39.47
76	39.57	39.67	39.77	39.87	39.97	40.07	34.17	40.27	40.37	40.47
77	40.57	40.68	40.78	40.88	40.98	40.08	41.18	41.28	41.38	41.48
78	41.58	41.69	41.79	41.89	42.00	42.10	42.20	42.31	42.41	42.52
79	42.62	42.73	42.83	42.94	43.05	43.15	43.26	43.37	43.48	43.59
80	43.69	43.81	43.91	44.02	44.13	44.24	44.36	44.46	44.57	44.68
81	44.78	44.89	45.00	45.11	45.23	45.34	45.45	45.57	45.68	45.80
82	45.90	46.02	46.13	4.24	46.35	46.47	46.58	46.69	46.71	46.82
83	47.04	47.16	47.28	47.40	47.52	47.63	47.75	47.87	48.00	48.10
84	48.22	48.34	48.46	48.58	48.70	48.82	48.94	49.06	49.19	49.31
85	49.43	49.56	49.68	49.70	49.92	50.05	50.17	50.29	50.41	50.54

ENTHALPY CHART

WET BULB TO ENTHALPY CONVERSION

Wet bulb temperature in tenths of a degree Fahrenheit

Measure any wet bulb temperature. Select the temperature from the left column, then the tenth of a degree from the columns to the right. This will be the heat content of one pound of air at the corresponding wet temperature. To determine enthalpy change, also known as ΔHT, locate the enthalpy of two wet bulb bulb readings subtract the enthalpy values.

Capacity Measurement

Formula:

Total Capacity = CFM X 4.5 X Delta H

Air Handler Supply

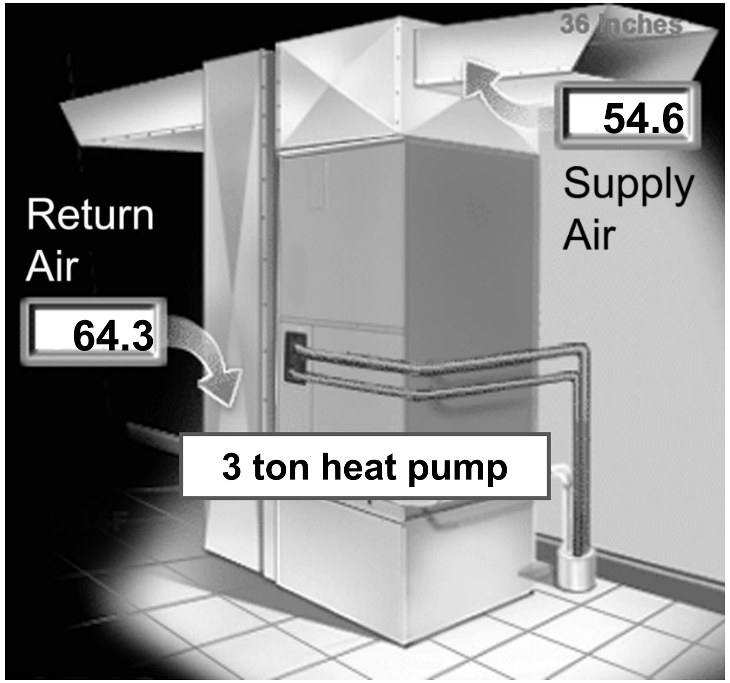
CFM: 1090

Supply Air Temp: 55 DB 54.6 WBF

Return Air Temp: 74 DB 64.3 WBF

1. **Check chart convert WB to Heat**
2. **29.53 – 22.98 = 6.55 (△H)**
3. **1090 X 4.5 X 6.55**
4. **32,127 TOTAL BTU's produced**

Cooling Mode



Example 2

Capacity Measurement

Formula:

Sensible Capacity = CFM X 1.08 X Delta T

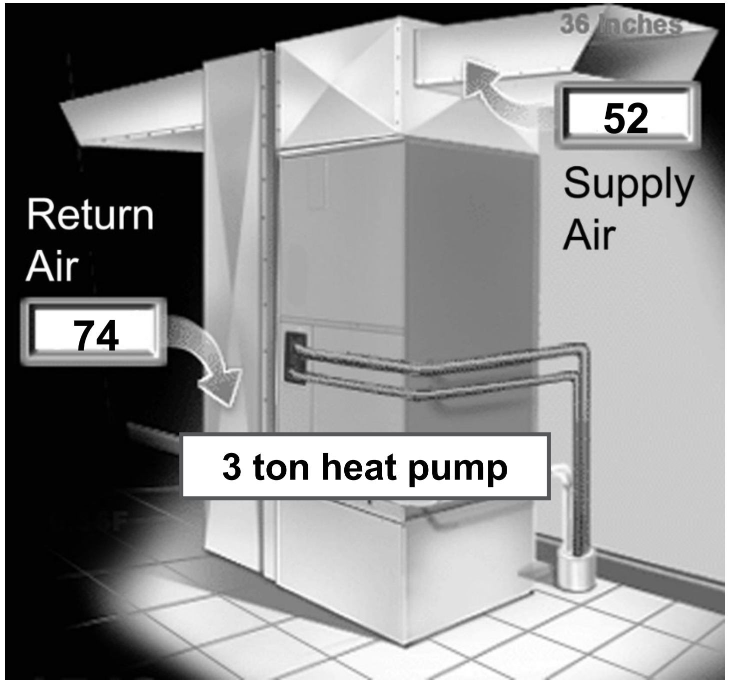
Air Handler Supply

CFM: 1090

Supply Air Temp: 55 DB 54.3 WBF

Return Air Temp: 74 DB 64.3 WBF

1. **74 – 55 = 19 (△T)**
2. **1090 X 1.08 X 19**
3. **22,366 SENSIBLE BTU's produced**



Cooling Mode

Example 2

Capacity Measurement

Cooling Mode

EVAPORATOR AIR		CONDENSER ENTERING AIR								
		75 (23.9)			85 (29.4)			95 (35)		
CFM	EWB °F (°C)	Capacity MBtuh		Total Syst. KW**	Capacity MBtuh		Total Syst. KW**	Capacity MBtuh		Total Syst. KW**
		Total	Sens‡		Total	Sens‡		Total	Sens‡	
25HCE436–31 Outdoor Section With FB4CNP036L										
1050	72 (22.2)	39.42	20.36	2.23	37.61	19.67	2.50	35.70	18.96	2.79
	67 (19.4)	35.87	25.19	2.24	34.23	24.50	2.50	32.48	23.78	2.78
	63 (17.2)††	33.28	24.23	2.25	31.76	23.54	2.50	30.14	22.82	2.77
	62 (16.7)	32.68	29.85	2.25	31.22	29.12	2.50	29.67	28.32	2.77
	57 (13.9)	31.63	31.63	2.26	30.46	30.46	2.50	29.20	29.20	2.77
1200	72 (22.2)	40.13	21.34	2.27	38.25	20.63	2.54	36.25	19.90	2.83
	67 (19.4)	36.53	26.77	2.28	34.82	26.07	2.54	33.00	25.34	2.82
	63 (17.2)††	33.92	25.70	2.29	32.33	25.00	2.54	30.64	24.26	2.82
	62 (16.7)	33.39	31.85	2.29	31.89	31.02	2.54	30.31	30.31	2.82
	57 (13.9)	32.83	32.83	2.29	31.58	31.58	2.54	30.24	30.24	2.82
1350	72 (22.2)	40.68	22.25	2.31	38.72	21.53	2.58	36.66	20.80	2.87
	67 (19.4)	37.04	28.29	2.32	35.25	27.57	2.58	33.37	26.81	2.86
	63 (17.2)††	34.40	27.11	2.33	32.75	26.38	2.58	31.00	25.62	2.86
	62 (16.7)	33.95	33.95	2.33	32.55	32.55	2.58	31.13	31.13	2.86
	57 (13.9)	33.84	33.84	2.33	32.51	32.51	2.58	31.10	31.10	2.86

32,127 TOTAL BTU's produced
22,366 SENSIBLE BTU's produced

THE PERFECT SERVICE VISIT

- Upon arrival meet & greet the homeowner
- Place the thermostat in the Emergency heat position
- Go to the indoor unit, operate the system for 10 mins.
- Measure the supply voltage, Aux heat amp draw, and measure the temp split of the Aux heat only. Inspect the coil, filter, drain pans and see what type of metering device.
- Calculate CFM, make any adjustments needed to meet target airflow, 400 cfm +/- 50 cfm per a ton before proceeding
- CFM Validated
- Place the unit in cooling mode and measure your return DB and WB temperature
- Allow the unit to run in cooling for 15 mins, every system, every type of metering device and measure the Hi and Low pressures and the Liquid and Vapor line temperatures.
- Charge Validated
- Measure WB and Dry bulb temperatures at the indoor unit
- **Calculate capacity verify according to charts**
- **DOCUMENT, DOCUMENT, DOCUMENT**
- **Cleanup and have closing conversation with customer discussing your findings and the condition of their system.**

SYSTEM ANALYZERS

- Fieldpiece
- Testo
- Imanifold

Verizon LTE 2:11 PM 31%

iManifold™ Report

[redacted]

Midlothian, VA 23113

Date of Service 7/6/2018
Time of Service 1:52:34PM

Work Performed
Equipment Service

Field Technician

iManifold ID
A10460

Job Number

VeriFi iManifold VERIFICATION IN FIELD

User Inputs / Measurements

Pressures	Value	VeriFied*
Suction Pressure	132.8 psig	✓
High Pressure	326.8 psig	✓

Temperatures		
Suction Pressure Saturation	45.5°F	✓
High Pressure Saturation	101.27°F	✓
Suction Line Temperature	60.8°F	✓
Liquid Line Temperature	88.9°F	✓
Discharge Line Temperature		
Outdoor Air Temperature	88.2°F	✓
Superheat	15.3°F	✓
Subcooling	12.4°F	✓

Air Side Measurments		
Supply Air Dry Bulb	54.0°F	✓
Supply Air Wet Bulb	53.1°F	✓
Supply Air Relative Humidity	94.9%	✓
Return Air Dry Bulb	72.9°F	✓
Return Air Wet Bulb	64.8°F	✓
Return Air Relative Humidity	65.3%	✓
Return Air Static Pressure		
Supply Air Static Pressure		
Total External Static Pressure	-0.50inH2O	✓
Estimated Airflow	1,050 cfm	✓

Electrical: Condenser	
Nominal System Voltage	240 volts
Phase	1
L1 Voltage to Ground	120 volts
L1 Current	11 amps
L2 Voltage to Ground	120 volts
L2 Current	11 amps
Power Factor	0.95

Electrical: Air Handler	
Nominal System Voltage	240 volts
Phase	1
L1 Voltage to Ground	120 volts
L1 Current	1.5 amps
L2 Voltage to Ground	120 volts
L2 Current	1.5 amps
Power Factor	0.95

System Information

Type of System
Heat Pump: Cooling Mode

Type of Metering Device
Electronic TXV

System Configuration
Split

Refrigerant
R410A

Nominal Tonnage
3

Nominal Capacity (BTU/hr)
36,000

Type of Condenser
18-22 SEER Ultra High E...

Nominal Airflow
1,200

Type of Evaporator
High Sensible Capacity

Target Superheat
15.0

Target Subcooling
10.0

Condenser:

Furnace/AHU:

Evaporator:

System Performance

System Capacity	
Adjusted BTU/Hour	34,580
BTU/Hour Total	36,791
Capacity Realized	106.4%
BTU/Hour Sensible	22,163
BTU/Hour Latent	14,628
Condenser Watts	2,508
Air Handler Watts	342
Sensible Heat Ratio	0.60
Bypass Factor	0.07

Evaporator Performance	
Temperature Split	18.9
Target Temperature Split	16.8
Deviation From Target	2.1

System Electrical Efficiency	
Total Watts	2,850
Current EER	12.91

Dehumidification	
Lbs/Hour	13.60
Gallons/Hour	1.63

Comments

This standard report is included with the current version of the iManifold App. To learn more about other reports and services visit **www.iManifold.com**

*If this column is checked, the values displayed were obtained directly by remote sensors. The value cannot be changed by the technician.

Done

CE

Verizon LTE 11:15 AM 70%

iManifold™ Report

[redacted]

Richmond, VA 23234

Mechanicsville, VA 23116

Date of Service 7/19/2018
Time of Service 10:47:49AM

Work Performed
Equipment Service

Field Technician
Joshua Goodman

iManifold ID A10460
Job Number

User Inputs / Measurements

Pressures	Value	VeriFied*
Suction Pressure	133.3 psig	✓
High Pressure	302.3 psig	✓

Temperatures	Value	VeriFied*
Suction Pressure Saturation	45.71°F	✓
High Pressure Saturation	95.9°F	✓
Suction Line Temperature	46.9°F	✓
Liquid Line Temperature	85.1°F	✓
Discharge Line Temperature		
Outdoor Air Temperature	81.1°F	✓
Superheat	1.2°F	✓
Subcooling	10.8°F	✓

Air Side Measurments	Value	VeriFied*
Supply Air Dry Bulb	56.1°F	✓
Supply Air Wet Bulb	53.8°F	✓
Supply Air Relative Humidity	86.1%	✓
Return Air Dry Bulb	72.0°F	✓
Return Air Wet Bulb	62.4°F	✓
Return Air Relative Humidity	59%	✓
Return Air Static Pressure		
Supply Air Static Pressure		
Total External Static Pressure	-0.59inH2O	✓
Estimated Airflow	1,578 cfm	✓

Electrical: Condenser	Value
Nominal System Voltage	240 volts
Phase	1
L1 Voltage to Ground	121 volts
L1 Current	13.1 amps
L2 Voltage to Ground	102.8 volts
L2 Current	13.4 amps
Power Factor	0.95

Electrical: Air Handler	Value
Nominal System Voltage	240 volts
Phase	1
L1 Voltage to Ground	121 volts
L1 Current	3.8 amps
L2 Voltage to Ground	120.8 volts
L2 Current	3.8 amps
Power Factor	0.95

System Information

Type of System
Heat Pump: Cooling Mode

Type of Metering Device
Standard TXV

System Configuration
Split

Refrigerant
R410A

Nominal Tonnage
3.5

Nominal Capacity (BTU/hr)
42,000

Type of Condenser
13-16 SEER High Eff.

Nominal Airflow
1,400

Type of Evaporator
Standard Operation

Target Superheat
17.0

Target Subcooling
10.0

Condenser:

Furnace/AHU:

Evaporator:

System Performance

System Capacity	
Adjusted BTU/Hour	39,579
BTU/Hour Total	39,260
Capacity Realized	99.2%
BTU/Hour Sensible	27,137
BTU/Hour Latent	12,123
Condenser Watts	2,814
Air Handler Watts	873
Sensible Heat Ratio	0.69
Bypass Factor	0.20

Evaporator Performance	
Temperature Split	15.8
Target Temperature Split	18.1
Deviation From Target	-2.3

System Electrical Efficiency	
Total Watts	3,687
Current EER	10.65

Dehumidification	
Lbs/Hour	11.24
Gallons/Hour	1.35

Comments

This standard report is included with the current version of the iManifold App. To learn more about other reports and services visit **www.iManifold.com**

*If this column is checked, the values displayed were obtained directly by remote sensors. The value cannot be changed by the technician.

Done

Thank You!