HVAC INSPECTIONS
MORE THAN A "Δ T"

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ADDITIONAL CLASSES FOR CONSIDERATION:

- Electrical Inspections for Home Inspectors
- Structural Inspections
- Inspecting Gas Fueled Appliances
- Advanced Pool Inspection
- Blueprint Reading for Home Inspectors
- Pre Drywall Inspections
- Advanced HVAC Inspections

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FOR STARTERS:

- Please silence your cellphone.
- Please ask questions.
- There is an expectation that you have some basic understanding of HVAC Systems.
- HVAC systems are very important in Florida
- HVAC systems are expensive to replace
- Most Home Inspectors were never properly trained to inspect HVAC systems properly.

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COURSE OBJECTIVE

At the end of this course the Inspector should be able to:

- Understand equipment labels
- Understand how the HVAC equipment operates
- Understand the importance of air flow / return air paths
- Be able to identify conditions that will result in reduced life span
- Understand the temperature split is only a small part of evaluating the system

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FABI STANDARDS -

- The Inspector shall –
- A – Inspect
- B – Describe
- C - Report

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A - INSPECT

- 2.2 A 2. – The installed systems and components of homes listed in these Standards of Practice
- 8 – Air Conditioning Systems – Inspect the installed Central & through wall cooling systems

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8.1 B – DESCRIBE

- Describe the cooling method by it's distinguishing characteristics
- Permanently installed components intended to improve air quality (filters, UV lights etc..) or enhance the system function (t-stats, zoned systems)

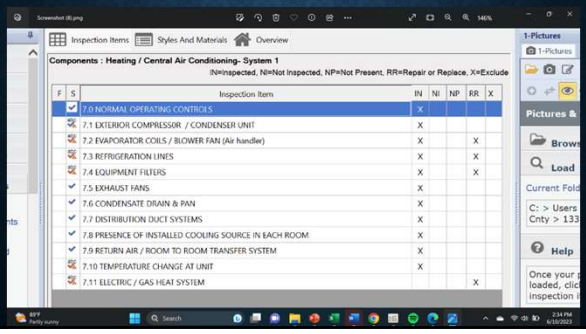
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C - REPORT

- The condition of the condensing unit
- The condition of the evaporator coils (when accessible)
- The success or failure of the operator controls to activate & deactivate the system
- The type & condition of the ductwork
- The temperature differential achieved by the system
- The presence / absence of functional condensate overflows
- Systems that are inoperable or fail to operate in the manner it was intended
- Conditions that will result in reduced life expectancy or inefficient operation

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REPORTING ITEMS-



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- Normal Operating Controls
- Exterior Compressor / Condenser Unit
- Evaporator Coils / Blower Fan (Air Handler)
- Refrigerant Lines
- Equipment Filters
- Exhaust Fans
- Condensate Drain / Pan
- Distribution Ducts
- Presence of Installed Cooling Source in Each Room
- Return Air / Room to Room Transfer Systems
- Temperature Change at Unit
- Electric/ Gas Heat System

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HVAC SYSTEMS

- HVAC systems have 2 individual components
- Equipment – Condenser Unit / Air Handler
- Distribution System – Supply ducts / Return ducts
- The distribution is critical to the performance of the equipment

As Home Inspectors, we need to start thinking about how the air flow works

Distribution can dramatically effect temperature splits

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ACCURATE MEASUREMENTS

- The location of the measurements are important –
- The supply temperature should be measured at the supply plenum on the air handler
- Return temperature should be taken as close to the unit as possible
- BUT – that only tells you about the equipment
- Will the air at the ceiling grills be the same temperature as the unit?
- You should also measure the temperature at the supply grills
  - That will tell you how the distribution system is working
  - Excessive heat rise in the duct system can indicate air flow restrictions

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ΔT = TEMPERATURE SPLITS

- The temperature split between the supply and return is, sometimes (almost always), the only consideration for Home Inspectors when determining the condition of the equipment.
- All Home inspectors are trained to look for 14-22 ° split between supply & return.
- **Accurate** measurements can help determine the conditions, but they are only one part of the diagnosis.
- Home Inspectors should not rely on temperature split alone to determine if the system is working.
- We will look at some typical examples of the Home Inspector's diagnosis.....

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EXAMPLE -

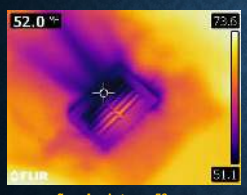




- Supply temp @ air handler = 53
- Return temp = 77
- Split = 22
- Delivered air temp = 76
- Is the system performing correctly?

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DELTA -T EXAMPLE



Supply air temp 52



Return air temp 69

Delta-T 17° - …..Discussion

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UNIT WAS 21 YEARS OLD

- If nothing else –
- Report that the unit is ***BEYOND*** its useful life and should be replaced with a newer, more efficient model.
- That is REQUIRED by the SOP's:
  - FL – 61-30.801 General
  - FABI – 2.2 C



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ACTUAL UNIT CONDITION

NOT SO GOOD

Elevated moisture @ Return Plenum

Suspected MOLD @ Return Plenum

The Home Inspector said it was working fine because he only looked at the temp split.



Filter being sucked into coils

Significant lack of air flow @ plenum

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ΔT -



Supply Temp @ grill



Return Temp @ grill



Supply Temp @ air handler

The ACTUAL ΔT at the equipment is 23° –
The equipment is working fine. This is a distribution issue.

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COIL CONDITION



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BLOWER CONDITION



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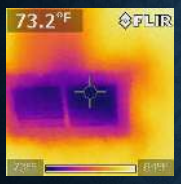
COILS ICE UP WHEN ACCESS PANEL REMOVED



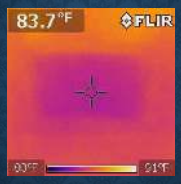


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TEMP SPLITS ---



Supply Temp @ Grill



Return Temp @ Grill

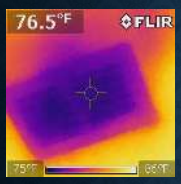


Supply Temp @ Unit

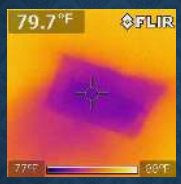
Initially the system is not working

Actually the UNIT is working
- the duct system is NOT

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Supply Temp @ Grill



Supply Temp @ Grill



Supply Temp @ Unit

- Unit has been running over 30 min.
- Does it matter what the ΔT is ?

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AIR- VERY IMPORTANT FOR HVAC SYSTEMS

- Air Makeup/ Composition
- Thermodynamics
- Enthalpy
- Dewpoint
- Humidity
- Wet Bulb
- Dry Bulb

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MOISTURE/ DENSITY RELATIONSHIP IN AIR

- *Humidity*
- *Wet bulb temperatures*
- *Dry bulb temperatures*
- *Condensation & Dew point*

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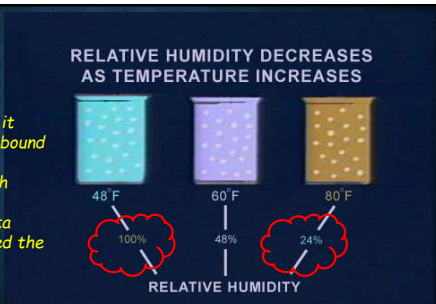
PRINCIPLES OF THERMODYNAMICS-

- **Enthalpy-** The amount of heat in air is referred to as enthalpy. The **enthalpy** of air (in the **HVAC** business) is measured in BTUs per pound of air. The **enthalpy** is to a close approximation directly related to the wet bulb temperature.
- **Relative humidity** is the ratio (expressed as %RH) of the amount of moisture actually in the air to the maximum amount that can be present at that temperature. Relative humidity changes when temperatures change.
- Warm air can hold more water vapor than cool air.
- **Dew point** is the temperature at which a given sample of air will have a relative humidity of 100 percent; hence, the saturation temperature.
- All three -- relative humidity, temperature and dew point -- are bound together in the mathematical relationship below.

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EXAMPLE

- *If warm air is cooled, it must lose some of its bound water vapor.*
- *This will occur through condensation.*
- *We can plot these data points on a graph called the "Physcometric Chart"*



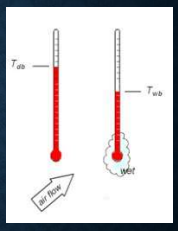
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- *At 40° air temperature, the parcel is saturated and will hold no more molecules of water vapor. The relative humidity is 100%.*
- *If the temperature of that air parcel is raised by 20°, it will hold about twice as many water molecules to reach saturation.*
- *Thus, the new relative humidity is now 48%. If the temperature is raised another 20°, it will again double its capacity to hold water vapor molecules. The relative humidity is only 24%.*

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ENTHALPY

- We measure the temperature of the air with a stick thermometer and this measurement is called the dry bulb temperature because the end of the thermometer that is making the measurement has no moisture on it.
- The wet bulb temperature is measured by having the bulb of the thermometer moist.
- The moisture evaporates, lowering the temperature recorded by the thermometer.
- Less moisture in the air will result in a faster rate of evaporation and therefore a colder reading.



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DEWPOINT

- **Dew Point:** The temperature to which a parcel of air must be cooled to reach its saturation point.
- The dew point is a useful reference because it tells at which temperature clouds and precipitation will occur.
- In any one stationary parcel of air, the dew point of that air will remain the same as will the amount of moisture in that parcel, regardless of air temperature.
- But as air temperature increases, so will the capacity of that air to hold more water vapor. The higher the air temperature, the stronger the bond between water and air molecules, and the drier the air seems to be.

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- *To determine how dry or wet the air is at any given temperature, we use a unit of measure called Relative Humidity.*
- *Does dew point change with changes in temperature or relative humidity?*
- *First, you should understand that the temperature of the air influences the amount of water vapor that can be bound to the molecules of air.*
- *Water vapor capacity increases with temperature increase*
- *If warm air is cooled, it must lose some of its bound water vapor. This will occur through condensation.*

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RELATIVE HUMIDITY

- **Relative Humidity**: The ratio of the actual amount of water vapor in a given volume of air to the amount which could be present if the air were saturated at the same temperature. It's commonly expressed as a %.
- Since warm air will hold more moisture than cold air, the % of relative humidity must change with changes in air temperature.
- The importance of air temperature to moisture is obvious. At 80°, the air has a relatively low humidity and is relatively dry. As it cools, the humidity increases, reaching its saturation point at 40°. Now the air is very moist, and clouds will form.

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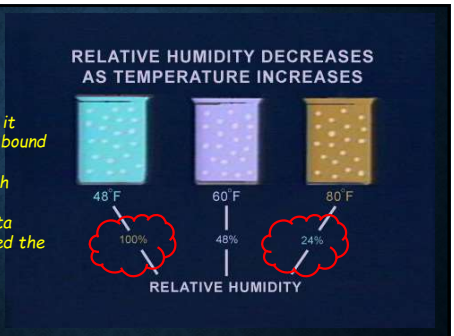
KEY NOTES:

- The measurement of heat removal by the air conditioning system is independent of the ambient temperature outside the building ***and also*** independent of the actual temperatures of the room itself.
- Only the air passing through the coils is relavent
- *If warm air is cooled, it must lose some of its bound water vapor. This will occur through condensation.*
- *The next graphic illustrates the %RH relationship.*

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EXAMPLE

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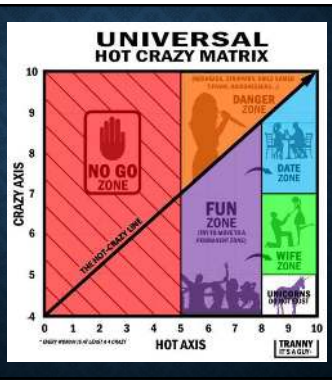
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CONDENSATION

- Condensation is the process by which water vapor in the air is changed into liquid water. In other words, the water in the air, a gas known as water vapor, from your hot shower cooled when it met the surface of the cold mirror. This caused the water vapor to condense or turn into its liquid form.
- Air contains water vapor or moisture. Too much moisture (humidity) in air is uncomfortable. As air containing too much moisture passes over a properly designed, installed, and operating air conditioning system, the air is cooled by the air conditioning coil (evaporator) located at the indoor blower section. If the air containing the moisture is cooled to the condensing temperature (dew point) of the moisture in the air, some of the moisture will condense and deposit on the coil and fins of the cooling coil. Since the water vapor is changing from a gas or vapor to a liquid, this is a latent heat process. The condensed water should run off the coil and be drained away.
- Psychrometry measures the rates of condensation through evaporation into the air moisture at various atmospheric pressures and temperatures.

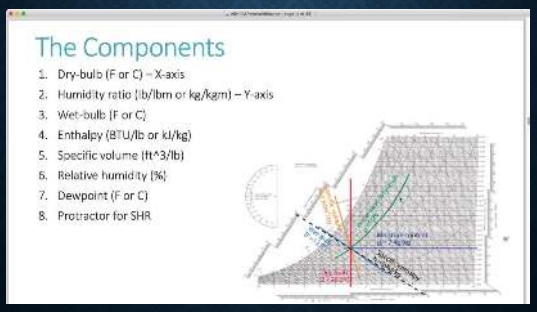
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PSYCHOMETRIC CHART - WOMEN MATRIX - HOT VS. CRAZY



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HVAC PSYCHOMETRIC CHART



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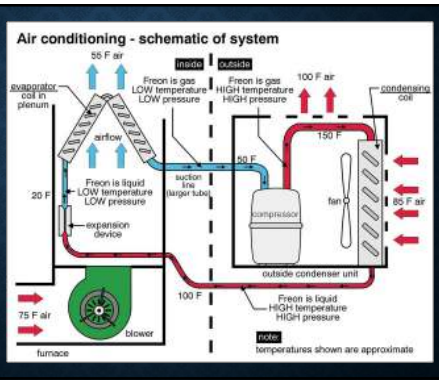
AIR FLOW

- Now that we understand the properties of air, we can look closer at how the refrigeration cycle works.
- Essentially the air has to do this:
  - ENTER (Return side) the air handler unit
  - Flow through the coils – where the refrigerant absorbs the heat
  - Then, be delivered to the respective rooms through the DISTRIBUTION SYSTEM
  - The FAN (blower) is the heart of the system and is responsible to move the air

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AIR FLOW

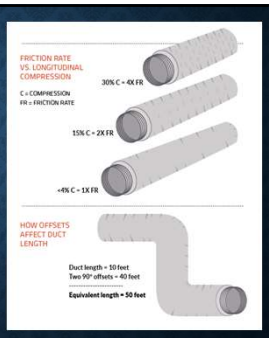
- Air flow is critical
- Poor air flow effects the refrigerant cycle
- Shortens equipment life
- Increases energy costs



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AIR FLOW DYNAMICS

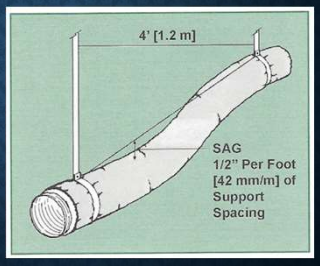
- *The blower provides the pressure to move the air from the ductwork to the space it serves.*
- *The amount of air the blower can move and the amount of energy it needs is controlled by the resistance to airflow.*
- *Everything attached to the air handler gives resistance to air flow.*



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DUCT INSTALLATION

- SMACNA – Fig. 3-10
- Maximum allowable sag = ½" per ft of support spacing.
- EX – supports @ 4ft OC = Max 2" sag between supports.
- Compressing the ducts increases the cost and the friction loss. Ducts should be fully extended.
- Bends shall be not less than 1 duct diameter measured at centerline.



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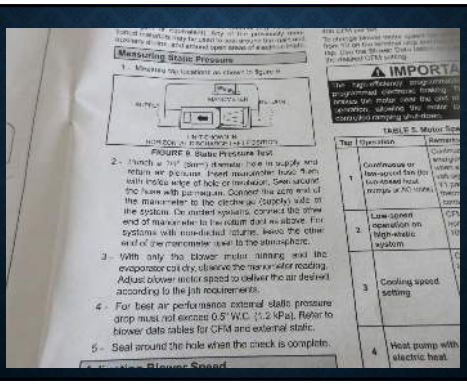
DUCT PRESSURES

- *There are two types of pressure in a closed system such as ductwork:*
- *Static pressure pushes the duct walls out. This is the pressure that expands a balloon when you blow it up.*
- ***Velocity pressure** causes the air to move in one direction. This is the pressure that causes the balloon you blew up to fly around when you let go of the valve.*
- *These two pressure types are created by the air handler blower. Static pressure plus velocity pressure equals **total pressure**.*
- *Measuring the static pressure in a ducted system can help us diagnose problems in the system.*

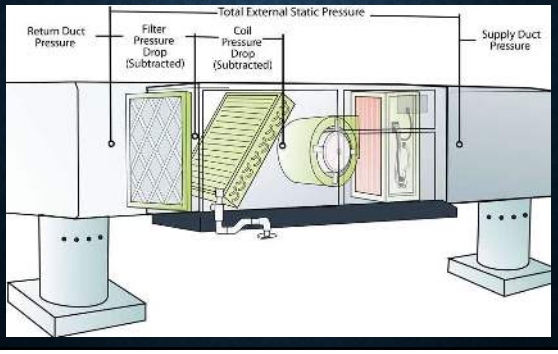
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- *Pressure is one of the most important factors in **HVAC** design.*
- ***Static pressure** refers to the resistance to airflow in a heating and cooling system's components and duct work. The push of the air must be greater than the resistance to the flow or no air will circulate through the ducts*
- *Static pressure is exerted equal on all sides of the duct; similar to blowing up a balloon.*
- *The pressure will be highest on the discharge side of the fan.*
- *An instrument used to measure pressure is called a "manometer." The most common manometer is a Magnehelic gauge. The 0-1-in. wc Magnehelic gauge works perfect for most testing, including residential and most light-commercial testing. The top port of this gauge measures positive pressure while the bottom port measures negative pressure.*

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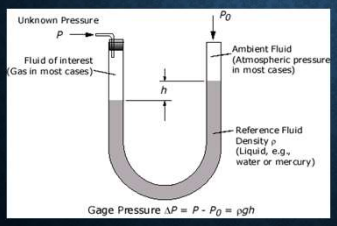
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MANOMETER

- A **Manometer** is a device to measure pressures.





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STATIC PRESSURE TEST

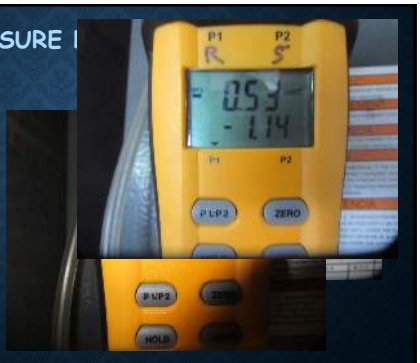
- Insert probes in the supply and return duct as close to the evaporator coils as possible.



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EX: STATIC PRESSURE

- Design = 0.5
- Supply = 0.62
- Return = 0.53
- Total = 1.14
- 120% over design pressure
- Delivering 65% of required air



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PRESSURE/ AIR FLOW RELATIONSHIP

Math 101 Model "B", Med Speed

14 SEER Heat Pump – Minimum SEER Rating required by FBC

- Air Handler rated at 0.52" W.C = 912 CFM per manufacturer
- Crap Duct Install increases pressure to 1.15" WC = > 587 CFM when measured in the field.
- Actual rated air flow is less than 64% of design.
- 587/ 912= 0.64 %
- Problems Created:
- SEER rating is now 64% of 14 = 8.9 - Below Energy Code
- Not enough air to supply all rooms
- Homeowner pays higher bills for 15 years and still doesn't get the desired comfort inside their house.
- Is air flow important ?

Blower Performance

Model	Motor HP	Blower Size	Temp. Rise	Blower Speed	CFM @ ext. Static Pressure - in. W.C. w/Filter(s)*							
					.20	.30	.40	.50	.60	.70	.80	.90
FURNACE MODEL "A"	1/3	10 x 8	35-65	High	1518	1446	1366	1287	1219	1122	1003	894
				Med/Hi	1340	1298	1234	1152	1101	1018	903	802
				Med	1099	1084	1060	1019	952	883	783	709
				Low	942	935	896	848	829	760	651	593
FURNACE MODEL "B"	1/3	10 x 8	45-75	High	1390	1337	1270	1207	1138	1063	949	838
				Med/Hi	1230	1176	1137	1082	1012	931	838	718
				~~Med~~	~~1099~~	~~1044~~	956	912	872	806	722	587
				Low	872	847	834	800	758	690	600	495
FURNACE MODEL "C"	3/4	12 x 10	35-65	High	1921	1888	1831	1759	1668	1624	1549	1445
				Med/Hi	1750	1720	1682	1661	1625	1494	1397	1327
				Med	1515	1491	1462	1421	1397	1330	1258	1185
				Med/Low	1315	1300	1255	1213	1188	1159	1103	1017
				Low	1033	982	962	652	906	851	804	721

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PROPER INSTALLATION?



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PRESSURE ISSUES?



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AIR FLOW ISSUES



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DUCT INSULATION FAILURE = EXCESSIVE HEAT GAIN





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SUPPLY PLENUM PRESSURE ISSUES?





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REPORTING ITEM:

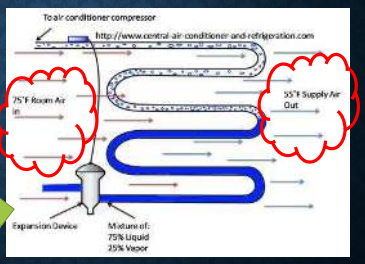
- *HVAC ducts were observed to be leaking at the connections to the distribution boxes. Leaking ducts cause energy loss and potential condensation issues at the ceiling grills. Sealing undersized ducts may cause additional problems with proper air flow through the coils. The duct system should be further evaluated for proper sizing and balanced air flow by a licensed HVAC contractor.*



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EVAPORATOR COIL

The evaporator changes (boils) the low pressure 2-phase mixture of liquid and vapor refrigerant into an all vapor stream of refrigerant, drawing heat into the refrigerant (which provides cooling) during the evaporation process.



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COMMON DUCT PROBLEMS

- Duct leakage to/ from the outdoors.
- Restricted return side.
- System not balanced.
- Temperature too high or too low at heat exchanger.
- Static pressure out of range.
- Airflow of air handler fan not matched to system.
- People live within the distribution system. Closing a bedroom door or covering a register or grille can significantly alter airflow.

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CONDENSER

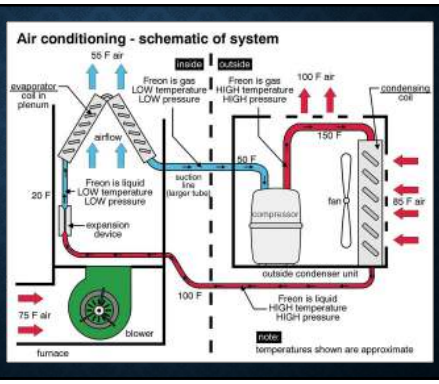
- The condenser changes a HIGH PRESSURE vapor to a HIGH PRESSURE liquid by rejecting the heat from the refrigerant causing the refrigerant to condense



Outdoor Condenser Unit

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REFRIGERATION CYCLE



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INSPECTING OUTDOOR EQUIPMENT

- Understanding labels & equipment specs
- Inspecting capacitors
- Inspecting contactors
- Inspecting High / Low Voltage

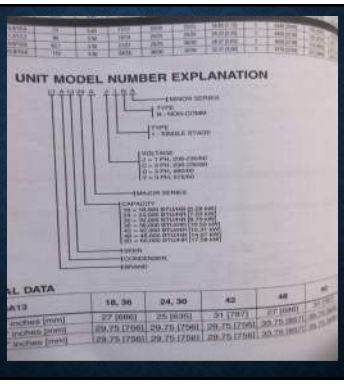
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CAPACITY – BTU'S - TONNAGE

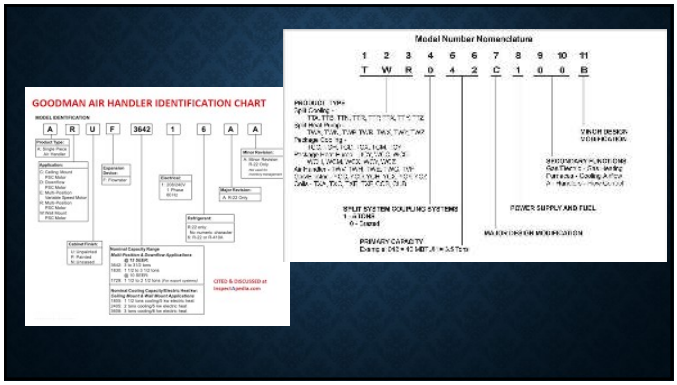
- HVAC equipment is typically described in "Tonnage"
- 12,000 BTU's = 1 ton
- The outdoor unit and the indoor unit may not be the same tonnage
- Find the labels, and look for numbers that can be divided by 12

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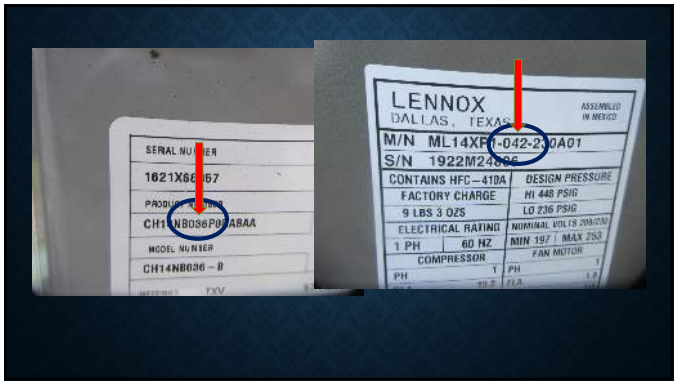
HOW TO READ LABELS



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GOODMAN AIR HANDLER IDENTIFICATION CHART
A R U F 3642 1 6 A A
Model Number Nomenclature
1 2 3 4 5 6 7 8 9 10 11
T W R 0 4 2 C 1 0 0 B

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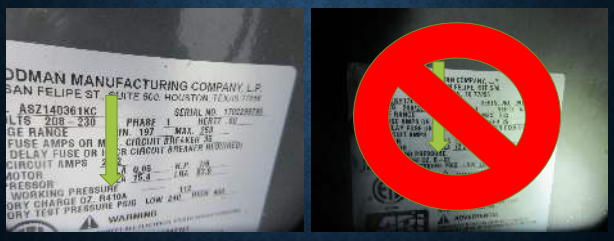

LENNOX
DALLAS, TEXAS
ASSEMBLED IN MEXICO
M/N ML14XP1-042-230A01
S/N 1922M24866
CONTAINS HFC-410A
FACTORY CHARGE
9 LBS 3 OZS
DESIGN PRESSURE
HI 448 PSIG
LO 236 PSIG
ELECTRICAL RATING
1 PH 60 HZ
NOMINAL VOLTS 208/230
MIN 197 MAX 253
COMPRESSOR
FAN MOTOR
MODEL NUMBER
CH14NB036-B

65


OUTDOOR UNIT = CONDENSER UNIT
1st - Read the Label

66

OUTDOOR UNIT = CONDENSER UNIT

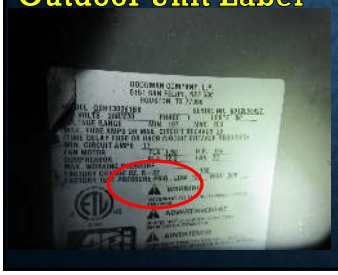


- What is the defect ?

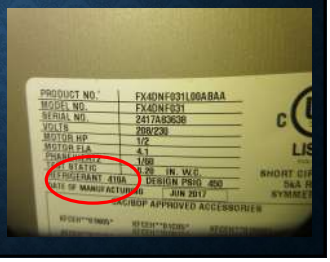
67

REFRIGERANT TYPE ?

Outdoor Unit Label



Air handler Label



68

COILS

The coil does not have anything to do with the refrigerant.

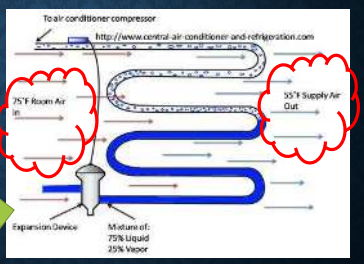
It is only a pipe.



69

EVAPORATOR COIL

The evaporator changes (boils) the low pressure 2-phase mixture of liquid and vapor refrigerant into an all vapor stream of refrigerant, drawing heat into the refrigerant (which provides cooling) during the evaporation process.

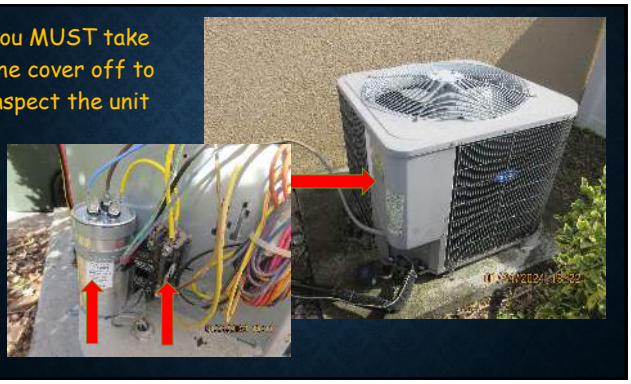


70

- Refrigerant type is determined by the Outdoor unit ONLY
- The air handler (evaporator coil) is nothing more than a pipe that is routed through a series of bends & turns so the air can pass over the surface area.
- Any R22 system should be considered at the end of it's useful life and recommend replacement.

71

You MUST take the cover off to inspect the unit



72

INSPECTING CAPACITORS

- Capacitors are used to store energy to provide a brief increase in the starting torque.
- A start capacitor usually stays in the circuit long enough to bring the motor up to a pre-determined speed. (usually 75%).
- Capacitors vary depending on the equipment manufacturer. Some will have a dual capacitor that runs both the fan motor and the compressor; others will have 2 separate capacitors: 1 for the fan: 1 for the compressor.

73

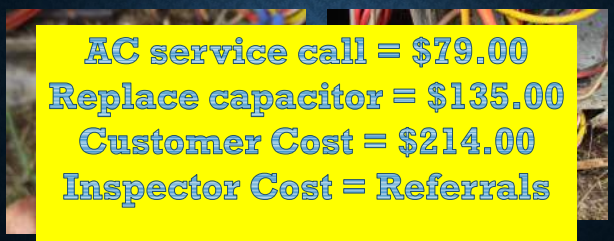
1+2=3 CAPACITOR CHECK






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BAD CAPACITOR



AC service call = $79.00
Replace capacitor = $135.00
Customer Cost = $214.00
Inspector Cost = Referrals

75

REPORT COMMENTS

- The HVAC equipment is at or near the end of it's useful life of 12-15 years and should be considered for a replacement with a newer, more efficient system prior to failure. The system was providing some cooling at the time of inspection, however, several repairs and maintenance issues were observed that require corrections by a licensed HVAC contractor.
- The internal parts of the outdoor unit (condenser) are in poor condition and may fail at any time. Recommend the system is serviced by a licensed HVAC Contractor that includes replacing the Contactor & Capacitors.

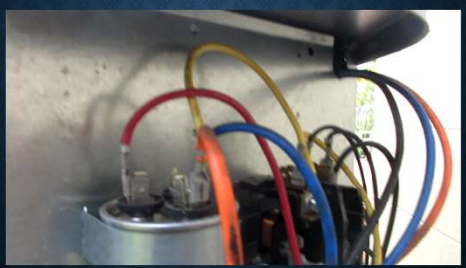
76

INSPECTING CAPACITORS- VIDEO



77

CAPACITOR CHECK



78

CONTACTORS-



AC service call = $79.00
Replace contactor = $85.00
Customer Cost = $164.00
Inspector Cost = Referrals

79

INSPECTING OUTDOOR EQUIPMENT

- If the cover is taken off, you are actually inspecting

Owner pays AC service call
Customer gets system serviced
Customer Cost = $0
Inspector Benefit = More Referrals

80

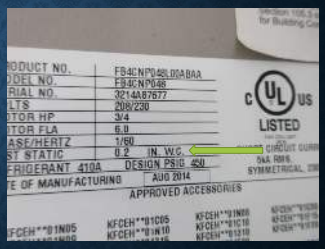
INSPECTING INDOOR COIL

- Remove the covers to expose:
- Blower & fan motor
- Evaporator coils
- Electric Heater
- Electrical connections

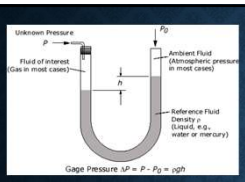
81

STATIC PRESSURES

- All HVAC equipment is designed to operate at a specific static pressure.
- The static pressure is provided by resistance within the ducts.
- The pressure inside the ducts should be positive- they are full of air.
- If the static pressure is too high, the air does not flow across the coils.
- If the static pressure is too low, too much air flows across the coils.
- Testing static pressure is easy.

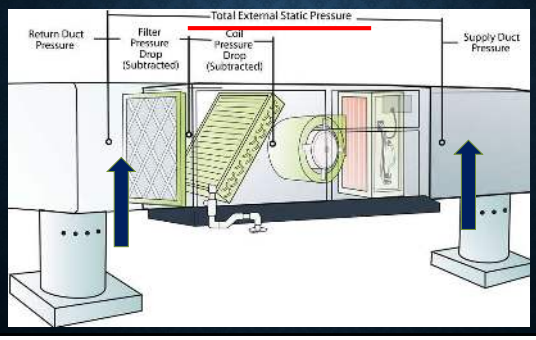


82



- Pressure is one of the most important factors in **HVAC** design. Simply put, **static pressure** refers to the resistance to airflow in a heating and cooling system's components and duct work. The push of the air must be greater than the resistance to the flow or no air will circulate through the ducts
- Static pressure is exerted equal on all sides of the duct; similar to blowing up a balloon.
- The pressure will be highest on the discharge side of the fan.
- An instrument used to measure pressure is called a "manometer." The most common manometer is a Magnehelic gauge. The 0-1-in. wc Magnehelic gauge works perfect for most testing, including residential and most light-commercial testing. The top port of this gauge measures positive pressure while the bottom port measures negative pressure.

83



84

INSPECTING INDOOR COIL

- Whenever possible, look at the underside of the coils to see if it is free of debris.
- Check for severe corrosion.
- Check for any damage to the refrigerant lines that would reduce the flow of refrigerant.
- Check the fan blades for debris buildup and proper balance.

85

FAN PERFORMANCE

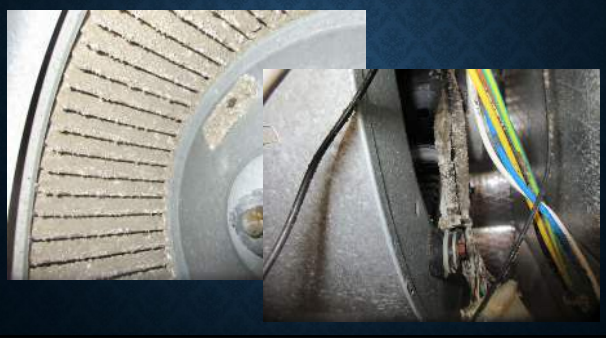
The fan (blower) depends moves air through the coils

If you decrease the space between the fan blades – the amount of air moving through the coils is also decreased

Furthermore, if the fan blades are contaminated –

- it increases the amperage on the motor
- causes the unit to vibrate

86



87

Dirty / contaminated coils will significantly impact the pressures in the distribution system and consequently the performance of the equipment.



88

CONDITIONS THAT WILL RESULT IN REDUCED LIFE EXPECTANCY OR INEFFICIENT OPERATION

89

WHAT ABOUT A LEAK CHECK ?

- *What if we actually use a tool to scan for refrigerant leaks?*
- *No special training required*
- *May reveal a situation where the seller just had the refrigerant system topped off to cover a failing system*
- *Maybe an opportunity to UPSELL while on site….$$$$*

90

INDOOR COILS



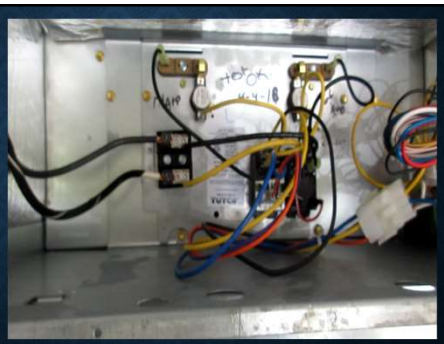
91

INDOOR COILS



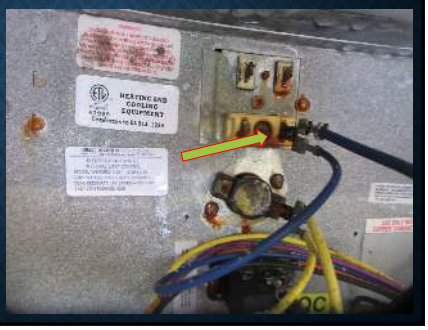
92

ELECTRIC HEAT



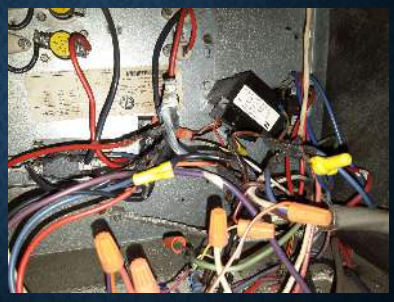
93

- Corroded connectors @ heat strip
- Will fail soon
- Did you check the electric heat ?
- How ?



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OVERHEATED WIRING



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