How to Verify Key Components of Heating & AC Systems in ENERGY STAR Certified Homes

February 28, 2013
RESNET Conference

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Agenda

- Value of quality-installed heating & cooling systems.
- Overview of Sections 1-4 of the HVAC System QI Rater Checklist.
- Critical details of Sections 1-4.
- Q&A.

Value of Quality-Installed Heating & Cooling Systems

Heating & cooling systems

2

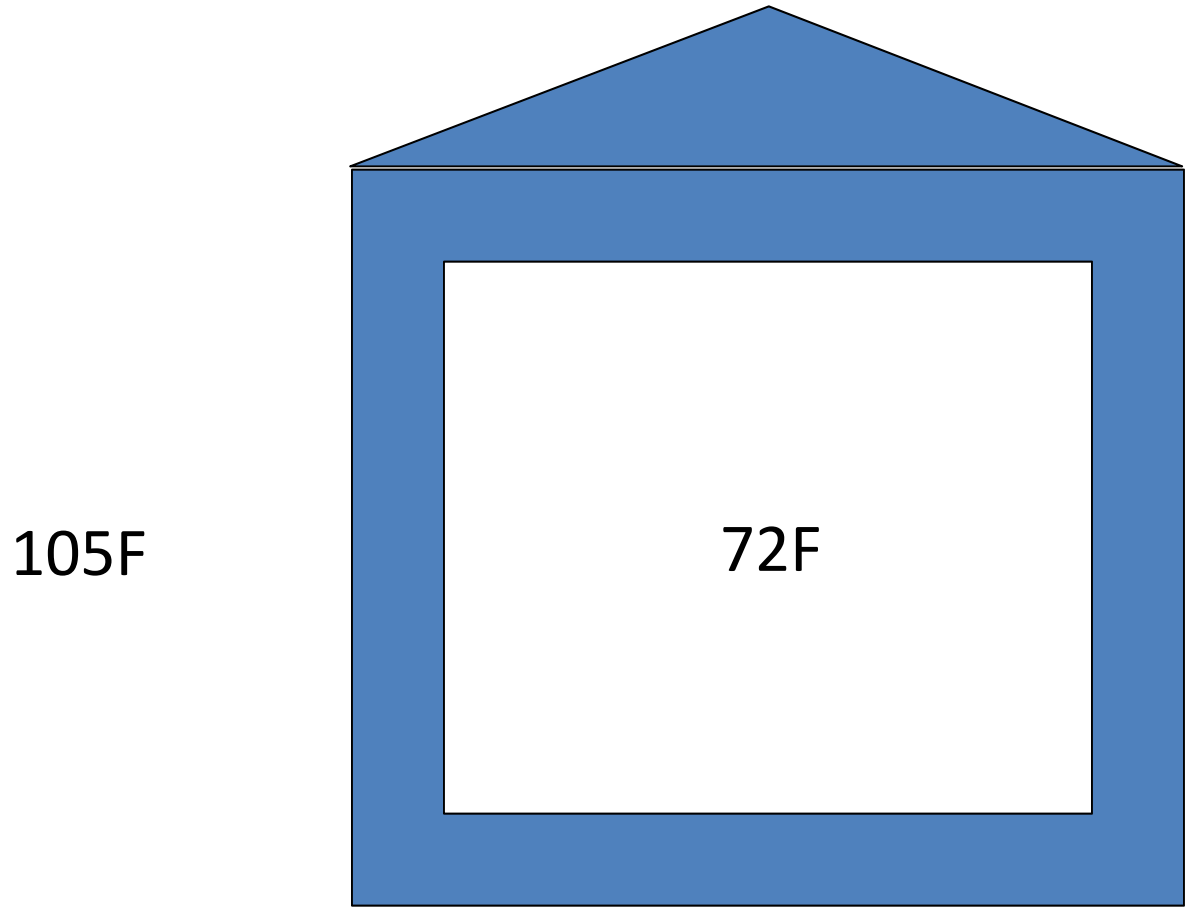
Heating, Cooling, & Ventilation System

- Heating and cooling equipment that is:
  - High efficiency
  - Properly designed and installed
  - Combined with a duct system that's insulated, sealed, and balanced

… maintains comfort with less energy.

Heating & cooling systems

- Adding & removing Btu's impacts the temp. inside the home.

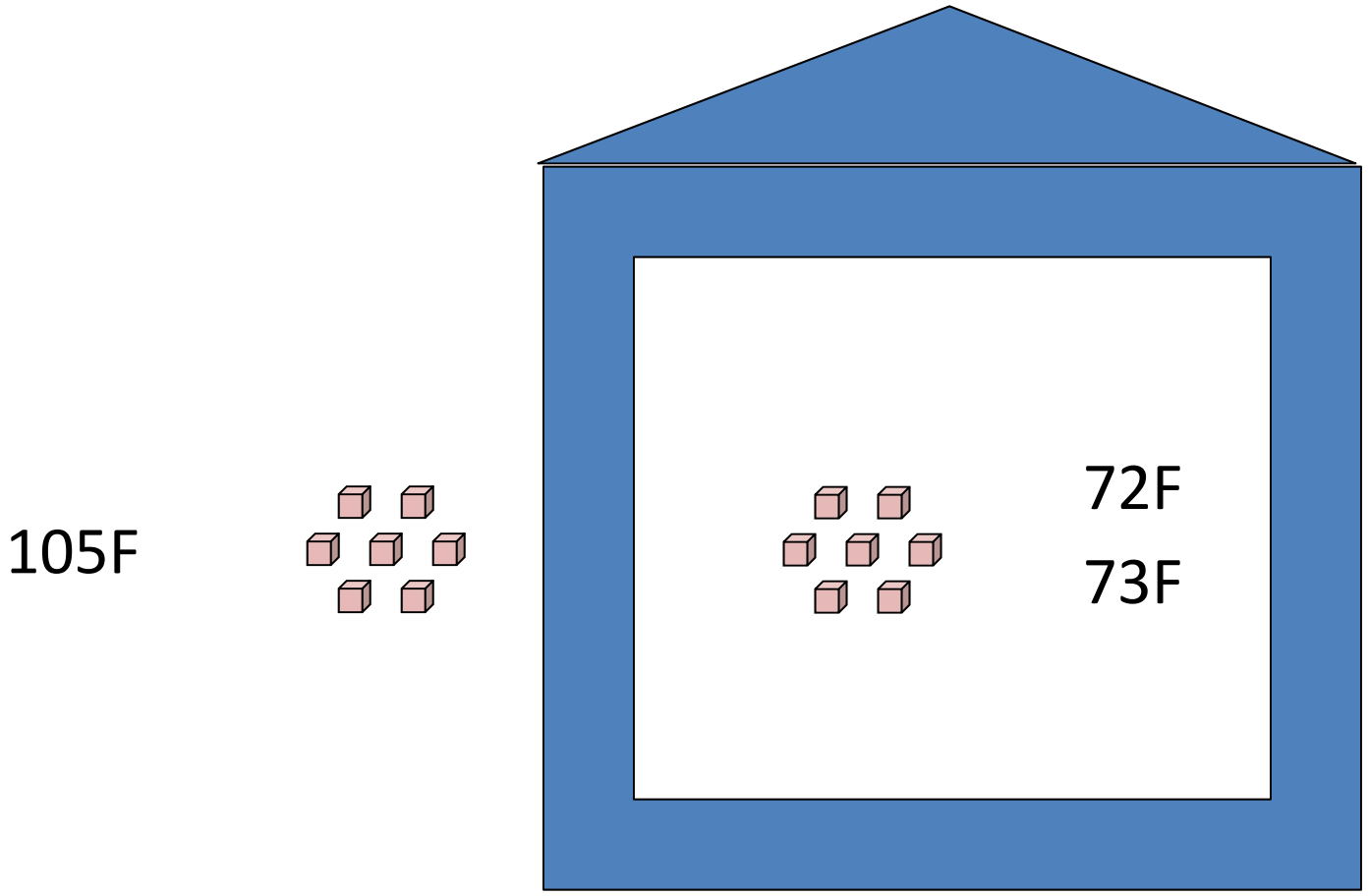


Heating & cooling systems

- You can't have a complete HVAC system until you first have a complete thermal enclosure system.
- The amount of heat transfer can be quantified in British Thermal Units (Btu's).
- 1 Btu is approximately equal to the energy in a single match.

Heating & cooling systems

- Adding & removing Btu's impacts the temp. inside the home.



Three major steps to design an HVAC system

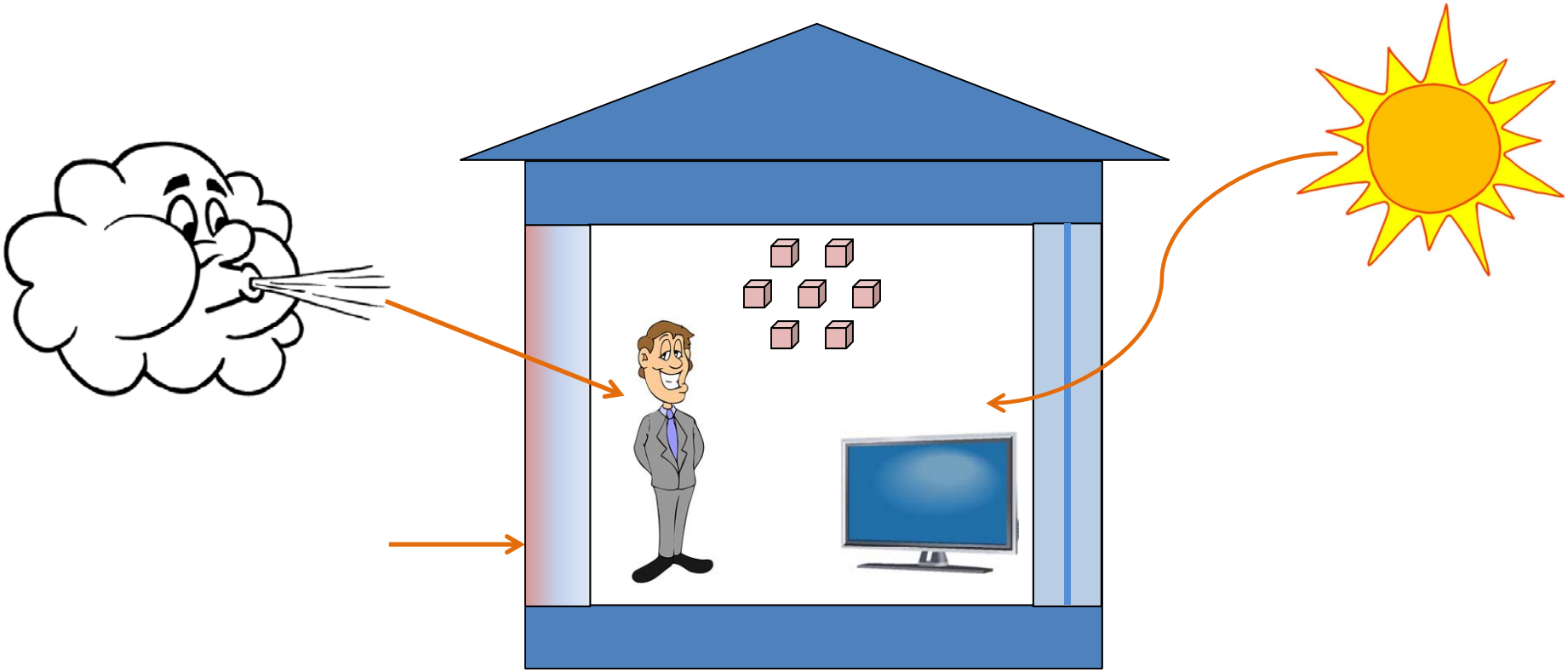
1) Calculate the heating & cooling load.

2) Select equipment to meet those loads.

3) Design ducts to get air from equipment to rooms, and then back to equipment, to offset loads.

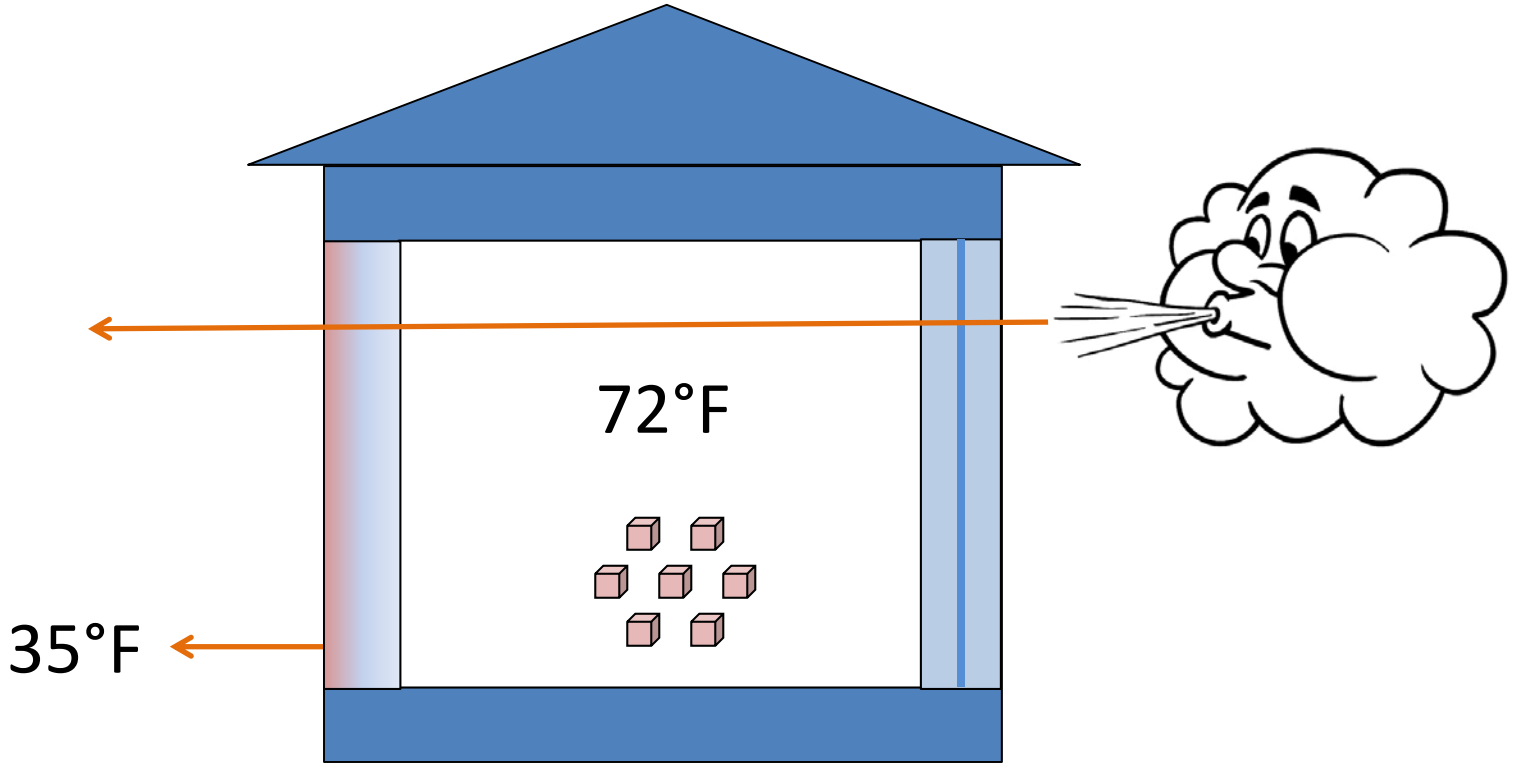
Step 1:
Calculate heating & cooling loads

- Cooling load is the maximum Btu's added in one hour.



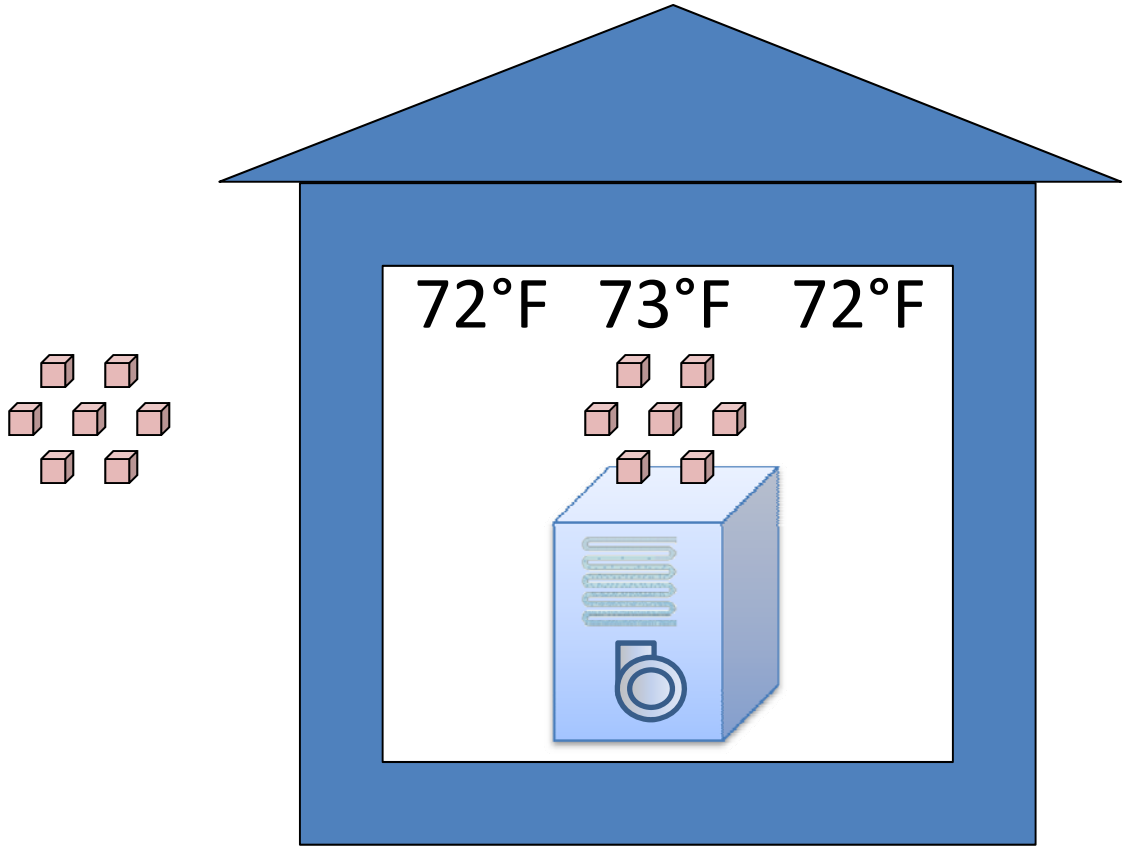
Step 1:
Calculate heating & cooling loads

- Heating load is the maximum Btu's lost in one hour.



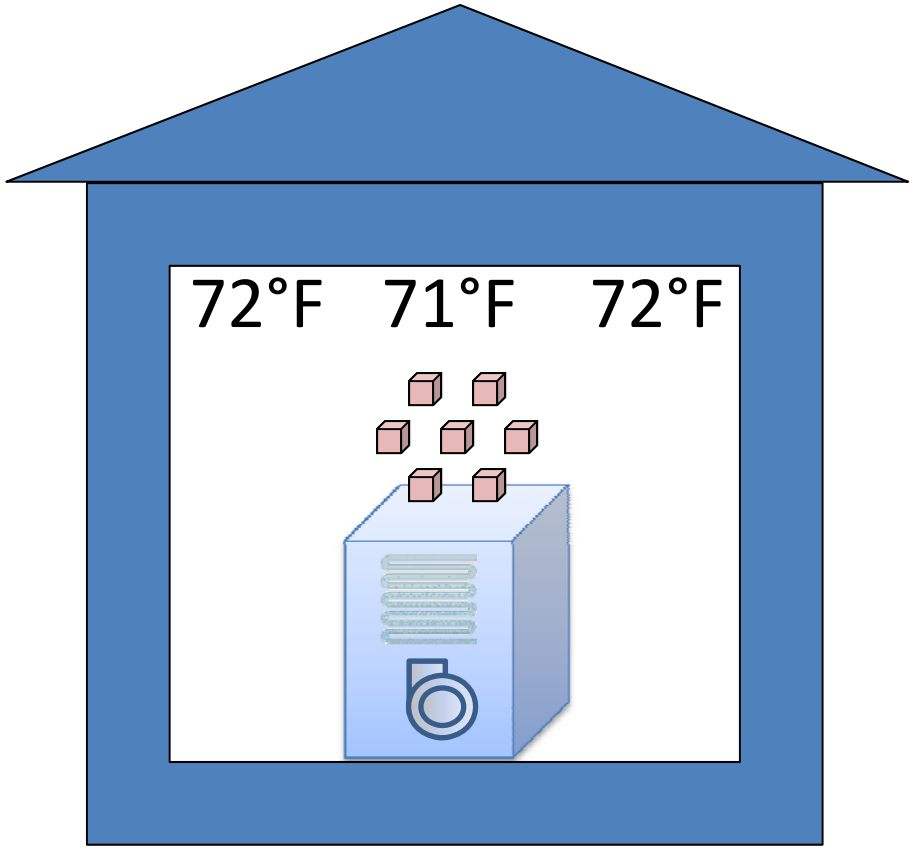
Step 2:
Select equipment that meets loads

- Select equipment that removes Btu's to meet cooling load.



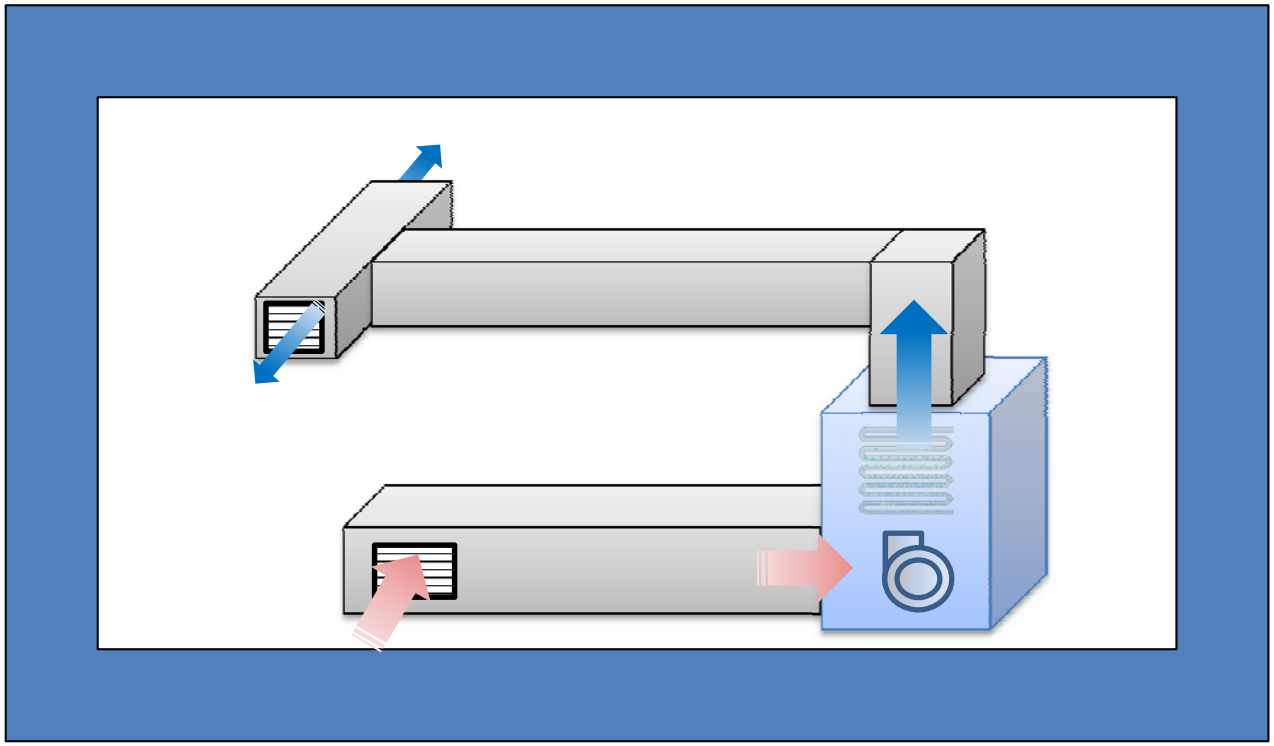
Step 2:
Select equipment that meets loads

- Select equipment which adds Btu's to meet heating load.



Step 3:
Design the duct system

- Design ducts to properly distribute air through house. This offsets the loads.



Value of quality-installed Heating & cooling systems

- Two components of a complete system:

Proper design

Proper installation

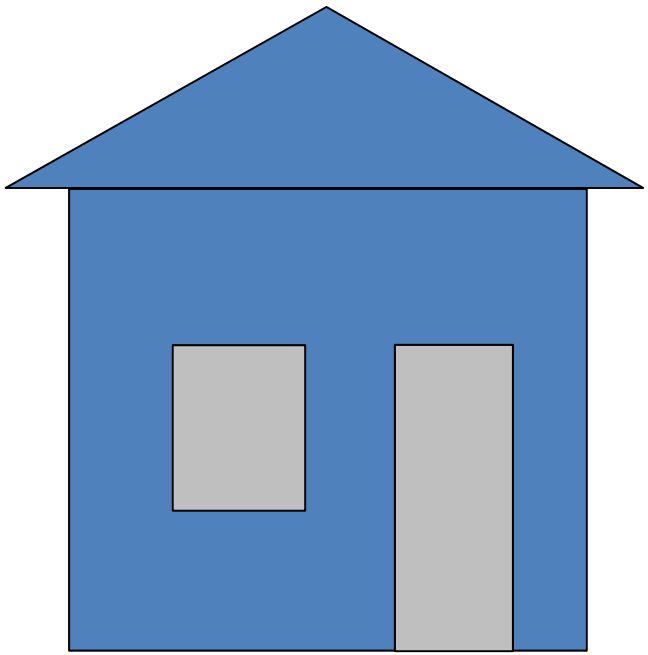
Overview of Sections 1-4 of the Checklist

Section 1: Review of HVAC System
QI Contractor Checklist

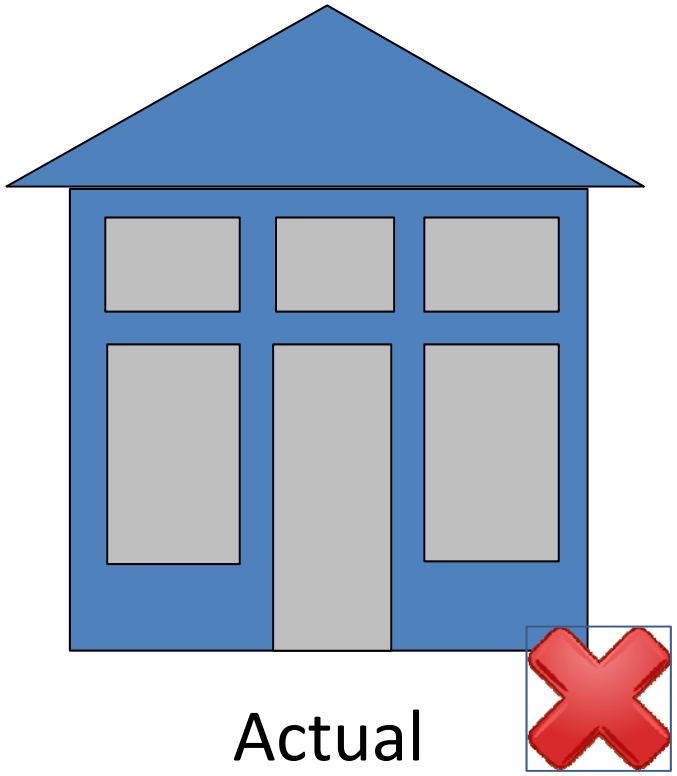
1) Collect design documentation for record-keeping.
2) Review design parameters to see if they match rated home.
3) Visually verify that equipment matches what was specified.
4) Check data from HVAC contractor's commissioning process.
5) Check if contractor holds required credentials.

Item 1.2.5:
Window area

- Window area is within ±10% of calculated window area of rated home.



Design



Actual

Section 2:
Duct quality installation

- Visual inspection of duct installation.
- Review of quantity and location of duct terminations.
- Bedroom pressure balancing.

Section 3 & 4:
Duct insulation & leakage

- Minimum insulation values for ductwork in unconditioned space.
- Maximum allowable total duct leakage levels and to outdoors.

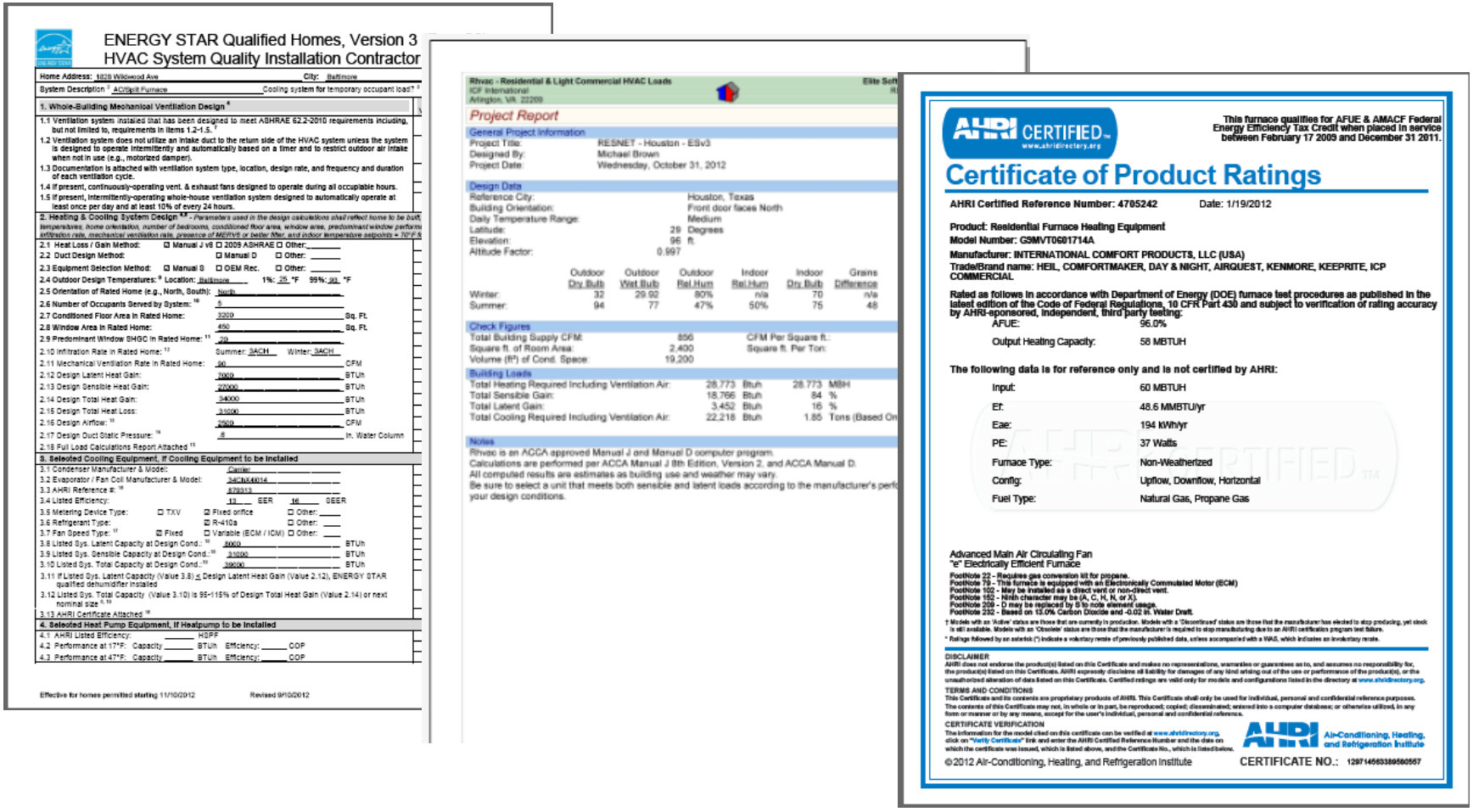
Section 1 through 4: Summary

- Oversight of key features of the design process.
- Inspection of duct installation quality.
- Verification of duct insulation and leakage levels.

Critical Details of the HVAC System QI Rater Checklist

Item 1.1:
Collection of required documentation

- Required documentation includes Checklist, ventilation system design, load calculations, & AHRI certificate.



ENERGY STAR Qualified Homes, Version 3
HVAC System Quality Installation Contractor

Home Address: 1828 Wildwood Ave City: Baltimore
System Description: AC/Split Furnace Cooling system for temporary occupant load?

1. Whole-Building Mechanical Ventilation Design
2. Heating & Cooling System Design
3. Selected Cooling Equipment, If Cooling Equipment to be Installed
4. Selected Heat Pump Equipment, If Heatpump to be Installed

Effective for homes permitted starting 11/10/2012 Revised 9/10/2012

Rhvac - Residential & Light Commercial HVAC Loads
ICF International
Arlington, VA 22209

Project Report

General Project Information
Project Title: RESNET - Houston - ESv3
Designed By: Michael Brown
Project Date: Wednesday, October 31, 2012

Design Data
Reference City: Houston, Texas
Building Orientation: Front door faces North
Daily Temperature Range: Medium
Latitude: 29 Degrees
Elevation: 96 ft.
Altitude Factor: 0.997

	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel Hum	Indoor Rel Hum	Indoor Dry Bulb	Grains Difference
Winter:	32	29.92	80%	n/a	70	n/a
Summer:	94	77	47%	50%	75	48

Check Figures
Total Building Supply CFM: 856 CFM Per Square ft.:
Square ft. of Room Area: 2,400 Square ft. Per Ton:
Volume (ft³) of Cond. Space: 19,200

Building Loads
Total Heating Required Including Ventilation Air: 28,773 Btuh 28.773 MBH
Total Sensible Gain: 18,766 Btuh 84 %
Total Latent Gain: 3,452 Btuh 16 %
Total Cooling Required Including Ventilation Air: 22,218 Btuh 1.85 Tons (Based On

Notes
Rhvac is an ACCA approved Manual J and Manual D computer program.
Calculations are performed per ACCA Manual J 8th Edition, Version 2, and ACCA Manual D.
All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's perf
your design conditions.

AHRI CERTIFIED
www.ahridirectory.org

This furnace qualifies for AFUE & AMACF Federal Energy Efficiency Tax Credit when placed in service between February 17 2009 and December 31 2011.

Certificate of Product Ratings

AHRI Certified Reference Number: 4705242 Date: 1/19/2012

Product: Residential Furnace Heating Equipment
Model Number: GSMVT0601714A
Manufacturer: INTERNATIONAL COMFORT PRODUCTS, LLC (USA)
Trade/Brand name: HEIL, COMFORTMAKER, DAY & NIGHT, AIRQUEST, KENMORE, KEEPRITE, ICP COMMERCIAL

Rated as follows in accordance with Department of Energy (DOE) furnace test procedures as published in the latest edition of the Code of Federal Regulations, 10 CFR Part 430 and subject to verification of rating accuracy by AHRI-sponsored, independent, third party testing:

AFUE:	96.0%
Output Heating Capacity:	58 MBTUH

The following data is for reference only and is not certified by AHRI:

Input:	60 MBTUH
Ef:	48.6 MMBTU/yr
Eae:	194 kWh/yr
PE:	37 Watts
Furnace Type:	Non-Weatherized
Config:	Upflow, Downflow, Horizontal
Fuel Type:	Natural Gas, Propane Gas

Advanced Main Air Circulating Fan
"e" Electrically Efficient Furnace

FootNote 22 - Requires gas conversion kit for propane.
FootNote 79 - This furnace is equipped with an Electronically Commutated Motor (ECM)
FootNote 102 - May be installed as a direct vent or non-direct vent.
FootNote 152 - Ninth character may be (A, C, H, N, or X).
FootNote 209 - D may be replaced by S to note exempt usage.
FootNote 232 - Based on 13.0% Carbon Dioxide and -0.02 in. Water Draft.

† Models with an 'Active' status are those that are currently in production. Models with a 'Discontinued' status are those that the manufacturer has elected to stop producing, yet stock is still available. Models with an 'Obsolete' status are those that the manufacturer is required to stop manufacturing due to an AHRI certification program test failure.
* Ratings followed by an asterisk (*) indicate a voluntary rerate of previously published data, unless accompanied with a WAS, which indicates an involuntary rerate.

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AHRI Air-Conditioning, Heating, and Refrigeration Institute

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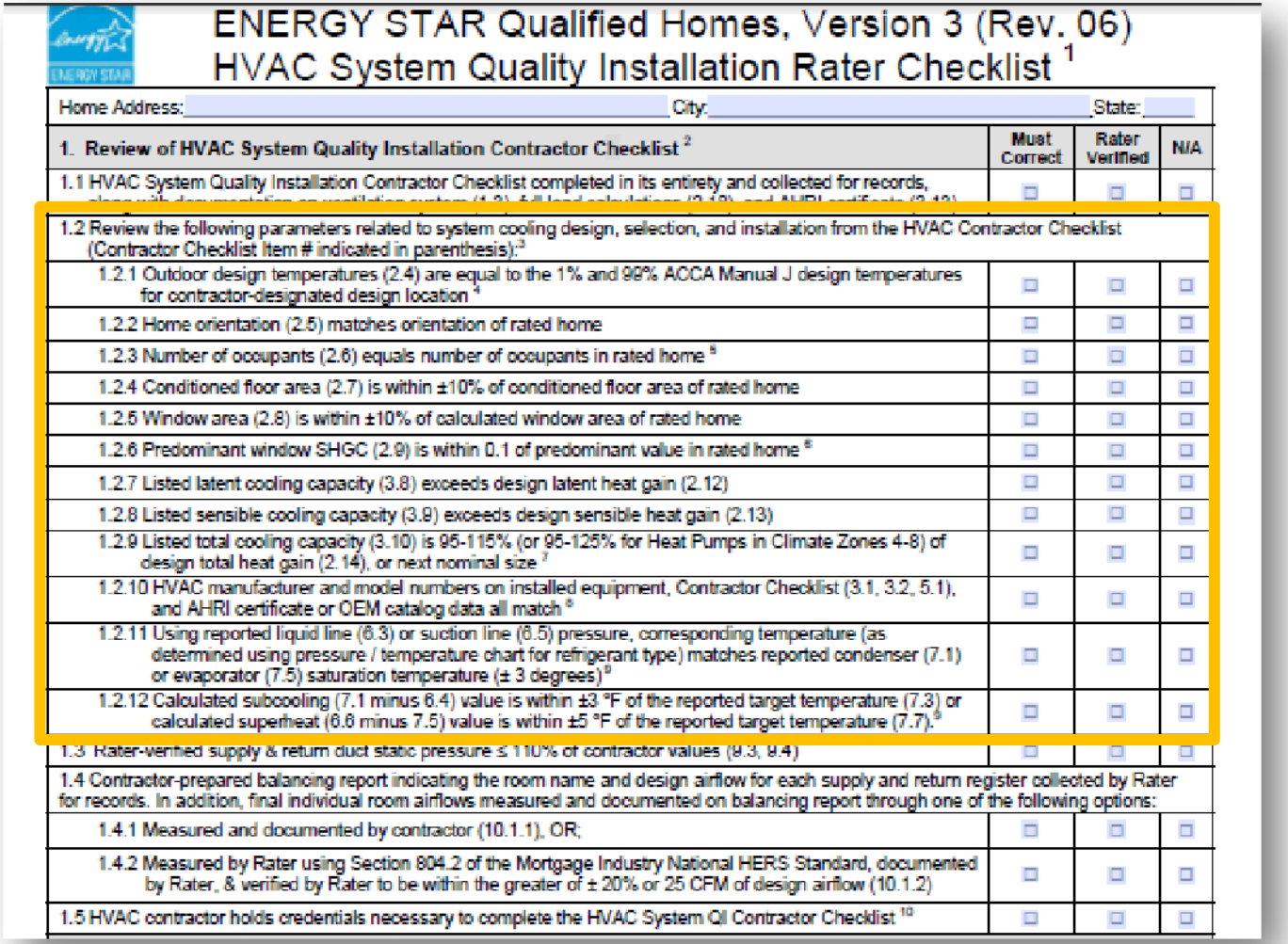
Item 1.2:
Review of contractor checklist & equipment



ENERGY STAR Qualified Homes, Version 3 (Rev. 06)
HVAC System Quality Installation Rater Checklist [1]

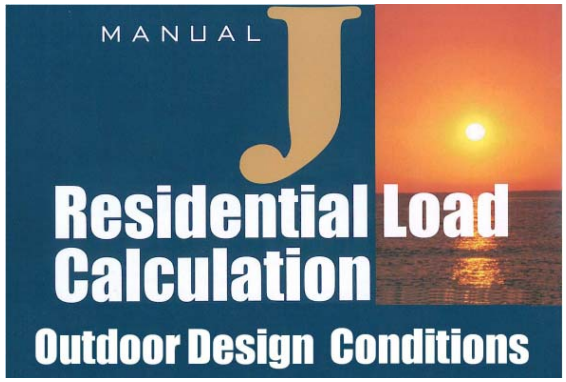
Home Address: _____ City: _____ State: _____

1. Review of HVAC System Quality Installation Contractor Checklist [2]	Must Correct	Rater Verified	N/A
1.1 HVAC System Quality Installation Contractor Checklist completed in its entirety and collected for records,	☐	☐	☐
1.2 Review the following parameters related to system cooling design, selection, and installation from the HVAC Contractor Checklist (Contractor Checklist Item # indicated in parenthesis):[3]			
1.2.1 Outdoor design temperatures (2.4) are equal to the 1% and 99% ACCA Manual J design temperatures for contractor-designated design location [4]	☐	☐	☐
1.2.2 Home orientation (2.5) matches orientation of rated home	☐	☐	☐
1.2.3 Number of occupants (2.6) equals number of occupants in rated home [5]	☐	☐	☐
1.2.4 Conditioned floor area (2.7) is within ±10% of conditioned floor area of rated home	☐	☐	☐
1.2.5 Window area (2.8) is within ±10% of calculated window area of rated home	☐	☐	☐
1.2.6 Predominant window SHGC (2.9) is within 0.1 of predominant value in rated home [6]	☐	☐	☐
1.2.7 Listed latent cooling capacity (3.8) exceeds design latent heat gain (2.12)	☐	☐	☐
1.2.8 Listed sensible cooling capacity (3.9) exceeds design sensible heat gain (2.13)	☐	☐	☐
1.2.9 Listed total cooling capacity (3.10) is 95-115% (or 95-125% for Heat Pumps in Climate Zones 4-8) of design total heat gain (2.14), or next nominal size [7]	☐	☐	☐
1.2.10 HVAC manufacturer and model numbers on installed equipment, Contractor Checklist (3.1, 3.2, 5.1), and AHRI certificate or OEM catalog data all match [8]	☐	☐	☐
1.2.11 Using reported liquid line (6.3) or suction line (6.5) pressure, corresponding temperature (as determined using pressure / temperature chart for refrigerant type) matches reported condenser (7.1) or evaporator (7.5) saturation temperature (± 3 degrees) [9]	☐	☐	☐
1.2.12 Calculated subcooling (7.1 minus 6.4) value is within ±3 °F of the reported target temperature (7.3) or calculated superheat (6.6 minus 7.5) value is within ±5 °F of the reported target temperature (7.7). [9]	☐	☐	☐
1.3 Rater-verified supply & return duct static pressure ≤ 110% of contractor values (8.3, 8.4)	☐	☐	☐
1.4 Contractor-prepared balancing report indicating the room name and design airflow for each supply and return register collected by Rater for records. In addition, final individual room airflows measured and documented on balancing report through one of the following options:			
1.4.1 Measured and documented by contractor (10.1.1), OR;	☐	☐	☐
1.4.2 Measured by Rater using Section 804.2 of the Mortgage Industry National HERS Standard, documented by Rater, & verified by Rater to be within the greater of ± 20% or 25 CFM of design airflow (10.1.2)	☐	☐	☐
1.5 HVAC contractor holds credentials necessary to complete the HVAC System QI Contractor Checklist [10]	☐	☐	☐

Item 1.2.1:
Review of contractor checklist

- Verify outdoor design temperatures equal 1% and 99% ACCA Manual J design temperatures for selected location.
- These design temperatures are available on EPA's website:

  http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Outdoor_Design_Conditions_508.pdf?7cdb-8623



Location	Dry Bulb Design Temperature	
	Winter / Heating / 99%	Summer / Cooling / 1%
Richmond, VA	18 F	92 F

Item 1.2.2 through 1.2.6: Review of contractor checklist

- Verify that the following parameters used in the load calculation match the rated home:
  - Home orientation
  - Number of occupants
  - Conditioned floor area (±10%)
  - Window area (±10%)
  - SHGC (±0.1 SHGC value)
- Use the tolerances provided to make compliance easier.

Example of Acceptable Floor Area

-10%	Design	+ 10%
1,980	2,200	2,420

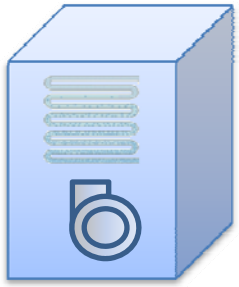
Item 1.2.2 through 1.2.6: Review of contractor checklist

2.4 Outdoor Design Temperatures: [9] Location: Baltimore	1%: 25 °F 99%: 93 °F	☐
2.5 Orientation of Rated Home (e.g., North, South):	North	☐
2.6 Number of Occupants Served by System: [10]	5	☐
2.7 Conditioned Floor Area in Rated Home:	3200 Sq. Ft.	☐
2.8 Window Area in Rated Home:	450 Sq. Ft.	☐
2.9 Predominant Window SHGC in Rated Home: [11]	.20	☐
2.10 Infiltration Rate in Rated Home: [12]	Summer: .3 ACH Winter: .3 ACH	☐
2.11 Mechanical Ventilation Rate in Rated Home:	90 CFM	☐
2.12 Design Latent Heat Gain:	9600 BTUh	☐
2.13 Design Sensible Heat Gain:	38400 BTUh	☐
2.14 Design Total Heat Gain:	48000 BTUh	☐
2.15 Design Total Heat Loss:	31000 BTUh	☐
2.16 Design Airflow: [13]	1600 CFM	☐
2.17 Design Duct Static Pressure: [14]	.6 In. Water Column	☐
2.18 Full Load Calculations Report Attached [15]		☐
3. Selected Cooling Equipment, If Cooling Equipment to be Installed		
3.1 Condenser Manufacturer & Model:	Carrier	☐
3.2 Evaporator / Fan Coil Manufacturer & Model:	34ChX4i014	☐
3.3 AHRI Reference #: [16]	879313	☐
3.4 Listed Efficiency:	13 EER 16 SEER	☐

Item 1.2.10:
Checking installed equipment

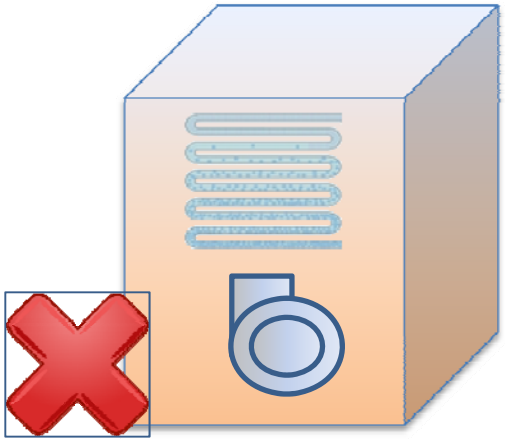
- HVAC manufacturer & model numbers on installed equipment, Contractor Checklist, & AHRI certificate match.

Equipment selected during design:



Model ABC

Equipment actually installed in home:

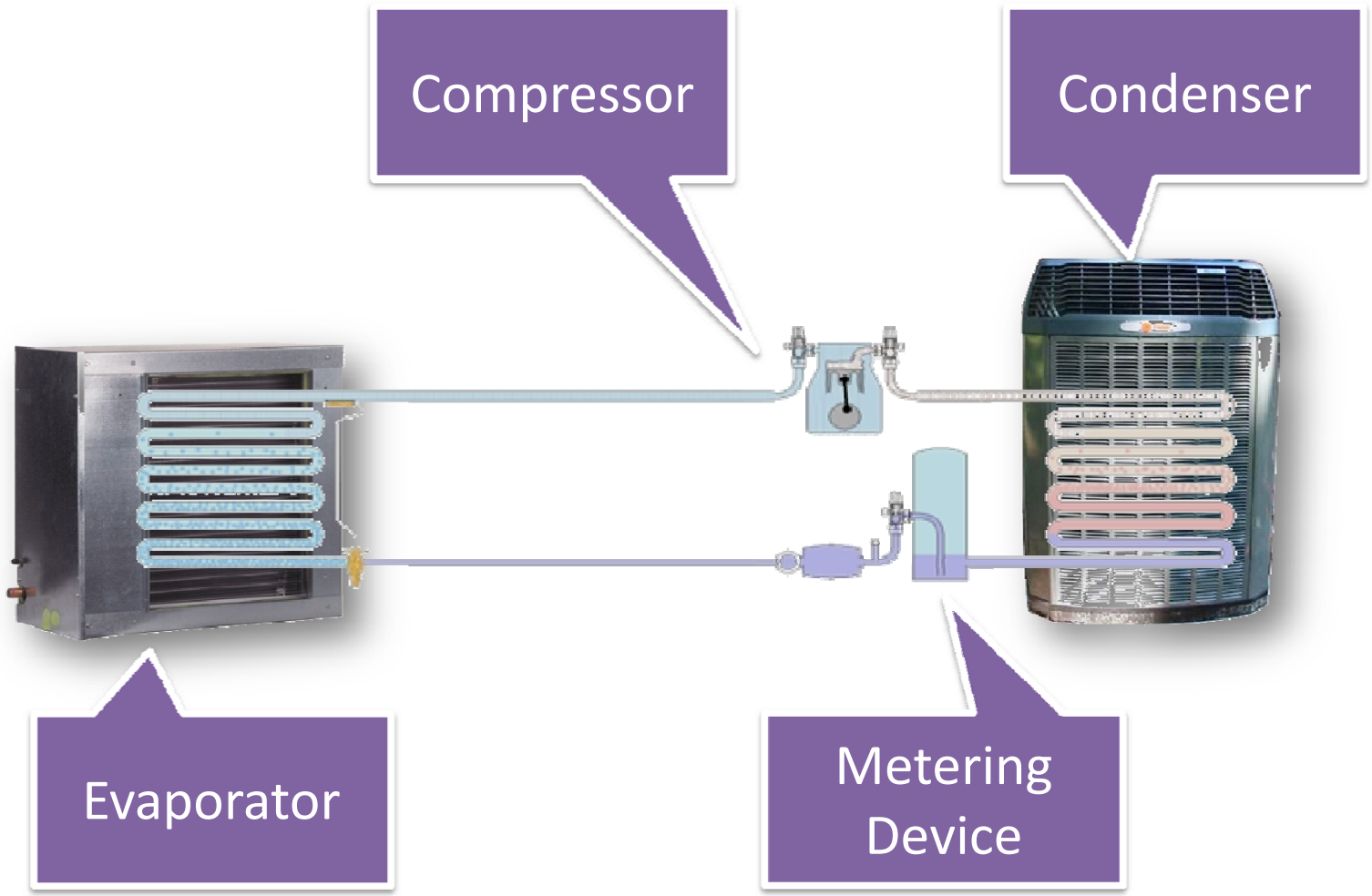


Model 123

Item 1.2.11 & 1.2.12: Review of contractor checklist

- The Rater completes two simple math calculations to help ensure that the equipment has the right amount of refrigerant.
- Even though these Items just require some simple math, it helps to understand the concepts behind them.

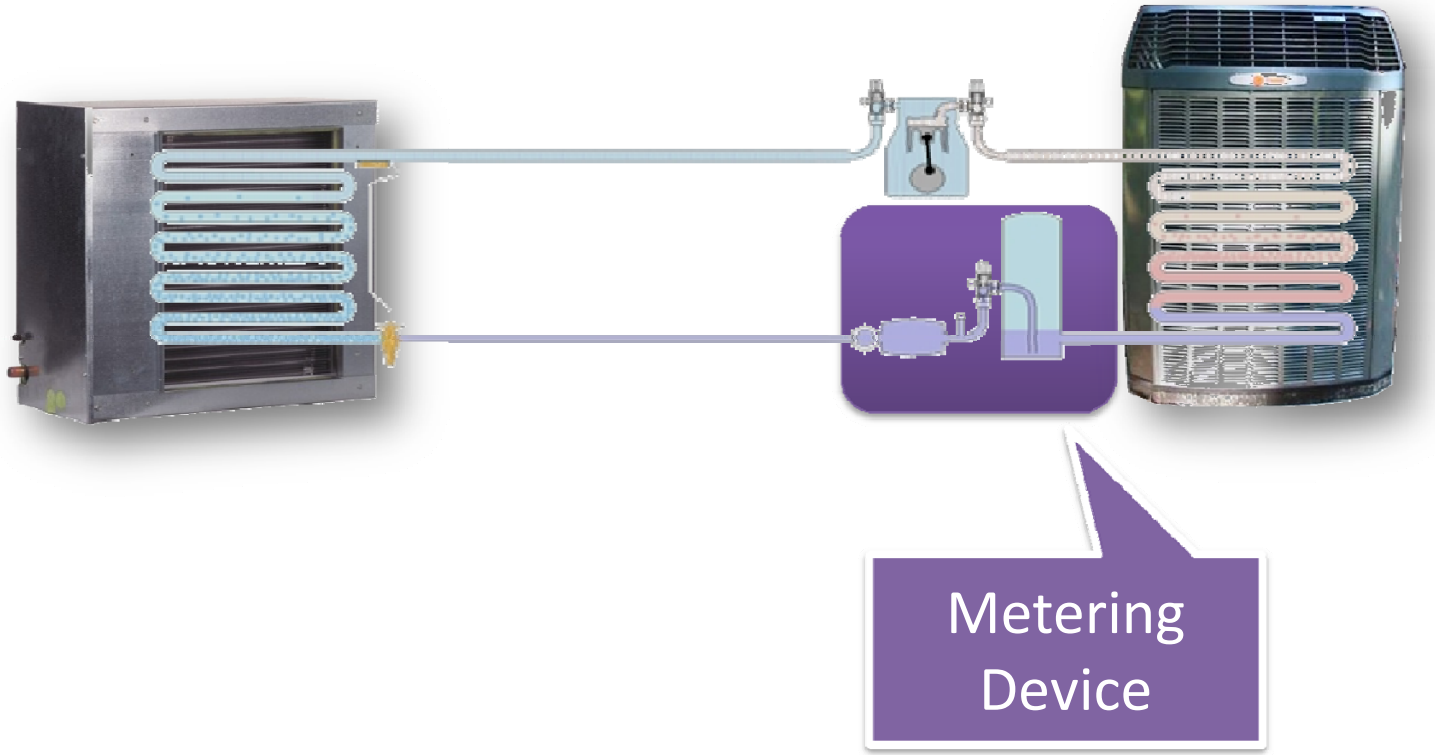
Refrigerant Tests & Calculations



Refrigerant Tests & Calculations

Step 1: Metering Device

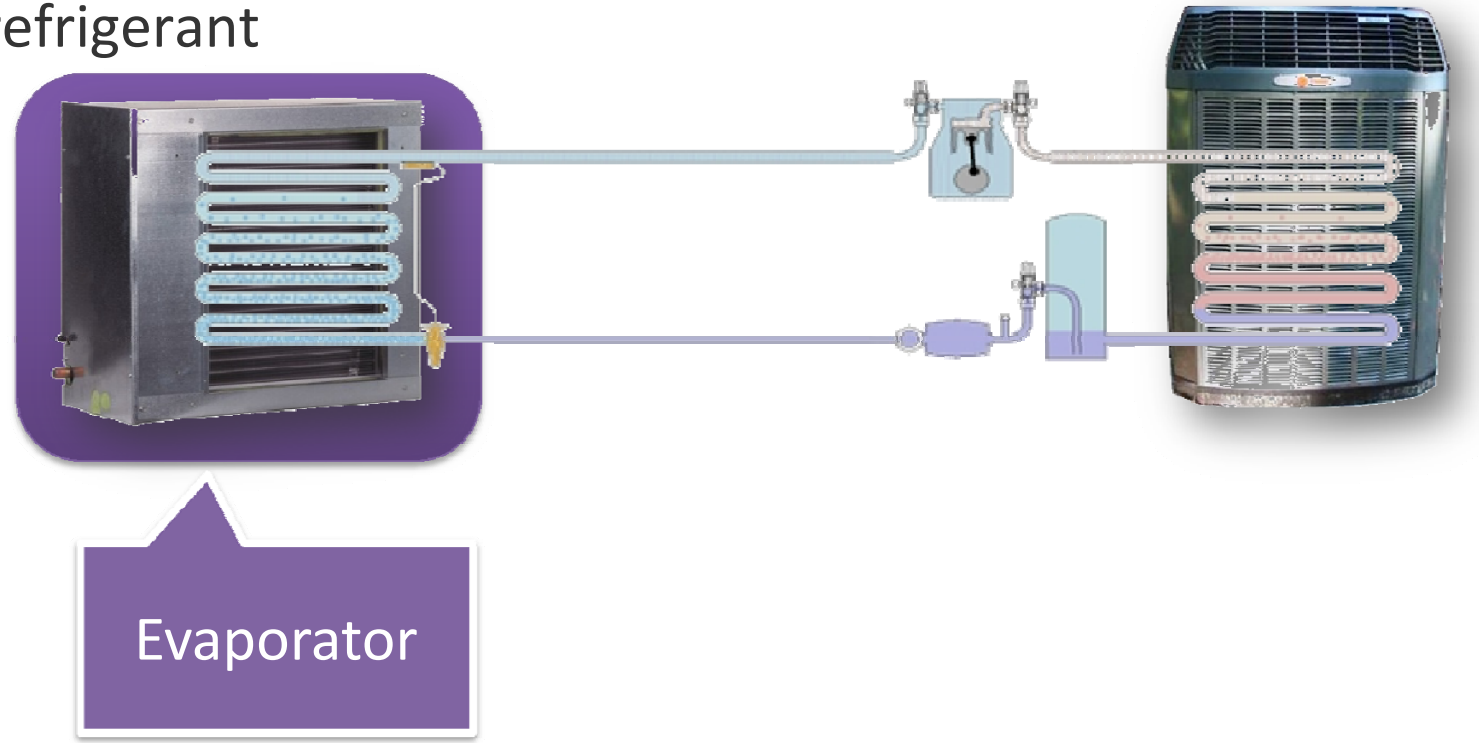
- The metering device controls how much refrigerant is released to the evaporator inside the home



Refrigerant Tests & Calculations

Step 2: Evaporator

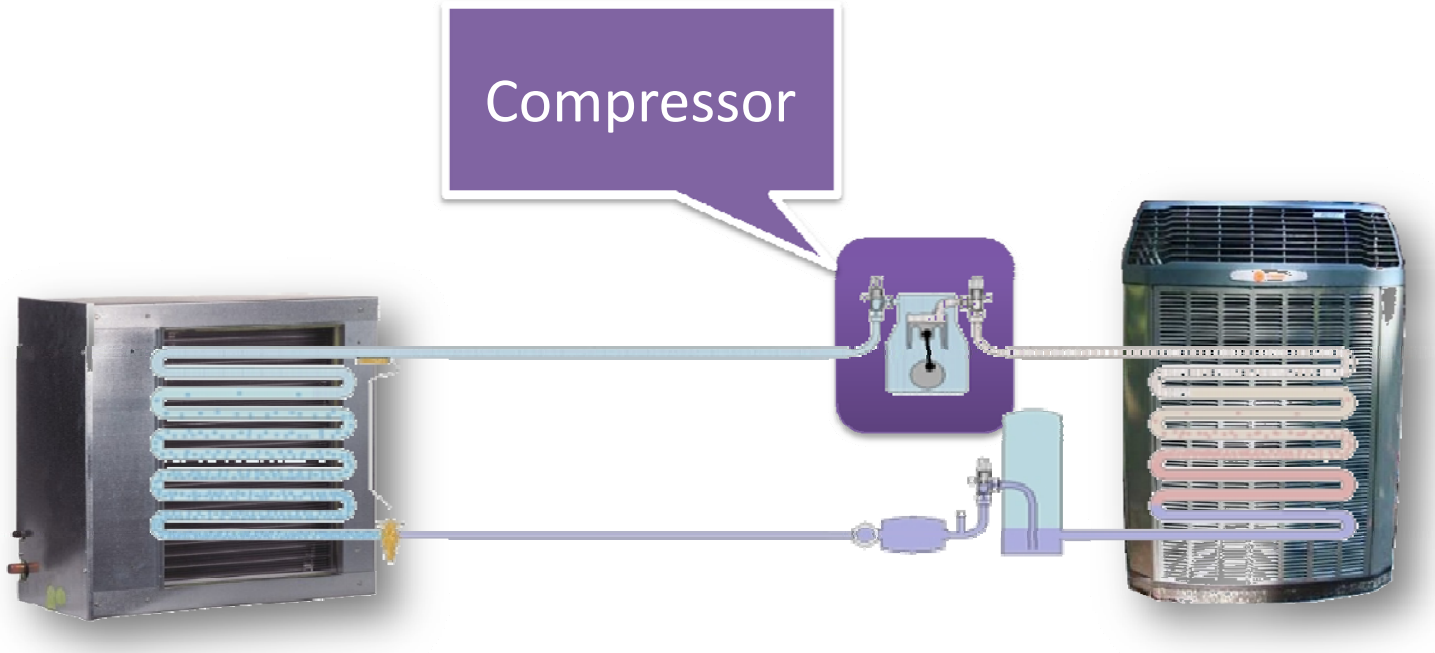
- The refrigerant flows through the evaporator or cooling coil in the air handler unit, transferring heat between the air and the refrigerant



Refrigerant Tests & Calculations

Step 3: Compressor

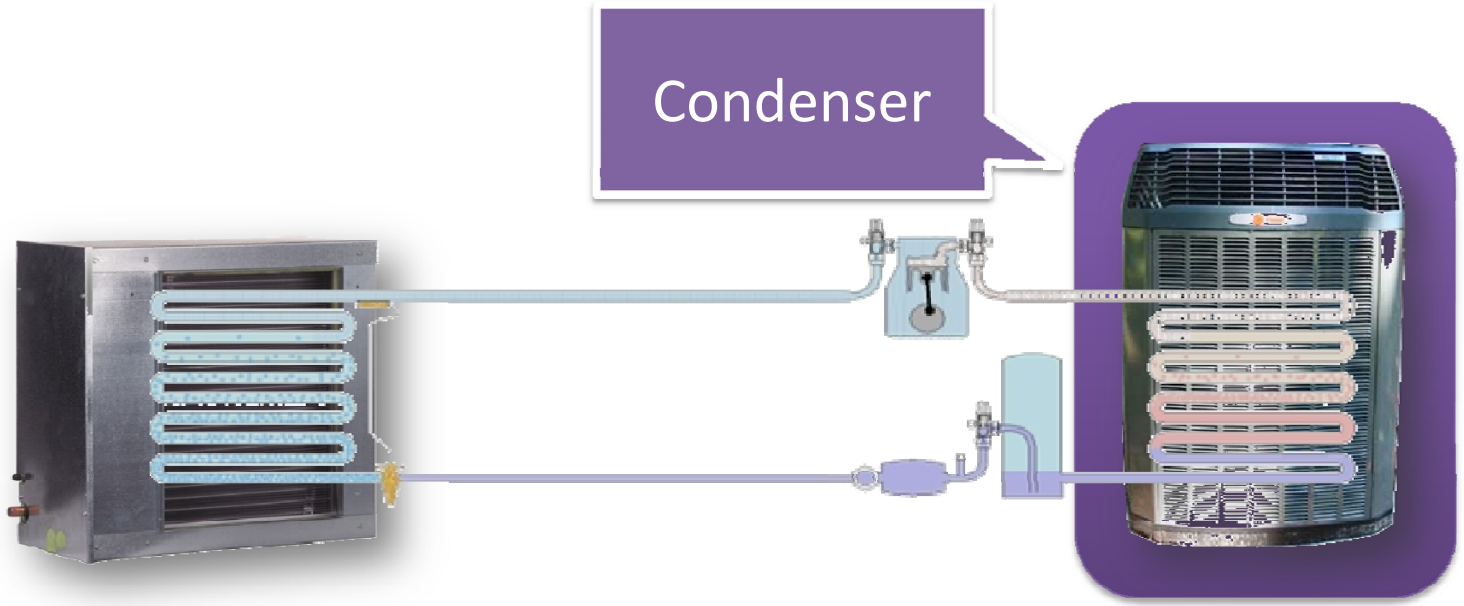
- The compressor is a small mechanical device that compresses the gas, raising its temperature



Refrigerant Tests & Calculations

Step 4: Condenser

- The condenser uses a fan to blow outdoor air across the refrigerant, removing heat, causing it to cool down and condense back into a liquid form



Refrigerant Tests & Calculations

Why is the amount of refrigerant so important to the operation of the A/C unit?

- Keep temperatures within target ranges
- Keep liquid out of gas side

Consequences of improper charging:

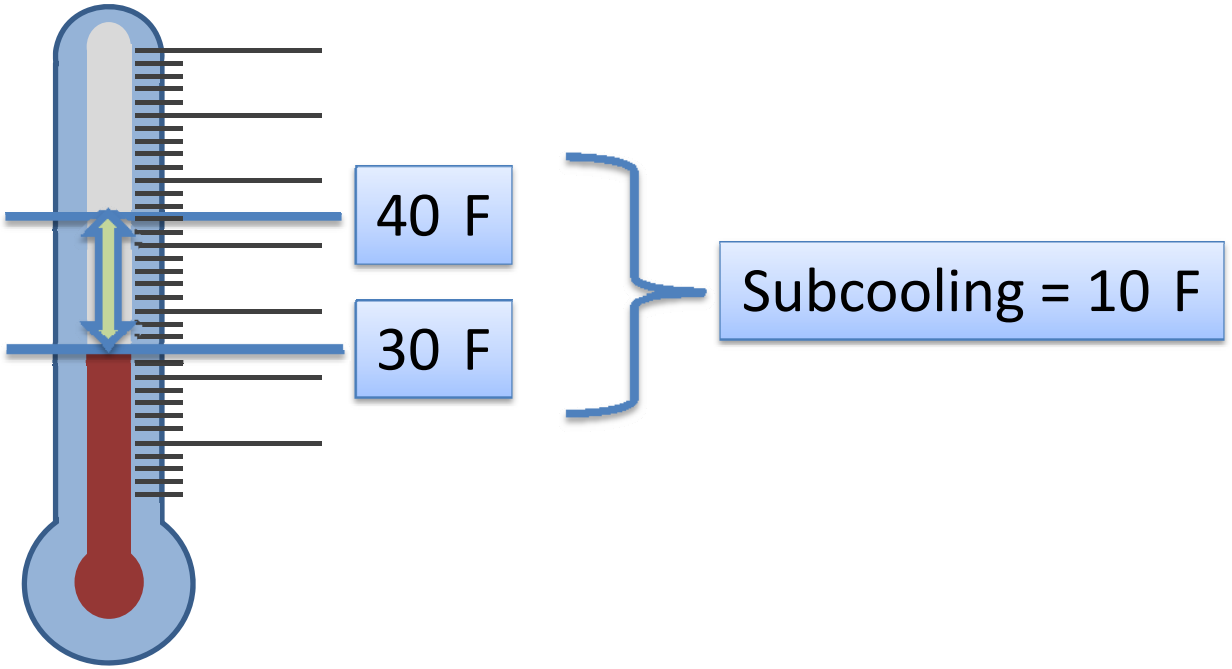
- Inefficient operation
- Premature compressor failures

Item 1.2.11 & 1.2.12: Review of contractor checklist

- Two tests can be done to ensure proper amount of refrigerant:
  - Subcooling test: Ensures the refrigerant is in liquid form after it leaves the condenser.
  - Superheat test: Ensures the refrigerant is in gas form before it arrives at the compressor.

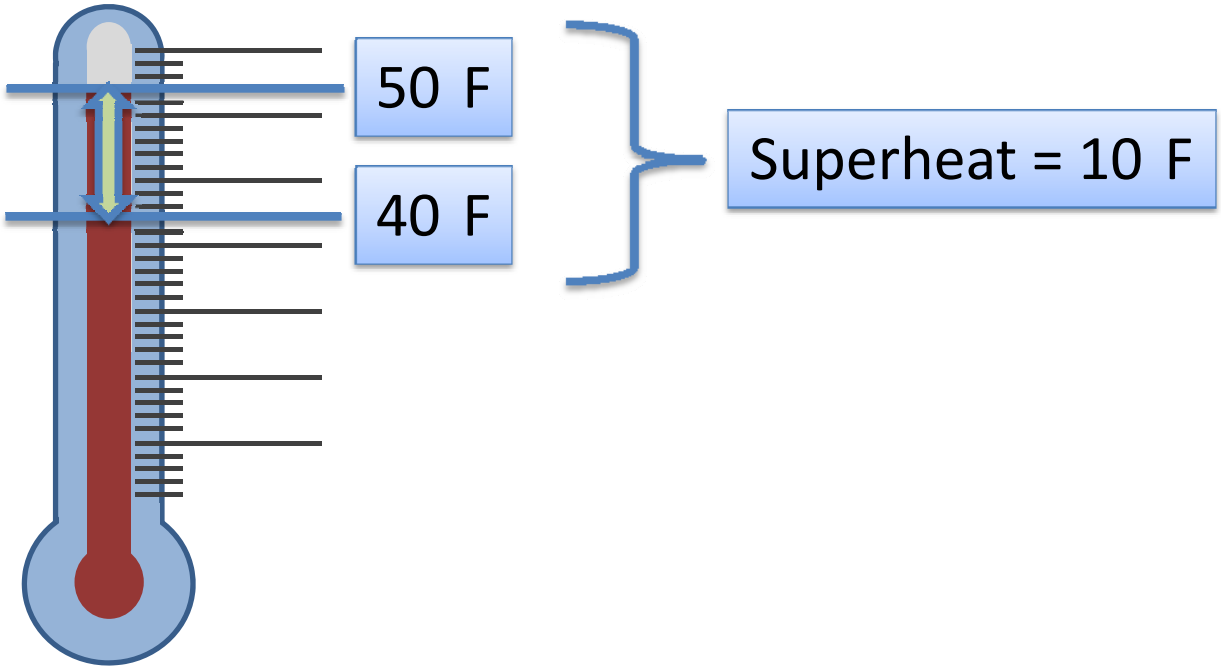
Item 1.2.11 & 1.2.12: Review of contractor checklist

- Subcooling is the temperature of a fluid below its boiling point (liquid saturation temperature).



Item 1.2.11 & 1.2.12: Review of contractor checklist

- Superheat is the temperature of a fluid above its boiling point (liquid saturation temperature).



Item 1.2.11:
Review of contractor checklist

- Verify that difference between Rater-verified and contractor-reported saturation temperature is ≤ 3ºF.
- A pressure – temperature chart shows the saturation temperature of a specific liquid at a variety of pressures.

Temp. (F)	R410A (psig)
35	107
40	118
45	130
50	142
55	155
60	170
65	185
70	201
75	217
80	235
85	254

Pressure / Temperature Chart

1) Contractor pressure = 118 psig

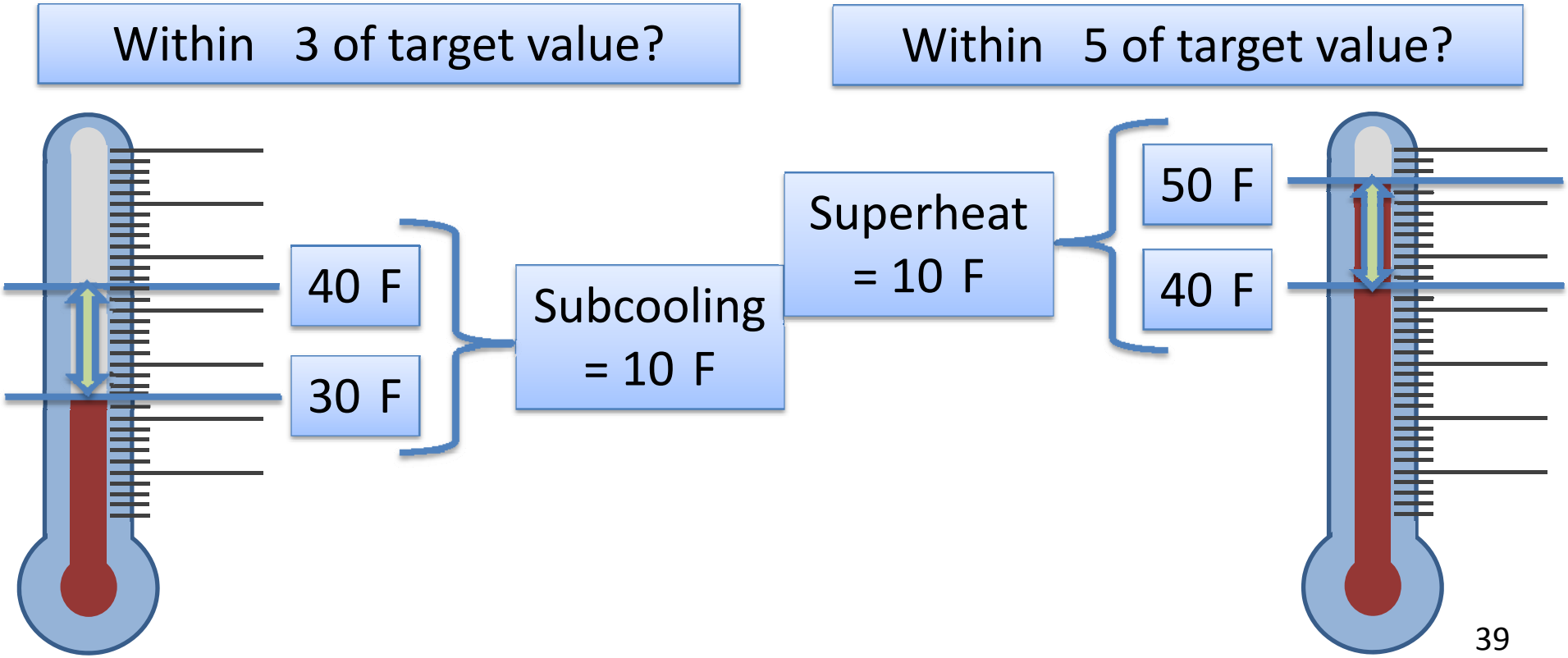
2) Contractor saturation temp. = 42 F

3) Rater saturation temp. = 40 F

4) Difference in saturation temp. = 2 F

Item 1.2.12:
Review of contractor checklist

- Verify difference between Rater-calculated and contractor-reported target temp.: Subcooling is ≤ 3°F or Superheat is ≤ 5°F.

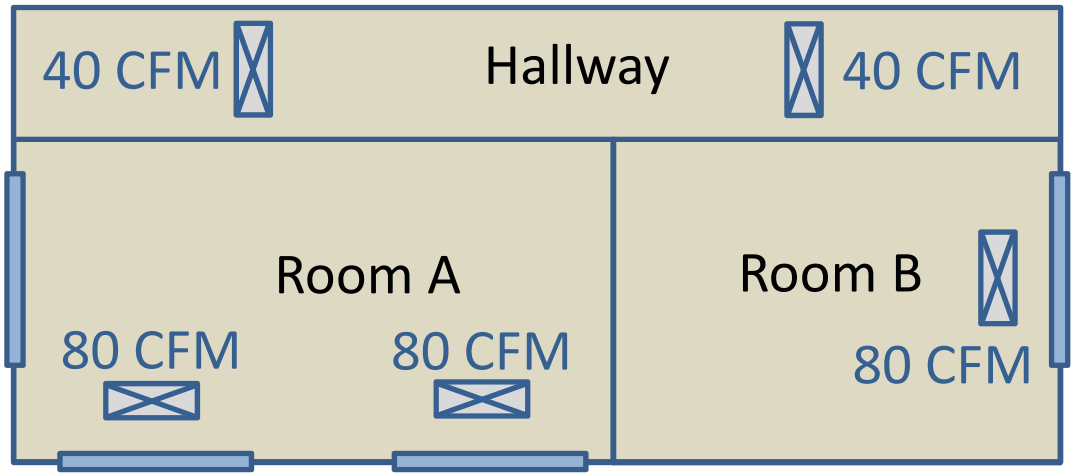


Item 1.3:
Static pressure test

- Measure the static pressure of the supply duct system and the return duct system.
- Use the same test hole locations as the contractor.
- Watch the video of how the contractor does this at:

http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_videos

Item 1.4:
Register airflow

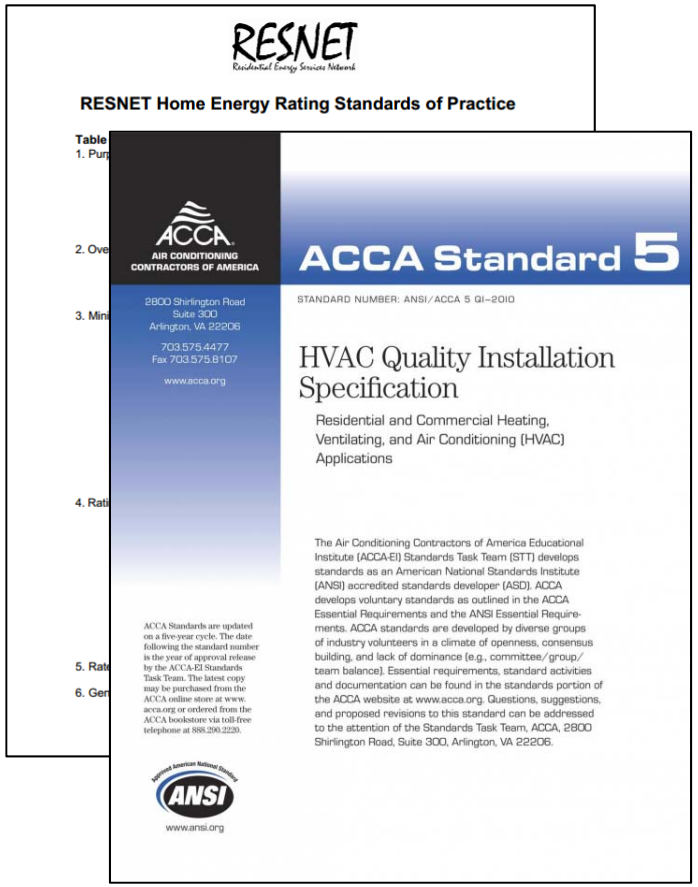


Sample Balancing Report

Room	Register	Design Airflow	Actual Airflow	Difference
Hallway	1	40	29	11
Hallway	2	40	52	12
Room A	1	80	76	4
Room A	2	80	66	14
Room B	1	80	95	15

Item 1.4:
Register airflow

- Methodologies for measuring airflow at registers:
  - ACCA QI 5 standard includes protocols for HVAC contractors (Section 5.2)
  - HERS Mortgage Industry National HERS Standards includes methods for Home Energy Raters to use (Section 804.2)


RESNET
Residential Energy Services Network
RESNET Home Energy Rating Standards of Practice
Table
1. Pur
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ACCA
AIR CONDITIONING CONTRACTORS OF AMERICA
2800 Shirlington Road
Suite 300
Arlington, VA 22206
703.575.4477
Fax 703.575.8107
www.acca.org
ACCA Standards are updated on a five-year cycle. The date following the standard number is the year of approval release by the ACCA-EI Standards Task Team. The latest copy may be purchased from the ACCA online store at www.acca.org or ordered from the ACCA bookstore via toll-free telephone at 888.290.2220.
ANSI
www.ansi.org
ACCA Standard 5
STANDARD NUMBER: ANSI/ACCA 5 QI–2010
HVAC Quality Installation Specification
Residential and Commercial Heating, Ventilating, and Air Conditioning (HVAC) Applications
The Air Conditioning Contractors of America Educational Institute (ACCA-EI) Standards Task Team (STT) develops standards as an American National Standards Institute (ANSI) accredited standards developer (ASD). ACCA develops voluntary standards as outlined in the ACCA Essential Requirements and the ANSI Essential Requirements. ACCA standards are developed by diverse groups of industry volunteers in a climate of openness, consensus building, and lack of dominance (e.g., committee/group/team balance). Essential requirements, standard activities and documentation can be found in the standards portion of the ACCA website at www.acca.org. Questions, suggestions, and proposed revisions to this standard can be addressed to the attention of the Standards Task Team, ACCA, 2800 Shirlington Road, Suite 300, Arlington, VA 22206.

Item 1.4:
Register airflow

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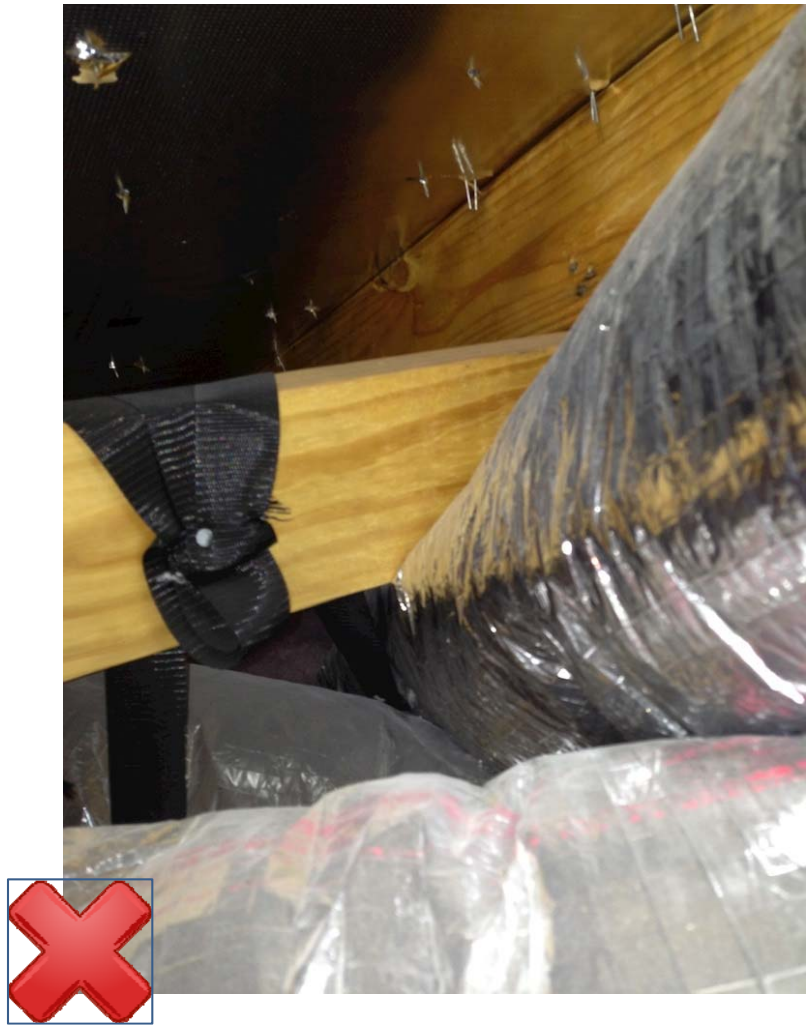
Section 2:
Duct quality installation

- Items 2.1 through 2.4 focus on installation defects like kinks, bends, compression, and excessive ductwork.

Section 2:
Duct quality installation

Compression

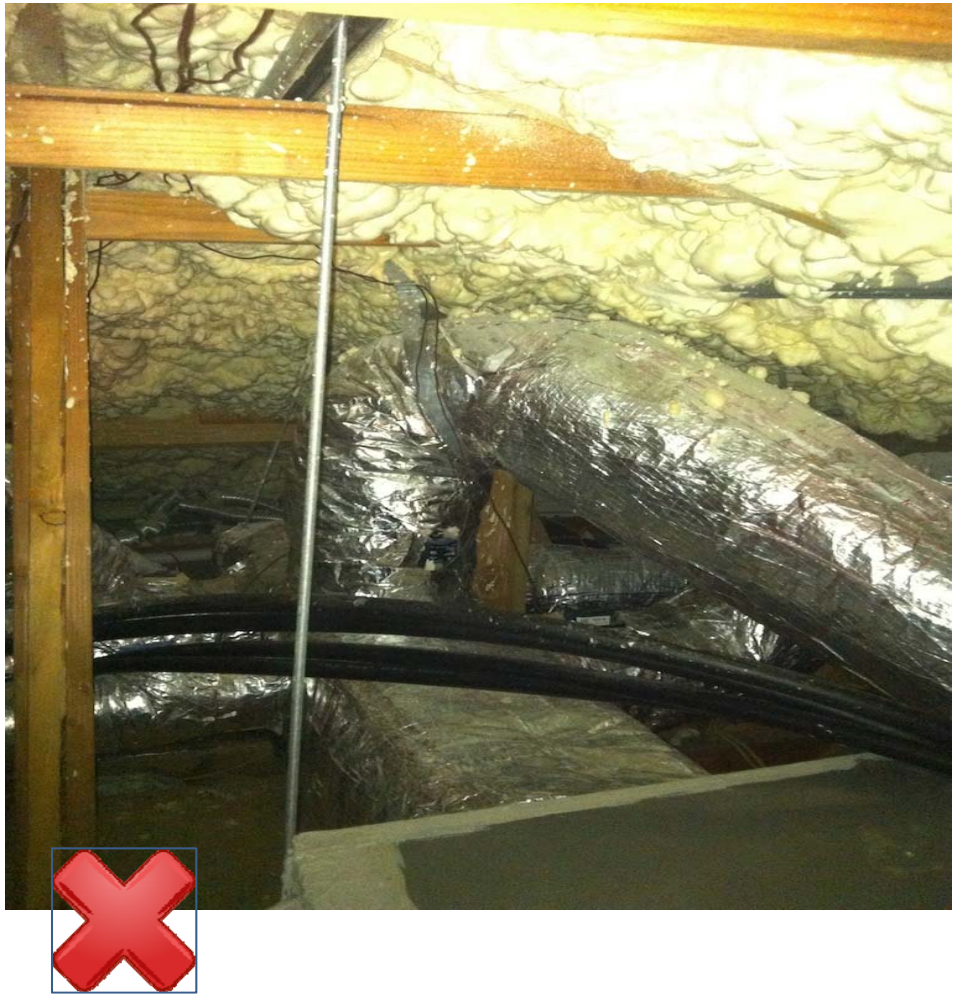


Section 2:
Duct quality installation

Bends & Kinks

Section 2:
Duct quality installation

Sharp Bend



Item 4.1:
Total duct leakage

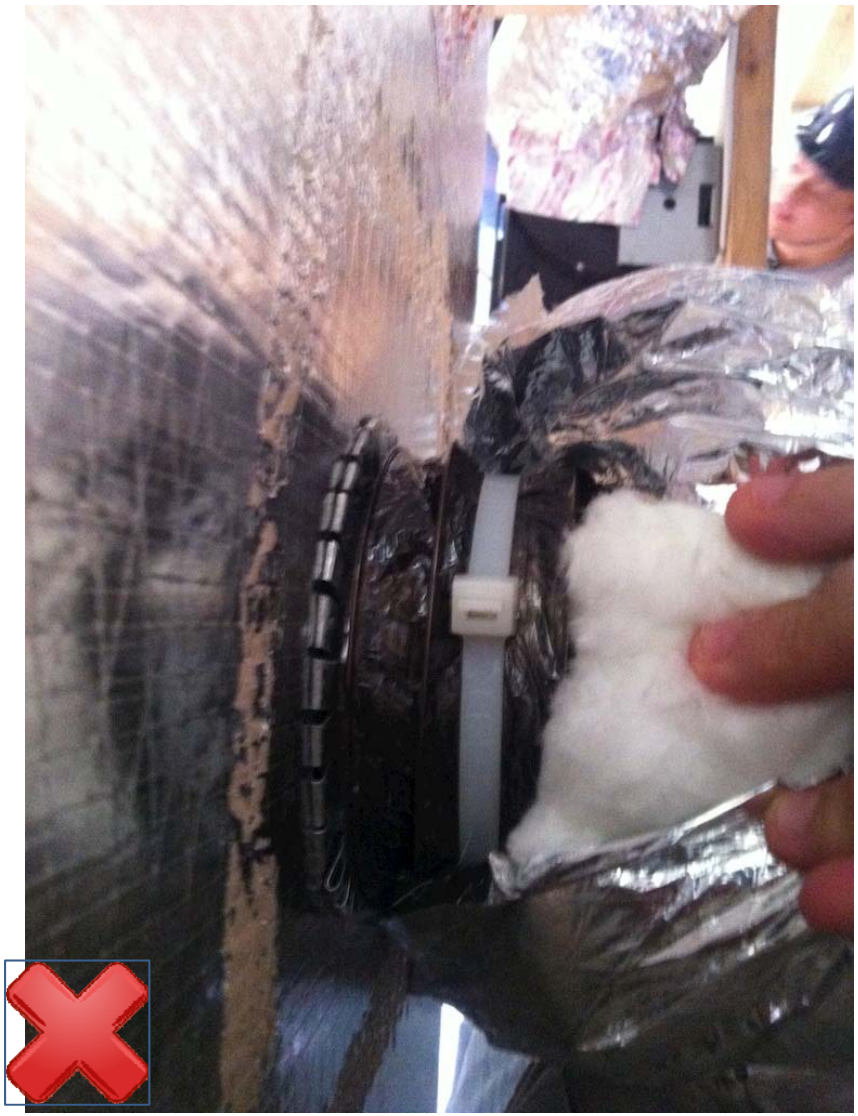
- Total duct leakage ≤ 8 CFM per 100 square feet of conditioned floor area.
- More challenging to meet with building cavities as ducts.
- Testing must occur at “final” – when all components of the system are installed including the air handler, ductwork, duct boots and register grills atop the finished surfaces.
- An additional test at “rough-in” is helpful to many partners, but is not mandatory.
- Partners are permitted to seal both the face *and* the perimeter of the register when testing.
- Sealing between duct boot & subsurface is critical.

Item 4.1:
Total duct leakage

- Using a building cavity for the return system makes it very challenging to meet the leakage limit.

Item 4.1:
Total duct leakage

- If the gap is big enough that your finger can fit in…
- There might be an air leak.



Summary

- A complete thermal enclosure system is the first step towards a complete HVAC system.
- HVAC design typically follows a three-step process:
  1. Calculate the loads.
  2. Select equipment to meet those loads.
  3. Design a duct system from the equipment to the rooms, and back, to offset those loads.
- Provided an overview and reviewed key details of Sections 1 through 4 of the HVAC System QI Rater Checklist.
- These features help improve the efficiency and comfort of every certified home.

ENERGY STAR Certified Homes

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