

## **Workshop Description and Outline:**

### **Title: “High Performance HVAC”**

#### *Brief highlights of the presentation:*

Recent changes in the International Energy Conservation Code 2012 and in energy efficiency and green building programs such as ENERGY STAR for Homes strongly encourage high performance HVAC best practices. We will discuss the changing requirements and how that will change the way you design, install and test HVAC systems. This seminar will help HVAC contractors identify and implement proven techniques and products that would make homes more energy efficient and incorporate green building elements through a high performance residential HVAC system.

An important element of the workshop will be to introduce the EPA Energy Star HVAC Quality Installation Program.

#### **Relevance to Attendees:**

The workshop could be targeted to at least the following groups:

- New home builders and remodelers, their site supervision staff, estimators and contract managers
- Designers and architects
- HVAC contractors
- Building Code Officials
- Utility and housing program officials who promote energy efficiency programs
- Designers and architects

#### **Learning Objectives:**

- Learn about the challenges and opportunities presented by new building codes and energy efficient programs
- Identify High Performance HVAC concepts
- Learn essential strategies for High Performance HVAC systems
- Learn about the Energy Star HVAC Quality Installation Program
- Know where to go for additional resources and support

#### **Workshop Format:**

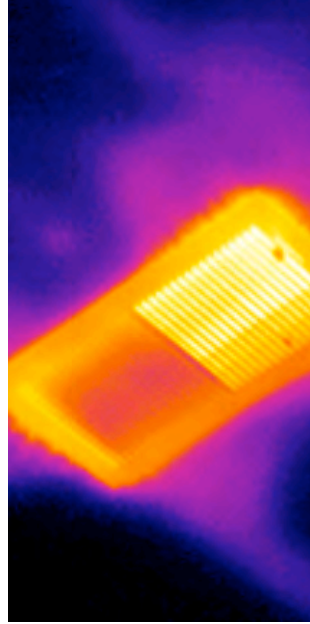
*Length of presentation:* The workshop is designed for a 90 minute format

*Overview of presentation structure:* The facilitator will use presentation software that will rely heavily on the use of graphics and pictures to tell the story.

#### **Workshop General Agenda:**

- |         |  |
|---------|--|
| 10 Min. | Introductions and Overview                           |
| 20 Min. | Key HVAC Design Concepts                             |
| 20 Min. | Key HVAC Installation and Testing Concepts           |
| 10 Min. | Implementing High Performance HVAC strategies        |
| 20 Min. | Review Energy Star HVAC Quality Installation Program |
| 10 Min. | Summary and Wrap-up                                  |

High  
Performance  
HVAC

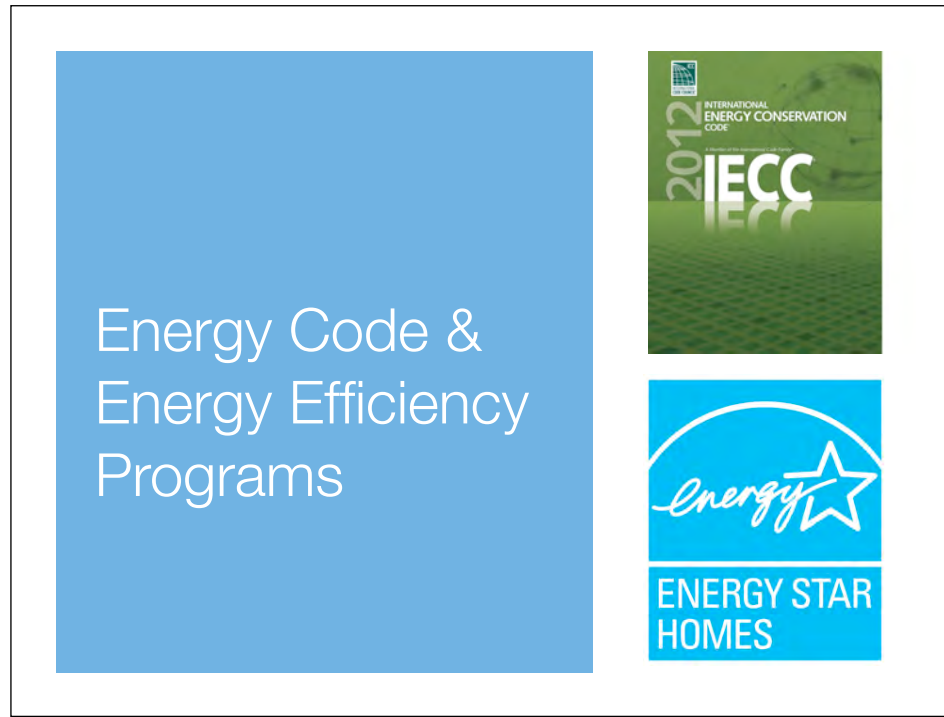


# **BUILDING KNOWLEDGE**

We are a leading training and consulting firm that uses a building science based systems approach to help our clients improve their businesses by Building Better Homes™.

We serve as a resource for the nation's leading energy efficient and green certification programs providing technical, marketing and verification support to developers, builders, contractors, architects and industry professionals.

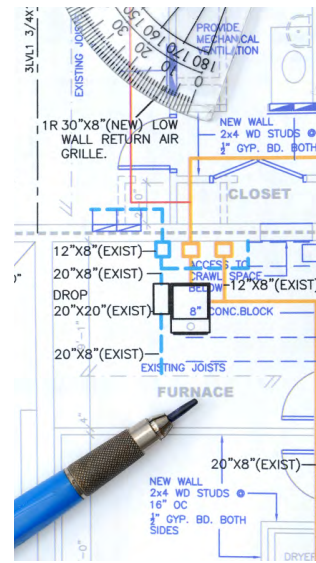




Overview of today's session:

We will review the IECC code and Energy Programs like Energy Star for Homes

# High Performance HVAC Design



High performance home building and remodeling requires a different approach than the traditional, established way of building. Building a high performance home must be a systematic approach and done as a team. The project must be looked at as a system, in which each component is connected to and depends on the other components. Teamwork is required to make it all come together. Addressing and optimizing key factors up front with the whole team will result in a smoother construction process, lower costs and a much better home.

High  
Performance  
HVAC Installation  
and Testing



Based on our experience with certification programs we will review the key best practices for HVAC installations and the available performance tests

Implementing  
High Performance  
HVAC Strategies



We will discuss strategies for improving you business through High Performance HVAC

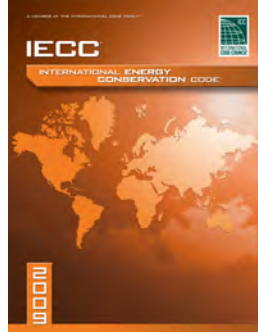
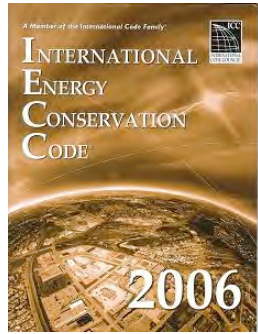


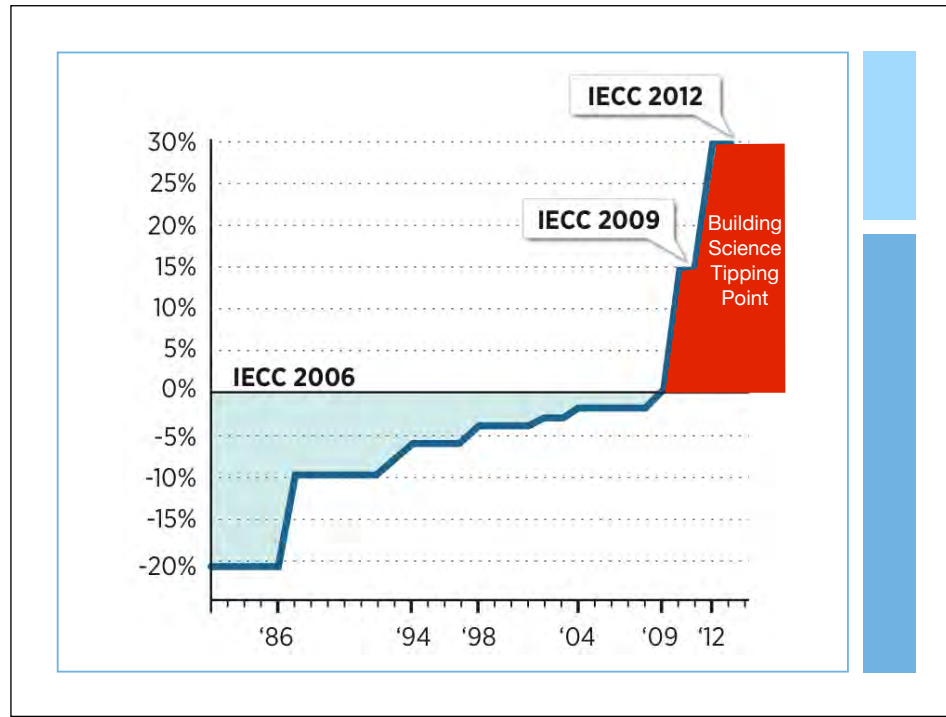
Finally we will review the Energy Star HVAC Quality Installation Program



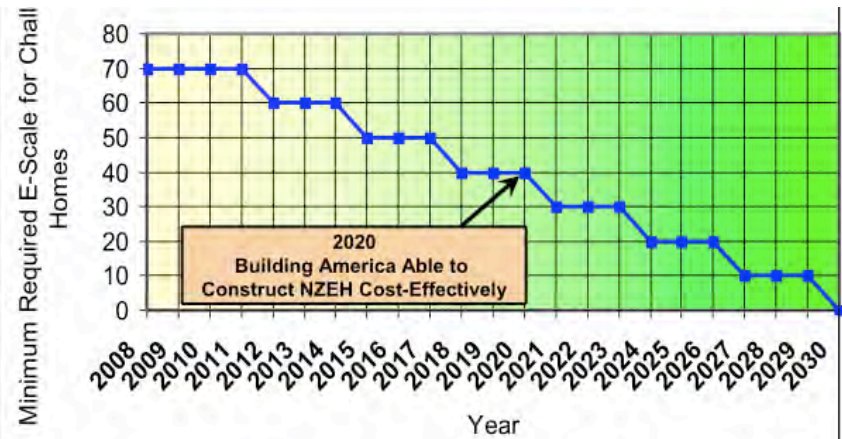
Energy Code &  
Energy Efficiency  
Programs



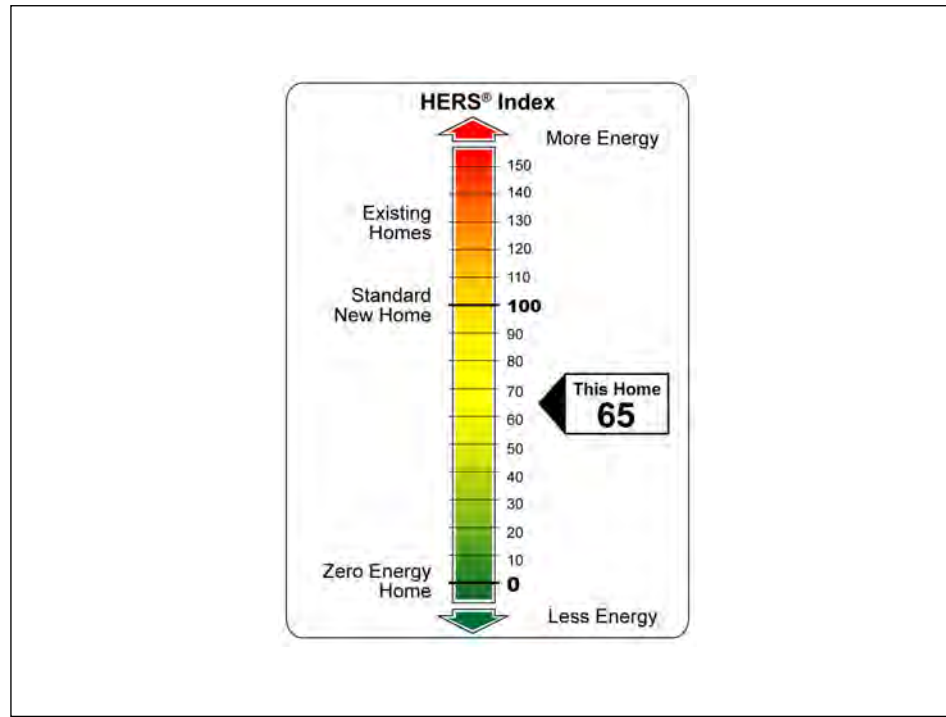





Building Science Tipping Point –  
Can't dry out if they get wet  
Can't assure adequate IAQ  
Greater combustion safety risks



Where are we headed?



HERS Index – Now included as a field in the MLS listings (as well as Green Certified field), allowing us to track the sales prices and length of time on market for energy efficient homes



## ENERGY STAR CERTIFIED NEW HOME

**Builder Name:** WeeBeeGood Builders  
**Permit Date/Number:** 123456789  
**Home Address:** 2342 Maybee Ave.  
**Denver, CO 80333**

**Rating Company:** L.A. Raters  
**Rater Identification Number:** 303 333 2222  
**Rating Date:** 4/12/95  
**Version:** 3.0

**Standard Features of an ENERGY STAR Certified New Home**

Your ENERGY STAR certified new home has been designed, constructed, and inspected to meet rigorous requirements of energy efficiency set by the U.S. Environmental Protection Agency (EPA), including:

**Thermal Enclosure System**

A complete thermal enclosure system includes comprehensive installed insulation at windows to deliver energy-efficient performance and lower utility bills.

**Air Infiltration Test:**  $\leq 0.05$  CFM 50 F/ft<sup>2</sup> ACH50

**Primary Insulation Levels:**  
**Ceiling:** R-50.0  
**Attic:** R-50.0  
**Floor:** R-35.0  
**Primary Windows Efficiency:**  
**U-Value = 0.300, SHGC = 0.130**

**Water Management System**

Water management systems include roof, exterior wall, and underlayment protection to prevent moisture from entering into the home.

Management of moisture levels in building materials during construction.

**Heating, Cooling, and Ventilation System**

A high-efficiency heating, cooling, and ventilation system that is designed and installed for optimal performance.

**Total Curt Leakage:**  
**108.85 CFM per Std 152**

**Curt Leakage to Outside:**  
**68.66 CFM per Std 152**

**Primary Heating (System Type + Fuel Type + Efficiency):**  
**Fuel-fired air distribution, Natural gas, 92.0 AFUE**

**Primary Cooling (System Type + Fuel Type + Efficiency):**  
**Air conditioner, Electric, 14.0 SEER.**

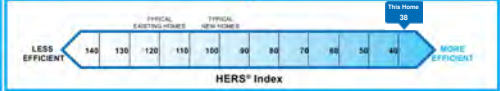
**Energy Efficient Lighting and Appliances**

Energy efficient products to help reduce utility bills, while providing high-quality performance.

**ENERGY STAR Qualified Lighting: 30%**

**ENERGY STAR Qualified Appliances and Fans:**  
**Refrigerators: 1 Dishwashers: 1**  
**Ceiling Fans: 0 Exhaust Fans: 0**

**Primary Water Heaters (System Type + Fuel Type + Efficiency):**  
**Instant water heater, Natural gas, 0.80 EF, 0.0 Gal.**



**HERS® Index**

This certificate is a summary of the major energy efficiency and other construction features that contribute to this home earning the ENERGY STAR, including the Home Energy Rating System (HERS) score, as determined through independent inspection and verification performed by a licensed professional. The Home Energy Rating System is a nationally recognized uniform measurement of the energy efficiency of homes.

Not all other energy efficiency and performance features are captured here by an independent or inspection level. The construction code is a guide. This home may be eligible to earn the ENERGY STAR using a different program, whereby you, the homeowner, who must be a member of an approved organization participating in such a program, may be eligible to earn the ENERGY STAR using a different program or to earn the ENERGY STAR through a different program. For more information, visit [www.energystar.gov](http://www.energystar.gov).

This certificate was prepared using the Home Energy Rating System (HERS) software version 1.0.0. Last date: 4/12/95. L.A. Raters at [www.laraters.com](http://www.laraters.com).

Energy Star Label for homes

## The Future of Housing—Today

Only a select group of the top builders in the country meet the extraordinary levels of excellence and quality specified by U.S. Department of Energy guidelines.

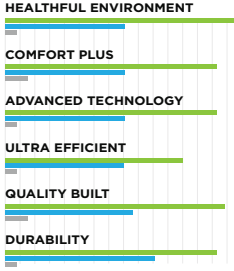




U.S. DEPARTMENT OF ENERGY  
**CHALLENGE HOME**

LEARN MORE AT:  
[buildings.energy.gov/challenge](http://buildings.energy.gov/challenge)

### A Symbol of Excellence



**KEY**

- DOE Challenge Home
- ENERGY STAR Home
- Existing Home

This label indicates relative performance of this DOE Challenge Home to existing homes (built between 1990 and 2010) and ENERGY STAR qualified homes. Actual performance may vary.





### A Symbol of Excellence

Every Challenge Home offers a cost-effective, high performance package of energy savings, comfort, health, and durability unparalleled in today's marketplace.

Exclusive. DOE Challenge Home requirements are so rigorous, homebuyers can feel great knowing they chose a home offered only by a select group of leading edge builders.

Tech-Savvy. Starting with comprehensive building science requirements from ENERGY STAR® for Homes, all DOE Challenge Homes include the most effective and proven innovations developed under Building America's world-class research program.

Advanced. All DOE Challenge Homes are constructed to meet forthcoming code requirements to lock in future value. It's great peace-of-mind knowing the largest investment of a lifetime won't be obsolete in a few years.

**Parade of  
Homes<sup>®</sup>**

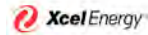
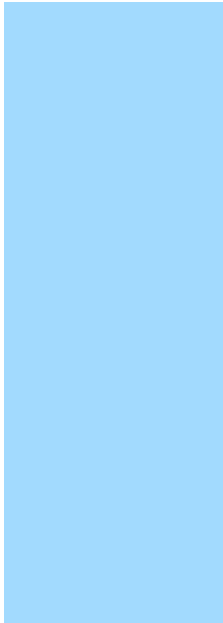
PRESENTED BY  **BATC**

Challenge Home Builder featured in this Fall Parade and in the Spring Preview

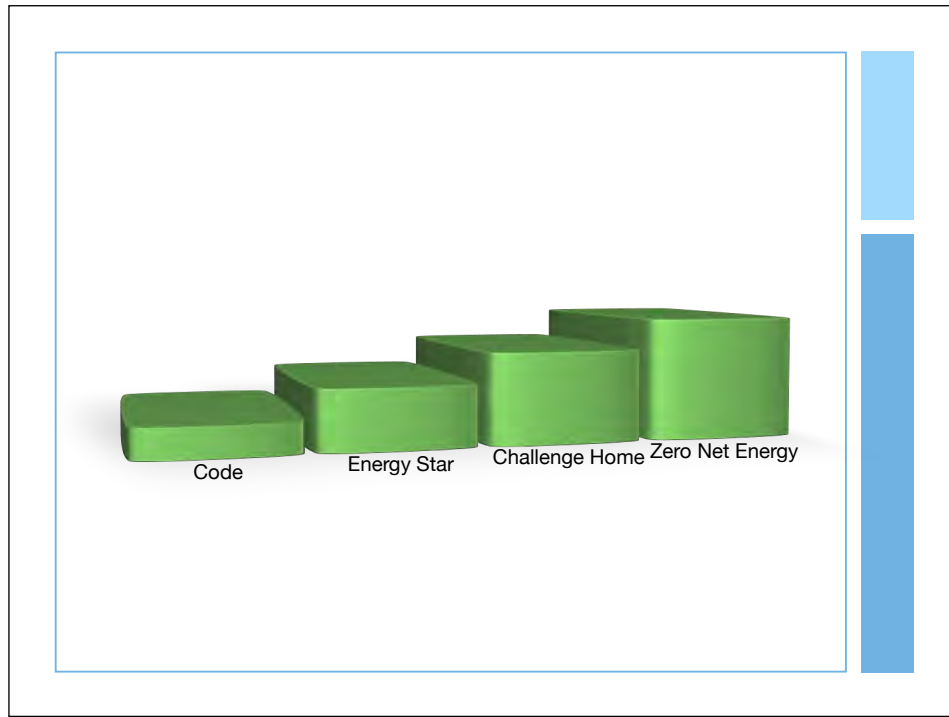


\$2000 per home



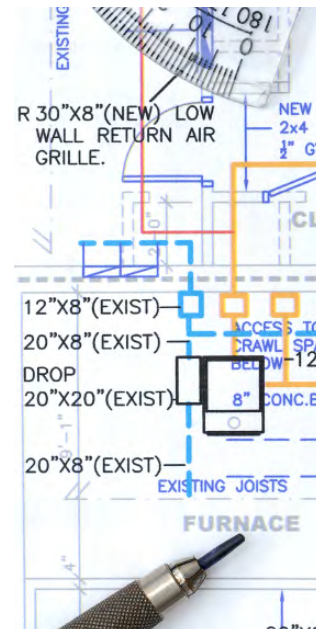


# Program Certification



Home Performance Stair Step

# High Performance HVAC Design



High performance home building and remodeling requires a different approach than the traditional, established way of building. Building a high performance home must be a systematic approach and done as a team. The project must be looked at as a system, in which each component is connected to and depends on the other components. Teamwork is required to make it all come together. Addressing and optimizing key factors up front with the whole team will result in a smoother construction process, lower costs and a much better home.

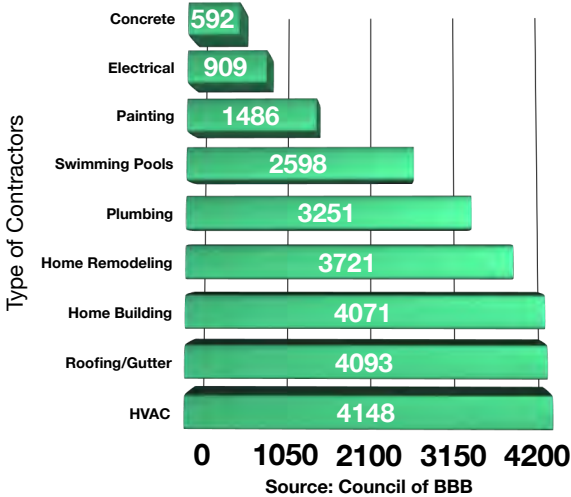
## HVAC Performance

- Heat when it's cold
- Cool when it's hot
- Humidify when it's dry
- Dehumidify when it's wet
- Bring in outside air
- Distribute outside air
- Exhaust pollutants
- Filter the air

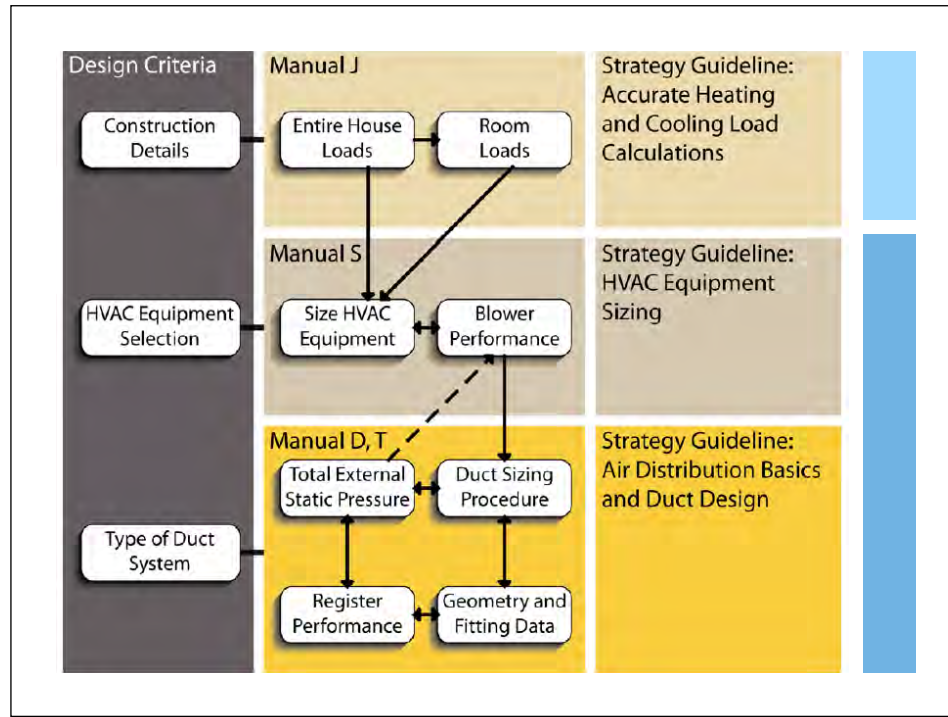


What we require from our HVAC systems

# Building-Related Complaints



- 60-80% of defect litigation cases are stimulated by failures of the building envelope. (Builder Magazine)
- \$9 billion is spent annually on construction defects. (ASHRAE) Water leakage is the #1 consequence of construction defects.
- The average callback costs contractors between \$500-\$1,500 per home.

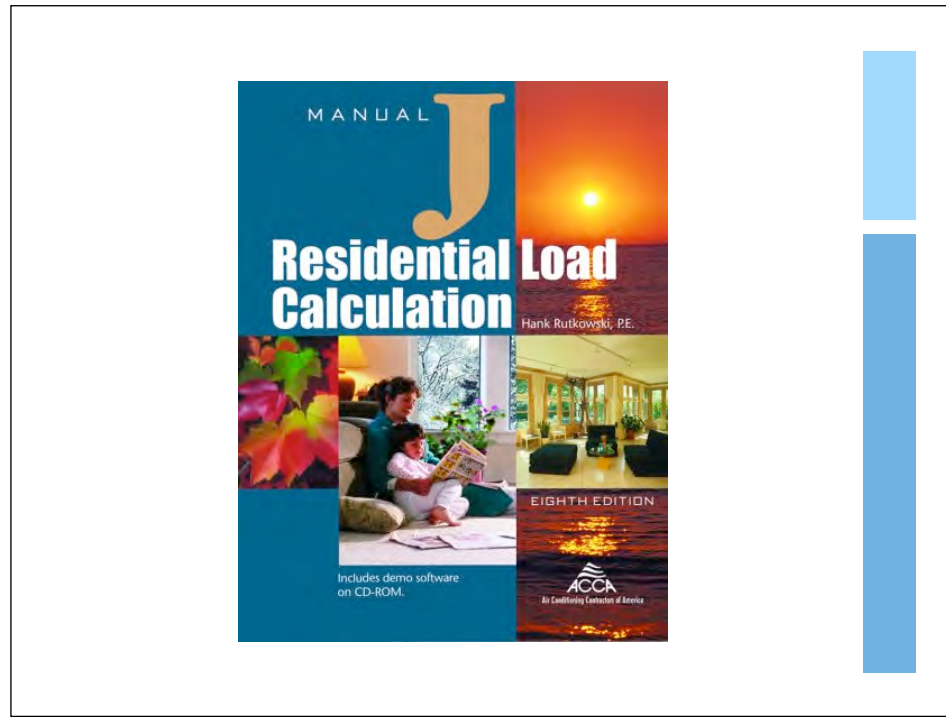


Load sizing



Garbage-in, Garbage-out





Check a home's approximate heating and cooling load and select equipment that match a buildings heating and cooling load

“Do not use “rules-of-thumb.” The idea that the required equipment capacity equals the floor area divided by some magic number is absurd.”

HVAC System Criteria: Do's and Don'ts for Manual J calcs

*Do not use “rules-of-thumb.” The idea that the required equipment capacity equals the floor area divided by some magic number is absurd.*

“Efforts to adjust the load to provide a “safety factor” or to produce a solution that is compatible with the “I have been doing it this way for 30 years” syndrome are forbidden.”


HVAC System Criteria: ACCA Do's and Don'ts for Manual J calcs  
*Efforts to “adjust the load” to provide a “safety factor” or to produce a solution that is compatible with the “I have been doing it this way for 30 years” syndrome are forbidden.*

## Manual J 8th edition example

Design Information					
Outside db (°F)	Htg	Cig	Infiltration		
Inside db (°F)	70	75	Method	Simplified	
Design TD (°F)	69	16	Construction quality	Tight	
Daily range	-	H	Fireplaces	1 (Tight)	
Inside humidity (%)	50	50			
Moisture difference (gr/lb)	61				

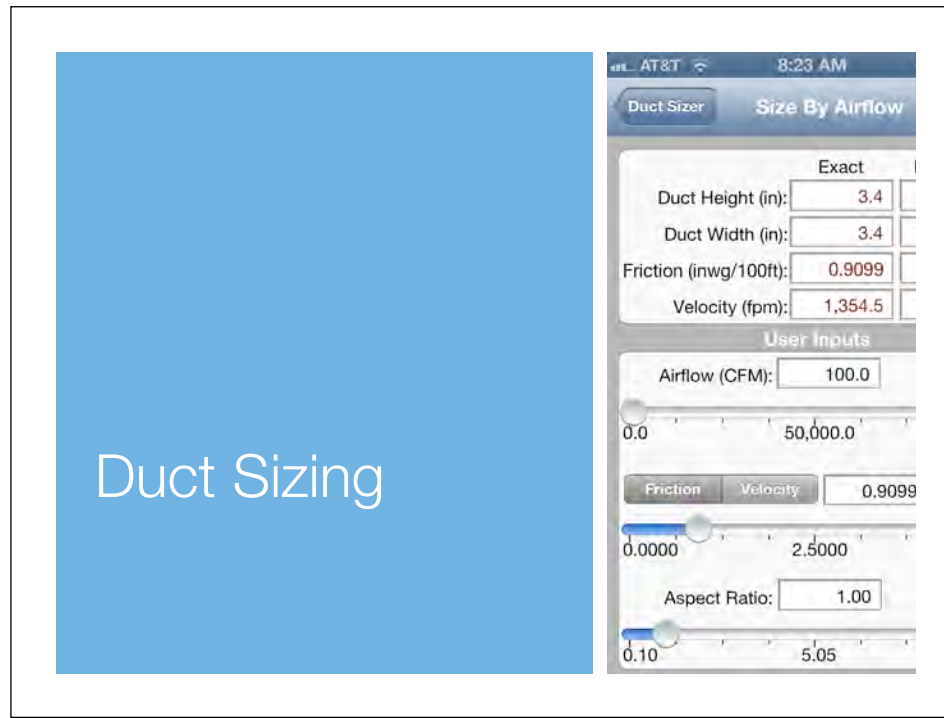
HEATING EQUIPMENT			COOLING EQUIPMENT		
Make	Rheem		Make	Rheem	
Trade	Rheem		Model	RAND Series	
Model	RGFD-07(E,N)MCKS**			RAND-030J'Z	
				RCFA-H*3617A*	
Efficiency	92.8 AFUE		SEER	13 SEER	
Heating input	75000 Btuh		Sensible cooling	25670 Btuh	
Heating output	71000 Btuh		Latent cooling	4530 Btuh	
Temperature rise	78 °F		Total cooling	30200 Btuh	
Actual air flow	1007 cfm		Actual air flow	1007 cfm	
Air flow factor	0.029 cfm/Btuh		Air flow factor	0.060 cfm/Btuh	
Static pressure	0.50 in H2O		Static pressure	0.50 in H2O	
Space thermostat			Load sensible heat ratio	1.00	

27

## HVAC System Criteria:

*Use ACCA Manual J, ASHRAE Handbook of fundamentals to determine heating and cooling loads. This is a sample Manual J report.*



Accurately size ducts to match required air flow of a room and the fan's capacity



67 percent of homes in the U.S. have a room that's too hot in the summer or too cold in the winter.

The kids room is freezing!!!!

“Research clearly demonstrates that duct system efficiency/ effectiveness is the single biggest issue as far as energy use is concerned (as well as health and comfort!)”

## Distribution Systems

HVAC contractor must use the heat loss/gain calculations to properly size duct work

- ▶ It is critical to consider the entire system and process.
- ▶ Layout & location of distribution system
- ▶ Materials used - flexible duct or sheet metal, insulated or non-insulated
- ▶ Impact on pressurization of rooms or spaces
- ▶ Effective occupant comfort control

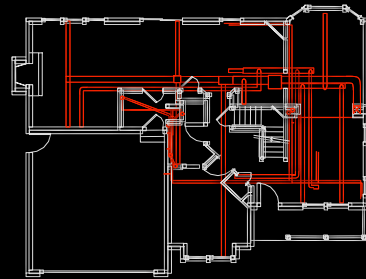
### Air Distribution Systems:

*HVAC contractor must use the heat loss/gain calculations to properly size duct work*

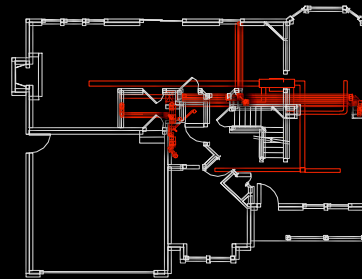
- *It is critical to consider the entire system and process.*
- *Layout & location of distribution system*
- *Materials used - flexible duct or sheet metal, insulated or non-insulated*
- *Impact on pressurization of rooms or spaces*
- *Effective occupant comfort control*



## Quality HVAC Design



Typical



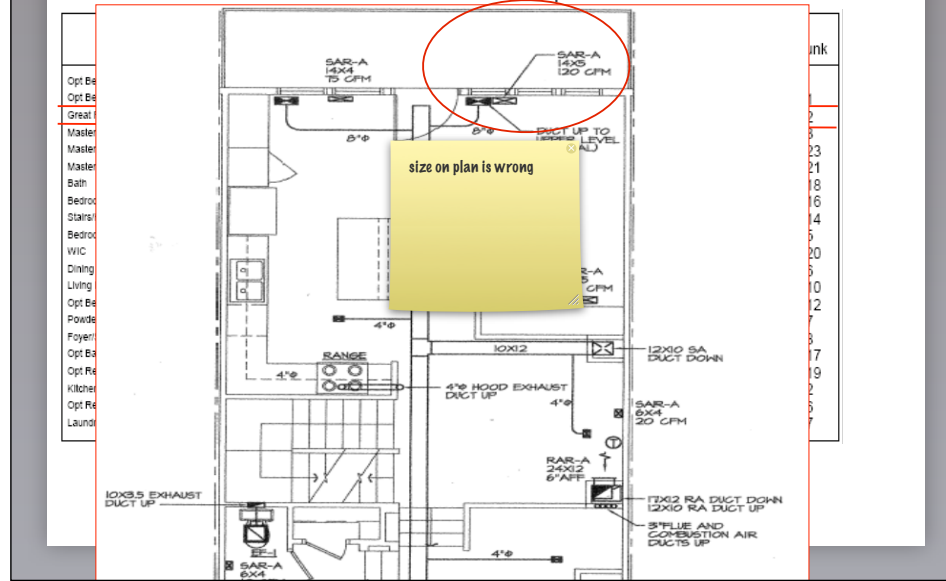
Best Practice

Air Distribution Systems:

*Properly sized system with optimized duct layout*

*Note reduction of materials and compactness of system*

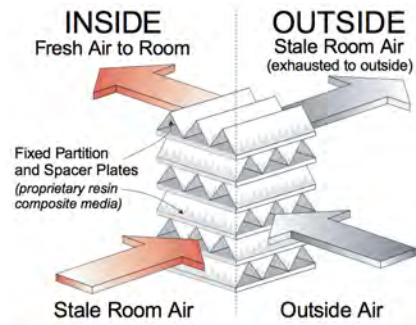
Manual D provides a duct sizing schedule to deliver the air to the space intended



## Air Distribution Systems:

*Ducts sized and installed in accordance with room-by-room loads calculations for sizing ductwork using ACCA Manual D.*

# Mechanical Ventilation



## Fresh Air Ventilation



### Fresh Air Ventilation:

*Homes with insufficient outdoor air have problems with humidity, odors and pollutants that can lead to discomfort and increased health risks. Designed ventilation systems help reduce occupants' exposure to indoor pollutants and improve comfort.*

# ASHRAE 62.2

Conditioned floor area	Bedrooms				
	0,1	2,3	4,5	6,7	> 7
<= 1,500	30	45	60	75	90
1,501 - 3,000	45	60	75	90	105
3,001 - 4,500	60	75	90	105	120
4,501 - 6,000	75	90	105	120	135
6,001 - 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

Outdoor Air Ventilation:

2013 version does not allow for infiltration in calculation.

*Minimum air flow requirements for continuous ventilation systems, in cfm*

*Note for typical homes we are only talking about 75 cfm or less*

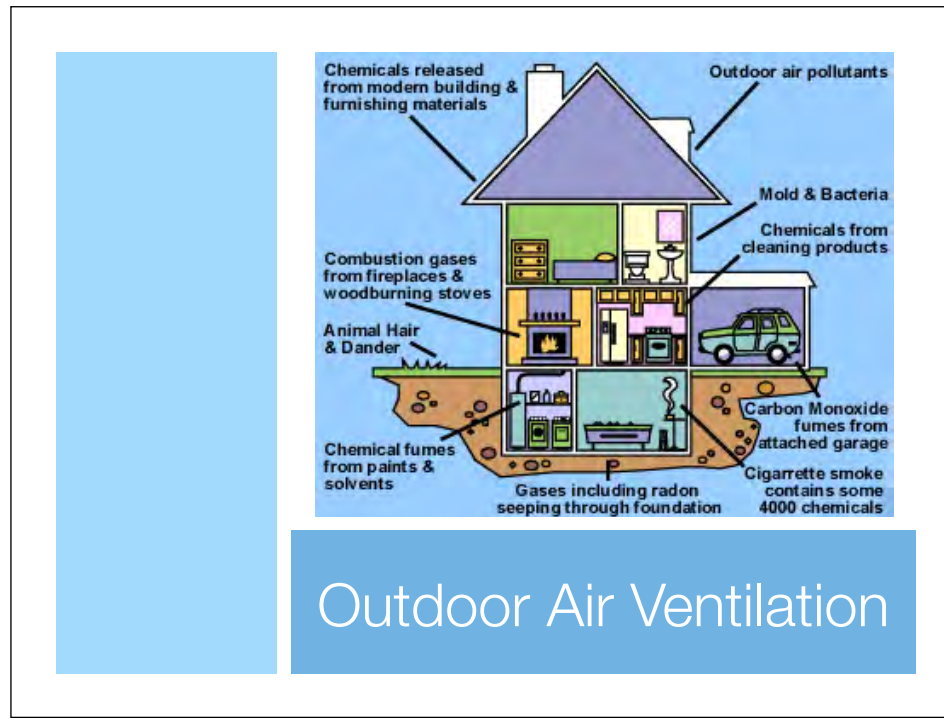
# MN Code

Conditioned floor area	Bedrooms [Total/Continuous Ventilation]					
	1	2	3	4	5	6
<= 1,500	60/40	75/40	90/45	105/53	120/60	135/68
1,501-2,000	70/40	85/43	100/50	115/58	130/65	145/73
2,001-2,500	80/40	95/48	110/55	125/63	140/70	155/78
2,501-3,000	90/45	105/53	120/60	135/68	150/75	165/83
3,001-3,500	100/50	115/58	130/65	145/73	160/80	175/88
3,500-4000	110/55	125/63	140/70	155/78	170/85	185/93

## Outdoor Air Ventilation:

*Minnesota State Energy Code Minimum air flow requirements for Total & Continuous ventilation systems, in cfm*

*Note the continuous ventilation rate for typical homes is less than 75 cfm*

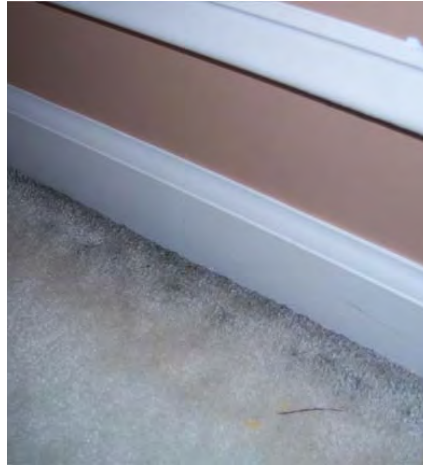


## Outdoor Air Ventilation:

*This is compounded by changes in lifestyle - people today spend more times indoors with windows and doors closed - and increased awareness of the risks associated with poor indoor air quality*

“ACCA has found that code fresh air requirements (such as 0.35 ACH) are being incorrectly used as default infiltration rates without considering the actual tightness of the construction.”





Fresh Air vs. Infiltration

Differentiate in your load calcs between fresh air and infiltration

“Exhaust only ventilation =  
asking your building to be  
the filter”

Joe Lstibuerk 2013 Summer Camp

High  
Performance  
HVAC Installation  
and Testing



Based on our experience with certification programs we will review the key best practices for HVAC installations and the available performance tests

# Duct Installation



“Poor installation practices common with HVAC system installations across the country can decrease rated efficiency levels up to 35 percent or more.”

HVAC System Criteria:

*Poor installation practices common with HVAC system installations across the county can decrease rated efficiency levels up to 35 percent or more.*

*Key quality installation practices include proper duct design, terminal design, air flow, pressure balancing, and refrigerant charge.*

*Chris Nieme, John Proctor, and Steven Nadel, “Energy Savings from Addressing Residential Air Conditioner and Heat Pump Installation Problems,” ACEEE, February 1999*

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Introduction:

*Proper installation is key - The best equipment cannot overcome poor installation practices*



Air Distribution System:

*Poorly planned and installed duct work*





Air Distribution System:

*Poorly planned and installed duct work*



Air Distribution System:

*Poorly planned and installed duct work*

## Duct Sealing

- ▶ Seal the ducts, air handlers, and filter box (R403.2.2).
- ▶ Use mastic to seal your ducts, contractors we have worked with say mastic saves them time and provides for better sealing.

Reemphasize this slide from the previous section on the code



Mastic should be applied “nickel thick”



Images are repeated from code section for emphasis

See How  
Happy He Is?



Images are repeated from code section for emphasis



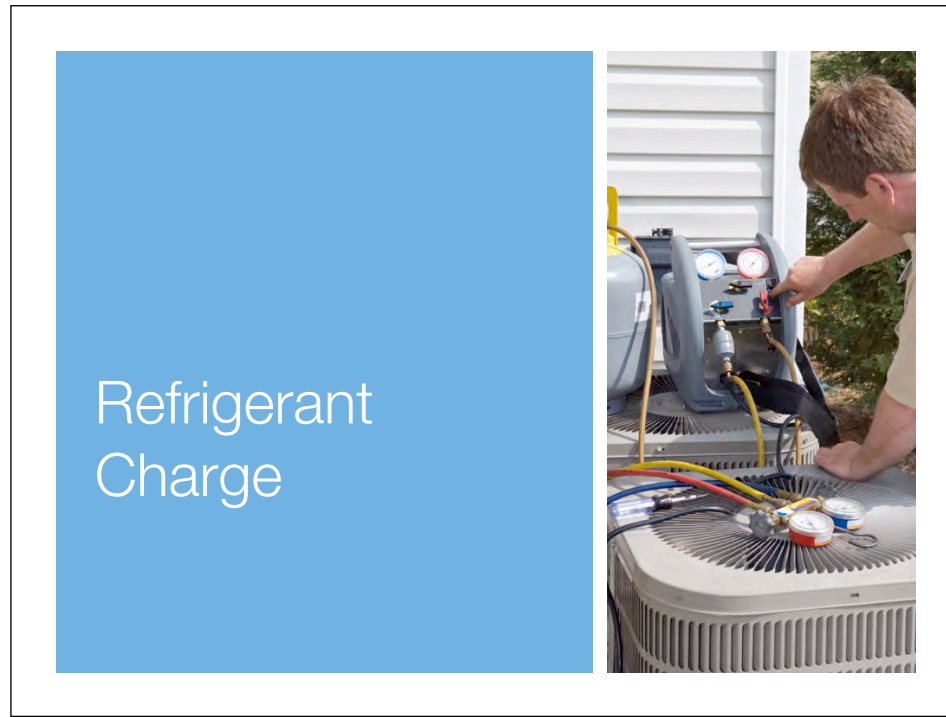


Images are repeated from code section for emphasis



Images are repeated from code section for emphasis





## Refrigerant Management:

*Both undercharge and overcharge can reduce cooling equipment longevity, capacity and efficiency*



## Refrigerant Management:

*Story of AC tech not using gauges for refrigerant charge and relying on the charge to be beer can cold to tell him when it was charged sufficiently.*

An under charge of as little as 15% can reduce the equipment's total capacity by as much as 20% and the energy efficiency ratio by as much as 15%

Refrigerant Management:

An under charge of as little as 15% can reduce the equipment's total capacity by as much as 20% and the energy efficiency ratio by as much as 15%

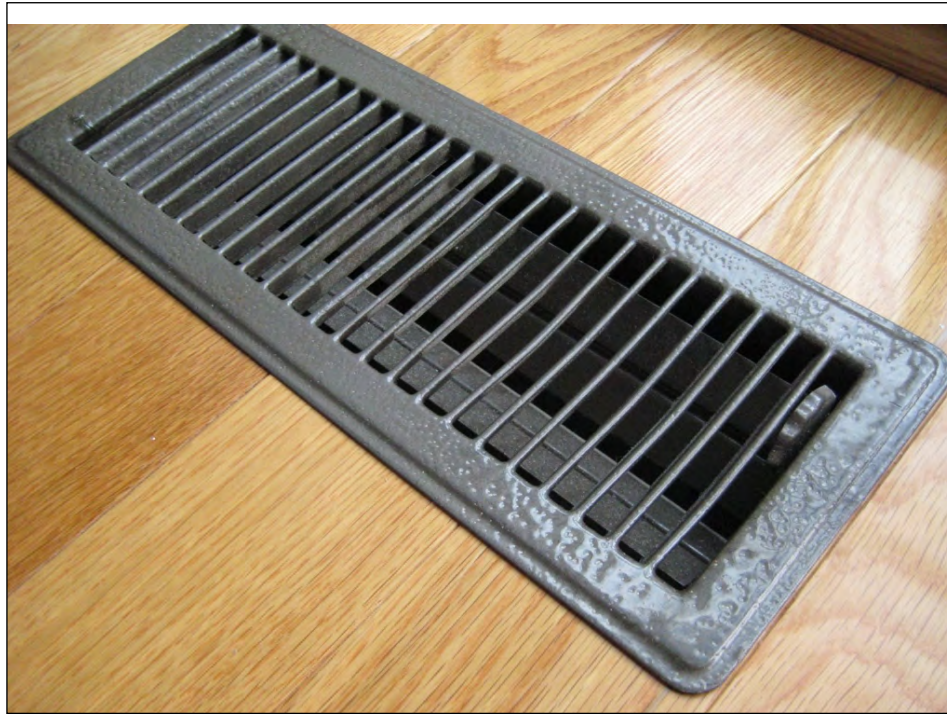
Performance  
Verification



## Air leakage testing- blower door

A Blower Door test can be used to quantify air leakage and potential air quality, durability & other issues.





How do we typically measure air flow – We hold our hand over the register, yup its blowing air!  
We must be OK!



## Airflow Testing

- exhaust fans
- supply and return flows based on comfort complaints



Duct leakage testing



HVAC Airflow		Address:			
A/C Size		2.5 tons			
Design Air Handler Flow		1,000 CFM @ 400 CFM/ton			
	Design		Actual		
	Branch Size	Airflow (CFM)	Branch Size	Airflow (CFM)	Pressure
<b>Main Floor Supplies</b>					
Living A	6"	93	6"	50	
Living B	6"	93	6"	47	
Living C	6"	93	6"	42	
Family/Den A	6"	92	6"	37	
Family/Den B	6"	92	6"	46	
Master BR A	6"	85	6"	66	+4.5 pa
Master BR B	6"	85	6"	68	
Master Closet	4"	40	6"	85	
Master Bath	5"	65	6"	79	
BR #2	6"	95	6"	65	+0.4 pa
BR #3	6"	95	6"	79	+1.2 pa
Main Bath	5"	62	6"	77	
<b>Total Supply Flow:</b>		<b>990</b>		<b>741</b>	
<b>Returns</b>					
Living		175		110	
Family/Den		175		102	

## Performance Testing:

*Sample report of measured duct air flow compared to design  
Note the differences in the Powder Room and Family Room*

**Test Results**

Measured Duct Leakage

Test Type: Total Leakage (Duct Blaster Only)

Test Pressure: 25.0 Pa

Leakage Rate: 97.4 CFM

Leakage Area: 18.4 sq. in.

Leakage Split

Supply Side: 39.0 CFM / 7.4 sq. in.

Return Side: 58.4 CFM / 11.0 sq. in.

Leakage Parameters

Leakage as a Percent of System Airflow: 7.0 %

Leakage as a Percent of Floor Area: 1.9 %

Annual System Efficiency Loss: 0.1 %

Duct Leakage Curve

Flow Coefficient (C): 14.1

Exponent (n): 0.500 (Assumed)

Tight System

97 CFM vs.  
1017 CFM

Leaky System

**Test Results**

Measured Duct Leakage

Test Type: Total Leakage (Duct Blaster Only)

Test Pressure: 25.0 Pa

Leakage Rate: 1017.9 CFM

Leakage Area: 192.0 sq. in.

Leakage Split

Supply Side: 356.2 CFM / 67.2 sq. in.

Return Side: 661.6 CFM / 124.8 sq. in.

Leakage Parameters

Leakage as a Percent of System Airflow: 84.8 %

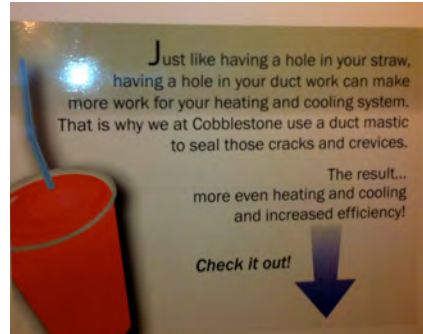
Leakage as a Percent of Floor Area: 34.4 %

Annual System Efficiency Loss: 10.0 %

Duct Leakage Curve

Flow Coefficient (C): 147.5

Exponent (n): 0.600 (Assumed)



Hole in a straw

Have you ever sucked on a straw that had a hole in it?

Implementing  
High Performance  
HVAC Strategies



# Education

- ▶ Hands on Training
- ▶ Seminars & Workshops
- ▶ Latest Research
- ▶ Best Practices

What else do they need to do?

## Hands on Training





Create your own checklist:

Healthy:

MERV 8 filters or better

Comfort:



## ENERGY STAR Certified Homes, Version 3 (Rev. 07) HVAC System Quality Installation Contractor Checklist <sup>1</sup>

Home Address: _____	City: _____	State: _____	Zip Code: _____
System Description: _____ Cooling system for temporary occupant load? <sup>2</sup> Yes <input type="checkbox"/> No <input type="checkbox"/>			
<b>1. Whole-Building Mechanical Ventilation Design <sup>4</sup></b>	<b>Builder Verified <sup>5</sup></b>	<b>Cont. Verified <sup>6</sup></b>	<b>N/A</b>
1.1 Ventilation system installed that has been designed to meet ASHRAE 62.2-2010 requirements including but not limited to, requirements in Items 1.2-1.5. <sup>7</sup>	<input type="checkbox"/>	<input type="checkbox"/>	-
1.2 Ventilation system does not utilize an intake duct to the return side of the HVAC system unless the system is designed to operate intermittently and automatically based on a timer and to restrict outdoor air intake when not in use (e.g., motorized damper).	<input type="checkbox"/>	<input type="checkbox"/>	-
1.3 Documentation is attached with ventilation system type, location, design rate, and frequency and duration of each ventilation cycle.	<input type="checkbox"/>	<input type="checkbox"/>	-
1.4 If present, continuously-operating vent. & exhaust fans designed to operate during all occupiable hours.	<input type="checkbox"/>	<input type="checkbox"/>	-
1.5 If present, intermittently-operating whole-house ventilation system designed to automatically operate at least once per day and at least 10% of every 24 hours.	<input type="checkbox"/>	<input type="checkbox"/>	-
<b>2. Heating &amp; Cooling System Design <sup>8</sup></b> <small><sup>8</sup> Parameters used in the design calculations shall reflect home to be built, specifically, outdoor design temperatures, home orientation, number of bedrooms, conditioned floor area, window area, predominant window performance and insulation levels, infiltration rate, mechanical ventilation rate, presence of MERV10 or better filter, and indoor temperature setpoints = 70°F for heating, 75°F for cooling.</small>			
2.1 Heat Loss / Gain Method: <input type="checkbox"/> Manual J v8 <input type="checkbox"/> 2009 ASHRAE <input type="checkbox"/> Other: _____	<input type="checkbox"/>	<input type="checkbox"/>	-
2.2 Duct Design Method: <input type="checkbox"/> Manual D <input type="checkbox"/> Other: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.3 Equipment Selection Method: <input type="checkbox"/> Manual S <input type="checkbox"/> OEM Rec. <input type="checkbox"/> Other: _____	<input type="checkbox"/>	<input type="checkbox"/>	-
2.4 Outdoor Design Temperature: <sup>9</sup> Location: _____ °F _____ °F _____ °F	<input type="checkbox"/>	<input type="checkbox"/>	-
2.5 Orientation of Rated Home (e.g., North, South): _____	<input type="checkbox"/>	<input type="checkbox"/>	-
2.6 Number of Occupants Served by System: <sup>10</sup> _____	<input type="checkbox"/>	<input type="checkbox"/>	-
2.7 Conditioned Floor Area in Rated Home: _____ Sq. Ft.	<input type="checkbox"/>	<input type="checkbox"/>	-
2.8 Window Area in Rated Home: _____ Sq. Ft.	<input type="checkbox"/>	<input type="checkbox"/>	-
2.9 Predominant Window SHGC in Rated Home: <sup>11</sup> Summer: _____ Winter: _____	<input type="checkbox"/>	<input type="checkbox"/>	-
2.10 Infiltration Rate in Rated Home: <sup>12</sup> _____	<input type="checkbox"/>	<input type="checkbox"/>	-
2.11 Mechanical Ventilation Rate in Rated Home: _____ CFM	<input type="checkbox"/>	<input type="checkbox"/>	-
2.12 Design Latent Heat Gain: _____ BTU/h	<input type="checkbox"/>	<input type="checkbox"/>	-
2.13 Design Sensible Heat Gain: _____ BTU/h	<input type="checkbox"/>	<input type="checkbox"/>	-
2.14 Design Total Heat Gain: _____ BTU/h	<input type="checkbox"/>	<input type="checkbox"/>	-
2.15 Design Total Heat Loss: _____ BTU/h	<input type="checkbox"/>	<input type="checkbox"/>	-
2.16 Design Airflow: <sup>13</sup> _____ CFM	<input type="checkbox"/>	<input type="checkbox"/>	-
2.17 Design Duct Static Pressure: <sup>14</sup> _____ In. Water Column	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.18 Full Load Calculations Report Attached <sup>15</sup>	<input type="checkbox"/>	<input type="checkbox"/>	-
<b>3. Selected Cooling Equipment, If Cooling Equipment to be Installed</b>			
3.1 Condenser Manufacturer & Model: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.2 Evaporator / Fan Coil Manufacturer & Model: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.3 AHRI Reference #: <sup>16</sup> _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.4 Listed Efficiency: _____ EER _____ SEER	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.5 Metering Device Type: <input type="checkbox"/> TXV <input type="checkbox"/> Fixed orifice <input type="checkbox"/> Other: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.6 Refrigerant Type: <input type="checkbox"/> R-410a <input type="checkbox"/> Other: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.7 Fan Speed Type: <sup>17</sup> <input type="checkbox"/> Fixed <input type="checkbox"/> Variable (ECM / ICM) <input type="checkbox"/> Other: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.8 Listed Sys. Latent Capacity at Design Cond.: <sup>18</sup> _____ BTU/h	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.9 Listed Sys. Sensible Capacity at Design Cond.: <sup>18</sup> _____ BTU/h	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.10 Listed Sys. Total Capacity at Design Cond.: <sup>18</sup> _____ BTU/h	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.11 If Listed Sys. Latent Capacity (Value 3.8) ≥ Design Latent Heat Gain (Value 2.12), ENERGY STAR certified dehumidifier installed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.12 Listed Sys. Total Capacity (Value 3.10) is 95-115% of Design Total Heat Gain (Value 2.14) or next nominal size <sup>19</sup>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.13 AHRI Certificate Attached <sup>16</sup>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>4. Selected Heat Pump Equipment, If Heatpump to be Installed</b>			
4.1 AHRI Listed Efficiency: _____ HSPF or Ground-Source: _____ COP	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.2 Performance at 17°F: Capacity _____ BTU/h Efficiency: _____ COP <sup>20</sup>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.3 Performance at 47°F: Capacity _____ BTU/h Efficiency: _____ COP <sup>20</sup>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



## ENERGY STAR Certified Homes, Version 3 (Rev. 07) HVAC System Quality Installation Contractor Checklist <sup>1</sup>

8. Selected Furnace: If Furnace to be installed	Builder Verified <sup>1</sup>	Cont. Verified <sup>1</sup>	N/A
8.1 Furnace Manufacturer & Model: _____ AFUE _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8.2 Listed Efficiency: _____ AFUE _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8.3 Listed Output Heating Capacity: _____ BTU/h _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8.4 Listed Output Heat Cap. (Value 8.3) is 100-140% of Design Total Heat Loss (Value 2.15) or next nominal size <sup>11</sup>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>9. Refrigerant Tests - Run system for 15 minutes before testing</b>			
<small>Note: If outdoor ambient temperature at the condenser is <math>\leq</math> 55°F or, if known, below the manufacture-recommended minimum operating temperature for the cooling cycle, then the system shall include a TXV, and the contractor shall mark "N/A" on the Checklist for Section 6 &amp; 7. <sup>12</sup></small>			
9.1 Outdoor ambient temperature at condenser: _____ °F DB	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9.2 Return side air temperature inside duct near evaporator, during cooling mode: _____ °F WB	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9.3 Liquid line pressure: _____ psig	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9.4 Liquid line temperature: _____ °F DB	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9.5 Suction line pressure: _____ psig	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9.6 Suction line temperature: _____ °F DB	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>10. Refrigerant Calculations</b>			
<small>For System with Thermal Expansion Valve (TXV):</small>			
10.1 Condenser saturation temperature: _____ °F DB (Using Value 9.3)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.2 Subcooling value: _____ °F DB (Value 7.1 - Value 6.4)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.3 OEM subcooling goal: _____ °F DB	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.4 Subcooling deviation: _____ °F DB (Value 7.2 - Value 7.3)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<small>For System with Fixed Orifice:</small>			
10.5 Evaporator saturation temperature: _____ °F DB (Using Value 9.1)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.6 Superheat value: _____ °F DB (Value 6.6 - Value 7.5)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.7 OEM superheat goal: _____ °F DB (Using superheat tables and Values 6.1 & 6.2)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.8 Superheat deviation: _____ °F DB (Value 7.6 - Value 7.7)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.9 Value 7.4 is $\geq$ 3°F or Value 7.8 is $\leq$ 5°F	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.10 An OEM test procedure (e.g., as defined for a ground-source heat pump) has been used in place of sub-cooling or super-heat process and documentation has been attached that defines this procedure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>11. Electrical Measurements - Taken at electrical disconnect while component is in operation</b>			
11.1 Evaporator or furnace air handler fan: _____ amperage _____ line voltage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11.2 Condenser unit: _____ amperage _____ line voltage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11.3 Electrical measurements within OEM-specified tolerance of nameplate value	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>12. Air Flow Tests</b>			
12.1 Air volume at evaporator: _____ CFM	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12.2 Test performed in which mode? <input type="checkbox"/> Heating <input type="checkbox"/> Cooling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12.3 Return duct static pressure: _____ inWC Test Hole Location: <sup>13</sup> _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12.4 Supply duct static pressure: _____ inWC Test Hole Location: <sup>13</sup> _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12.5 Test hole locations are well-marked and accessible <sup>14</sup>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12.6 Airflow volume at evaporator (Value 12.1), at fan design speed and full operating load, $\pm$ 15% of the airflow required per system design (Value 2.16) or within range recommended by OEM	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>13. Air Balance</b>			
13.1 Balancing report prepared and attached indicating the room name and design airflow for each supply and return register. In addition, final individual room airflows measured and documented through one of the following options:			
13.1.1 Measured by contractor using ANSI / ACCA 5 Q1-2007 protocol, documented by contractor on the balancing report, & verified by contractor to be within the greater of a 20% or 25 CFM of design airflow <sup>15</sup> , OR;	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13.1.2 To be measured, documented, and verified by a Rater per item 14.2 of the HVAC System QI Rater Checklist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>14. System Controls</b>			
14.1 Operating and safety controls meet OEM requirements	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>15. Drain Pan</b>			
15.1 Corrosion-resistant drain pan, properly sloped to drainage system, included with each HVAC component that produces condensate <sup>16</sup>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
HVAC Company Name: _____ Credentialed Organization: ACCA / AE / Other _____			
HVAC Contractor Name: _____		HVAC Contractor Signature: _____ Date: _____	
Builder Name: <sup>1</sup> _____		Builder Signature: <sup>1</sup> _____ Date: _____	



# Integrated Project Planning



Integrated Design:

Integrated Project Planning -

*When the parts fit together, the house is better. The regular way to build is a linear approach that moves neatly from one step to the next. The only problem is that it's not guaranteed to produce the best result. How come?*

*Key players may not share common objectives for the project, may not understand how their work affects the work of others, and aren't looking for ways to make the house more efficient and less costly to build and operate.*

*A successful sustainable green home project begins with a common understanding of the project goals.*

*When everyone involved in the project can gather before construction begins to discuss the products and systems that will be installed, it helps to ensure that the entire construction team knows their role and plays their part in the process.*

*One or two advanced planning meetings with the project team early in the design & building process makes installation easier and more efficient.*



Hold a pre-construction meeting with all subcontractors present to talk about the schedule and trade interactions, especially any changes from the typical routine to accommodate new methods or technologies.

Energy Star  
HVAC Quality  
Installation  
Program





## HVAC and ENERGY STAR Certified Homes

Tools for Market Leaders

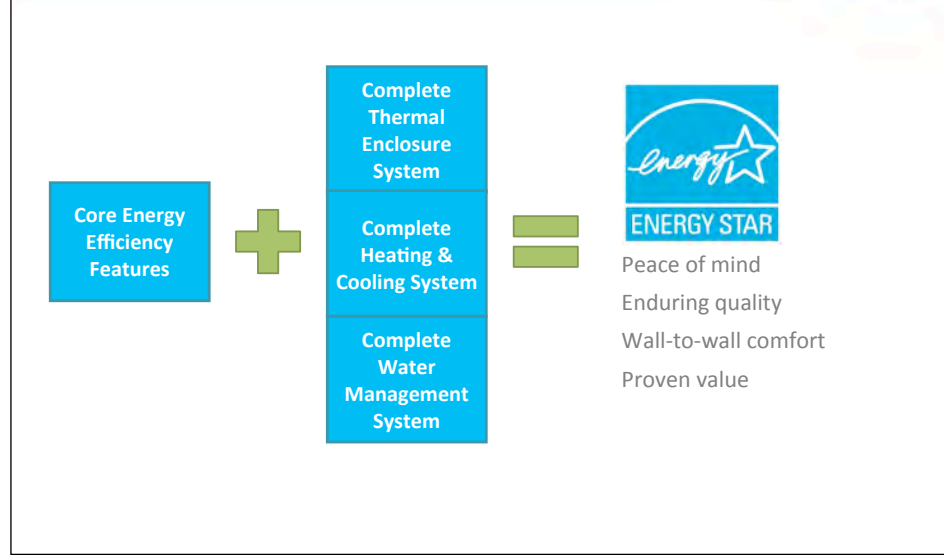
Learn more at [energystar.gov](http://energystar.gov)

Purpose: EPA is looking for contractors who want grow their new construction business Benefits

- Work with ENERGY STAR's 4,500 builder partners
- These select builders who can consistently deliver high-quality homes
- Contractors get a marketing tool to differentiate themselves

Result: fewer callbacks and complaints, more premium sales

## What's in ENERGY STAR?



### Features

- Money-saving energy efficiency
- Market-leading comfort and durability features
- Home Energy Rater verification

### Benefits

- Peace of mind
- Enduring quality
- Wall-to-wall comfort
- Proven value

### **Animation**

HVAC is critical to delivering promised value

HVAC must be designed and installed to best-practice standards by expert contractors Historically, two obstacles:

## Quality HVAC Performance



Solution: ENERGY STAR = complete thermal envelopes

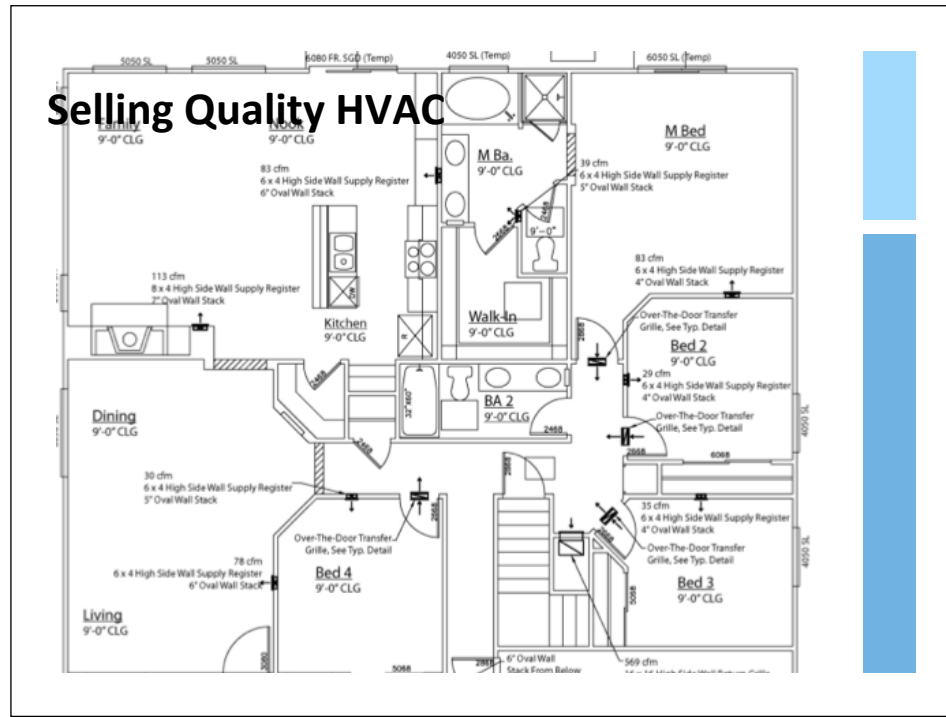
- High-quality insulation
- Reduced thermal bridging
- Effective air barriers and air sealing.
- Inspection by a Home Energy Rater ensures consistency

Now HVAC system & home can work together. Example

- Large production builder joined ENERGY STAR a few years ago
- Comfort complaints decreased by 90% in year 1, 90% again in year 2

Example

- HVAC contractor using ENERGY STAR to focus on premium services
- Moved into a new office
- For the first time, engineering staff took up more space than warranty staff
- Instead of competing on price and managing problems later → Focus on highly-engineered services up front



Obstacle: Selling best-practice HVAC design and installation to builders

- ☒ Many builders don't know difference between typical & best-practice install
- ☒ HVAC looks like a commodity



The credential makes it easy for builders to know which contractors can perform this work

Opportunity:

- ENERGY STAR builder partners are looking for credentialed HVAC contractors right now
- Builders use proven ENERGY STAR guidelines + Rater verification to consistently deliver homes that perform
- Credentials help contractors stand out from the crowd & get access to ENERGY STAR builders

Credentials are offered by independent, third-party oversight organizations whose programs have been recognized by EPA, including ACCA's Quality Assured Contractor program and Advanced Energy's Quality-Assured Professional program

Now HVAC contractors can:

- Reduce complaints and service calls
- Focus on higher-value services
- Build their reputation as market leaders



## Get Started Today!



<b>Join</b>	a credentialing program <a href="http://www.energystar.gov/newhomesHVAC">www.energystar.gov/newhomesHVAC</a>
<b>Find</b>	builder partners <a href="http://www.energystar.gov/partnerlocator">www.energystar.gov/partnerlocator</a>
<b>Read</b>	the technical guidelines <a href="http://www.energystar.gov/newhomesguidelines">www.energystar.gov/newhomesguidelines</a>
<b>Ask</b>	questions <a href="mailto:energystarhomes@energystar.gov">energystarhomes@energystar.gov</a>



[@energystarhomes](https://twitter.com/energystarhomes)



[facebook.com/energystar](https://facebook.com/energystar)

Getting started is easy

- Go to [www.energystar.gov/newhomesHVAC](http://www.energystar.gov/newhomesHVAC)
- Click on “Become a Credentialed HVAC Contractor” for links to recognized programs
- Each program has its own application process
- Typically, there’s a short online orientation to familiarize you with their program

ENERGY STAR builder and Rater partners are looking for credentialed HVAC contractors now So get started today!



### Footnotes:

1. The HVAC System Quality Installation Rater Checklist is designed to align with the requirements of ASHRAE 62.2-2010 and published addenda and ANSI / ACCA's 5 QI-2010 protocol, thereby improving the performance of HVAC equipment in new homes when compared to homes built to minimum code. However, these features alone cannot prevent all ventilation, indoor air quality, and HVAC problems, for instance those caused by a lack of occupant maintenance. Therefore, this checklist is not a guarantee of proper ventilation, indoor air quality, or HVAC performance. This checklist with supporting documents may also be used to demonstrate compliance with Indoor airPLUS specifications 4.1, 4.2, 4.5, 4.6, and 7.1.

HVAC SYSTEM QUALITY INSTALLATION RATER CHECKLIST			
1 REVIEW OF HVAC SYSTEM QUALITY INSTALLATION CONTRACTOR CHECKLIST			
1 CHECKLIST COMPLETED			

ENERGY STAR Qualified Homes, Version 3 (Rev. 04) HVAC System Quality Installation Contractor Checklist <sup>1</sup>			
Name Address _____ City _____ State _____			
System Description <sup>1</sup> _____ Cooling system for temporary occupancy? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>			
<b>1 Whole-Building Mechanical Ventilation Design<sup>2</sup></b>			
1.1 Ventilation system installed that has been designed to meet ASHRAE 62.2-2010 requirements including, but not limited to, requirements for airflow per room and to the total rate of all HVAC systems unless the system is designed to provide mechanical and natural ventilation on a timer and to receive outdoor air intake when not in use (e.g., residential demand)	Pass/Fail	Notes	Pass
1.2 Documentation is attached with ventilation system type, location, design rate, and frequency and duration of each ventilation type	Pass/Fail	Notes	Pass
1.3 If present, continuously operating vent & exhaust fans designed to operate during all occupiable hours	Pass/Fail	Notes	Pass
1.4 If present, intermittently operating whole-house ventilation system designed to automatically operate at least once per day and at least 30% of every 24 hours	Pass/Fail	Notes	Pass
<b>2 Heating &amp; Cooling Equipment<sup>3</sup></b>			
2.1 Heating & Cooling Equipment <sup>3</sup> - Heating system is not energy inefficient unless where in a hot climate; water usage efficiency meets minimum number of requirements; conditions for use, unless area equipped with a furnace and includes area information on mechanical equipment and controls installed in order that other documents reference it (e.g., floorplans, etc.)			
2.1 Heat Loss / Gain Method	Manual v.1	AGI-2006	Other
2.2 Heat Loss Method	Manual v.1	Other	
2.3 Equipment Function Method	Manual v.1	ODM Rev.	Other
2.4 Outdoor Design Temperature <sup>4</sup>	Location	°F	°C
2.5 Orientation of Rated Heat Loss (e.g., North, South)			
2.6 Number of Occupants Served by System <sup>5</sup>		Sq. Ft.	
2.7 Conditioned Floor Area in Rated Home <sup>6</sup>		Sq. Ft.	
2.8 Window Area in Rated Home <sup>7</sup>		Sq. Ft.	
2.9 Floor-to-Ceiling Height in Rated Home <sup>8</sup>		ft.	
2.10 Infiltration Rate in Rated Home <sup>9</sup>	Summer	Winter	
2.11 Mechanical Ventilation Rate in Rated Home <sup>10</sup>		CFM	
2.12 Design Load Heat Gain		BTU/h	
2.13 Design Load Heat Loss		BTU/h	
2.14 Design Load Heat Gain		BTU/h	
2.15 Design Load Heat Loss		BTU/h	
2.16 Design Airflow <sup>11</sup>		CFM	
2.17 Design Load Pressure <sup>12</sup>		inches Water Column (IWC)	
2.18 Full Load Calculations Report Attached			
<b>3 Selected Cooling Equipment, If Cooling Equipment to be Installed</b>			
3.1 Condenser Manufacturer & Model			
3.2 Compressor Field #			
3.3 Evaporator / Fan Coil Manufacturer & Model			
3.4 Evaporator / Fan Coil Detail #			
3.5 ARI-Reference # <sup>13</sup>			
3.6 Label Efficiency	SEER	SEER	
3.7 Heating Device Type	<input type="checkbox"/> Direct Drive	<input type="checkbox"/> Other	
3.8 Refrigerant Type	R-410A	Other	
3.9 Fan Speed Type <sup>14</sup>	Fixed	Variable (ODM / ECM)	Other
3.10 Label (e.g., Label Capacity at Design Cond. <sup>15</sup> )		BTU/h	
3.11 Label (e.g., Sensible Capacity at Design Cond. <sup>15</sup> )		BTU/h	
3.12 Label (e.g., Total Capacity at Design Cond. <sup>15</sup> )		BTU/h	
3.13 Full Load EER, Label Capacity (Value 3) $\geq 1.5$ Design Label Heat Gain (Value 2.1c) or near room size <sup>16</sup>			
3.14 Label Total Cap. (Value 3.12) is 95-105% of Design Total Heat Gain (Value 2.1c) or near room size <sup>16</sup>			
3.15 Label Efficiency Attached <sup>17</sup>			
<b>4 Selected Heat Pump Equipment, If Heatpumps to be Installed</b>			
4.1 ARI-Label Efficiency	SEER	SEER	SEER
4.2 Performance at 17°F <sup>18</sup>	Capacity	BTU/h	Efficiency
4.3 Performance at 47°F <sup>18</sup>	Capacity	BTU/h	Efficiency
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ENERGY STAR Qualified Homes, Version 3 (Rev. 04) HVAC System Quality Installation Contractor Checklist <sup>1</sup>			
Name Address _____ City _____ State _____			
System Description <sup>1</sup> _____ Cooling system for temporary occupancy? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>			
<b>5 Selected Furnace, If Furnace to be Installed</b>			
5.1 Furnace Manufacturer & Model			
5.2 Furnace Detail #			
5.3 Label Efficiency	AFUE		
5.4 Label Output Heating Capacity		BTU/h	
5.5 Label Output Heat Cap. (Value 5.4) is 100-140% of Design Total Heat Loss (Value 2.1c) or near room size <sup>16</sup>			
<b>6 Background Facts - All systems for 15 minutes before testing their outdoor ambient temperature at a minimum at 10°F in winter (use the manufacturer's recommended minimum ambient temperature for the setting location) and a maximum at 90°F in summer (use the manufacturer's recommended maximum ambient temperature for the setting location)</b>			
6.1 Outdoor ambient temperature at construction		°F DB	
6.2 Return-air temperature inside duct near evaporator, during cooling mode		°F WB	
6.3 Liquid line pressure		psig	
6.4 Liquid line temperature		°F DB	
6.5 Suction line pressure		psig	
6.6 Suction line temperature		°F DB	
<b>7 Background Calculations</b>			
7.1 System with Normal Expansion Valve (NEV)			
7.1.1 Condenser saturation temperature		°F DB (Using Value 6.3)	
7.1.2 Subcooling value		°F DB (Value 7.1 - Value 6.4)	
7.1.3 ODM subcooling grad.		°F DB	
7.1.4 Subcooling deviation		°F DB (Value 7.2 - Value 7.3)	
Four System with Fixed Orifice			
7.1.5 Evaporator saturation temperature		°F DB (Using Value 6.5)	
7.1.6 Superheat value		°F DB (Value 6.6 - Value 7.1)	
7.1.7 ODM superheat grad.		°F DB (Using superheat value and Values 6.1 & 6.2)	
7.1.8 Superheat deviation		°F DB (Value 7.6 - Value 7.7)	
Two System with Fixed Orifice			
7.1.9 Value 7.4 is $\geq 1.7$ or Value 7.5 is $\geq 1.7$			
7.2 All ODM heat provisions has been used in place of subcooling or super-heat process and documentation has been attached that verifies this procedure			
<b>8 Electrical Measurements - Series of electrical measurements while component is in operation</b>			
8.1 Evaporator (at handle fan)		amperage	line voltage
8.2 Condenser unit		amperage	line voltage
8.3 Electrical measurements within OEM specified tolerance of representative value			
<b>9 Air Flow Tests</b>			
9.1 In return air evaporator		CFM	
9.2 Test performed in what mode? <input type="checkbox"/> Heating <input type="checkbox"/> Cooling			
9.3 Return duct static pressure		IWC	Test Hole Location <sup>19</sup>
9.4 Supply duct static pressure		IWC	Test Hole Location <sup>19</sup>
9.5 Test hole locations are well-sealed and accessible <sup>20</sup>			
9.6 Measurement method used <input type="checkbox"/> Anemometer <input type="checkbox"/> Pressure matching <sup>21</sup>			
9.7 Airflow volume in evaporator (Value 9.1) or fan speed and full operating load, a 10% of the airflow (airflow per system design Value 2.1c) or within range recommended by OEM			
<b>10 Fan Blower</b>			
10.1 Individual room airflow within the greater of a 20% or 20 CFM of the design application requirements for the return and main ducts <sup>22</sup>			
10.2 Blowing report including, for each supply and return register room name, design airflow, and final measured airflow			
<b>11 System Controls</b>			
11.1 Controls and safety controls meet OEM requirements			
<b>12 Drain Pan</b>			
12.1 Condensate drain pan properly sloped to drainage system, include with each HVAC component that produces condensate			
Technician Signature: _____ Equipment Installation Date: _____ Designer Name: _____ Company: _____ Designer Signature: _____ System Design Date: _____ Company: _____			
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**Critical Point:**

**Summary:**

**Construction Phase:**

**Inspection:**

**Footnotes:**

2. The Rater is only responsible for ensuring that the Contractor has completed the Contractor checklist in its entirety and verifying the discrete objective parameters referenced in Section 1 of this checklist, not for assessing the accuracy of the load calculations or field verifications included or to verifying the accuracy of every input on the Contractor checklist.

HVAC SYSTEM QUALITY INSTALLATION RATER CHECKLIST		ENERGY STAR
1	REVIEW OF HVAC SYSTEM QUALITY INSTALLATION CONTRACTOR CHECKLIST	
2	PARAMETERS RELATED TO SYSTEM COOLING MET	

**DETAIL 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) (DETAILS 1.2.1 - 1.2.10):**<sup>1</sup>

- 1.2.1. Outdoor design temperatures (2.4) are equal to the 1% and 99% ACCA Manual J design temperatures for contractor-designated location or alternate temps supported with documentation<sup>4</sup>
- 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<sup>5</sup>
- 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<sup>6</sup>
- 1.2.7. Listed latent cooling capacity (3.10) exceeds design latent heat gain (2.12)
- 1.2.8. Listed sensible cooling capacity (3.11) exceeds design sensible heat gain (2.13)
- 1.2.9. Listed total cooling capacity (3.12) 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<sup>7</sup>
- 1.2.10. HVAC manufacturer and model numbers on installed equipment, contractor checklist (3.1, 3.3, 5.1), and AHRI certificate or OEM catalog data all match<sup>8</sup>

<sup>1</sup> Footnotes located on page 17

**ENERGY STAR Qualified Homes, Version 3 (Rev. 04)**  
**HVAC System Quality Installation Contractor Checklist**<sup>1</sup>

System Description: \_\_\_\_\_ Cooling System for temporary occupant load?  Yes  No

1. Whole-Building Mechanical Ventilation Design<sup>2</sup>

Item	Pass/Fail	Notes
1.1 Ventilation system installed that has been designed to meet ASHRAE 62.2-2010 requirements including but not limited to requirements in Items 1.1.1-1.1.3		
1.2 Ventilation system does not utilize an intake duct to the return side of the HVAC system unless the system is designed to handle contaminants and particulates loaded in a home and to avoid outdoor air intake through the duct, mechanical exhaust		
1.3 Documentation is attached with ventilation system type, location, design rate, and frequency and duration of each ventilation cycle		
1.4 If present, continuously operating unit, & exhaust fans designed to operate during all occupiable hours		
1.5 If present, intermittently operating whole-house ventilation system designed to automatically operate at least once per day and at least 50% of every 24 hours		

2. Orientation & Conditioned Floor Area<sup>3</sup>

Item	Pass/Fail	Notes
2.4 Outdoor Design Temperature <sup>4</sup> Location: _____ °F _____ °C		
2.5 Orientation of Rated Home (e.g., North, South)		
2.6 Number of Occupants, Listed by System <sup>5</sup>		
2.7 Conditioned Floor Area in Rated Home		
2.8 Window Area in Rated Home		
2.9 Predominant Window SHGC in Rated Home <sup>6</sup>		
2.10 Infiltration Rate in Rated Home <sup>7</sup>		
2.11 Mechanical Ventilation Rate in Rated Home		
2.12 Design Latent Heat Gain		

3. Equipment Selection & Model<sup>8</sup>

Item	Pass/Fail	Notes
3.1 Compressor Manufacturer & Model		
3.2 Condenser Total B		
3.3 Evaporator / Fan Coil Manufacturer & Model		
3.4 Evaporator / Fan Coil Serial #		
3.5 Listed Efficiency <sup>9</sup>		
3.6 Listed Efficiency <sup>10</sup>		
3.7 Heating Device Type: <input type="checkbox"/> TRV <input type="checkbox"/> Fixed orifice <input type="checkbox"/> Other		
3.8 Refrigerant Type: <input type="checkbox"/> R-410A <input type="checkbox"/> Other		
3.9 Fan Speed Type <sup>11</sup> : <input type="checkbox"/> Fixed <input type="checkbox"/> Variable (ECM / ECM) <input type="checkbox"/> Other		
3.10 Listed Total Cooling Capacity at Design Condition <sup>12</sup>		
3.11 Listed Sensible Capacity at Design Condition <sup>13</sup>		

4. Performance at 47°F<sup>14</sup>

Item	Pass/Fail	Notes
4.1 AHRI Listed Efficiency		
4.2 Performance at 47°F: Capacity		
4.3 Performance at 47°F: Efficiency		

Footnotes:  
<sup>1</sup> Effective for homes permitted starting 10/1/2011. Revisions 8/20/2011. Page 7 of 18

**Critical Point:**

**Summary:**

**Construction Phase:**

**Inspection:**

Important to emphasize rater is not liable for the HVAC contractor work, sizing, and equipment selection. They just will be verifying the checklist was completed as required by EPA. The items in this group are asking the rater to objectively verify the HVAC contractor used appropriate inputs in their sizing calculations and equipment installed has nameplate specifications consistent with those specified from the calculations.

**Footnotes:**

4. The number of occupants among all HVAC systems in the home shall be equal to the number of RESNET-defined bedrooms plus one. Occupants listed for systems for which the header of the contractor checklist indicates that it is designed to handle temporary occupant loads, as defined in footnote 3 of the HVAC System Quality Installation Contractor Checklist, shall be permitted to exceed this limit.
5. "Predominant" is defined as the SHGC value used in the greatest amount of window area in the home.
6. For cooling systems, the next largest nominal piece of equipment may be used that is available to satisfy the latent and sensible requirements. Single-speed systems generally have OEM nominal size increments of 1/2 ton. Multi-speed or multi-stage equipment may have OEM nominal size increments of one ton. Therefore, the use of these advanced system types can provide extra flexibility to meet the equipment sizing requirements.
7. In cases where the condenser unit is installed after the time of inspection by the Rater, the HVAC manufacturer and model numbers on installed equipment can be documented through the use of photographs provided by the HVAC Contractor after installation is complete.
8. If contractor has indicated that an OEM test procedure has been used in place of a sub-cooling or super-heat process and documentation has been attached that defines this procedure, then the box for "n/a" shall be checked for this item.

HVAC SYSTEM QUALITY INSTALLATION RATER CHECKLIST		ENERGY STAR	
1	REVIEW OF HVAC SYSTEM QUALITY INSTALLATION CONTRACTOR CHECKLIST		
2	PARAMETERS RELATED TO SELECTED COOLING EQUIPMENT MET		

**DETAIL 1.2 (Continued)**

Review the following parameters related to system cooling design, selection, and installation from the HVAC Contractor checklist (Contractor checklist item # indicated in parenthesis) (DETAILS 1.2.11 - 1.2.12): <sup>1,†</sup>

1.2.11. Using reported liquid line (6.3) or suction line (6.5) pressure, corresponding temp. (as determined using pressure/temperature chart for refrigerant type) matches reported condenser (7.1) or evaporator (7.5) saturation temperature (+/- .3 degrees) <sup>‡</sup>

1.2.12. Calculated subcooling (7.1 minus 6.4) or superheat (6.6 minus 7.5) value equals reported target subcooling (7.3) or superheat (7.7) temperature. <sup>‡</sup>

<sup>†</sup> Footnotes located on page 17

ENERGY STAR Qualified Homes, Version 3 (Rev. 04) HVAC System Quality Installation Contractor Checklist <sup>1</sup>		Pass	Fail
<b>B. Selected Parameters, if Permitted to be Installed</b>			
B.1 Furnace Manufacturer & Model			
B.2 Furnace Serial #			
B.3 Furnace Efficiency	AFUE		
B.4 Lesser Output Heating Capacity	BTU/h		
B.5 Lesser Output Heat Cap. (Value 1.4) is 100-140% of Design Heat Load (see Tables 2, 3) or heat gain, whichever is greater			
<b>C. Refrigerant Tests - Run system for 15 minutes before testing</b>			
Note: Outdoor ambient temperature at the time tested is 55°F or greater, unless the contractor has documented through written verification that the cooling load (see Table 2) is greater than 10,000 BTU/h and the ambient air temperature is 50°F or greater, and the contractor has documented through written verification that the cooling load (see Table 2) is greater than 10,000 BTU/h and the ambient air temperature is 50°F or greater.			
C.1 Outdoor ambient temperature at completion	°F DB		
C.2 Suction line pressure	PSIG		
C.3 Liquid line temperature	°F DB		
C.4 Suction line pressure	PSIG		
C.5 Suction line temperature	°F DB		
<b>D. Refrigerant Calculations</b>			
<b>For System with Thermal Expansion Valve (TXV)</b>			
D.1 Condenser saturation temperature	°F DB (Using Value 6.3)		
D.2 Subcooling value	°F DB (Value 7.1 - Value 6.4)		
D.3 OEM subcooling goal	°F DB		
D.4 Subcooling deviation	°F DB (Value 7.2 - Value 7.3)		
<b>For System with Fixed Orifice</b>			
D.5 Evaporator saturation temperature	°F DB (Using Value 6.5)		
D.6 Superheat value	°F DB (Value 6.6 - Value 7.5)		
D.7 OEM superheat goal	°F DB (Using superheat value and Value 6.5 & 6.6)		
D.8 Value 7.4 is a "Y" or Value 7.5 is a "Y"			
† Note: All OEM test procedures that have used a piece of each cooling or super-heat process are documented and have been attached that defines this procedure.			
<b>E. Electrical Measurements - Taken at electrical disconnect or other component in operation</b>			
E.1 Evaporator fan handle fan	amperage	volts	
E.2 Condenser unit	amperage	volts	
E.3 Electrical measurements within OEM specified tolerance of manufacturer value			
<b>F. Air Flow Tests</b>			
F.1 Air volume at evaporator	CFM		
F.2 Test performed in which mode?	Heating	Cooling	
F.3 Return duct static pressure	inWC	Test Hole Location <sup>†</sup>	
F.4 Supply duct static pressure	inWC	Test Hole Location <sup>†</sup>	
F.5 Test hole locations are well-marked and accessible <sup>†</sup>			
F.6 Measurement method used:	Anemometer	Pressure balancing	
	Flow grid	Flow cone	
F.7 Airflow volume of evaporator (Value 2.1) is at fan design speed and full operating load ± 10% of the airflow specified per equipment label (Value 2.1) or with single refrigerant (see Table 2)			
<b>G. Air Balance</b>			
G.1 Total air flow within ± 5% of 20% of the design operational requirements for the supply and return ducts <sup>†</sup>			
G.2 Subcooling record indicating, for each supply and return register, meter name, design airflow, and final measured airflow			
<b>H. System Controls</b>			
H.1 Operating and safety controls meet OEM requirements			
<b>I. Other Data</b>			
I.1 Component-warranted drip pan, properly signed to drainage system, included with each HVAC component that produces condensate			
I.2	Technician Name	Equipment Installation Date	
I.3	Technician Signature <sup>†</sup>	Contractor	
I.4	Designer Signature <sup>†</sup>	System Design Date	
I.5	Designer Signature <sup>†</sup>	Company	

Revision 04

Relative to homes permitted starting 10/1/2011 | Revised 8/24/2011 | Page 8 of 18

**Critical Point:**

**Summary:**

**Construction Phase:**

**Inspection:**

From Sam: Important to emphasize rater is not liable for the HVAC contractor work, sizing, and equipment selection. They just will be verifying the checklist was completed as required by EPA. The items in this group are asking the rater to objectively verify the HVAC contractor used appropriate inputs in their sizing calculations and equipment installed has nameplate specifications consistent with those specified from the calculations.

**Footnotes:**

- The number of occupants among all HVAC systems in the home shall be equal to the number of RESNET-defined bedrooms plus one. Occupants listed for systems for which the header of the contractor checklist indicates that it is designed to handle temporary occupant loads, as defined in footnote 3 of the HVAC System Quality Installation Contractor Checklist, shall be permitted to exceed this limit.
- "Predominant" is defined as the SHGC value used in the greatest amount of window area in the home.
- For cooling systems, the next largest nominal piece of equipment may be used that is available to satisfy the latent and sensible requirements. Single-speed systems generally have OEM nominal size increments of ½ ton. Multi-speed or multi-stage equipment may have OEM nominal size increments of one ton. Therefore, the use of these advanced system types can provide extra flexibility to meet the equipment sizing requirements.
- In cases where the condenser unit is installed after the time of inspection by the Rater, the HVAC manufacturer and model numbers on installed equipment can be documented through the use of photographs provided by the HVAC Contractor after installation is complete.
- If contractor has indicated that an OEM test procedure has been used in place of a sub-cooling or super-heat process and documentation has been attached that defines this procedure, then the box for "n/a" shall be checked for this item.



HVAC SYSTEM QUALITY INSTALLATION RATER CHECKLIST			ENERGY STAR
1	REVIEW OF HVAC SYSTEM QUALITY INSTALLATION CONTRACTOR CHECKLIST		
3	SUPPLY & RETURN DUCT STATIC PRESSURE <110% OF CONTRACTOR VALUES		

**DETAIL 1.3**

**Rater-verified supply & return duct static pressure < 110% of contractor values (9.3, 9.4)**

A. Locate the return static pressure and the supply static pressure on the HVAC System Quality Installation Contractor checklist.

B. Verify the return static pressure and the supply static pressure are less than 110% of the values listed on the checklist.

**STATIC PRESSURE TESTING LOCATIONS**

Examples of return or supply duct static pressure measurement locations are: plenum, cabinet, trunk duct, as well as front, back, left or right side. Test hole locations shall be well marked and accessible.

ENERGY STAR Qualified Homes, Version 3 (Rev. 04) HVAC System Quality Installation Contractor Checklist <sup>1</sup>			
Item	Pass/Fail/NA	Pass	Fail
<b>5. Selected Parameters, if Planned to be Installed</b>			
5.1 Furnace Manufacturer & Model			
5.2 Furnace Size #			
5.3 Load Efficiency			
5.4 Load Output Heating Capacity			
5.5 Load Output Heat Cap. (Value 1.4) x 100/142% of Design Total Heat Load (Value 2.1) or heat den. den. 1/4"			
<b>6. Refrigerant Levels - Rpt system for 15 minute indoor testing</b>			
Note: Refrigerant level measurements are required for all R-410A systems and are optional for R-22 systems. Minimum testing frequency is 10% of the cooling load per the load per design (Table 2.1) or which range recommended by OEM.			
6.1 Outdoor ambient temperature at condenser			
6.2 Return side air temperature inside duct near evaporator, during cooling cycle			
6.3 Suction line pressure			
6.4 Liquid line temperature			
6.5 Suction line pressure			
6.6 Suction line temperature			
<b>7. Refrigerant Calculations</b>			
For System with Thermal Expansion Valve (TXV)			
7.1 Condenser subcooling temperature			
7.2 Subcooling value			
7.3 OEM subcooling goal			
7.4 Subcooling deviation			
For System with Fixed Orifice			
7.5 Evaporator superheat temperature			
7.6 Superheat value			
7.7 OEM superheat goal			
7.8 Superheat deviation			
7.9 Value 7.4 is > 2% or Value 7.6 is > 2%			
7.10 For OEM test procedure that does not use a table of subcooling or superheat process and documentation has been attached that outlines the procedure			
<b>8. Electrical Measurements - None of the measurements are required in all operations</b>			
8.1 Evaporator fan motor load			
8.2 Condenser unit			
8.3 Electrical measurements within OEM specified tolerance of manufacturer value			
<b>9. Air Flow Tests</b>			
9.1 Test performed in which mode? Heating <input type="checkbox"/> Cooling <input type="checkbox"/>			
9.2 Return duct static pressure			
9.3 Supply duct static pressure			
9.4 Test hole locations are well-marked and accessible			
<b>10. Air Flow</b>			
10.1 Test performed in which mode? Heating <input type="checkbox"/> Cooling <input type="checkbox"/>			
10.2 Return duct static pressure			
10.3 Supply duct static pressure			
10.4 Test hole locations are well-marked and accessible			
<b>11. System Controls</b>			
11.1 Control and safety controls meet OEM requirements			
11.2 Control panel			
11.3 Control panel			
11.4 Control panel			
11.5 Control panel			
11.6 Control panel			
11.7 Control panel			
11.8 Control panel			
11.9 Control panel			
11.10 Control panel			
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11.94 Control panel			
11.95 Control panel			
11.96 Control panel			
11.97 Control panel			
11.98 Control panel			
11.99 Control panel			
12.00 Control panel			

**Critical Point:**  
Air Flow, Heat Flow

**Summary:**  
Follow directions based on how your pressure gauge manual specifies

**Construction Phase:**  
Final

**Inspection:**  
Final

## 4.1-2

Total Rater-measured duct leakage  $\leq 6$  CFM25 per 100 sq. ft. of conditioned floor area<sup>15,16</sup>  
Rater -measured duct leakage to outdoors  $\leq 4$  CFM25 per 100 sq. ft. of conditioned floor area.<sup>15, 16, 17</sup>



Connection in place but not sealed.

A



Mechanically fastened and sealed.



HVAC System Quality Installation Rater Checklist

### Critical Point:

Air Flow, Heat Flow

### Picture Description:

These recommendations will aid the HVAC contractor in meeting the targets for duct leakage. It will be difficult to meet the requirements if these steps aren't followed.

The bad picture shows a duct that is not sealed to the take off. Eventually the duct could fall off because it is only held in place by a metal strap. This sealing should be done before insulation is installed around the duct.

The good picture shows sealing around the inner liner complete.

**Construction Phase: Rough in**

**Inspection: Rough in**

ENERGY STAR® QUALIFIED HOMES  
HVAC SYSTEM QUALITY INSTALLATION RATER  
CHECKLIST



**SECTION 4. DUCT LEAKAGE**


- 4.3 Duct boots sealed to floor, wall, or ceiling using caulk, foam, mastic tape, or mastic paste.



**Critical Point:**

**Summary:**

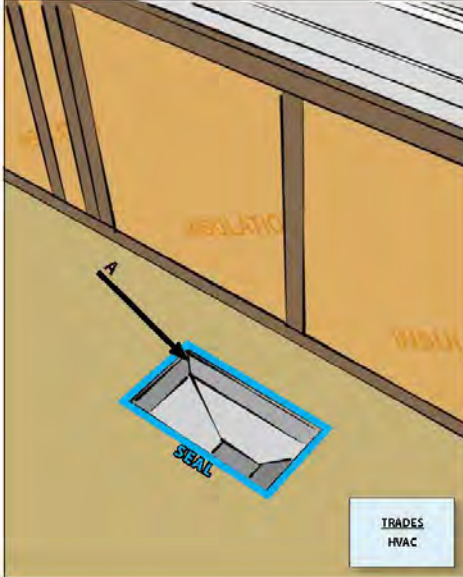


HVAC SYSTEM QUALITY INSTALLATION RATER CHECKLIST		
4	DUCT LEAKAGE	
3	DUCT BOOTS SEALED TO FLOOR, WALL, OR CEILING	

**DETAIL 4.3**  
**Duct boots sealed to floor, wall, or ceiling using caulk, foam, mastic tape, or mastic paste**

A. Seal all seams, gaps, and holes of all duct boots to the floor, wall, or ceiling, preferably with mastic.



TRADES  
HVAC

**Critical Point:**

Air Flow —

**Picture Description:**

**Construction Phase:**

**Inspection:**

## 4.3

Duct boots sealed to floor, wall, or ceiling using caulk, foam, mastic tape, or mastic paste.



Boot to floor connection not sealed.

A



Boot to floor connection sealed.



HVAC System Quality Installation Rater Checklist

### Critical Point:

Air Flow, Heat Flow

### Picture Description:

The bad picture shows a boot not sealed to the floor. Conditioned air could leak into the unconditioned space creating energy loss and comfort complaints.

The good picture shows a duct sealed to the floor with mastic. Caulk, foam or mastic shall be used to seal penetrations to exterior or to unconditioned space (i.e. chases/shafts that terminate in the attic). Penetrations include any ducts, pipes, wires, refrigerant or condensate lines, etc. It is the responsibility of whoever created the hole to verify it is sealable. You make the hole, you own the hole. Caulk, foam or mastic should be used because other materials commonly used, such as fiberglass insulation, are not effective at stopping air flow.

### Construction Phase: Insulation

### Inspection: Insulation

## 4.3

Duct boots sealed to floor, wall, or ceiling using caulk, foam, mastic tape, or mastic paste.



Boot to drywall connection not sealed.

A



Boot to drywall connection sealed.



### Critical Point:


Air Flow, Heat Flow

### Picture Description:

The bad picture shows a boot installed in the ceiling and it is not sealed to the drywall. This gap can provide a lot of leakage.

**Construction Phase: Final for attics**

**Inspection: Final for attics**

HVAC SYSTEM QUALITY INSTALLATION RATER CHECKLIST		
6	CONTROLS	
1-3	THERMOSTAT CONTROLS	

**DETAIL 6.1**

**Air flow is produced when central HVAC fan is energized (set thermostat to "fan")**

A. Turn the fan on at the thermostat.  
 B. Reset the thermostat to the original settings before continuing.

---

**DETAIL 6.2 <sup>19, 20†</sup>**

**Cool air flow is produced when the cooling cycle is energized (set thermostat to "cool")**

D. Turn the system on to cool and change the set point temperature to 3 degrees below the ambient temperature.  
 E. Reset the thermostat to the original settings before continuing.  
 F. If the system does not have air conditioning, this item does not need to be verified.

† Footnotes located on page 62.

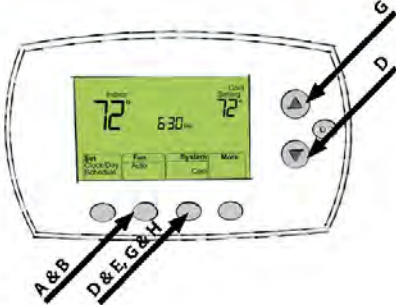
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**DETAIL 6.3 <sup>19†</sup>**

**Heated air flow is produced when the heating cycle is energized (set thermostat to heat)**

G. Turn the system on to heat and change the set point temperature to 3 degrees above the ambient temperature.  
 H. Reset the thermostat to the original settings before continuing.

† Footnotes located on page 62.



The diagram shows a thermostat with a digital display showing 72 degrees and 6:30 AM. Below the display are buttons for 'Set', 'Fan', 'System', and 'More'. To the right are two large circular buttons with up and down arrows. Callout 'A' points to the 'Fan' button, 'B' to the 'Set' button, 'D' to the 'System' button, 'E' to the 'More' button, 'G' to the top arrow button, and 'H' to the bottom arrow button.

**Critical Point:**

Air Flow —

**Picture Description:**

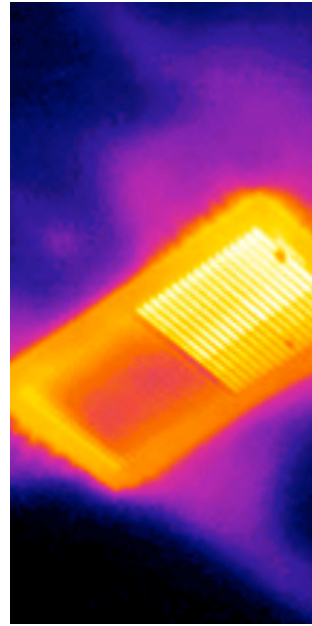
**Construction Phase:**

**Inspection:**

**Footnotes:**

17. In cases where the condenser unit is installed after the time of inspection by the Rater, the Rater is exempt from verifying item 6.2 when the condenser is for an AC unit and also item 6.3 when the condenser is for a heat pump unit.

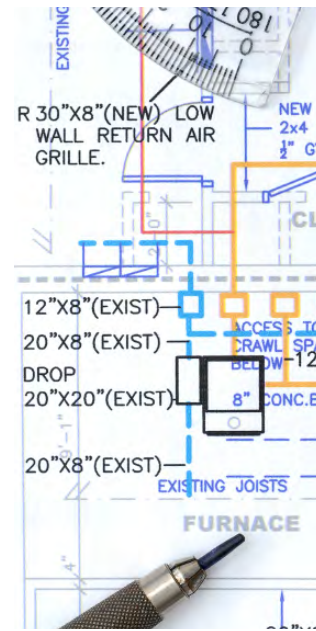
Takeaways





We talked about the IECC code and the Energy Star for Homes program and the potential market opportunities

# High Performance HVAC Design



We reviewed how high performance home building and remodeling requires a different approach than the traditional, established way of building. Building a high performance home must be a systematic approach and done as a team. The project must be looked at as a system, in which each component is connected to and depends on the other components. Teamwork is required to make it all come together. Addressing and optimizing key factors up front with the whole team will result in a smoother construction process, lower costs and a much better home.

High  
Performance  
HVAC Installation  
and Testing



We talked about the key best practices for HVAC installations and the available performance tests



Implementing  
High Performance  
HVAC Strategies



We talked about strategies for improving you business through High Performance HVAC



We talked about the Energy Star HVAC Quality Installation Program



"Mr. Osborne, may I be excused?  
My brain is full."

Q&A

**BUILDING  
KNOWLEDGE**

Thank You!