Commissioning Residential Homes

Where do we start?

Emmett Leffel

- Certified AHFC Rater
- BPI Building Analyst
- BPI Healthy Home Evaluator
- ITC Level II thermographer
- ABAA Certified Air Barrier Auditor
- Air Barrier Testing Professional
- Combustion Safety Specialist
- SOA Mechanical Administrator
- SOA Plumbing License.
- UA Journeyman Pipefitter/Plumber

Speaker

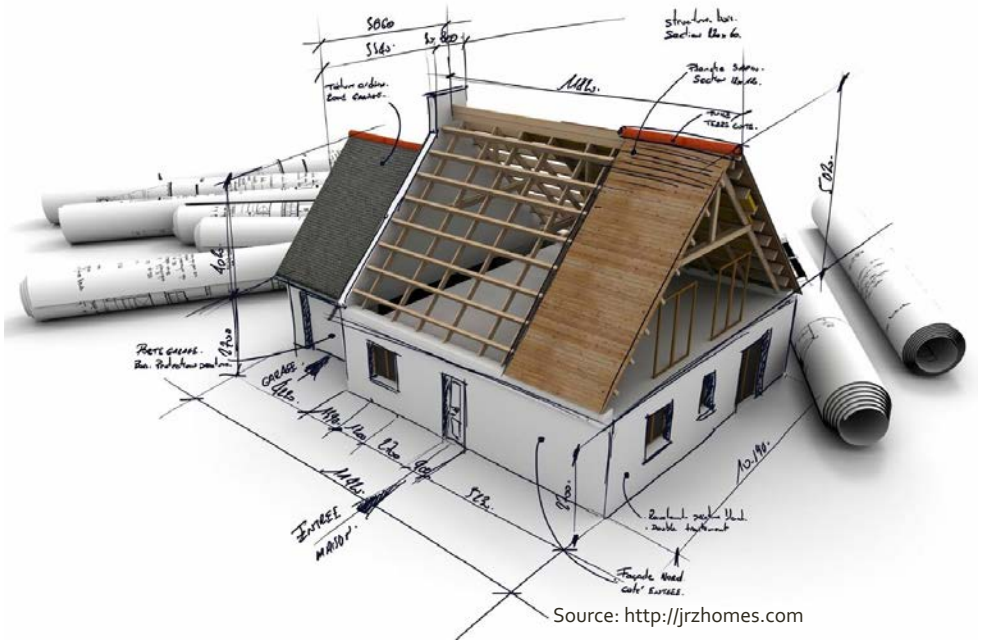
Emmett has traveled across the State of Alaska performing building diagnostic on everything from Natatoriums in South East Alaska to Groceries Stores in the Aleutians and energy audits on residential and commercial audits across Alaska for the last 10 years. Before becoming an Energy Professional Emmett worked in the heating and plumbing industry in the interior of Alaska.

www.alaskathermalimaging.com

BPI

itc INFRARED TRAINING CENTER

What is Commissioning?



Source: http://jrzhomes.com

- Commissioning is the action of bringing something newly produced into working conditioned.
- Typically there are aspects of any system that requires verification, inspection, or tests to verify if it functions according to its manufacture design objectives and specifications.

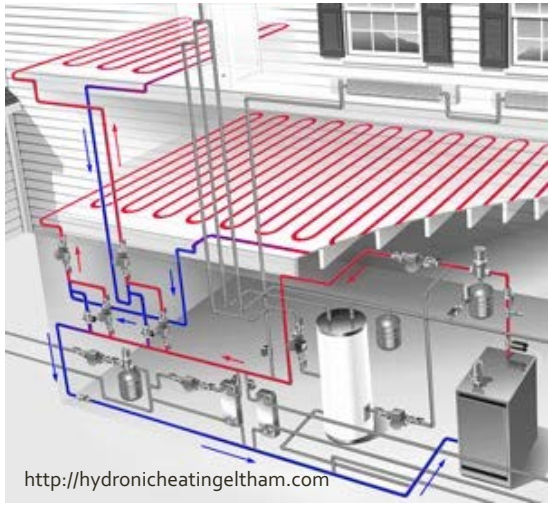
Pre-Commissioning: Activities involving Inspection & Verification

→

Post Commissioning: Activities involving Testing, Adjusting & Balancing

Commissioning can be broke into
Two Categories

Commissioning Systems Must Be Systematic.



- Designed

- Inspected

- Tested

Who's Commissioning Alaskan Homes?

Inspectors?

Energy Raters?

Sub Contractors?

Who's Interest do they Represent?

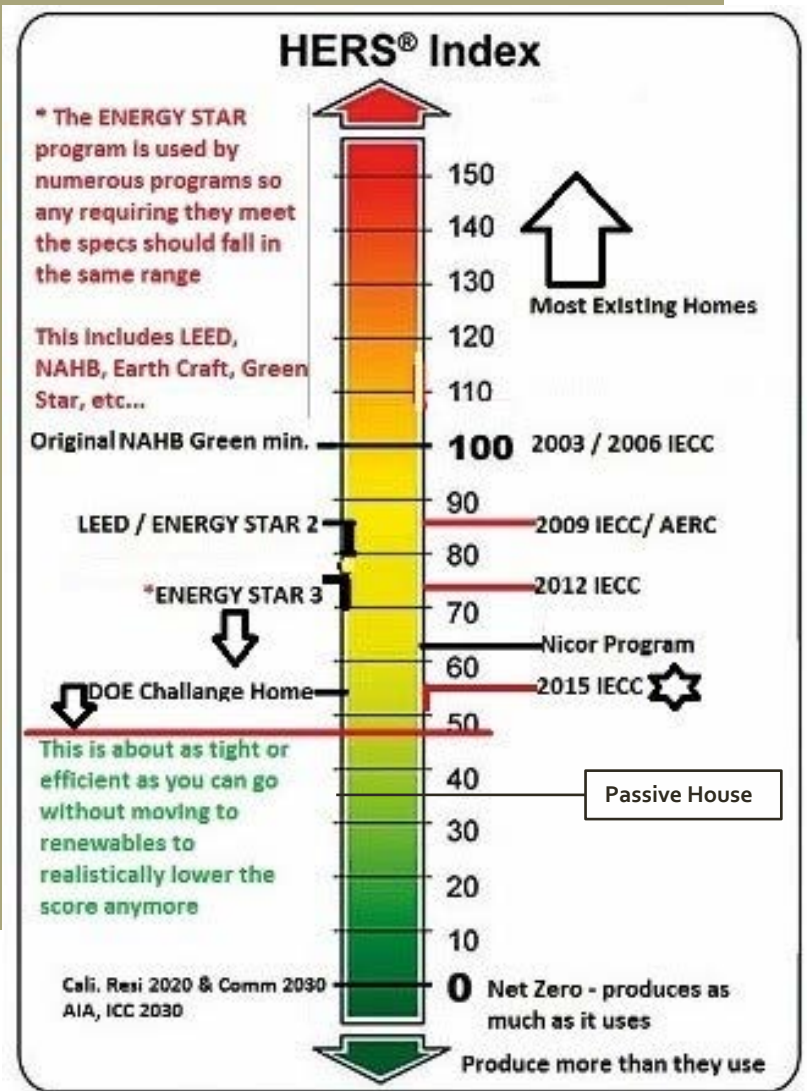
http://www.technical-designs.com/cxa/images/Picture1.jpg

- ICC Code Group
- AK Building Energy Efficiency Standard
  - 2018 IECC & ASHRAE-16

- Energy Star
  - LEED for Homes
  - DOE Zero Energy Ready Home
- Passive House

Examples of Residential Building Codes & Standards that require Commissioning in Alaska.

How Do You Rate?



ECO ACHIEVERS
Building Wisdom

Enterprise green communities

REPS ENERGY SCORE

2012 IECC

WATERSENSE CERTIFIED

Home Innovation NGBS GREEN CERTIFIED

LEED FOR HOMES

LIVING BUILDING CHALLENGE 2.0

PHIUS
Passive House Institute US

RESNET HERS INDEX

EPA Indoor airPLUS QUALIFIED HOME

ENERGY STAR HOMES

greenstar

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

HOME ENERGY SCORE

RESTORATIVE/ REGENERATIVE PRACTICES

PURSUING SUSTAINABILITY

HIGH PERFORMANCE GREEN HOMES

BETTER BUILDING PRACTICES

TYPICAL CODE HOMES

http://www.ecoachievers.com/services-view/green-certifications/

Is the level of efficiency achievable because of the commissioning required?

Or

Is the level of commissioning required because of the efficiency achieved?

						Source Zero Renewable Energy System
					Balanced Ventilation HRV/ERV	Balanced Ventilation HRV/ERV
				SOLAR READY Depends on climate	SOLAR READY ALWAYS	SOLAR READY ALWAYS
				Eff. Comps. & H2O Distrib	Eff. Comps. & H_2O Distrib	Eff. Comps. & H_2O Distrib
				EPA Indoor Air Pacakge	EPA Indoor Air Pacakge	EPA Indoor Air Pacakge
				Ducts in Condit. Space	Ducts in Condit. Space	Ducts in Condit. Space
		HVAC QI w/WHV	HVAC QI w/WHV	HVAC QI w/WHV	Micro-load HVAC QI	Micro-load HVAC QI
		Water Management	Water Management	Water Management	Water Management	Water Management
		Independent Verification	Independent Verification	Independent Verification	Independent Verification	Independent Verification
IECC 2009 Enclosure	IECC 2012 Enclosure	IECC 2009 Enclosure	IECC 2012 Enclosure	IECC 2012/15 Encl./ES Win.	Ultra-Efficient Enclosure	Ultra-Efficient Enclosure
HERS 85-90	HERS 70-80	HERS 65-75	HERS 55-65	HERS 48-55	HERS 35-45	HERS < 0
IECC 2009	IECC 2012	ENERGY STAR v3	ENERGY STAR v3.1	ZERH	PHIUS PHIUS+	PHIUS+ SourceZero

https://www.energy.gov/sites/prod/files/2017/02/f34/PHIUS%2B2015%20Passive%20Building%20Standards.pdf

Energy Star Certification

- **NATIONAL REGISTRY OF ACCREDITEDRATING SOFTWARE PROGRAMS**

1. Ekotrope, V1.9.0, V2.1 V2.2, V3.0 & 3.1
   1. Ekotrope Optimzer & Calculators
2. EnergyGauge® USA Version 4.0, 5.1, 6.0 $ 6.1
3. REM/Rate v14.6.4, v15.2, v15.3, v15.4, v15.5, v15.6 &15.7
   http://www.resnet.us/professional/programs/energy_rating_software

- ES Certification also requires the completion of the following:
  1. Rater Design Review Checklist and Rater Field Checklist (PDF)
  2. HVAC Design Report (PDF)
  3. HVAC Commissioning Checklist (PDF)
  4. Water Management System Builder Requirements (PDF)

Passive House Certification Criteria

- Energy Star Checklist + Passive House Checklist
- RESNET QA/QC Protocols + Passive House Training
- Wuffi Passive Energy & Hygrothermal Modeling
- Climate Specific Comfort and Performance Criteria
- Passive House Product Certifications
  - Windows Performance Data Program
  - Building/Panel System Program
  - Ventilation Product Program

	Heating Demand/Load*	Cooling Demand/Load*	AIR-TIGHTNESS (cfm50/sf envelope)	Source Energy Demand	Renewable Generation for Source Zero
SINGLE FAMILY	1 - 16.8 kBTU/ft^2.yr 0 - 7.6 BTU/hr.ft^2	1 - 23.4 kBTU/ft^2.yr 1.3 - 9.5 BTU/hr.ft^2	0.05	6200 kWh/person.yr	>Source Energy Demand
COMMERCIAL				38 kBTU/ft2.yr	>Source Energy Demand
MULTIFAMILY			0.08**	6200 kWh/person.yr / 38 kBTU/ft2.yr	>Source Energy Demand
RETROFIT	As above, + allowance for existing thermal bridges	As above, + allowance for existing thermal bridges	0.05 / 0.08**		

*Maximum climate specific targets for each individual project
**Buildings with 5 stories+, non-combustible construction

Residential Systems that Require Commissioning

- Building Thermal Envelope
- Air Barrier System
- Heating Systems
- HVAC Duct System
- Domestic Hot Water System
- Mechanical Ventilation Systems
- Renewable Energy Systems
- Other Systems?

Building Thermal Envelope Code Requirements

http://www.mytown.center

1) **Wall assemblies, attic/roofing, slab insulation and fenestration all must comply with either the IECC**
   - **Prescriptive Method or**
   - **Performance Method (Akwarm).**

2) **Installation of components of the building thermal envelope shall be installed in accordance with the manufacture's instructions and the criteria indicated in IECC.**
   - **Inspection ICC Inspectors (AK only)**
   - **Energy Modeled by Energy Auditors at Final**

BEES Energy Modeling with Akwarm Software

Home Energy Rating Certificate

Alaska Housing Finance Corporation

The Building Located At:

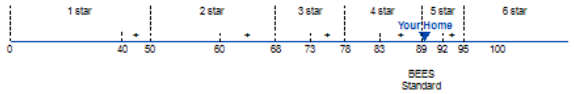
Has Been Energy-Rated As:

★★★★★

Five Star

Efficiency Score

89.4 points



Amount of CO2 Produced by the Home

24,612 pounds per year

Projected Annual Energy Costs

$4,234 per year

Score with Renewables

89.4 points

Estimated Annual Energy Costs

Space Heating	$1,670
Water Heating	$483
Space Cooling	$0
Lights & Appli.	$2,081
Renewables	$0

Owner of Record:

Legal Description

Date Construction Began: 6/11/2018

Certifying BEES: 2012

Energy Rating Date: 11/8/2018

File:

Energy Rater: Emmett Leffel
Alaska Thermal Imaging LLC

AkWarm: 2.9.0.0 **Library:** 9/27/2018

I certify that this Energy Rating is true and correct, to the best of my knowledge and belief, and the structure located on the above described property complies with the all the requirements of the building energy efficiency standards as required by Section .04 Part A. of the AHFC New Construction Inspection Guidelines, per the standards adopted by 15 AAC 155.010.

Energy Rater Signature Date

Return to: _____

Form PUR-101 v.3/1/16

Energy Cost and Features Report

(DOCUMENT DOES NOT NEED TO BE RECORDED)

Property:

House: Single Family
Living Floor Area: 1,488 square feet
Attached Garage, 398 square feet

Rater: Emmett Leffel
Alaska Thermal Imaging LLC
PO Box 2674
Palmer, AK 99645

Rating: BEES

Envelope Efficiency

Floor Insulation	R-26.0 *
Wall/Door Insulation	R-16.7 *
Ceiling Insulation	R-36.8
Window U-Value	U-0.31
Window SHGC	0.34
Window to Wall Ratio, Living Space	7.0%
South Facing Window Area	70 square feet
Air Leakage	1.0 Air Changes per Hour at 50 Pascals 0.06 Air Changes per Hour Natural

* Includes the insulating value of the ground in contact with these components.

Space Heating System

Fuel	#1 Oil
System Type	Boiler
Model	OM-128-HH
Efficiency	87%
Btu/hr Output	128,900 Btu/hr
Primary Htg. Sys. Design Load	19,489 Btu/hr
Garage Htg. Sys. Design Load	0 Btu/hr
Supplemental Fuel	None
Thermostat Setting	70.0 degrees F
Setback Thermostat	None

Water Heater

Efficiency	88%
Location	Conditioned Space
Fuel Type	#1 Oil

Space Cooling System None Present

Ventilation

System Type	Continuous Ventilation without
Required Ventilation	55 CFM
Measured Ventilation	124 CFM

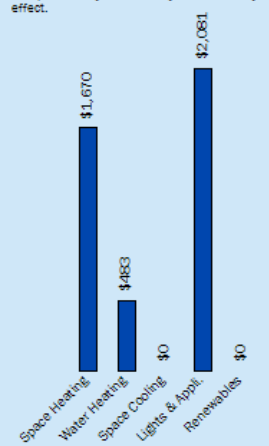
Other

Number of Bedrooms	3
Clothes Dryer Fuel	Electricity
Cooking Range Fuel	Propane
Oven Fuel	Propane
Miscellaneous Lights/Appliance Use	Average
CAZ Test Normal Conditions	Pass

ver. 2.9.0.0, library: 9/27/2018, file:

Estimated Annual Energy Costs

Actual use and costs may vary from these estimates depending upon weather conditions, occupant life styles and utility rates currently in effect.



Electricity: $0.2836/kWh, Propane: $4/gallons, #1 Oil: $3.38/gallons
Space Heating: 163 kWh of Electricity, 480 gallons of #1 Oil
Water Heating: 143 gallons of #1 Oil
Space Cooling:
Lights & Appliances: 6,549 kWh of Electricity, 56 gallons of Propane

ENERGY STAR Qualified Homes, Version 3 (Rev. 06)
Thermal Enclosure System Rater Checklist

Home Address: City: State:

4. Reduced Thermal Bridging				
4.1 For insulated ceilings with attic space above (i.e., non-cathedralized), Grade I insulation extends to the inside face of the exterior wall below at these levels: CZ 1-5: ≥ R-21; CZ 6-8: ≥ R-30 [11]	☐	☐	☐	☐
4.2 For slabs on grade in CZ 4 and higher, 100% of slab edge insulated to ≥ R-5 at the depth specified by the 2009 IECC and aligned with thermal boundary of the walls [4,5]	☐	☐	☐	☐
4.3 Insulation beneath attic platforms (e.g., HVAC platforms, walkways) ≥ R-21 in CZ 1-5; ≥ R-30 in CZ 6-8	☐	☐	☐	☐
4.4 Reduced thermal bridging at above-grade walls separating conditioned from unconditioned space (rim / band joists exempted) using one of the following options: [12,13]				
4.4.1 Continuous rigid insulation, insulated siding, or combination of the two; ≥ R-3 in Climate Zones 1 to 4, ≥ R-5 in Climate Zones 5 to 8 [14,15], **OR**;	☐	☐	☐	☐
4.4.2 Structural Insulated Panels (SIPs), **OR**;	☐	☐	☐	☐
4.4.3 Insulated Concrete Forms (ICFs), **OR**;	☐	☐	☐	☐
4.4.4 Double-wall framing [16], **OR**;	☐	☐	☐	☐
4.4.5 Advanced framing, including all of the items below:				
4.4.5a All corners insulated ≥ R-6 to edge [17], **AND**;	☐	☐	☐	☐
4.4.5b All headers above windows & doors insulated [18], **AND**;	☐	☐	☐	☐
4.4.5c Framing limited at all windows & doors [19], **AND**;	☐	☐	☐	☐
4.4.5d All interior / exterior wall intersections insulated to the same R-value as the rest of the exterior wall [20], **AND**;	☐	☐	☐	☐
4.4.5e Minimum stud spacing of 16 in. o.c. for 2x4 framing in all Climate Zones and, in Climate Zones 5 through 8, 24 in. o.c. for 2x6 framing [21]	☐	☐	☐	☐

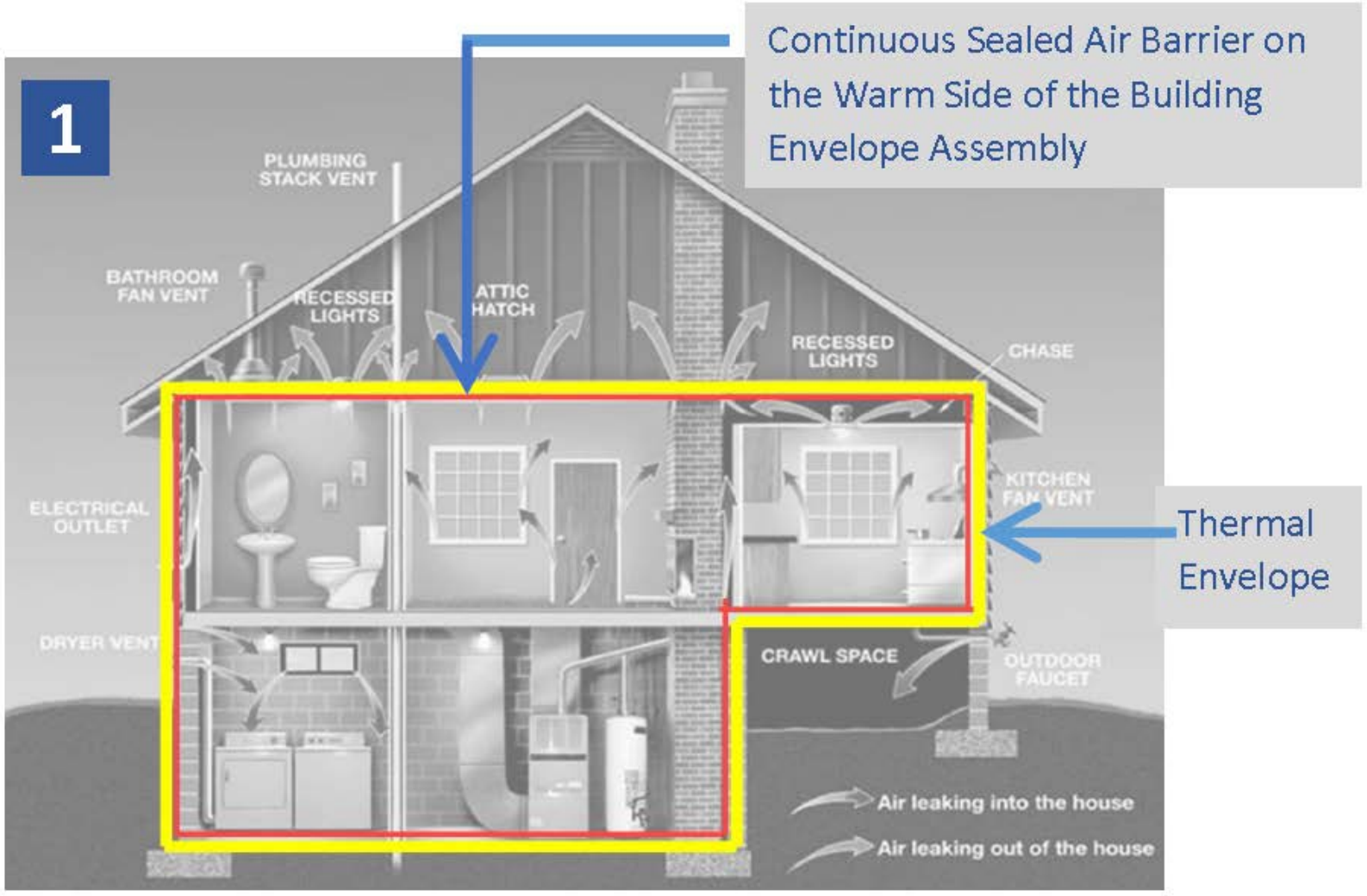
Air Barrier System Commissioning

1. The building thermal envelope shall be constructed to limit air leakage in accordance with IECC requirements.
   - Inspection by ICC Inspectors (AK only)
   - Air leakage testing by Energy Auditors

2. Components of the air barrier and other required air sealing shall be installed in accordance with the manufacture's instructions and the criteria indicated in IECC Table R402.4.1.1.

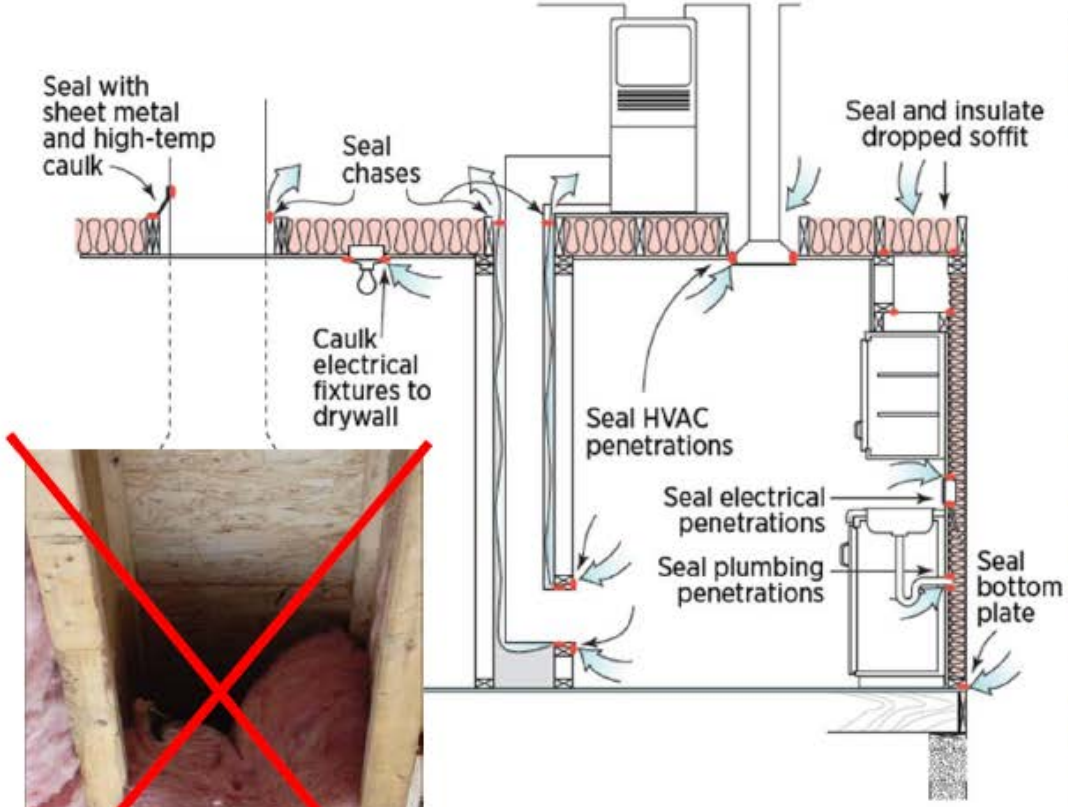
3. Whole Building Air Leakage ≤ 4ach50 (BEES Amended)

TABLE R402.4.1.1 AIR BARRIER AND INSULATION INSTALLATION



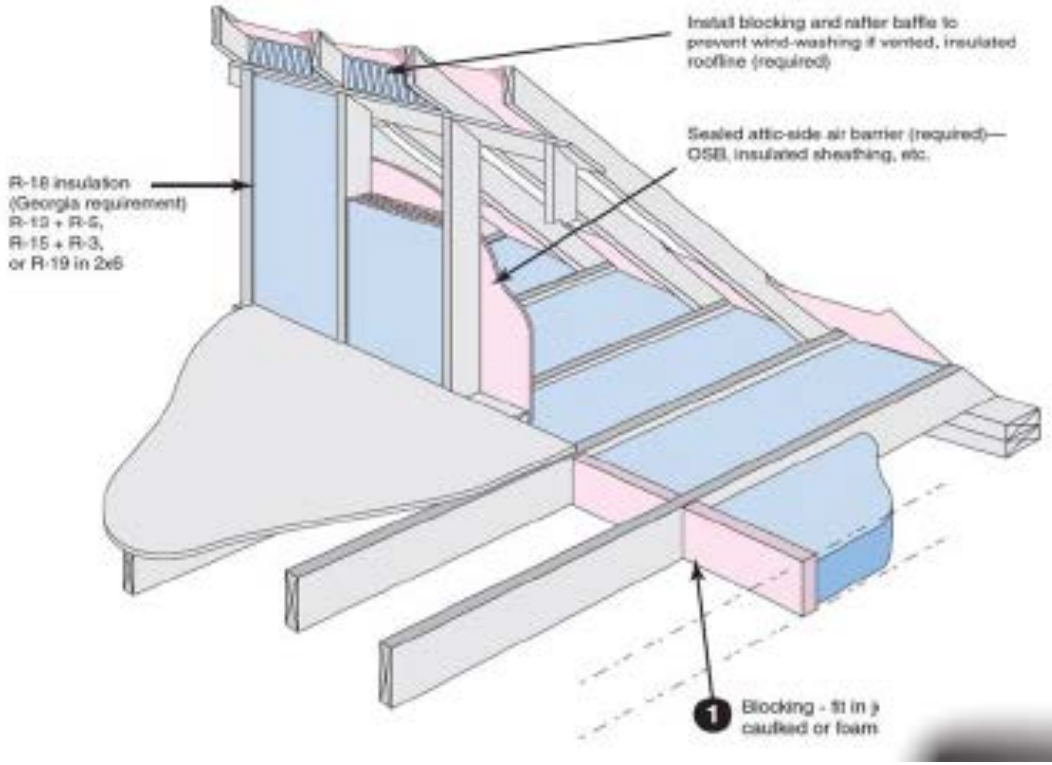
2 Ceiling/attic

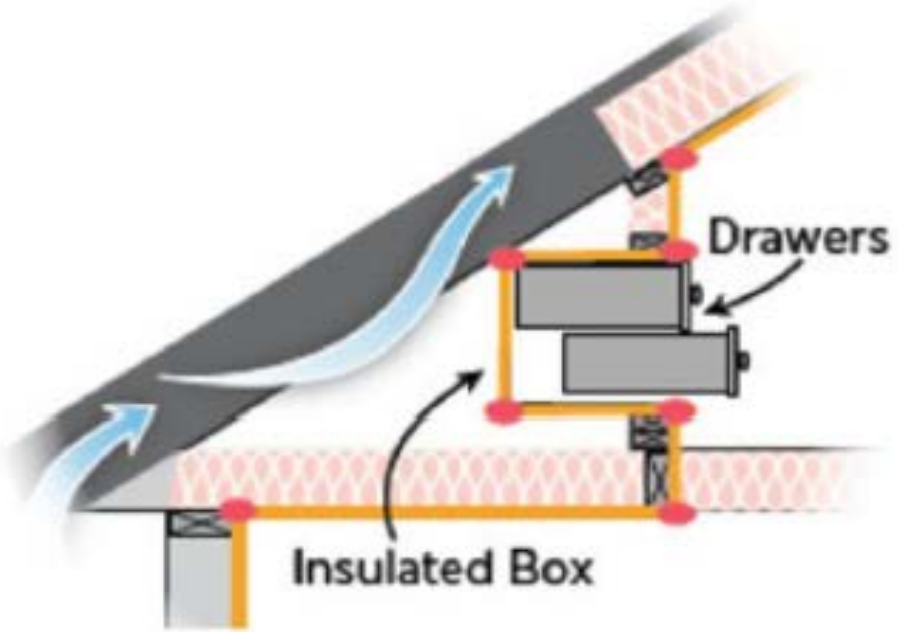
The air barrier in any dropped ceiling/soffit shall be aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop down stair or knee wall doors to unconditioned attic spaces shall be sealed.



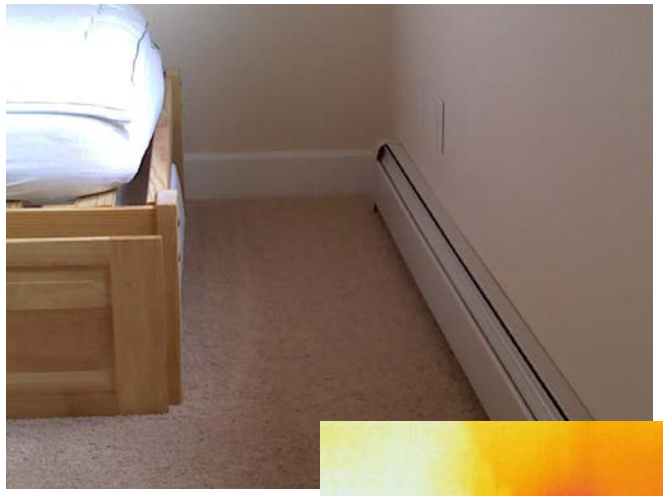
3 Walls

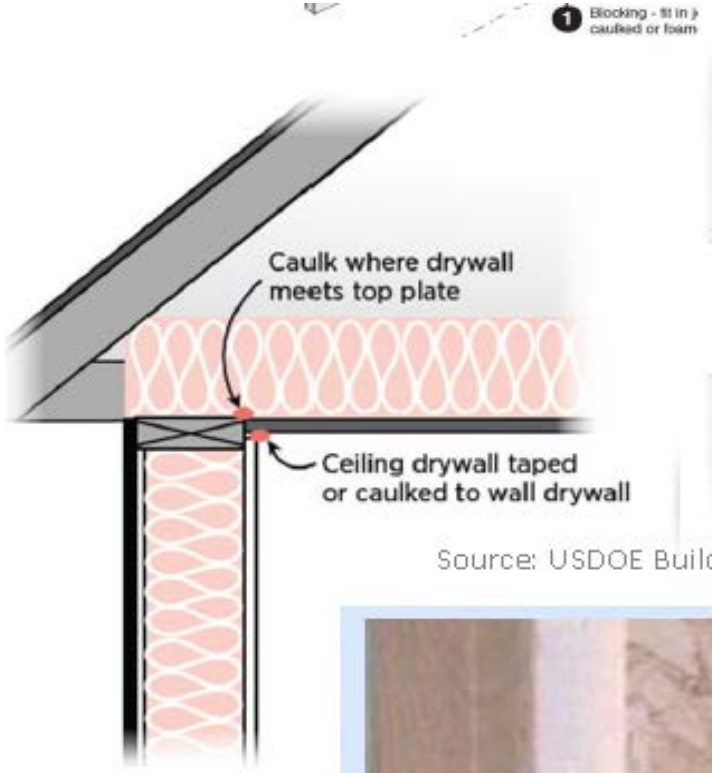
Corners and headers shall be insulated and the junction of the foundation and sill plate shall be sealed. The junction of the top plate and top of exterior walls shall be sealed. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier. Knee walls shall be sealed.

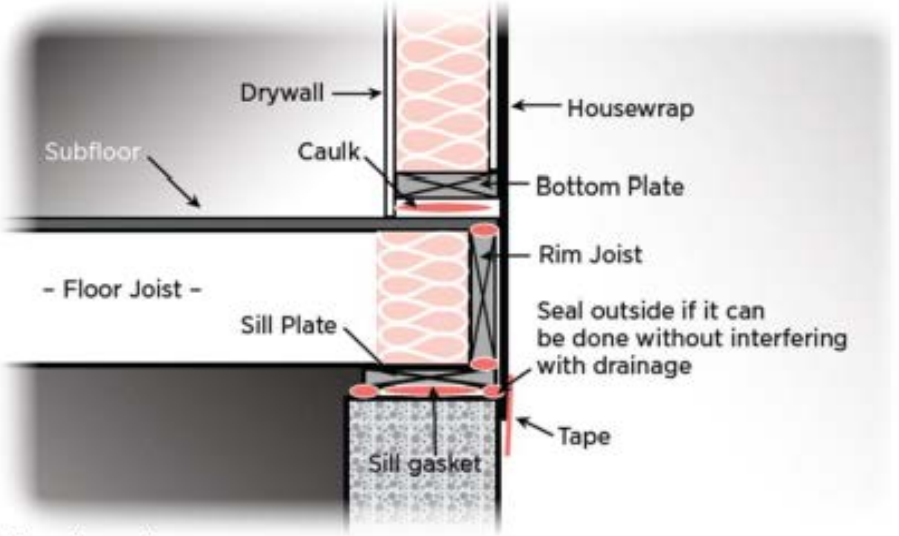




3 Walls





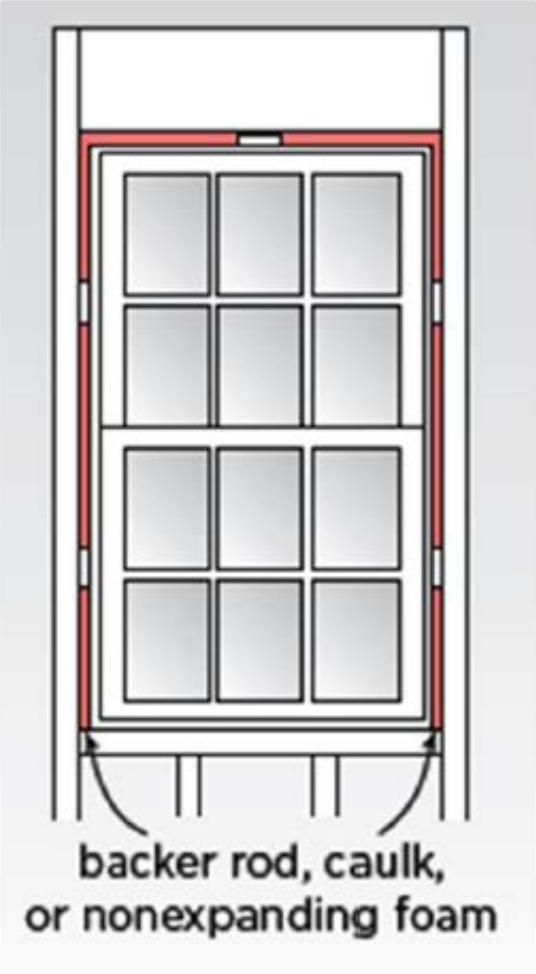


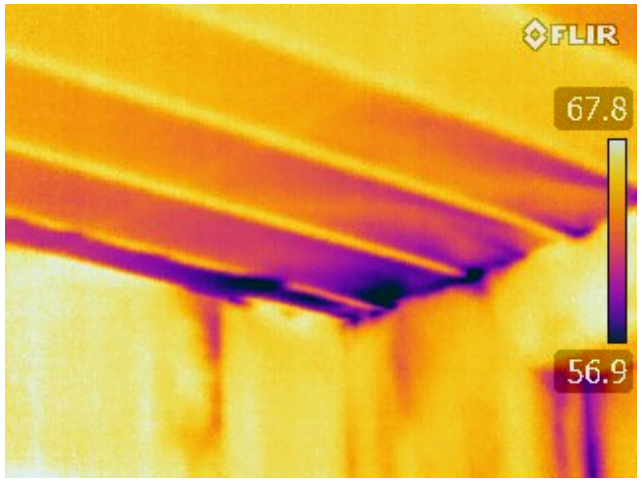
Source: USDOE Building America

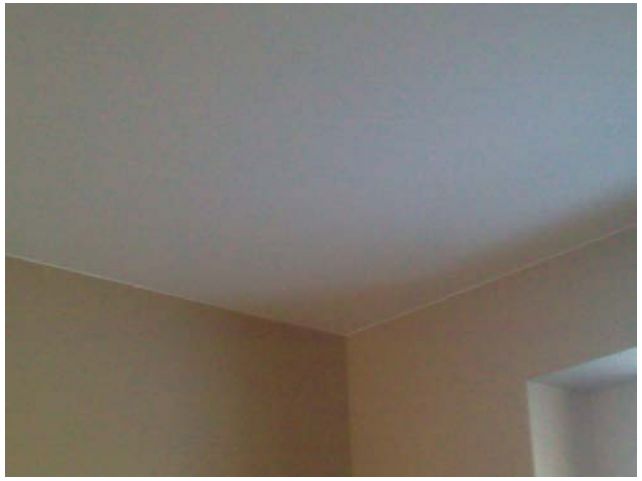
Source: Northwest ENERGY STAR Homes Program

4 Windows, skylights and doors

The space between window/door jambs and framing and skylights and framing shall be sealed.







5 Rim Joists

Rim joists shall be insulated and include the air barrier.

MONTANA Energy Code Reference Guide
Based on the 2012 IECC as amended by Montana in 2014

6 Floors (including above-garage and cantilevered floors)

Insulation shall be installed to maintain permanent contact with underside of subfloor decking. The air barrier shall be installed at any exposed edge of insulation.

7 Crawl space walls

Where provided in lieu of floor insulation, insulation shall be permanently attached to the crawlspace walls. Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.

8	Shafts, penetrations	Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed.

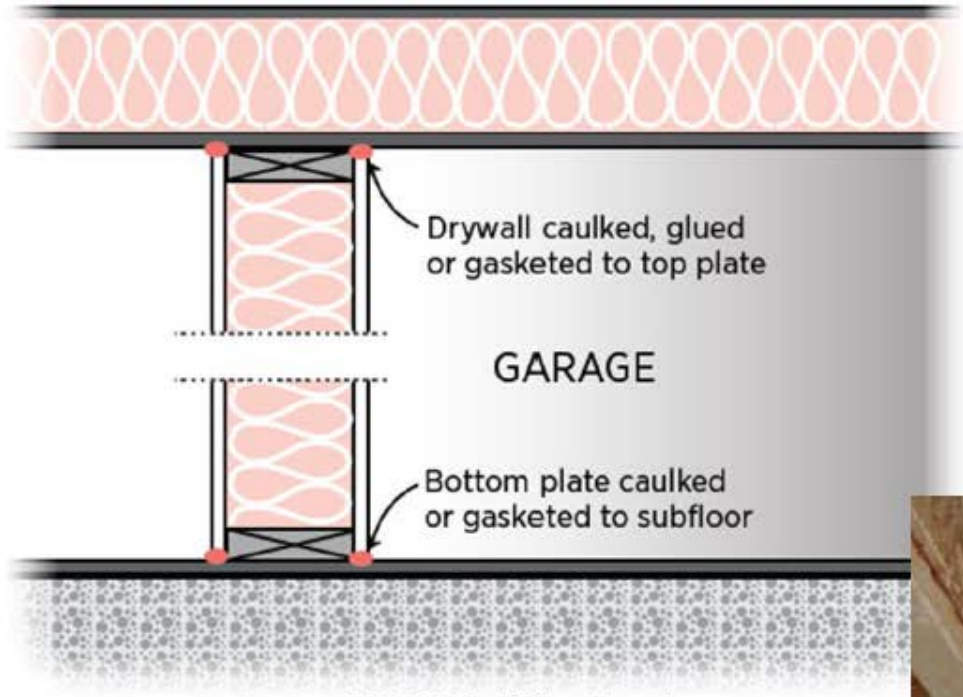
9 **Narrow cavities**

Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled by insulation that on installation readily conforms to the available cavity space.

Source: NCAT

10 Garage separation

Air sealing shall be provided between the garage and conditioned spaces.

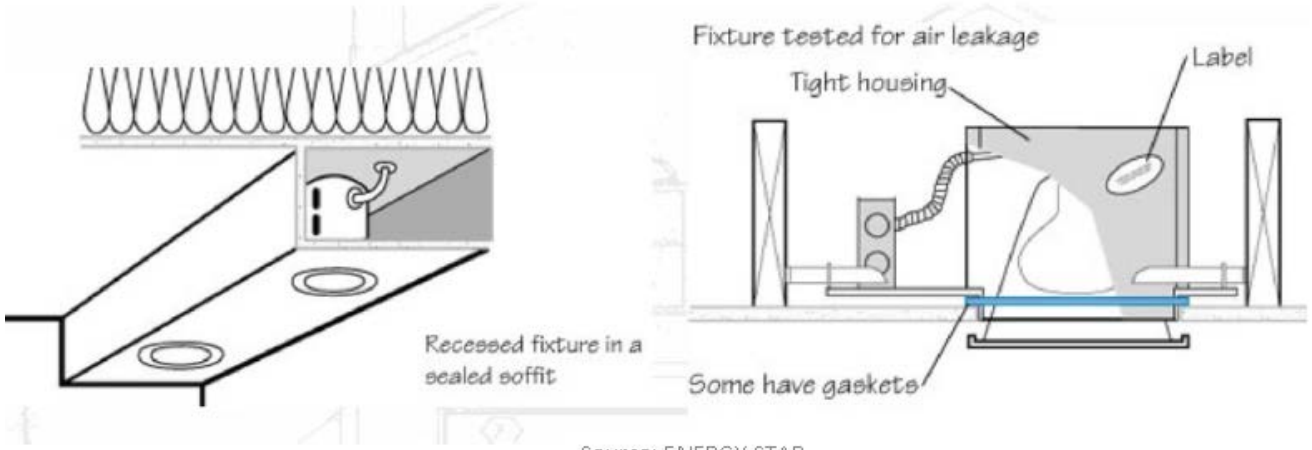


Source: USDOE Building America

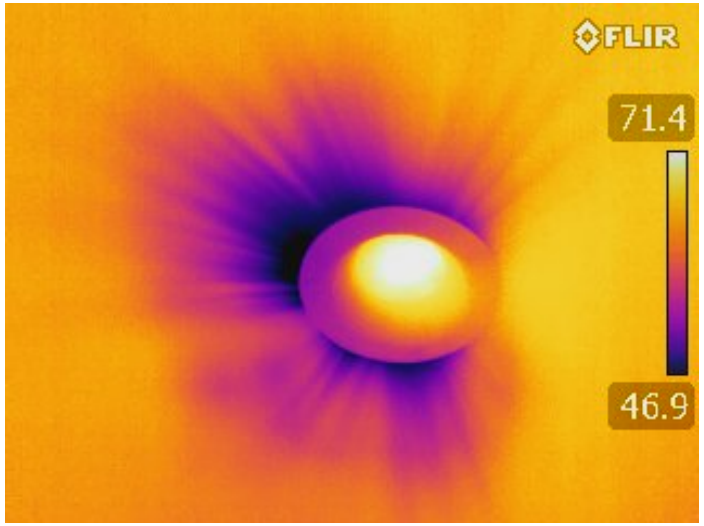
Source: ENERGY STAR New Homes

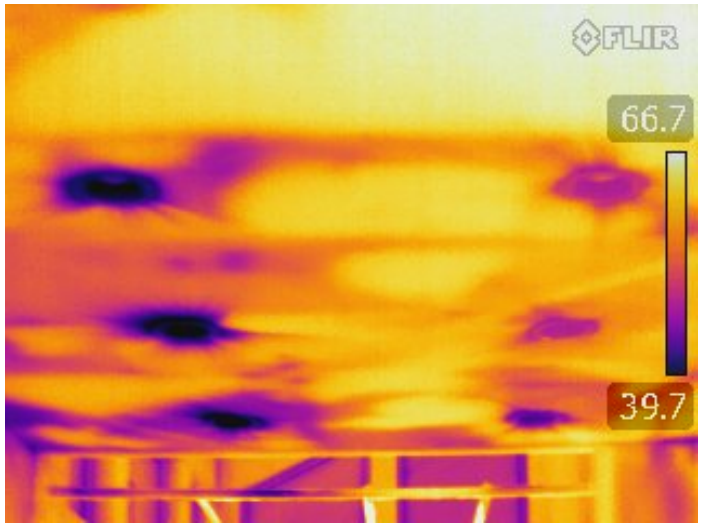
11 **Recessed lighting**

Recessed light fixtures installed in the building thermal envelope shall be air tight, IC rated, and sealed to the drywall.



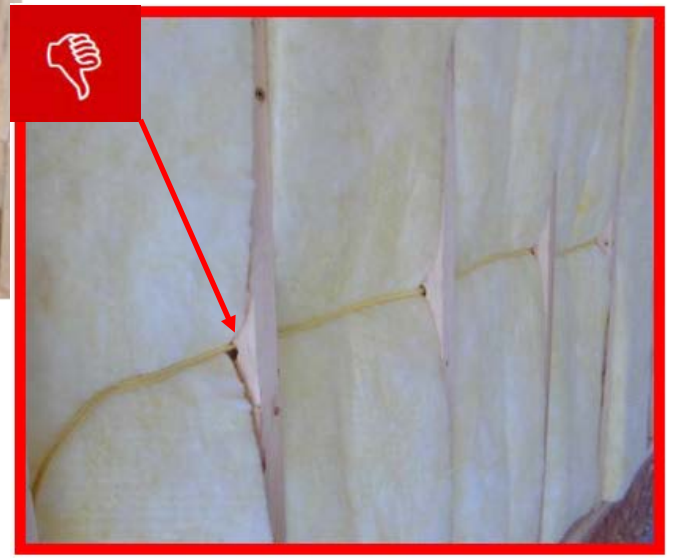
Source: ENERGY STAR





12 **Plumbing and wiring**

Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation that on installation readily conforms to available space shall extend behind piping and wiring.



Source: Energy Star Thermal Enclosure System Rater Checklist

Compression and misalignment because insulation is not split around wires.

A

Batt was properly split around wires to achieve RESNET Grade I.

13 Shower/tub on exterior wall

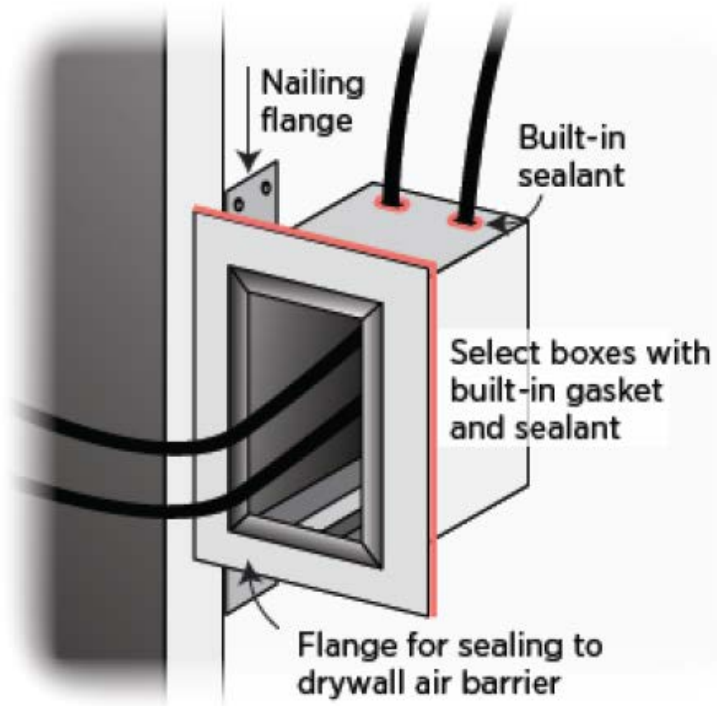
Exterior walls adjacent to showers and tubs shall be insulated and the air barrier installed separating them from the showers and tubs.

Source: Northwest ENERGY STAR Homes

Source: Northwest ENERGY STAR Homes

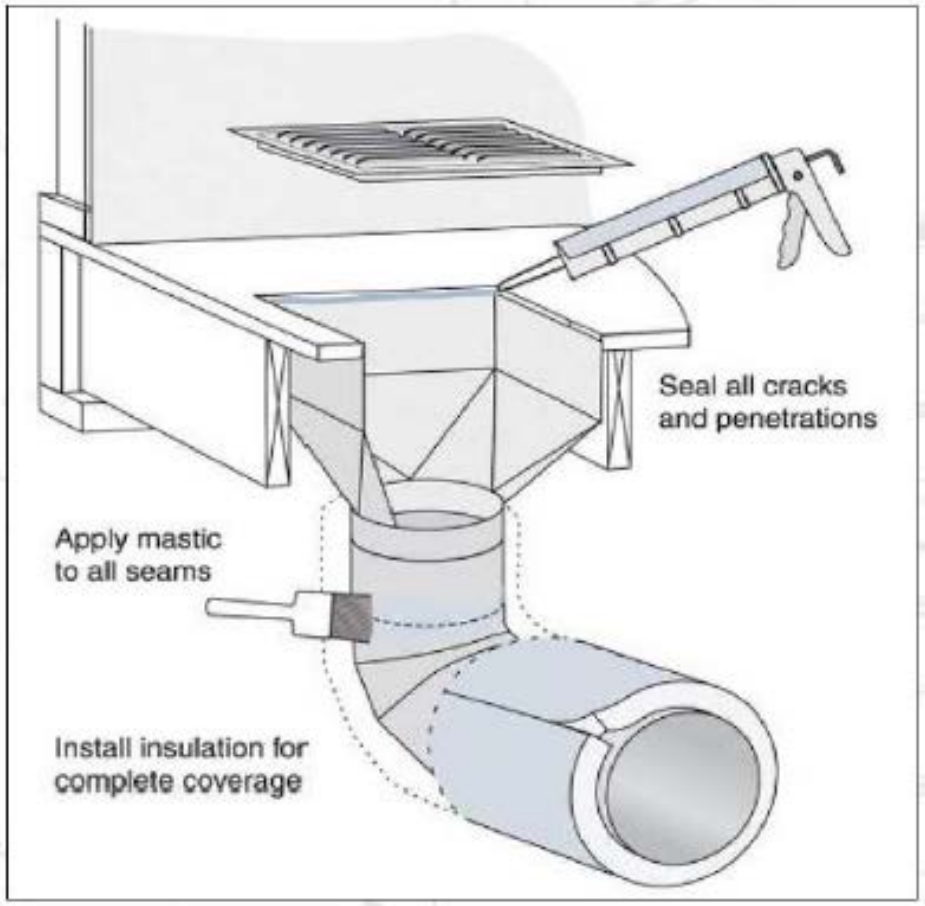
14 Electrical/phone box on exterior walls

The air barrier shall be installed behind electrical or communication boxes or air sealed boxes shall be installed.



15 **HVAC register boots**

HVAC register boots that penetrate building thermal envelope shall be sealed to the subfloor or drywall.



DUCT BOOTS & SEAMS SEALED WITH MASTIC

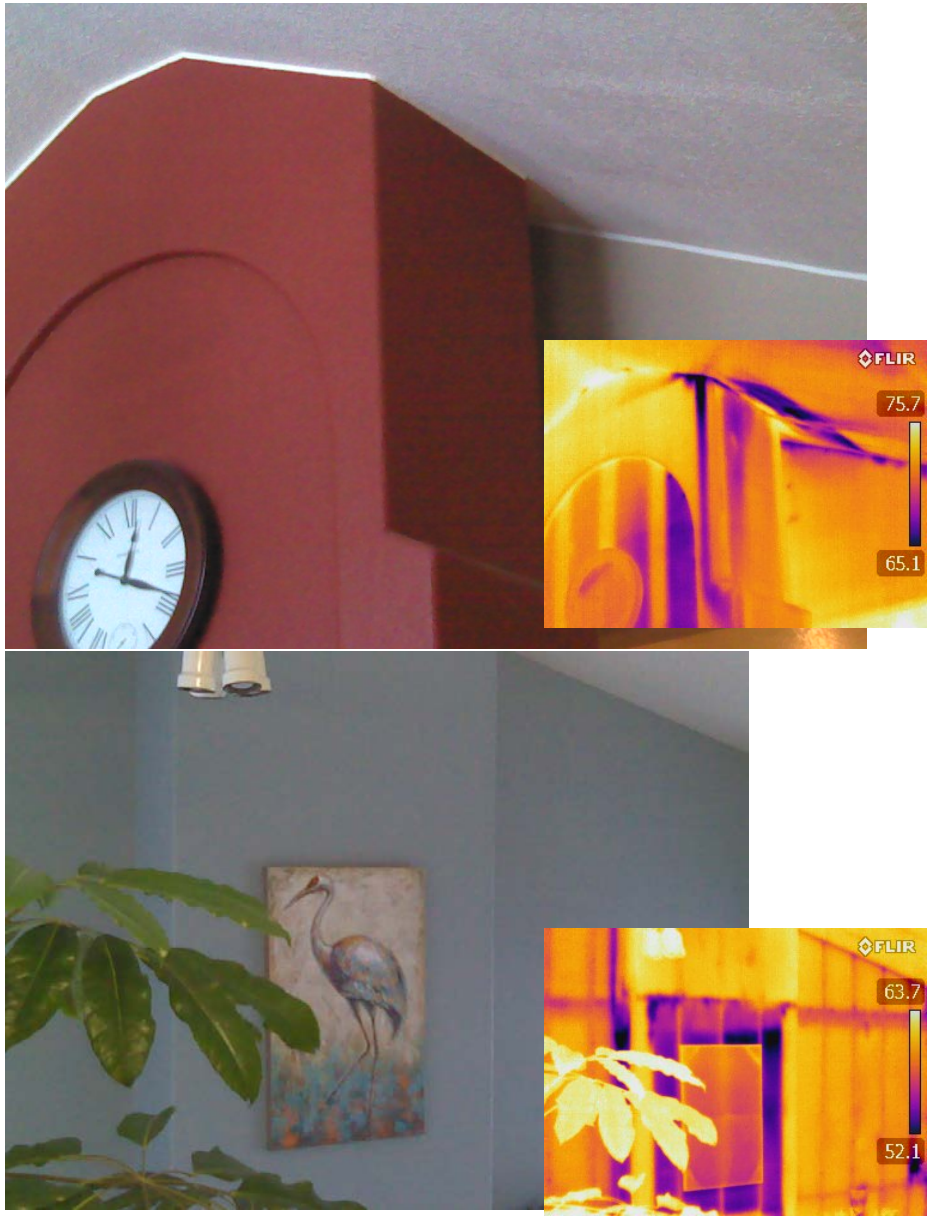
Source: ENERGY STAR New Homes

16 Fireplace

An air barrier shall be installed on fireplace walls. Fireplaces shall have gasketed doors.

Source: ENERGY STAR New Homes

Source: ENERGY STAR and Building Science Corp



Energy Star Thermal Enclosure System Rater Checklist

- Fenestrations
- Insulation
- Aligned Air Barrier
- Thermal Bridging

ENERGY STAR Qualified Homes, Version 3 (Rev. 06)
Thermal Enclosure System Rater Checklist

Home Address: City: State:

	Must Correct	Builder Verified [1]	Rater Verified	N/A
3. Fully-Aligned Air Barriers [6]				
At each insulated location noted below, a complete air barrier shall be provided that is fully aligned with the insulation as follows: • At interior or exterior surface of ceilings in Climate Zones 1-3; at interior surface of ceilings in Climate Zones 4-8. Also, include barrier at interior edge of attic eave in all climate zones using a wind baffle that extends to the full height of the insulation. Include a baffle in every bay or a tabbed baffle in each bay with a soffit vent that will also prevent wind washing of insulation in adjacent bays • At exterior surface of walls in all climate zones; and also at interior surface of walls for Climate Zones 4-8 [7] • At interior surface of floors in all climate zones, including supports to ensure permanent contact and blocking at exposed edge [8,9]				
3.1 Walls [10]				
3.1.1 Walls behind showers and tubs	☐	☐	☐	☐
3.1.2 Walls behind fireplaces	☐	☐	☐	☐
3.1.3 Attic knee walls	☐	☐	☐	☐
3.1.4 Skylight shaft walls	☐	☐	☐	☐
3.1.5 Wall adjoining porch roof	☐	☐	☐	☐
3.1.6 Staircase walls	☐	☐	☐	☐
3.1.7 Double walls	☐	☐	☐	☐
3.1.8 Garage rim / band joist adjoining conditioned space	☐	☐	☐	☐
3.1.9 All other exterior walls	☐	☐	☐	☐
3.2 Floors				
3.2.1 Floor above garage	☐	☐	☐	☐
3.2.2 Cantilevered floor	☐	☐	☐	☐
3.2.3 Floor above unconditioned basement or unconditioned crawlspace	☐	☐	☐	☐
3.3 Ceilings [10]				
3.3.1 Dropped ceiling / soffit below unconditioned attic	☐	☐	☐	☐
3.3.2 All other ceilings	☐	☐	☐	☐

https://www.youtube.com/watch?v=hb5LmY3Rj20

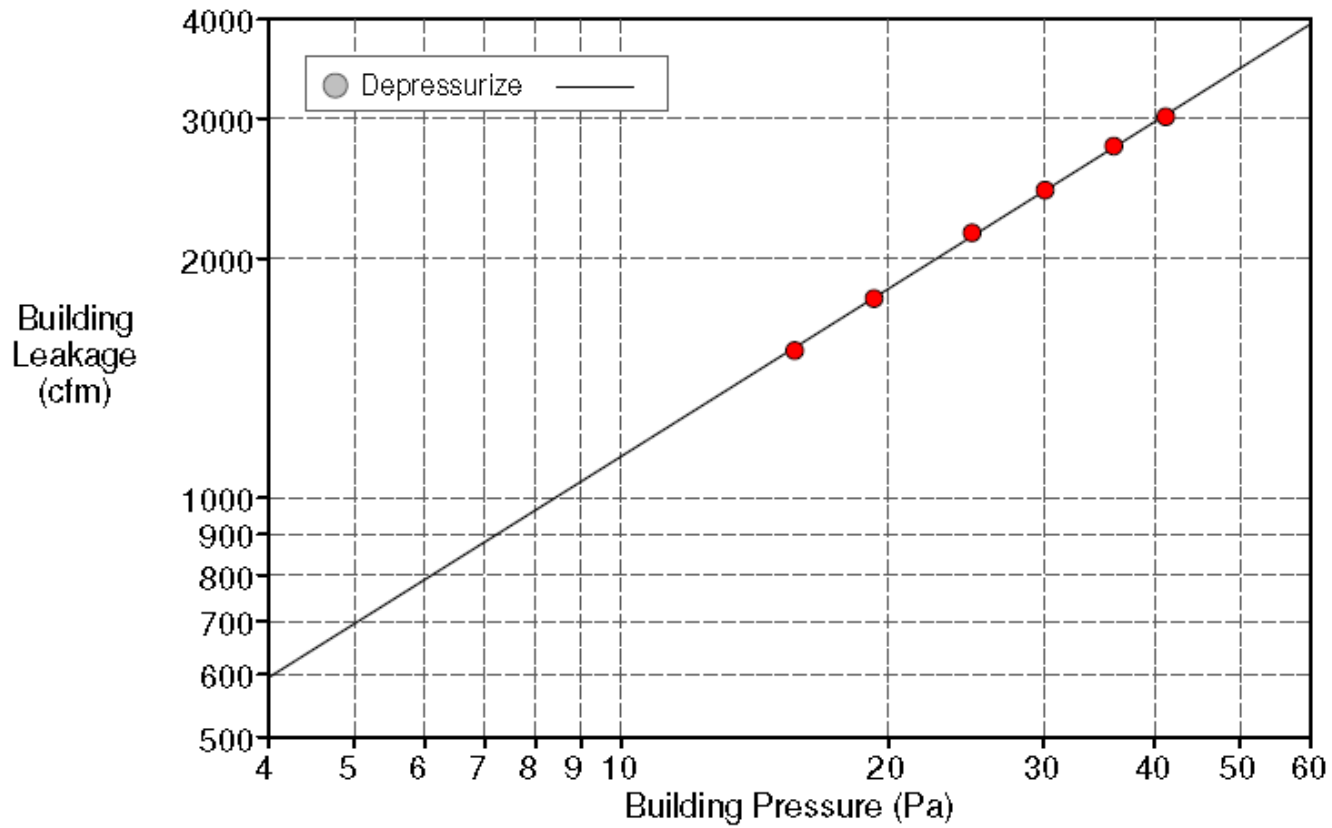
Whole Building Air Leakage Testing is a Commissioning Test of the Air Barrier System

Test Results at 50 Pascals:

Airflow (cfm50)	3475 (+/- 0.5 %)
Air Changes per Hour 50 (1/h)	7.26
cfm50/ft² Floor Area	1.3038

2014 Construction (Non-BEES Compliant)
2,665 sqft Floor Area

Leakage Areas:	331.8 in² (+/- 1.1 %) Canadian EqLA @ 10 Pa 169.0 in² (+/- 1.9 %) LBL ELA @ 4 Pa
Building Leakage Curve:	Flow Coefficient (C) = 226.2 (+/- 3.3 %) Exponent (n) = 0.698 (+/- 0.009) Correlation Coefficient = 0.99963
Test Standard:	CGSB
Test Mode:	Depressurization



This Builder did his home work.

If you don't test it, YOU don't know!

Test Results at 50 Pascals:

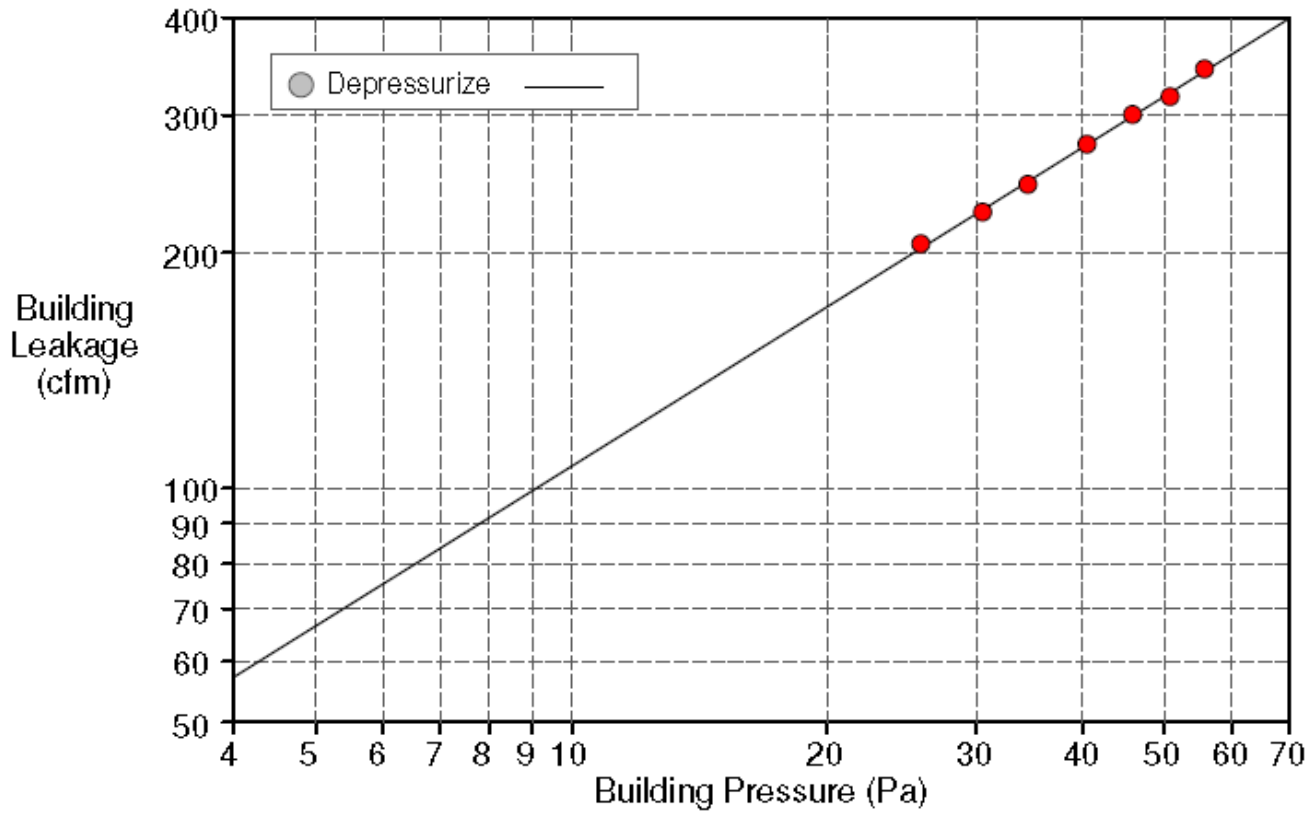
Airflow (cfm50)	318 (+/- 0.4 %)
Air Changes per Hour 50 (1/h)	0.97
cfm50/ft² Floor Area	0.1685
cfm50/ft² Surface Area	0.0696

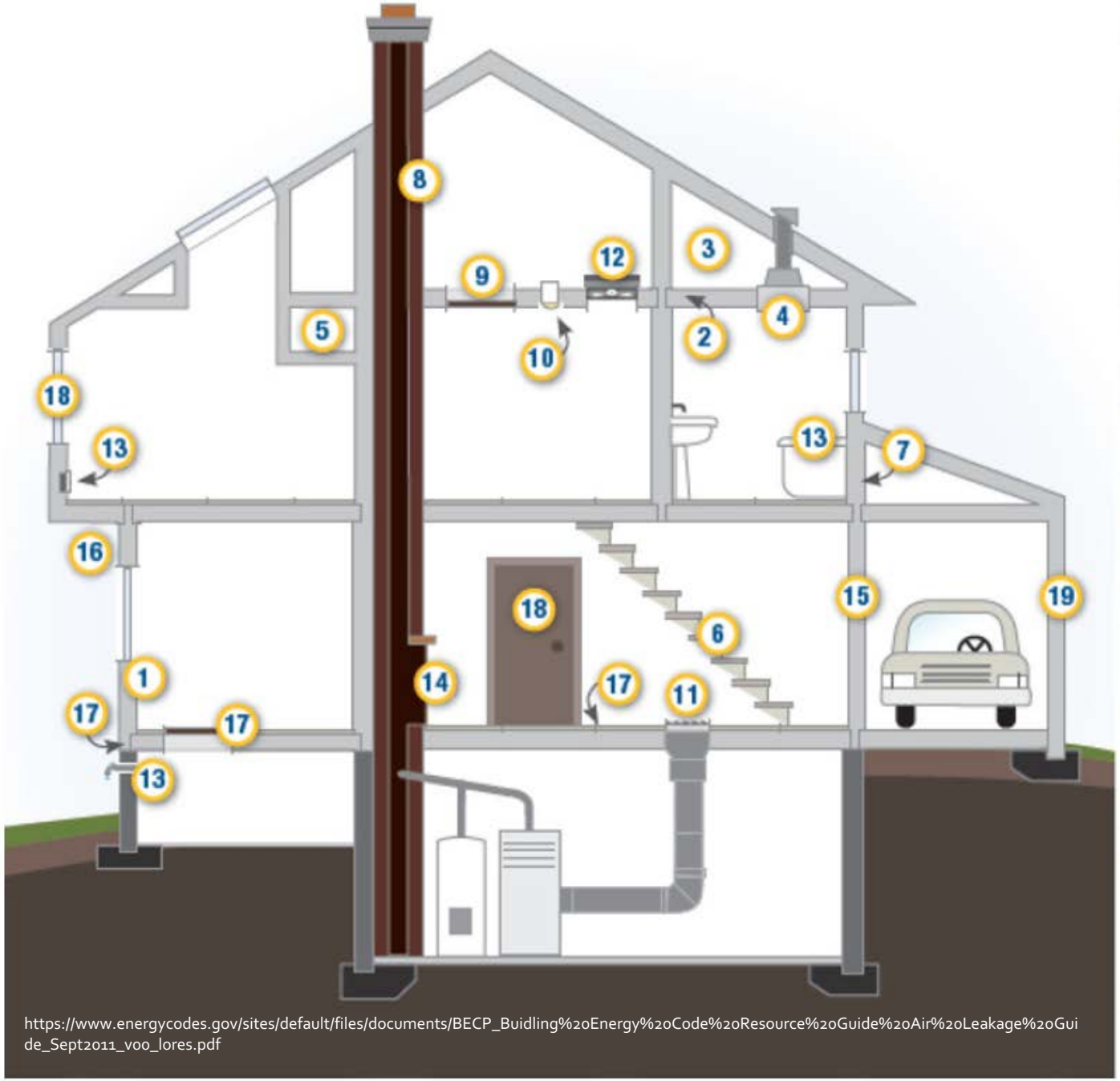
2018 Construction
1885 sqft Floor Area

Leakage Areas: 31.3 in² (+/- 2.2 %) Canadian EqLA @ 10 Pa or 0.0069 in²/ft² Surface Area
16.2 in² (+/- 3.5 %) LBL ELA @ 4 Pa or 0.0036 in²/ft² Surface Area

Building Leakage Curve: Flow Coefficient (C) = 22.3 (+/- 5.5 %)
Exponent (n) = 0.679 (+/- 0.015)
Correlation Coefficient = 0.99884

Test Standard: CGSB
Test Mode: Depressurization





https://www.energycodes.gov/sites/default/files/documents/BECP_Buidling%20Energy%20Code%20Resource%20Guide%20Air%20Leakage%20Guide_Sept2011_voo_lores.pdf

Air Sealing Trouble Spots

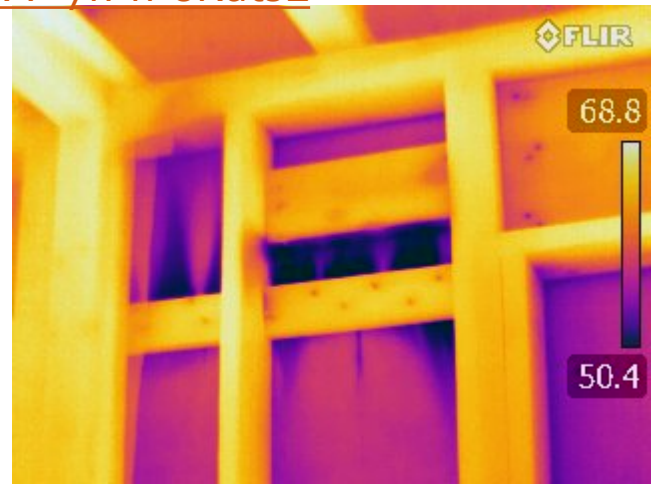
1. Air Barrier and Thermal Barrier Alignment
2. Attic Air Sealing
3. Attic Kneewalls
4. Shaft for Piping or Ducts
5. Dropped Ceiling/Soffit
6. Staircase Framing at Exterior Wall
7. Porch Roof
8. Flue or Chimney Shaft
9. Attic Access
10. Recessed Lighting
11. Ducts
12. Whole-House Fan
13. Exterior Wall Penetrations
14. Fireplace Wall
15. Garage/Living Space Walls
16. Cantilevered Floor
17. Rim Joists, Sill Plate, Foundation, Floor
18. Windows & Doors
19. Common Walls Between Attached Dwelling Units

ENERGY STAR Qualified Homes, Version 3 (Rev. 06)
Thermal Enclosure System Rater Checklist

5. Air Sealing	Must Correct	Builder Verified[1]	Rater Verified	N/A
5.1 Penetrations to unconditioned space fully sealed with solid blocking or flashing as needed and gaps sealed with caulk or foam				
5.1.1 Duct / flue shaft	☐	☐	☐	☐
5.1.2 Plumbing / piping	☐	☐	☐	☐
5.1.3 Electrical wiring	☐	☐	☐	☐
5.1.4 Bathroom and kitchen exhaust fans	☐	☐	☐	☐
5.1.5 Recessed lighting fixtures adjacent to unconditioned space ICAT labeled and fully gasketed. Also, if in insulated ceiling without attic above, exterior surface of fixture insulated to ≥ R-10 in CZ 4 and higher to minimize condensation potential.	☐	☐	☐	☐
5.1.6 Light tubes adjacent to unconditioned space include lens separating unconditioned and conditioned space and are fully gasketed [22]	☐	☐	☐	☐
5.2 Cracks in the building envelope fully sealed				
5.2.1 All sill plates adjacent to conditioned space sealed to foundation or sub-floor with caulk, foam, or equivalent material. Foam gasket also placed beneath sill plate if resting atop concrete or masonry and adjacent to conditioned space [23]	☐	☐	☐	☐
5.2.2 At top of walls adjoining unconditioned spaces, continuous top plates or sealed blocking using caulk, foam, or equivalent material	☐	☐	☐	☐
5.2.3 Drywall sealed to top plate at all unconditioned attic / wall interfaces using caulk, foam, drywall adhesive (but not other construction adhesives), or equivalent material. Either apply sealant directly between drywall and top plate or to the seam between the two from the attic above.	☐	☐	☐	☐
5.2.4 Rough opening around windows & exterior doors sealed with caulk or foam [24]	☐	☐	☐	☐

Higher Levels of Efficiency & Performance Require Higher Levels of Commissioning.

https://www.youtube.com/watch?v=7fPn-8RatsE



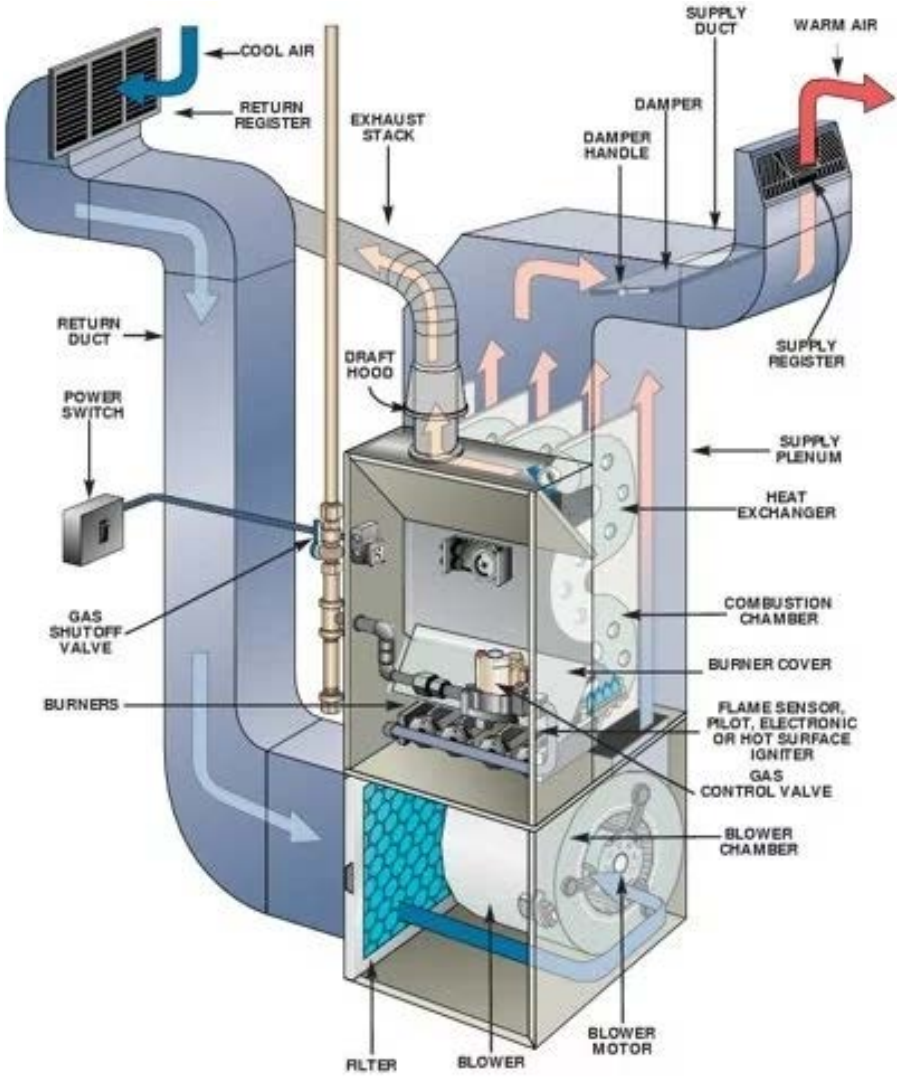
Heating System Commissioning

1) Sized Per Manual J or other approved method (IECC)
2) Installed per Manufacture Recommendations (ICC)

   Each Manufacture has a different installation and commissioning or start up requirements.

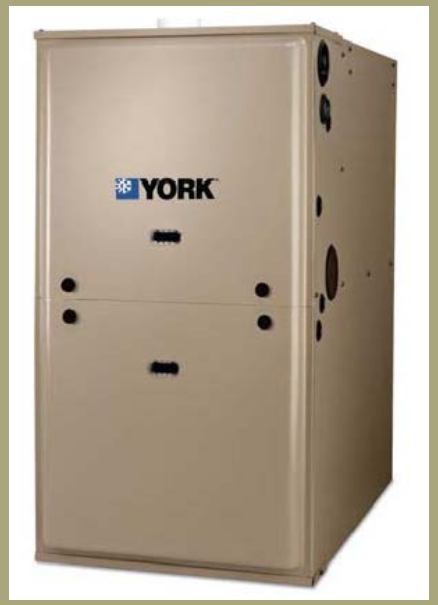
3) Combustion Safety Testing performed by Energy (BEES) Auditor

ASHRAE 62.2-16 6.4 Combustion and Solid-Fuel-Burning Appliances must be provided with adequate combustion and ventilation air and installed in accordance with manufacturers' installation instructions; NFPA 54/ANSI Z223.1



https://s3-production.bobvila.com/2013/02/19/03/25/02/188/Forced_air_furnace_ablegroup.jpg

York MODULATING PSC RESIDENTIAL GAS FURNACES MODELS: TM9M Series (97% AFUE Mult-position) Commissioning Sheet



SECTION XIII: START UP SHEET

33" 97% - 98% AFUE Modulating Gas Furnace Start Up Sheet

Proper furnace start up is critical to customer comfort and equipment longevity

Start-Up Date

Technician Performing Start-Up | Installing Contractor Name

Owner Information

Name | Address

City | State or Province | Zip or Postal Code

Equipment Data

Furnace Model | Furnace Serial

Evaporator Coil Model | Evaporator Coil Serial

Outdoor Unit Model | Outdoor Unit Serial

Furnace Configuration

○ Upflow ○ Downflow ○ Horizontal Left ○ Horizontal Right

Filter, Thermostat, Accessories

Filter Type | Filter Size | Filter Location(s)

Thermostat Type | Other System Equipment and Accessories

Connections -- All Per Installation Instructions and Local Code

☐ Unit is level ☐ Gas piping is connected (including drip leg) ☐ Supply plenum and return air are connected

☐ Vent system is connected

Condensate Management

☐ Condensate tubing is correctly installed for the furnace position ☐ Condensate drain is connected

Venting

Intake Size | # of 90 Degree Ells | # Of 45 Degree Ells | Length

Exhaust Size | # of 90 Degree Ells | # Of 45 Degree Ells | Length

☐ Venting system is the proper size, within the limitations of the chart in the installation instructions, properly connected to the furnace, and properly pitched

Exhaust Termination: ○ Roof ○ Sidewall

Intake Termination: ○ Roof ○ Sidewall ○ Attic

Electrical: Line Voltage

☐ Polarity is correct (black is L1 (hot), white is N (neutral) ☐ Ground wire is connected

Line voltage value to furnace (volts AC)

Electrical: Low Voltage

☐ Thermostat heat anticipator set to .1 (if present)

☐ Thermostat wiring is complete ☐ Thermostat cycle rate set to 6 cycles/hour (if present)

Low voltage value between "R" and "C" on furnace control board (volts AC)

Continued on next Page

Gas Side

Gas Type ○ Natural Gas ○ LP Gas (Requires LP conversion kit)

LP Gas Conversion Kit Part # Used | LP Conversion Kit Installed By

Inlet Gas Pressure (in. w.c.") | Manifold Gas Pressure (in. w.c.") - furnace must be in TEST mode for setup

Calculated input in btuh - clock the gas meter (Nat Gas Only)

☐ Burner flame inspected – flames are blue and extending directly into the primary heat exchanger cells

Air Side: System External Static Pressure (Cooling Mode)

Supply static **before** evaporator coil (in w.c.") | Supply static **after** evaporator coil (in w.c.")

Return Static (in w.c.") **before** filter | Return Static (in w.c.") **after** filter (furnace side)

Total External Static Pressure

Air Side: Heating

ATR Setting ○ NOM ○ +10F ○ -10F

Temperature Rise in Degrees F

Other Jumpers

De-humidistat ○ YES ○ NO

Heat Pump ○ YES ○ NO

Zone Control ○ YES ○ NO

Air Side: Cooling

COOL Speed Selected ○ L (Low) ○ ML (Med Low) ○ MH (Med High) ○ H (High)

ADJUST Setting (ECM Models) ○ C ○ B ○ A

DELAY Setting (ECM Models) ○ L (Low) ○ ML (Med Low) ○ MH (Med High) ○ H (High)

Air Side: Continuous Fan

Blower Speed Selected ○ L (Low) ○ M (Med) ○ H (High)

Cycle Test

☐ Operate the furnace through several heating cycles from the thermostat, noting and correcting any problems

☐ Operate the furnace through continuous fan cycles from the thermostat, noting and correcting any problems

☐ Operate the furnace through cooling cycles (as applicable), noting and correcting any problems

Clean Up

☐ Installation debris disposed of and furnace area cleaned up?

Owner Education

☐ Give owner the owner's manual provided

☐ Explain operation of system to equipment owner

☐ Explain the importance of regular filter replacement and equipment maintenance

☐ Explain thermostat use and programming (if applicable) to owner

Additional Job Detail

1083293-UIM-A-0114
Supersedes: 1031201-UIM-D-1013

York International Corp.
5005 York Drive
Norman, OK 73069

Installation & Servicing Instructions High efficiency condensing gas boiler E75CN/E110CN E75CP/E110CP

12 Commissioning

NOTICE

Work on the boiler must be carried out by a competent person, using correctly calibrated instruments with current test certification.
These installation instructions are intended for professional installers, who have the necessary knowledge and are approved for working on heating and gas systems.

Before the boiler is fired, ensure that the boiler and the system are well de-aerated and free of air. Purge the gas line between the gas meter and the boiler.

NOTICE

The boiler and its individual shut off valve must be disconnected from the gas supply piping system during any pressure testing of that system at test pressures in excess of 1/2 PSI (3.5kPa).

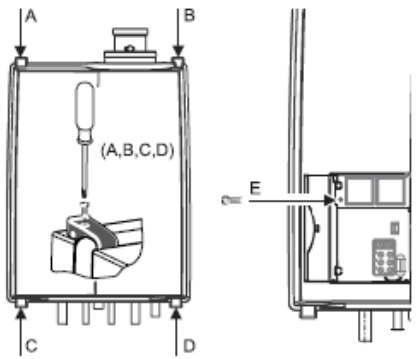
To commission the boiler the casing has to be removed.
- remove the 4 screws A,B,C and D in the quick releases of the casing (figure 24);
- remove the screw E behind the door on the front of the casing (figure 24);
- remove it towards the front.

The boiler settings, such as burner pressure and adjustment of the air quantity are unnecessary, due to the fact that the boiler operates with a zero pressure control. This means the correct gas quantity is controlled by the suction operation of the fan. The fine adjustment which is carried out at the factory is once-only, which means that adjusting of these values is unnecessary. Only in case of replacing of the gas valve, venturi and/or fan, the zero pressure and the incorrect O_2 adjustment has to be checked and, if necessary, adjusted at the right value.

DANGER

Always check the installation of all parts through which gas flows (by bubble test using leak-search spray)

During the commissioning of the boiler the Rinnai Installation, Commissioning, and Service card must be filled out.



Removing casing figure 24

12.1 Testing for gas leaks

Prior to start-up of the boiler you must check the external tightness of the gas supply valve and confirm this in the start-up report.

WARNING

- **Cover endangered positions before leak testing.**
- **Do not spray the leak testing agent onto cables, plugs, electrical connection lines or electronic circuit boards. Do not allow it to drip onto them either.**

DANGER

Leaks may be caused to pipes and screw connections during commissioning and maintenance activities.
- **Carry out a proper leak test.**
- **Only use approved leak detection agents for leak detection.**

- Disconnect the heating system from the power supply.
- Check the exterior tightness of new conduit sections up to and including the direct sealing point on the gas burner fitting. The maximum test pressure allowed on the input of the gas burner fitting is 14 inch W.C. (35mbar).

12.2 Testing the Ignition Safety shut off device

- Switch off system using the Central Heating button and the DHW button
- Disconnect the plug and socket connection of the ionization cable.
- Switch on the sytem using the Central Heating button and the DHW button.
- Press the MODE-button for 5 seconds.
- The display will show COdE followed by an arbitrary number;
- Select by means of the or the button the code C123;
- Press the Store-button to confirm the code (code blinks 1 x);
- Press the MODE-button until SERV is shown;
- Press the STEP-button once until 1 is shown; alternately 1 and OFF will be shown.
- Press the button once;
  Check if the boiler does one start-up attempt and four restart attempts.
  After the last start-up attempt, the boiler will lock out. The gas valve is shut off.
  The E02 code is blinking in the display.
- Connect the plug and socket connection of the ionization cable.
- Press the reset button.
- Check if the boiler starts-up.

WARNING

Do not touch the inside of the igntion cable while it is disconnected during start up of the boiler.

Condensing Oil Fired Boiler

5.3 - Commissioning the oil burner

- While the oil burner has been adjusted at the factory, it is recommended that the operating characteristics of the burner be determined at start-up and readjusted if necessary. Run the unit long enough at the burner maximum firing rate to make sure the burner has reached a stable maximum operating temperature. THEN, check the burner as follows:
- When commissioning the oil burner for the first time:
  - check that the smoke spot number does not exceed 0.5 (BACHARACH control),
  - check the CO2 rate - 11.5 to 12.5 %, CO < 100 ppm (watch out for secondary air inlets),
  - check the temperature of the combustion products (under 230°F - 110 °C).

Models		FCX 22 C	FCX 30 C
oil burner RIELLO		RDB 2.2 (T1)	RDB 2.2 (T3)
		Réglage à la puissance maxi	Réglage à la puissance maxi
Heat flow	Btu/hr kW	81250 23.8	107500 31.5
Pump pressure	Psi bar	185 13	180 12
Nozzle		0,55 60A	0,7 60A
Position of the air flap (FCX balanced flue outlet)		1,5 B	3,5 C

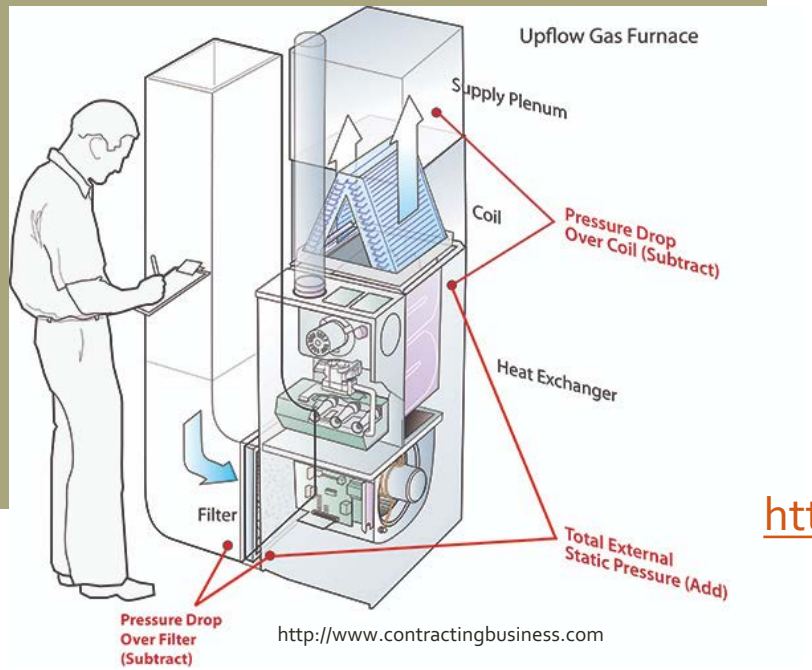
ENERGY STAR Qualified Homes, Version 3 (Rev. 06)
HVAC System Quality Installation Contractor Checklist [1]

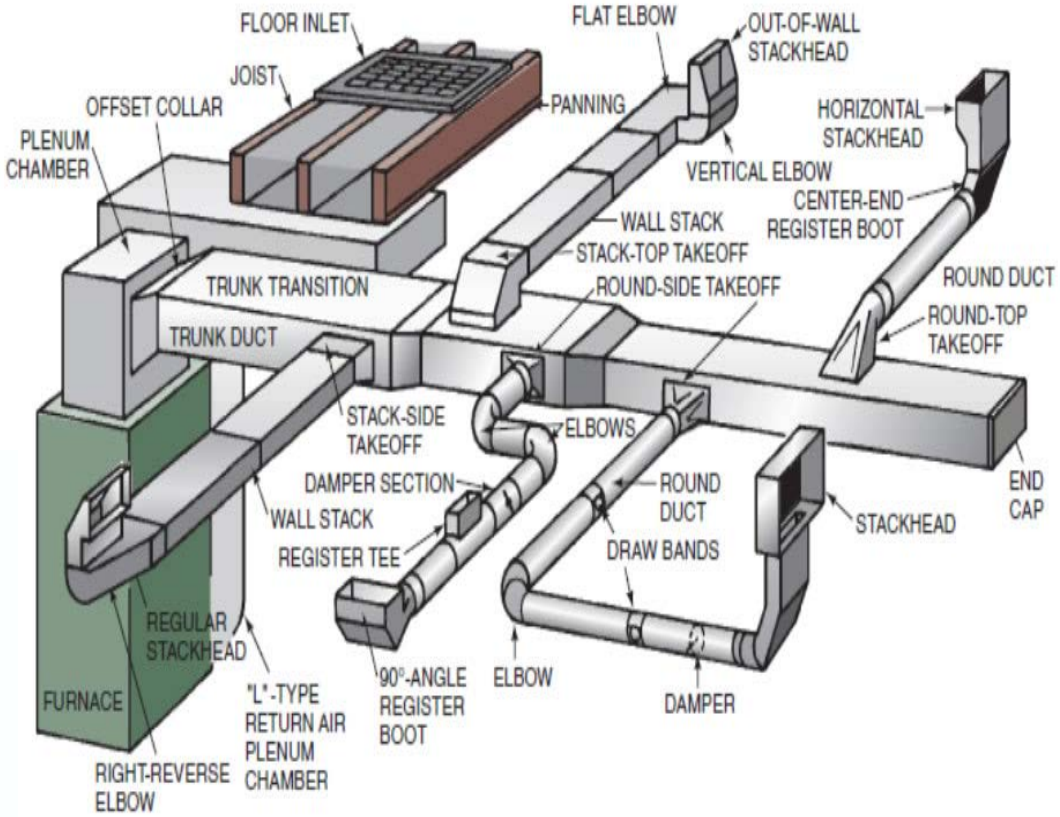
2. Heating & Cooling System Design [4,8] - *Parameters used in the design calculations shall reflect home to be built, specifically, outdoor design temperatures, home orientation, number of bedrooms, conditioned floor area, window area, predominant window performance and insulation levels, infiltration rate, mechanical ventilation rate, presence of MERV6 or better filter, and indoor temperature setpoints = 70°F for heating; 75°F for cooling.*

2.1 Heat Loss / Gain Method: ☐ Manual J v8 ☐ 2009 ASHRAE ☐ Other: _____	☐	☐	-
2.2 Duct Design Method: ☐ Manual D ☐ Other: _____	☐	☐	☐
2.3 Equipment Selection Method: ☐ Manual S ☐ OEM Rec. ☐ Other: _____	☐	☐	-
2.4 Outdoor Design Temperatures: [9] Location: _____ 1%: ____ °F 99%: ____ °F	☐	☐	-
2.5 Orientation of Rated Home (e.g., North, South): _____	☐	☐	-
2.6 Number of Occupants Served by System: [10] _____	☐	☐	-
2.7 Conditioned Floor Area in Rated Home: _____ Sq. Ft.	☐	☐	-
2.8 Window Area in Rated Home: _____ Sq. Ft.	☐	☐	-
2.9 Predominant Window SHGC in Rated Home: [11] _____	☐	☐	-
2.10 Infiltration Rate in Rated Home: [12] Summer: _____ Winter: _____	☐	☐	-
2.11 Mechanical Ventilation Rate in Rated Home: _____ CFM	☐	☐	-
2.12 Design Latent Heat Gain: _____ BTUh	☐	☐	-
2.13 Design Sensible Heat Gain: _____ BTUh	☐	☐	-
2.14 Design Total Heat Gain: _____ BTUh	☐	☐	-
2.15 Design Total Heat Loss: _____ BTUh	☐	☐	-
2.16 Design Airflow: [13] _____ CFM	☐	☐	-
2.17 Design Duct Static Pressure: [14] _____ In. Water Column	☐	☐	☐
2.18 Full Load Calculations Report Attached [15]	☐	☐	-

HVAC Duct Work Commissioning

1. Ducts, Air Handlers & Filter Boxes shall be sealed (ICC)
2. Air Handler < 2% of Design Air flow (IECC)
3. Designed in accordance with ACCA Manual D (IRC)
4. Duct Testing Required (IECC & Energy Star)
    - Exception: Ducts & Air Handlers are inside the Thermal Boundary (IECC)





https://www.youtube.com/watch?v=sk-Ao8zsguE

Energy Star HVAC Commissioning Checklist

HVAC Commissioning Checklist [1,2]
ENERGY STAR Certified Homes, Version 3 / 3.1 (Rev. 08)

HVAC Commissioning Contractor Responsibilities:

- The commissioning contractor must be credentialed by an HVAC oversight organization to complete this checklist. One checklist must be completed and signed by the commissioning contractor for each HVAC system that is commissioned.
- The completed checklist for each commissioned system, along with the corresponding HVAC Design Report, shall be retained by the contractor for quality assurance purposes. Furthermore, the contractor shall provide the completed checklist to the builder, the Home Energy Rater responsible for certifying the home, and the HVAC oversight organization upon request.
- Visit www.energystar.gov/newhomes hvac for information about the credential requirement and this checklist.

1. Commissioning Overview

1.1 Contractor name _____ Contractor company _____ Date _____

1.2 Organization that your company is credentialed with: ☐ ACCA ☐ Advanced Energy ☐ NYSERDA

1.3 Builder client name: _____

1.4 Home address: _____ City: _____ State: _____ Zip code: _____

1.5 HVAC Design Report corresponding to this system has been collected from designer or builder. ☐ Contractor-verified

1.6 Area that system serves, per Item 1.4 of HVAC Design Report: ☐ Whole-house ☐ Upper-level ☐ Lower-level ☐ Other _____

1.7 House plan, per Item 1.6 of HVAC Design Report _____ ☐ Site-specific design ☐ Group design #: _____

Footnotes

1. This Checklist is designed to align with the requirements of ANSI / ACCA's 5 QI-2015 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 (e.g., those caused by a lack of maintenance by occupants). Therefore, this Checklist is not a guarantee of proper ventilation, indoor air quality, or HVAC performance.

HVAC Commissioning Checklist [1,2]
ENERGY STAR Certified Homes, Version 3 / 3.1 (Rev. 08)

3. Indoor HVAC Fan Airflow		
3.1 The mode with the higher design HVAC fan airflow used, per Item 5.2 of HVAC Design Report: ☐ Heating ☐ Cooling	☐	-
3.2 Static pressure test holes have been created, and test hole locations are well-marked and accessible.	☐	-
Test hole location for return external static pressure: ☐ Plenum ☐ Cabinet ☐ Transition ☐ Other: _____	-	-
Test hole location for supply external static pressure: ☐ Plenum ☐ Cabinet ☐ Transition ☐ Other: _____	-	-
3.3 Measured return external static pressure (Enter value only, without negative sign): _____ IWC	-	-
3.4 Measured supply external static pressure (Enter value only, without positive sign): _____ IWC	-	-
3.5 Measured total external static pressure = Value-only from Item 3.3 + Value-only from Item 3.4 = _____ IWC	-	-
3.6 Measured (Item 3.5) - Design (Item 5.4 on HVAC Design Report) total external static pressure = _____ IWC	-	-
3.7 Measured HVAC fan airflow, using Item 3.5 and fan speed setting: _____ CFM	-	-
3.8 Measured HVAC fan airflow (Item 3.7) is ± 15% of design HVAC fan airflow (Item 5.2 on HVAC Design Report)	☐	-
4. Air Balancing of Supply Registers & Return Grilles (Recommended, but not Required) [4]		
4.1 Balancing report attached with room-by-room design airflows from Item 5.5 on HVAC Design Report, and contractor-measured airflow using ANSI / ACCA 5 QI-2015 protocol	☐	☐
4.2 Room-by-room airflows verified by contractor to be within the greater of ± 20% or 25 CFM of design airflow	☐	☐

https://www.youtube.com/watch?v=45gX7Jb6oJM

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

2. Duct Quality Installation - *Applies to All Heating, Cooling, Ventilation, Exhaust, and Pressure Balancing Ducts*[11]			
2.1 Connections and routing of ductwork completed without kinks or sharp bends. [12]	☐	☐	☐
2.2 No excessive coiled or looped flexible ductwork. [13]	☐	☐	☐
2.3 Flexible ducts in unconditioned space not installed in cavities smaller than outer duct diameter; in conditioned space not installed in cavities smaller than inner duct diameter	☐	☐	☐
2.4 Flexible ducts supported at intervals as recommended by mfr. but at a distance ≤ 5 ft.	☐	☐	☐
2.5 Building cavities not used as supply or return ducts unless they meet Items 3.2, 3.3, 4.1, and 4.2 of this Checklist.	☐	☐	☐
2.6 HVAC ducts, cavities used as ducts, and combustion inlets and outlets may pass perpendicularly through exterior walls but shall not be run within exterior walls unless at least R-6 continuous insulation is provided on exterior side of the cavity, along with an interior and exterior air barrier where required by the Thermal Enclosure System Rater Checklist.	☐	☐	☐
2.7 Quantity & location of supply and return duct terminals match contractor balancing report. [11]	☐	☐	☐
2.8 Bedrooms pressure-balanced using any combination of transfer grills, jump ducts, dedicated return ducts, and / or undercut doors to either: a) provide 1 sq. in. of free area opening per 1 CFM of supply air, as reported on the contractor-provided balancing report; or b) achieve a Rater-measured pressure differential ≤ 3 Pa (0.012 in. w.c.) with respect to the main body of the house when all bedroom doors are closed and all air handlers are operating. [11,14,15]	☐	☐	☐

Ratings & Physical / Electrical Data

Models	Input Max/Min	Output Max/Min	AFUE	Nominal Airflow	Total Unit Amps	Air Temp. Rise Max Input	Air Temp. Rise Min Input
	MBH	MBH	%	CFM		°F	°F
YP9C060B12MP12C	60/21	58/20	97.5	1200	7.0	40-70	20-50
YP9C080B12MP12C	80/28	77/27	97.5	1200	7.5	40-70	20-50
YP9C080C16MP12C	80/28	78/27	97.7	1600	10.0	40-70	20-50
YP9C100C16MP12C	100/35	97/34	97.7	1600	10.0	40-70	20-50
YP9C100C20MP12C	100/35	97/34	97.7	2000	12.0	45-75	25-55
YP9C120D20MP12C	120/42	116/40	98.0	2000	12.0	45-75	25-55

Models	Max. Outlet Air Temp	Blower		Blower Wheel Size	Max Over-Current Protect	Min. wire Size (awg) @ 75 ft one way	Approximate Operating Weights
	°F	HP	Amps				Lbs
YP9C060B12MP12C	170	1/2	4.8	11 x 8	15	14	113
YP9C080B12MP12C	175	1/2	4.8	11 x 8	15	14	119
YP9C080C16MP12C	175	3/4	7.5	11 x 10	15	14	134
YP9C100C16MP112C	175	3/4	7.5	11 x 10	15	14	140
YP9C100C20MP12C	180	1	14.5	11 x 11	20	12	143
YP9C120D20MP12C	180	1	14.5	11 x 11	20	12	152

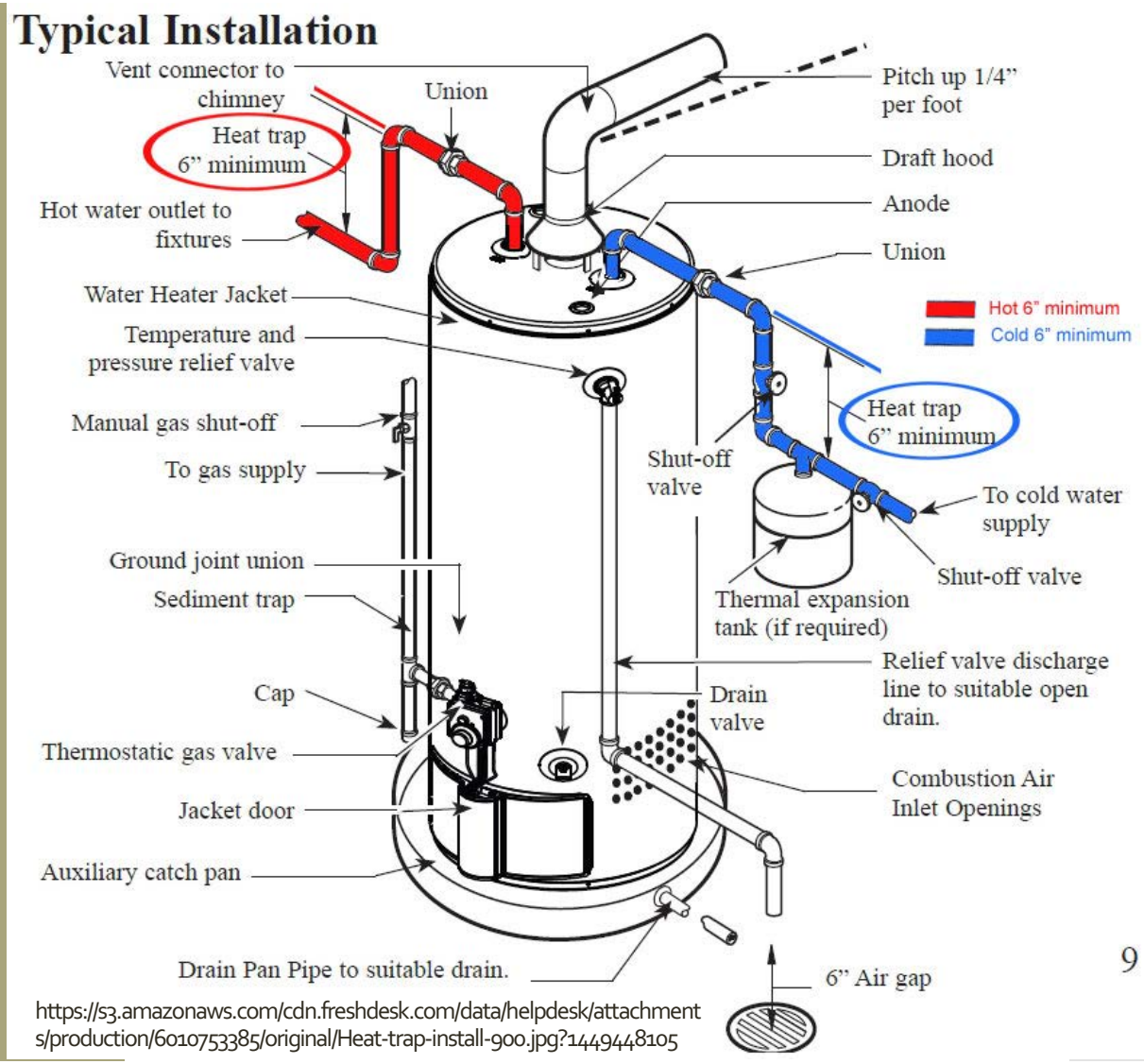
Annual Fuel Utilization Efficiency (AFUE) numbers are determined in accordance with DOE Test procedures.
Wire size and over current protection must comply with the National Electrical Code (NFPA-70-latest edition) and all local codes.
The furnace shall be installed so that the electrical components are protected from water.

Domestic Hot Water System Commissioning

1. Installed per Manufacture Recommendations (ICC)
2. All Plumbing Systems must be Tested (ICC)
3. Demand Hot Water Recirculation Water Systems Require
   - Controls (IECC)
   - Gravity Thermos-Syphon circulation <u>prohibited</u> (IECC)
     This is a manufacture recommendation & now code prohibited design.
   - Insulation (Prescriptive)
4. Combustion Safety Testing performed by Energy Auditor (BEES Specific)

ASHRAE 62.2-16 6.4 Combustion and Solid-Fuel-Burning Appliances must be provided with adequate combustion and ventilation air and installed in accordance with manufacturers' installation instructions; NFPA 54/ANSI Z223.1

Commissioning of DHW Appliance Is Similar to Boilers



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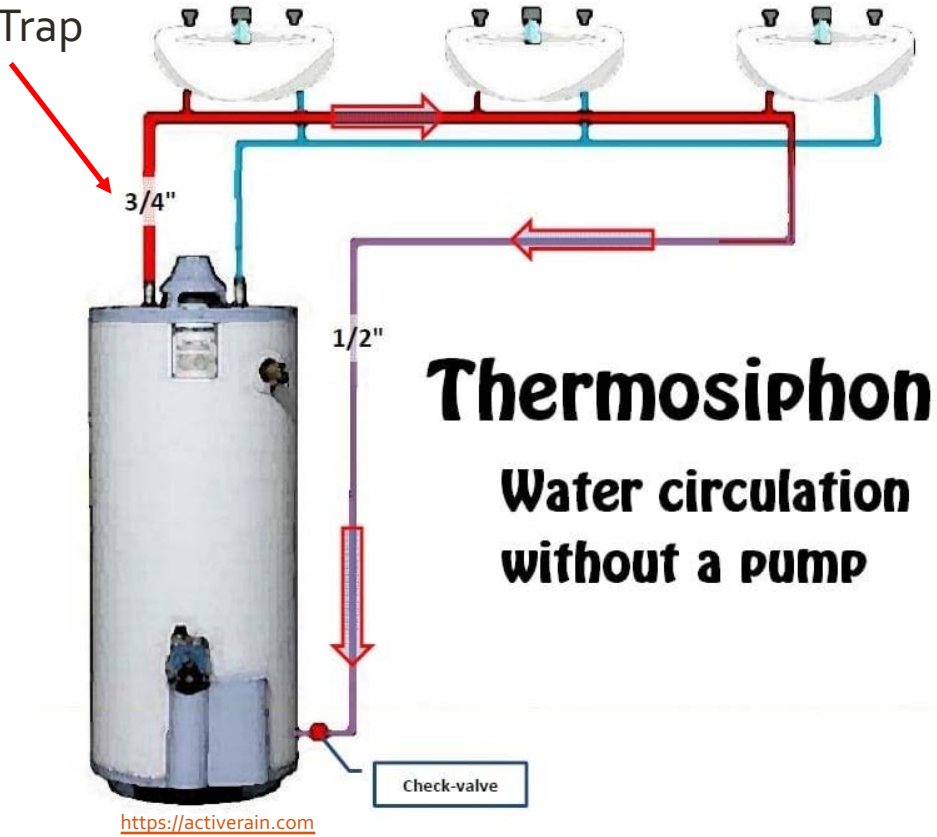
Hot Water Recirculation without a Pump

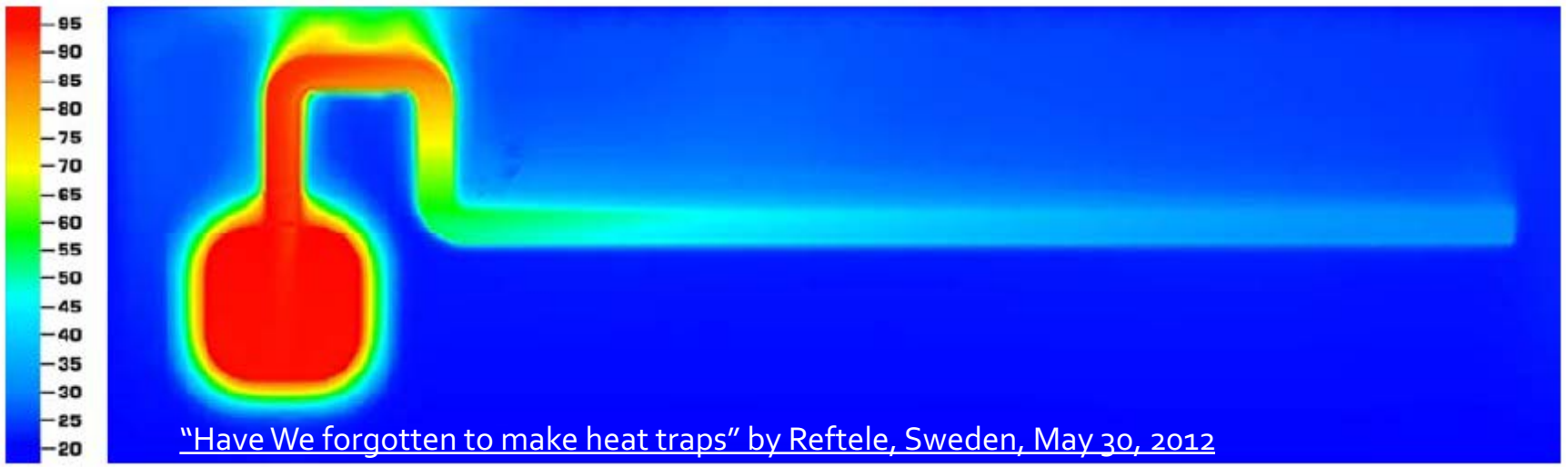
Is it Prohibited?

Should it be?



Every hot water system since they invented hot water systems!

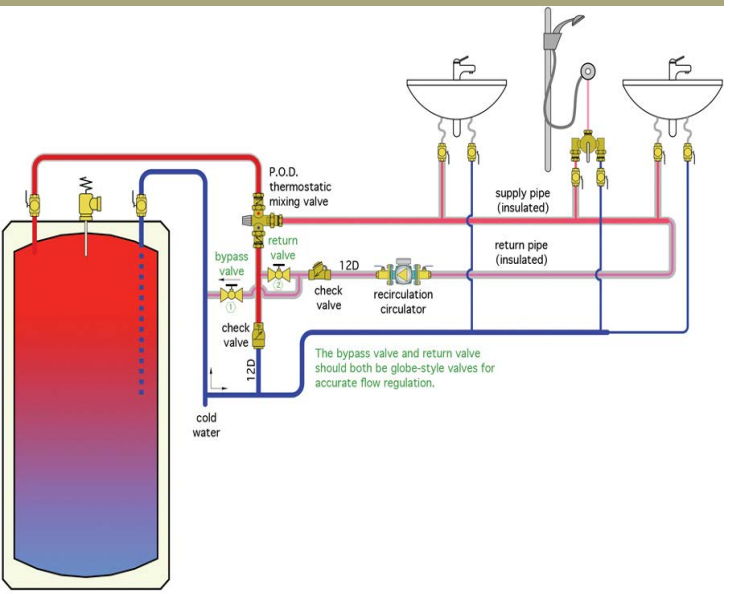
Except?



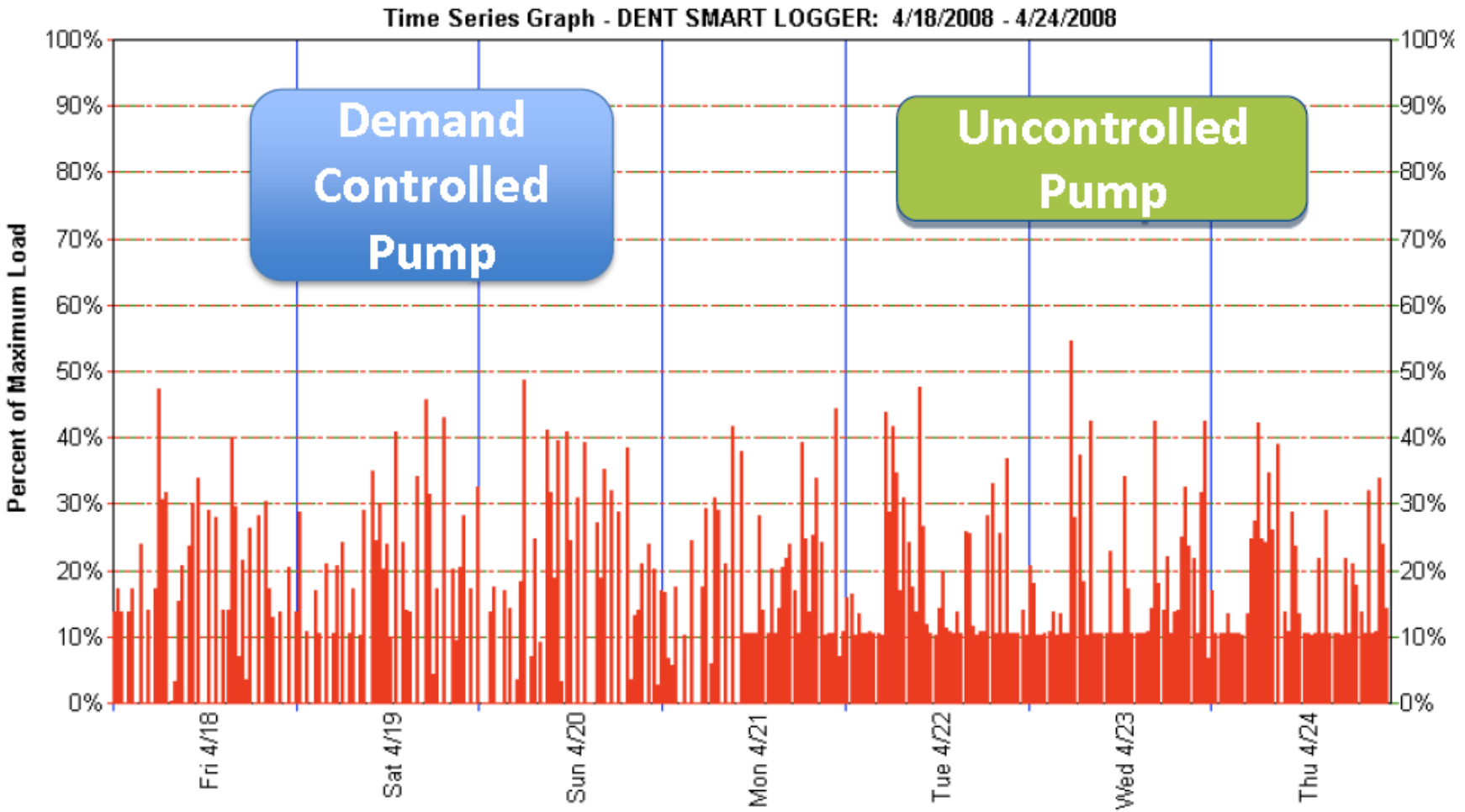
Reduced Water Heater Cycling

"DHW Recirc Design Elements

- Pipe Insulation
- On-Demand Recirculation
- System Balancing
- Crossover Prevention
- Optimized Loop Design"

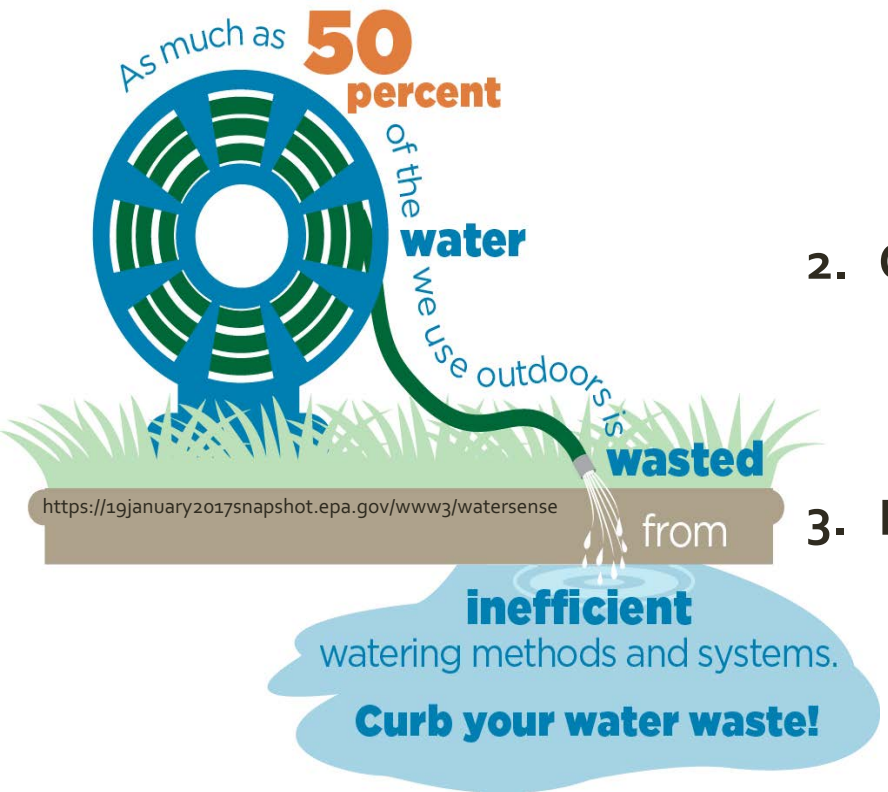


https://www.hpacmag.com



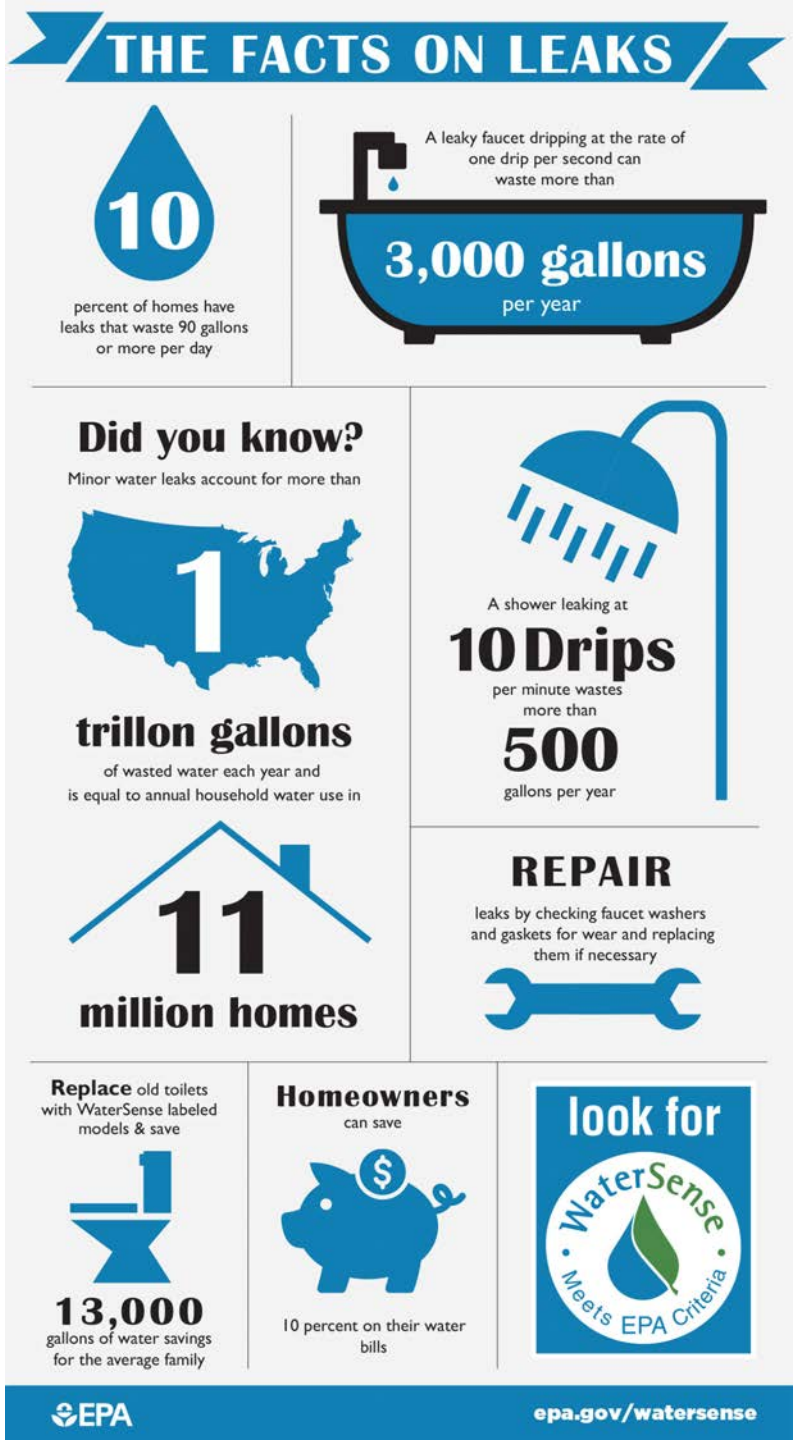
"DOE Zero Energy Ready Home, Efficient Hot Water Distribution in Zero Energy Ready Multifamily Buildings." 4/25/17 By: Gabriel Ayala, gabe@enovativegroup.com

Advanced Water Efficiency

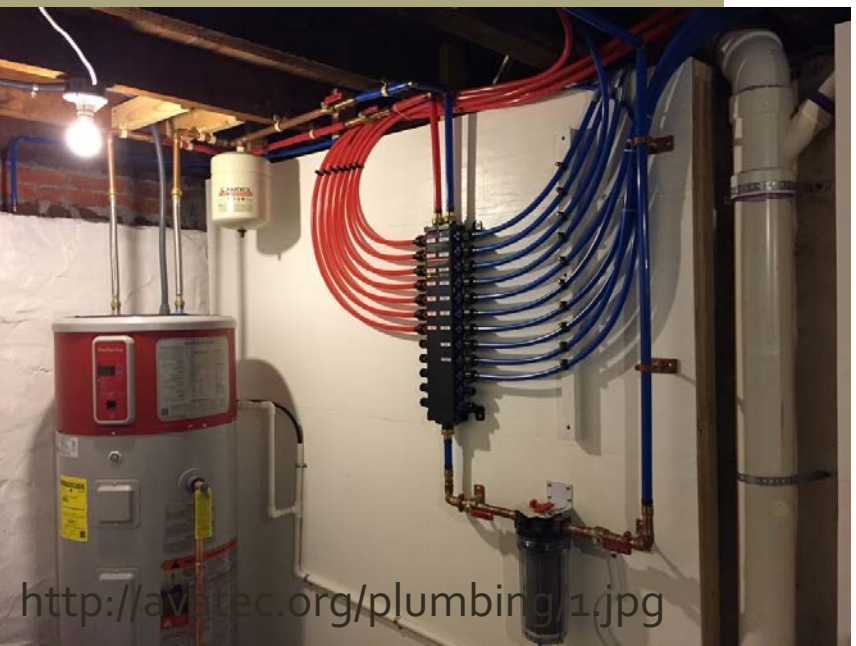


EPA WaterSense

1. **Indoor Water Use**
   - Leaks
     - Compliance shall be verified through pressure-loss testing & visual inspection.
   - Water Pressure & Fixture Flow Criteria
   - Hot Water Delivery Eff.
   - Appliances, ex. Clothes Washers & Dishwashers
2. **Outdoor Water Use**
   - Landscaping Design
   - Irrigation System Criteria and Design
3. **Homeowner Education**



Tackling the White Elephant in the Room



http://avatec.org/plumbing1.jpg

EPA WaterSense

II.C Hot Water Delivery Systems (3.3)

WaterSense Criteria

To minimize water loss from delivering hot water, the hot water delivery system shall store no more than 0.5 gallons (1.9 liters) of water in any piping/manifold between the hot water source and any hot water fixture. To account for the additional water that must be removed from the system before hot water can be delivered, no more than 0.6 gallons (2.3 liters) of water shall be collected from the hot water fixture before hot water is delivered. Recirculation systems must be demand-initiated. Systems that are activated based solely on a time and/or temperature sensor do not meet this requirement.

Intent
Efficiently designed hot water delivery systems reduce the amount of time it takes hot water to reach a fixture, saving both water and energy.

Background

One of the primary factors affecting homeowner satisfaction is the relative comfort associated with the hot water delivery system. The distance from the water heater has a great impact on the temperature of the water that arrives at a fixture and how long it takes for the hot water to be delivered.[2]

Heating water is typically the second largest use of energy in a home (after space heating and cooling).[3] Despite its resource intensity, the hot water delivery system is seldom an area of significant focus when constructing a home. As a result, many homes today are built with poor

[2] U.S. Green Building Council. 2008. LEED for Homes Reference Guide.
[3] Energy Information Administration, Office of Energy Consumption and Efficiency Statistics, 2009 Residential Energy Consumption Survey.

Ventilation Systems

ASHRAE 62.2-2016

Local Ventilation

Bathrooms (>50cfm/20cfm)

Kitchens (>100cfm)

Whole House Ventilation

Qtotal = 0.03Afloor + 10(Nbedroom +1)

- Natural Ventilation (2013-2016)

Must Be verified.

"If we don't test it we don't know."

TABLE 4.1a (I-P) Ventilation Air Requirements, cfm

	Bedrooms				
Floor Area, ft^2	1	2	3	4	5
<500	30	38	45	53	60
501–1000	45	53	60	68	75
1001–1500	60	68	75	83	90
1501–2000	75	83	90	98	105
2001–2500	90	98	105	113	120
2501–3000	105	113	120	128	135
3001–3500	120	128	135	143	150
3501–4000	135	143	150	158	165
4001–4500	150	158	165	173	180
4501–5000	165	173	180	188	195

Heat Recovery Ventilation Systems

- Design
- Installation
- Air Flow

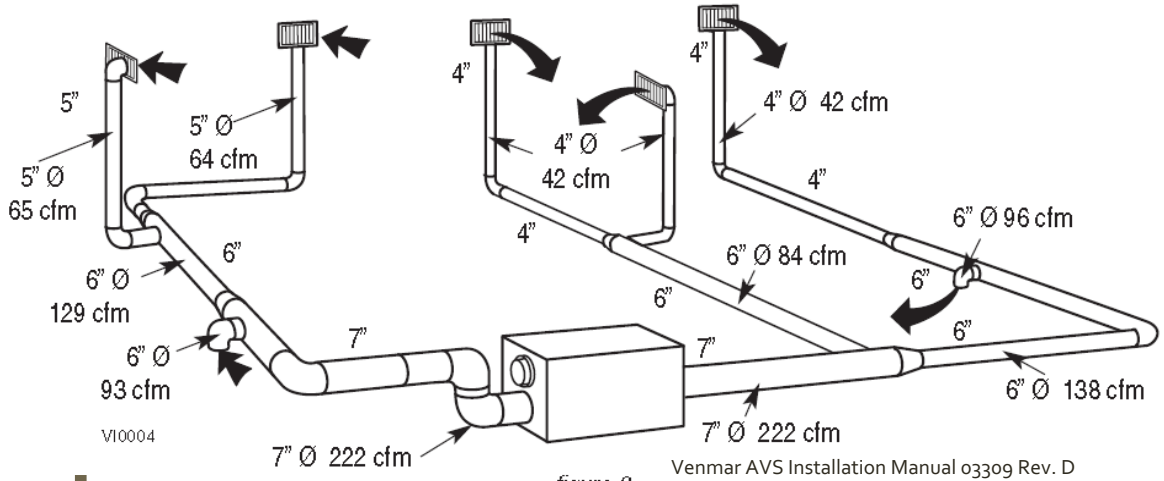


figure 8

Venmar AVS Installation Manual 03309 Rev. D

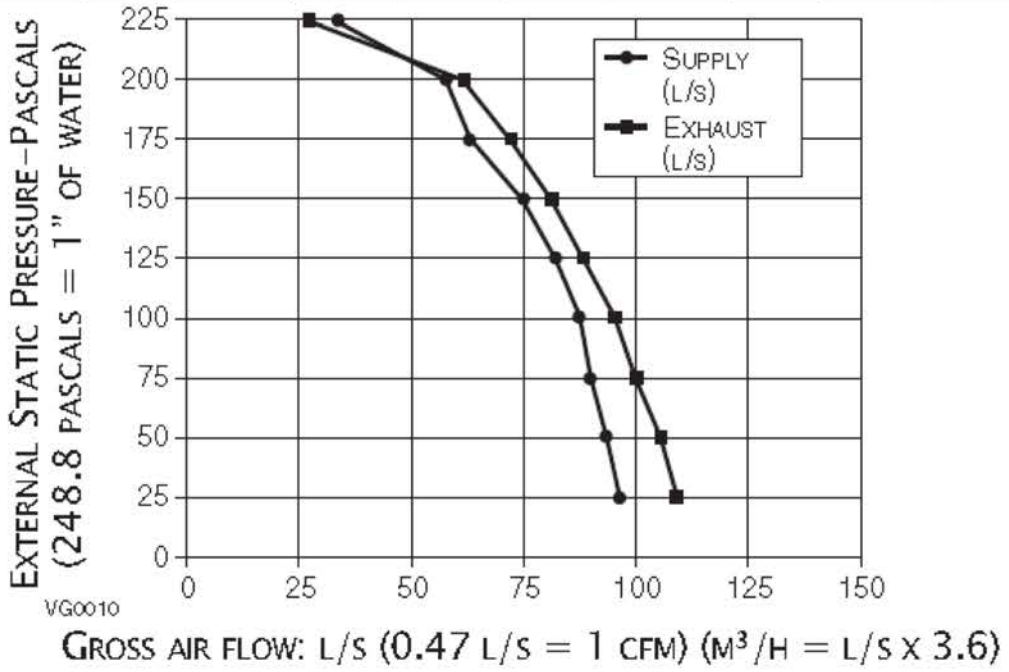
Balancing & Testing

- "Balanced heat recovery ventilation systems that provide well distributed ventilation throughout the entire occupied space are strongly recommended in Alaska" (BEES)

Duct Diameter	Recommended Air Flow			Maximum Air Flow		
4" (102 mm)	40 cfm	19 l/s	68 m³/h	60 cfm	28 l/s	102 m³/h
5" (127 mm)	75 cfm	35 l/s	127 m³/h	110 cfm	52 l/s	187 m³/h
6" (152 mm)	120 cfm	57 l/s	204 m³/h	180 cfm	85 l/s	306 m³/h
7" (178 mm)	185 cfm	87 l/s	314 m³/h	270 cfm	127 l/s	459 m³/h
8" (203 mm)	260 cfm	123 l/s	442 m³/h	380 cfm	179 l/s	645 m³/h

Ventilation Performance

Ext. static Pressure		Net supply Air flow			Gross air flow					
					Supply			Exhaust		
Pa	in. w.g.	l/s	cfm	m³/h	l/s	cfm	m³/h	l/s	cfm	m³/h
25	0.1	83	175	299	83	176	299	83	175	295
50	0.2	79	168	284	80	169	288	78	165	281
75	0.3	75	159	270	75	159	270	75	158	270
100	0.4	71	150	256	71	151	256	69	146	248
125	0.5	64	136	230	64	136	230	60	127	216
150	0.6	59	126	216	60	127	216	49	103	273
175	0.7	53	113	191	53	113	191	38	80	227
200	0.8	43	91	155	43	91	155	21	45	76



Energy Performance

Supply temperature		Net air flow			Power consumed Watts	Sensible recovery efficiency	Apparent sensible effectiveness	Latent/recovery moisture transfer
°C	°F	l/s	cfm	m³/h				
Heating								
0	32	31	66	112	85	69	81	-0.01
0	32	56	119	202	124	60	70	-0.01
0	32	–	–	–	–	–	–	–
-25	-13	34	72	133	114	62	80	0.08
Cooling						Total recovery efficiency		
35	95					Not tested		

Why it Matters

"VENMAR AVS SOLO 1.5 Spec Sheet
Part no. 43720 Canada
Part no. 43725 U.S.A.
64 to 150 CFM (0.4 in. w.g.)"

NOTE: All specifications are subject to change without notice.

HRV Manufacture Recommendations

Venmar AVS
Installation Manual
03309 Rev. D

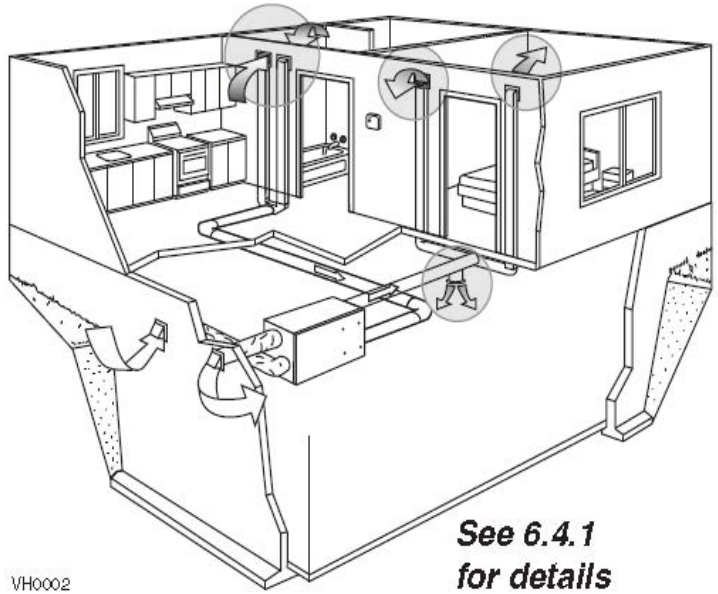


figure 1

"6.4.1 Fully Ducted System (as illustrated in Section 5.1)

Stale air exhaust ductwork:

- Install registers in areas where contaminants are produced: Kitchen, bathrooms, laundry room, etc.
- Install registers 6 to 12 inches from the ceiling on an interior wall OR install them in the ceiling.
- Install the kitchen register at least 4 feet from the range.
- If possible, measure the velocity of the air flowing through the registers. If the velocity is higher than 400 ft/min., then the register type is too small. Replace with a larger one.

Fresh air distribution ductwork:

- Install registers in bedrooms, dining room, living room and basement.
- Install registers either in the ceiling or high on the walls with air flow directed towards the ceiling. (The cooler air will then cross the upper part of the room, and mix with room air before descending to occupant level.)
- If a register must be floor installed, direct the air flow up the wall."

HRV Balancing

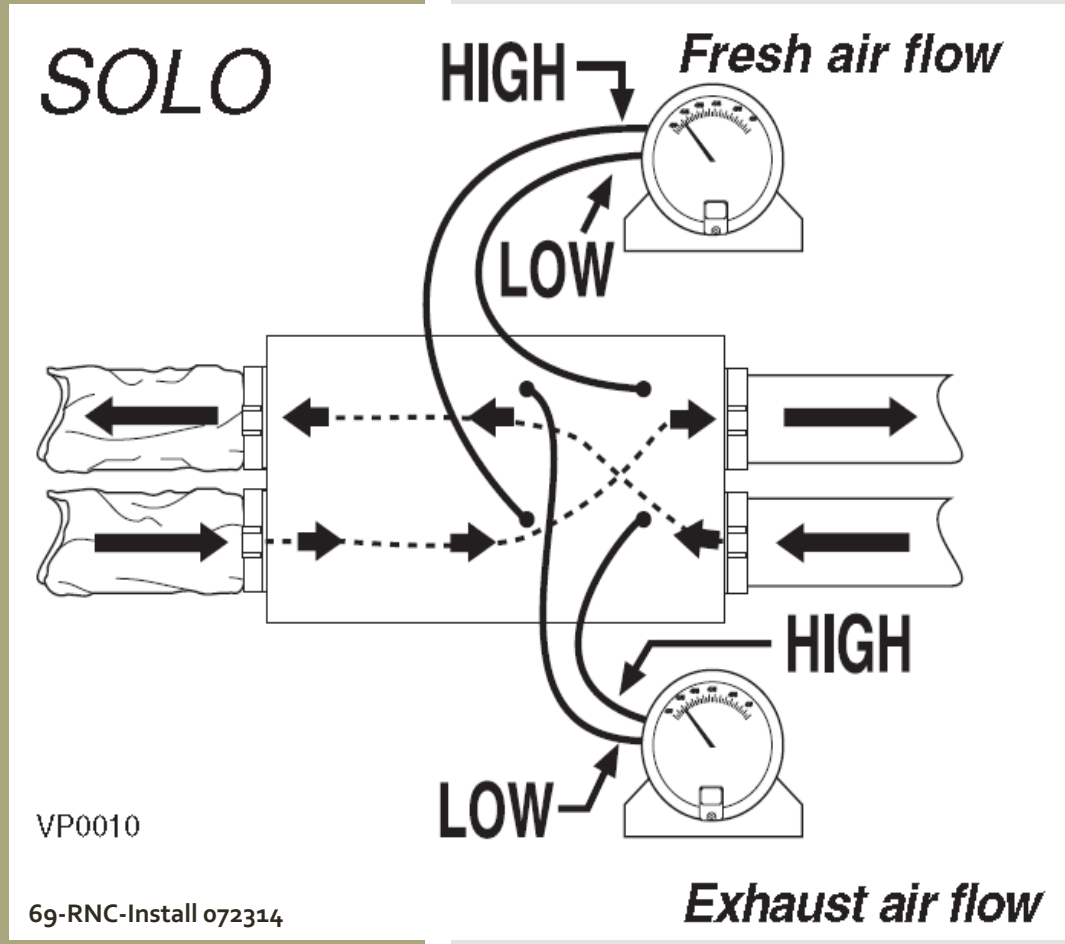
"Balancing the airflows is critical to ensuring that the amount of air introduced from the outside of the building equals the amount of air exhausted to the outside of the building. If these two airflows are not properly balanced, the following issues may occur:

1) A positive or negative pressure in the house

2) HRV not operate at its maximum efficiency

3) The unit not defrost properly"

(Lifebreath RNC Series Installation Guide 072314)



What About The Distribution?

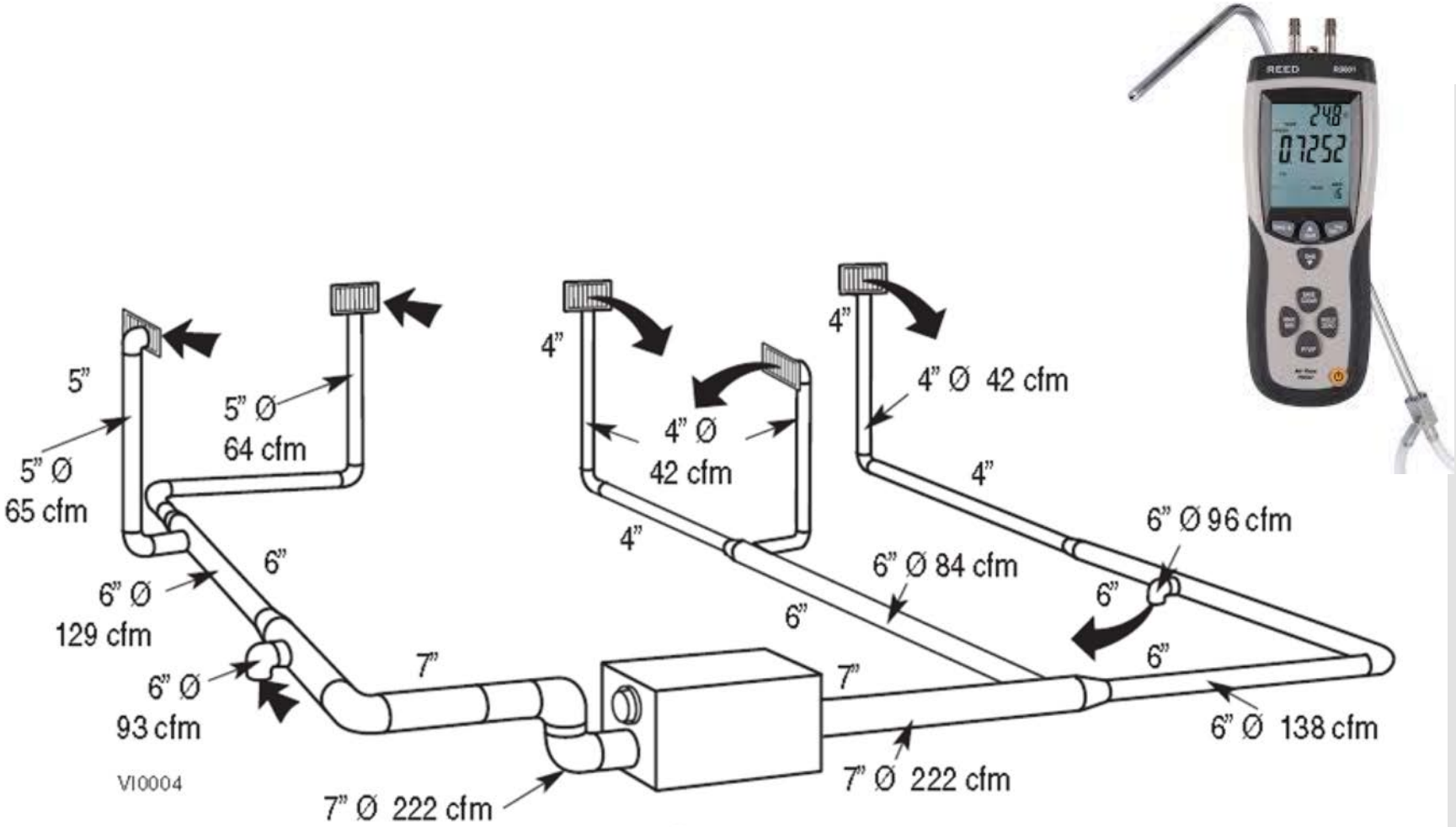


figure 8

Rater Design Review Checklist
ENERGY STAR Certified Homes, Version 3 / 3.1 (Rev. 08)

7. Whole-House Mechanical Ventilation System				Must Correct	Rater Verified [2]	N/A [3]
7.1 Rater-measured ventilation rate is within either ± 15 CFM or ±15% of design value (2.3) [42]				☐	☐	-
7.2 A readily-accessible ventilation override control installed and also labeled if its function is not obvious (e.g., a label is required for a standalone wall switch, but not for a switch that's on the ventilation equipment)				☐	☐	-
7.3 No outdoor air intakes connected to return side of the HVAC system, unless controls are installed to operate intermittently & automatically based on a timer and to restrict intake when not in use (e.g., motorized damper)				☐	☐	-
7.4 System fan rated ≤ 3 sones if intermittent and ≤ 1 sone if continuous, or exempted [43]				☐	☐	-
7.5 If system utilizes the HVAC fan, then the specified fan type is ECM / ICM (4.7), or the controls will reduce the standalone ventilation run-time by accounting for hours when the HVAC system is heating or cooling				☐	☐	☐
7.6 Bathroom fans are ENERGY STAR certified if used as part of the whole-house system [44]				☐	☐	☐
7.7 Air inlet location (Complete if ventilation air inlet location was specified (2.12, 2.13); otherwise check "N/A"): [45, 46]				-	-	☐
7.7.1 Inlet pulls ventilation air directly from outdoors and not from attic, crawlspace, garage, or adjacent dwelling unit				☐	☐	-
7.7.2 Inlet is ≥ 2 ft. above grade or roof deck; ≥ 10 ft. of stretched-string distance from known contamination sources (e.g., stack, vent, exhaust, vehicles) not exiting the roof, and ≥ 3 ft. distance from sources exiting the roof				☐	☐	-
7.7.3 Inlet is provided with rodent / insect screen with ≤ 0.5 inch mesh				☐	☐	-
8. Local Mechanical Exhaust - In each kitchen and bathroom, a system is installed that exhausts directly to the outdoors and meets one of the following Rater-measured airflow and manufacturer-rated sound level standards: [42, 47]						
Location		**Continuous Rate**	**Intermittent Rate** [48]			
8.1 Kitchen	Airflow	≥ 5 ACH, based on kitchen volume [49, 50]	≥ 100 CFM and, if not integrated with range, also ≥ 5 ACH based on kitchen volume [49, 50, 51]	☐	☐	-
	Sound	Recommended: ≤ 1 sone	Recommended: ≤ 3 sones			
8.2 Bathroom	Airflow	≥ 20 CFM	≥ 50 CFM	☐	☐	-
	Sound	Required: ≤ 1 sone	Recommended: ≤ 3 sones			
9. Filtration						
9.1 At least one MERV 6 or higher filter installed in each ducted mechanical system in a location that facilitates access and regular service by the owner [52]				☐	☐	☐
9.2 Filter access panel includes gasket or comparable sealing mechanism and fits snugly against the exposed edge of filter when closed to prevent bypass [53]				☐	☐	☐
9.3 All return air and mechanically supplied outdoor air passes through filter prior to conditioning				☐	☐	☐

ASHRAE 62.2 Commissioning

More than just Ventilation.

Attached Garages

- Must prevent migration of contaminates to adjoining occupiable spaces **(Can we test this?)**
  - All penetrations, joints, seams and openings must be sealed and/or gasketed **(Visual Inspections)**
- Any ducts in the garage must be leak tested and have less than 6% of total system air flow.

Other Requirements

- Dryers must be vented to the outside. **(Visual Verifications)**
- Sound Ratings for Fans
- Occupant Education

EPA Indoor airPLUS Verification Checklist

Moisture Control

1. Water-Managed Site and Foundation
2. Water-Managed Wall Assemblies
3. Water-Managed Roof Assemblies
4. Interior Water Management
    1. Radon
    2. Pests
    3. HVAC

Combustion Pollutants

5. Combustion Source Controls
6. Attached Garage Isolation

Materials

Final

EPA United States Environmental Protection Agency

Indoor airPLUS Verification Checklist

Address or Div/Lot #:

City/State/Zip: Date:

Section		Requirements (see Indoor airPLUS Construction Specifications for details)	N/A	Verified by: Builder	Verified by: Rater
Moisture Control		**Water-Managed Site and Foundation**			
	1.1	Site & foundation drainage: sloped grade, protected drain tile, & foundation floor drains		☐	☐
	1.2	Capillary break below concrete slabs & in crawlspaces (Exception - see specification)	☐	☐	☐
	1.3	Foundation wall damp-proofed or water-proofed (Except for homes without below-grade walls)	☐	☐	☐
	1.4	Basements/crawlspaces insulated & conditioned (Exceptions - see specification)	☐	☐	☐
		Water-Managed Wall Assemblies			
	1.5	Continuous drainage plane behind exterior cladding, properly flashed to foundation		☐	☐
	1.6	Window & door openings fully flashed		☐	☐
		Water-Managed Roof Assemblies			
	1.7	Gutters/downspouts direct water a minimum of 5' from foundation (Except in dry climates)	☐	☐	☐
	1.8	Fully flashed roof/wall intersections (step & kick-out flashing) & roof penetrations		☐	☐
	1.9	Bituminous membrane installed at valleys & penetrations (Except in dry climates)	☐	☐	☐
	1.10	Ice flashing installed at eaves (Except in Climate Zones 1 - 4)	☐	☐	☐
		Interior Water Management			
	1.11	Moisture-resistant materials/protective systems installed (i.e., flooring, tub/shower backing, & piping)			☐
	1.12	No vapor barriers installed on interior side of exterior walls with high condensation potential		☐	☐
	1.13	No wet or water-damaged materials enclosed in building assemblies		☐	☐
Radon	2.1	Approved radon-resistant features installed (Exception - see specification)	☐	☐	☐
	2.2	Two radon test kits & instructions/guidance for follow-up actions provided for buyer (Advisory-see specification)	☐	☐	☐
Pests	3.1	Foundation joints & penetrations sealed, including air-tight sump covers			☐
	3.2	Corrosion-proof rodent/bird screens installed at all openings that cannot be fully sealed (e.g., attic vents)		☐	☐
HVAC	4.1	HVAC room loads calculated, documented; system design documented; coils matched			☐
	4.2	Duct system design documented & properly installed OR duct system tested (check box if tested) ☐	☐		☐
	4.3	No air handling equipment or ductwork installed in garage; continuous air barrier required in adjacent assemblies			☐
	4.4	Rooms pressure balanced (using transfer grills or jump ducts) as required OR tested (check box if tested) ☐	☐		☐
	4.5	Whole house ventilation system installed to meet ASHRAE 62.2 requirements			☐
	4.6	Local exhaust ventilation to outdoors installed for baths, kitchen, clothes dryers, central vacuum system, etc.			☐
	4.7	Central forced-air HVAC system(s) have minimum MERV 8 filter, no filter bypass, & no ozone generators			☐
	4.8	Additional dehumidification system(s) or central HVAC dehumidification controls installed (In warm-humid climates only)	☐		☐
Combustion Pollutants		**Combustion Source Controls**			
	5.1	Gas heat direct vented; oil heat & water heaters power vented or direct vented (Exceptions - see specifications)	☐		☐
	5.2	Fireplaces/heating stoves vented outdoors & meet emissions/efficiency standards/restrictions	☐		☐
	5.3	Certified CO alarms installed in each sleeping zone (e.g., common hallway) according to NFPA 720			☐
	5.4	Smoking prohibited in common areas; outside smoking at least 25' from building openings (Multi-family homes only)	☐	☐	☐
		Attached Garage Isolation			
	5.5	Common walls/ceilings (house & garage) air-sealed before insulation installed; house doors gasketed & closer installed	☐		☐
	5.6	Exhaust fan (minimum 70 cfm, rated for continuous use) installed in garage & vented to outdoors (controls optional)	☐		☐
Materials	6.1	Certified low-formaldehyde pressed wood materials used (i.e., plywood, OSB, MDF, cabinetry)		☐	☐
	6.2	Certified low-VOC or no-VOC interior paints & finishes used		☐	☐
	6.3	Carpet, adhesives, & cushion qualify for CRI Green Label Plus or Green Label testing program	☐	☐	☐
Final	7.1	HVAC system & ductwork verified dry, clean, & properly installed			☐
	7.2	Home ventilated before occupancy OR initial ventilation instructions provided for buyer		☐	☐
	7.3	Completed checklist & other required documentation provided for buyer		☐	☐

Rater/Provider: Builder:

Company: Company:

Signature: Signature:

Photovoltaic System Commissioning

"How to Identify Issues on Installed Photovoltaic Systems "
by Fredrick Brooks
Aug. 23, 2017

"Proper system commissioning using a thermal imager at the start of a system's life, coupled with an annual inspection, helps ensure peak performance."

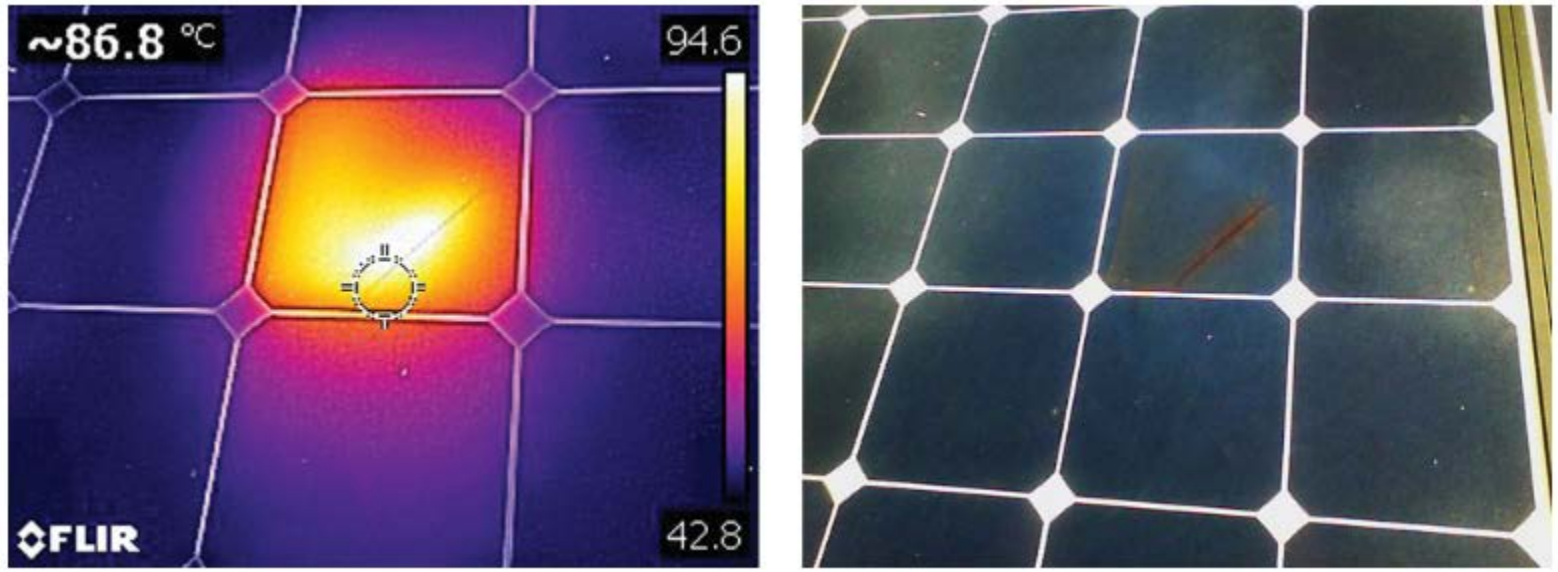


Fig. 2a and 2b. A cell in this panel has failed to the point that there is a full visible crack inside the wafer of the cell.

"How to Identify Issues on Installed Photovoltaic Systems"

by Fredrick Brooks Aug. 23, 2017

https://www.ecmweb.com/solar/how-identify-issues-installed-photovoltaic-systems

"Panels

< 10°C, Δt is not a major issue.

>10˚C, Δt should be examined to see if there is anything that might be causing this issue. Further action will need to be taken (those steps are stated below).

Inside of a combiner box and a service disconnect

< 2˚C, Δt is not a major issue.

> 2˚C, Δt needs to be addressed.

Combiner boxes

Torque specification was not properly met.

The string is a higher performing string and can cause heat.

The string has failed and is no longer producing (this is when you see a cold line) — this can be caused by a string being disconnected. Blown fuse in the combiner box.

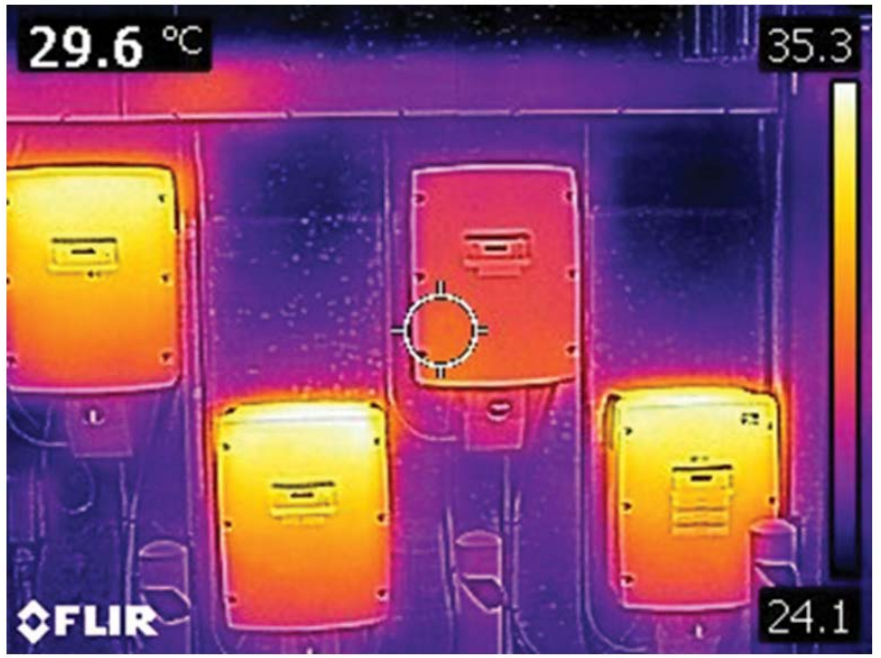


Fig. 9. The top right inverter was having a minor issue, which would trip it off line for a couple of minutes after it was running. This was an underperforming unit but all light indicators stated it was operating properly.

Inverters

Inverter ventilation covers not properly sealed.

Unit is not operating (**Fig. 9**).

Poor ventilation (externally or internally such as the intake screens or blocked or a failed fan).

Unit has a problem with the PV system not performing as designed and is under producing."

EPA
United States
Environmental Protection
Agency

Solar Photovoltaic
SPECIFICATION, CHECKLIST AND GUIDE

file:///C:/Users/ATI/Downloads/rerh_pv_checklist%20guide.pdf

Renewable Energy Ready Home Solar Photovoltaic Checklist

Home Location:	City:	State:

	RERH Checklist (See Renewable Energy Ready Home (RERH) specifications for details)	Builder Verified	NA
1 Building/Array Site Assessment			
1.1	Designate a proposed array location and square footage on architectural diagram: _____sq. ft.	❑	
1.2	Identify orientation (azimuth) of proposed array location: _____degrees.	❑	
1.3	Identify inclination of proposed array location: _____degrees.	❑	
1.4	Conduct a shading study documenting impacts on proposed array location: _____% adjusted annual shading impact. If using monthly values as verified through the solar path assessments, check here: _____.	❑	
1.5	Assess if proposed array location supports a solar resource potential of more than 75 percent of the optimal solar resource potential for the same location using the online RERH Solar Site Assessment Tool (SSAT). Yes ❑ This home meets the minimum recommended solar resource potential of 75 percent per the RERH SSAT results; continue with Section 2 below. No ❑ This home does not meet the recommended solar resource potential per the RERH SSAT results; this location is not a good host for a future solar energy system and should not be made renewable energy ready.	❑	
2 Structural and Safety Considerations: Solar Photovoltaics			
2.1	Provide code-compliant documentation of the maximum allowable dead load and live load ratings of the existing roof; recommended allowable dead load rating can support an additional 6 lbs/sq. ft. for future solar system.	❑	
2.2	Install permanent roof anchor fall safety system (NA for roof pitch ≤ 3:12).	❑	❑
3 Renewable Energy Ready Home Infrastructure: Solar Photovoltaics			
3.1	Install and label a 4' x 4' plywood panel area for mounting an inverter and balance of system components.	❑	
3.2	Install a 1" metal conduit for the DC wire run from the designated array location to the designated inverter location (cap and label both ends).	❑	
3.3	Install a 1" metal conduit from designated inverter location to electrical service panel (cap and label both ends).	❑	
3.4	Install and label a 70-amp dual pole circuit breaker in the electrical service panel for use by the PV system (label the service panel).	❑	
3.5	Provide architectural drawing and riser diagram of RERH solar PV system components.	❑	
4 Homeowner Education			
4.1	Provide to the homeowner a copy of this checklist and all the support documents listed below (to be provided to future solar designer).		
	- Copy of the Renewable Energy Ready Home Specification guide	❑	
	- Fully completed RERH checklist (all sections)	❑	
	- Architectural drawings detailing proposed array location and square footage	❑	
	- Electrical drawings and riser diagram of RERH PV system components that detail the dedicated location for the mounting of the balance components	❑	
	- Shading study with percent monthly or adjusted annual shading impact(s)	❑	
	- Site assessment record generated by the online RERH SSAT indicating that the proposed site meets a minimum solar resource potential of 75 percent of optimal	❑	
	- Code-compliant documentation of the maximum allowable dead load and live load ratings of the roof	❑	
4.2	Record electric utility service providers contact information:		
	Electric utility service providers name and Web address:		
5 Builder Best Practices (Optional Elements)			
5.1	Develop a detailed landscape plan with a clear emphasis on low-growth vegetation	❑	❑
5.2	Place roof penetrations above or north of the proposed array to prevent casting shadows on the array location	❑	❑

Builder Completion Date:	Builder Company Name:
Builder Employee Name:	Builder Employee Signature:

Interested in Solar Incentives? Please visit: http://www.dsireusa.org/solar/

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Best Practices in Photovoltaic System Operations and Maintenance

2nd Edition

"6.3 Use of O&M Plan

Following construction and **commissioning**, the O&M plan is the only surviving operational plan that contains the complete history of the plant in its archive. Therefore, it is critical to ensure that the O&M plan is well-documented and safely archived." https://www.nrel.gov/docs/fy17osti/67553.pdf

"Aerial Thermal Imaging

Aerial thermal imaging inspections refer to the collection and processing of image data collected by aerial sensors with the goal of detecting string, module, and sub-module faults in the array. By detecting thermal variations between modules, any critical defect that is causing a reduction in module efficiency can be detected, in addition to the proactive detection of hot spots and potential fire risks (**Fig. 14**). These inspections can be performed instead of manual electrical testing as part of an annual preventative maintenance, and can also be **used for system commissioning** and end-of-warranty inspections, and infrared inspection of AC substation."

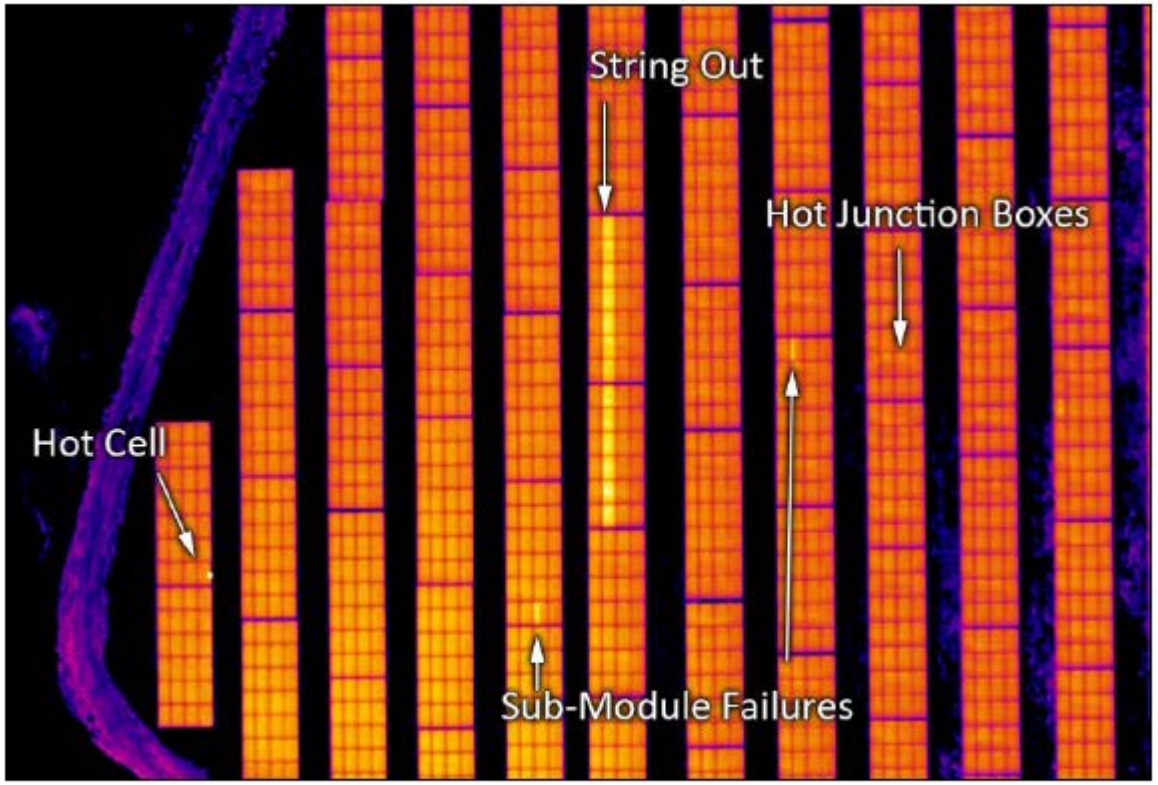


Figure 14. High-resolution infrared aerial imaging can identify failed strings, modules, and cells within modules as shown on this image. (by Rob Andrews, courtesy of Heliolytics Inc.)

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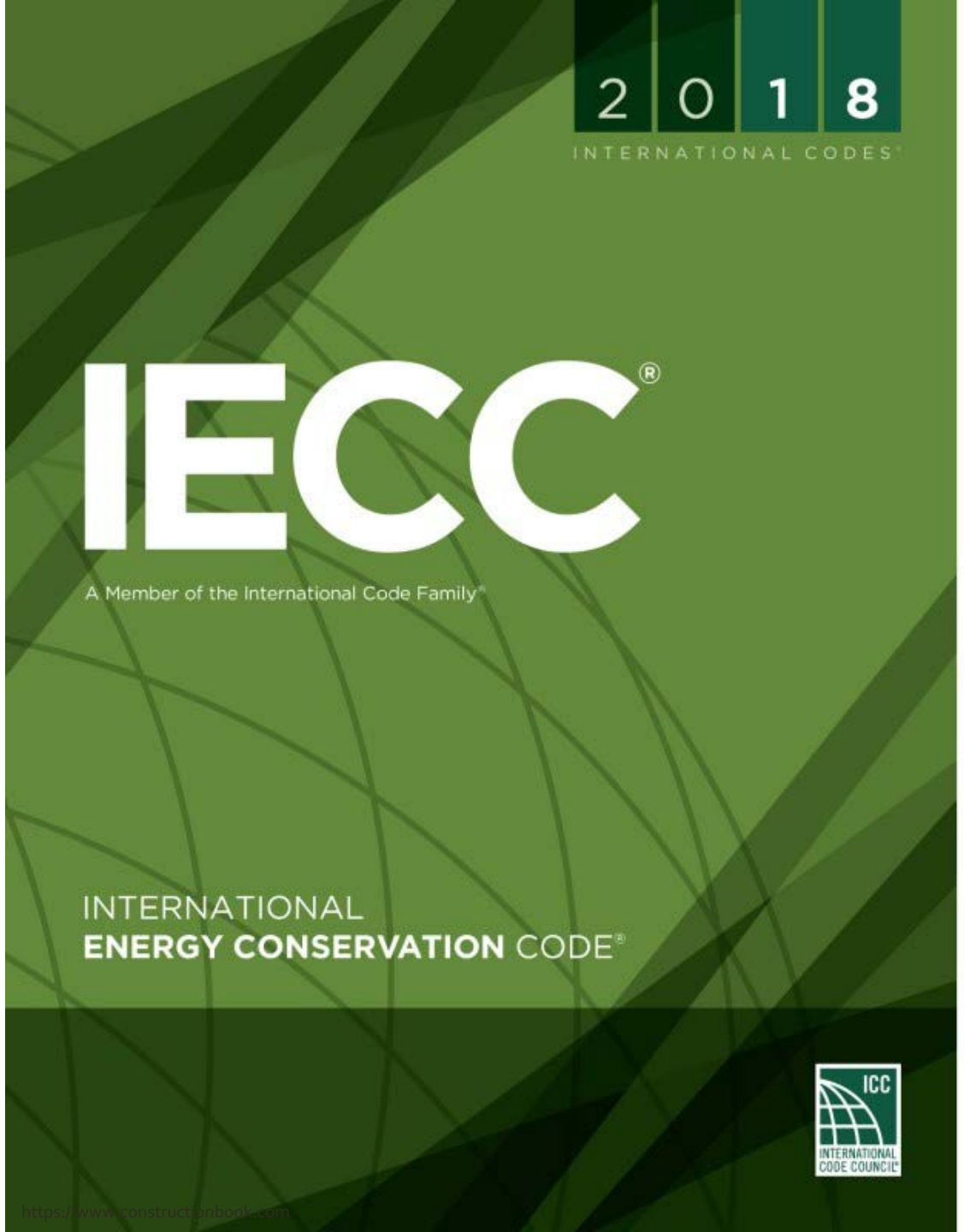
NREL/Sandia/Sunspec Alliance SuNLaMP PV O&M Working Group

https://www.nrel.gov/docs/fy17osti/67553.pdf

In Conclusion

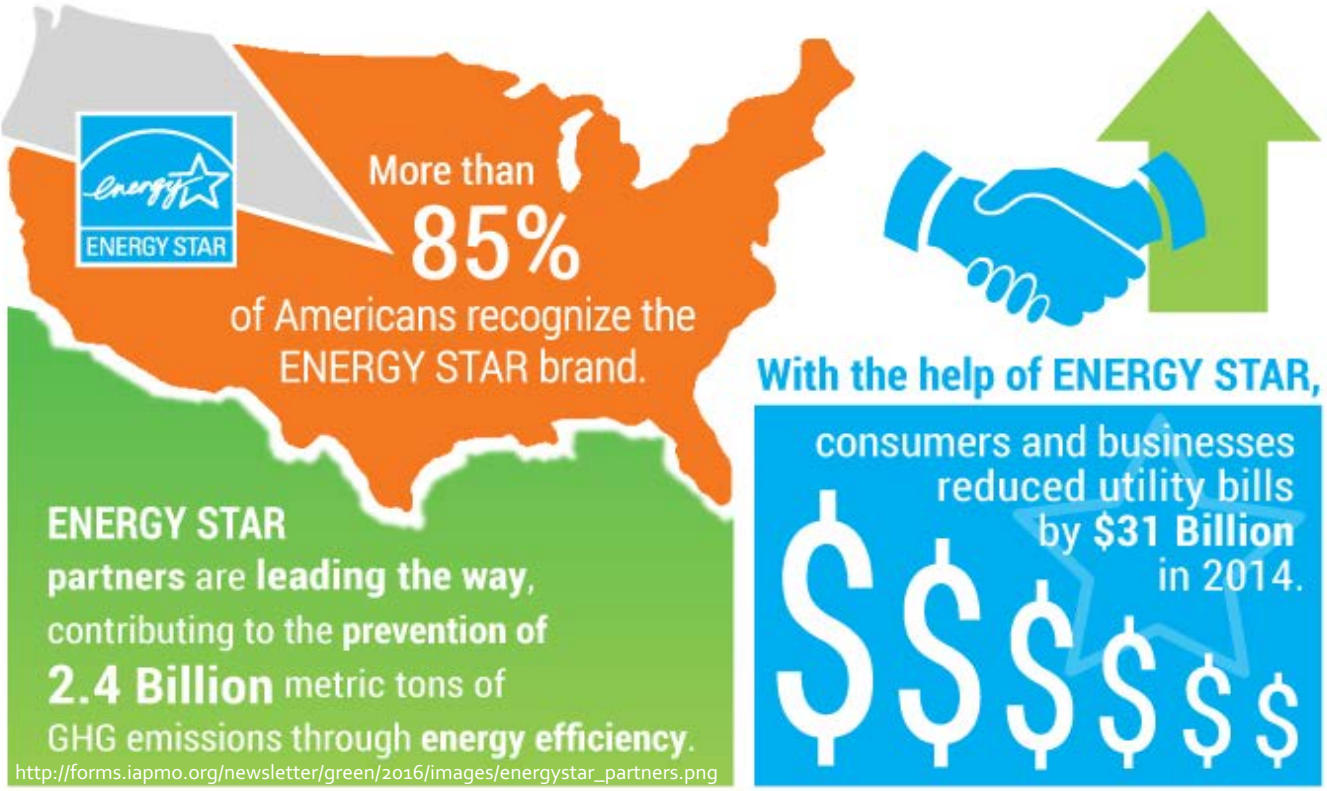
Why Build it to Code

- Financing
- Lawyers
- Resale
- You Have To?



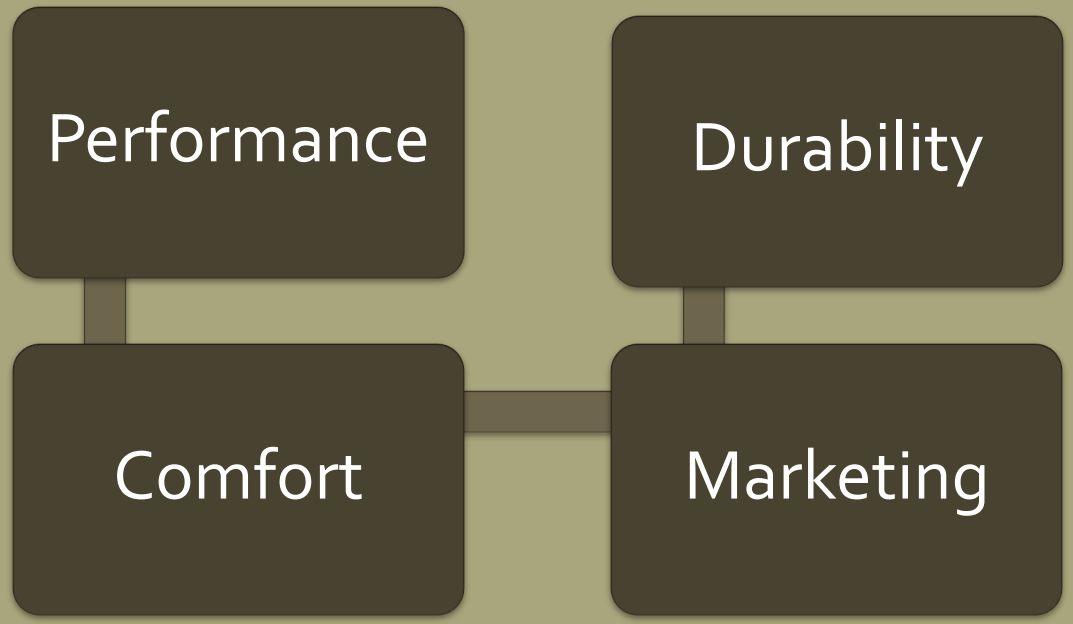
Why Energy Star

- Tax Credits/ Rebates
- Durability
- Comfort
- Marketing



http://forms.iapmo.org/newsletter/green/2016/images/energystar_partners.png

Why Passive House



PHIUS

Passive House Institute US

http://www.phius.org

What is Continuous Commissioning?

- Passive House Additional Resources Include
  1. Power Wise Monitoring Systems
     - Total electricity use
     - Electricity use by circuit, including HVAC, domestic hot water, lighting, and outlets
     - Air quality
     - Thermal comfort
     - Mechanical system performance
     - Thermostat settings, room temperatures, and humidity

Thank you

Emmett Leffel

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