



# Massachusetts Energy Code Technical Support Initiative

*Massachusetts Residential Energy  
Code: HVAC and Indoor Air Quality*

Nantucket Builders Association

March 15, 2017

# Codes and Standards Initiative - Sponsors



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- Columbia Gas of Massachusetts
- Eversource Energy
- Liberty Utilities
- National Grid
- Unitil

The Sponsors of Mass Save work closely with the Massachusetts Department of Energy Resources to provide a wide range of services, incentives, trainings, and information promoting energy efficiency that help residents and businesses manage energy use and related costs.

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These trainings are being offered through the support of Mass Save<sup>®</sup> and in cooperation with the Massachusetts Board of Building Regulations and Standards (BBRS).

- The Energy Code Technical Support staff, consisting of CLEAResult and other contractors, are not code officials, and the information provided through the program is not a formal interpretation of the code.
- **Your local building code official is responsible for the enforcement of the code** and the Massachusetts BBRS is the governing body responsible for interpretations of the code.

# Learning Objectives



- Know mechanical ventilation options
- Plan for better indoor air quality
- Understand ducting requirements
- Know heating/cooling equipment requirements

# Mass Save<sup>®</sup> Energy Code Technical Support



## Project Specific Code Assistance

- MA code officials
- Design professionals
- Contractors
- Sub contractors
- Material suppliers



Toll-free energy code support

**855-757-9717**

Phone assistance

Office visits

Project site visits



Photo © CLEAResult





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# Half a Loaf



# Major Changes in the Code

# Major Mechanical Changes in 2015 IECC



- R403.3.1 Return ducts in attic from R-6 to R-8 (>3" dia.)
- R403.4.1 New language for DHW re-circ systems
  - R403.4.1.1 & R403.4.1.2 makes IECC, IRC and IPC consistent clarifies requirements if installed
- R403.4.2 Removes kitchen DHW ins requirement & generic ins requirement on long/large diameter pipes
  - Adds pipe ins requirement on all  $\frac{3}{4}$ " pipe
  - Adds demand control requirements for recirc systems that use cold water supply line to return to water tank
- R403.2 Adds requirement for outdoor reset control for HW boilers

- Duct leakage testing must be performed by HERS Rater, HERS Rating Field Inspector, BPI Professional
- R403.6 Mechanical Ventilation. Replaces IECC Reference with 3 alternative compliance paths
  - Energy Star Homes v3.1
  - ASHRAE 62.2-2013 or
  - Specific formulas for calculating ventilation rate
- R403.6.2-R403.6.6 Adds ventilation sections for:
  - Verification, equipment selection, sound rating, documentation, and inlet/outlet configurations

# New MA Stretch Code



- AA 103.1 R-use buildings
  - In all R-use buildings, of four stories or less above *grade plane* with one or more dwelling units, each *dwelling unit* shall comply with Section R406 (Energy Rating Index Compliance Method)
  
- AA104 Existing (residential) buildings
  - For alterations, renovations, additions or repairs of existing buildings the energy efficiency requirements of the residential code shall be used.



# Energy Use Due to Non-Compliance



| Building System   | 2012 IECC  | Stretch Code |
|-------------------|------------|--------------|
| Lighting          | 3%         | 1%           |
| Ducts             | 4%         | 1%           |
| Air Leakage       | 3%         | 0%           |
| Above Grade Walls | 2%         | 1%           |
| Frame Floors      | 2%         | 1%           |
| Foundation Walls  | 1%         | 0%           |
| Ceilings          | 1%         | 0%           |
| Windows           | 1%         | 0%           |
| Slabs             | 0%         | 0%           |
| <b>Overall</b>    | <b>18%</b> | <b>5%</b>    |

# Mechanical Ventilation

# A Building is a System



- Enclosure
  - Controls water, air movement, heat loss
- Heating/Cooling Equipment
  - Controls temperature and humidity
- Mechanical Ventilation
  - Controls moisture, odors, fresh air

# Why Ventilation



- Moisture
- Carbon dioxide
- Nitrogen dioxide
- Tobacco smoke
- Volatile organic compounds (off-gassing)
- Chemicals/cleaners
- Carbon monoxide
- Other pollutants

# Uncontrolled Ventilation

## Natural Air Exchange

- Unreliable
  - Temperature Difference
  - Wind
- No occupant control



# Controlled Ventilation

- Occupant control
- Incoming air can be filtered/tempered
- Houses can be built tighter

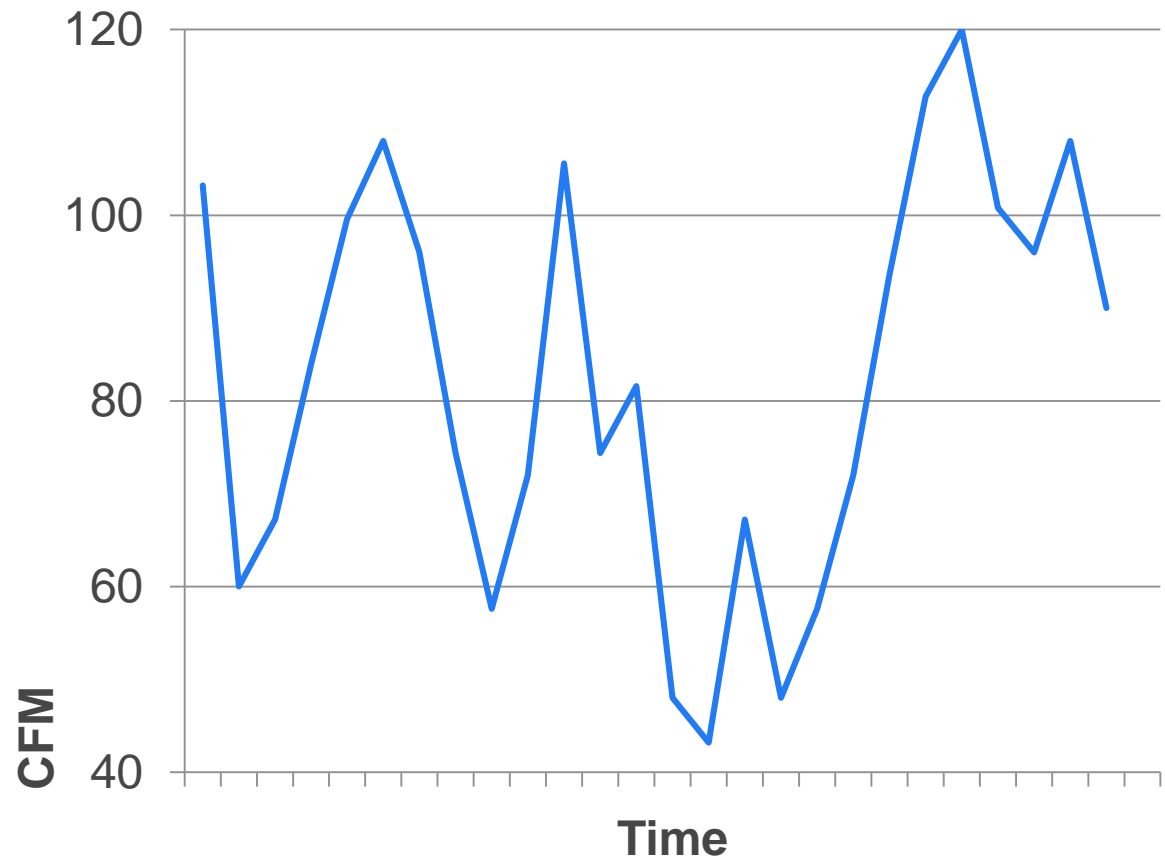


# What is the Right Ventilation Rate?



- What are the loads in the house?
- Will they change over time?
- Capacity and Control

Ventilation Needs Over Time



# R403.6 Mechanical Ventilation (Mandatory MA Amendment)



3 options for determining minimum ventilation airflow rate:

1. Energy Star Homes Version 3.1

*OR*

2. ASHRAE 62.2-2013

*OR*

3. MA formula



- Regardless of option you choose, rate is based on
  - house size
  - # of bedrooms
  - height
  - air leakage
  - location

# R403.6 Mechanical Ventilation (MA Amend) Options Comparison



## 2500 sf home – 3 bedrooms

| Option | Compliance Metric                              | CFM |
|--------|--|-----|
| 1a     | ENERGY STAR V3<br>(ASHRAE 62.2-2010 - formula) | 55  |
| 1b     | ENERGY STAR V3<br>(ASHRAE 62.2-2010 - table)   | 60  |
| 2a     | ASHRAE 62.2-2013 formula                       | 66  |
| 2b     | ASHRAE 62.2-2013 table                         | 66  |
| 3      | MA Formula                                     | 77  |

# Ventilation Strategies

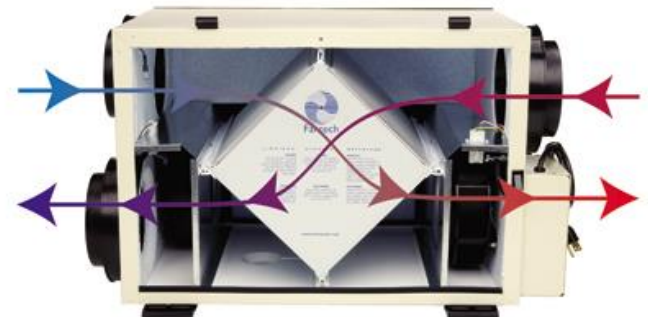
1. Exhaust-only ventilation

*OR*

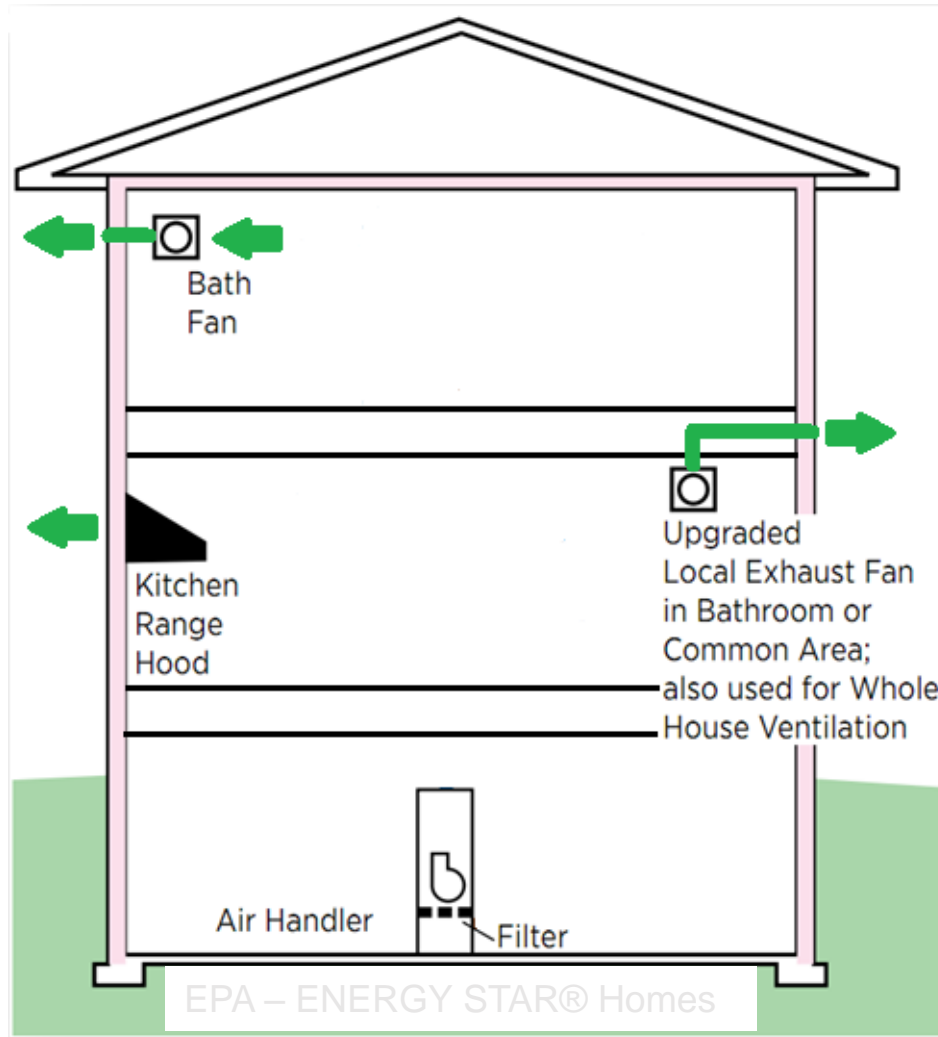
2. Supply

*OR*

3. Balanced ventilation



# Exhaust-Only Ventilation



# Controller

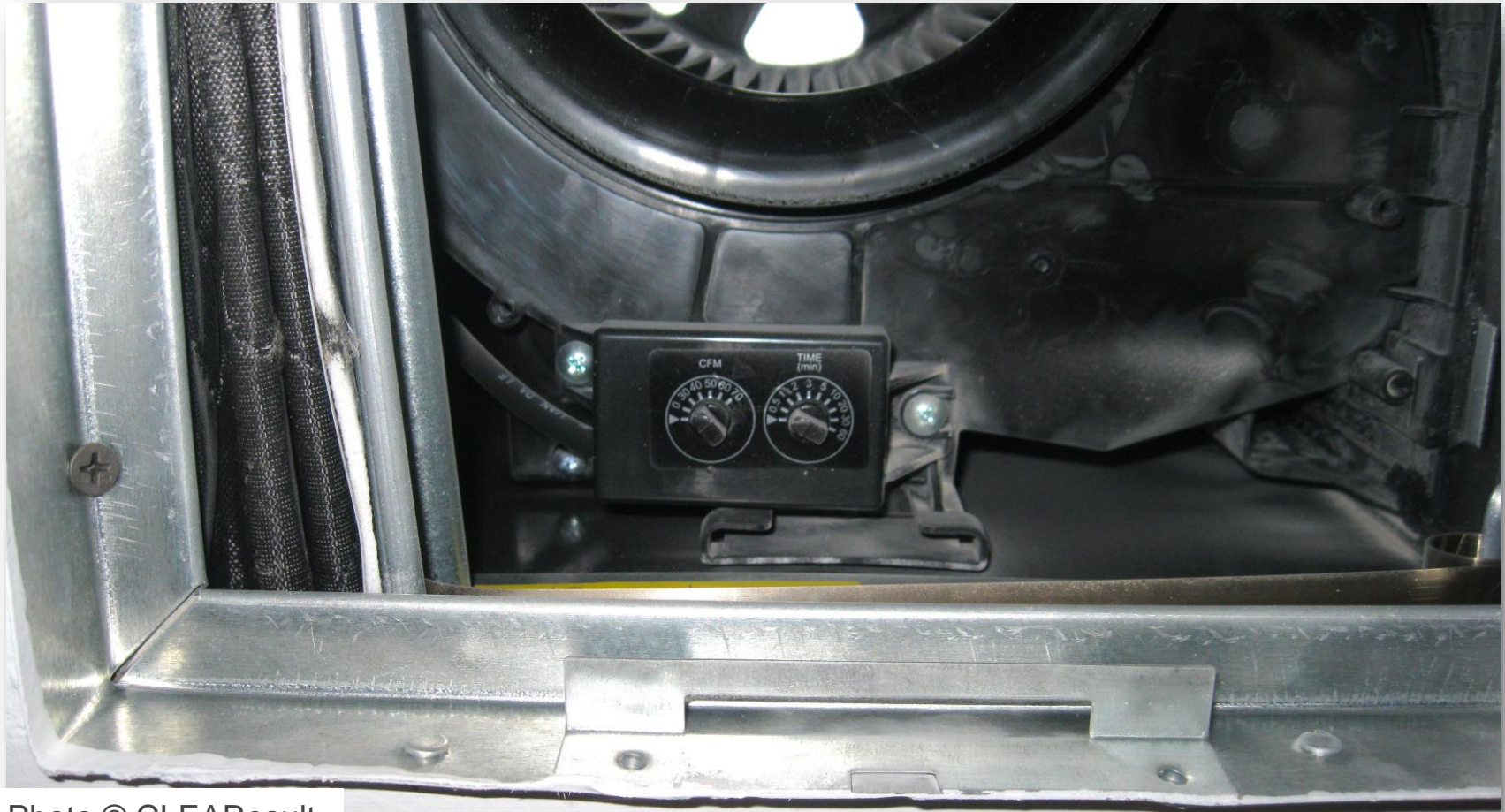


Photo © CLEARresult

# Controller



# Controller



Photo © CLEAResult

# Exhaust Only Ventilation





# Advantages: Exhaust-Only



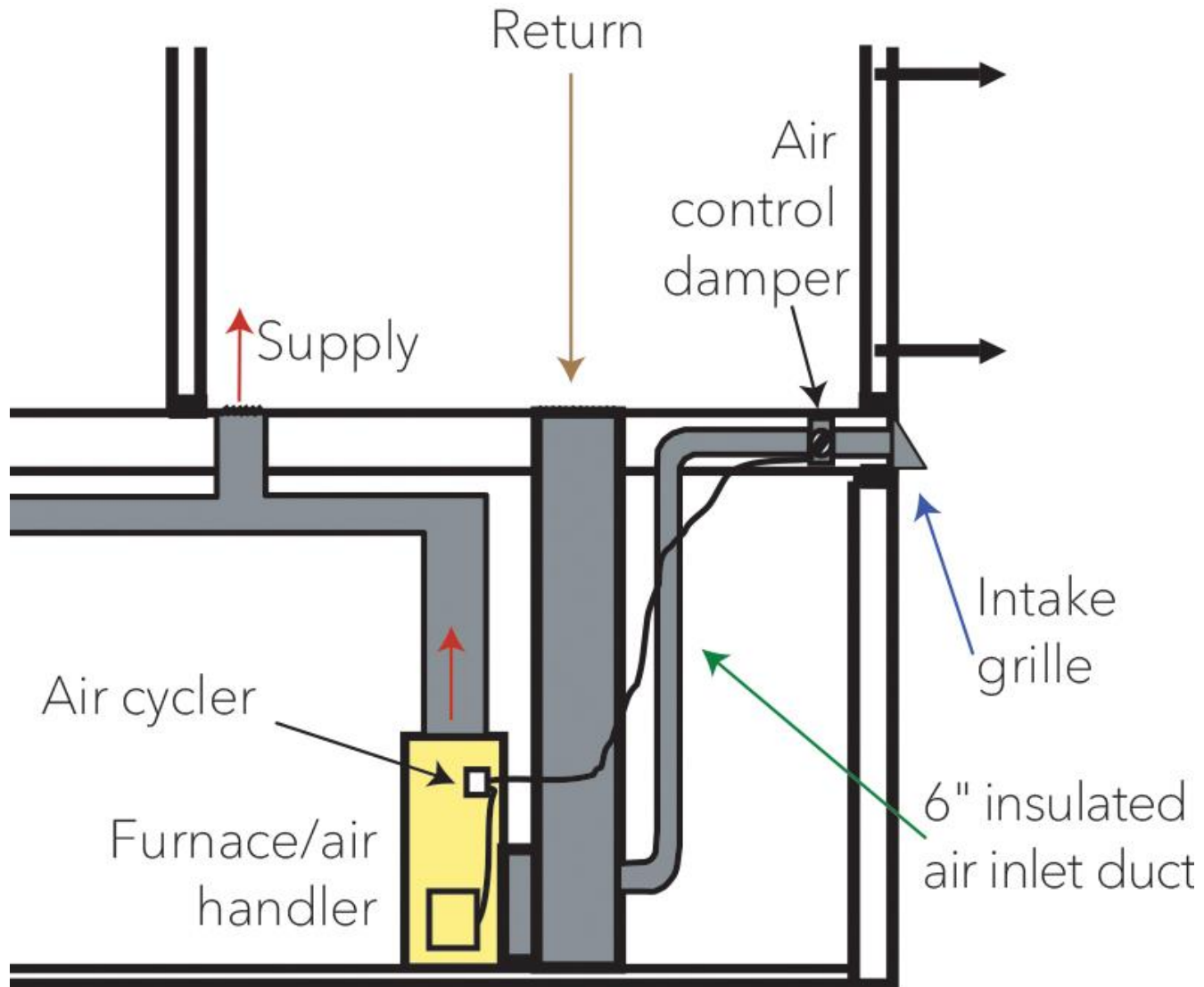
- Easy to install
- Simple
- Inexpensive: \$70 - \$300
- Reduces moisture loading of the wall assemblies

# Disadvantages: Exhaust-Only



- Make-up air takes path of least resistance
- Ineffective distribution in larger homes
- Removes heated or cooled air

# Supply-Only Ventilation



# Advantages: Supply Side



- Does not interfere with combustion appliances
- Better distribution of fresh air

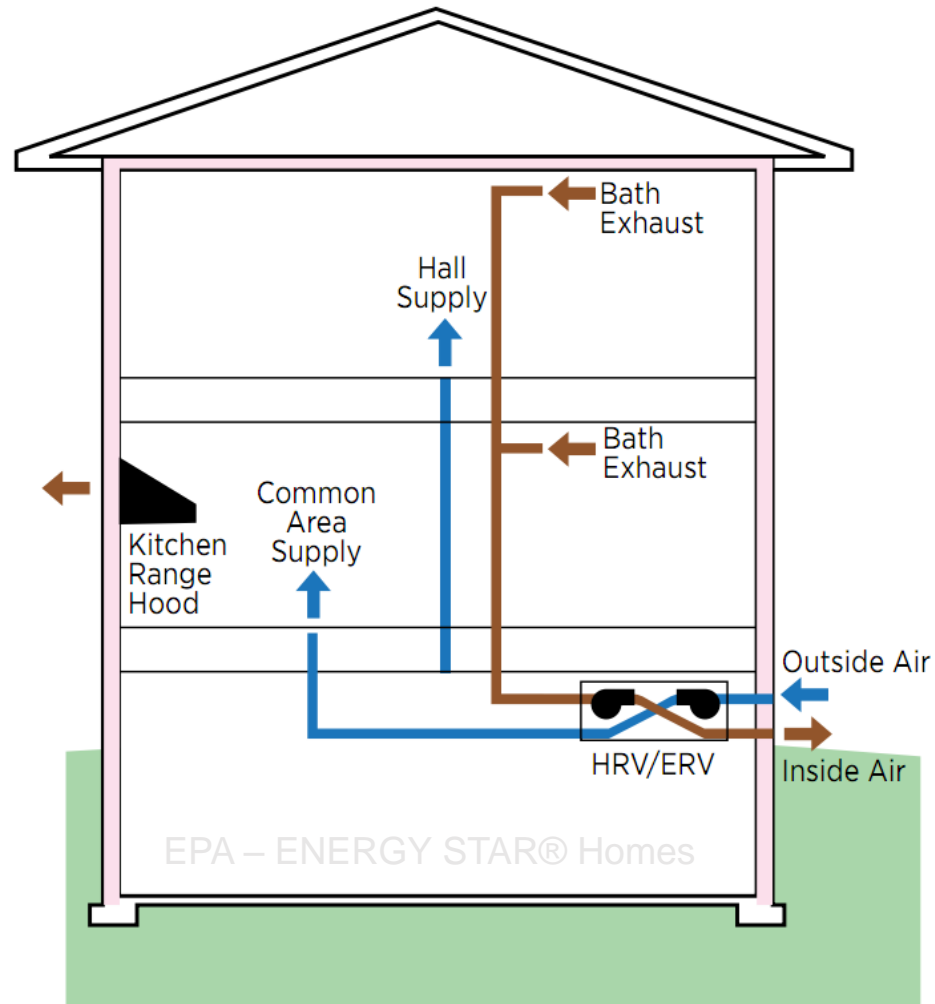


# Disadvantages: Supply Side

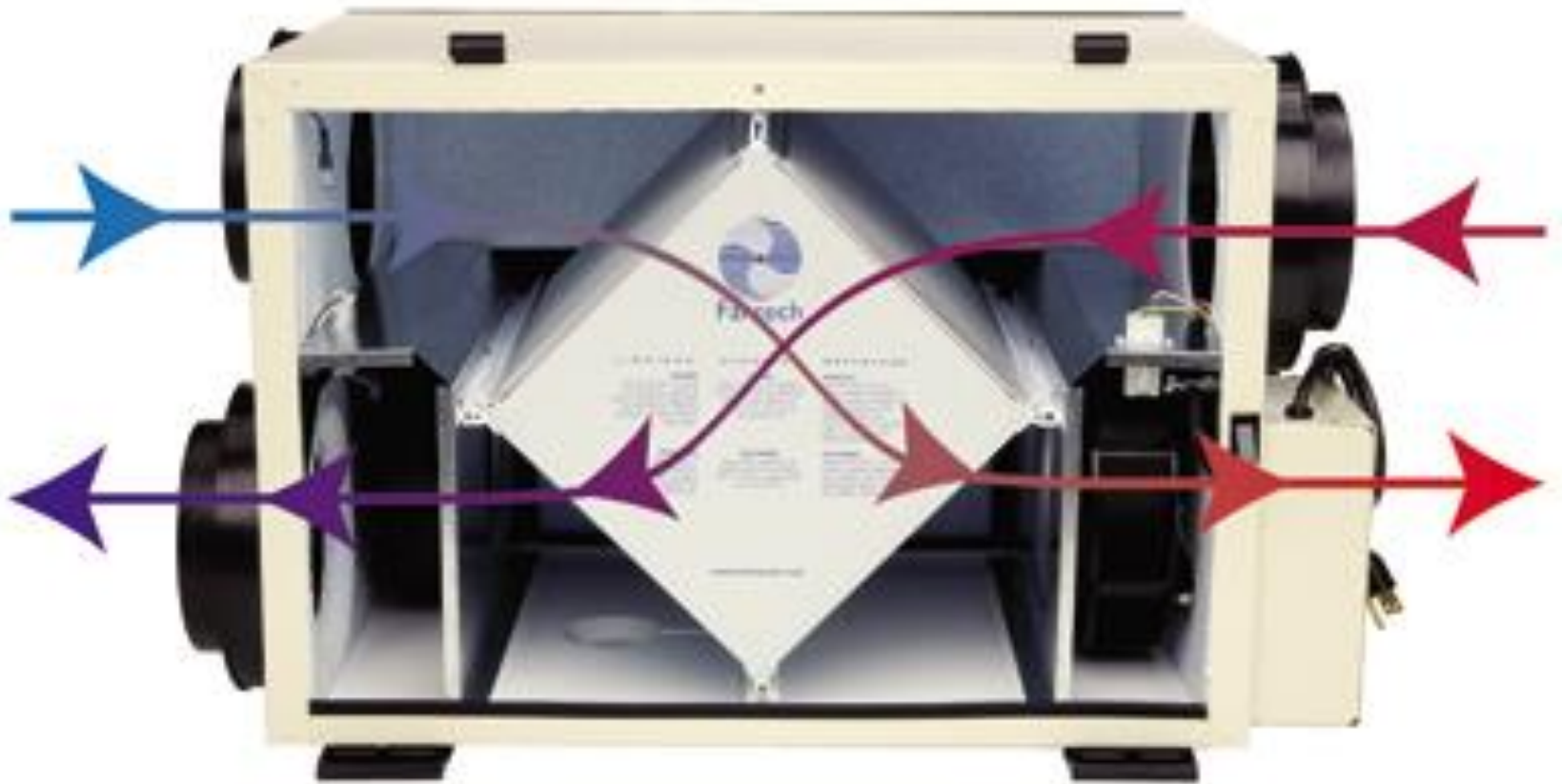


- Does not remove indoor air pollutants
- Brings in cold (or hot) air, or moisture from outside
- Air circulation can feel drafty
- Furnace fan runs more often
- Interior air is pushed into assemblies

# Balanced Ventilation



# HRV / ERV



# Advantages: Balanced Ventilation



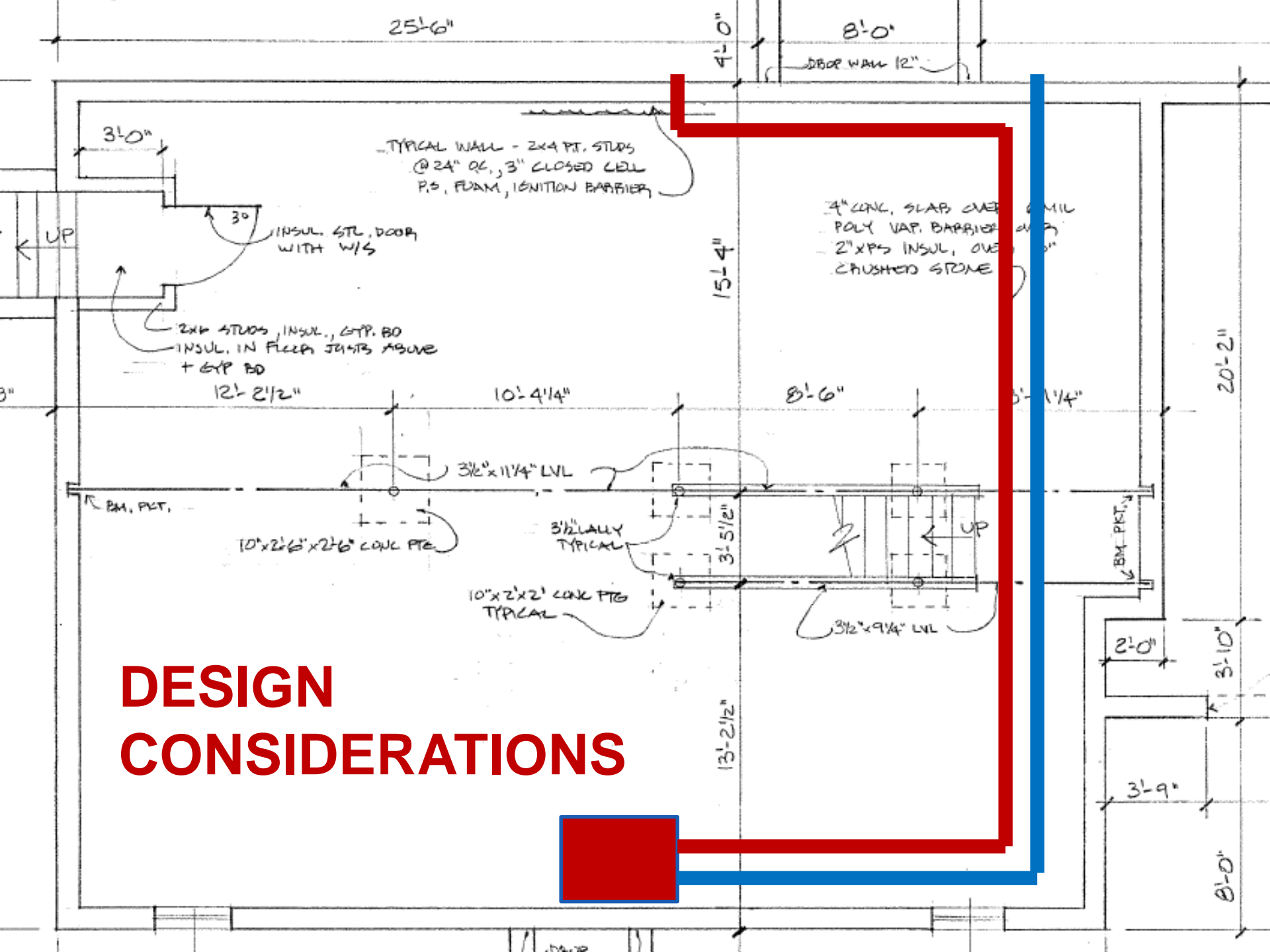
- Make-up air pathway is known
- Distribution is known
- Filter the air
- Recovers heat/cool/moisture
- No induced infiltration



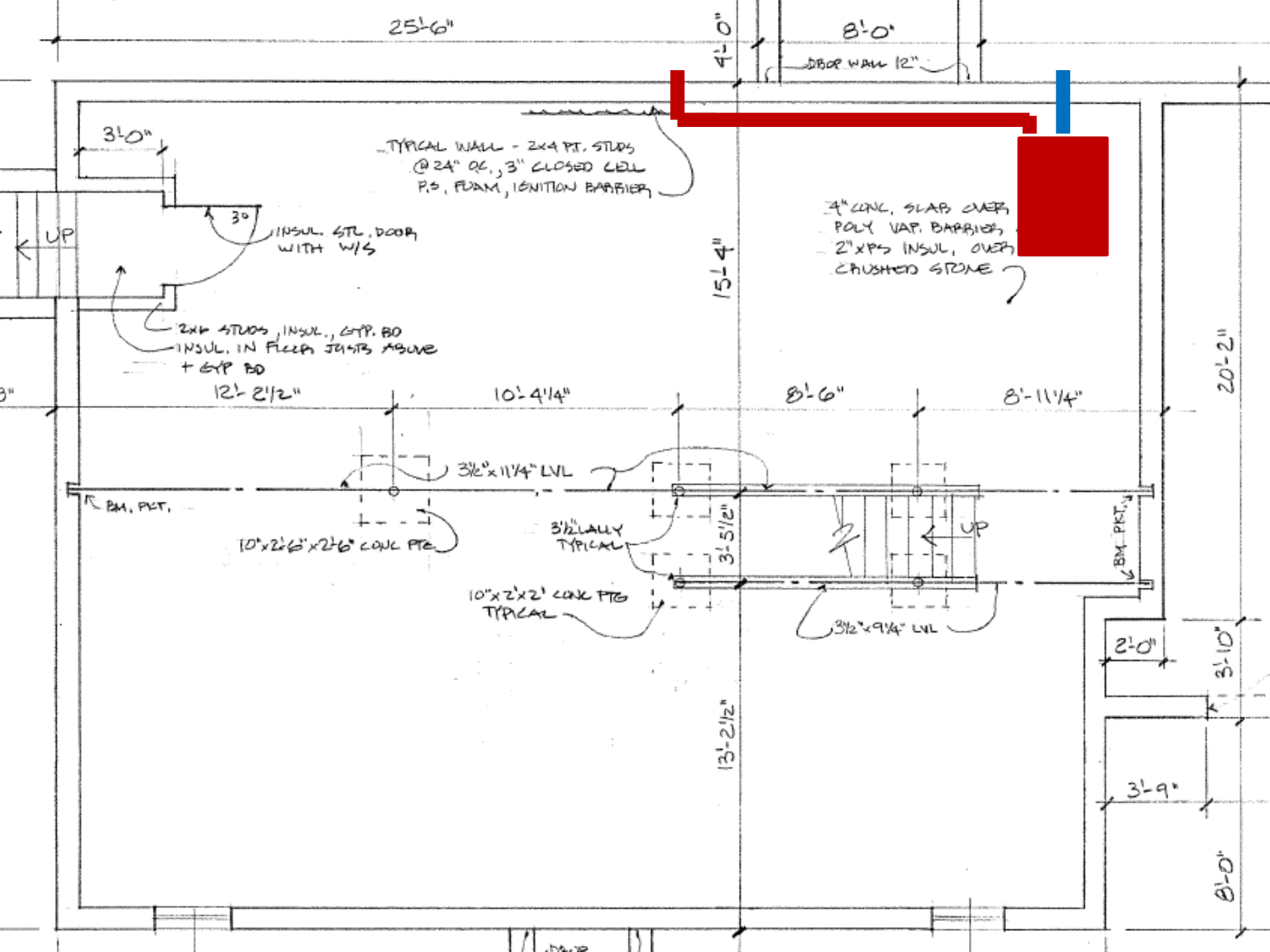
# Disadvantages: Balanced



- Cost
  - Installation: \$650 - \$3,000+
- Complexity
- Higher electric consumption



# DESIGN CONSIDERATIONS



# R403.6.1 - Ventilation Fan Efficacy (Mandatory)



| Fan Location             | Air Flow Rate<br>Min. (cfm) | Minimum<br>Efficacy<br>(cfm/watt) |
|--------------------------|-----------------------------|-----------------------------------|
| Range hoods              | Any                         | 2.8                               |
| In-line fan              | Any                         | 2.8                               |
| Bathroom/utility<br>room | 10 – 89                     | 1.4                               |
| Bathroom/utility<br>room | 90 +                        | 2.8                               |

# Costs of Ventilation: Fan Power + Space Conditioning



| Make/Model                        | CFM | Est. Ventilation Cost (year) | % of Total Energy Bill |
|-----------------------------------|-----|------------------------------|------------------------|
| Panasonic Whisper Green FV-08VKS3 | 60  | \$54                         | 2%                     |
| Panasonic Whisper Value FV-10VS1  | 60  | \$75                         | 3%                     |
| Broan-Nutone ZN80                 | 60  | \$54                         | 2%                     |
| Broan-Nutone QTRN110              | 60  | \$94                         | 3%                     |
| Fantech FR125                     | 60  | \$59                         | 2%                     |
| Fantech FR110                     | 60  | \$88                         | 3%                     |

source: Home Ventilating Institute

## R403.6.2 Ventilation Verification (Mandatory MA Amendment)



Installed performance of the system shall be tested by one of the following:

- HERS Rater
- HERS Rating Field Inspector
- BPI Certified Professional

# Measure it!



# R403.6.2 Ventilation Verification (Mandatory MA Amendment)



Photo © CLEARresult



# R403.6.3 Air-Moving Equipment (Mandatory MA Amendment)



Ventilation equipment must be certified by:

HVI (Home Ventilating  
Institute)

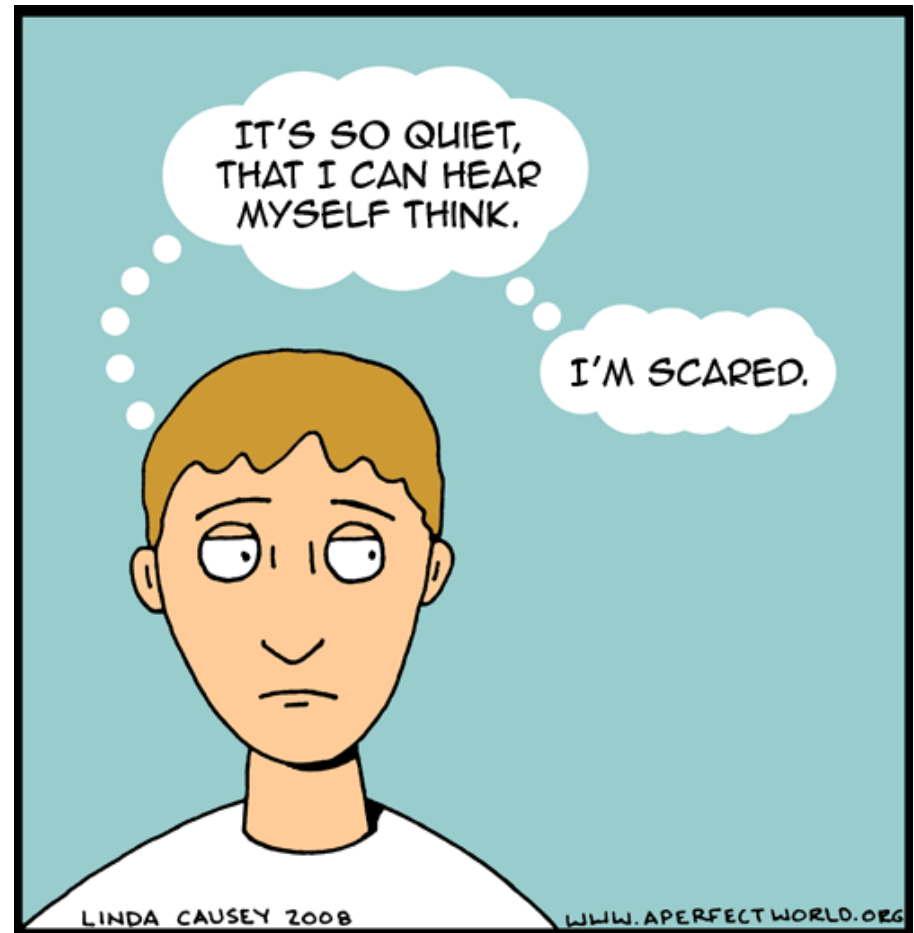
*OR*

AMCA (Air Movement  
and Control Association)



# R403.6.4 Sound Ratings (Mandatory MA Amendment)

- 1 sone or less
- Exception - Air handlers and remote fans (with 4 feet of duct)



# Bathroom Fans

## Home Ventilating Institute



| Make/Model                             | CFM | Watts | CFM/Watt | Sones | Type          |
|--|-----|-------|----------|-------|---------------|
| Panasonic<br>Whisper Green<br>FV08VKS3 | 80  | 7.5   | 10.6     | <0.3  | Ceiling Mount |
| Panasonic<br>Whisper Value<br>FV10VKS3 | 100 | 29.6  | 3.4      | 1.4   | Ceiling Mount |
| Broan-Nutone<br>ZB110                  | 30  | 3.3   | 9.1      | <0.3  | Ceiling Mount |
| Broan-Nutone<br>QTRE110                | 110 | 38.2  | 2.9      | 1.3   | Ceiling Mount |
| Fantech FR125                          | 130 | 19.2  | 6.8      |       | In-line       |
| Fantech FR110                          | 160 | 64.6  | 2.5      |       | In-line       |

# R403.6.5 Ventilation Documentation (Mandatory MA Amendment)



- Provide information to owner and occupant
- Instructions on operation and maintenance
- Label controls

# R403.6.6 Mechanical Ventilation (Mandatory MA Amend)



- Air Inlets and Exhausts
  - Inlets at least 10 feet from plumbing drainage, appliance vent outlets, exhaust hood outlets, vehicle exhaust, other contamination sources
  - Inlets shall have rodent screens with  $< \frac{1}{2}$ " mesh
  - Vents  $< 7'$  above grade will be labeled
  - No fresh air from unconditioned basement without design professional approval
- Exceptions:
  - no minimum separation distance between local kitchens/bathroom exhaust outlets and windows
  - Inlets more than 3' from dryer exhaust

# Keep Runs Short & Straight (Best Practice)



# Installation Quality (Best Practice)



Photo © CLEARresult

Photo © CLEARresult



***“Build Tight,  
Ventilate Right!”***

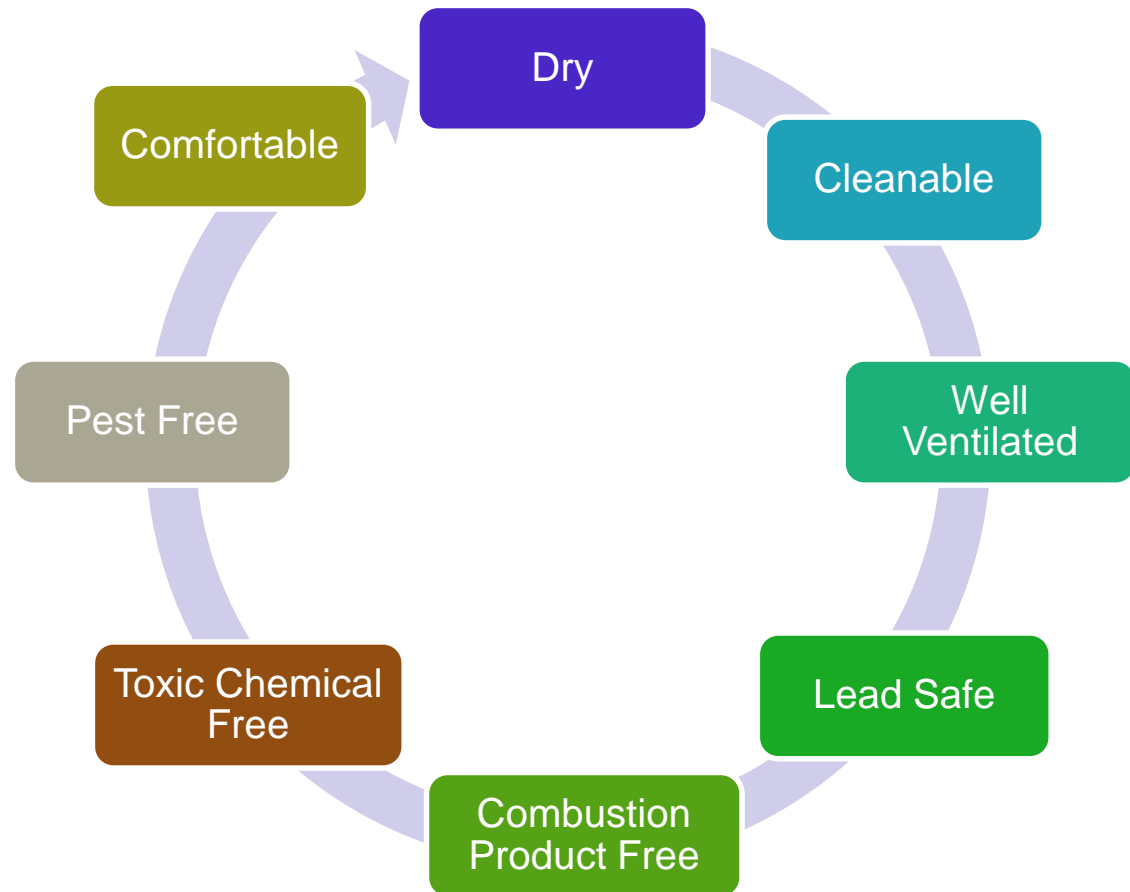


# Indoor Air Quality (IAQ)

# 8 Steps to a Healthy Home



DOE -  
Healthy &  
Affordable  
Housing



# Keep Materials Dry During Construction (Best Practice)



Photo © CLEAResult

# Keep Materials Dry During Construction (Best Practice)



Photo © CLEARresult

# Moisture Sources



- People
  - Breathing
  - Showering
  - Cooking
- Crawlspace dirt floor
- Construction materials
- “Vent free” fireplace
- Pool, greenhouse, other large sources. . .

# How Much Water?



## Daily water vapor produced by family of 4:

- Respiration and perspiration 1.7 Gal
- Showers & bathing 0.4 Gal
- Cooking 0.2 Gal
- Other activities 0.2 Gal

**Total Gallons 2.5 gal**

# Toxic Chemical Free (Best Practice)



Photo © CLEARresult

# Combustion Product Free (Best Practice)



Photo © CLEAResult



# Use Power Vented or Direct Vented Appliances (Best Practice)



Photo © CLEARresult

## R402.4.4 Rooms Containing Fuel-burning Appliances (Mandatory)



- Atmospheric combustion equipment with dedicated combustion air ducted from outside must be located outside the building envelope. (i.e., in a thermally isolated room)
- Room insulated to Table R402.1.2 and air sealed
- Exceptions:
  - Direct vent appliances
  - Fireplaces and stoves complying with R402.4.2 and Section R1006 of IRC

# R402.4.2 Fireplaces (Mandatory)



New wood burning fireplaces shall have:

- "tight-fitting" flue dampers OR doors
- outdoor combustion air (per IRC)



## IRC M1503.4 Makeup Air Required



“Exhaust hood systems capable of exhausting in excess of 400 CFM shall be provided with makeup air at a rate approximately equal to the exhaust air rate. Such makeup air systems shall be equipped with a means of closure and shall be automatically controlled to start and operate simultaneously with the exhaust system.”

# Achieving Good Indoor Air Quality (Best Practice)



1. Eliminate sources of contaminants
2. Separate sources from people
3. Exhaust contaminants
4. Dilute contaminants with fresh outdoor air
5. Filter interior air

# HVAC

## R403.3 Ducts

There is a better way to treat your ducts. . .



## R403.3.2 Duct Sealing (Mandatory)

Ducts, air handlers, and filter boxes shall be sealed



Photo © CLEARResult



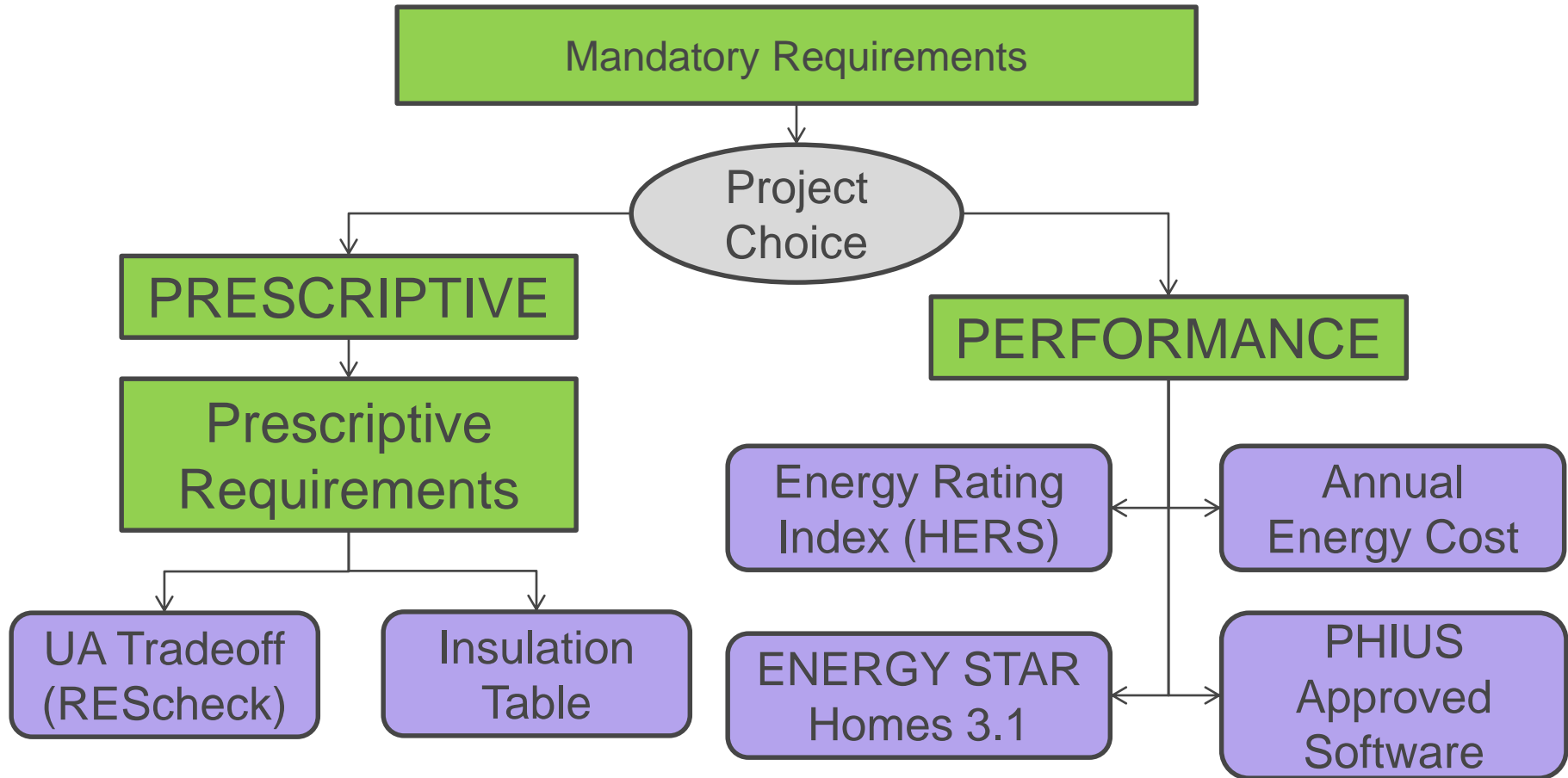
# R403.3.1 Duct Insulation (Prescriptive)

- Attic ducts
  - Based on duct diameter
  - $\geq 3''$  R-8
  - $< 3''$  R-6
- Other spaces
  - $\geq 3''$  R-6
  - $< 3''$  R-4.2
- Applies to supply and return
- Exception: Ducts or portions thereof completely the thermal envelope



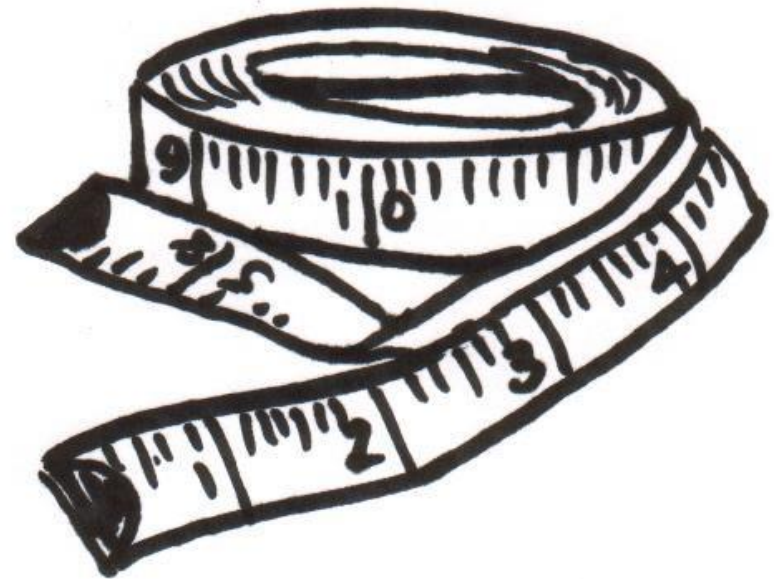
# R403.3.3

## Duct Testing (Mandatory)



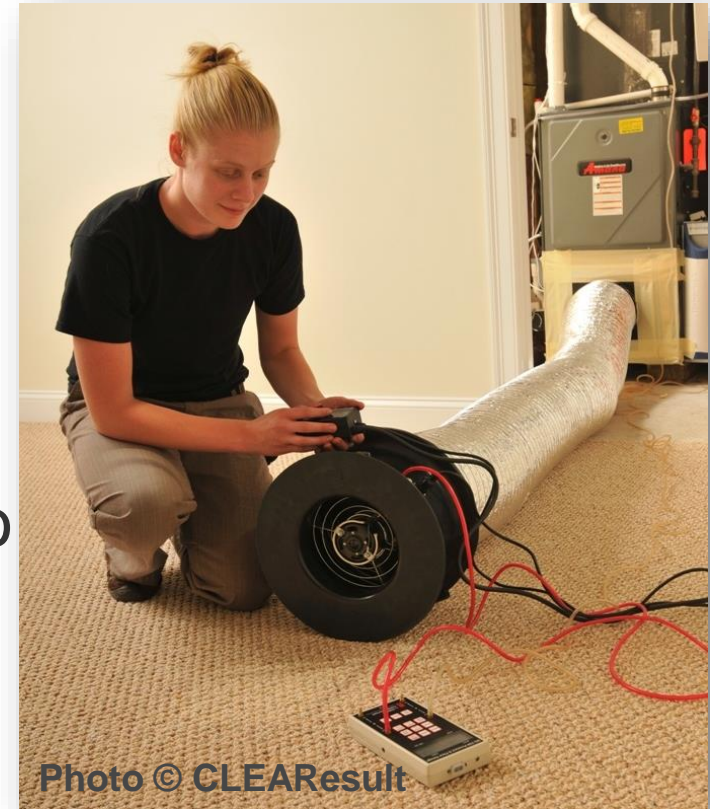
“Things that are measured tend to improve.”

(J.K. Galbraith)



# R403.3.3 Duct Testing (Mandatory)

- Post-construction or rough-in testing and verification shall be done by a HERS Rater, HERS Rating Field Inspector, or an applicable BPI Certified Professional. (MA Amendment)
- Written report by testing party to building official
- Exception if ducts and air handlers entirely within conditioned space



# R403.3.4 Duct Leakage (Prescriptive)

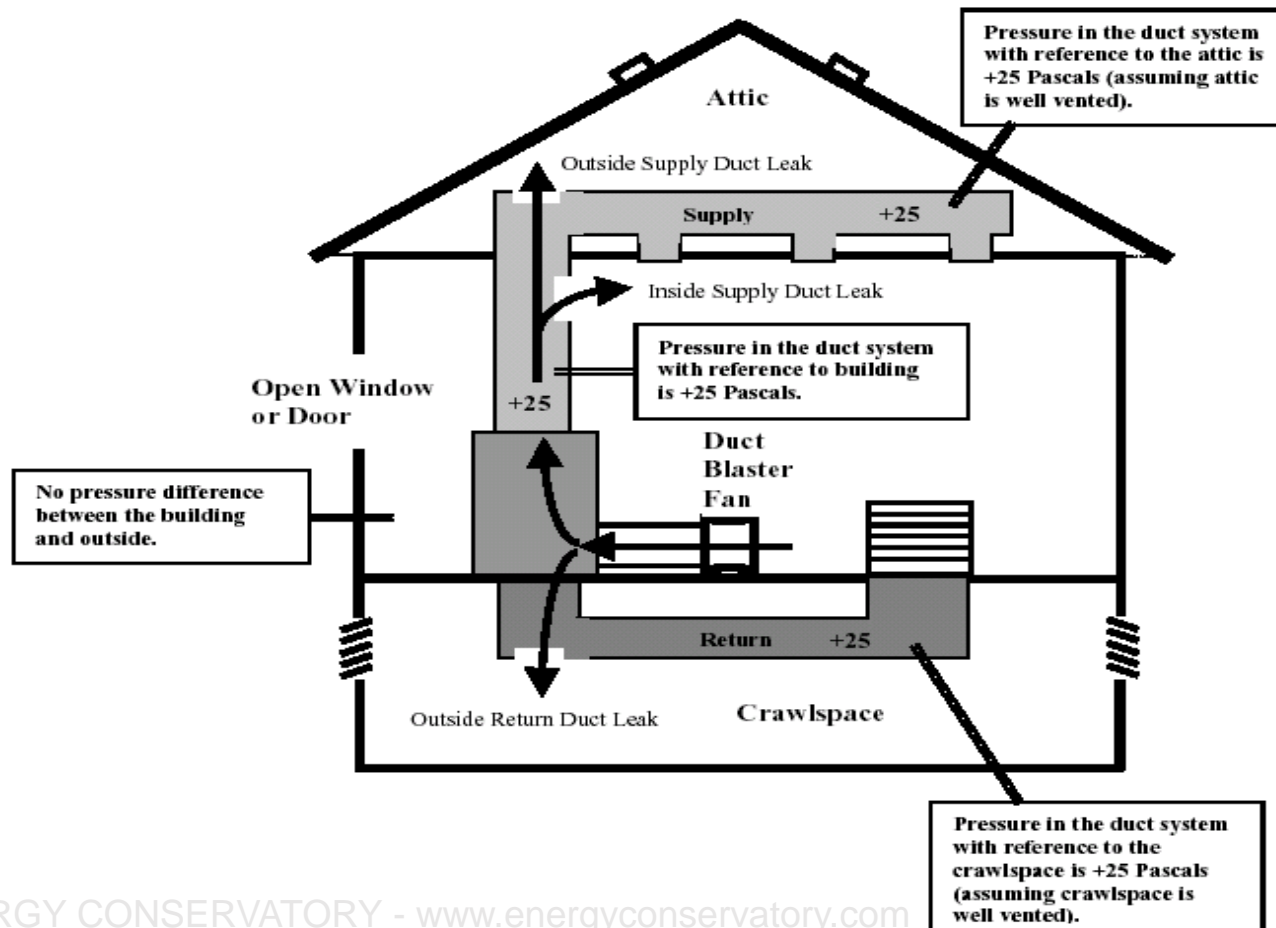


| Test Options      |                                 |     |
|-------------------|---------------------------------|-----|
| Rough-in          | Total Leakage                   | 4   |
|                   | Total Leakage w/out air handler | 3   |
| Post-Construction | Total Leakage                   | 4   |
|                   | Leakage to Outside              | n/a |

Max CFM per 100 sq. ft. of conditioned floor area

# Total Leakage

Figure 1: Illustration of Total Leakage Pressurization Test  
(at a Test Pressure of 25 Pascals)  
with Duct Blaster Fan Installed at Air Handler



# Code Allowed Leakage Area



| Home Size (ft <sup>2</sup> ) | Leakage Flow (CFM <sub>25</sub> ) | Leakage Area (in <sup>2</sup> ) | Approximately the Size of... |
|------------------------------|-----------------------------------|---------------------------------|------------------------------|
| 1,000                        | 40                                | 8                               | Two sticky notes             |
| 2,000                        | 80                                | 15                              | Note card                    |
| 3,000                        | 120                               | 23                              | 4x6 picture                  |
| 5,000                        | 200                               | 38                              | Envelope                     |

# Keep Ducts Out of Unconditioned Spaces (Best Practice)



Photo © CLEARresult



# 5 Strategies to Bring Ducts Inside



- Dropped soffits
- Inverted soffits
- Conditioned attic
- Open web trusses
- Conditioned basement

# Conditioned Attic



Photo © CLEAResult

# Avoid Ducts, Duct Testing...



Photo © CLEAResult

# Why Bring the Duct Systems Inside?



- Eliminate need to insulate and test
- Improve Comfort and indoor air quality
  - Reduce callbacks
- Ensure load calculation works
  - Do not lose capacity

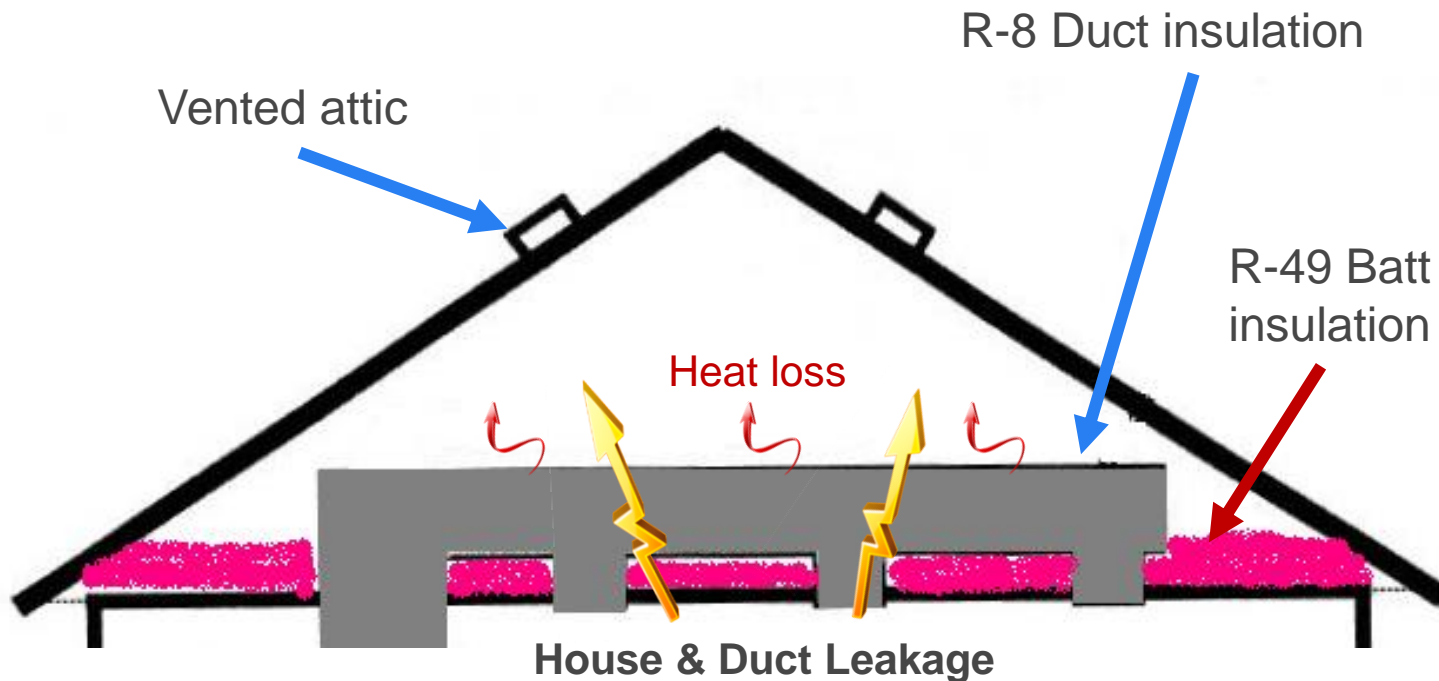


- Supply air leaks – heating unconditioned space
- Return air leaks – condition uncontrolled outdoor air
- Pressure imbalance drives up house leakage
- Extreme temperatures in attic
- Standby losses



# Efficiency Penalties - System Off

- Pathway for building air leakage
- Ductwork is less insulated

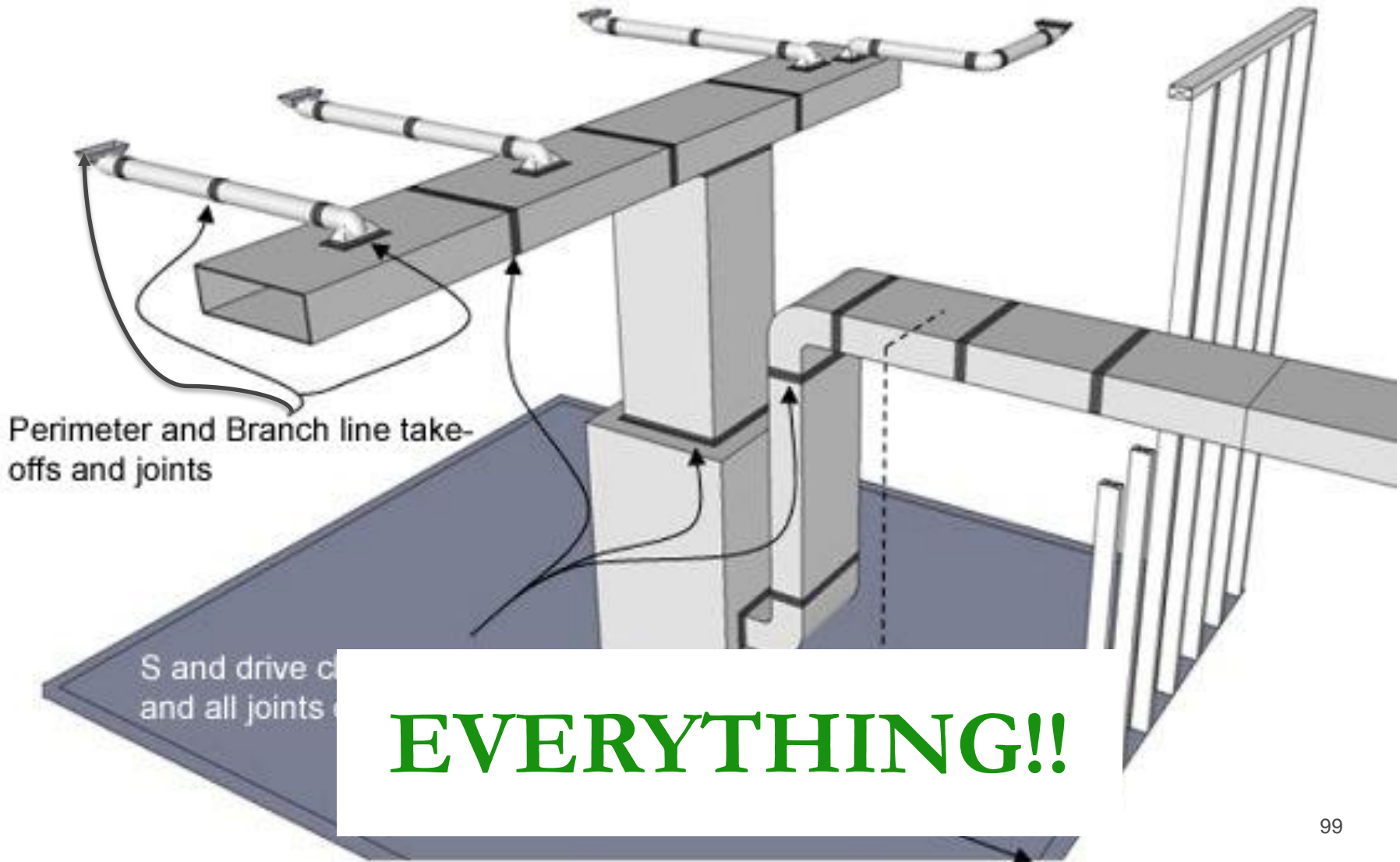


# R403.3.5 Building Cavities (Mandatory)

Building framing cavities **shall not be used** as ducts or plenums (supply OR return)



# What to Seal?





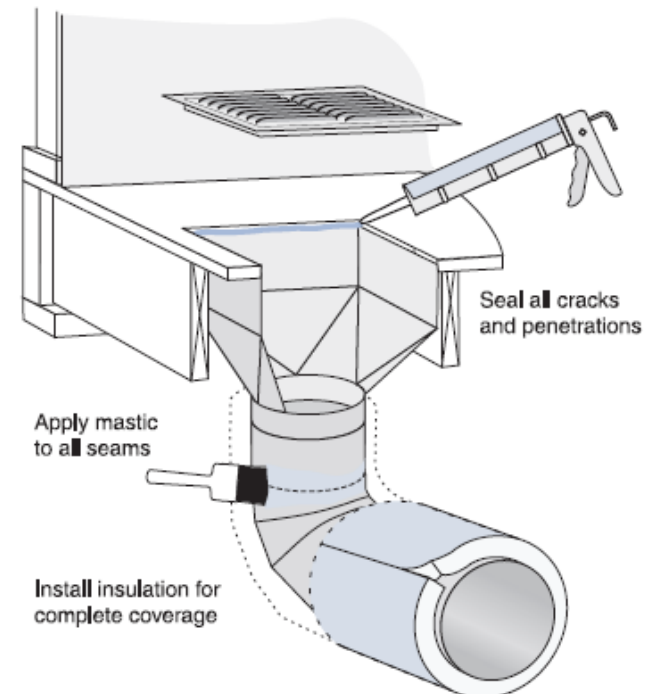
# Examples of Duct Sealing Materials



# Largest Sources of Leakage



- Missing and disconnected sections
- Branch takeoffs from trunk ducts
- Folded corners of boots
- Section connections
- Swivel elbows
- Boot to finish
- Filter racks



# Application of Duct Mastic



Photo © CLEAResult

# Nice Insulation, But What's Underneath?

Photo © CLEAResult

A trunk in the attic



# Finger Joint at Takeoff

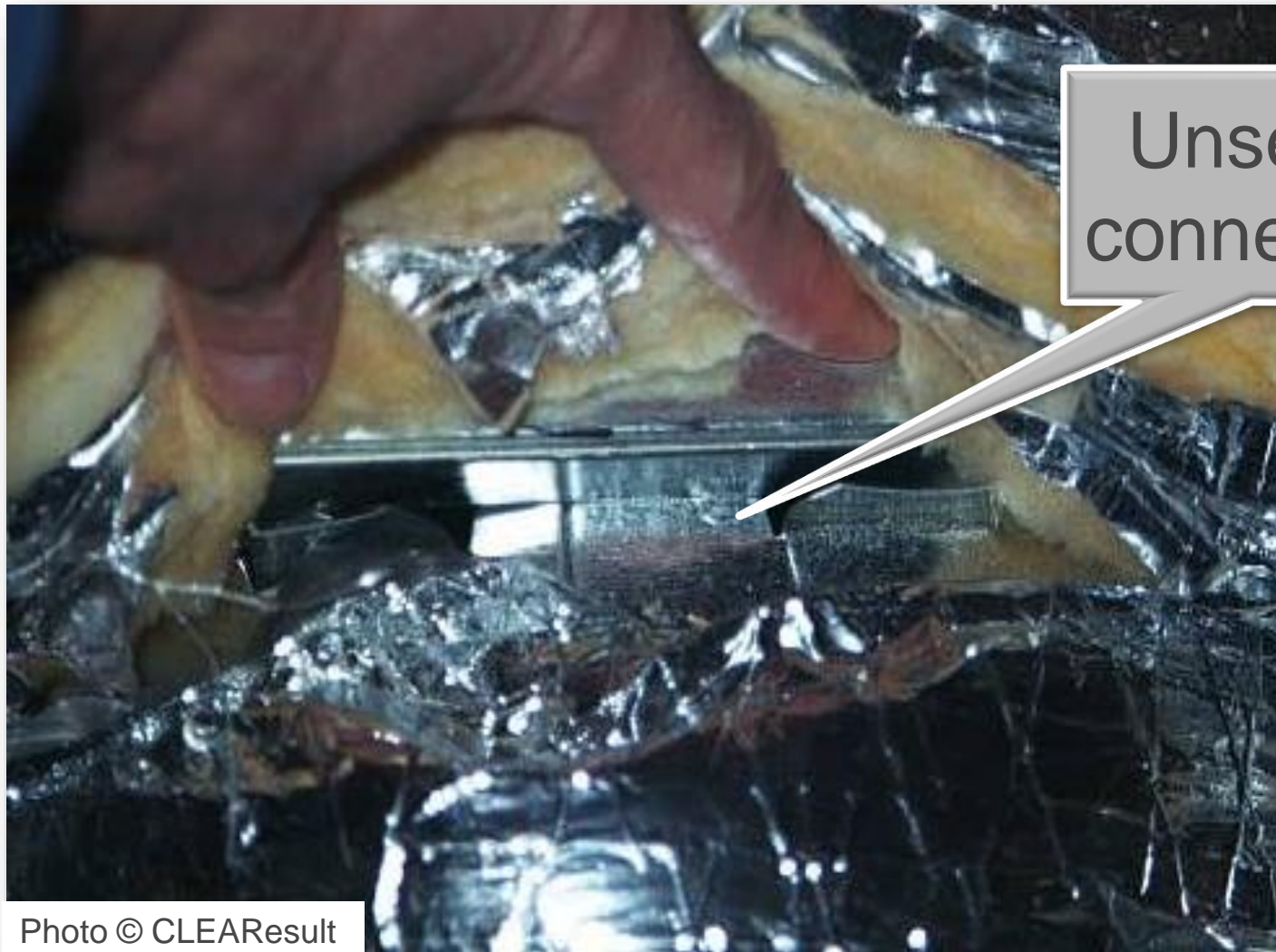


Photo © CLEAResult

# Sealed Takeoff Connection



Photo © CLEARresult

# Sealed Trunk



Photo © CLEARResult

# Unsealed Boot and Supply Line



Unsealed joints

Unsealed  
factory seams



# Sealed Swivel Joints



Dirty fiberglass from  
prior air leakage

Photo © CLEARresult

# Register Boots Sealed to Finish



Photo © CLEARResult



Photo © CLEARResult

Boot not sealed to drywall

# R403.3.2

## Filter Slots Shall Be Sealed (**Mandatory**)



Photo © CLEARResult



Photo © CLEARResult

# Seal Metal to Metal

Gasketed connection sealed to insulation instead of trunk

Insulation should be cut wide to allow metal to metal connection – then sealed with mastic

Photo © CLEARresult

# Unsealed Air Handler Penetration



Open  
knock-out

Photo © CLEAResult

## R403.3.2.1

### Sealed Air Handler (Mandatory)



Air handler leakage rate no more than 2% of design flow rate, per manufacturer's designation



Photo © CLEAResult

# System Design



- Old Way
  - Oversized system – Rule of Thumb
  - Small ducts
  - Worked- Why?
    - Oversized system made up for duct losses
- New Way
  - Size system (Manual J)
  - Select correct system (Manual S)
  - Seal and insulated ducts (2015 IECC requirement)
  - Design ducts – will be bigger (Manual D)

## R403.7

# Equipment Sizing (Mandatory)



- Heating and cooling equipment shall be *sized according to ACCA Manual S based on building loads calculated with ACCA Manual J or other approved heating and cooling calculation methodologies*
- New or replacement heating/cooling equip shall have an efficiency rating equal to or greater than the minimum required by federal law for the geographic location where equipment is installed



# ACCA Manual J Residential Load Calculation



| FORM J1 <sub>AF</sub> • ABRIDGED VERSION of MANUAL J, 8TH EDITION  |                                    |  |                              |                                      |                                  |   |          |              |              |       |     |
|--|------------------------------------|--|------------------------------|--------------------------------------|----------------------------------|---|----------|--------------|--------------|-------|-----|
| Project  | Sam and Ruthie                     |  |                              | Design State & City                  | New York                         | Albany CO                                   |          |              |              |       |     |
| Indoor Design Heating db   | 70                                 | Outdoor 99% db   |                              | 1                                    | HTD                              |   | 69       |              |              |       |     |
| Indoor Design Cooling db   | 75                                 | Outdoor 1% db  |                              | 98                                   | CTD                              |   | 13       |              |              |       |     |
| Indoor Design Cooling RH   | 50%                                | Grains Difference  |                              | 30                                   | Daily Range                      |   | Medium   |              |              |       |     |
| Latitude   | 42                                 | Elevation  |                              | 275                                  | ACF                              |   | 0.993    |              |              |       |     |
| Glass Direction  |                                    | Construction Detail                                      |                              |                                      | Heating HTM                      | Cooling HTM                                 | Net Area | Heating BTUH | Cooling BTUH |       |     |
| Partition Ceilings   | c                                  |  |                              |                                      |                                  |   |          |              |              |       |     |
|  | d                                  |  |                              |                                      |                                  |   |          |              |              |       |     |
|  | e                                  |  |                              |                                      |                                  |   |          |              |              |       |     |
| 11   | Passive Floors                     | a  | 19A-0cp,None,c               |                                      | 2.21                             | 1.45  | 443      | 980          | 640          |       |     |
|  |                                    | b  |                              |                                      |                                  |   |          |              |              |       |     |
|  | Exposed Floors                     | c  | 20P-10 R-10 Board Insulation |                                      | 5.59                             | 1.05  | 205      | 1146         | 216          |       |     |
|  | Slab (Perimeter Ft.)               | d  | 22A-pm no insulation slab    |                                      | 81.42                            |   | 24       | 1954         |              |       |     |
|  | Basement Floor                     | e  | 21A-20 no insulation slab    |                                      | 1.86                             |   | 86       | 160          |              |       |     |
|  | Partition Floors                   | f  |                              |                                      |                                  |   |          |              |              |       |     |
|  |                                    | g  |                              |                                      |                                  |   |          |              |              |       |     |
| 12   | Infiltration                       | Envelope Leakage   | Average                      | Heated & Cooled Floor Area = Sq. Ft. | 1420                             | Above Grade = Cu. Ft.                       |          | 960          | 2049         | 52    |     |
|  |                                    | No. of Fireplaces  | 1                            |                                      |                                  |   |          |              |              |       |     |
| 13   | Internal Gains                     | Number of Bedrooms                                       |                              |                                      | 3                                | Occupants                                   |          | 4            |              | 920   |     |
|  |                                    | Appliance - 0 BTUH                                       |                              |                                      |                                  |   |          |              |              |       |     |
| 14   | <b>Sub Totals</b>                  |  |                              |                                      |                                  |   |          |              | 54725        | 21072 |     |
| 15   | Duct Loss & Gain                   | 7F-Ducts in Conditioned Space                            |                              |                                      |                                  |   |          |              |              |       |     |
|  |                                    | R-Value = 2  | Leakage Class .35/.70        |                                      |                                  |   |          |              |              |       |     |
|  |                                    | Installed Square Feet of Surface or Default = 1          |                              | Supply                               | 1                                | Return                                      | 1        |              |              |       |     |
| 16   | Ventilation                        | Combustion Air From Conditioned Space                    |                              |                                      | <input type="checkbox"/> Furnace | <input type="checkbox"/> Water Heater       | 25 CFM   |              | 25           | 1883  | 355 |
| 19   | Blower Heat Gain                   | Manufacturer's performance data has blower heat discount |                              |                                      |                                  |   |          |              |              |       |     |
| 20   | <b>Total Sensible Loss or Gain</b> |  |                              |                                      |                                  |   |          |              | 56608        | 21427 |     |
| <p style="text-align: center; color: red;">                     Enter Company Name Here<br/>                     Enter Company Address Here<br/>                     Enter Company City, State and Zip Code Here<br/>                     Enter Company Phone Numbers Here<br/>                     Enter Website or Email Address Here                 </p> |                                    |  |                              |                                      | 21                               | Latent Infiltration load for cooling        |          |              |              | 75    |     |
|  |                                    |  |                              |                                      |                                  | Latent load for occupants                   |          |              |              | 800   |     |
|  |                                    |  |                              |                                      |                                  | Latent load for plants                      | Small    | Medium       | Large        | 2     | 60  |
|  |                                    |  |                              |                                      |                                  |   |          |              |              |       |     |
|  |                                    |  |                              |                                      |                                  | Latent load for duct in unconditioned space |          |              |              |       |     |
| Latent ventilation load for cooling  |                                    |  |                              | 506                                  |                                  |   |          |              |              |       |     |
| <b>Total Latent Gain</b>   |                                    |  |                              |                                      |                                  |   |          |              | 1441         |       |     |

# Oversized



## Right Sized



**Load Short Form**  
*Entire House*

Job:  
Date:  
By:

### Design Information

|                             |            |                |                      |                                   |
|-----------------------------|------------|----------------|----------------------|-----------------------------------|
|                             | <b>Htg</b> | <b>Clg</b>     |                      | <b>Infiltration</b>               |
| Outside db (°F)             | 12         | → 96 <b>88</b> | Method               | Simplified                        |
| Inside db (°F)              | 65         | → 70 <b>75</b> | Construction quality | → Loose <b>Average</b>            |
| Design TD (°F)              | 53         | 26             | Fireplaces           | → 2 (Semi-loose) <b>1 (Tight)</b> |
| Daily range                 | -          | L              |                      |                                   |
| Inside humidity (%)         | 30         | 50             |                      |                                   |
| Moisture difference (gr/lb) | 19         | 57             |                      |                                   |

| ROOM NAME         | Area (ft²) | Htg load (Btuh) | Clg load (Btuh) | Htg AVF (cfm) | Clg AVF (cfm) |
|-------------------|------------|-----------------|-----------------|---------------|---------------|
| Entire House      | 2400       | 50833           | 33058           | 1517          | 1517          |
| Other equip loads |            | 0               | 0               |               |               |
| Equip. @ 1.01 RSM |            |                 | 33256           |               |               |
| Latent cooling    |            |                 | 12092           |               |               |
| <b>TOTALS</b>     | 2400       | → 50833         | → 45348         | 1517          | 1517          |
|                   |            | <b>33210</b>    | <b>20030</b>    |               |               |

# Reviewing Calculation Inputs



- Square footages
  - Wall area usually within a few hundred sq. ft. of floor area
  - Ceiling area vs. footprint
- Orientation
- Window areas (10% – 25% window/wall ratio)
- U-values: windows, doors
- R-values: walls, ceiling, floors
- Air infiltration
- Design temperatures
- Duct gains should not be zero (unless ductless/conditioned space)
- Do the inputs match the building?

# ACCA Manual D Residential Duct Design

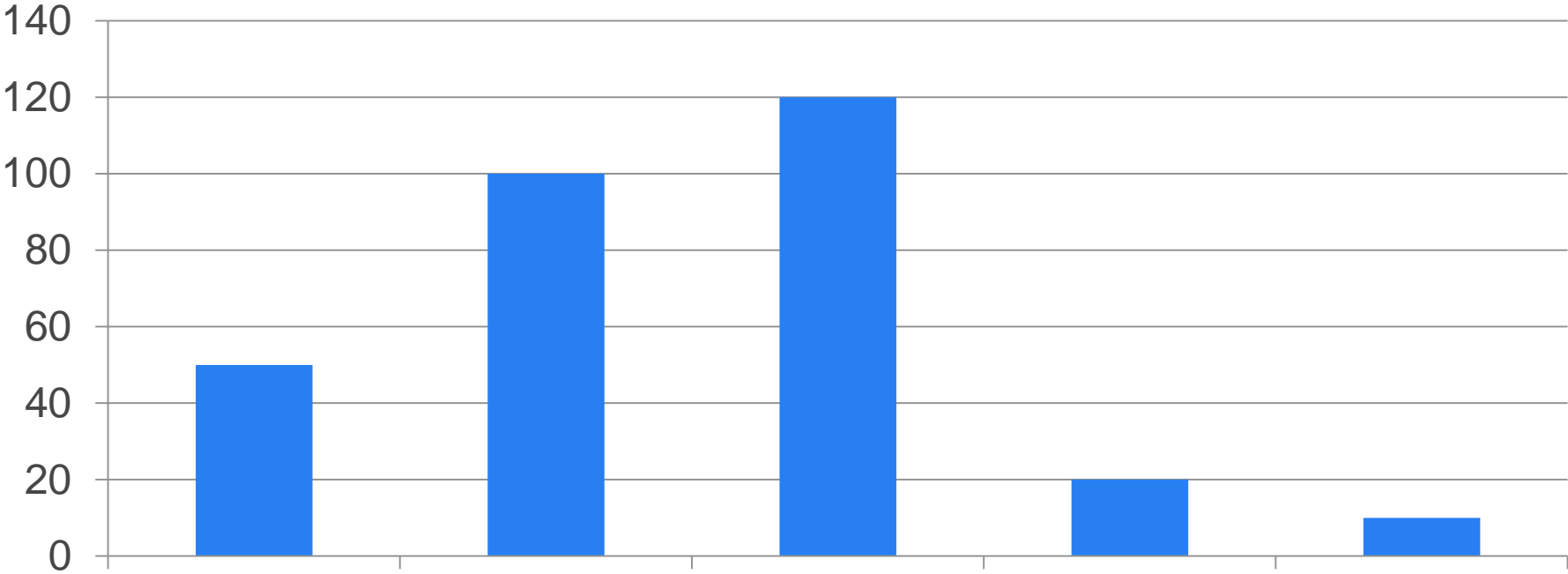


# Moving Air Likes Smooth Turns

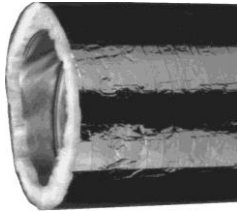


Brian Wolfe CC BY 2.0

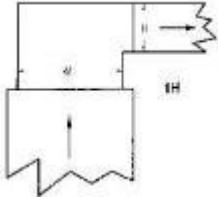
# Equivalent Length



50'



50', 15% compressed



# Flex Duct



Photo © CLEARresult

- Straight ducts
- Streamlined transitions
- High radius elbows and/or vanes
  - Radius  $\geq$  1/3 duct width
- Takeoffs 4' from fans or transitions
- Flexible connectors to isolate noise



# R403.1 Controls (Mandatory)



- Heating and cooling systems
  - R403.1.1
    - At least one thermostat per system
    - Primary heating & cooling system must be programmable
  - R403.1.2 Heat pump supplementary heat
    - Controls that prevent supplementary heat from operating if compressor can meet load
      - Except during defrost cycle

# R403.2 Hot water boiler outdoor temperature setback (New)

- One or two pipe hot water boilers shall have an outdoor setback control that lowers the boiler water temperature based on the outdoor temperature.

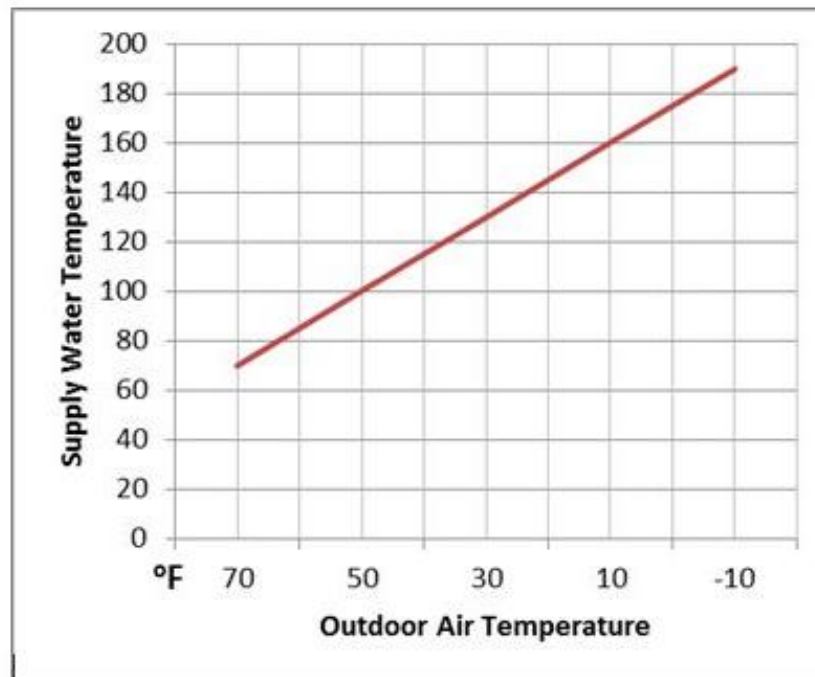
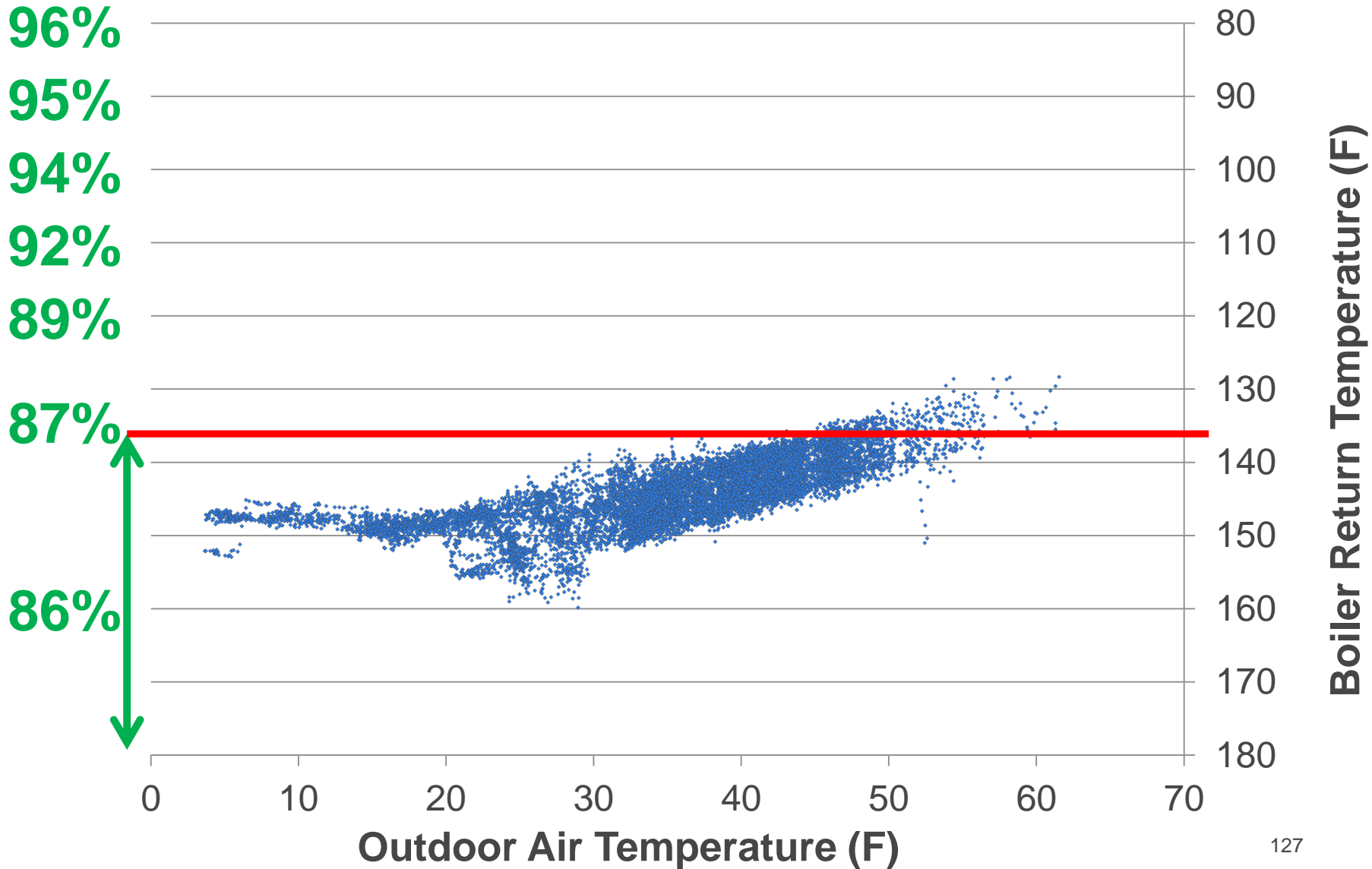


image courtesy of Weil-McLain

# Boiler Efficiency



# R403.4 Mechanical System Piping Insulation (Mandatory)



- R-3

- Below 55°
- Above 105°



- R403.4.1 Exposed to the weather – protect from damage
  - Shield from sunlight
  - Protect from moisture, equipment maintenance, wind
  - Adhesive tape not permitted

# R403.5 Service Hot Water Systems



- R403.5.1
  - Heated water circulation and temperature systems
- R403.5.2
  - Demand recirculation systems (new in 2015)
- R403.5.3
  - Hot water pipe insulation
- R403.5.4
  - Drain water heat recovery (new in 2015)

# R403.5.1 Heated Water Circulation & Temperature Maintenance Systems



- R 403.5.1 (Mandatory)
  - Automatic controls, temp sensors and pumps shall be accessible
  - R403.5.1.1 Circulating hot water systems
    - Shall have circulation pump(s) - gravity and thermo-syphon systems prohibited
    - Control shall turn pump on when there is hot water demand
    - Control shall turn pump pump when set temp is reached and when there is no hot water demand

## R403.5.2 Demand recirculation system



- Water distribution system with one or more recirculation pumps that pump water from a heated water supply pipe back to the heated water source through a cold water supply pipe. Controls required.
  - Control shall turn pump on when there is hot water demand
  - Water entering cold water pipe limited to 104°F

# R403.5.3 Hot water pipe insulation (Prescriptive)



- R-3 pipe insulation required for:
  - Piping  $\geq \frac{3}{4}$ " nominal diameter
  - Piping serving > 1 dwelling unit
  - Piping located outside conditioned space
  - Piping from water heater to distribution manifold
  - Piping located under a floor slab
  - Buried in piping
  - Supply and return piping in recirculation systems other than demand recirculation systems
  
- no more maximum run length table (2015 update)



## R403.5.4 Drain water heat recovery units



- Requirements apply only if a heat recovery unit is installed
- Comply with CSA B55.2, tested in accordance with CSA B55.1
- Potable water-side pressure limits
  - Pressure loss < 3psi for individual units connected to 1-2 showers
  - Pressure loss < 2 psi for individual units connected to 3 or more showers

# R404

## Lighting Equipment (Mandatory)

- R404.1 Minimum **75%** high-efficacy lamps in permanent fixtures
  - Exception: low voltage lighting



# Mass Save<sup>®</sup> Energy Code Technical Support



## Project Specific Code Assistance

- MA code officials
- Design professionals
- Contractors
- Material suppliers
- Other



Toll-free energy code support

**855-757-9717**

Phone assistance

Office visits

Project site visits

- **Individually Metered Low-Rise New Construction**
  - Performance Path – based upon a % improvement over the MA baseline – incentives up to \$4,500
  - Prescriptive Path – incentives up to \$4,500 for measures beyond MA baseline
- **Master Metered and High-Rise New Construction**
  - Incentives based upon modeling by Program Manager

We also offer incentives and rebates for existing buildings as well. Please visit [www.MassSave.com](http://www.MassSave.com) for the details.

# Massachusetts Gas Heating Rebates



| Heating Equipment   | Efficiency Requirement | Rebate |
|---------------------|------------------------|--------|
| Boiler              | AFUE 95 or greater     | \$1500 |
| Boiler              | AFUE 90 or greater     | \$1000 |
| Furnace w/ECM Motor | AFUE 97 or greater     | \$600  |
| Furnace w/ECM Motor | AFUE 95 or greater     | \$300  |

| Water Heaters                   | Efficiency Requirement | Rebate |
|---------------------------------|------------------------|--------|
| Tankless w/ electronic ignition | EF .94 or greater      | \$800  |
| Condensing                      | TE 95% or greater      | \$500  |
| Tankless w/ electronic ignition | EF .82 or greater      | \$500  |
| Indirect w/ gas boiler          |                        | \$400  |
| ENERGY STAR storage             | EF .67 or greater      | \$100  |
| Combo condensing on-demand      | AFUE 90+               | \$1200 |
| Combo condensing on-demand      | AFUE 95+               | \$1600 |
| HRV                             | Efficiency Requirement | Rebate |
| Heat Recovery Ventilator        |                        | \$500  |

# Massachusetts Oil and Propane Heating Rebates



| Oil System              | Efficiency Requirement | Rebate |
|-------------------------|------------------------|--------|
| Furnace with ECM Blower | AFUE 86% or greater    | \$350  |
| Hot Water Boiler        | AFUE 86% or greater    | \$500  |

| Propane System                           | Efficiency Requirement | Rebate |
|--|------------------------|--------|
| Furnace with ECM Blower                  | AFUE 95% or greater    | \$750  |
| Hot Water Boiler                         | AFUE 90% or greater    | \$1500 |
| Condensing Boiler w/ On Demand Hot Water | AFUE 90% or greater    | \$1500 |
| Condensing Boiler w/ On Demand Hot Water | AFUE 95% or greater    | \$1750 |

# Massachusetts AC and Heat Pump



| Ducted Equipment            | Efficiency Requirement | Rebate |
|-----------------------------|------------------------|--------|
| Central AC                  | ≥16 SEER; ≥13 EER      | \$250  |
| Ducted Air Source Heat Pump | ≥16 SEER; ≥8.5 HSPF    | \$250  |
| Ducted Air Source Heat Pump | ≥18 SEER; ≥9.6 HSPF    | \$500  |

| Ductless Equipment            | Efficiency Requirement | Rebate<br>Per indoor unit |
|-------------------------------|------------------------|---------------------------|
| Ductless Mini-Split Heat Pump | ≥18 SEER; ≥10 HSPF     | \$100                     |
| Ductless Mini-Split Heat Pump | ≥20 SEER; ≥12 HSPF     | \$300                     |

# MA RNC Tiers & Incentives



## 2017 Incentives Per Unit – through June 30

| Tier     | Savings over Baseline | Single Family | Multifamily (2-99 units) |
|----------|-----------------------|---------------|--------------------------|
| Tier I   | 15-29.9%              | \$750         | \$650                    |
| Tier II  | 30-44.9%              | \$1,250       | \$1,150                  |
| Tier III | 45+%                  | \$4,500       | \$2,000                  |

- Beginning July 1 incentives will be paid using a “blended savings approach” per kWh of electricity and MMBTU of natural gas
- Minimum 5% below baseline home
- Maximum \$10,000 per unit



# Thank you!



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