Office of Education and Data Management

Spring 2018 Career Development

January 2018

Inspecting the Thermal Envelope and Practical Whole House Ventilation Compliance Assessment

Christopher Larkum, Owner, Dartmouth Residential Energy Consulting

Inspecting the Thermal Envelope

Table 402.4.1.1

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Dartmouth Residential Energy Consulting

Objectives:

- Review of Table 402.4.1.1 in the Residential 2015 IECC
  - Special Focus
    - Common, overlooked, and high impact items

Table 402.4.1.1– The Air Barrier & Air Sealing Table

For builders, understanding and following this table is the difference between passing the Blower Door Test and *failing*:

Delays

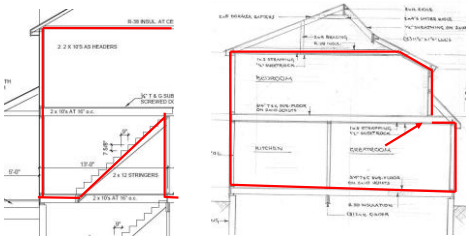
Costly repairs

Air Sealing and Air Barriers are Important

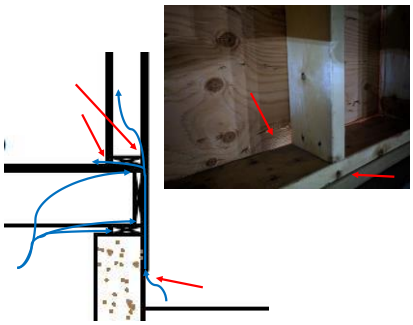
Fiberglass is a Filter

General Requirements

General requirements	A continuous air barrier shall be installed in the building envelope. The exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed.	Air-permeable insulation shall not be used as a sealing material.



General Requirements – Breaks in the Air Barrier



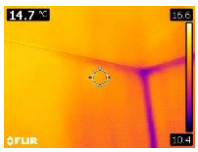
General Requirements – Air Permeable Material Used to Seal Air Barrier

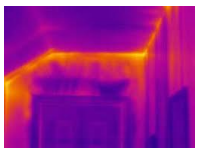
Ceilings

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

Ceilings – Double Walls

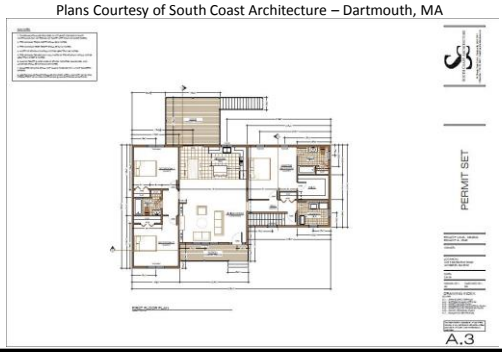
Sealing Top Plates – Gaps in the Air Barrier





Top Plates in Perspective

Plans Courtesy of South Coast Architecture – Dartmouth, MA



Top Plates in Perspective

This home has 188 lineal ft of exterior wall

Top Plates in Perspective

This home has 188 lineal ft of interior partitions

Top Plates in Perspective

This example assumes an average 1/8" gap at all connections between top plates and drywall

No big deal, right?

Top Plates in Perspective

Total lineal footage of top plate to drywall
- 188 + (188*2) = 564ft

Total in^2 = Total footage x gap
- 564 x (1/8) = 70.5in^2

Total ft^2 = Total in^2 x (1/12)
- 70.5/12 = 5.8ft^2

This house has a **5.8ft^2 hole in the attic**, just in top plates
- before attic hatches, lights, HVAC boots, chases, etc.

Walls

Walls	The junction of the foundation and sill plate shall be sealed. The junction of the top plate and the top of exterior walls shall be sealed. Knee walls shall be sealed.	Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance of R-3 per inch minimum. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.

Walls

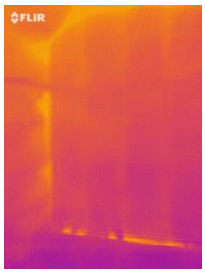
Truss walls especially over garages

No Air Barrier on Back Side

No Top Plate

No Bottom Plate

Walls



Walls

Walls



Walls – Air Barrier Installed before Insulation


Windows

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

Doors installed after draft-stopping

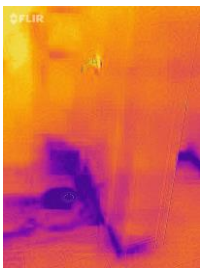
- Garage Door
- Basement Stairwell Door
- Attic Doors
- Attic Scuttles
- Pulldown Stairs
- Attic Hatches

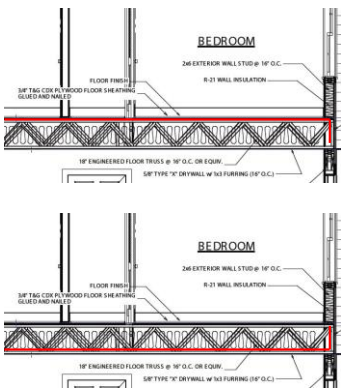
Rims

Rim joists	Rim joists shall include the air barrier.	Rim joists shall be insulated.

Floors

Floors (including above garage and cantilevered floors)	The air barrier shall be installed at any exposed edge of insulation.	Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of subfloor decking, or floor framing cavity insulation shall be permitted to be in contact with the top side of sheathing, or continuous insulation installed on the underside of floor framing and extends from the bottom to the top of all perimeter floor framing members.





Contact with the Subfloor

"Insulation Tub"

Floors

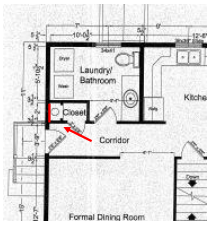
Crawl Space Walls

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

Shafts, Penetrations, Chases

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

Shafts, Penetrations, Chases

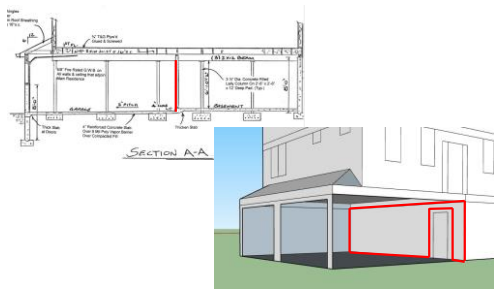


Narrow Cavities

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.

Garage Separation (Basement, Attic)

Garage separation	Air sealing shall be provided between the garage and condtioned spaces.



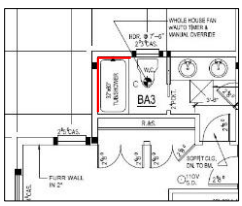
Plumbing and Wiring

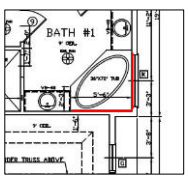
Plumbing and wiring		Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation that on installation readily conforms to available space shall extend behind piping and wiring.

Showers and Tubs on Exterior Walls

Shower/tub on exterior wall	The air barrier installed at exterior walls adjacent to showers and tubs shall separate them from the showers and tubs.	Exterior walls adjacent to showers and tubs shall be insulated.

Showers and Tubs on Exterior Walls





Showers and Tubs on Exterior Walls

Electrical Boxes on Exterior Walls

Electrical/phone box on exterior walls	The air barrier shall be installed behind electrical or communication boxes or air-sealed boxes shall be installed.

HVAC Boots

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

Concealed Sprinklers

Concealed sprinklers	When required to be sealed, concealed fire sprinklers shall only be sealed in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.

Air Sealing and Air Barriers

Additional illustrations, guidance, and resources are available

- 2015 IECC Residential Requirments (DOE)
- Energy Star v.3 TERC Guidebook

Questions and Discussion

Thank you

Practical Whole House Ventilation Assessment

Chris Larkum

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Dartmouth Residential Energy Consulting

Objectives:

- Whole House Ventilation
  - Benefits and Requirement
  - Special Focus on Compliance Assessment

Indoor Air Quality (IAQ) and Whole-House Mechanical Ventilation

What is the goal of Whole-House Mechanical Ventilation?

- Deliver predictable fresh air to the living space
- Predictably exhaust stale air and contaminates from the living space

What are contaminates?

- VOCs and other Pollutants Associated with New Construction
- Water Vapor
  - Building Materials
  - General Household Use
  - Building Assembly Failure
  - Poor or Poorly Used Local Ventilation
- Dust Mites, Pet and Pest Dander, Pollen
- CO, CO_2, and CO_3
- Stored Household Chemicals
- Geologic Pollutants
  - Radon
  - Lead
  - PCBs

Indoor Air Quality (IAQ) and Whole-House Mechanical Ventilation

What are some of the Benefits of Healthy IAQ?

- Respiratory Health
  - Quality of Life
  - Lower Health Care Costs
  - Less Lost Time at Work due to Respiratory Illness
- CO_2 Balance
  - Studies in Commercial Settings
  - Cognitive Scores are 62-101% higher in spaces with healthy IAQ than conventional spaces
- Environment that Promotes Healthy Sleeping Habits

Prescriptive requirement for Whole-House Mechanical Ventilation

2015 IECC Sec. R402.4 and R402.1.2
Air Leakage and Testing

- R402.4 – Air Leakage (Mandatory)
- R402.4.1.2 – Testing (Blower Door Test)
  - 3 Air Changes per Hour at 50 Pascals (3ACH50)

Pro tip - 3ACH50 = Volume/20 CFM

2015 IRC Sec. R303.4
Mechanical Ventilation

Dwelling Units with infiltration rates (air leakage) under 5ACH50 requires whole-house mechanical ventilation in accordance with 2015 IMC Sec. M1507.3

2015 IMC Sec. M1507.3
Whole-House Mechanical Ventilation System

Design

- Exhaust Only
- Supply Only
- Combination (balanced)

Minimum Air Flow Required

TABLE M1507.3.3(1) CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0 – 1	2 – 3	4 – 5	6 – 7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 – 3,000	45	60	75	90	105
3,001 – 4,500	60	75	90	105	120
4,501 – 6,000	75	90	105	120	135
6,001 – 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

2015 IECC Table R403.6.1
Mechanical Ventilation System Fan Efficacy

Exhaust Fan Efficacy Requirements

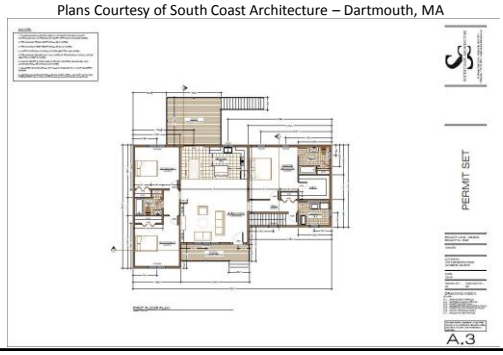
*not all fans meet the minimum rating

TABLE R403.6.1
MECHANICAL VENTILATION SYSTEM FAN EFFICACY

FAN LOCATION	AIR FLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)	AIR FLOW RATE MAXIMUM (CFM)
Range hoods	Any	2.8 cfm/watt	Any
In-line fan	Any	2.8 cfm/watt	Any
Bathroom, utility room	10	1.4 cfm/watt	< 90
Bathroom, utility room	90	2.8 cfm/watt	Any

Example Ventilation Requirement

Plans Courtesy of South Coast Architecture – Dartmouth, MA



Example Ventilation Requirement

Building Information

- 1,602 Ft^2
- 3 Bedrooms

Minimum Air Flow Required

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6,001 – 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

Ventilation Requirement
60 CFM

Example Ventilation Requirement

Ventilation Information

- Building Uses a 110 CFM Bath Fan for Ventilation Compliance
- Bath Fan is Operating at 71 CFM
- Bath Fan is Controlled by an External Timer
  - Set to Operate 50 Min/Hr
  - Required CFM / Operating CFM * 60 = Min/Hr
  - (60/71) * 60 = 50 Min/Hr

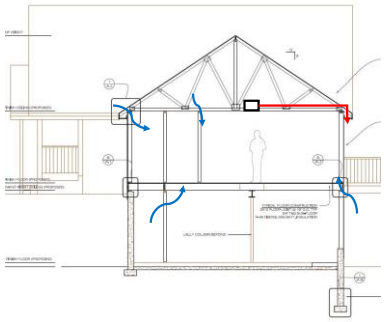


Types of Ventilation
Exhaust Only Ventilation

Exhaust Only Ventilation uses an Exhaust Fan for Ventilation Compliance

- Fans operate continuously or controls operate intermittently
- Typically performed by fan intended for local ventilation
- Depressurizes living space
  - Pulls fresh air through breaks in the Thermal Envelope
- Most common method of Whole-House Ventilation

Exhaust Only Ventilation



Exhaust Only Ventilation

Pros

- Most Economical Input Method for Compliance
  - Typically Low Operational Cost
- Multiple Options Readily Available in the Marketplace
- Available Options able to be Installed with Minimal Additional Training

Cons

- Makeup Air is Unfiltered
- May not Deliver Fresh Air to most Desired Areas
- Potential Combustion Safety Concerns

Examples of Exhaust Only Ventilation
Continuous Run Fans

Continuous Run Fans are Typically Dual-Purpose Designed -
Typically Use DC Motors to Modulate CFM and Fan Speed

- Panasonic Whisper Green Select (FV05-11-VKS1) – Bath Fan
  - "Optional Timer" has 30-100CFM settings in 10CFM increments
  - Recommendations for Electricians
    - Review wiring details
    - Search video sites (YouTube) for "Panasonic Whisper Green Select Wiring"
- Delta Breeze (SIG80-110D) – Bath Fan
  - Built-in controller has continuous 0, 30, 50, 60, and 80 CFM settings
- NuTone Ultra Green (ZN110L) – Bath Fan
  - Built-in rheostat controls CFM between 30 and 110
- Air King ECQ and ECV Series - Range Hood
  - Built-in controls allow for continuous 30, 50, 70, and 90 CFM settings

Examples of Exhaust Only Ventilation
External Controls

External Controls are Economic Methods of Ventilation Compliance for New Construction without Designed Systems and Retrofit in Existing Homes

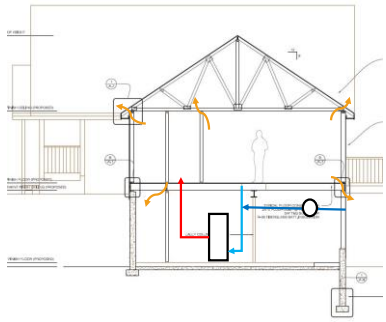
- AirCycler *Smart*Exhaust switch
  - Intermittent minutes/hr setting for predictable fan operation
  - "Fan Only" wiring option available for separate Fan/Light Function
- Broan 82W switch/sensor
  - RH Sensor operates fan when RH exceeds set humidity
  - Intermittent minutes/hr setting for predictable fan operation
  - "Fan Only" wiring option available for separate Fan/Light Function

Types of Ventilation
Supply Only Ventilation

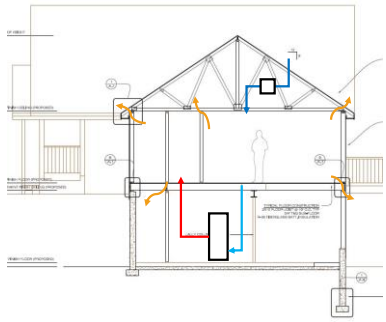
Supply Only Ventilation uses HVAC Ducting and a Controllable Damper or a Ducted Fresh Air Supply Fan for Ventilation Compliance

- Used most often as an Integrated Fresh Air Ducted into the HVAC Return with a Controllable Damper
- Pressurizes living space
  - Pushes stale air through breaks in the Thermal Envelope

Supply Only Ventilation (HVAC Integrated)



Supply Only Ventilation (Independent)



Supply Only Ventilation

Pros

- Opportunity to Filter Fresh Air Supply
- Opportunity for HVAC Equipment to Address Temperature Change
- Atmospheric Fuel-Fired Appliance Safety

Cons

- Design/Function Complexity
- Operational Costs esp. using HVAC Integrated Method
  - Additional heating fuel consumption
  - HVAC blower motor – higher electrical consumption
- Possible Condensation Issues

Examples of Supply Only Ventilation
Products

HVAC Integrated Options use a Controllable Damper and Fresh Air Duct Installed into the HVAC Return
Independent Systems use a Dedicated Fan and Duct Work to Supply Fresh Air to the Living Space

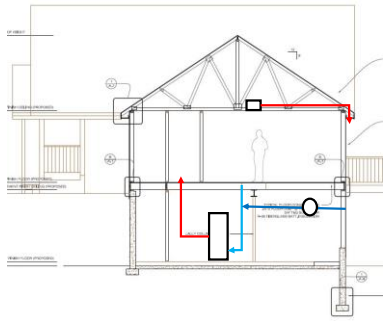
- Honeywell - Y8150 and W8150/W8150A (Integrated)
  - Low Voltage Controlled Damper Supplies Fresh Air to HVAC Return
  - Controls Allow for Easy to Set Compliance
    - Damper Limits Air Intake and Run Time Based on Setting
- AirCycler – VS (Integrated)
  - Low Voltage Controlled Damper Supplies Fresh Air to HVAC Return
  - Control Setting Option to Synch with HVAC Blower Motor Run Time
- Air King – FAS (Independent)
  - 40-120 CFM Speeds at 10 CFM Increments
  - Air Filter Included in Unit
  - Lower Electrical Consumption Compared to HVAC Blower Motor

Types of Ventilation
Combination (Balanced)

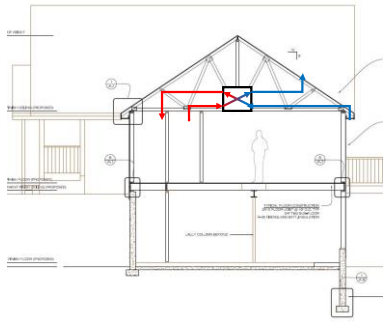
Combination or Balanced Ventilation Controls both Supply and Exhaust Ventilation Air through Designed Mechanical Systems

- HRV/ERV are the most common Equipment for Balanced Ventilation

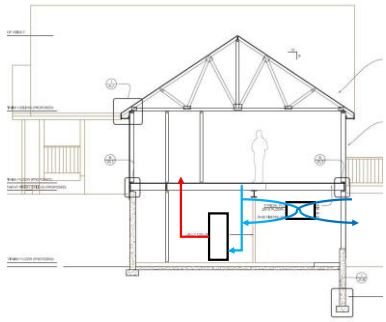
Balanced Ventilation (Hybrid)



Balanced Ventilation (HRV/ERV)



Balanced Ventilation (HRV/ERV HVAC Integrated)



Balanced Ventilation

Pros

- Opportunity to Optimize Fresh Air Supply Design
- Heat and/or Energy Recovery Lowers Operational Costs
- No Designed Pressure Imbalance

Cons

- Most Expensive Initial Install Cost
- Requires Trained Designer/Installation Contactor
  - Hybrid or HVAC Integrated may not operate as designed
- Difficult to Measure Performance
  - Esp. HVAC integrated method

Examples of Balanced Ventilation Products

Hybrid Options use a Controllable Damper and Fresh Air Duct Installed into the HVAC Return Combined with an Exhaust Fan

Independent and HVAC Integrated Systems use a HRV/ERV Ducted Independently or Ducted into the HVAC Return

- Panasonic – FV-10EV1 (ERV)
  - 50-100 CFM at 10 CFM Increment Settings for both Supply and Exhaust Air
  - Low Electrical Consumption
- Life Breath – Max Series (HRV)
  - Multiple CFM Settings
  - DC Motor Units Available
- Air Cycler – g-2K (Hybrid)
  - VS System Combined with Exhaust Fan Switch

Best Practices and Recommendations

- Use Largest Available Duct Size
- Use Rigid Duct or Install Flex Duct to Manufacturer's Instructions
- Exhaust Fans as Directly as Possible

Pros

- Occupant Satisfaction
- Fan and System Performs more Efficiently
- Quieter System Operation

Cons

- Possibly Higher Installation Cost
- Typically Requires Competent Installer

Exhaust Fans Rarely Operate at Their Rate Capacity

This Home has 2 Bath Fans Both Rated to Operate at 80 CFM

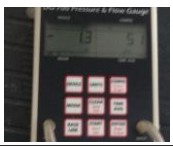
They Operate at 67 and 63 CFM Or about 85%, and 75% of Their Rated Capacity

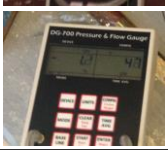
Recommendation – Request Compliance Documentation

There is no requirement for compliance documentation, why would you ask for it?

This Home has 3 Bath Fans All Rated to Operate at 80 CFM

They Operate at 39, 47, and 51 CFM Or 48%, 58%, and 63% of Their Rated Capacity





Above Code Programs and Existing Home Calculation ASHRAE 62.2

ASHRAE 62.2

- 2015 IECC R102.1.1 (N1101.4) - Above Code Programs such as LEED, Energy Star for Homes, and PassiveHouse Require Ventilation Meet the ASHRAE 62.2 Standard
- The ASHRAE Requirement will probably be lower than the IMC Requirement
- The ASHRAE Standard is also a Good Tool to Assess the Ventilation Requirements of Existing Homes

Whole House Ventilation

Additional illustrations, guidance, and resources are available

- Specification Sheets for Referenced Products
- ASHRAE 62.2 Calculation Website
  - http://www.residentialenergydynamics.com/REDCalcFree/Tools/ASHRAE6222013.aspx

Questions and Discussion

Thank you