Welcome

Effective Strategies for Building Enclosures

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Learning Objectives

1. Review building enclosure design best practices
2. Demonstrate effective methods of controlling air movement through assemblies and discuss the impacts on energy performance
3. Discuss common products details used for thermal control, focusing on the differences between cavity insulation and continuous insulation
4. Using case studies and project details, demonstrate unique considerations and for the five control layers

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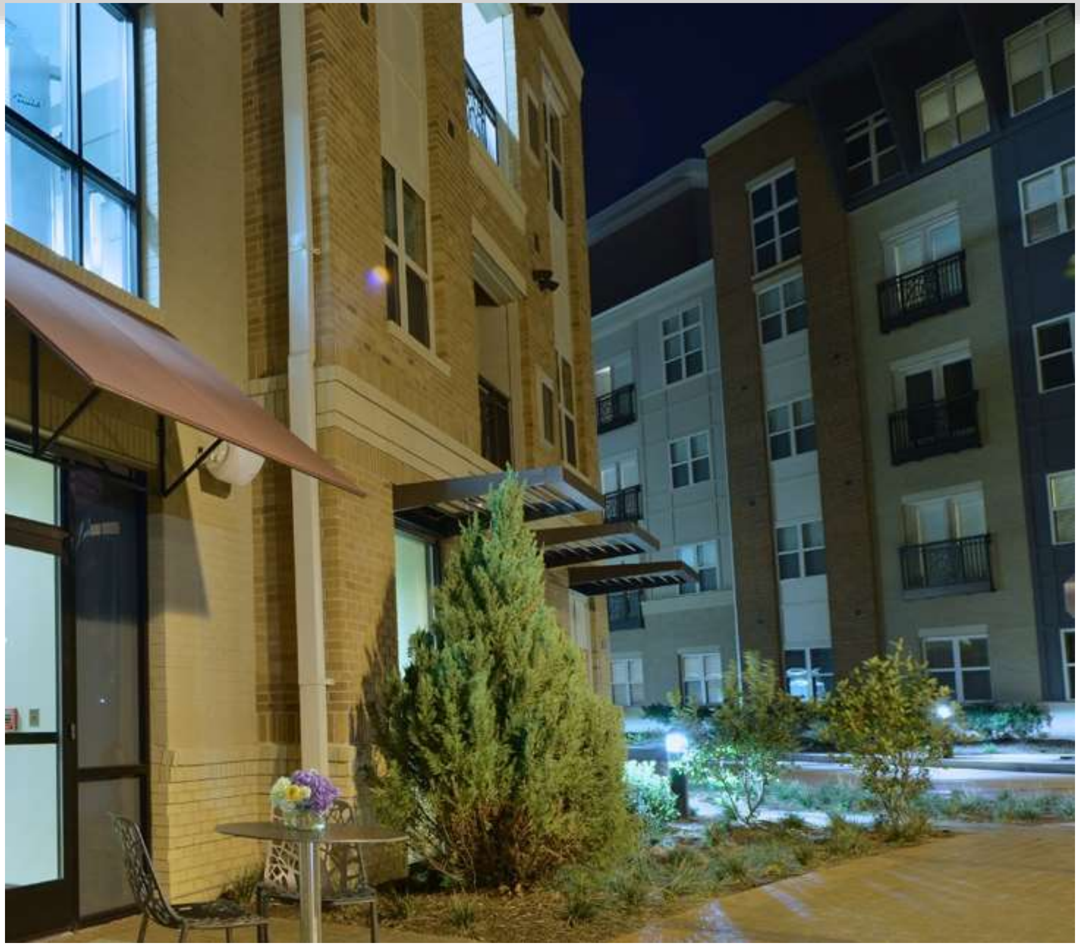
Control Layers

1. Rainscreen – Sheds the Majority of Water
2. *Drainage Plane – Water Resistive Barrier (WRB), moves* water away from substrates (flashing, weeps)
3. Air Barrier – Prevent Air Leakage
4. Thermal – Prevent Conductive Energy Loss
5. Vapor Barrier – Prevents Warm Humid Air from reaching a Cold Surface and Condensing

Rainscreen - Cladding

- Masonry
  - Brick/CMU/Cast Stone (Anchored Masonry Veneer)
  - Thin Brick/Cultured Stone (Adhered Masonry Veneer)
- Fiber Cement Panels/Siding
- Wood/Synthetic Wood Panels/Siding/Trim
- Metal Panels/Trim
- High Pressure Laminate Panels
- EIFS
- Cement Plaster

Cladding - Masonry



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Panels/Siding/Trim – Directly Attached

Panels/Siding/Trim – Sub Framing Attached

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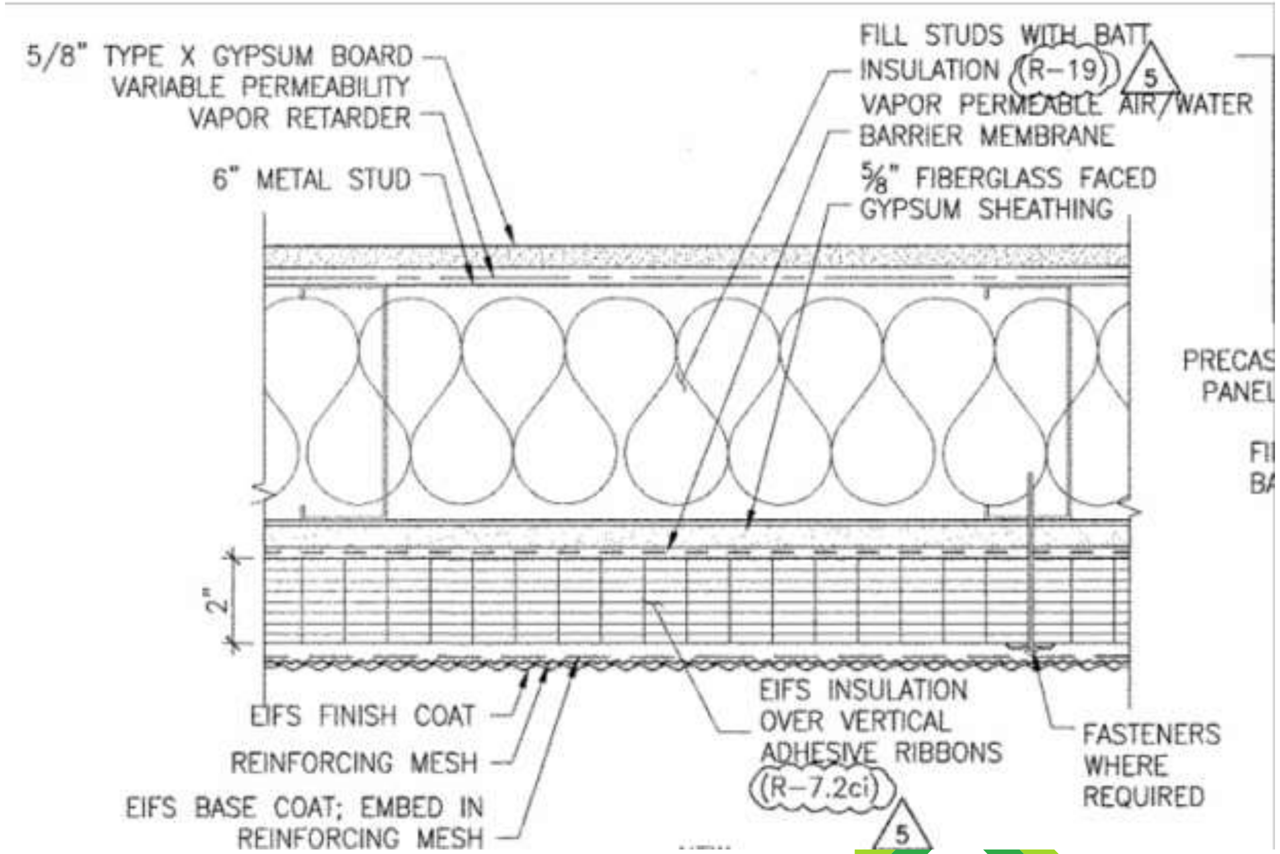
EIFS/Cement Plaster



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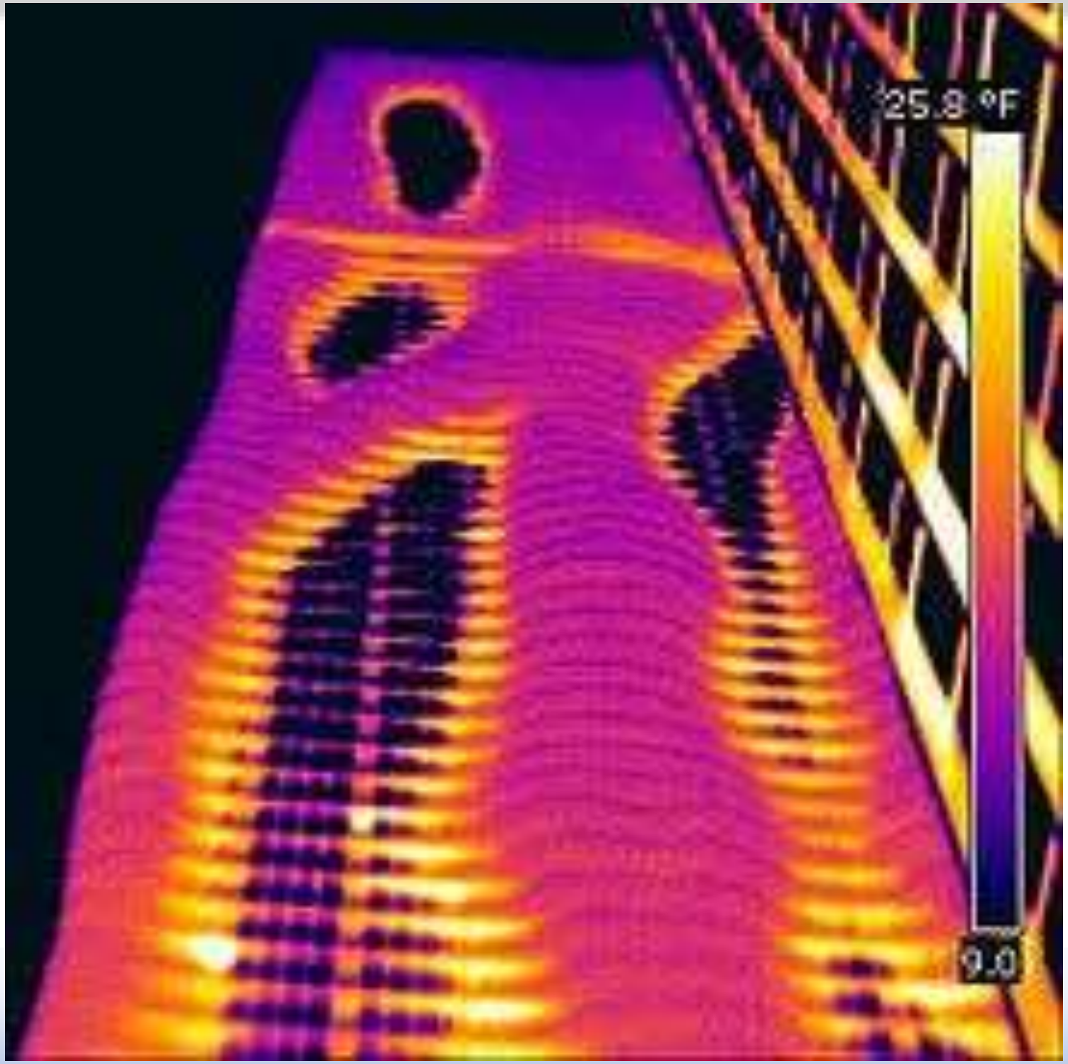
Design Strategies



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Water Management Design

Barrier Systems

- Water Management by a continuous, impervious surface
- Vulnerable to any defects (continuity) in the cladding surface
- Relies on sealant at transitions

Drainage Systems

- Durable cladding resists bulk water penetration
- Continuous backup waterproofing layer (can also function as air barrier)

Rainscreen Systems

- Pressure Equalized
- Back Ventilated

Barrier Systems

Mass Masonry

Cast-in-Place concrete

Coating

Architectural Precast Concrete Panels

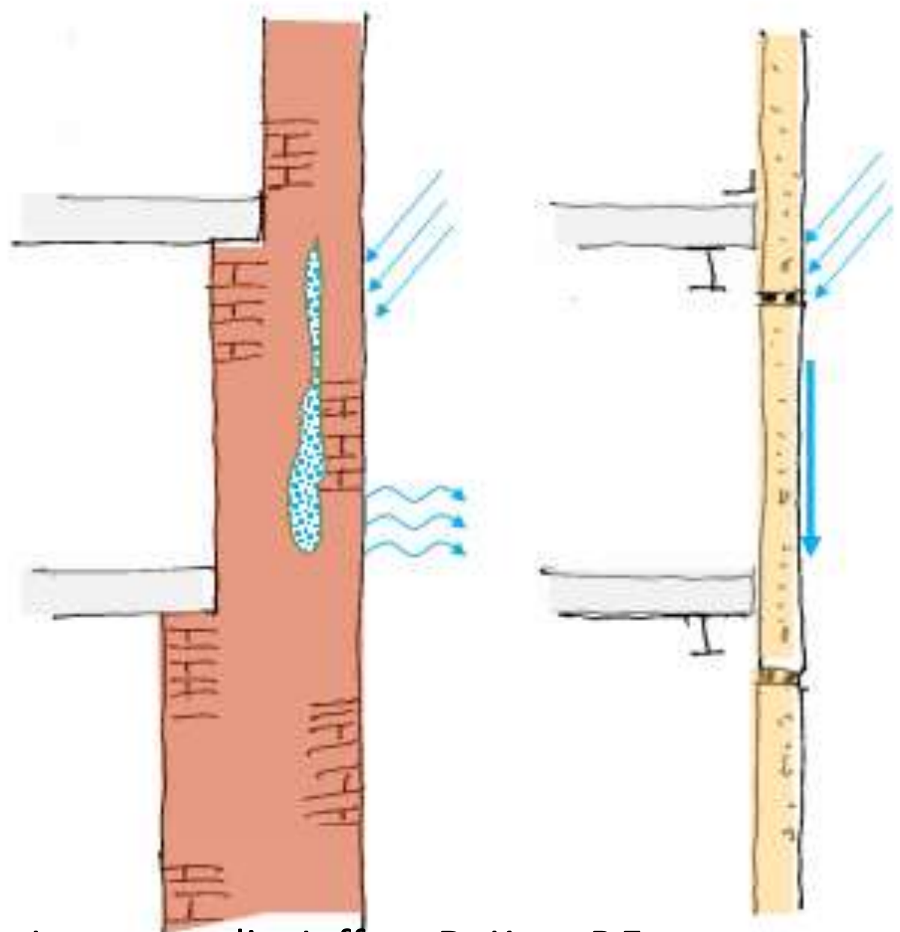


Image credit: Jeffrey D. Kerr, P.E.

Drainage Systems

Masonry Veneer

Adhered Masonry Veneer

Panels/Siding/Trim

Cement Plaster

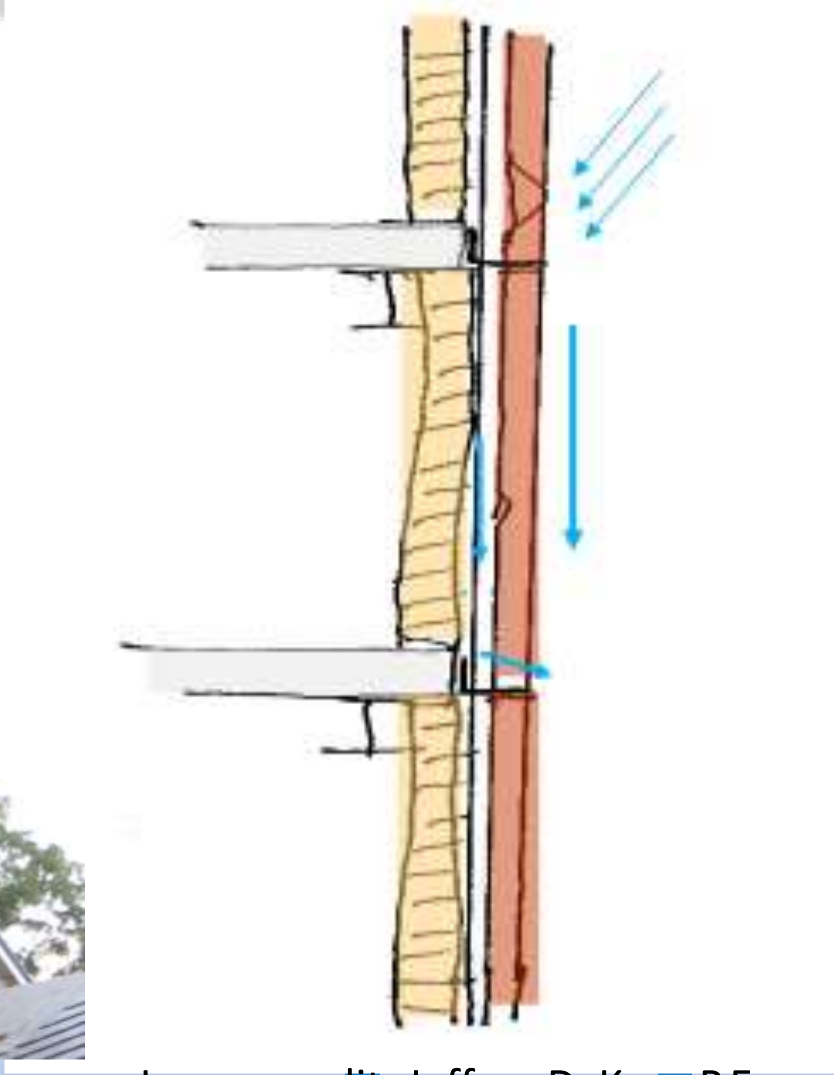
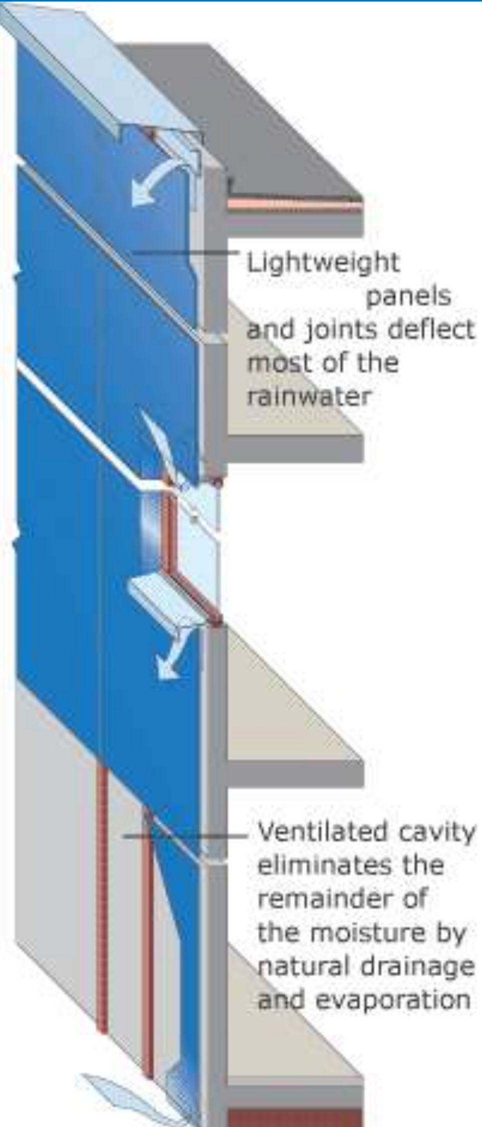


Image credit: Jeffrey D. Kerr, P.E.

Rainscreen Systems



Barrier Systems

Rainscreen Systems

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Attachment Design

Discrete Anchor Systems

Masonry Veneer/Siding/EIFS

Limited thermal bridging

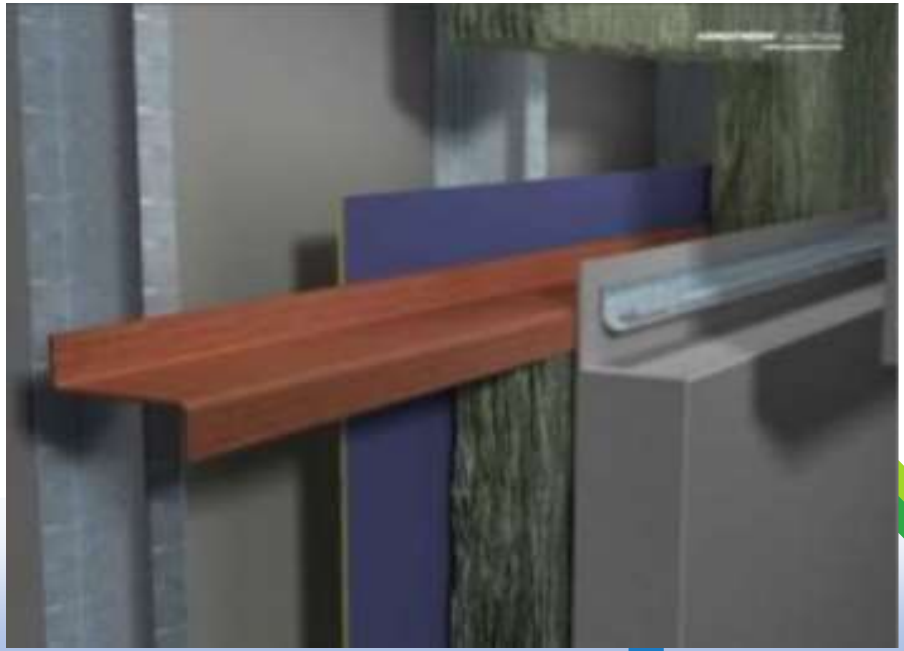
Consider fastener penetration through water/air barrier

Ties

Attachment Design

Girt Systems

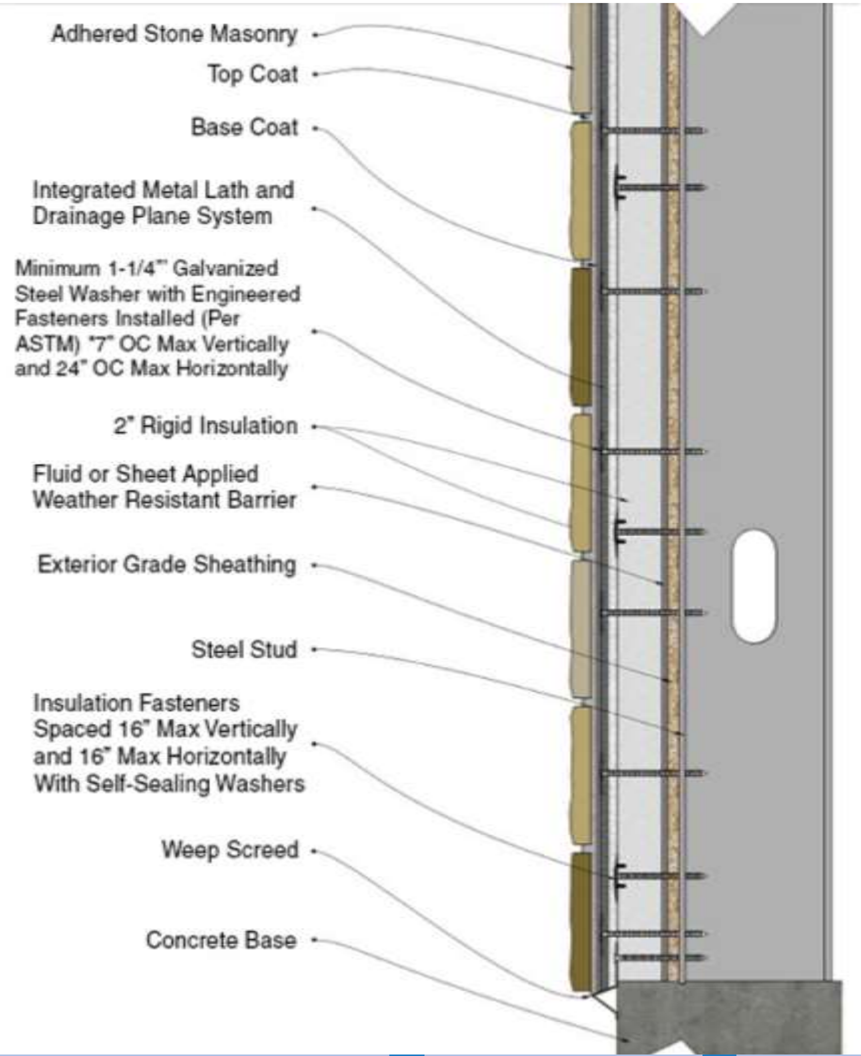
- Panel Systems
- Some thermal bridging
- Provide improved detailing at penetrations
- Combining clips and girts can improve thermal performance



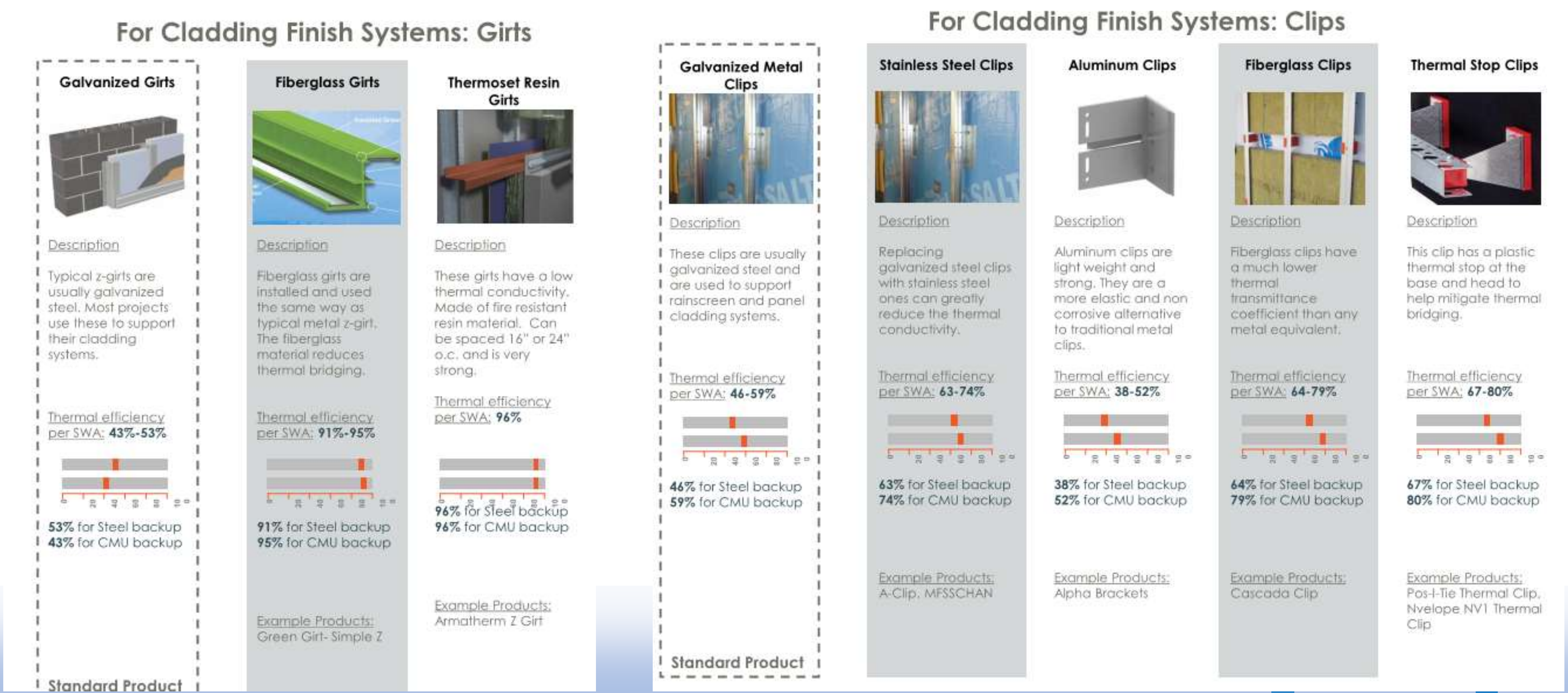
Attachment Design

Adhered Systems

Thin masonry veneer/ Cement Plaster
Difficult to incorporate continuous insulation
Sensitive to installation environmental factors



Attachment Design



For Cladding Finish Systems: Girts

Galvanized Girts

Description

Typical z-girts are usually galvanized steel. Most projects use these to support their cladding systems.

Thermal efficiency per SWA: **43%-53%**

53% for Steel backup
43% for CMU backup

Standard Product

Fiberglass Girts

Description

Fiberglass girts are installed and used the same way as typical metal z-girt. The fiberglass material reduces thermal bridging.

Thermal efficiency per SWA: **91%-95%**

91% for Steel backup
95% for CMU backup

Example Products:
Green Girt- Simple Z

Thermoset Resin Girts

Description

These girts have a low thermal conductivity. Made of fire resistant resin material. Can be spaced 16" or 24" o.c. and is very strong.

Thermal efficiency per SWA: **96%**

96% for Steel backup
96% for CMU backup

Example Products:
Armatherm Z Girt

For Cladding Finish Systems: Clips

Galvanized Metal Clips

Description

These clips are usually galvanized steel and are used to support rainscreen and panel cladding systems.

Thermal efficiency per SWA: **46-59%**

46% for Steel backup
59% for CMU backup

Standard Product

Stainless Steel Clips

Description

Replacing galvanized steel clips with stainless steel ones can greatly reduce the thermal conductivity.

Thermal efficiency per SWA: **63-74%**

63% for Steel backup
74% for CMU backup

Example Products:
A-Clip, MFSSCHAN

Aluminum Clips

Description

Aluminum clips are light weight and strong. They are a more elastic and non corrosive alternative to traditional metal clips.

Thermal efficiency per SWA: **38-52%**

38% for Steel backup
52% for CMU backup

Example Products:
Alpha Brackets

Fiberglass Clips

Description

Fiberglass clips have a much lower thermal transmittance coefficient than any metal equivalent.

Thermal efficiency per SWA: **64-79%**

64% for Steel backup
79% for CMU backup

Example Products:
Cascada Clip

Thermal Stop Clips

Description

This clip has a plastic thermal stop at the base and head to help mitigate thermal bridging.

Thermal efficiency per SWA: **67-80%**

67% for Steel backup
80% for CMU backup

Example Products:
Pos-I-Tie Thermal Clip, Nvelope NV1 Thermal Clip

Attachment Design

For Brick Veneer Systems: Ties

Galvanized Steel Brick Ties

Description

Typical brick ties are galvanized steel. Most brick veneer projects use this type of product.

Thermal efficiency per SWA: **75-84%**

75% for Steel backup
84% for CMU backup

Standard Product

Stainless Steel Brick Ties

Description

Stainless steel ties are less conductive than galvanized steel ties.

Thermal efficiency per SWA: **87-93%**

87% for Steel backup
93% for CMU backup

Example Products:
2 Seal Tie Thermal, Original Pos-I-Tie

Thermal Break Brick Ties

Description

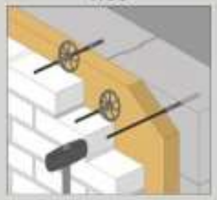
This stainless steel brick tie has a plastic coating, which reduces thermal bridging.

Thermal efficiency per SWA: **88-94%**

88% for Steel backup
94% for CMU backup

Example Products:
2 Seal Tie Thermal Wing Nut Anchor

Basalt Fiber Wall Ties



Description

Basalt fiber is a material made from fine fibers of basalt. They tend to be stronger and lighter than stainless steel wall ties and much less thermally conductive.

Example Products:
Teplo Ties, Galen Wall Ties

Connectors

Description

These are used in place of brick ties. The combination of horizontal and vertical elements increases strength despite its small size.

These can be applied prior to liquid applied air barrier installation, so air tightness is improved.

Example Products:
Block Shear Connector

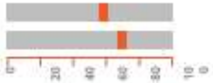
For Brick Veneer Systems: Angles

Typical Shelf Angle

Description

Typically, shelf-angles are made of galvanized steel.

Thermal efficiency per SWA: **58-69%**



58% for Steel backup
69% for CMU backup

Standard Product

Stand-off Shelf Angle

Description

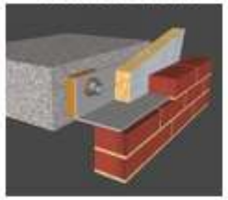
This stand off shelf angle allows insulation to be installed behind it. The bracket can be used with readily available shelf angles.

Thermal efficiency per SWA: **73-81%**

73% for Steel backup
81% for CMU backup

Example Products:
FAST (Fero Angle Support Technology).

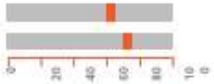
Shelf Angle with Thermal Break



Description

The thermal break plate is installed between the shelf angle and bracket to reduce the thermal bridge at those points.

Thermal efficiency per SWA: **63-74%**



63% for Steel backup
74% for CMU backup

Example Products:
Armatherm Shelf Angle

Detailing the Control Layers

Continuity of Control Layers

Readability – clearly communicate the intent

Durability – select materials appropriate for the life of the building

Maintainability – consider frequency and effort of maintenance

Sustainability – consider impact on the environment

Liability – shortcomings in the above can contribute to costly remediation

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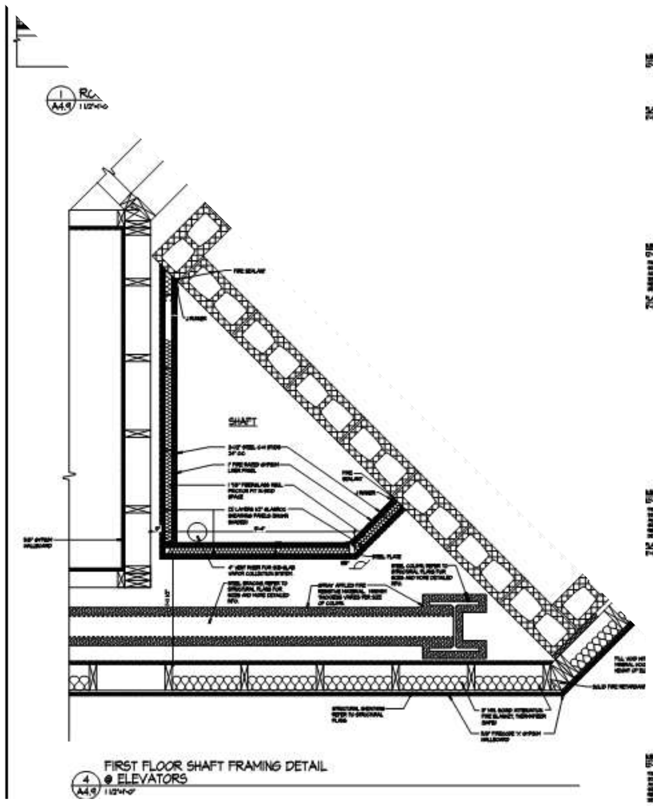
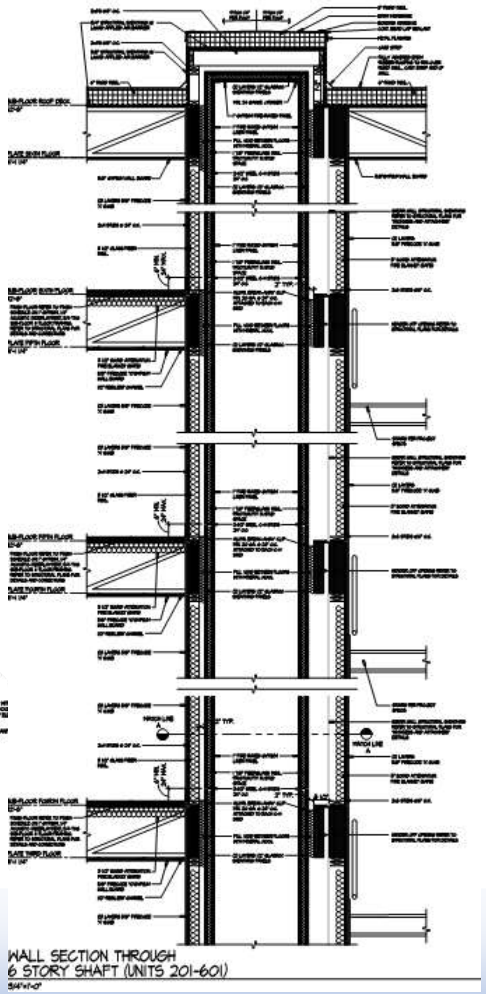
Detailing the Control Layers





Detailing the Control Layers

Detailing the Control Layers

Detailing the Control Layers

Condensation Control

- Why does condensation form on the outside of a cold drink in the summer?

Dew point!

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Detail Moisture Vapor Control Strategy

- First condensing surface must be above dew point temperature of ambient air

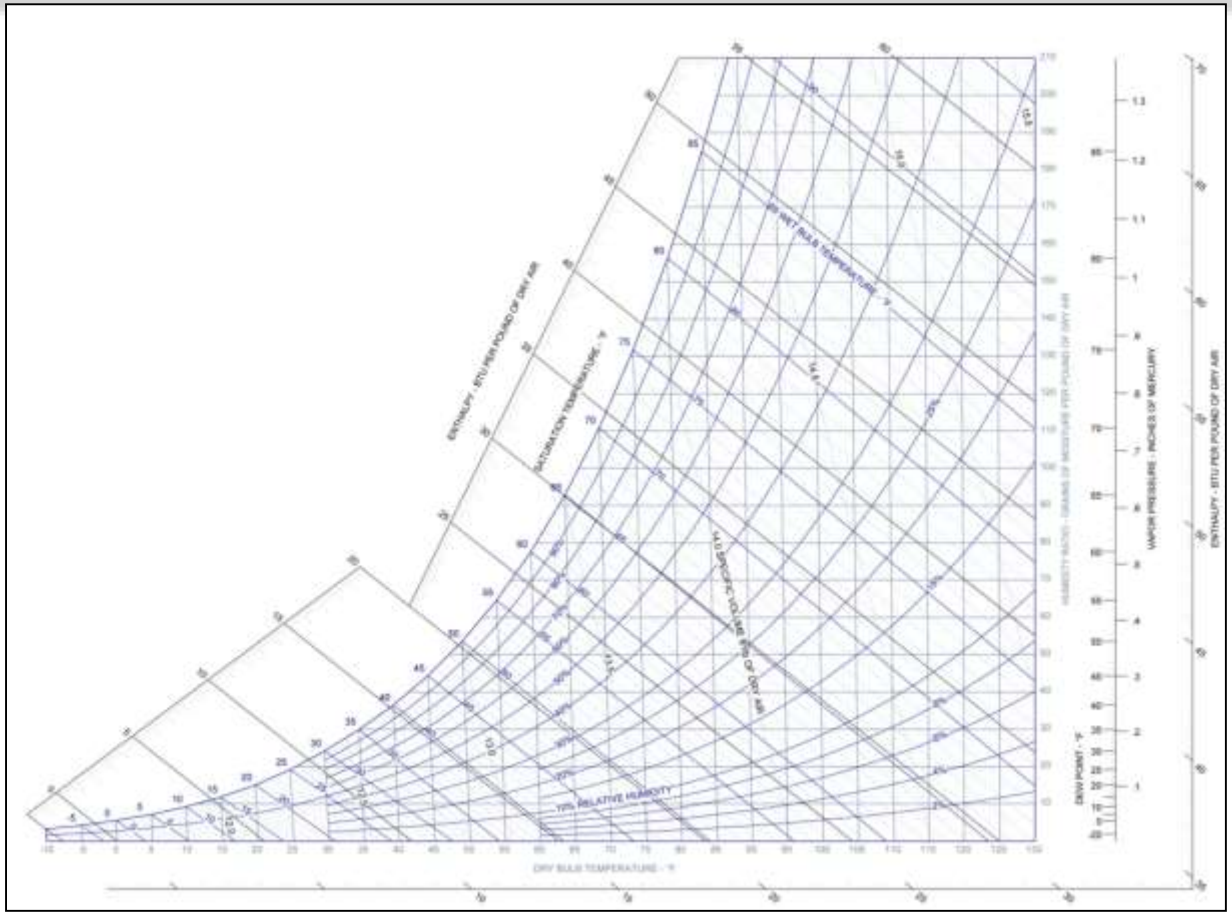
- Thermally broken windows

- Control indoor humidity conditions, specify:

  Proper local ventilation

- Construction moisture!

What is Dew Point?



- Warm air can hold more moisture than cold air
- The dew point is reached when the air is cooled to the point of saturation (100% Relative Humidity)
- When this occurs we call it condensation

Psychometric Chart

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Cold Weather Condensation

- Can occur when warm moist interior air contacts cooler surfaces such as windows
- Condensation forms when the surface temperature is below the dew point temperature for the interior air

Prevent Condensation

- Raise the temperature of the condensing surfaces
- Add a vapor retarder to inhibit the moisture from reaching the condensing surface
- Lower the interior space relative humidity
- Reduce the interior "moisture loading"

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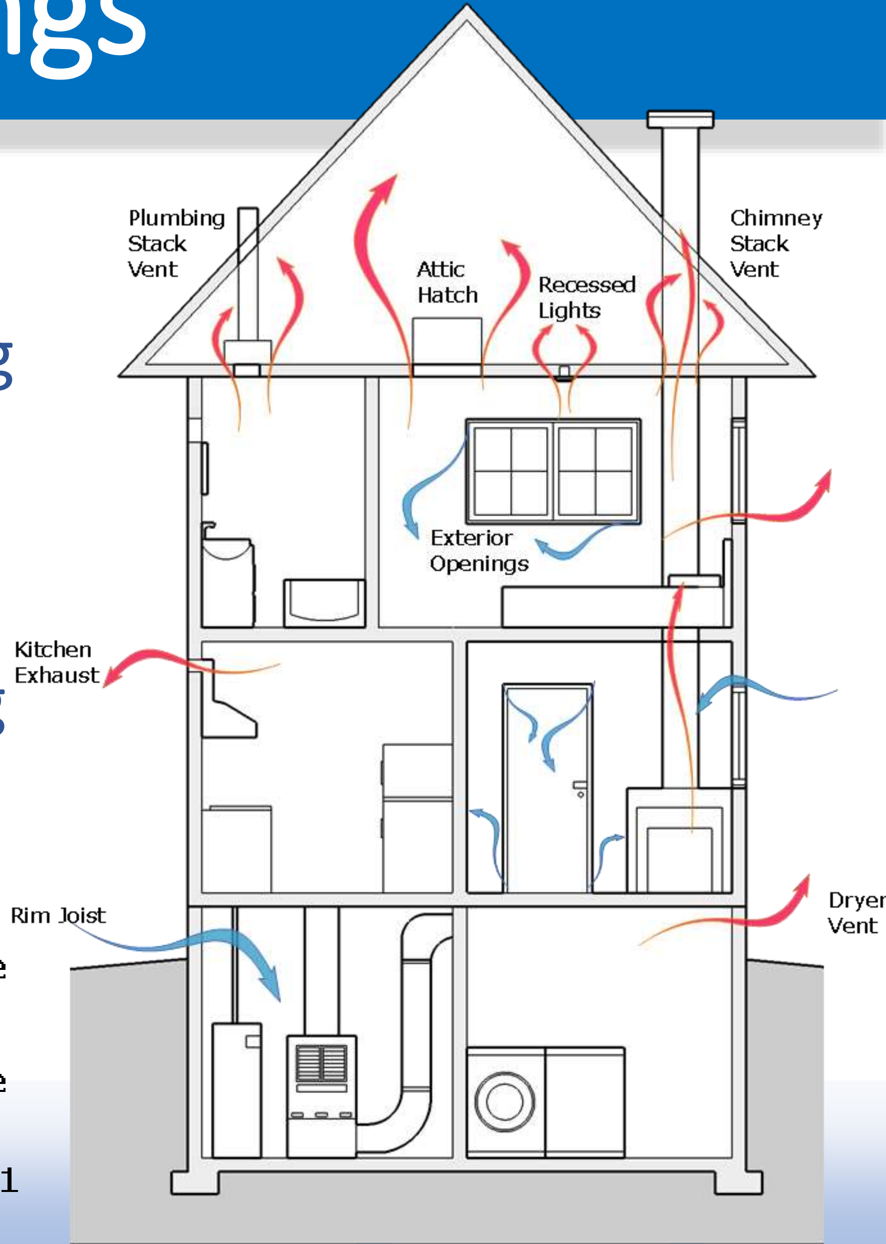
Airflow in Buildings

Infiltration: air movement into the building

Occurs in areas of negative pressure inside the building

Exfiltration: air movement out of the building

Occurs in areas of positive pressure inside the building



Exfiltration
Air Leakage from Inside to Outside

Infiltration
Air Leakage from Outside to Inside

Air Flow in Buildings

3 Main Driving Forces:

- Stack effect
- Mechanical effect
- Wind effect

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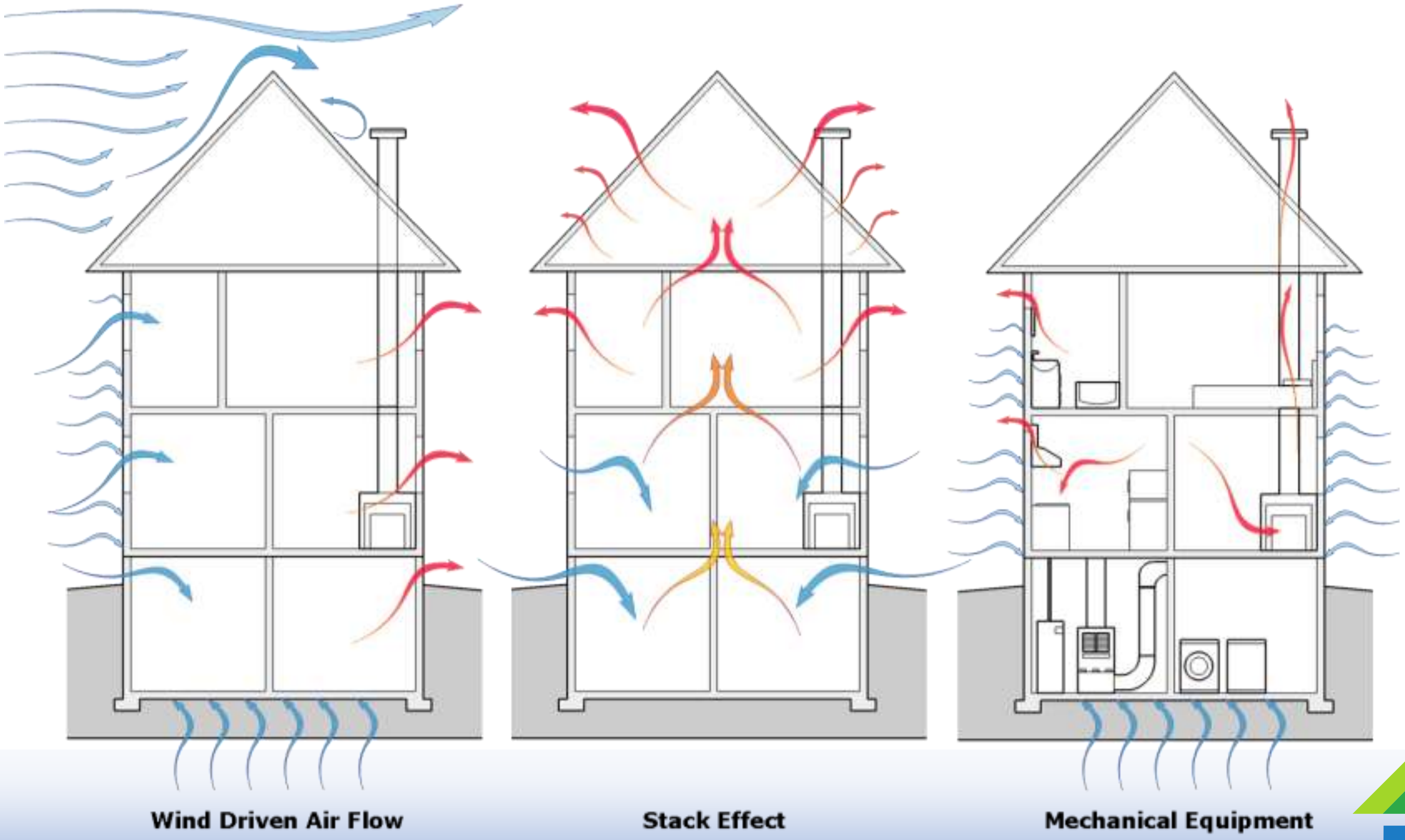
Air Flow in Buildings



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Air Sealing Priorities

- Stop the Stack Effect!
- Go after biggest holes first, duh
- Top of the building is usually first priority
- Base of the building is next
- Center of building last, if even necessary

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Methods of Heat Transfer

- Heat is a form of energy
- When heat moves from place to place, it is referred to as “Heat Transfer”
- Heat Transfer occurs in three ways:
    - **Conduction**
    - **Convection**
    - **Radiation**

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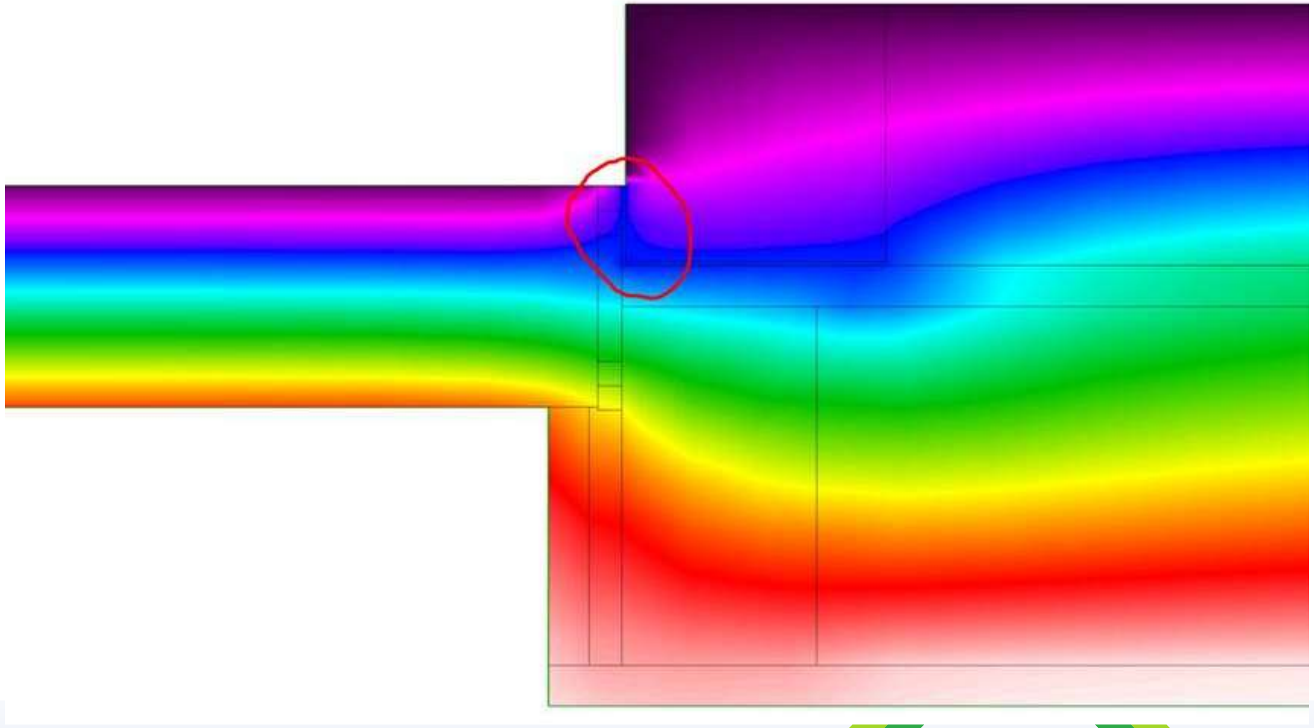
Heat Transfer

Conduction

- Occurs when heat energy moves through a solid or fluid material
- Energy is transferred from one molecule to the next
- Examples of conduction:

Heat Transfer

Conduction



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Heat Transfer

Convection

- Convection occurs when heat is carried from one place to another
- Convection requires a “fluid medium” (i.e. a gas or liquid)

Heat Transfer

Convection

- Convection in homes usually occurs when air in the house moves around due to temperature gradients
- Warm air is lighter (i.e. less dense) than cold air
- Cold air falls, warm air rises

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Heat Transfer

Convection Loops

- When convection occurs in an enclosed space, the air (or fluid) will circulate around the space as it is heated and cooled, this is referred to as a convective loop

- Examples of places where convective loops could be found . . .?

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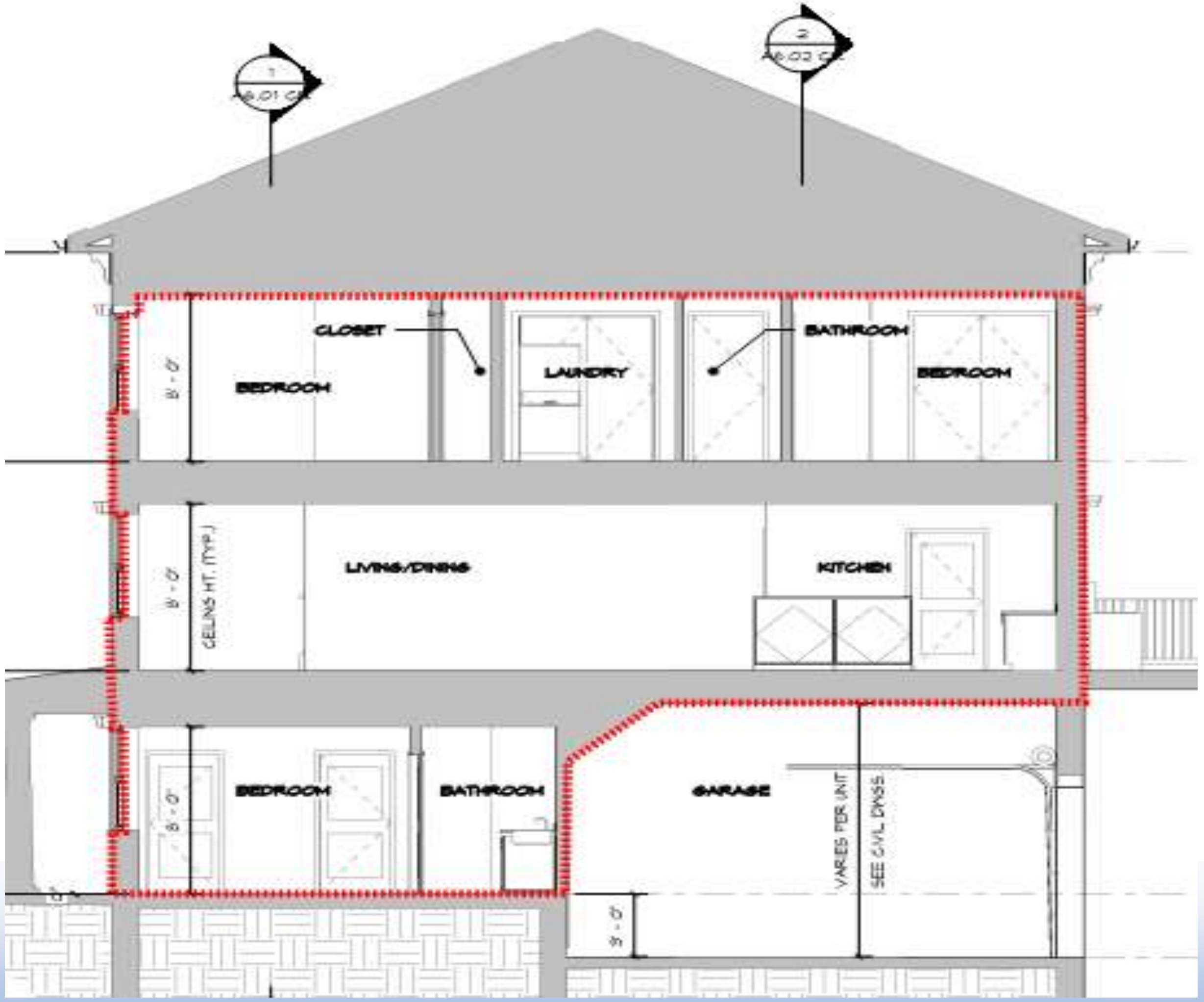
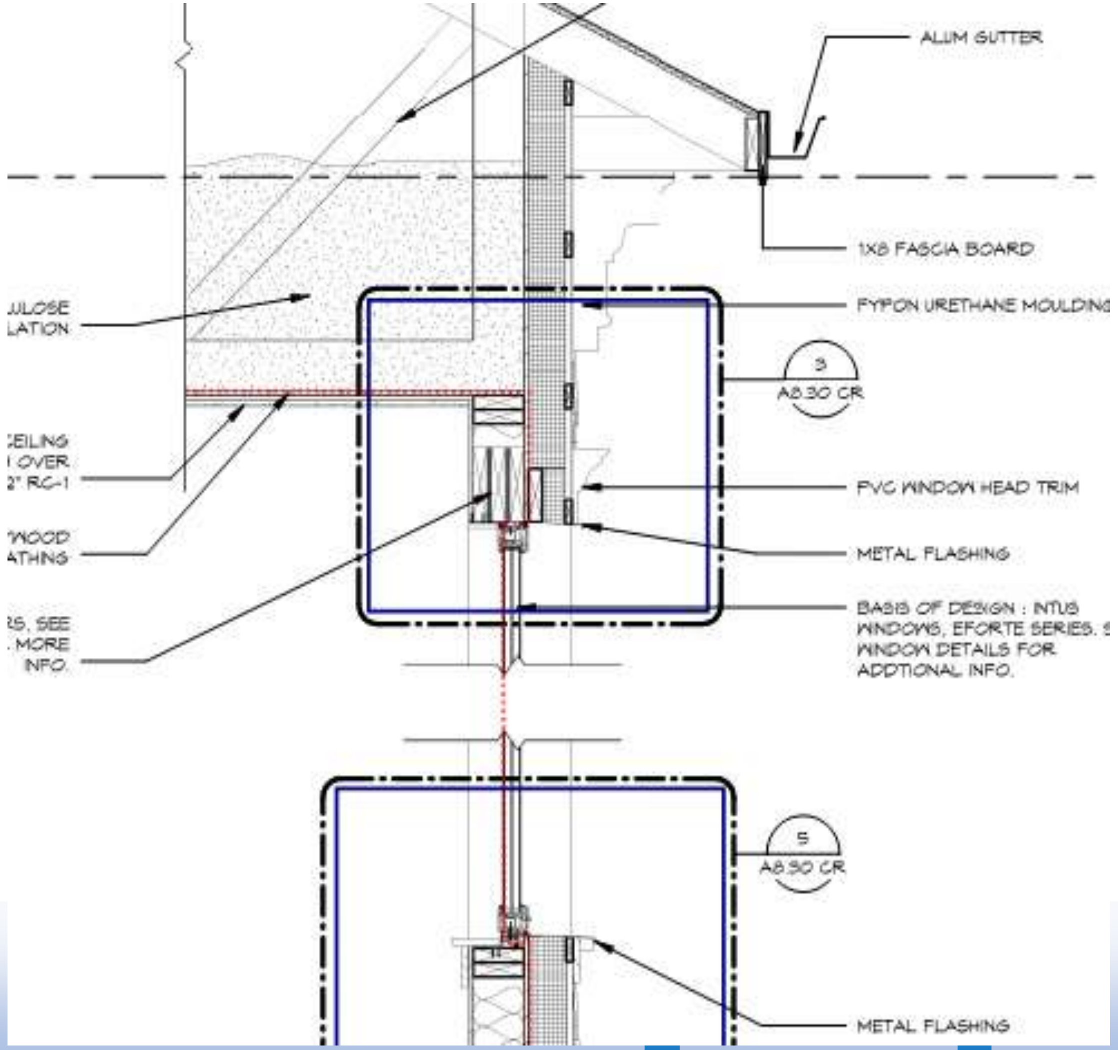
Heat Transfer

Radiation

- Heat radiates to cold surfaces. Must be an air gap between the two bodies.
- Examples of places where radiation effects can be found . . . ?

Air Barrier & Thermal Barrier





Air Barrier & Thermal Barrier

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Air Barrier & Thermal Barrier

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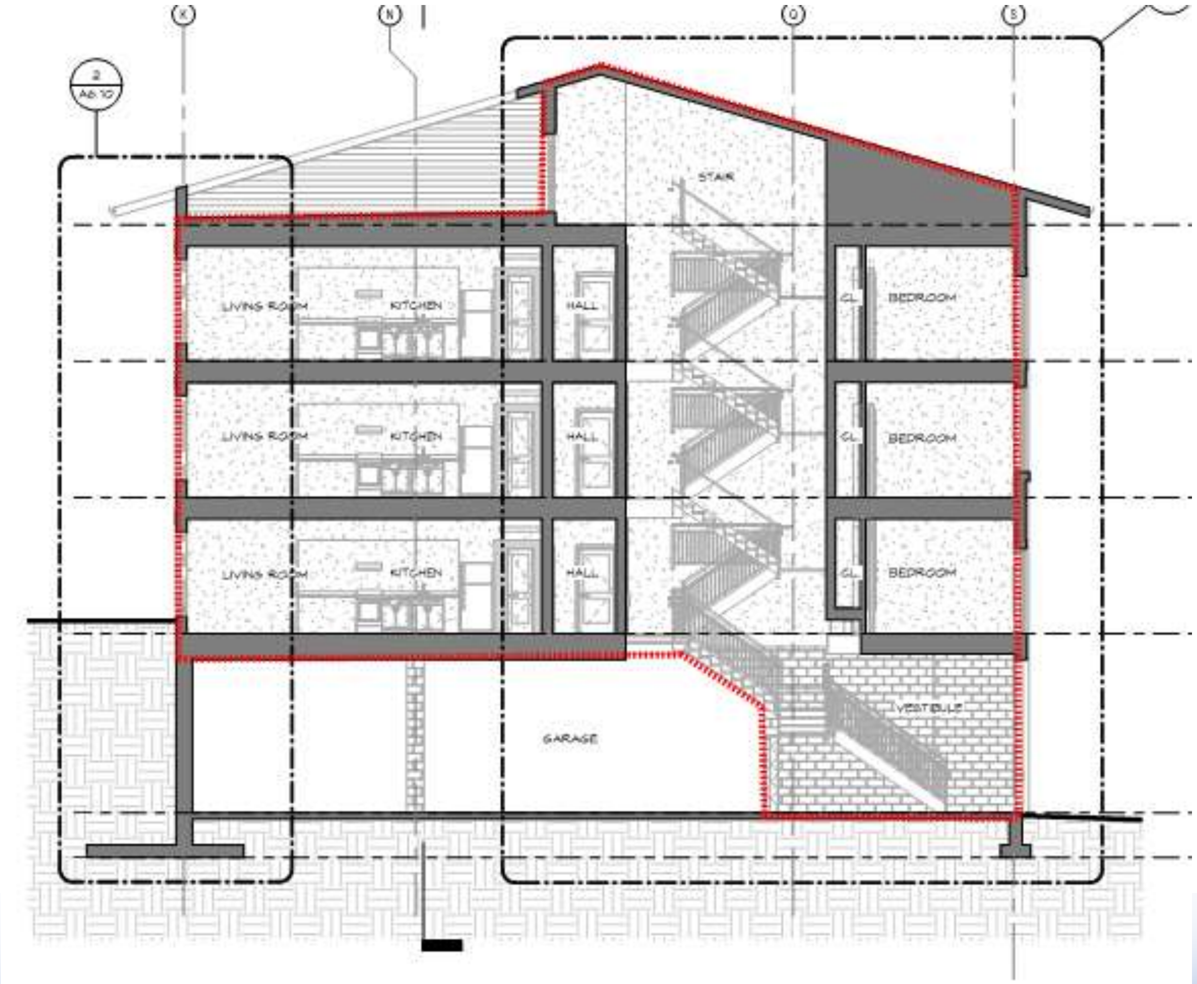
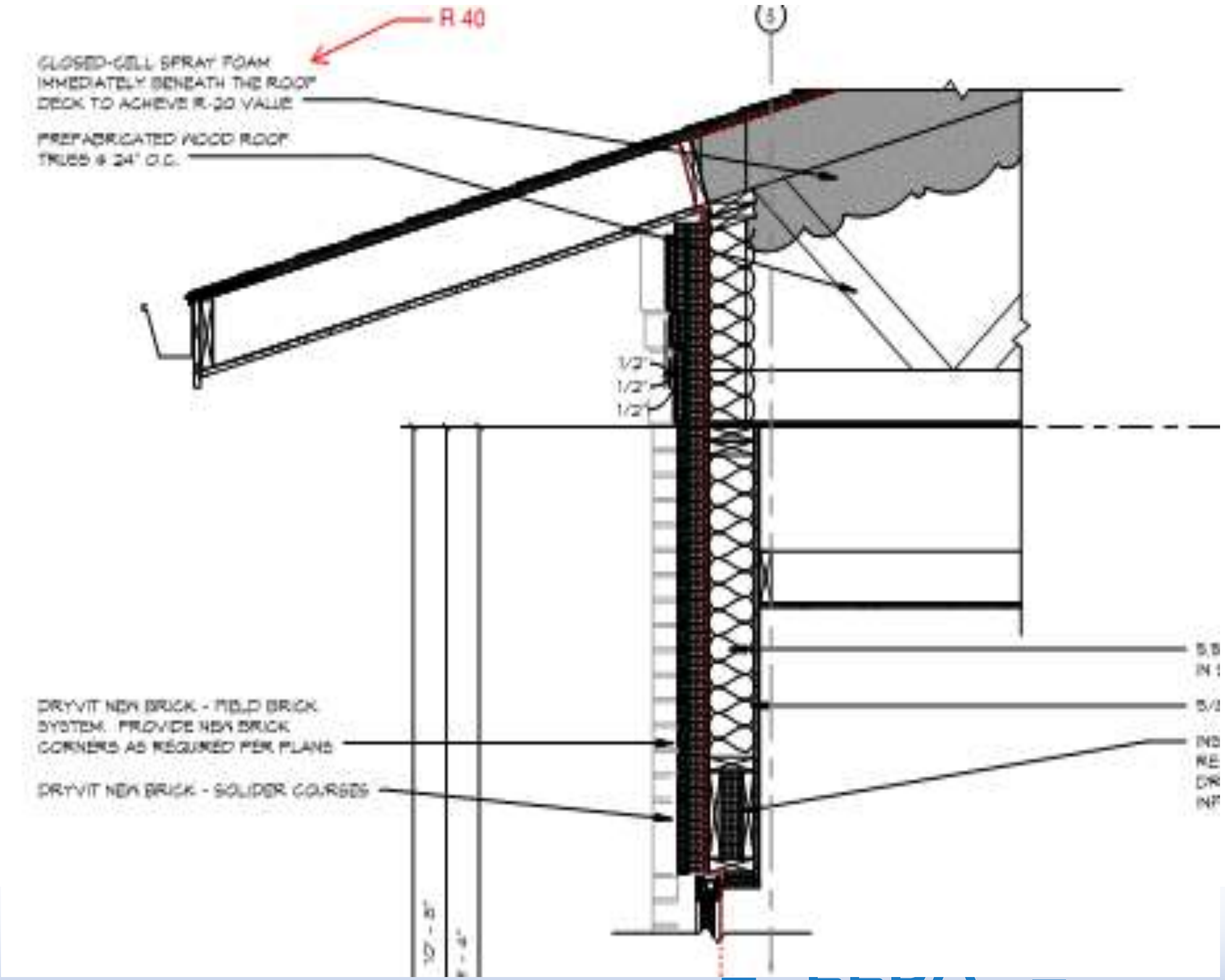
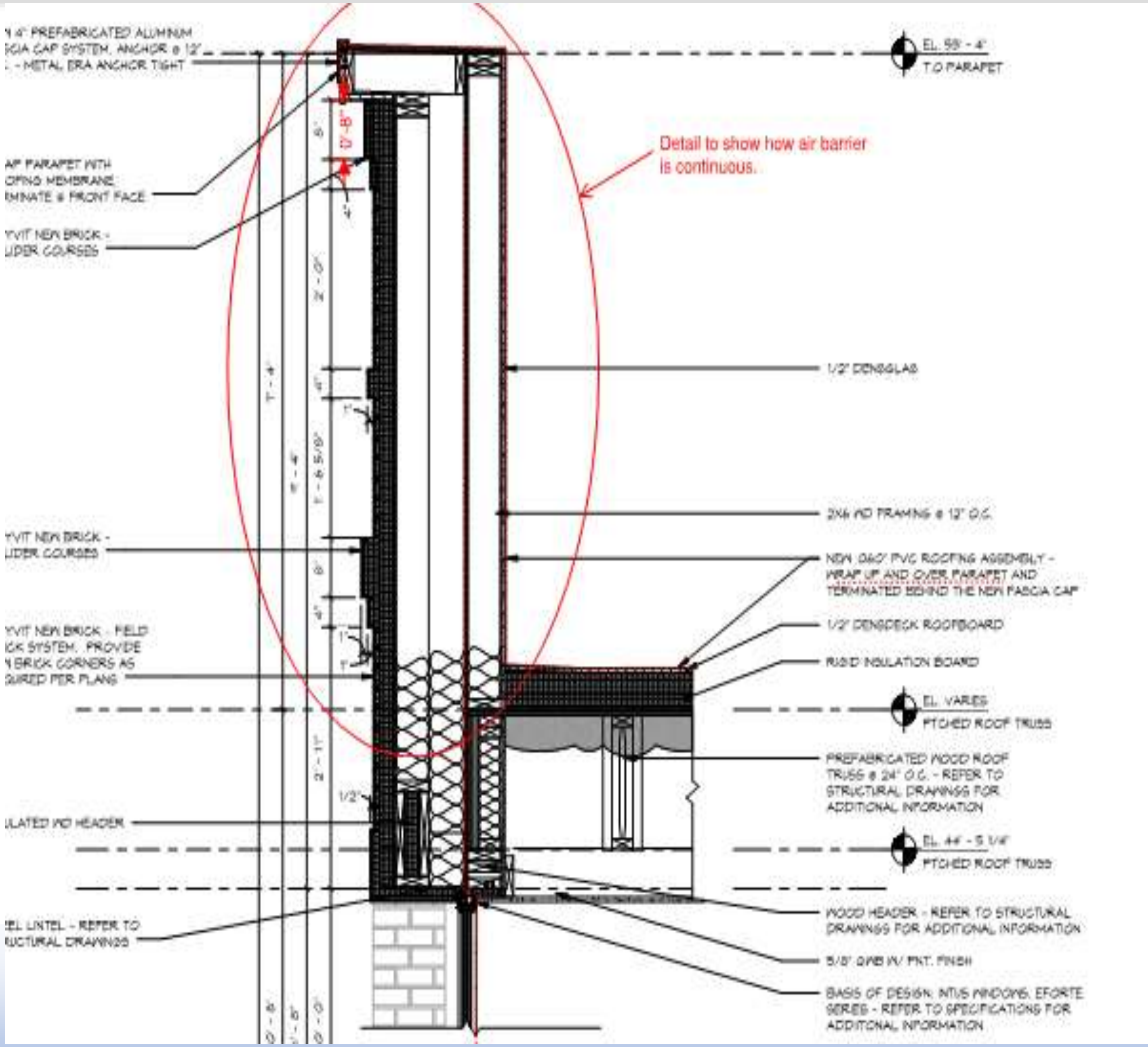
Air Barrier & Thermal Barrier



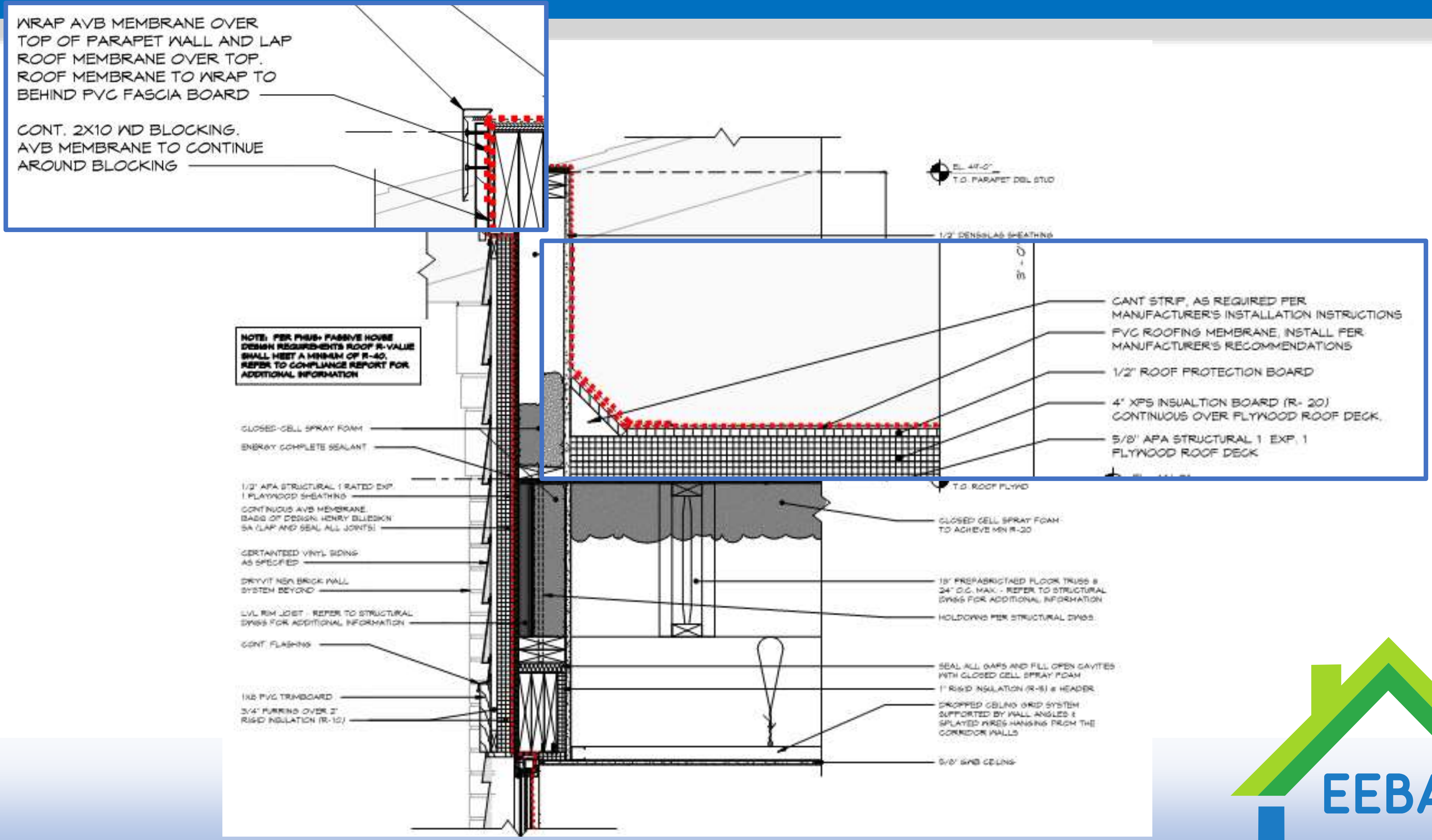


Air Barrier & Thermal Barrier

Air Barrier & Thermal Barrier



Air Barrier & Thermal Barrier



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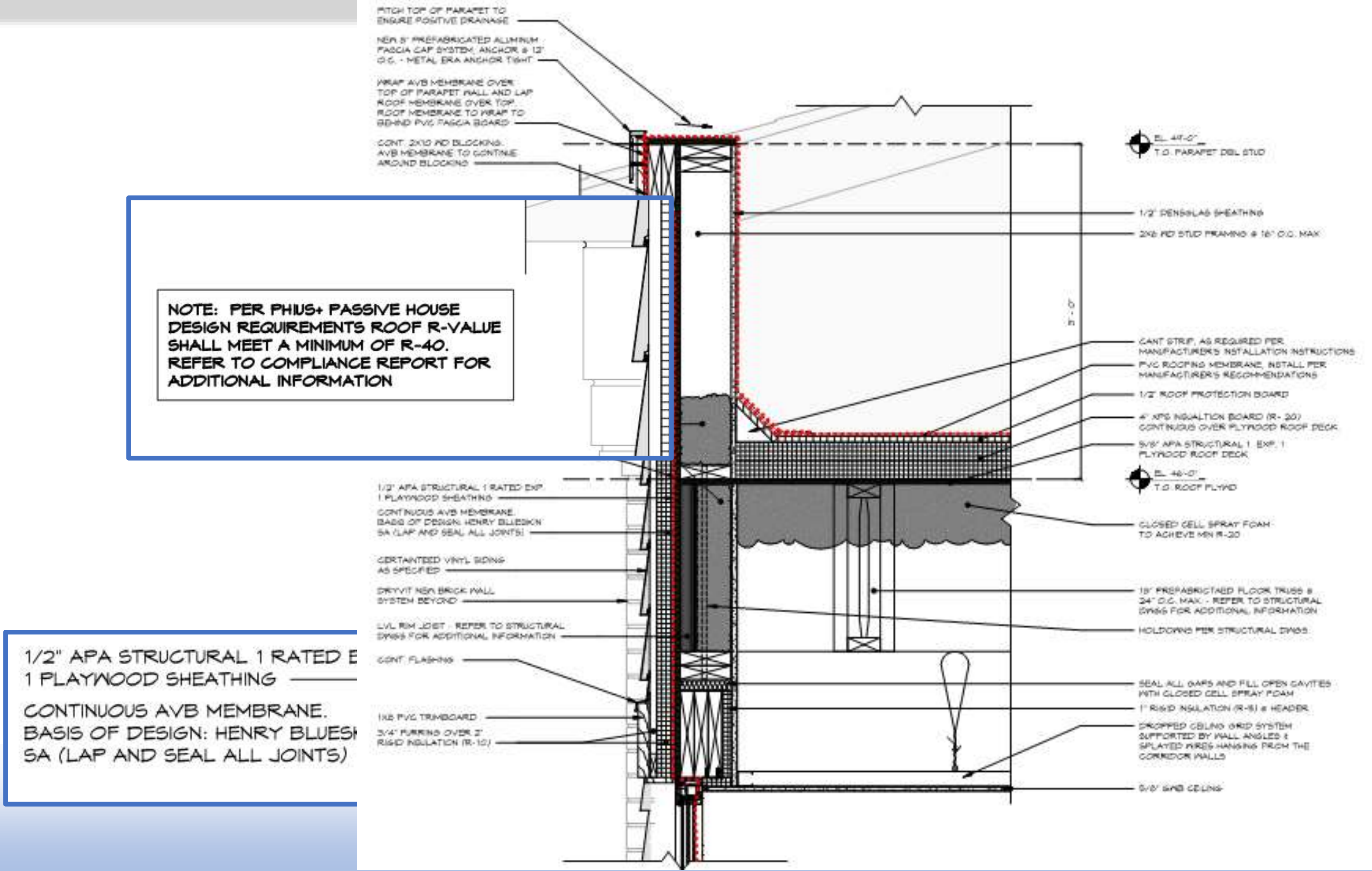
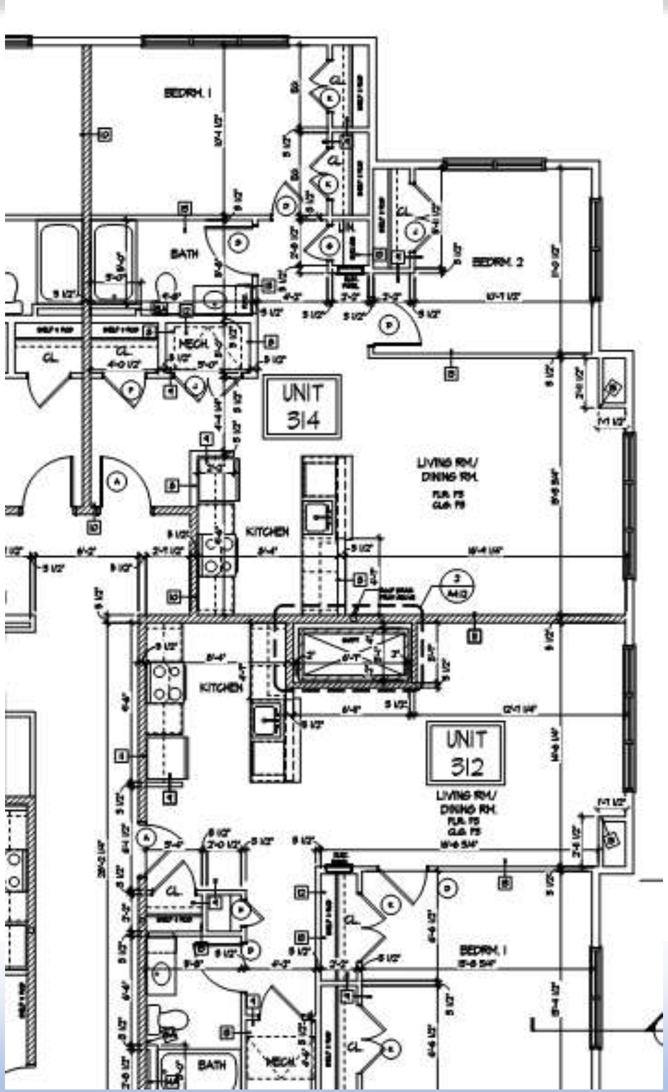
Air Barrier & Thermal Barrier



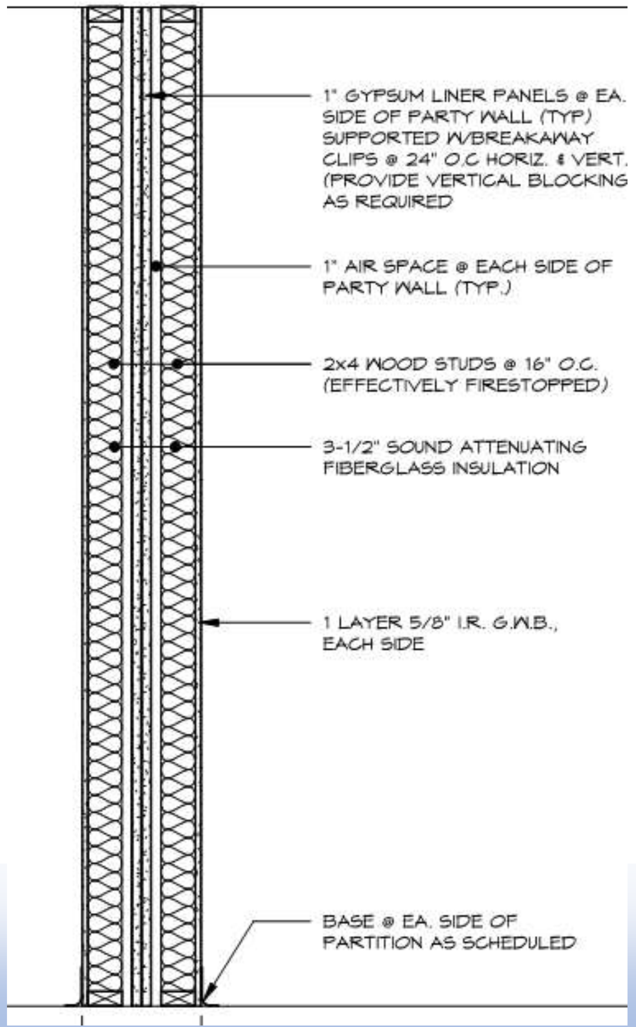
Air Barrier & Thermal Barrier

Common Walls

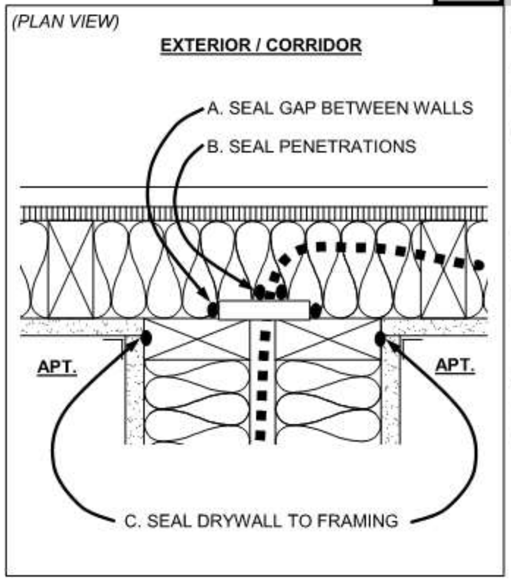


Air Barrier

Demising Walls



7 DEMISING DOUBLE WALL AT EXTERIOR / CORRIDOR WALL



Notes:

A, B, C. Intent: reduce leakage between exterior / corridor wall and demising wall / interior partition

A. Options:
- Expanding foam
- Plywood, drywall or rigid foam board with edges caulked

A. Mineral wool or fiberglass batts are NOT acceptable as an air barrier

C. Option: apply drywall adhesive to framing BEFORE installing drywall

Responsibilities:

Drywall: C
Mech/Elec/Plumb: A, B

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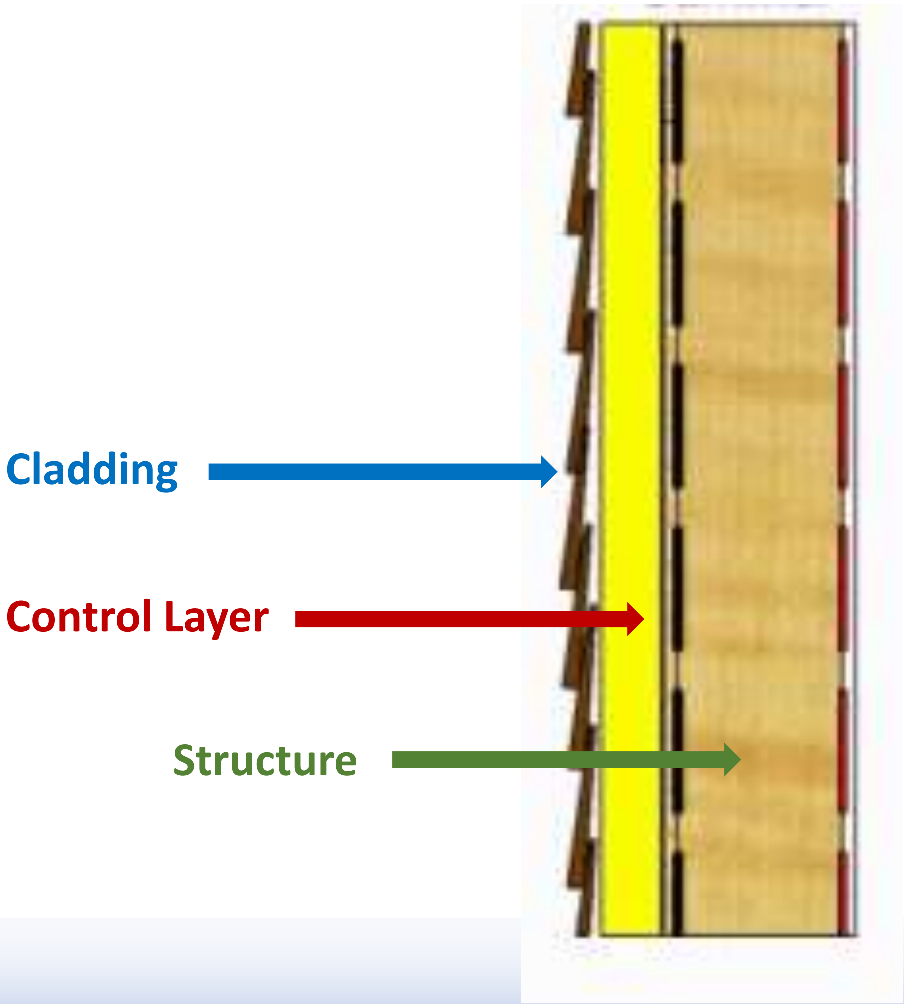
Vapor Control

Air Control Layer

Vapor Control Layer

Thermal Control Layer



Vapor Control

Class I . <0.1 perms e.g. polyethylene sheet, sheet metal, or aluminum facing.

Class II. 0.1 - 1.0 perms e.g., faced batts, and some vapor control paints.

Class III. 1.0 - 10 perms e.g. latex or enamel paints.

Vapor Retarder Definitions

Permeance [perm]: the rate that moisture vapor moves through a given construction layer for the given **thickness**

Permeability [perm in]: the rate that moisture vapor moves through a given construction material at a standard thickness (1 in or 1 cm)

Permeance = Permeability ÷ Layer Thickness

Vapor Retarder Definitions

Example:

A certain type of SPF has a permeability of 1.2 perm per inch

A) What is the perm rating of 1.5 inches of SPFA?

B) What vapor retarder class does this fall under?

Answer:

A) Permeance = permeability ÷ layer thickness

Permeance = 1.2 perm in/1.5 in = 0.8 perm

Class III: 1.0 < perm <=10 perm

B) **Class II: 0.1 < perm <=1.0 perm**

Class I: < =0.1 perm

Vapor Control

Code: CZ 1-3, 4A, 4B: No Interior Vapor Control is required (or recommended) on the interior side of framed walls

Wood sheathing and plywood: 10 perms (very permeable) might allow drying to outside
OSB: 2 perms becomes more of a Vapor Retarder as it gets wet.

Vapor Control

(2015 IBC): CZ 5-8, Marine 4: Class I or II Vapor Retarders SHALL be provided on the interior side of frame walls.

UNLESS

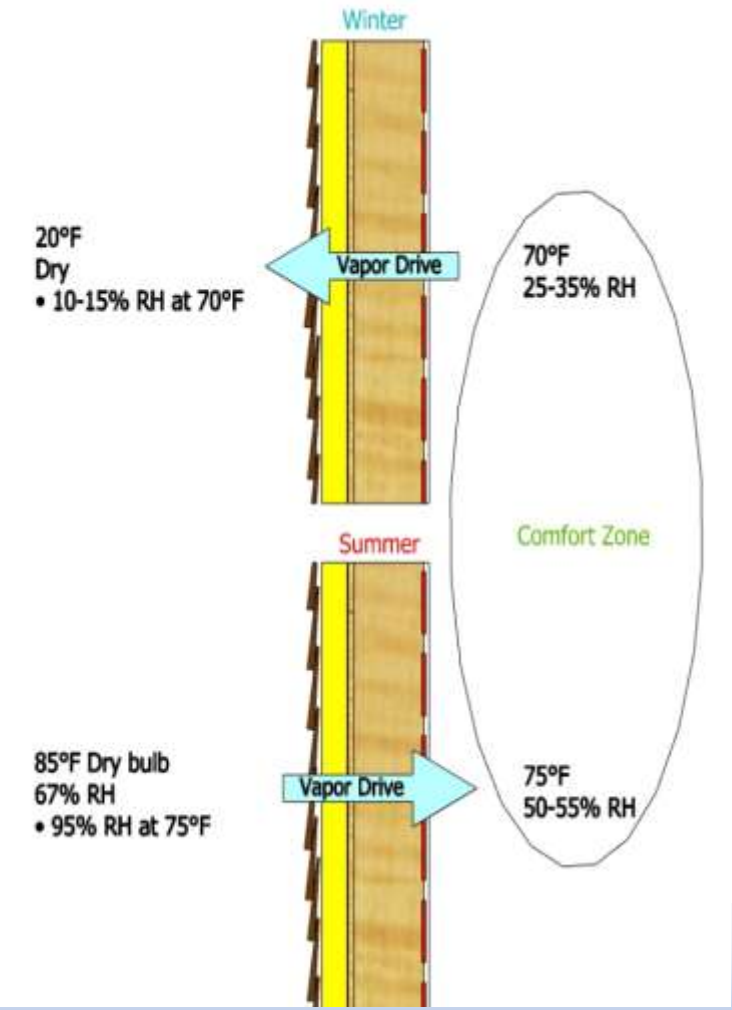
Continuous Insulation meets the required R value . . . than a Class III (latex paint) VR is allowed (Class I & II should not be allowed!).

EXTERIOR WALLS

TABLE 1405.3.2
CLASS III VAPOR RETARDERS

ZONE	CLASS III VAPOR RETARDERS PERMITTED FOR:[a]
Marine 4	Vented cladding over wood structural panels Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with *R*-value ≥ R2.5 over 2 × 4 wall Insulated sheathing with *R*-value ≥ R3.75 over 2 × 6 wall
5	Vented cladding over wood structural panels Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with *R*-value ≥ R5 over 2 × 4 wall Insulated sheathing with *R*-value ≥ R7.5 over 2 × 6 wall
6	Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with *R*-value ≥ R7.5 over 2 × 4 wall Insulated sheathing with *R*-value ≥ R11.25 over 2 × 6 wall
7 and 8	Insulated sheathing with *R*-value ≥ R10 over 2 × 4 wall Insulated sheathing with *R*-value ≥ R15 over 2 × 6 wall

Thermal Barrier & Vapor Control



Tinterface= Tindoor-[(Tindoor-Toutdoor) x (Rcavity/Rtotal)]

Ok for some gut check math but Avg. temp is too arbitrary

Average Daily Temperature °F Dec/Jan/Feb	Minimum Recommended Exterior CI R-Value		
	R21 Stud Cavity	R15 Stud Cavity	
34°	R 4	R 3	
32°	R 5.5	R 4	
30°	**R 7**	R 5	Washington, DC ~ CZ 4
28°	**R 8.5**	R 6	Baltimore, MD ~ CZ 4
26°	R 10	R 7	Worcester, MA ~ CZ 5

Thermal Barrier & Vapor Control

EXTERIOR INSULATION — 2" POLYISO (R-12)

STUD BAY INSULATION — 5½" FG BATT (R-19)

$$T_{\text{back of sheathing}} = T_{\text{interior}} - (T_{\text{interior}} - T_{\text{exterior}}) \frac{R_{\text{stud bay}}}{R_{\text{total}}}$$

$$= 68^\circ - (68^\circ - 26^\circ)\frac{19}{31}$$

$$= 68^\circ - [42^\circ \cdot .6129]$$

$$= 68^\circ - 25.7^\circ$$

$$= 42.3^\circ$$ In trouble if RH exceeds ±38%

$$T_{\text{back of sheathing}} = T_{\text{interior}} - (T_{\text{interior}} - T_{\text{exterior}}) \frac{R_{\text{stud bay}}}{R_{\text{total}}}$$

$$= 68^\circ - (68^\circ - 26^\circ)\frac{26.2}{32.8}$$

$$= 68^\circ - [42^\circ \cdot 0.79878]$$

$$= 68^\circ - 33.5^\circ$$

$$T_{\text{back of sheathing}} = 34.5^\circ$$ In trouble if RH exceeds ±28%

2" INSULATED ZIP (R-9.6)

$$T = 68^\circ - (68^\circ - 26^\circ)\frac{26.2}{35.8}$$

$$= 68 - [42 \cdot .7318]$$

$$= 37.3^\circ$$ In trouble if RH exceeds ±32%

2½" INSULATED ZIP (R-12.6)

$$T = 68^\circ - (68^\circ - 26^\circ)\frac{26.2}{38.8}$$

$$= 68^\circ - [42^\circ \cdot .6752]$$

$$= 39.7^\circ$$ In trouble if RH exceeds ±35%

Thermal Barrier & Vapor Control

This is also achievable with closed cell foam in the cavity (CZ 4, R8-ish)

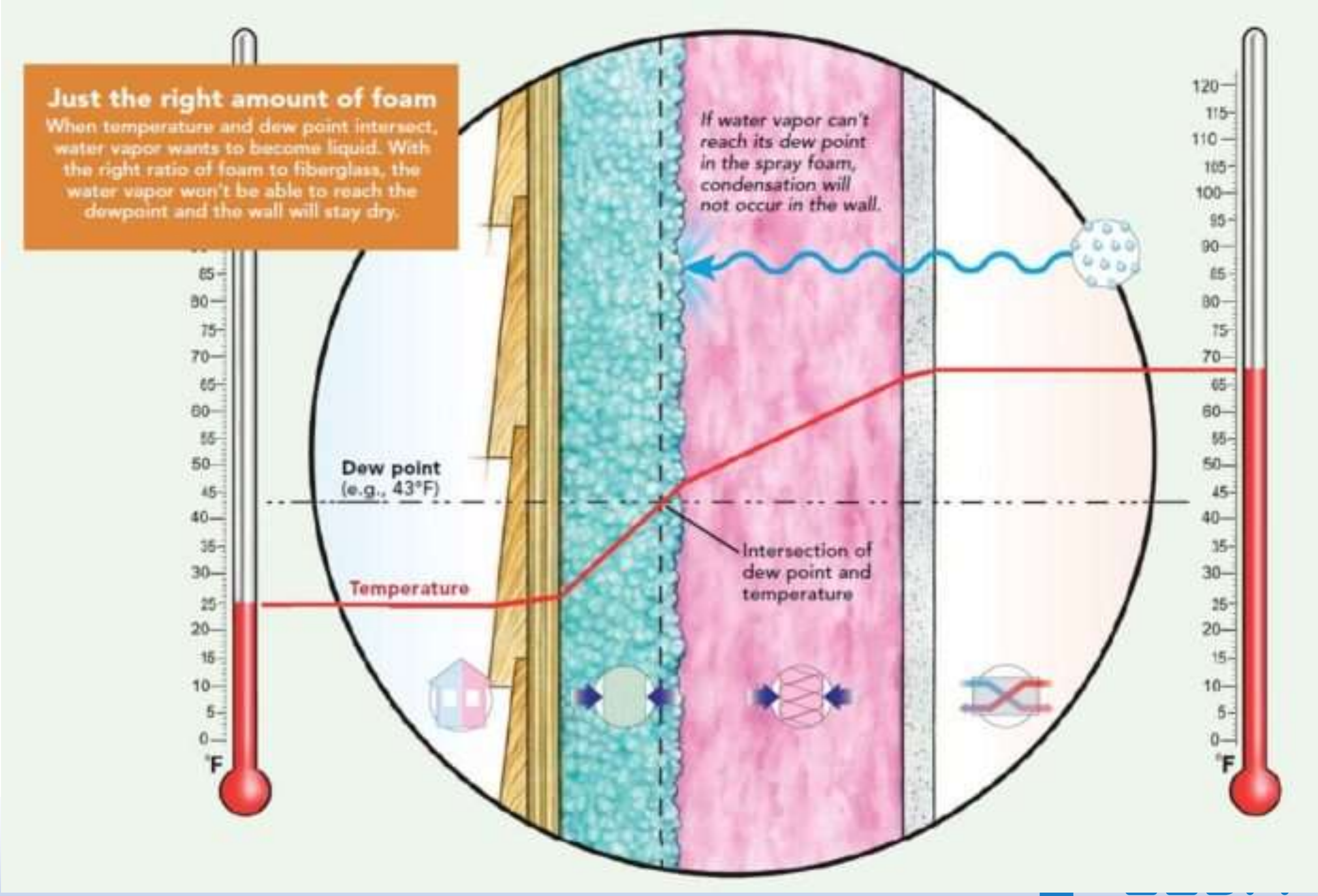


Image credit: Green Building Advisor

Thermal Barrier & Vapor Control

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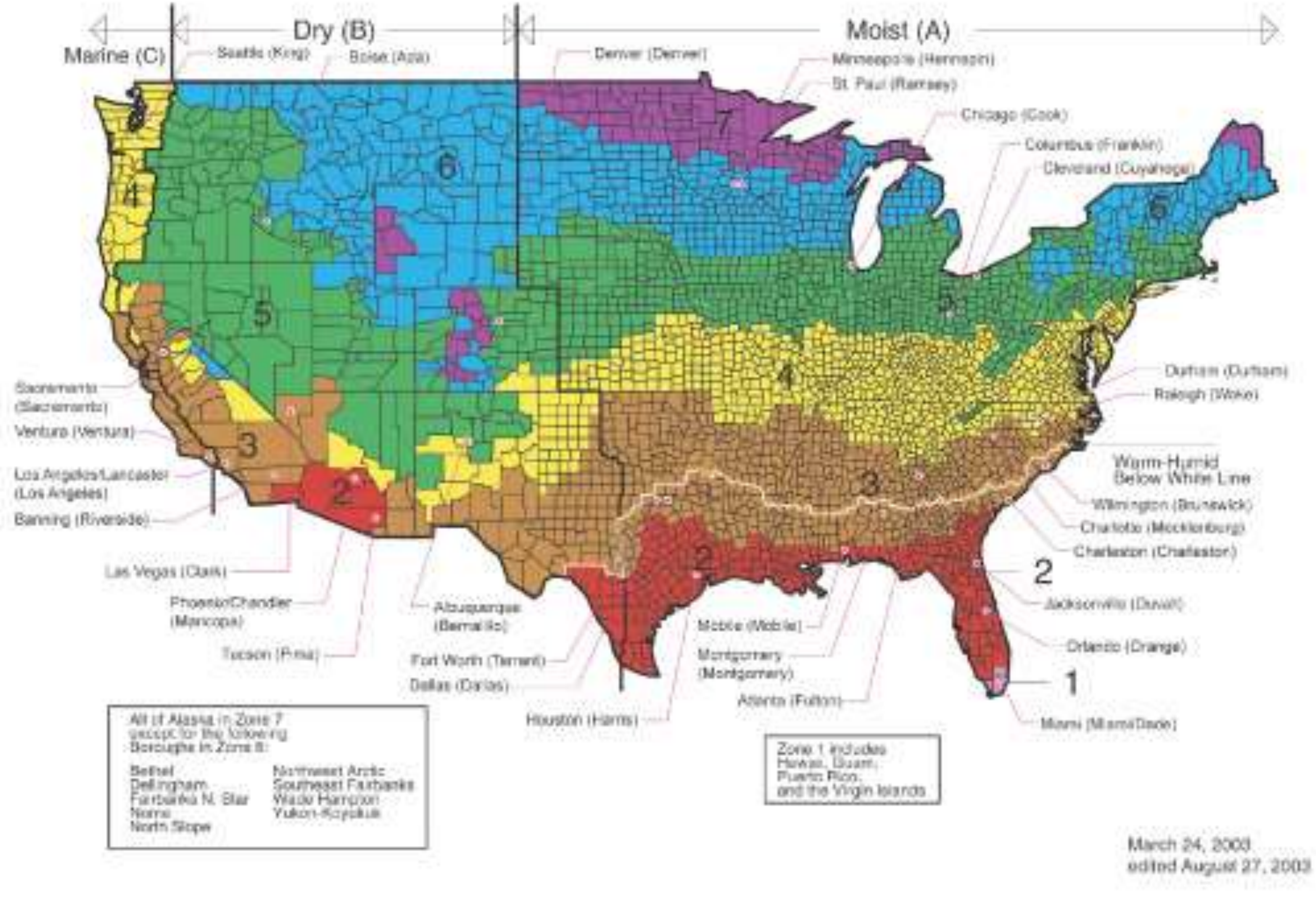
Thermal Barrier & Vapor Control

Thermal Barrier & Vapor Control

No vapor control required on the interior side of framed walls in CZ 1, 2, 3, 4a, 4b



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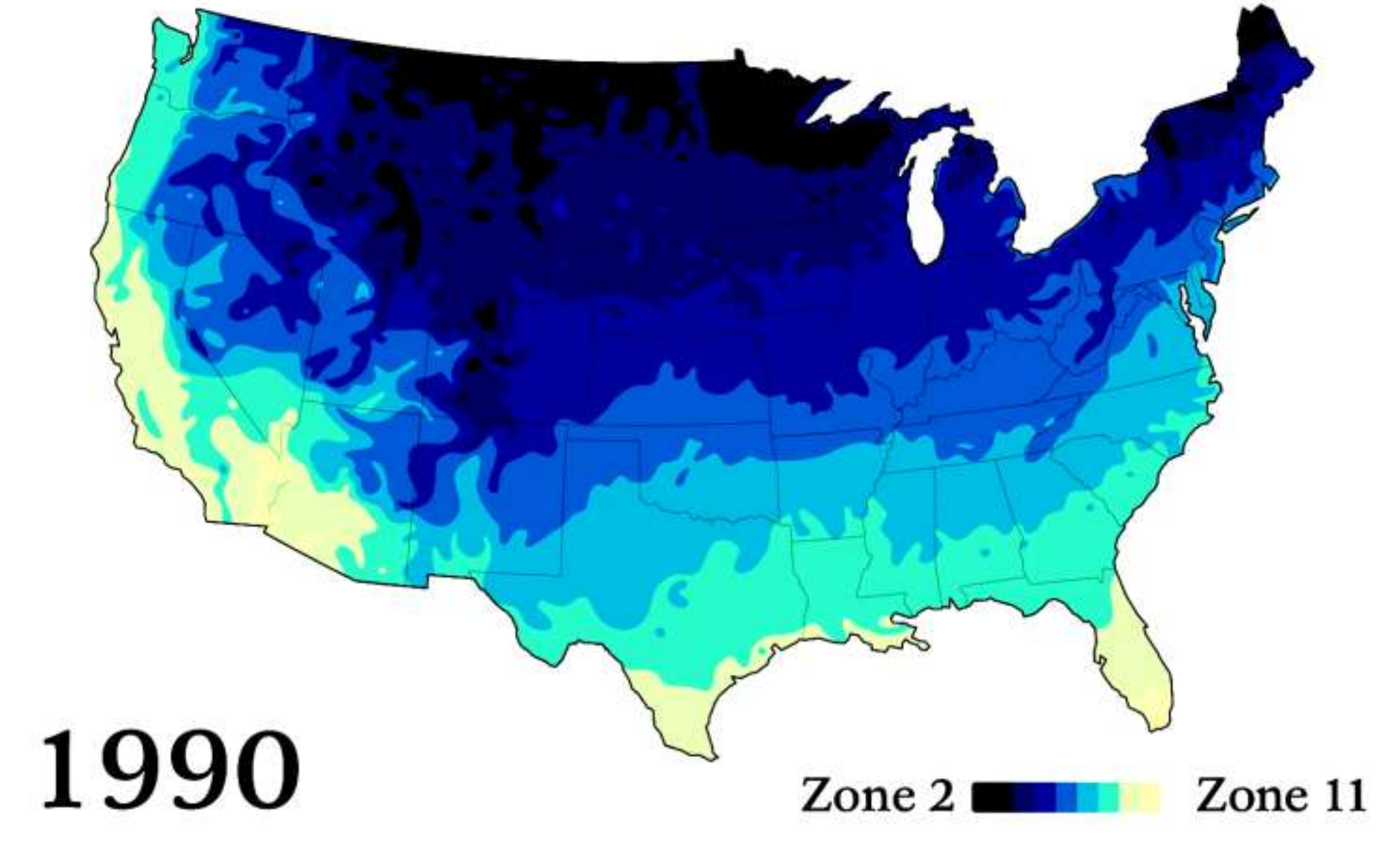
Thermal Barrier & Vapor Control

Plant hardiness zones are moving North at the rate of 13 miles per decade



Thermal Barrier & Vapor Control

2009 IECC

TABLE 402.1.1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION U-FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c] WALL R-VALUE
1	1.2	0.75	0.30	30	13	3/4	13	0	0	0
2	0.65[j]	0.75	0.30	30	13	4/6	13	0	0	0
3	0.50[j]	0.65	0.30	30	13	5/8	19	5/13[f]	0	5/13
4 except Marine	0.35	0.60	NR	38	13	5/10	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.35	0.60	NR	38	20 or 13+5[h]	13/17	30[g]	10/13	10, 2 ft	10/13
6	0.35	0.60	NR	49	20 or 13+5[h]	15/19	30[g]	15/19	10, 4 ft	10/13
7 and 8	0.35	0.60	NR	49	21	19/21	38[g]	15/19	10, 4 ft	10/13

2018 IECC

CLIMATE ZONE	FENESTRATION U-FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c] WALL R-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.32	0.55	0.25	38	20 or 13+5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.32	0.55	0.40	49	20 or 13+5[h]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.30	0.55	NR	49	20 or 13+5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.30	0.55	NR	49	20+5[h] or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.30	0.55	NR	49	20+5[h] or 13+10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

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2015 IBC

TABLE 1405.3.2
CLASS III VAPOR RETARDERS

ZONE	CLASS III VAPOR RETARDERS PERMITTED FOR:[a]
Marine 4	Vented cladding over wood structural panels Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with *R*-value ≥ R2.5 over 2 × 4 wall Insulated sheathing with *R*-value ≥ R3.75 over 2 × 6 wall
5	Vented cladding over wood structural panels Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with *R*-value ≥ R5 over 2 × 4 wall Insulated sheathing with *R*-value ≥ R7.5 over 2 × 6 wall
6	Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with *R*-value ≥ R7.5 over 2 × 4 wall Insulated sheathing with *R*-value ≥ R11.25 over 2 × 6 wall
7 and 8	Insulated sheathing with *R*-value ≥ R10 over 2 × 4 wall Insulated sheathing with *R*-value ≥ R15 over 2 × 6 wall

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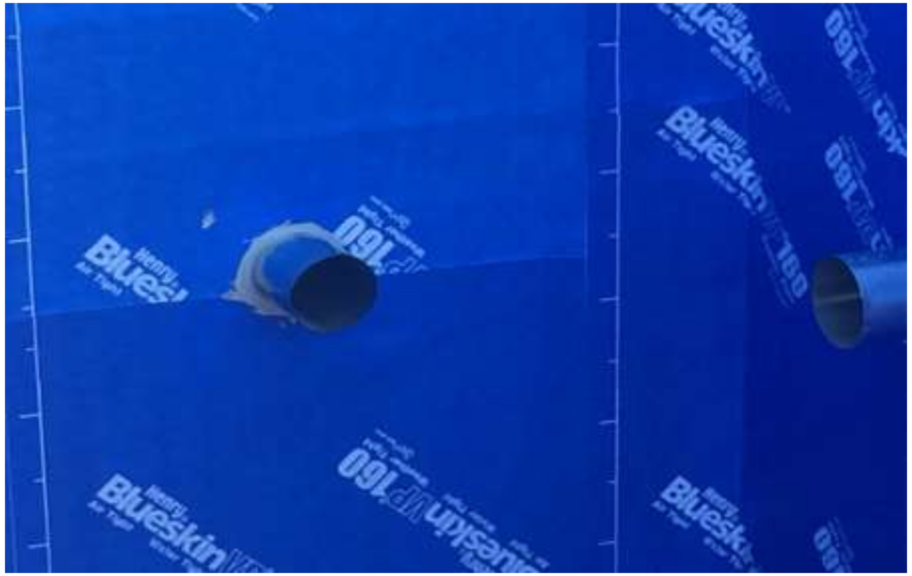

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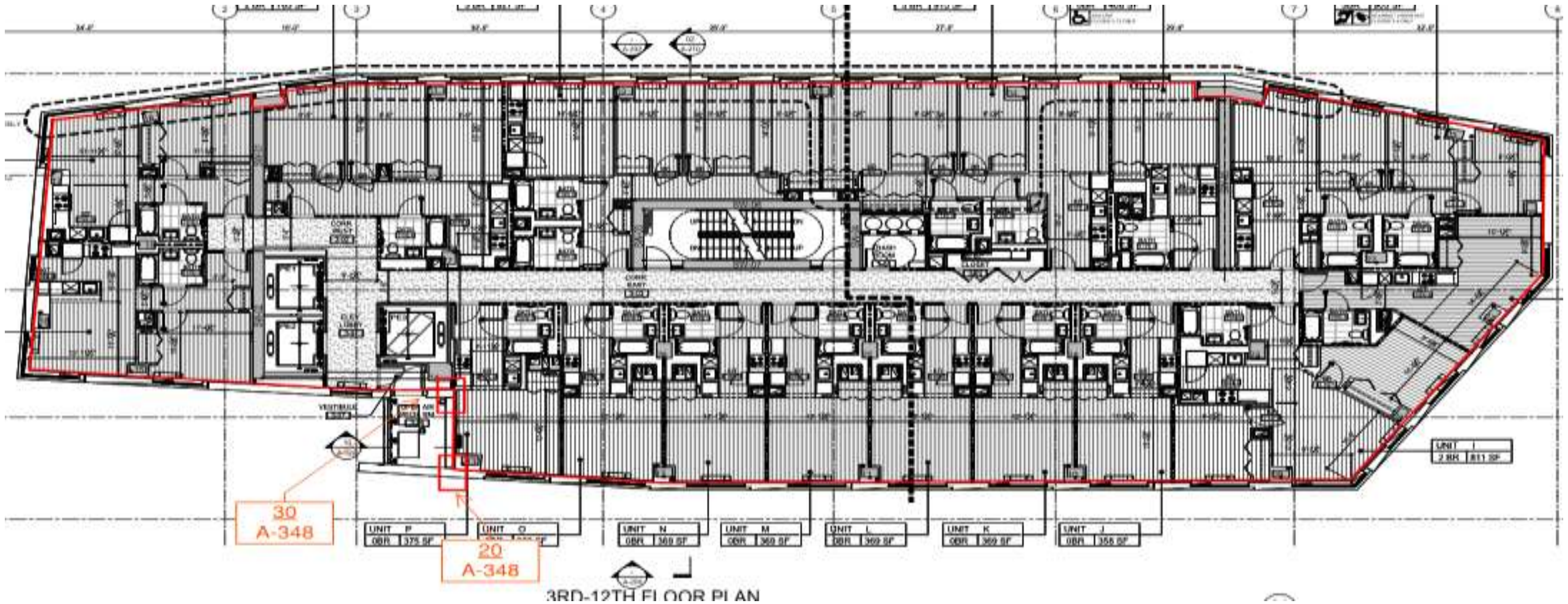

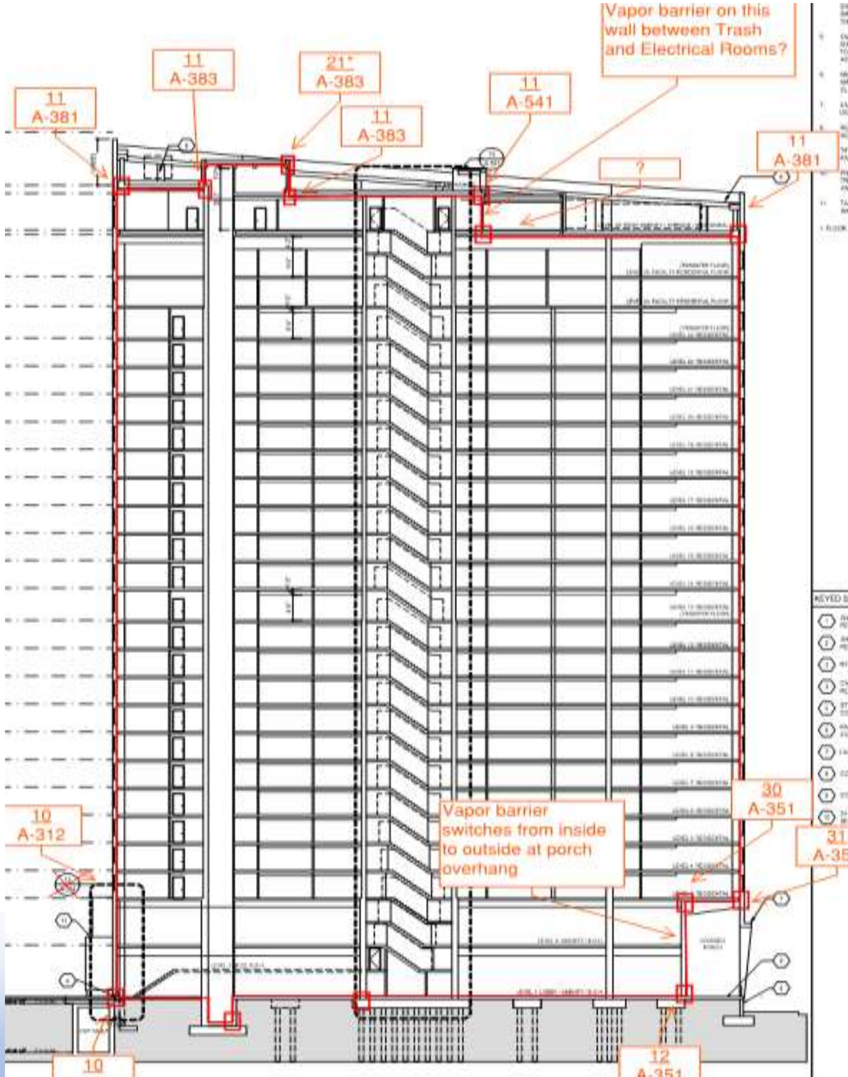

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Photo: Pavel Bendov

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2015 IBC

TABLE 1203.3
INSULATION FOR CONDENSATION CONTROL

CLIMATE ZONE	MINIMUM R-VALUE OF AIR-IMPERMEABLE INSULATION[a]
2B and 3B tile roof only	0 (none required)
1, 2A, 2B, 3A, 3B, 3C	R-5
4C	R-10
4A, 4B	R-15
5	R-20
6	R-25
7	R-30
8	R-35

a. Contributes to, but does not supersede, thermal resistance requirements for attic and roof assemblies in Section C402.2.1 of the *International Energy Conservation Code*.

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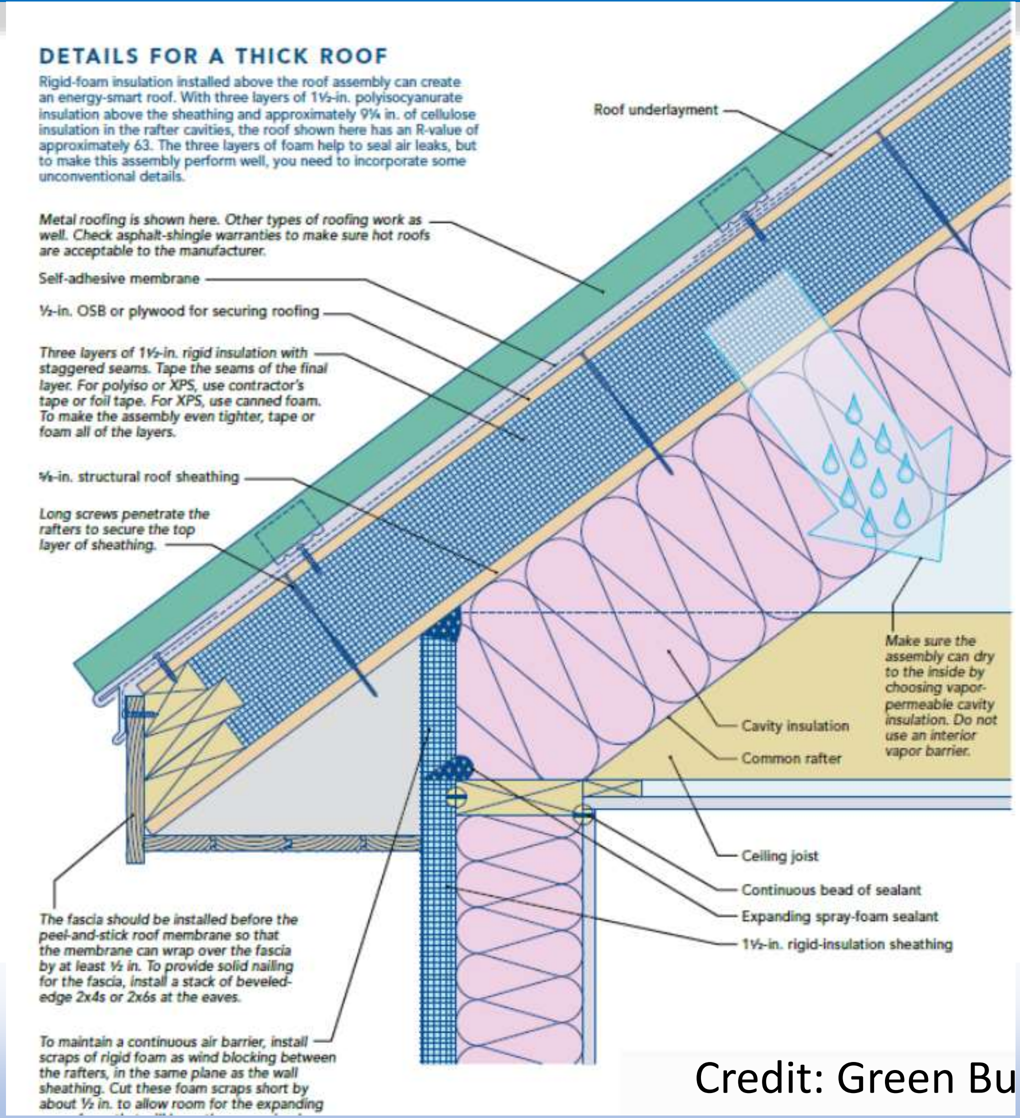
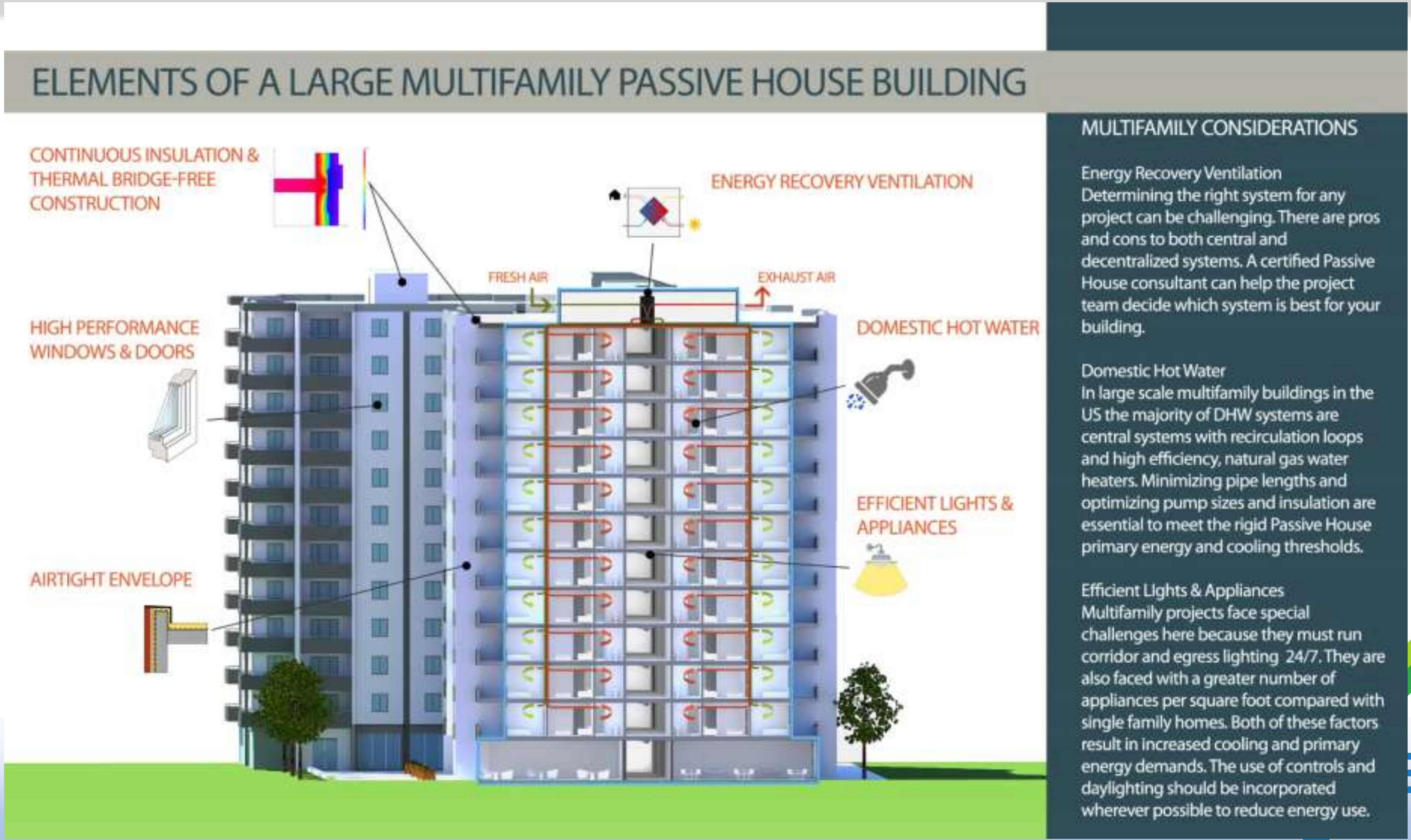
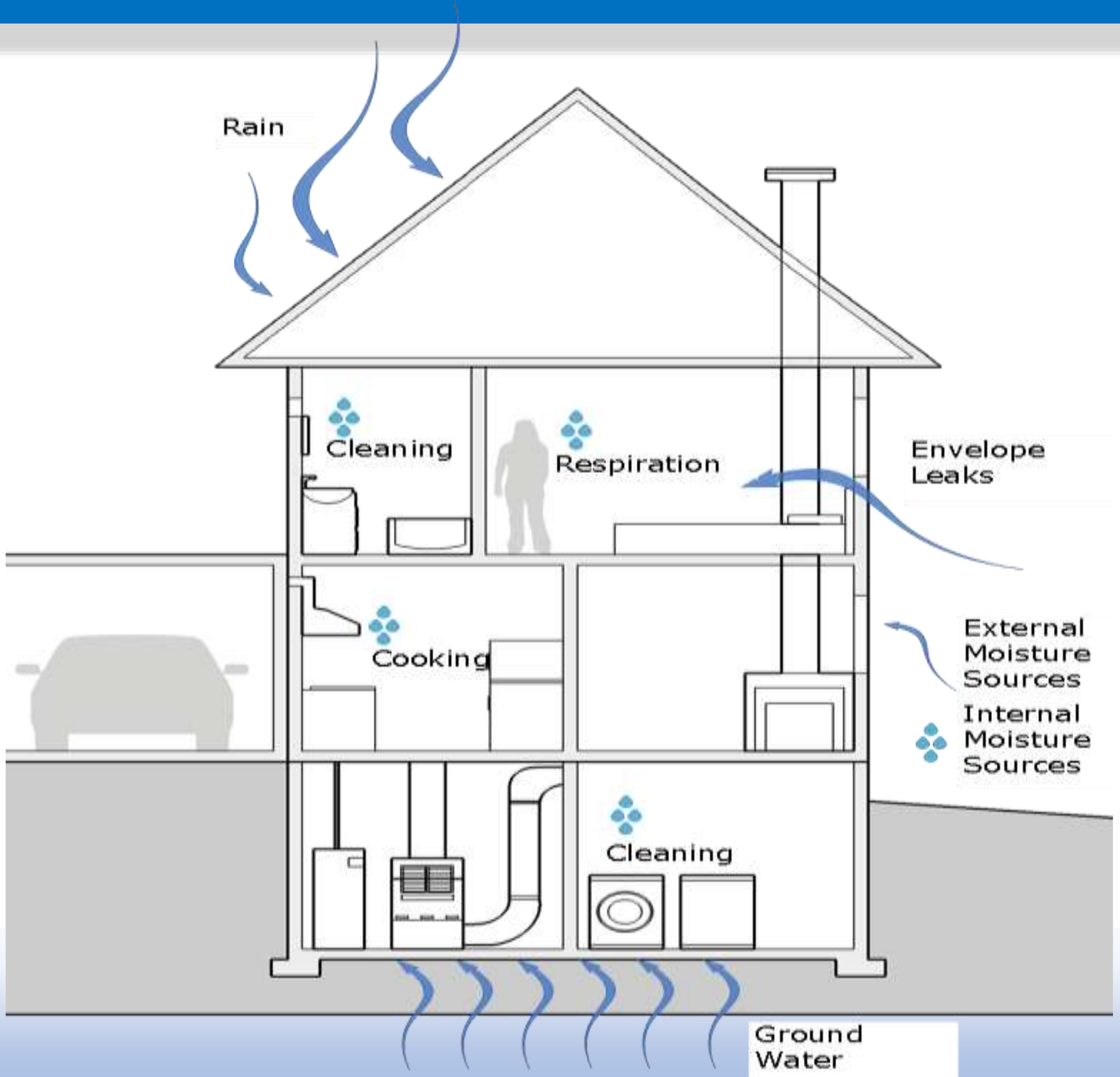


Credit: Green Building Advisor

Vapor Control

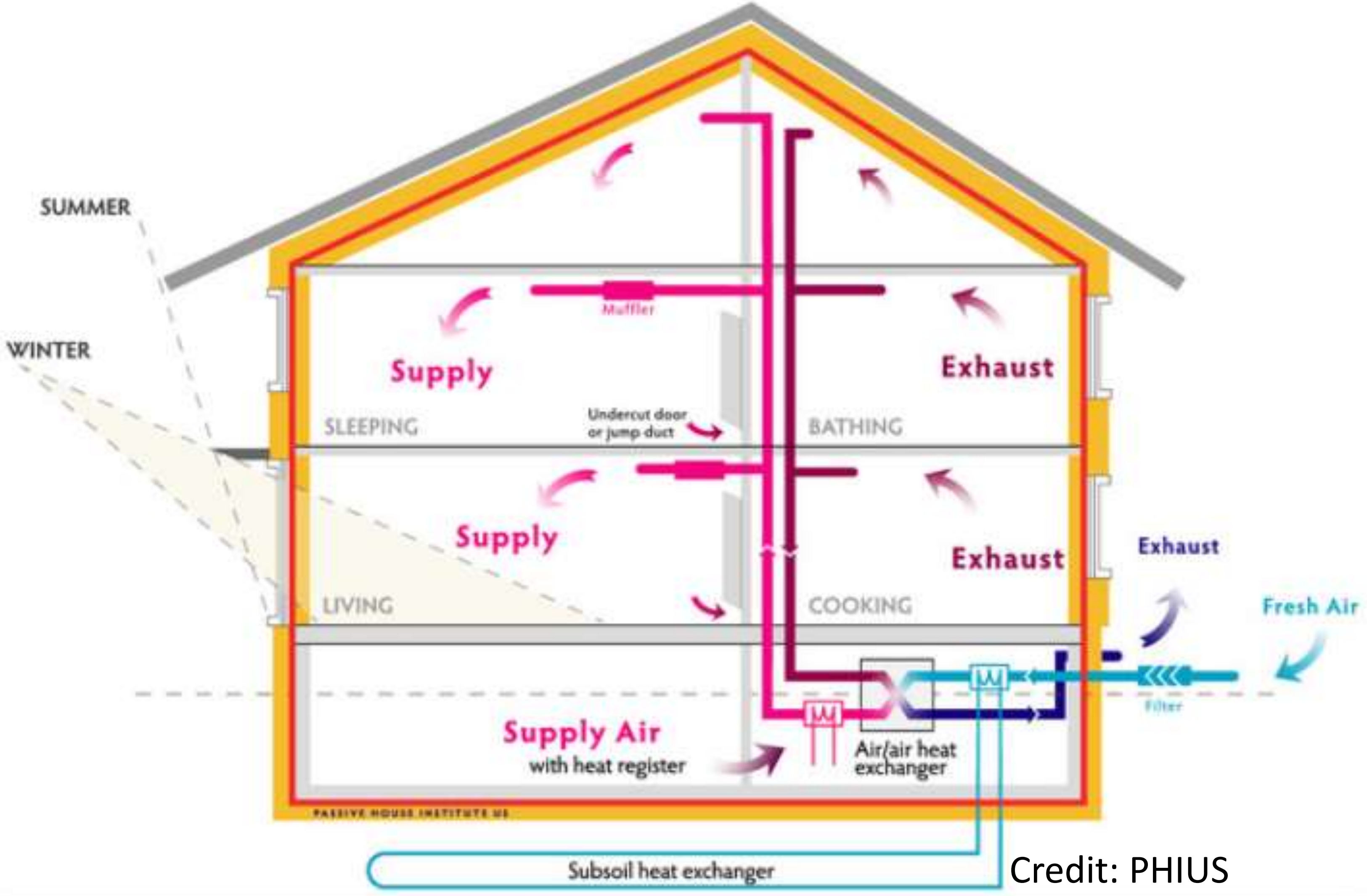


Vapor Control



Vapor Control

Vapor Control



Credit: PHIUS

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Thank you!

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Save the dates for next year:

HIGH PERFORMANCE HOME SUMMIT 2020

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SEPT 29 - OCT 1 \ DENVER

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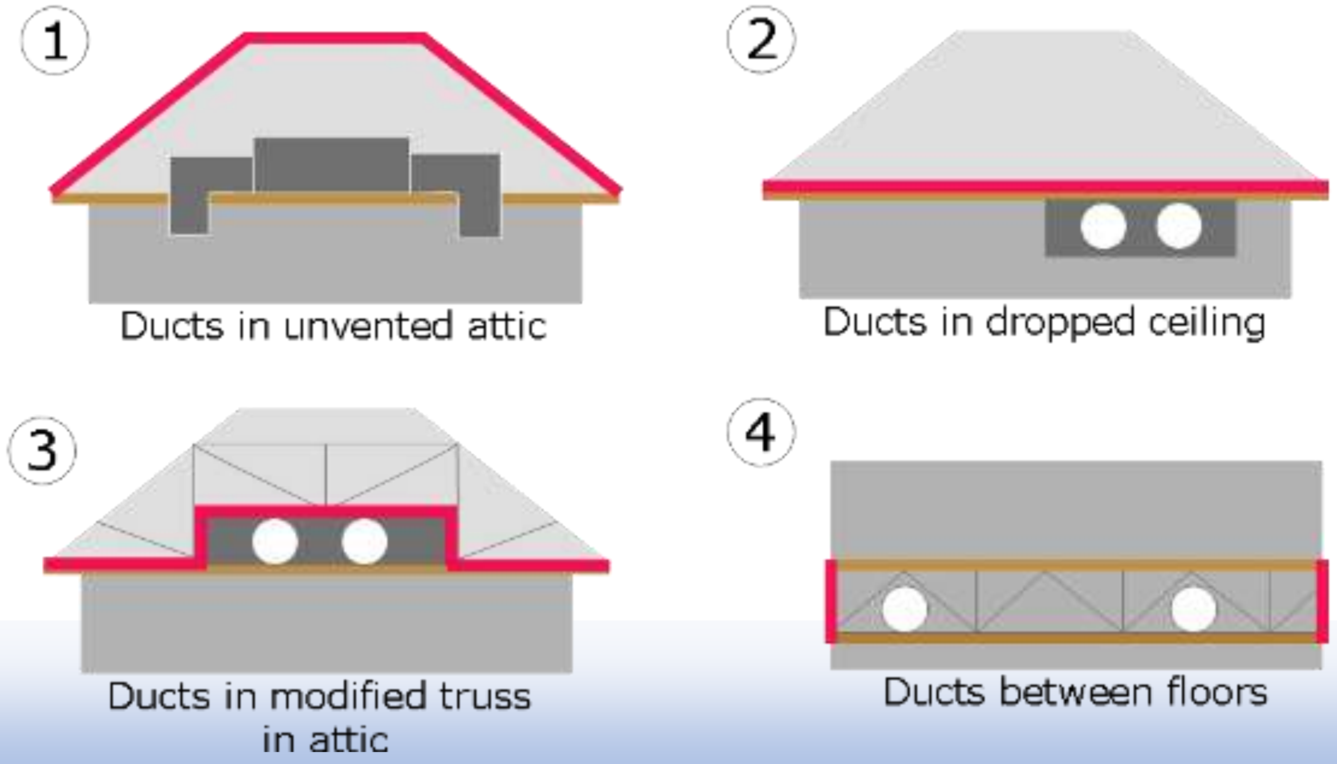
Resources

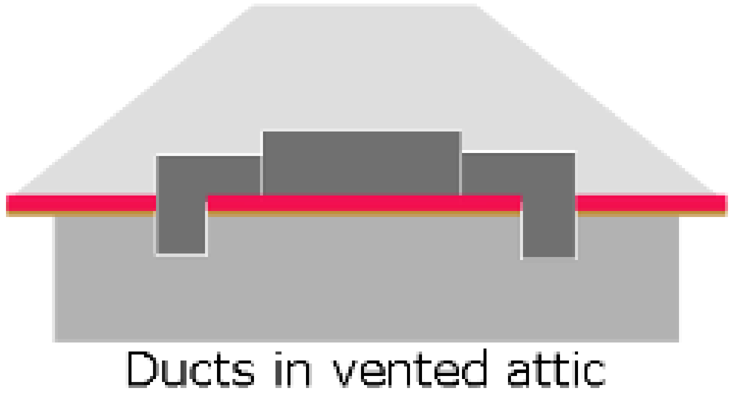
http://www.swinter.com/wp-content/uploads/SWA_High-Performance-Walls-Handout.pdf

http://www.swinter.com/wp-content/uploads/SWA-MultifamilyAirSealingGuide-Masonry.pdf

Durability & Comfort

- Ductwork thermal losses can range from 10-45%
- Interior ducts locations may impact cost, aesthetics and envelope loads





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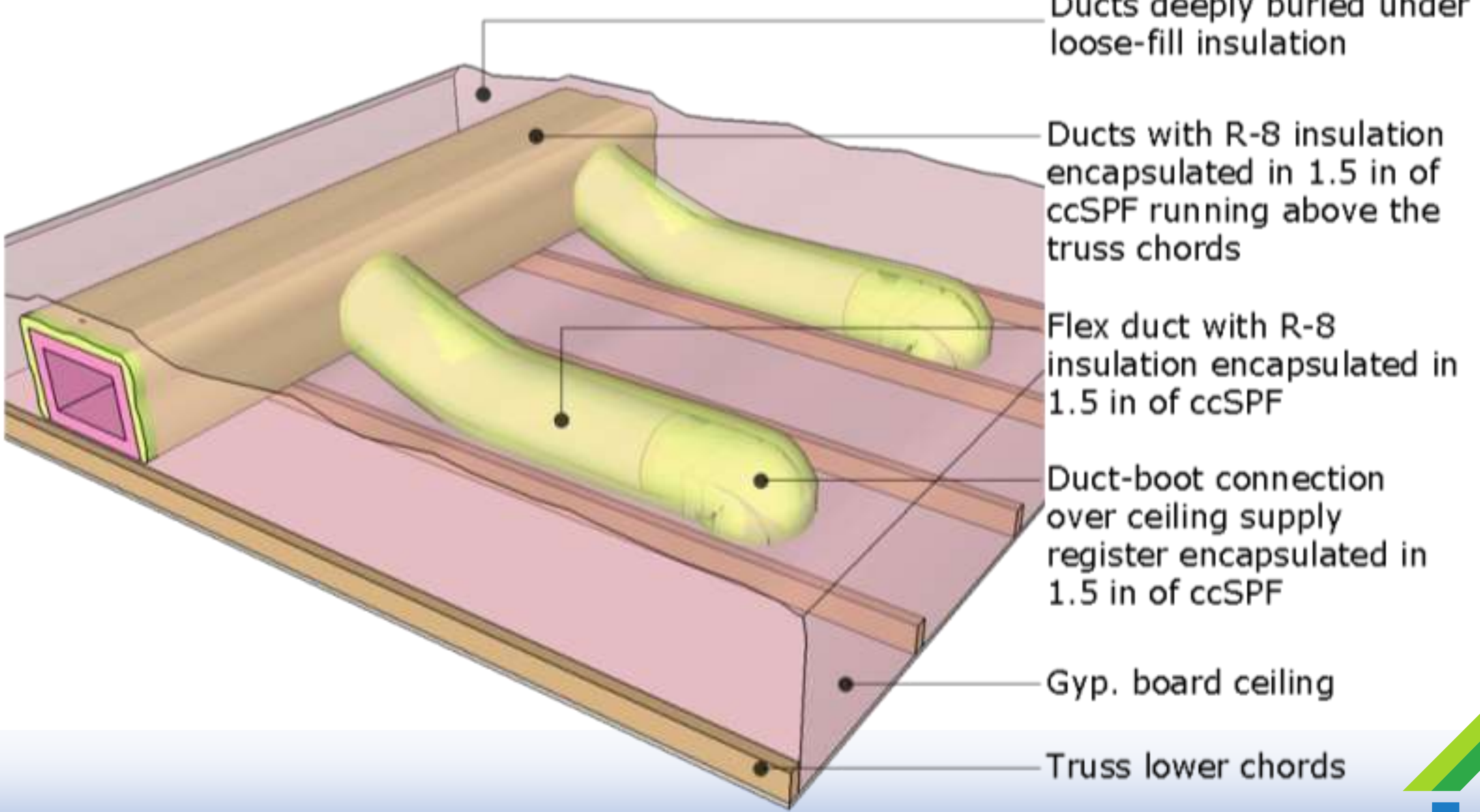


Durability & Comfort



Durability & Comfort

How ventilation works

1. Fresh air is fed into the system via an external wall vent. With an optional air/ground source geothermal heat exchanger, the heat exchangers use geothermal energy to pre-temper outside air before it enters the system.

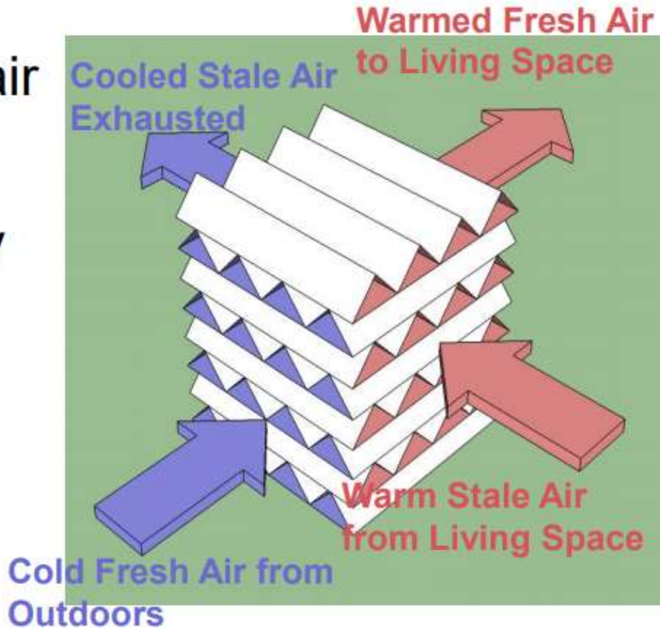
2. The Zehnder ComfoAir ventilation device recovers up to 95% of the energy from the extract air and returns it to the fresh air. This can be humidified, dehumidified, heated and cooled using optional components.

3. The Zehnder ComfoFresh air distribution system channels optimally tempered fresh air to individual rooms as needed and vents extract air to the outside. The air volume can be adjusted individually for each room.

Benefits

- Continuous supply of fresh air
- Saves energy through heat recovery
- Retains property value by preventing mildew
- Promotes good health
- Protects against outside noise
- Government subsidized (in select markets)

- Warms incoming winter air (or the reverse)
- Good to remove humidity
- Good for favorable humidity levels in & out



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Durability & Comfort

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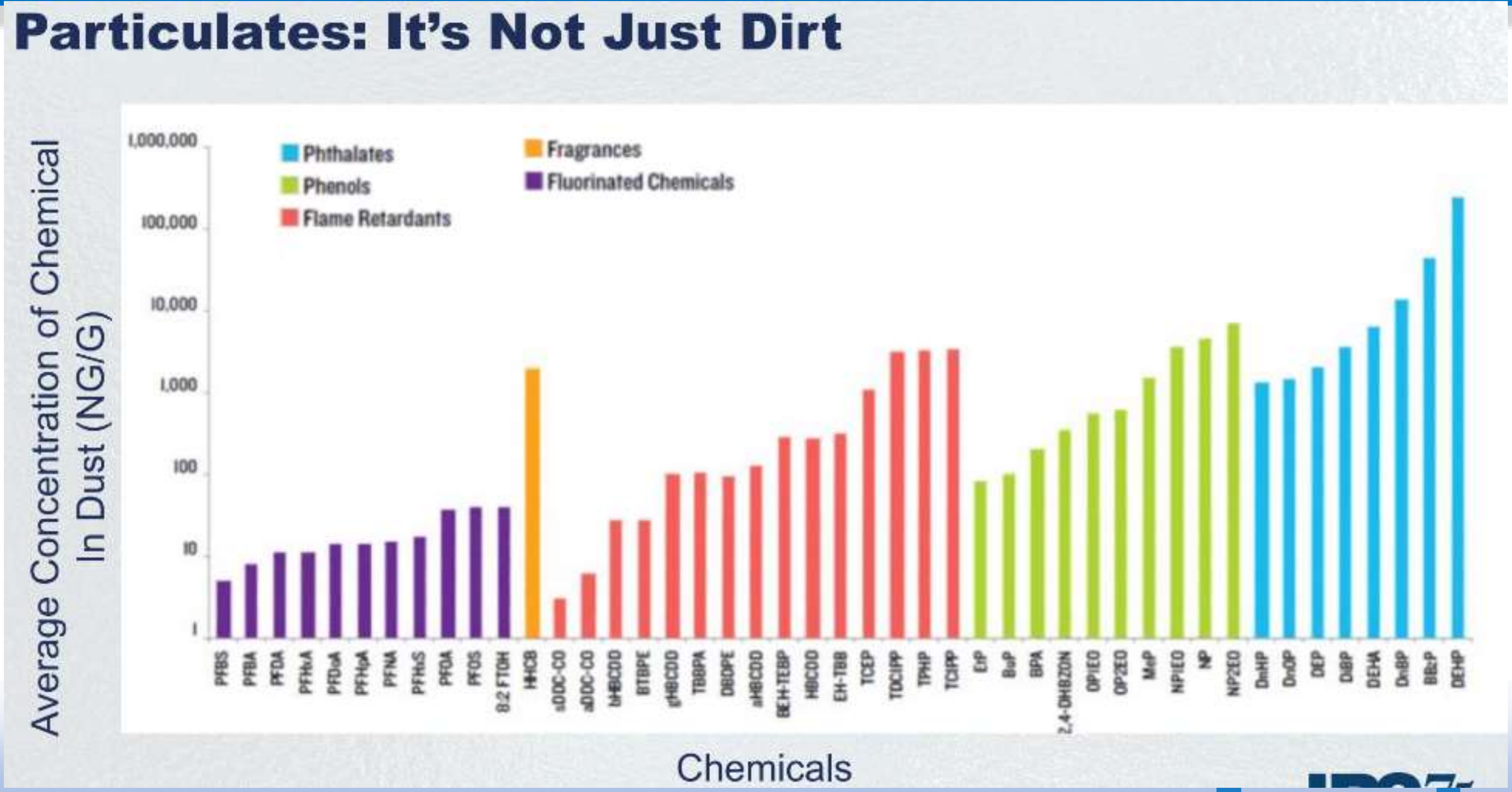
MERV Rating Chart

14	90-95%	>98%	Most Tobacco Smoke	Smoking Lounges	synthetic media, 12-36 in. deep, 6-12 pockets
					Box Filter- Rigid Style Cartridge
13	89-90%	>98%	Proplet Nuceli (Sneeze)	Superior Commercial Buildings	Filters 6 to 12" deep m ay use lofted or paper media.
12	70-75%	>95%	1.0-3.0 pm Particle Size Legionella	Superior Residential	**Bag Filter**- Nonsupported microfine fiberglass or synthetic media, 12-36 in. deep, 6-12 pockets
11	60-65%	>95%	Humidifier Dust Lead Dust	Better Commercial Buildings	**Box Filter**- Rigid Style Cartridge Filters 6 to 12" deep m ay use lofted or paper media.
10	50-55%	>95%	Milled Flour Auto Emissions	Hospital Laboratories	
9	40-45%	>90%	Welding Fumes		
8	30-35%	>90%	3.0-10.0 pm Particle Size	Commercial Buildings	**Pleated Filters**- Disposable, extended surface area, thick with cotton-polyester blend media

Durability & Comfort



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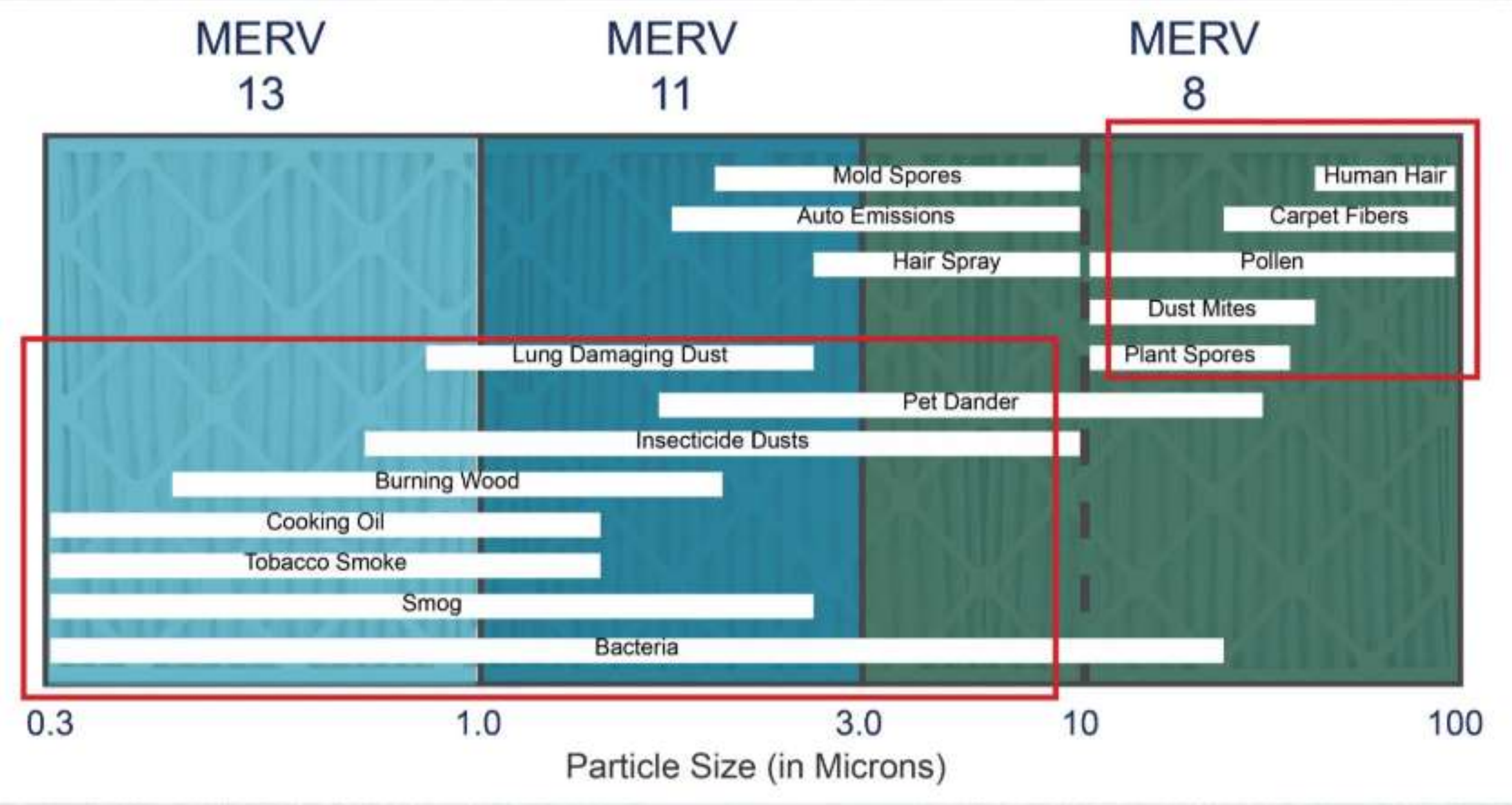

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