

Welcome

Effective Strategies for Building Enclosures

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EEBATM



HIGH PERFORMANCE
HOME SUMMIT 2019

OCTOBER 1-3 \ DENVER, CO

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



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



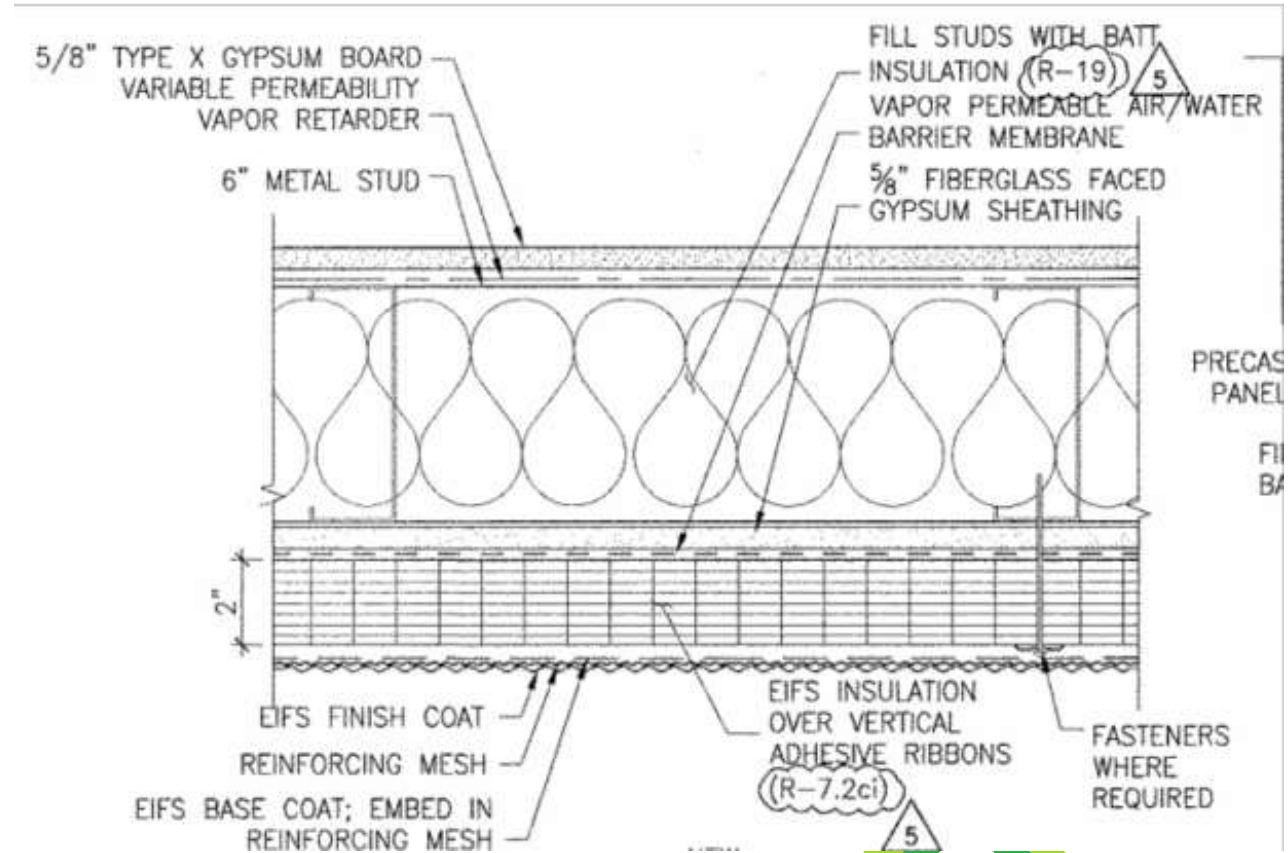
Panels/Siding/Trim – Directly Attached



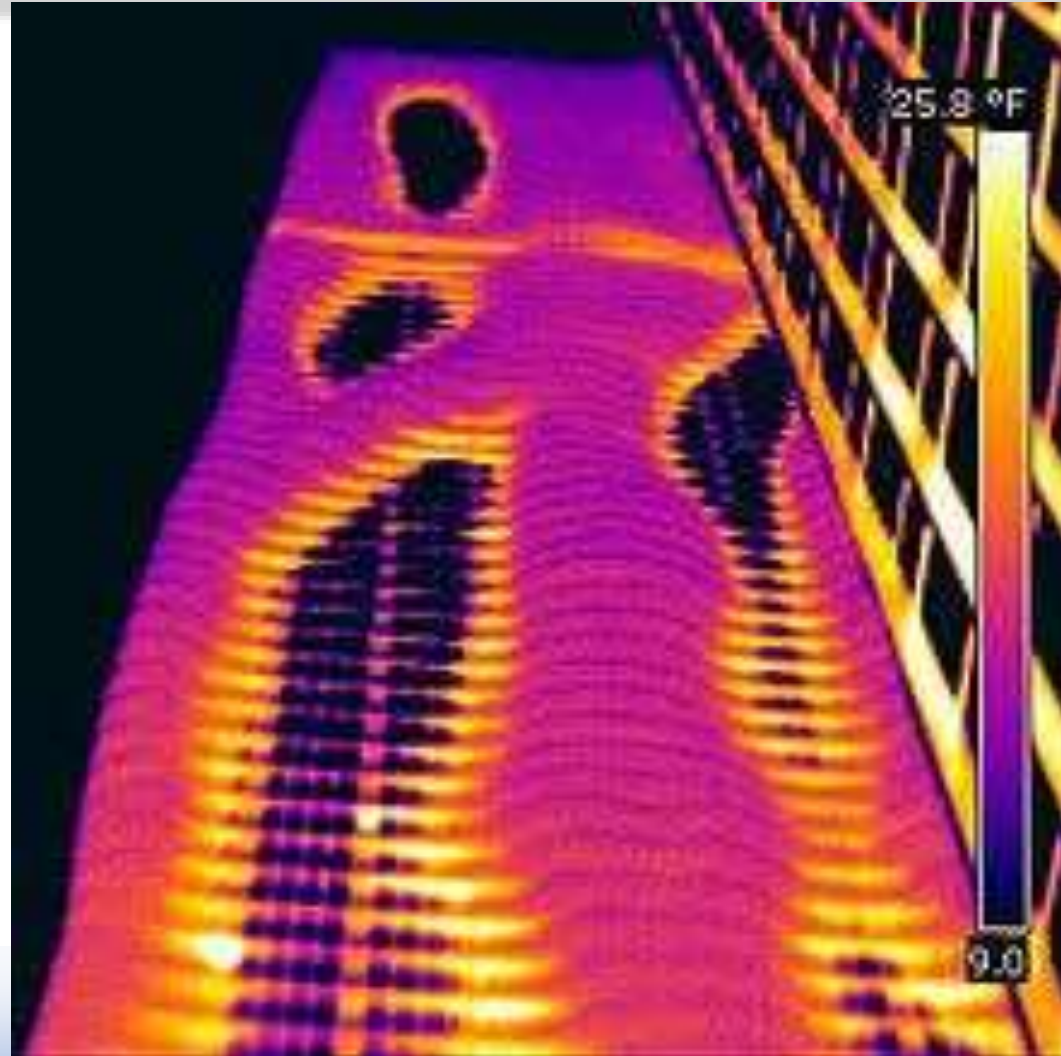
Panels/Siding/Trim – Sub Framing Attached



EIFS/Cement Plaster



Design Strategies



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

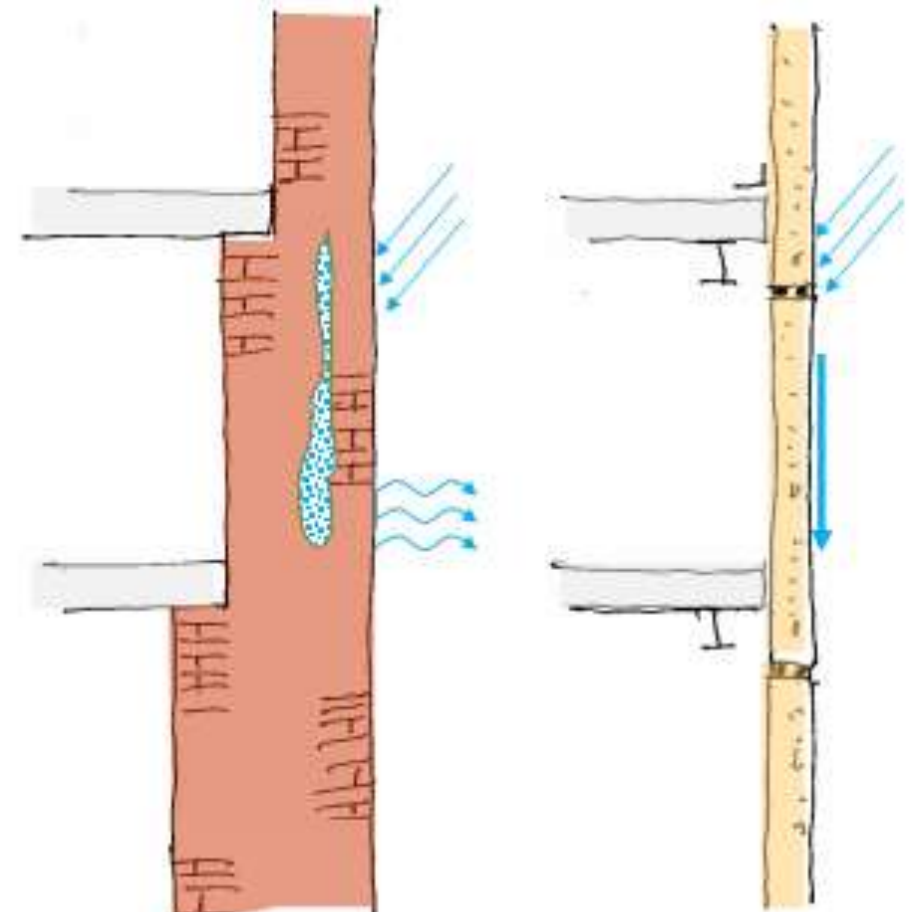


Image credit: Jeffrey D. Kerr, P.E.

Drainage Systems

Masonry Veneer

Adhered Masonry Veneer

Panels/Siding/Trim

Cement Plaster

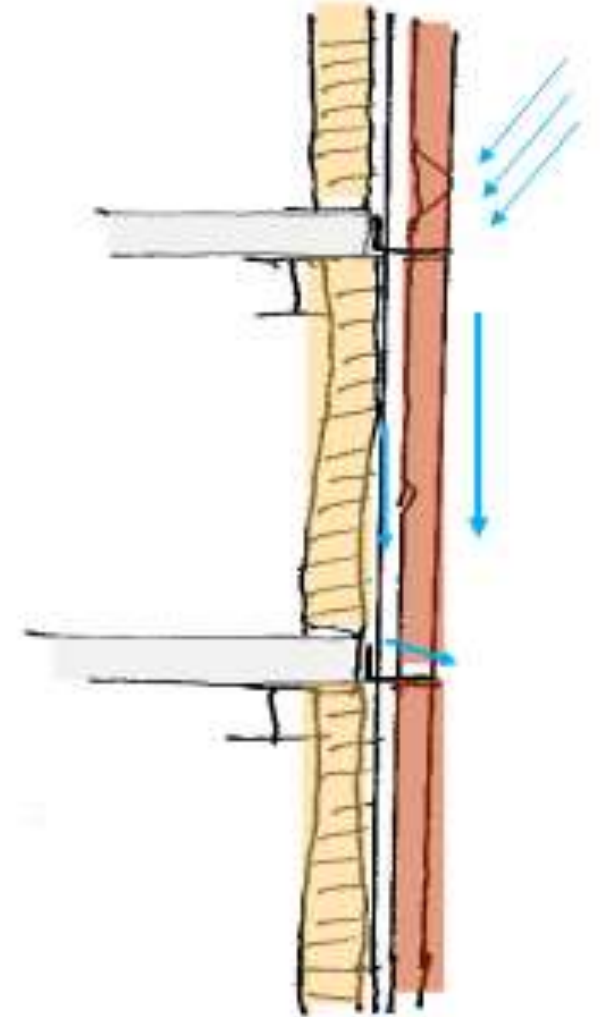
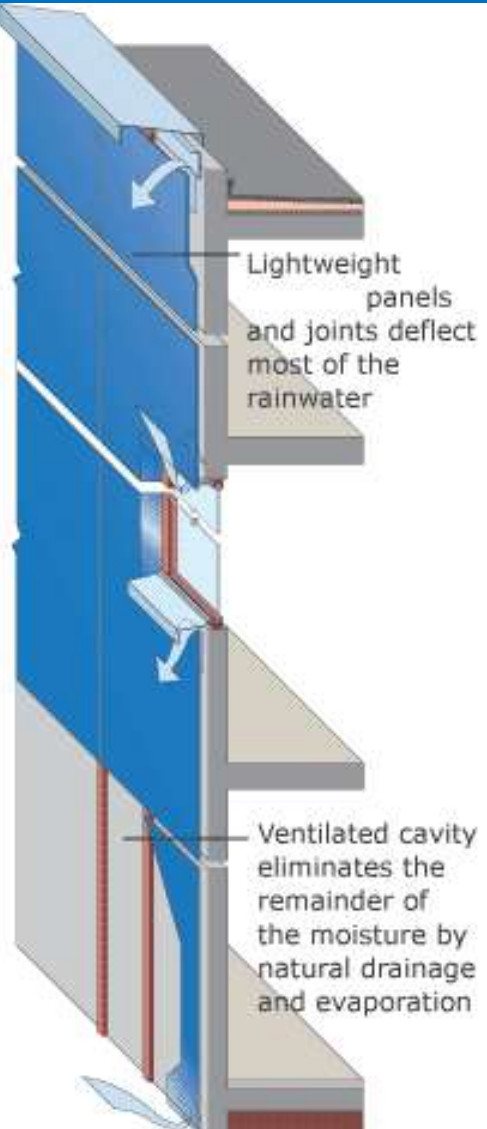


Image credit: Jeffrey D. Kerr, P.E.

Rainscreen Systems



Barrier Systems



Rainscreen Systems



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



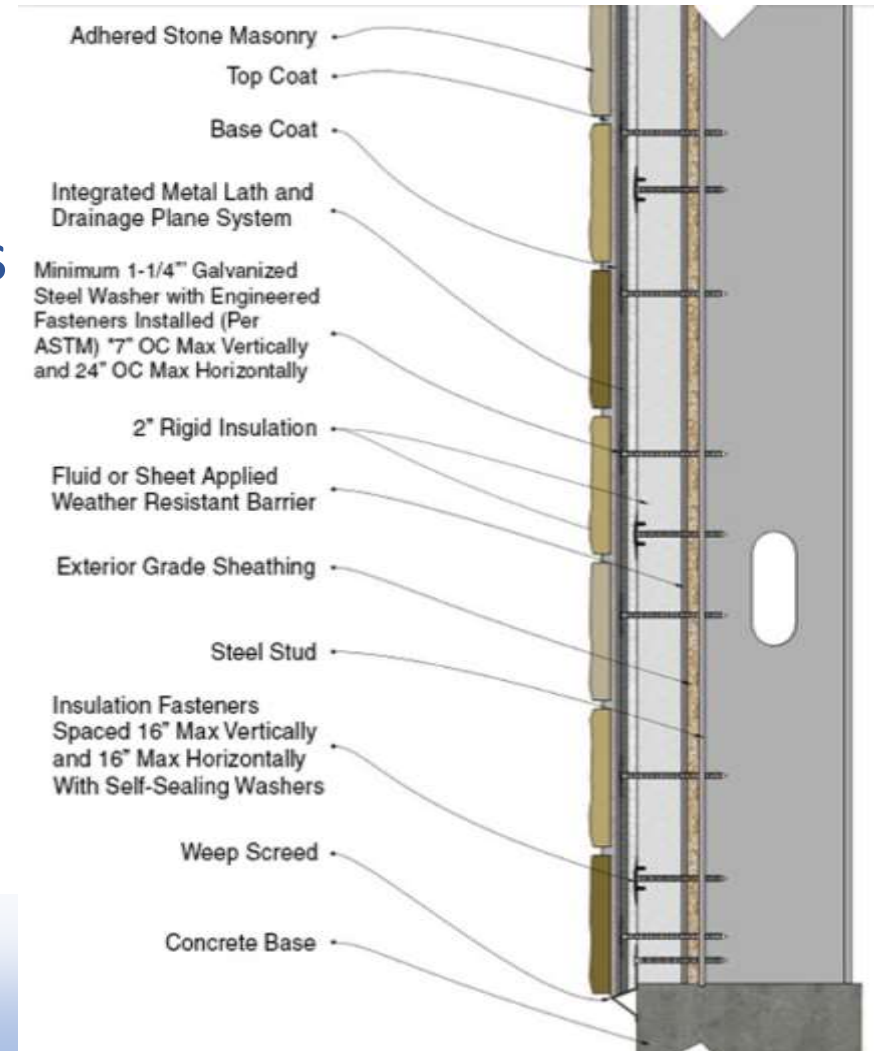
Attachment Design

Adhered Systems

Thin masonry veneer/ Cement Plaster

Difficult to incorporate continuous insulation

Sensitive to installation environmental factors



Attachment Design

For Cladding Finish Systems: Girts

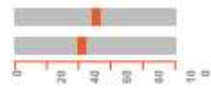
Galvanized Girts



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

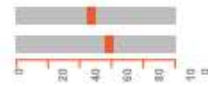
Galvanized Metal Clips



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

For Cladding Finish Systems: Clips

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

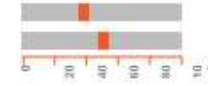
Aluminum Clips



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:
Tepla-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.

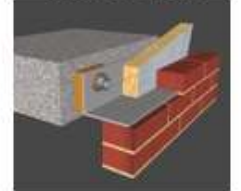
Thermal efficiency per SWA: **73-81%**



73% for Steel backup
81% for CMU backup

Example Products:
FAST (Fero Angle Support Technology),

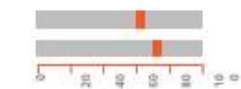
Shelf Angle with Thermal Break



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

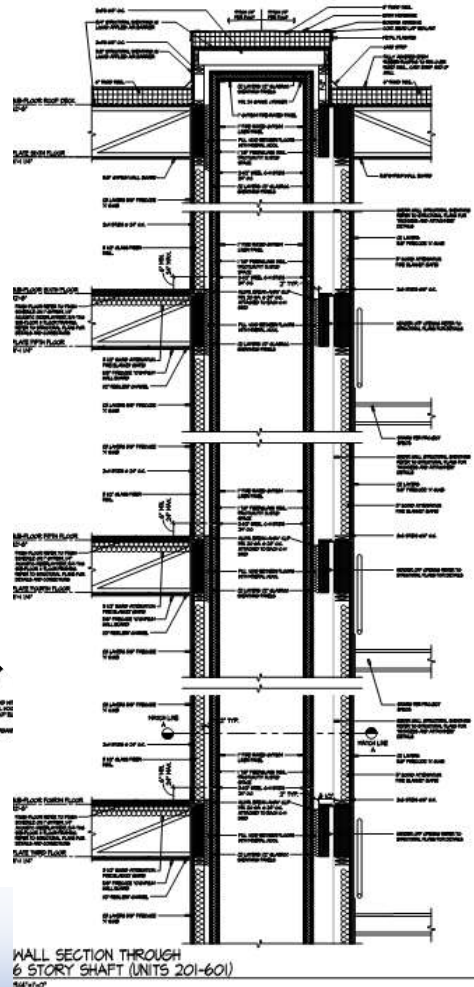
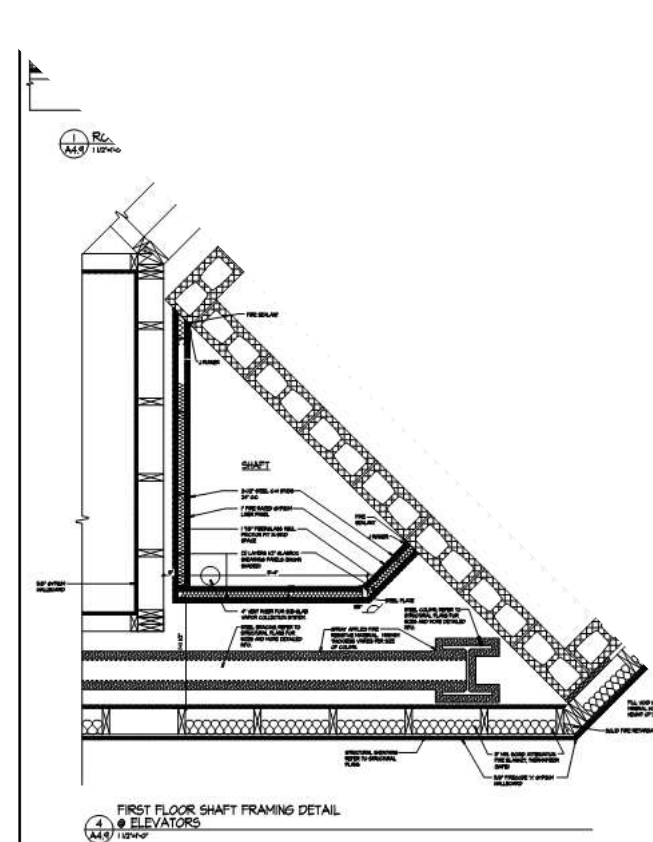
Maintainability – consider frequency and effort of maintenance

Sustainability – consider impact on the environment

Liability – shortcomings in the above can contribute to costly remediation



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!



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

Psychrometric Chart



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”



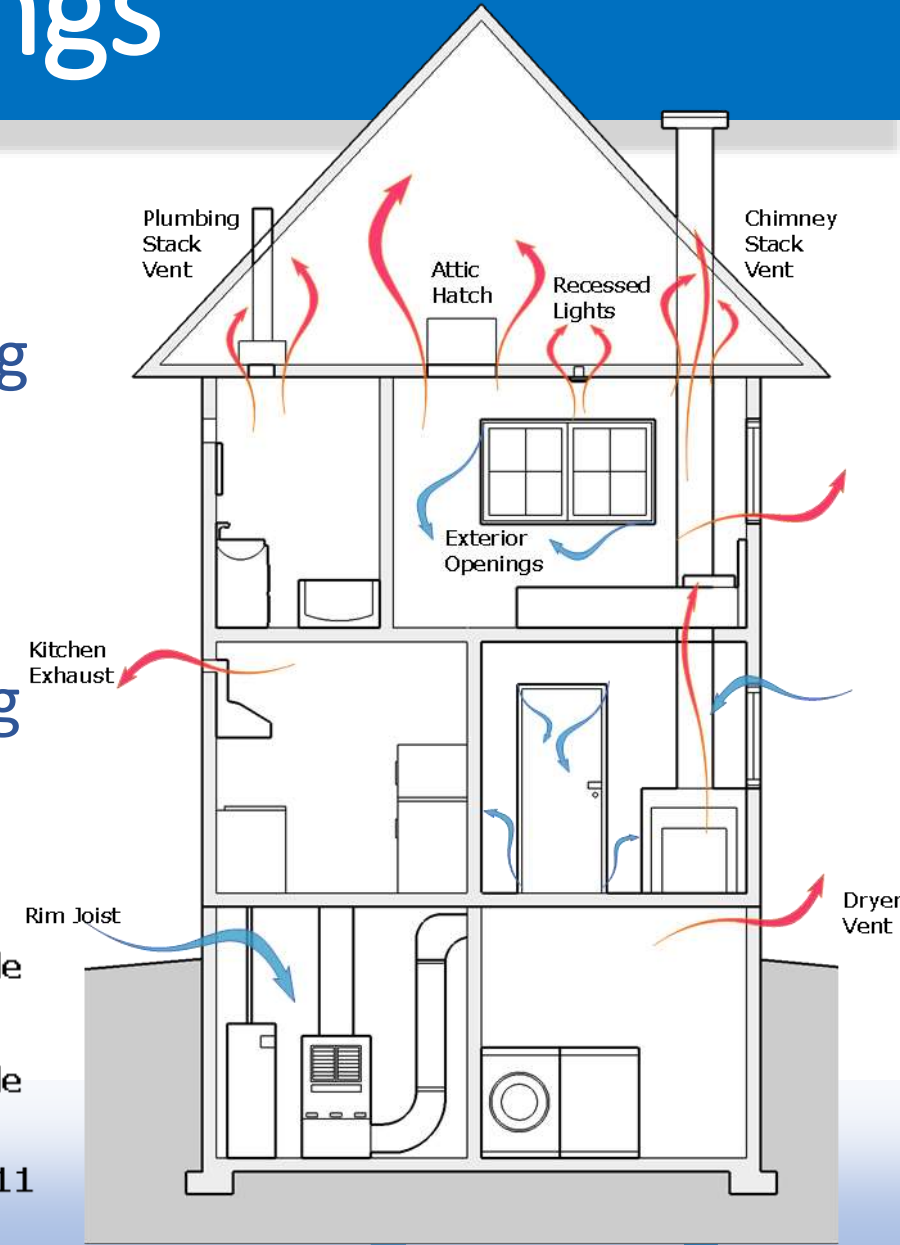
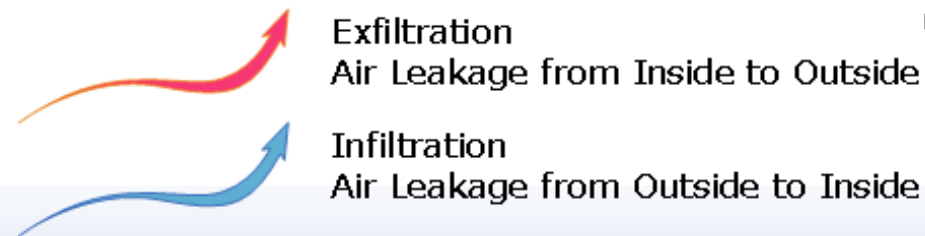
Airflow in Buildings

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



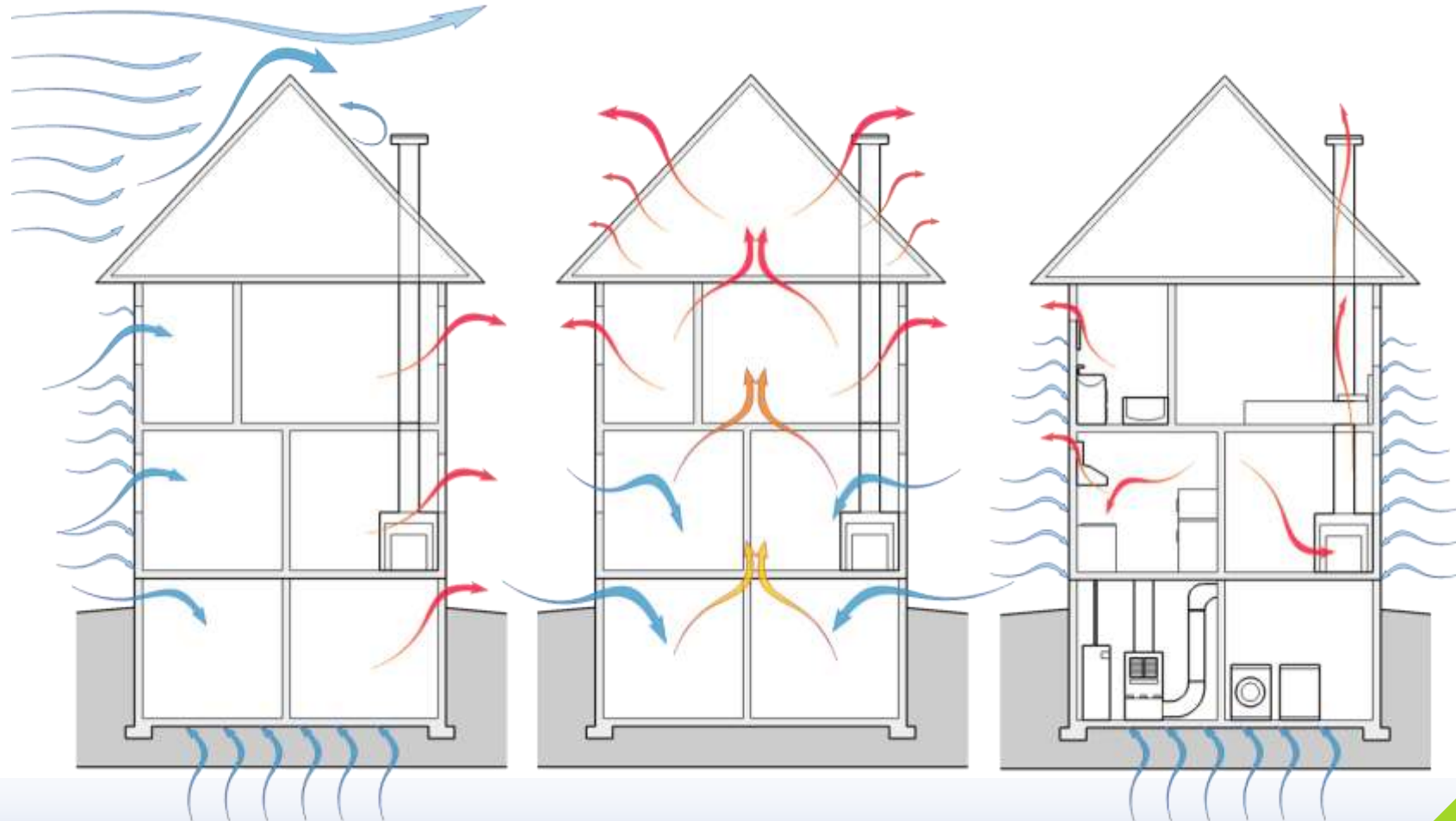
Air Flow in Buildings

3 Main Driving Forces:

- Stack effect
- Mechanical effect
- Wind effect



Air Flow in Buildings



Wind Driven Air Flow

Stack Effect

Mechanical Equipment



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



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**



Heat Transfer

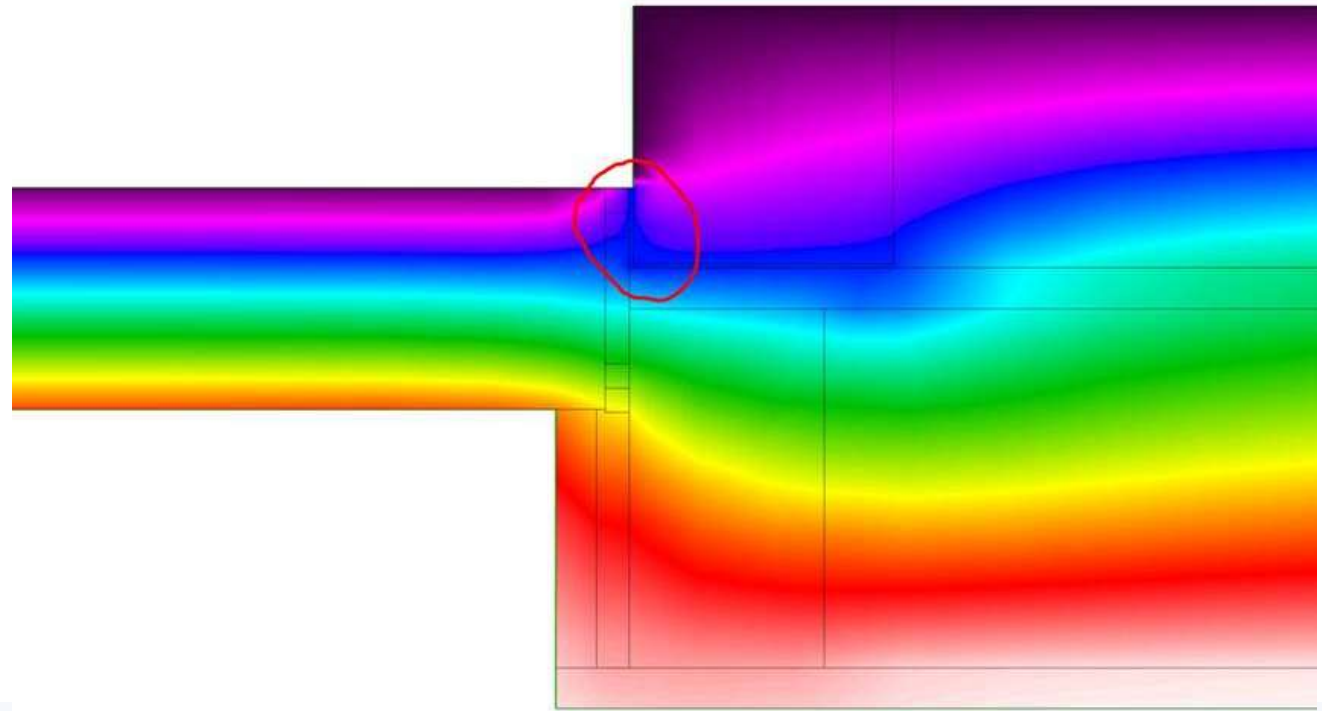
Conduction

- 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



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



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 . . . ?



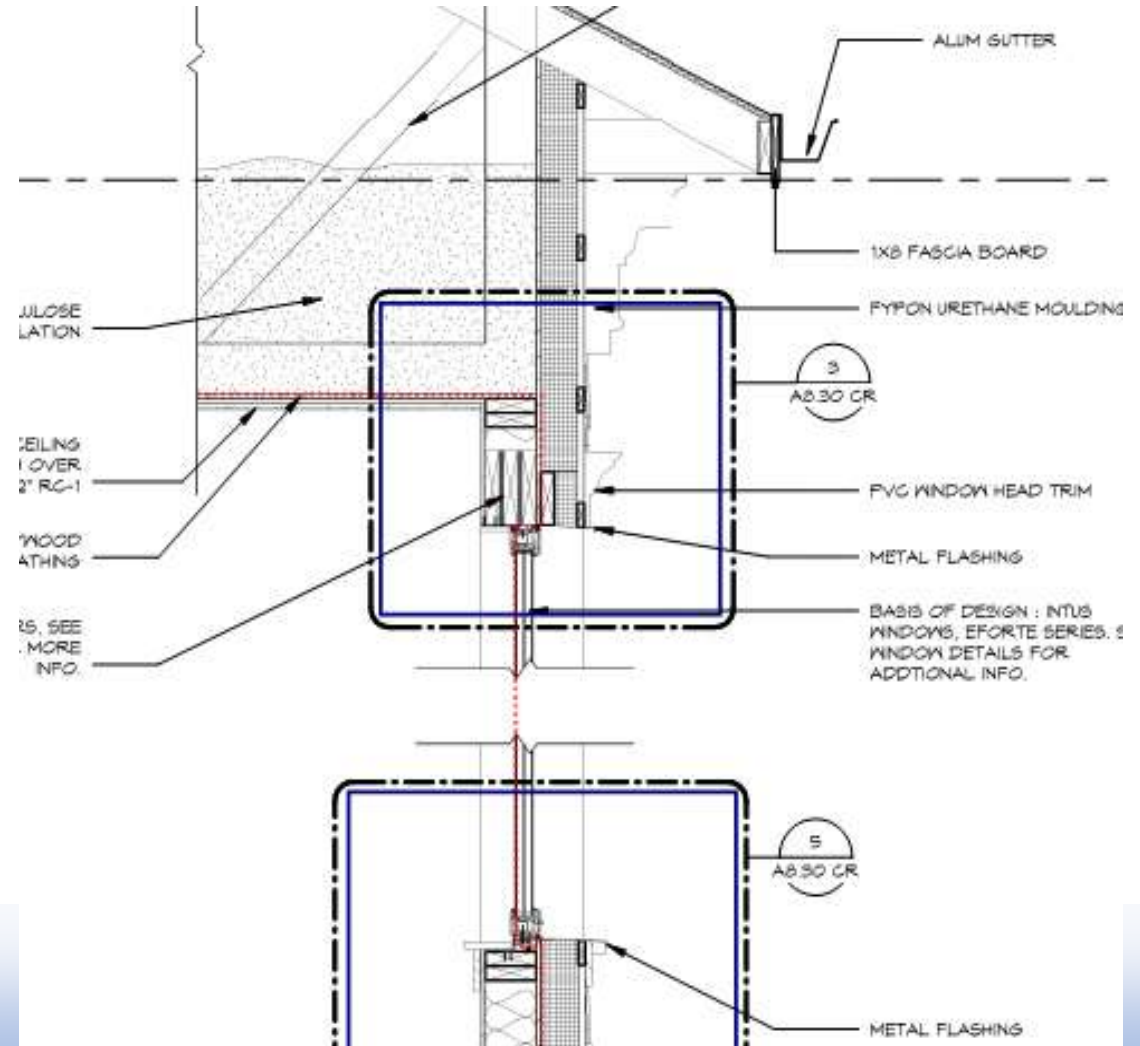
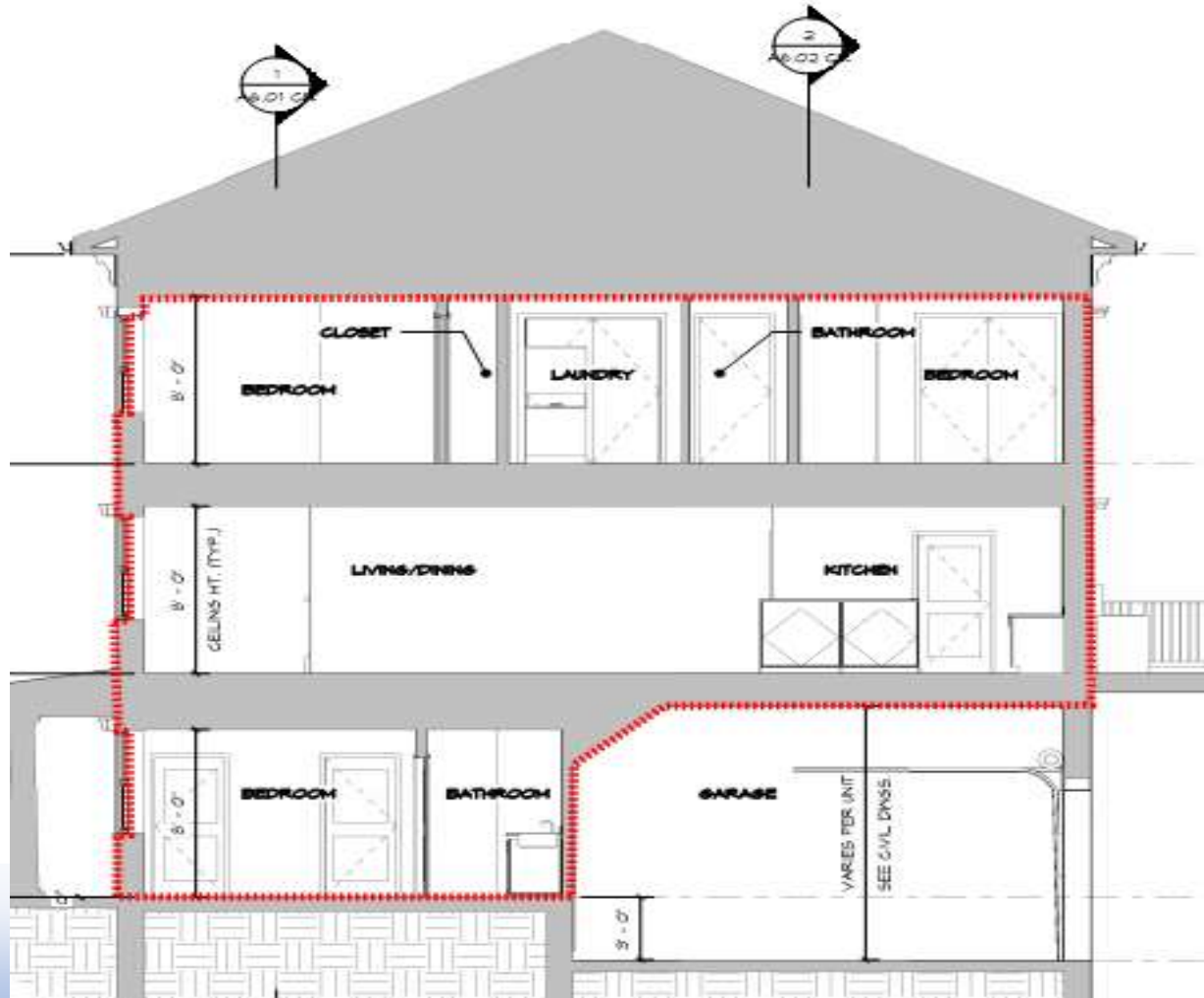
Heat Transfer

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



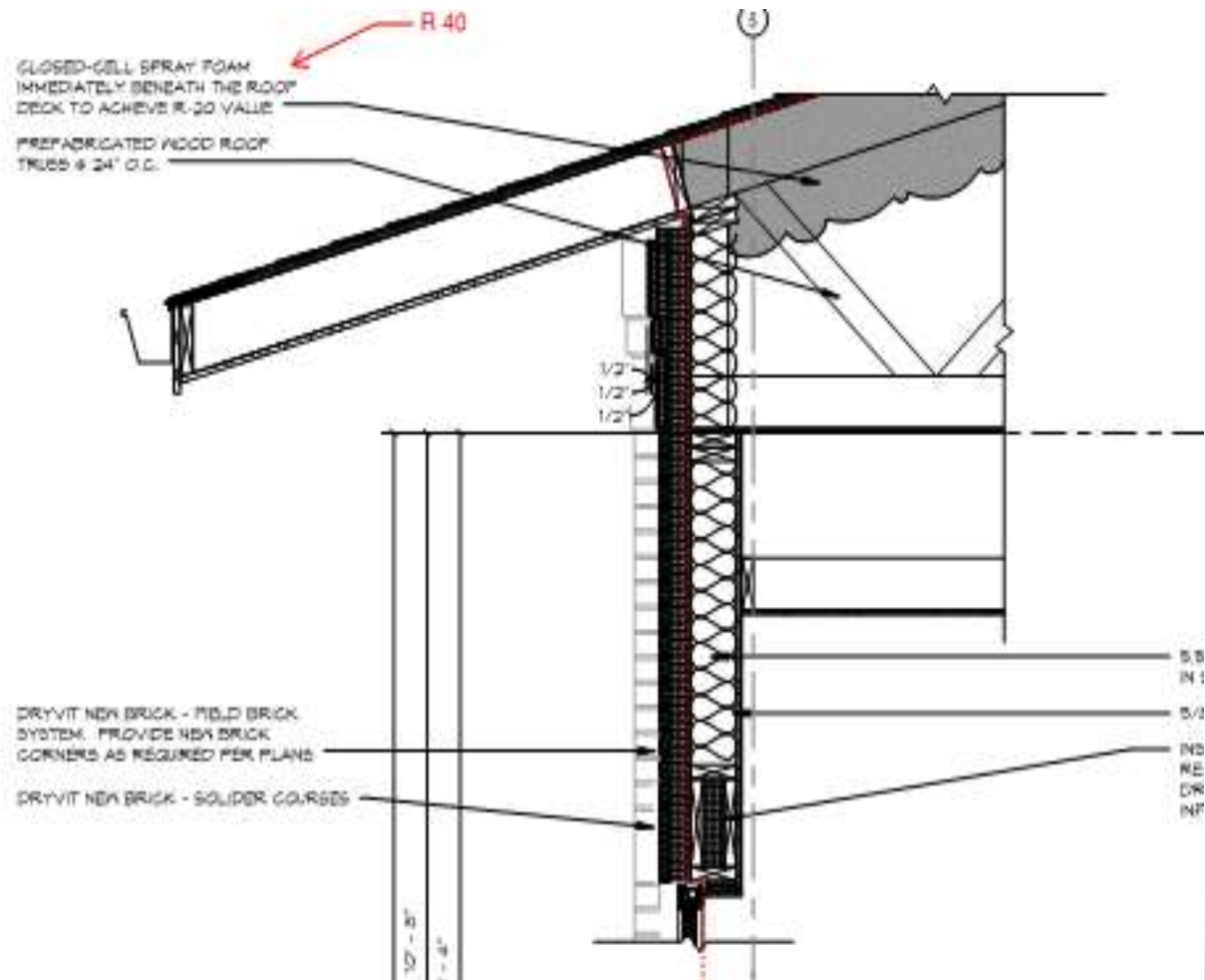
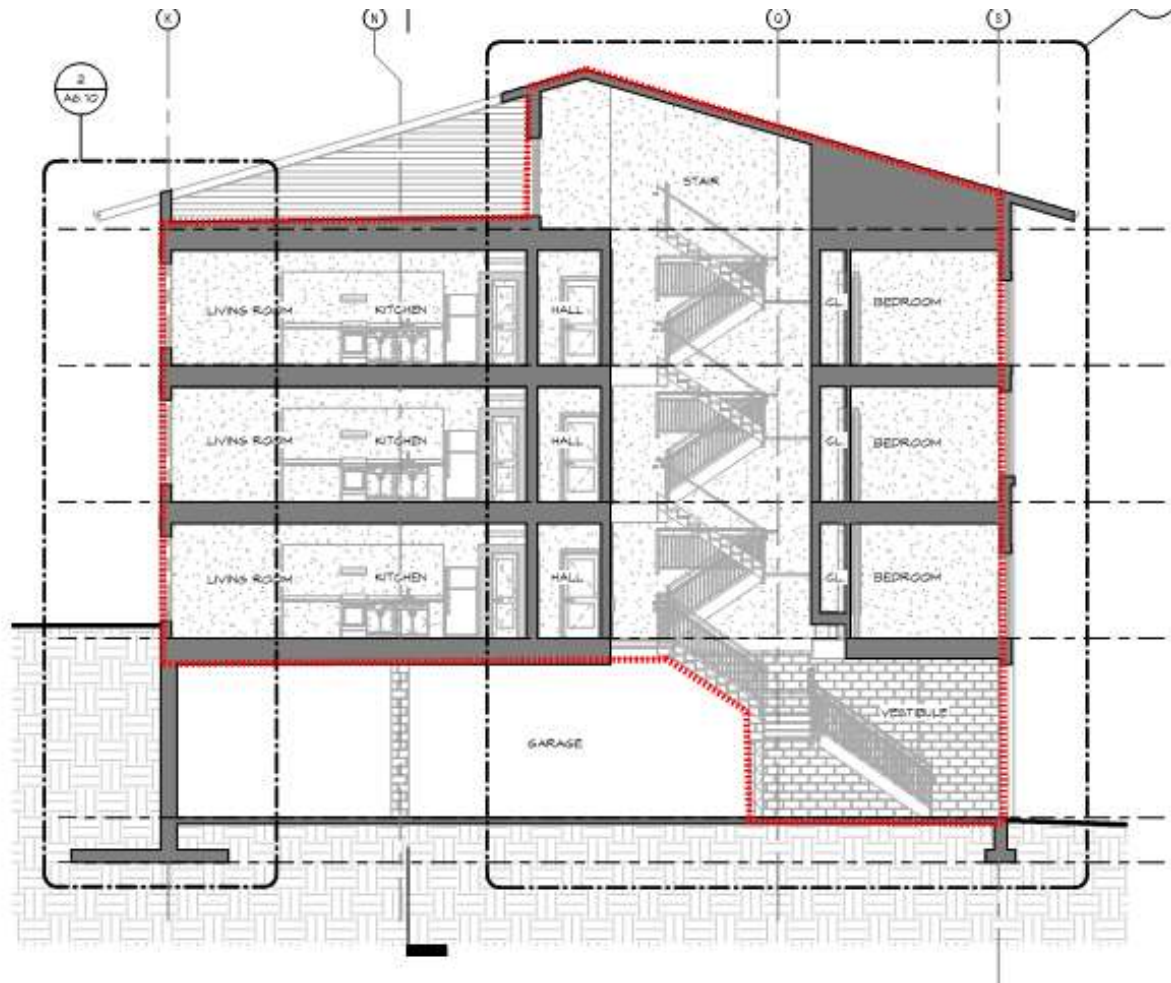
Air Barrier & Thermal Barrier



Air Barrier & Thermal Barrier



Air Barrier & Thermal Barrier



Air Barrier & Thermal Barrier



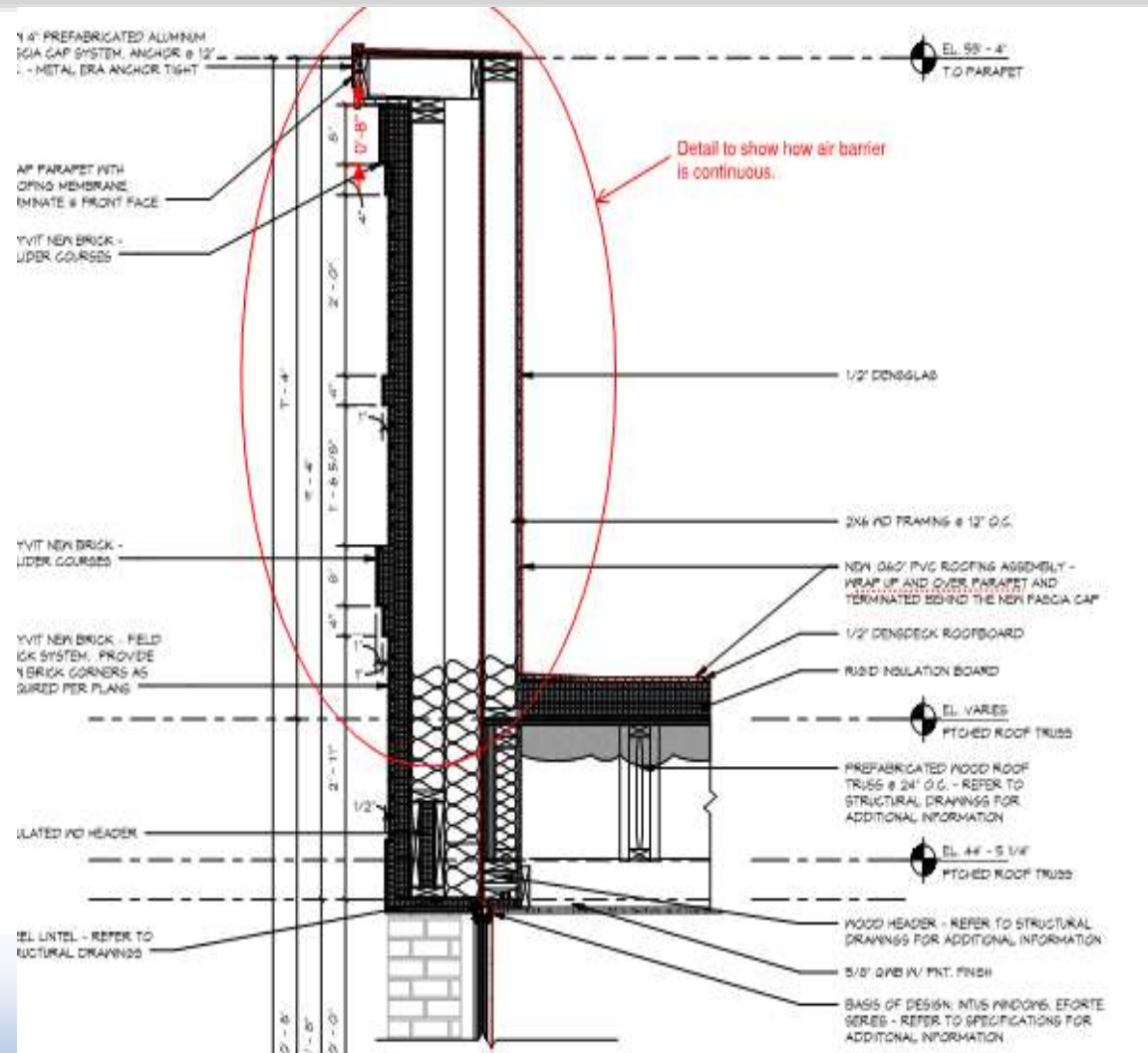
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DRAWING LIST

GENERAL		MECHANICAL		MECHANICAL, GORT		MECHANICAL, GORT		MECHANICAL	
001	COVER	R10	CODE DRAIN / GENERAL NOTES LIST MECHANICAL	A20	EXTERIOR ELEVATIONS	A214	DOOR DETAILS	M10	BASEMENT MECHANICAL PLAN
010	EXTERIOR CONDITIONS MAP	R11	HALL TYPES	A21	EXTERIOR ELEVATIONS	A211	WINDOW DETAILS	M11	FIRST FLOOR MECHANICAL PLAN
020	SECTION & ELEVATION CONTROL PLAN	R12	FLOOR/CEILING/ROOF TYPES	A22	EXTERIOR ELEVATIONS	A212	WINDOW DETAILS	M12	SECOND TO FIFTH FLOOR MECHANICAL PLAN
030	SITE PREPARATION PLAN	R13	RAISED HALL FLOOR CONSTRUCTION	A23	BUILDING SECTIONS	A222	WINDOW DETAILS	M13	SIXTH FLOOR MECHANICAL PLAN
040	TEMPORARY FOUNDATION PLAN	R14	AIR SEALING DETAILS	A24	BUILDING SECTIONS	A224	WINDOW DETAILS	M14	ROOF MECHANICAL PLAN
050	LANDSCAPE PLAN	R15	AIR SEALING DETAILS	A25	BUILDING SECTIONS	A224	WINDOW DETAILS	M15	UNDER FLOOR DUCT PLAN (BASEMENT & GROUND FLOOR)
060	LANDSCAPE PLAN	L10	LIFE SAFETY PLAN - BASEMENT FLOOR	A41	HALL SECTION	A228	WINDOW DETAILS		



Air Barrier & Thermal Barrier



Air Barrier & Thermal Barrier

WRAP AVB MEMBRANE OVER
TOP OF PARAPET WALL AND LAP
ROOF MEMBRANE OVER TOP.
ROOF MEMBRANE TO WRAP TO
BEHIND PVC FASCIA BOARD

CONT. 2X10 WD BLOCKING.
AVB MEMBRANE TO CONTINUE
AROUND BLOCKING

**NOTE: PER PHUS+ PASSIVE HOUSE
DESIGN REQUIREMENTS ROOF R-VALUE
SHALL MEET A MINIMUM OF R-40.
REFER TO COMPLIANCE REPORT FOR
ADDITIONAL INFORMATION**

CLOSED-CELL SPRAY FOAM
ENERGY COMPLETE SEALANT

1/2" APA STRUCTURAL 1 RATED EXP
1 PLYWOOD SHEATHING
CONTINUOUS AVB MEMBRANE
BADS OF DESIGN HENRY BLUESKIN
SA (LAP AND SEAL ALL JOINTS)

CERTAINTED VINYL SIDING
AS SPECIFIED

DRYVIT NSR BRICK WALL
SYSTEM BEYOND

LVL RM JOIST - REFER TO STRUCTURAL
ENGINE FOR ADDITIONAL INFORMATION

CONT. FLASHING

1/2" PVC TRIMBOARD
3/4" FURRING OVER 2"
RIGID INSULATION (R-10)

EL. 41'-0"
T.O. PARAPET DEL. STUD

1/2" DENSELAP SHEATHING

0
1
in

CANT STRIP, AS REQUIRED PER
MANUFACTURER'S INSTALLATION INSTRUCTIONS
PVC ROOFING MEMBRANE, INSTALL PER
MANUFACTURER'S RECOMMENDATIONS

1/2" ROOF PROTECTION BOARD

4" XPS INSULATION BOARD (R-20)
CONTINUOUS OVER PLYWOOD ROOF DECK.

5/8" APA STRUCTURAL 1 EXP, 1
PLYWOOD ROOF DECK

T.O. ROOF PLYWD

CLOSED CELL SPRAY FOAM
TO ACHIEVE MIN R-20

18" PREFABRICATED FLOOR TRUSS @
24" O.C. MAX. - REFER TO STRUCTURAL
ENGINE FOR ADDITIONAL INFORMATION
HOLDINGS PER STRUCTURAL ENGINE

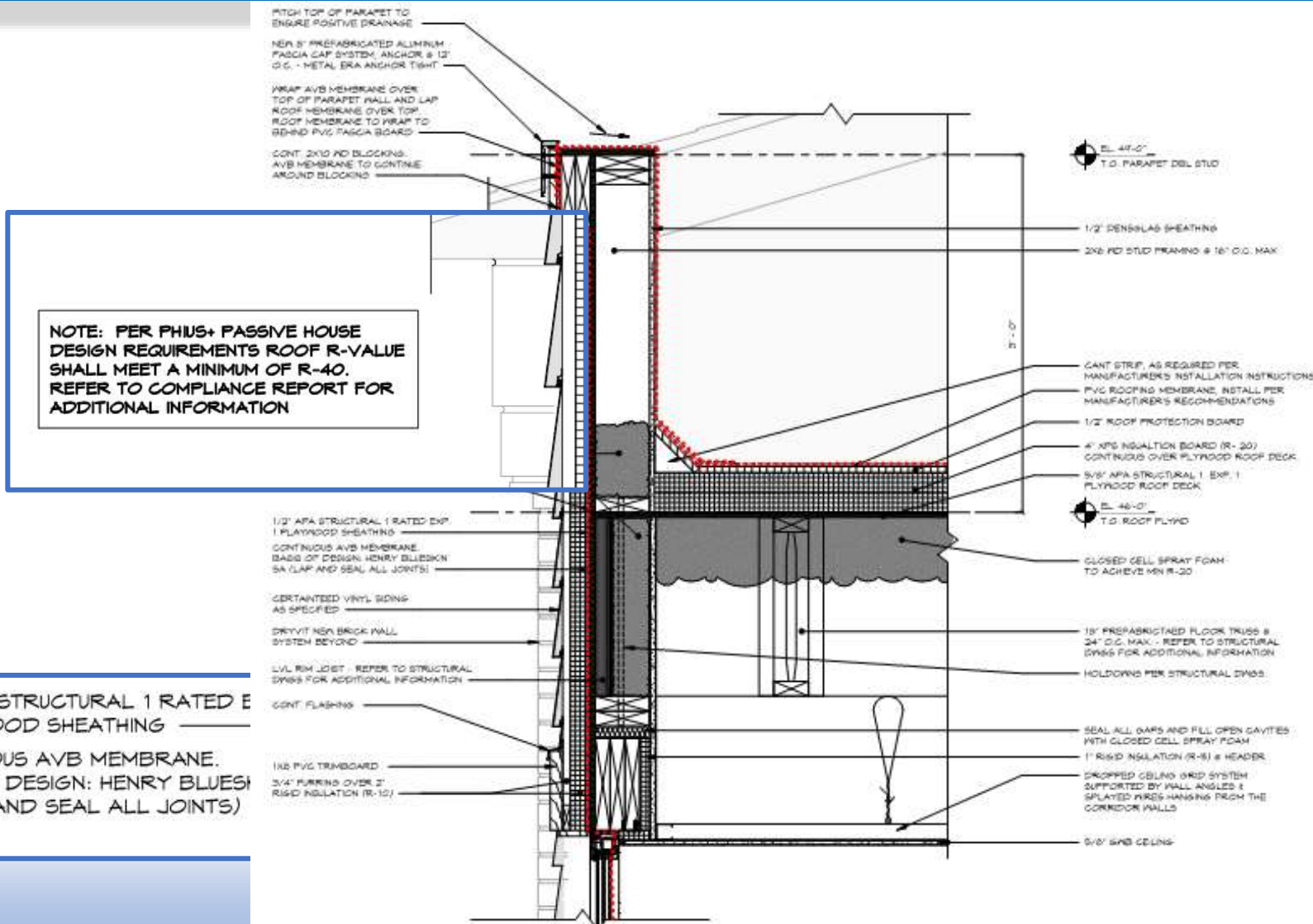
SEAL ALL GAPS AND FILL OPEN CAVITIES
WITH CLOSED CELL SPRAY FOAM
1" RIGID INSULATION (R-8) @ HEADER

DROPPED CEILING GRID SYSTEM
SUPPORTED BY WALL ANGLES &
SPRAYED WIRE HANGING FROM THE
CORRIDOR WALLS

5/8" GIBB CEILING



Air Barrier & Thermal Barrier



NOTE: PER PHIUS+ PASSIVE HOUSE DESIGN REQUIREMENTS ROOF R-VALUE SHALL MEET A MINIMUM OF R-40. REFER TO COMPLIANCE REPORT FOR ADDITIONAL INFORMATION

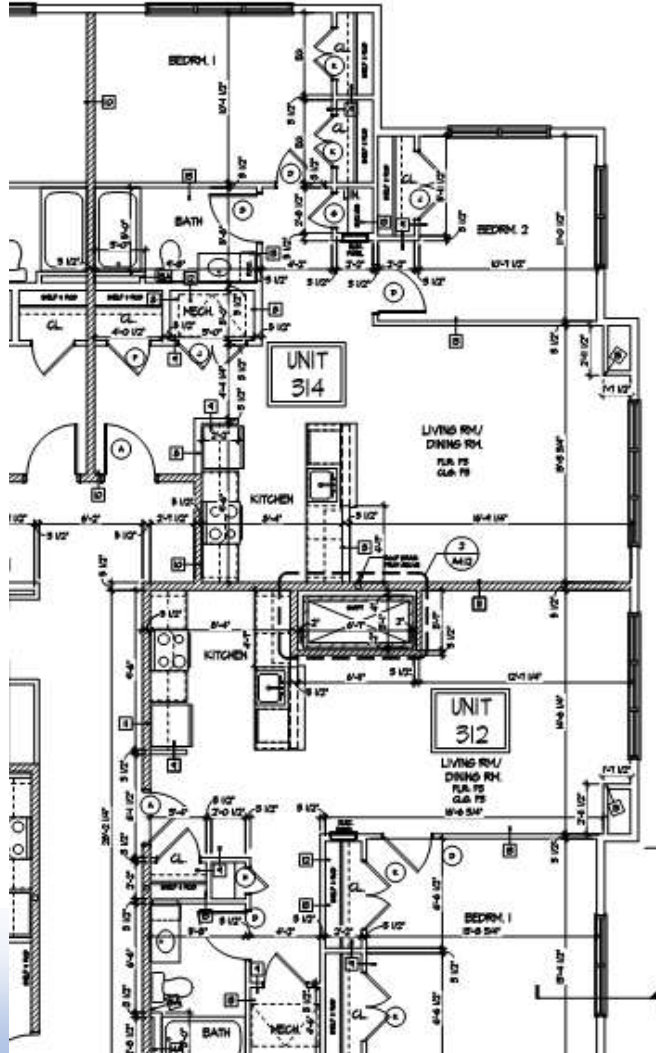
1/2" APA STRUCTURAL 1 RATED E 1 PLYWOOD SHEATHING

CONTINUOUS AVB MEMBRANE. BASIS OF DESIGN: HENRY BLUESH SA (LAP AND SEAL ALL JOINTS)



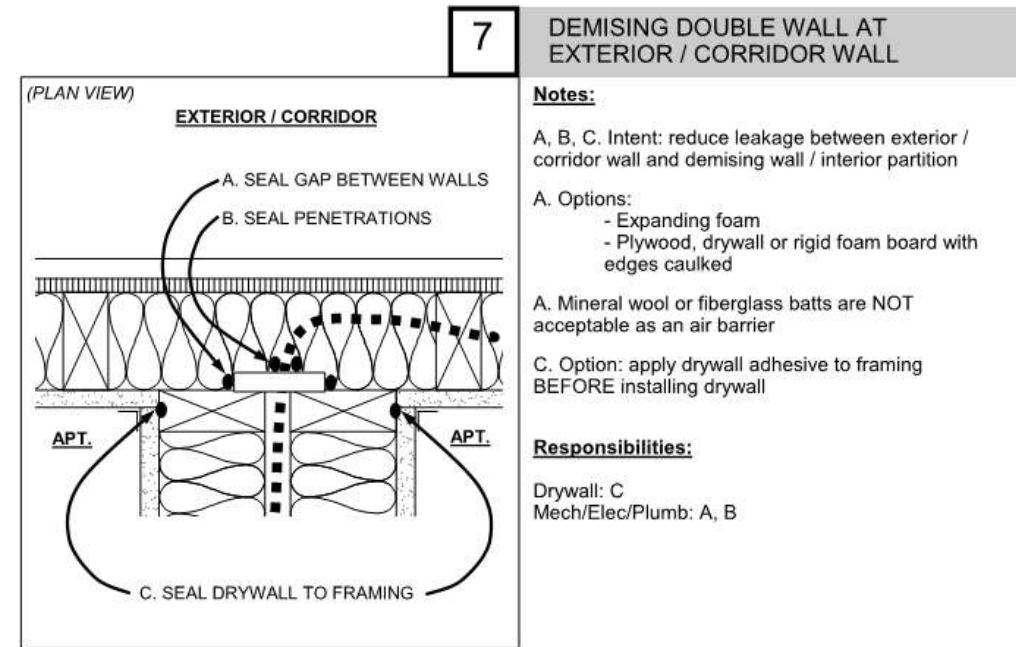
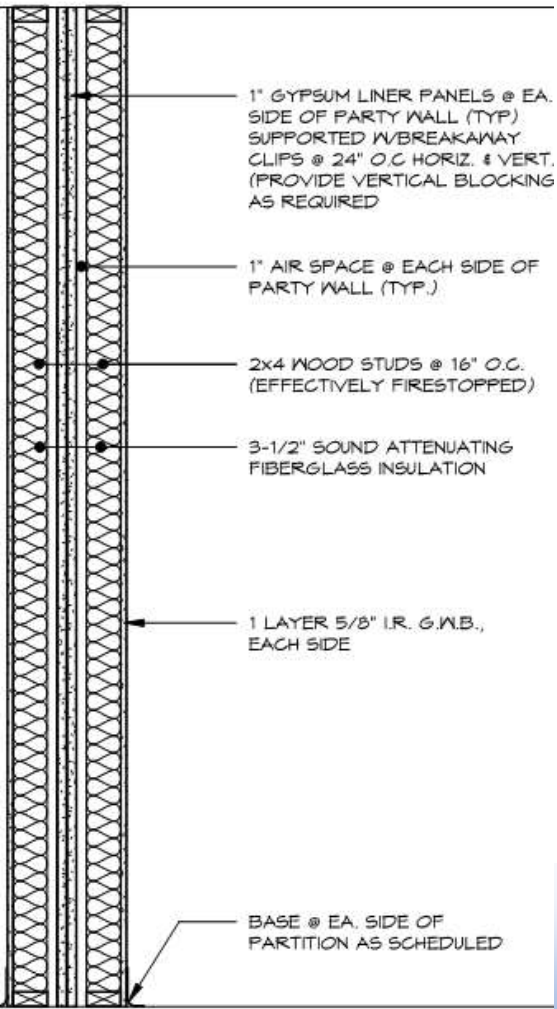
Air Barrier & Thermal Barrier

Common Walls



Air Barrier

Demising Walls



Vapor Control

Air Control Layer

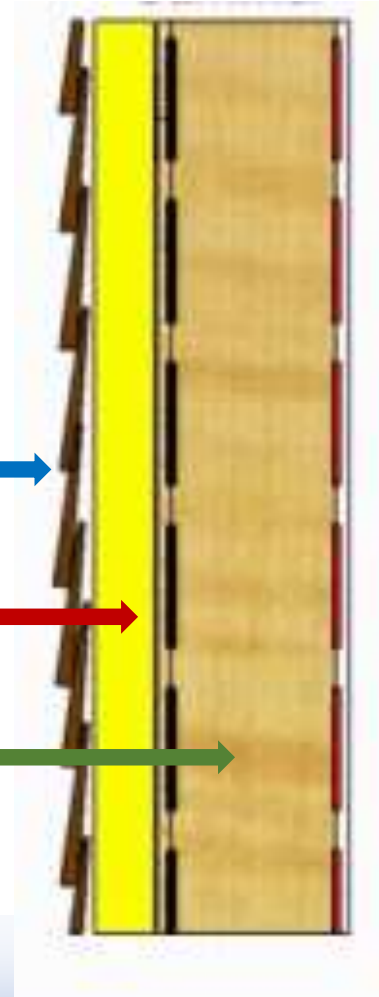
Vapor Control Layer

Thermal Control Layer

Cladding

Control Layer

Structure



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: $1.0 < \text{perm} \leq 10 \text{ perm}$

B) **Class II: $0.1 < \text{perm} \leq 1.0 \text{ perm}$**

Class I: $\leq 0.1 \text{ perm}$



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.

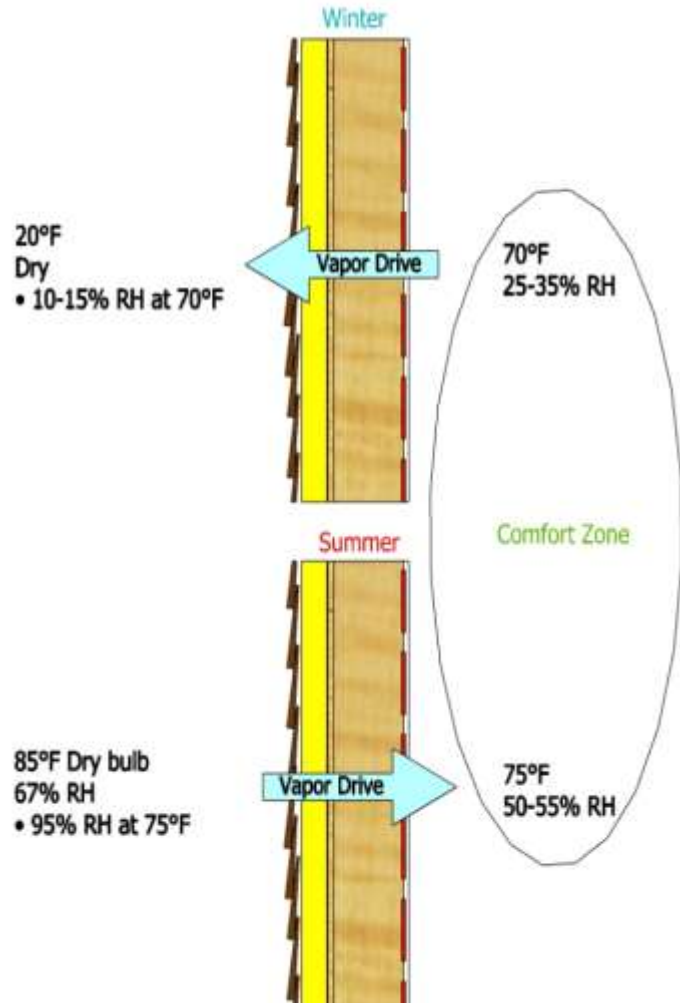
UNLESS Continuous Insulation meets the required R value . . . than a Class III (latex paint) VR is allowed (Class I & II should not be allowed!).

EXTERIOR WALLS

**TABLE 1405.3.2
CLASS III VAPOR RETARDERS**

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

Thermal Barrier & Vapor Control



$$T_{interface} = T_{indoor} - [(T_{indoor} - T_{outdoor}) \times (R_{cavity} / R_{total})]$$

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

Average Daily Temperature °F	Minimum Recommended Exterior CI R-Value			
	Dec/Jan/Feb	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

18
 ARY
 T F S
 4 5 6
 11 12 13
 18 19 20
 25 26 27

ARY
 T F S
 1 2 3
 8 9 10
 15 16 17
 22 23 24

CH
 T F S
 1 2 3
 8 9 10
 15 16 17
 22 23 24
 29 30 31

IL
 T F S
 5 6 7
 12 13 14
 19 20 21
 26 27 28

EXTERIOR INSULATION
 2" POLYISO (R-12)

STUD BAY INSULATION
 5 1/2" FG BATT (R-19)

$$T_{\text{BACK OF SHEATHING}} = T_{\text{interior}} - (T_{\text{interior}} - T_{\text{exterior}}) \frac{R_{\text{stud bay}}}{R_{\text{total}}}$$

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

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

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

$$= 42.3^{\circ} \quad \text{In trouble if RH exceeds } \pm 38\%$$

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31					

FEBRUARY

4	5	6	7	8	9
10	11	12	13	14	15
16	17	18	19	20	21
22	23	24	25	26	27
28	29	30	31		

MARCH

5	6	7	8	9	10
11	12	13	14	15	16
17	18	19	20	21	22
23	24	25	26	27	28
29	30	31			

APRIL

2	3	4	5	6	7
8	9	10	11	12	13
14	15	16	17	18	19
20	21	22	23	24	25
26	27	28	29	30	31

MAY

7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31					

JUNE

4	5	6	7	8	9
10	11	12	13	14	15
16	17	18	19	20	21
22	23	24	25	26	27
28	29	30	31		

JULY

2	3	4	5	6	7
8	9	10	11	12	13
14	15	16	17	18	19
20	21	22	23	24	25
26	27	28	29	30	31

AUGUST

5	6	7	8	9	10
11	12	13	14	15	16
17	18	19	20	21	22
23	24	25	26	27	28
29	30	31			

SEPTEMBER

3	4	5	6	7	8
9	10	11	12	13	14
15	16	17	18	19	20
21	22	23	24	25	26
27	28	29	30	31	

OCTOBER

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31					

NOVEMBER

5	6	7	8	9	10
---	---	---	---	---	----

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

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

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

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

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

2" INSULATED ZIP (R-9.6)

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

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

$$= 37.3^{\circ} \quad \text{In trouble if RH exceeds } \pm 32\%$$

2 1/2" INSULATED ZIP (R-12.6)

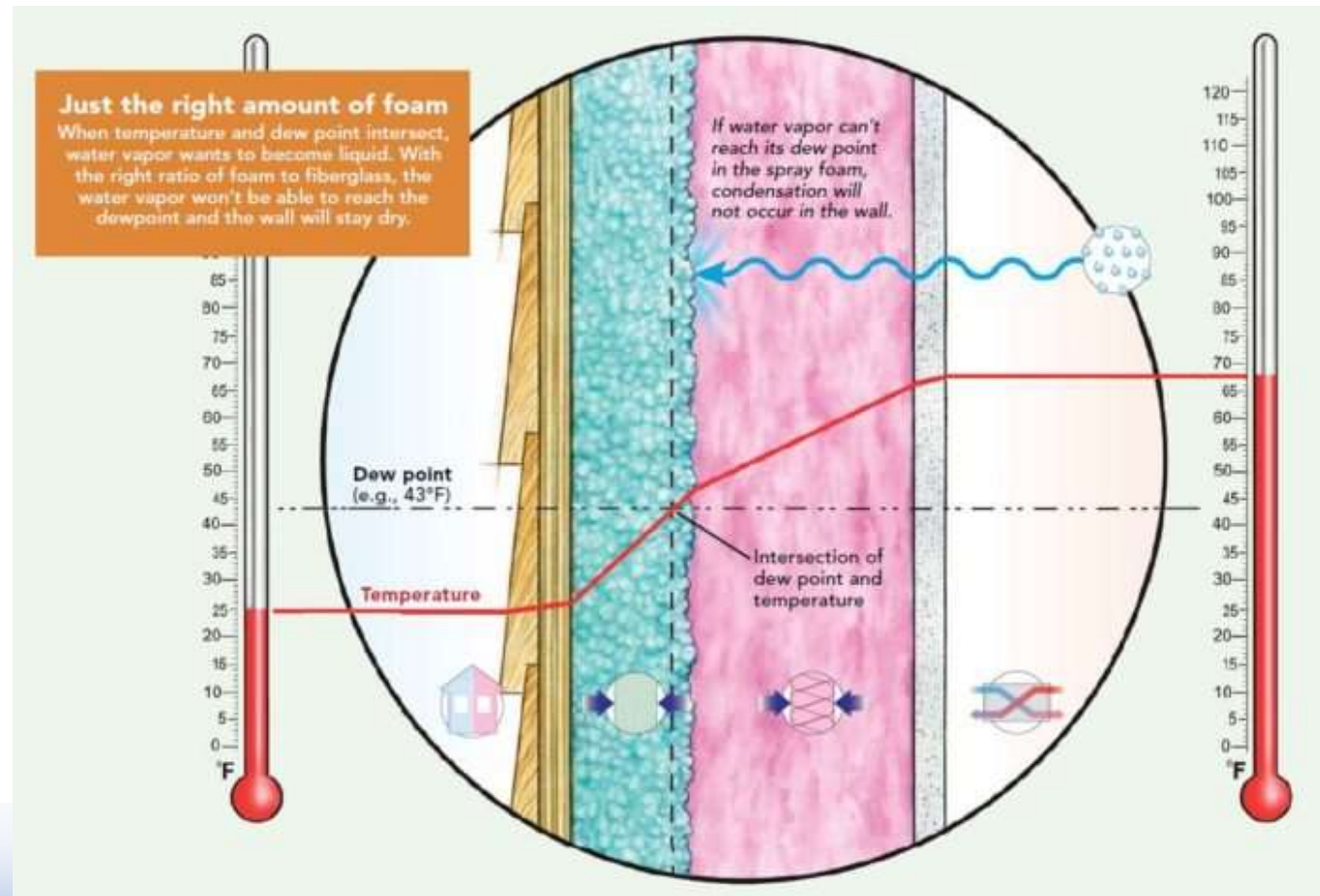
$$T = 68^{\circ} - (68^{\circ} - 26^{\circ}) \frac{26.2}{38.8}$$

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

$$= 39.7^{\circ} \quad \text{In trouble if RH exceeds } \pm 35\%$$

Thermal Barrier & Vapor Control

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



Thermal Barrier & Vapor Control

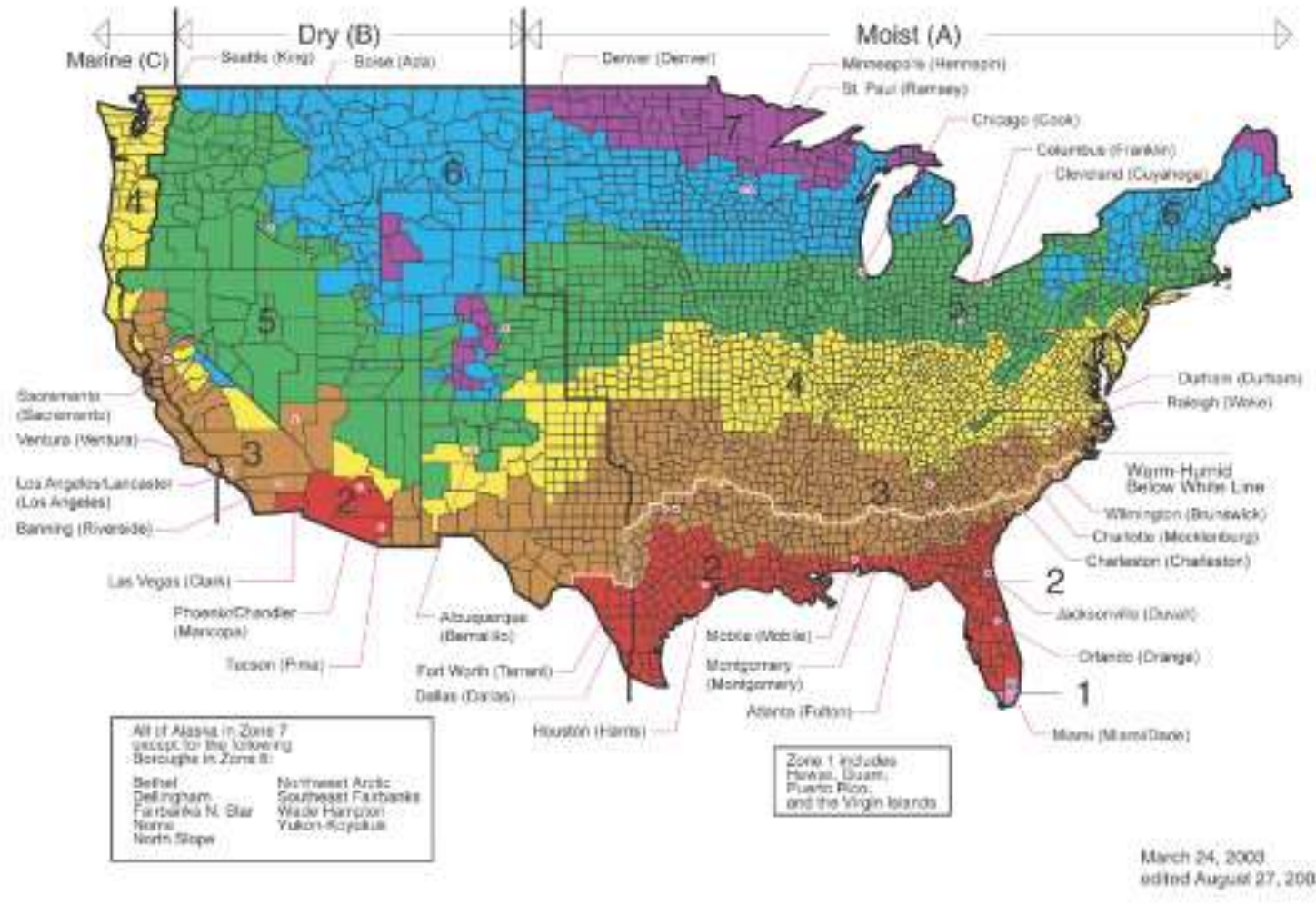


Thermal Barrier & Vapor Control



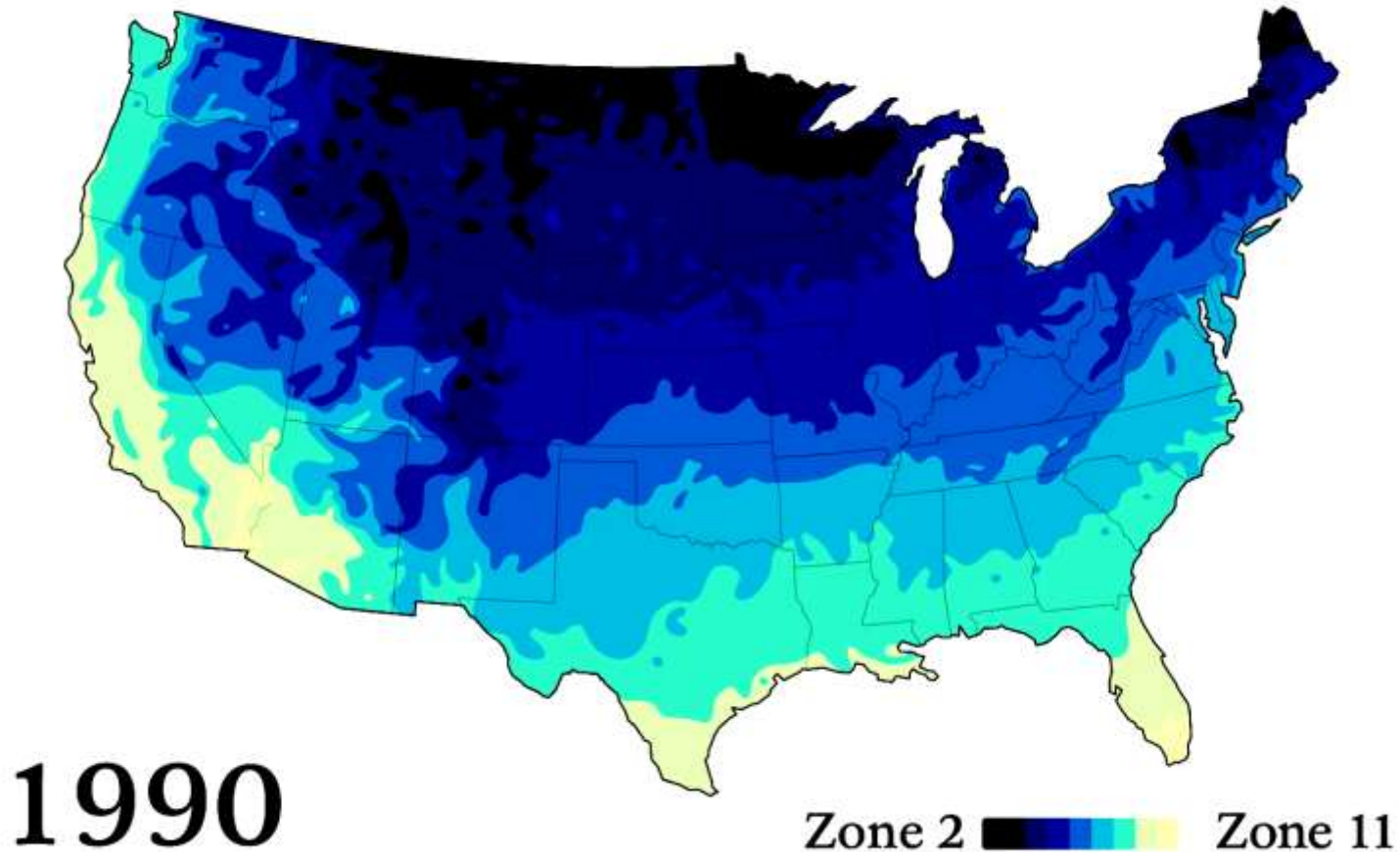
Thermal Barrier & Vapor Control

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



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 ⁱ	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



Thermal Barrier & Vapor Control

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 $\geq R2.5$ over 2×4 wall Insulated sheathing with R -value $\geq R3.75$ over 2×6 wall
5	Vented cladding over wood structural panels Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with R -value $\geq R5$ over 2×4 wall Insulated sheathing with R -value $\geq R7.5$ over 2×6 wall
6	Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with R -value $\geq R7.5$ over 2×4 wall Insulated sheathing with R -value $\geq R11.25$ over 2×6 wall
7 and 8	Insulated sheathing with R -value $\geq R10$ over 2×4 wall Insulated sheathing with R -value $\geq R15$ over 2×6 wall

2015 IBC



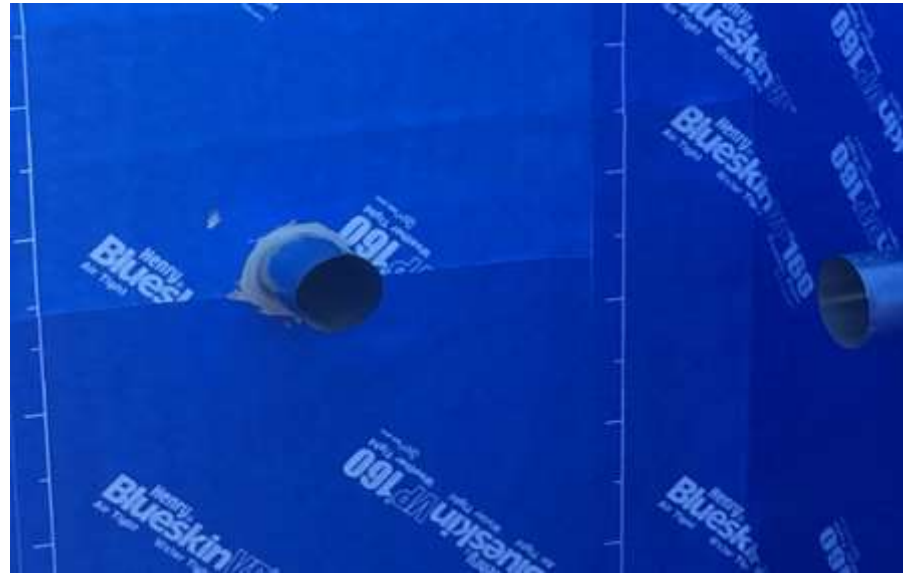
Thermal Barrier & Vapor Control



Thermal Barrier & Vapor Control



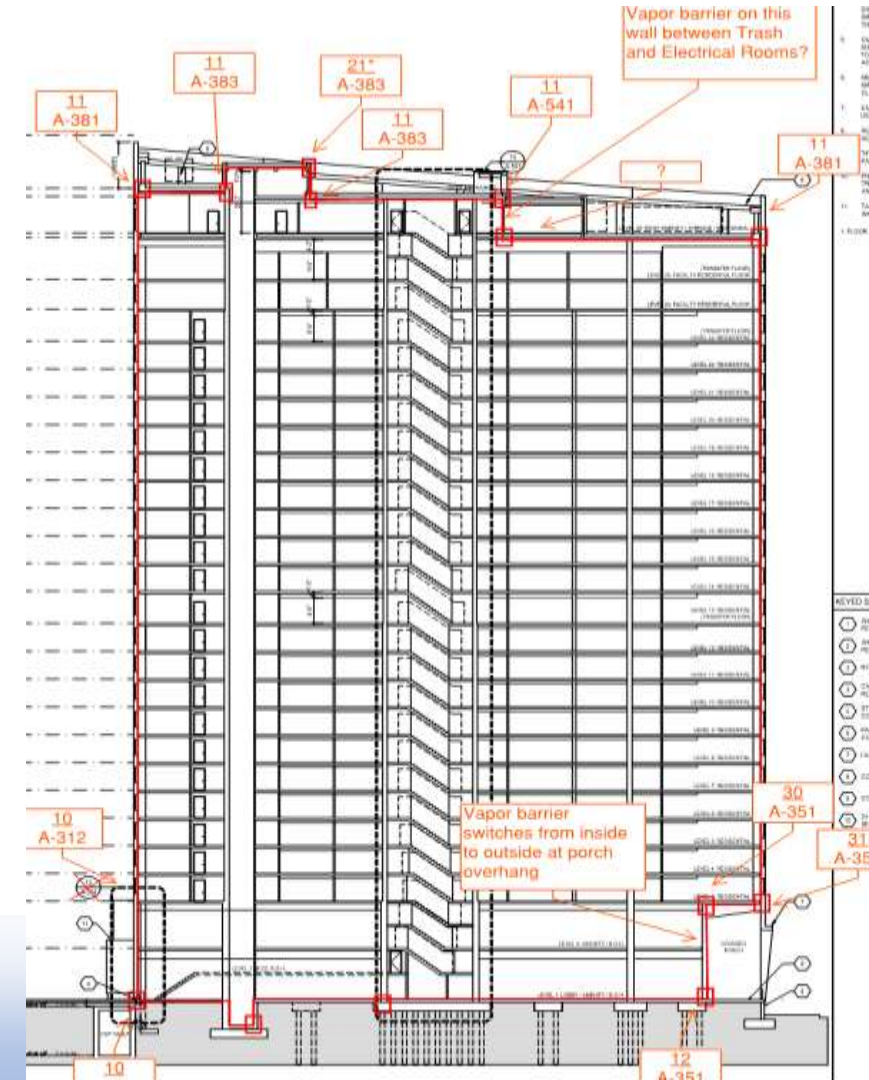
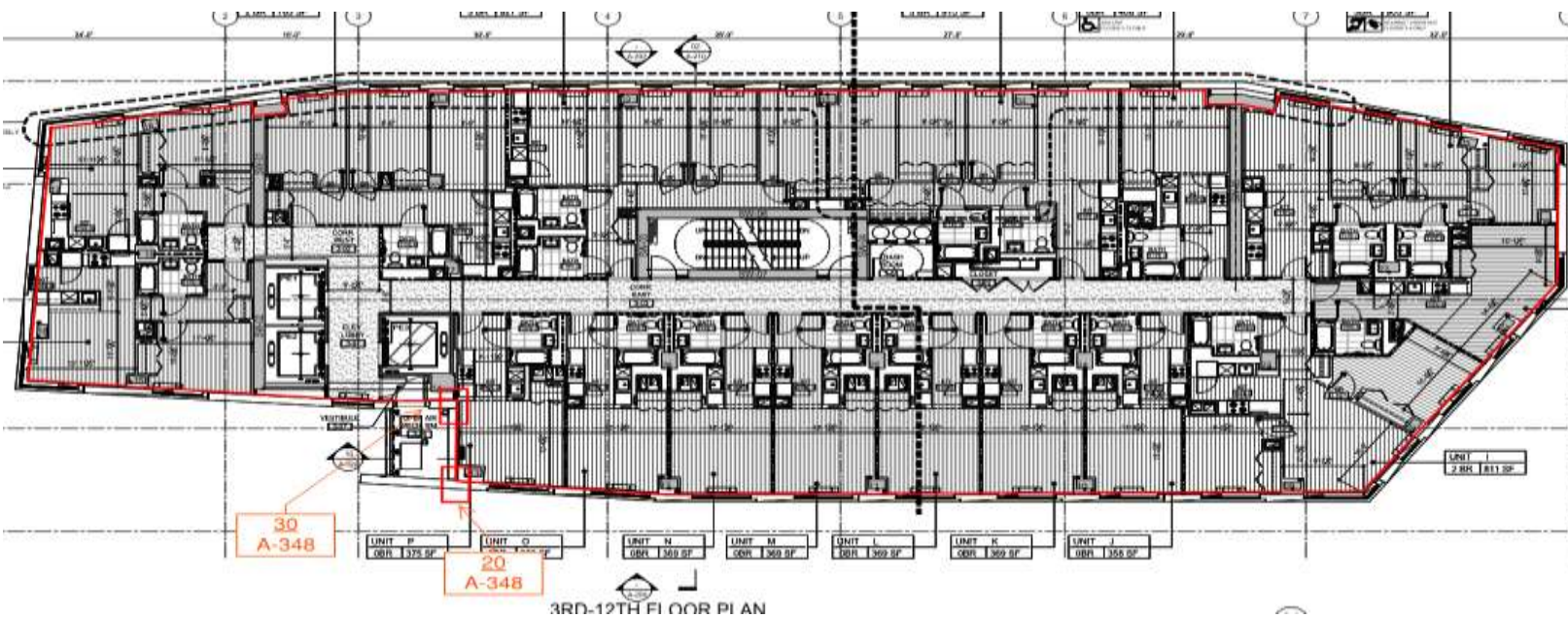
Thermal Barrier & Vapor Control



Thermal Barrier & Vapor Control



Thermal Barrier & Vapor Control



Thermal Barrier & Vapor Control



Thermal Barrier & Vapor Control



Photo: Pavel Bendov



Thermal Barrier & Vapor Control



Thermal Barrier & Vapor Control



Thermal Barrier & Vapor Control

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*.



Thermal Barrier & Vapor Control

DETAILS FOR A THICK ROOF

Rigid-foam insulation installed above the roof assembly can create an energy-smart roof. With three layers of 1½-in. polyisocyanurate insulation above the sheathing and approximately 9¼ in. of cellulose insulation in the rafter cavities, the roof shown here has an R-value of approximately 63. The three layers of foam help to seal air leaks, but to make this assembly perform well, you need to incorporate some unconventional details.

Metal roofing is shown here. Other types of roofing work as well. Check asphalt-shingle warranties to make sure hot roofs are acceptable to the manufacturer.

Self-adhesive membrane

½-in. OSB or plywood for securing roofing

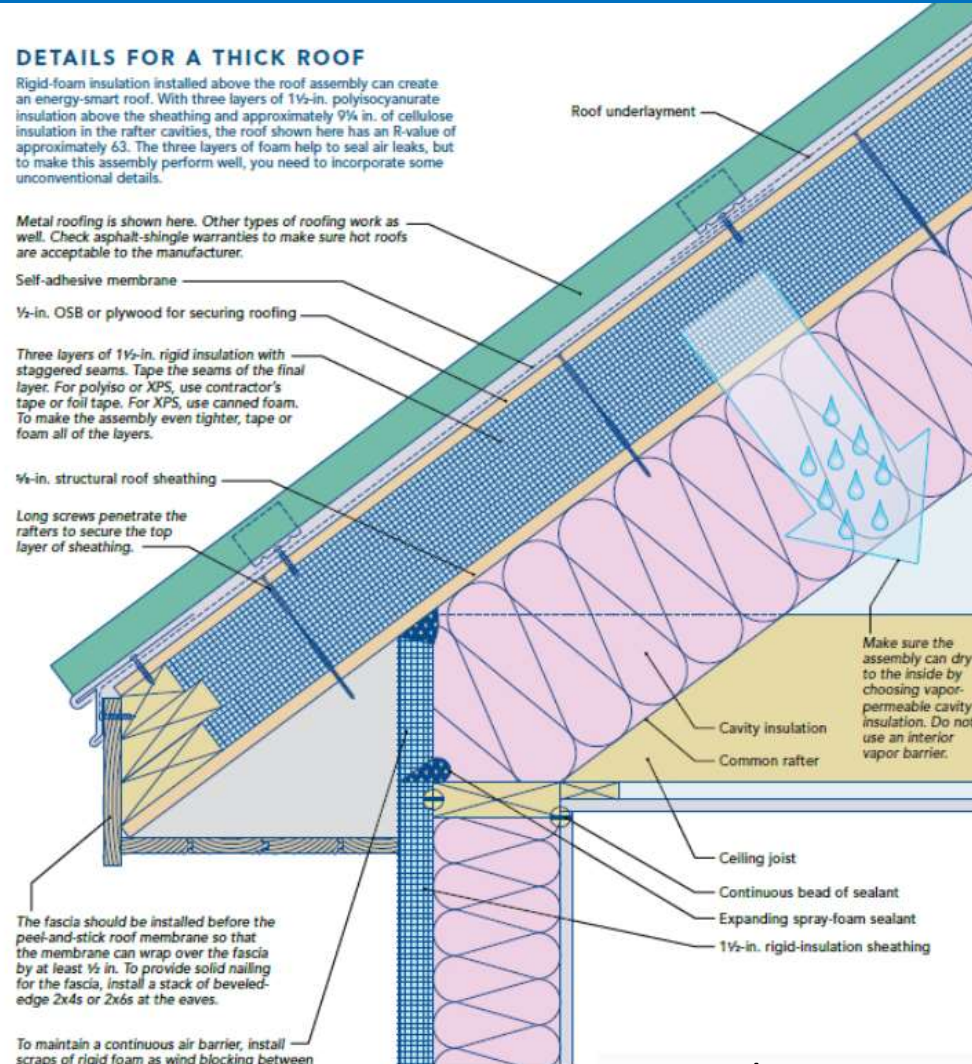
Three layers of 1½-in. rigid insulation with staggered seams. Tape the seams of the final layer. For polyiso or XPS, use contractor's tape or foil tape. For XPS, use canned foam. To make the assembly even tighter, tape or foam all of the layers.

¼-in. structural roof sheathing

Long screws penetrate the rafters to secure the top layer of sheathing.

The fascia should be installed before the peel-and-stick roof membrane so that the membrane can wrap over the fascia by at least ½ in. To provide solid nailing for the fascia, install a stack of beveled-edge 2x4s or 2x6s at the eaves.

To maintain a continuous air barrier, install scraps of rigid foam as wind blocking between the rafters, in the same plane as the wall sheathing. Cut these foam scraps short by about ½ in. to allow room for the expanding



Credit: Green Building Advisor



Vapor Control

ELEMENTS OF A LARGE MULTIFAMILY PASSIVE HOUSE BUILDING



MULTIFAMILY CONSIDERATIONS

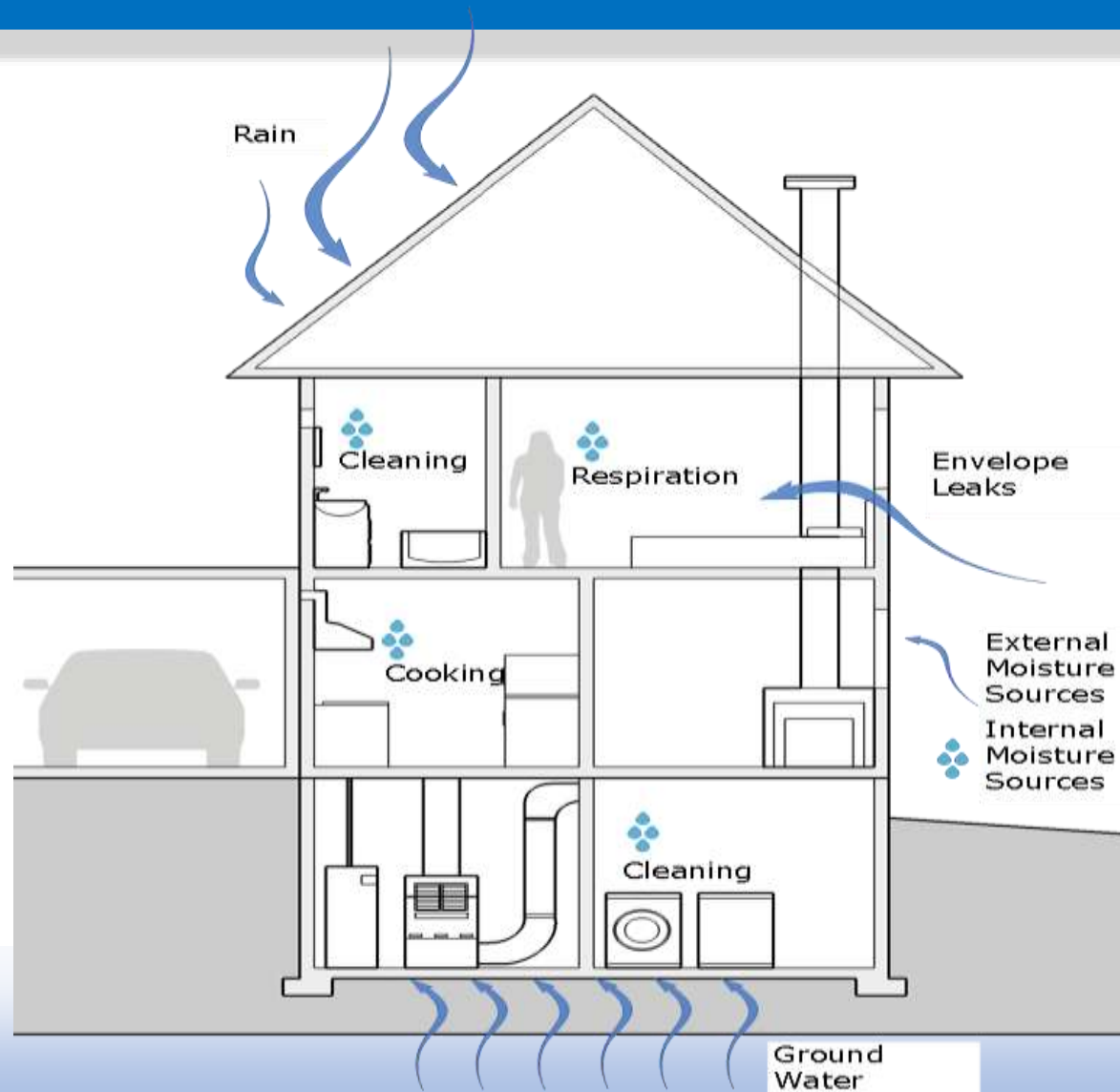
Energy Recovery Ventilation
Determining the right system for any project can be challenging. There are pros and cons to both central and decentralized systems. A certified Passive House consultant can help the project team decide which system is best for your building.

Domestic Hot Water
In large scale multifamily buildings in the US the majority of DHW systems are central systems with recirculation loops and high efficiency, natural gas water heaters. Minimizing pipe lengths and optimizing pump sizes and insulation are essential to meet the rigid Passive House primary energy and cooling thresholds.

Efficient Lights & Appliances
Multifamily projects face special challenges here because they must run corridor and egress lighting 24/7. They are also faced with a greater number of appliances per square foot compared with single family homes. Both of these factors result in increased cooling and primary energy demands. The use of controls and daylighting should be incorporated wherever possible to reduce energy use.



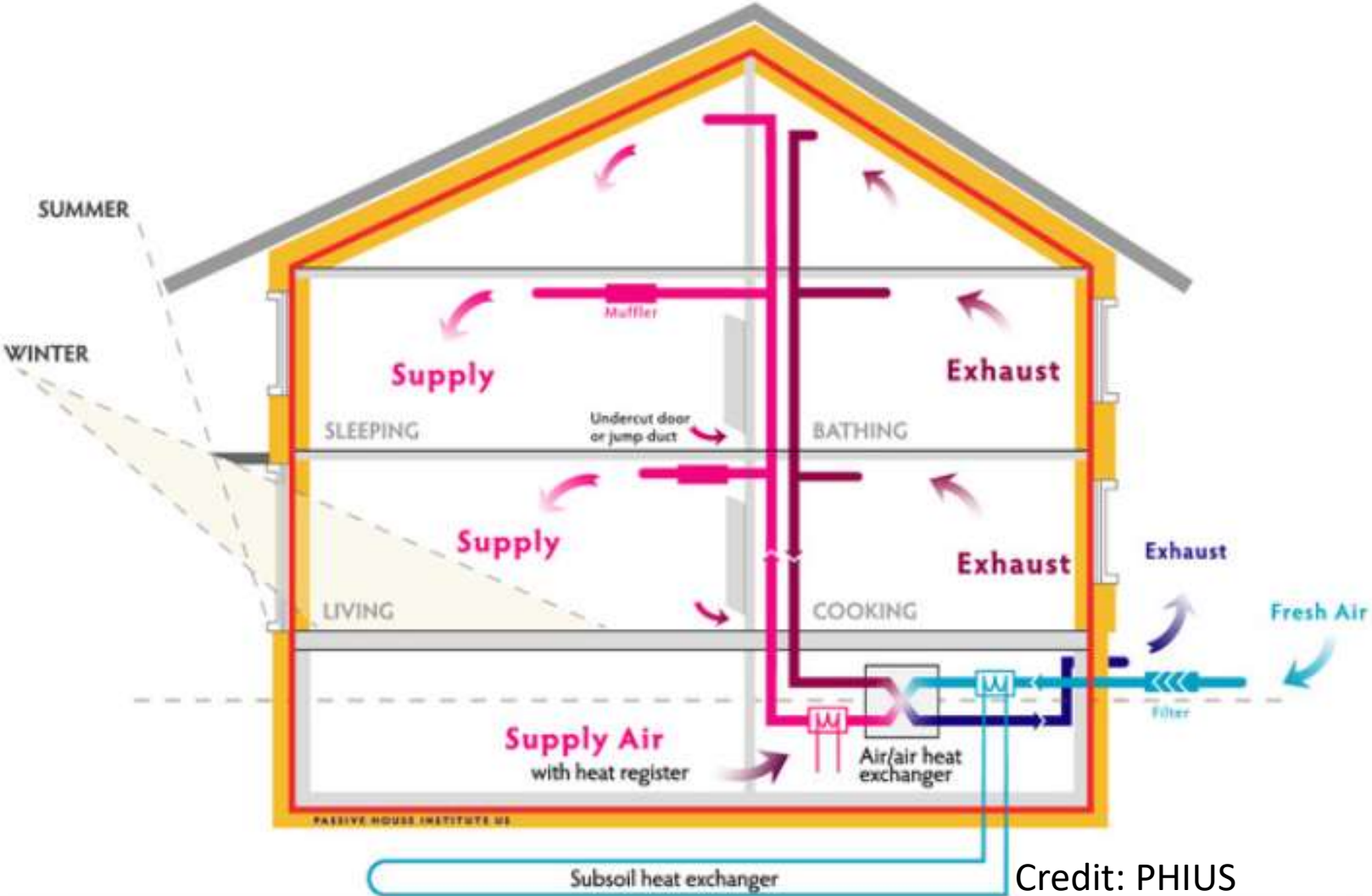
Vapor Control



Vapor Control



Vapor Control



Thank you!

Join the conversation - #EEBASummit2019

Save the dates for next year:



Resources

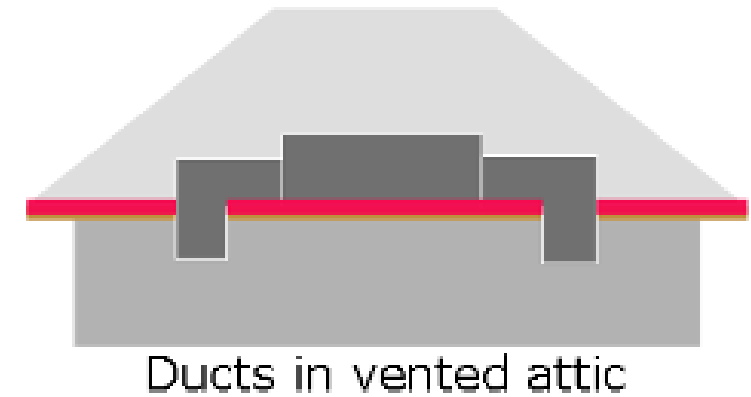
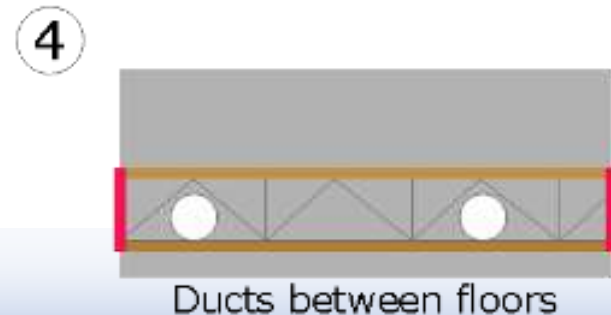
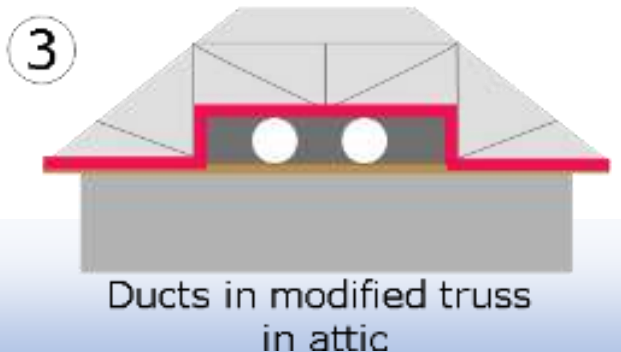
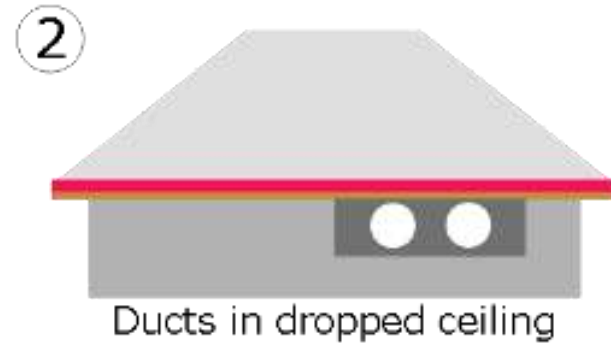
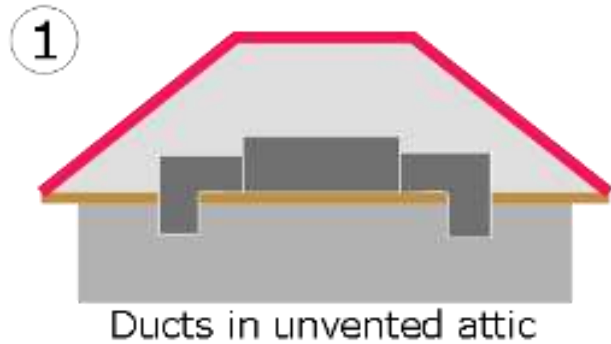
http://www.swinter.com/wp-content/uploads/SWA_High-Performance-Walls-Handout.pdf

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

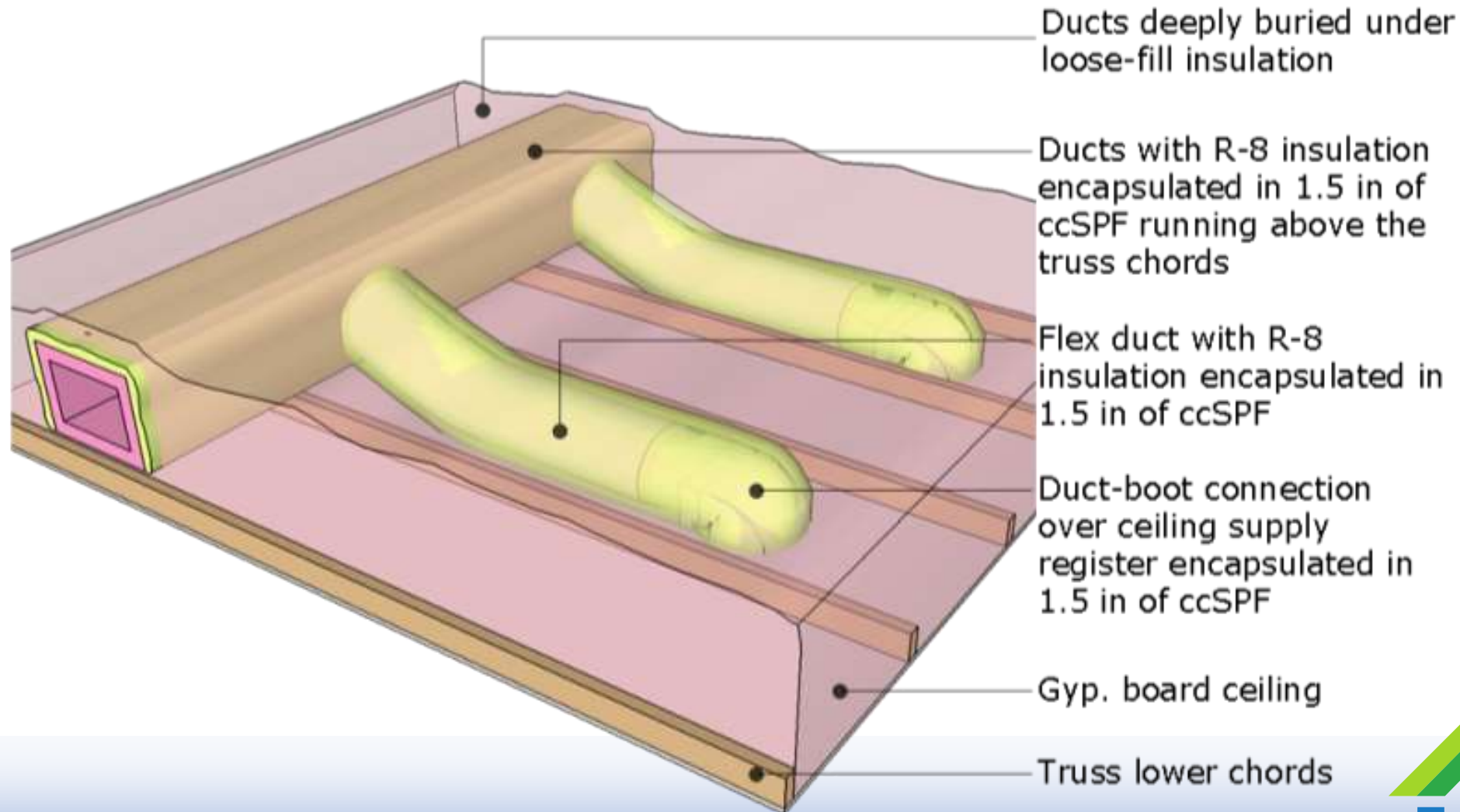


Durability & Comfort

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



Durability & Comfort



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.

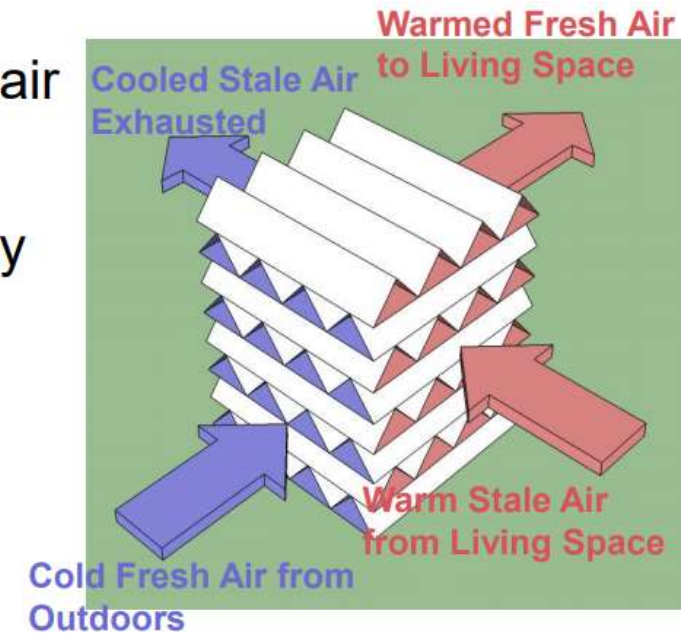
3. The Zehnder ComfoFresh air distribution system channels optimally tempered fresh air to individual rooms as needed and vents extract air to the outside. The air volume can be adjusted individually for each room.

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



Durability & Comfort



Durability & Comfort

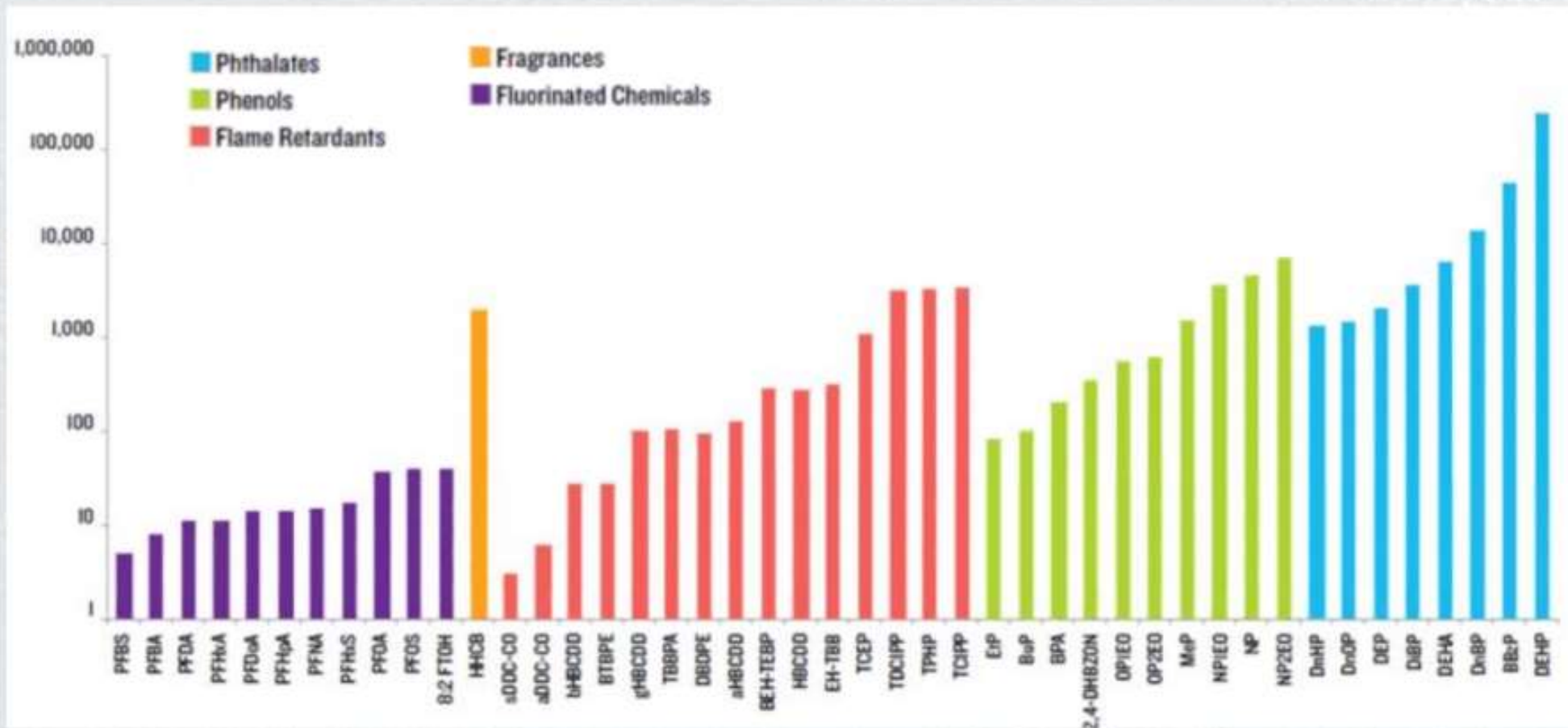
MERV Rating Chart

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 Nucell (Sneeze)	Superior Commercial Buildings	Filters 6 to 12" deep may 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 may 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

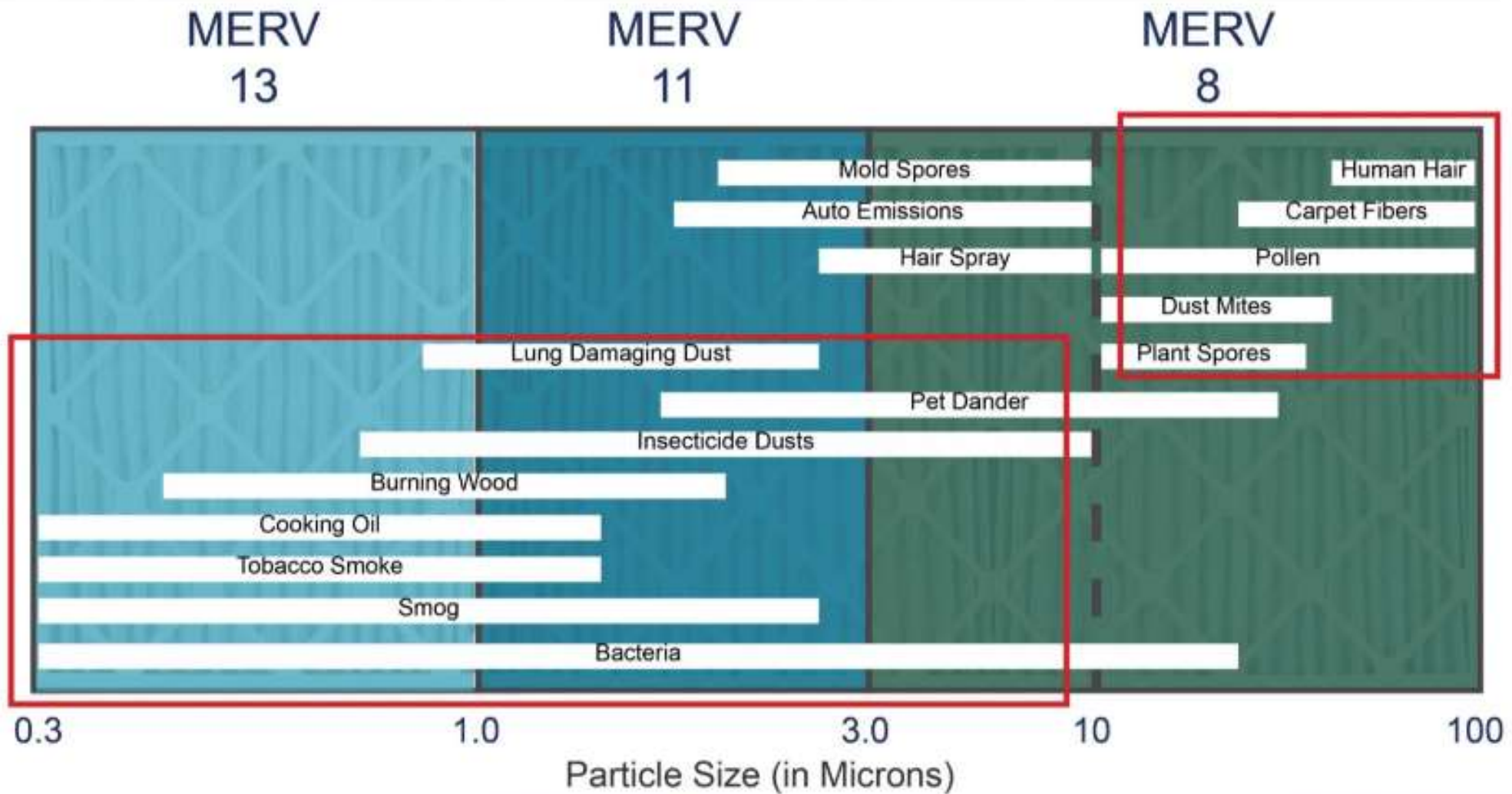
Particulates: It's Not Just Dirt

Average Concentration of Chemical
In Dust (NG/G)



Chemicals

Durability & Comfort



Durability & Comfort

Multi-family

