Kohta Ueno

Monuments Builder Group: Top 10 Building Science Problems

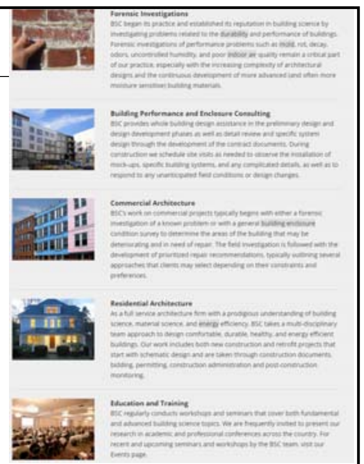
September 17, 2018

Building Science Corporation

Background

About BSC

- Massachusetts-based consulting firm
- Founded by Joseph Lstiburek ("Dr. Joe")
- Forensics
- Design reviews
- Construction admin
- https://buildingscience.com/



Topics

1. Stucco problems over OSB (and CMU)
2. Sweating mechanicals in vented attics and closets
3. Make up air for big kitchen range hoods
4. Make up air for big fireplaces
5. Building wraps vs fluid applied vs fully adhered vs ZIP/taped sheathings

Topics

6. Air leakage, blower doors, and spray foam
7. Indoor swimming pools and spas
8. Wood floors on concrete slabs
9. Ventilation and over ventilation
10. HRVs vs ERVs and dehumidifiers

Stucco Problems

Stucco on Frame Construction

Stucco on Frame Failures

Stucco on Frame Failures

Stucco on Frame Failures

Stucco on Frame Failures

Adhered Stone ("Lumpy Stucco")

Adhered Stone ("Lumpy Stucco")

Building Science Corporation 2018-09 Monuments Builder Group 13

Adhered Stone ("Lumpy Stucco")

Building Science Corporation 2018-09 Monuments Builder Group 14

"Perfect Storm" of Stucco Failures

- Change from plywood sheathings to OSB sheathings
- Changes in the properties of building papers and water resistant barriers (WRB's)
- Higher levels of thermal resistance
- Use of interior plastic vapor barriers
- Changes in the properties of stucco renderings

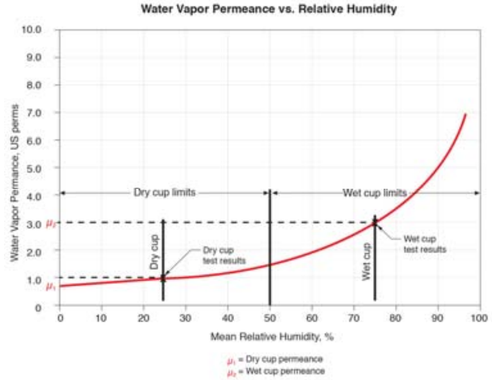
Building Science Corporation 2018-09 Monuments Builder Group 15

OSB Manufacturing

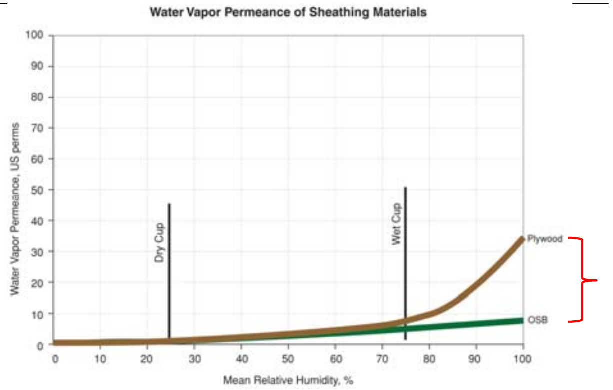
Building Science Corporation 2018-09 Monuments Builder Group 16

OSB Manufacturing

Vapor Permeance-Dry & Wet Cup



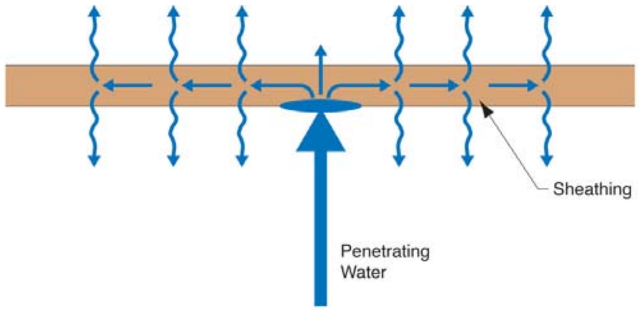
Plywood vs. OSB



Plywood vs. OSB

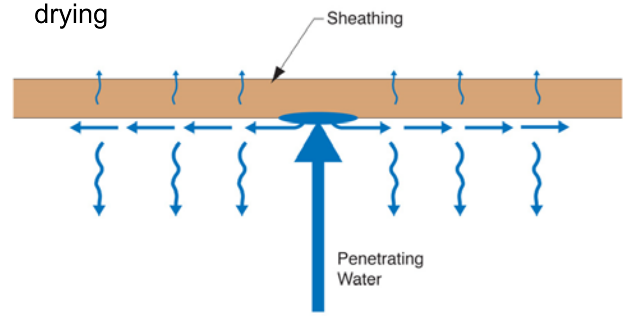
Water "Lateral Redistribution"

- Plywood: inward, outward, lateral movement



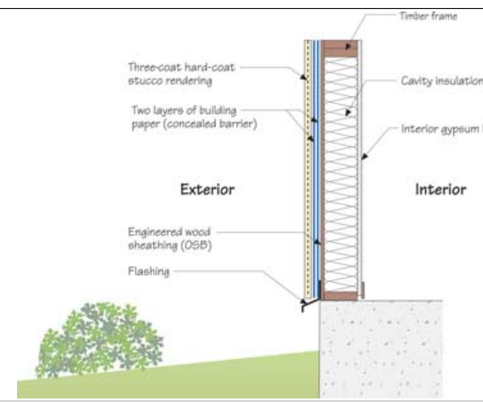
Water "Lateral Redistribution"

- OSB: much less redistribution, inward/outward drying



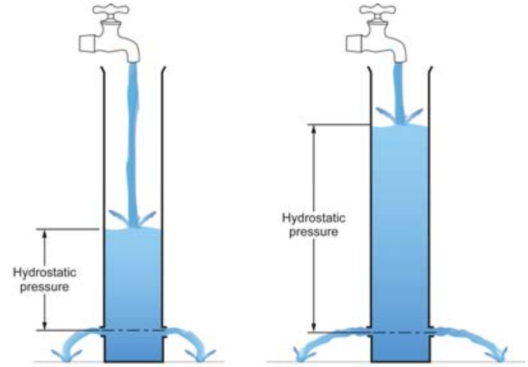
Stucco-to-Paper Bond

Stucco on Wood Frame Walls



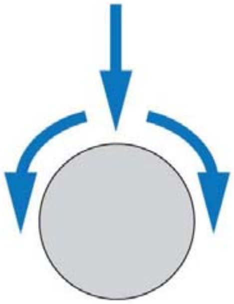
Paper-Backed Lath

Hydrostatic Pressure

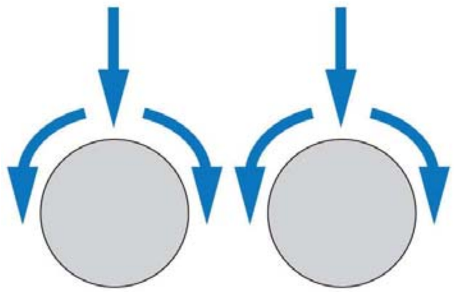


Hockey Pucks & Hydrostatic Pressure

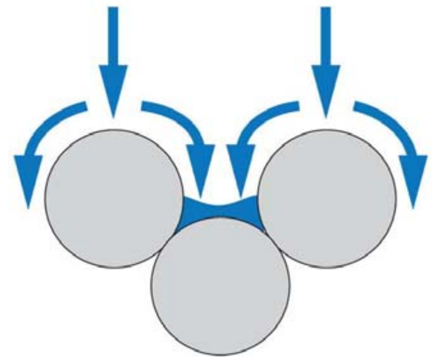
Hockey Pucks & Hydrostatic Pressure



Hockey Pucks & Hydrostatic Pressure

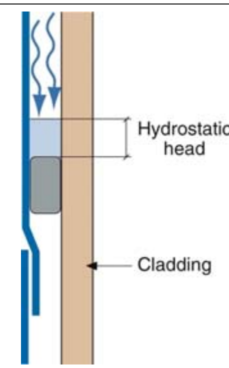


Hockey Pucks & Hydrostatic Pressure

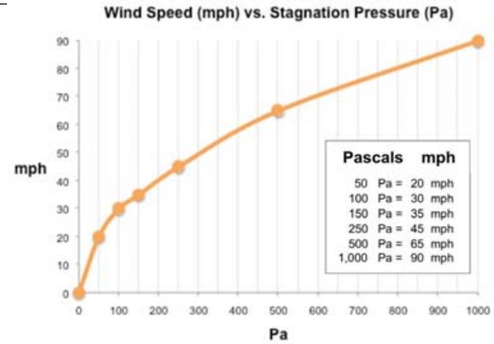


Hockey Pucks & Hydrostatic Pressure

Hockey Pucks & Hydrostatic Pressure

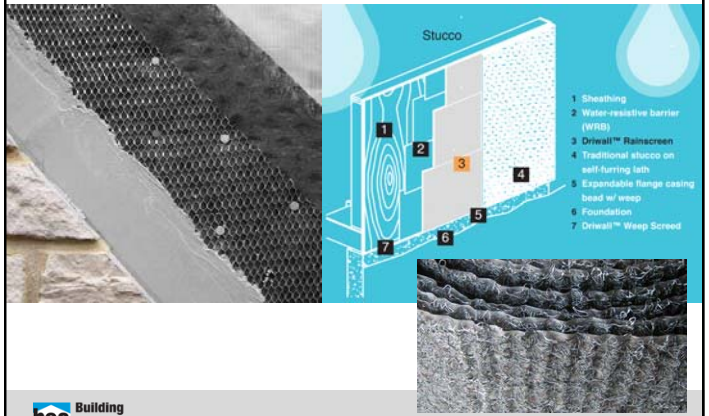


Wind Speed vs. Pressures



- ½" of "perched" water ≈ 35 mph wind force

Add a "Gap"—Solves Hydrostatic Head



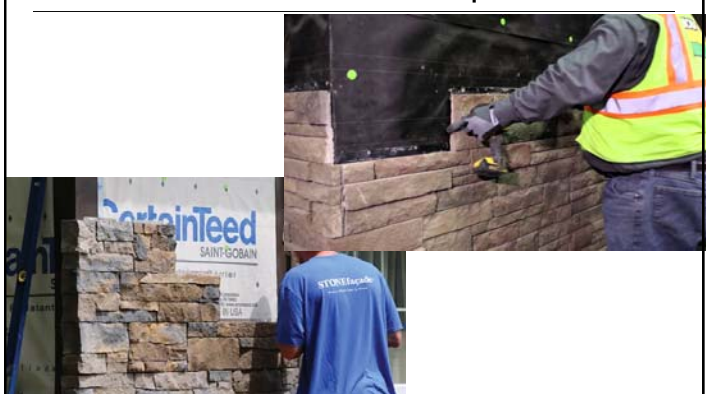
Drainage Plane, Spacer Mesh

Drainage Plane, Spacer Mesh

Stucco Application

Adhered Stone Veneer

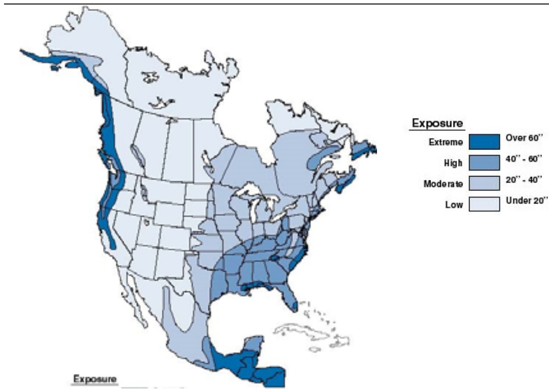
Stone Veneer Rainscreen Options



Stucco Recommendations….

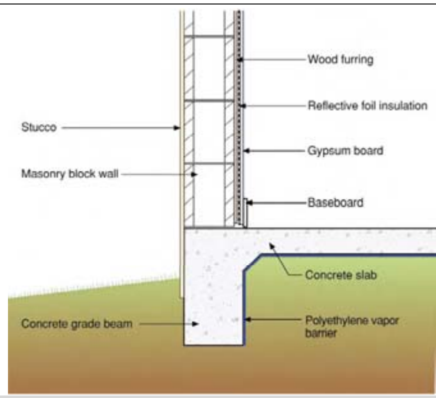
- Provide a 3/8 inch air space behind all stucco in regions where it rains more than 20 inches per year
- Provide a 3/8 inch air space behind all stucco over three stories
- Don’t install interior vapor barriers

North American Rainfall Map



CMU Wall Stucco

CMU-Stucco Walls: “Mass Walls”



Stucco Has Cracks

Stucco Has Cracks

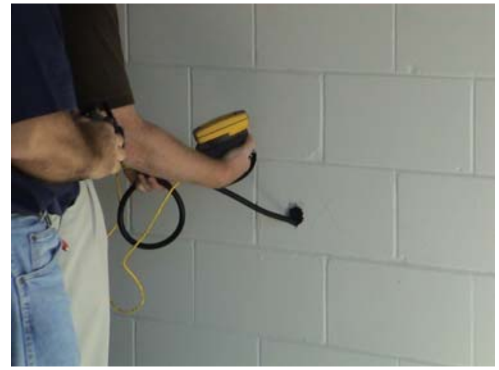
Water Testing (RILEM Tube)

Water Testing (Spray Rack)

Water Testing (Spray Rack)

Boroscope Camera Examination

Boroscope Camera Examination

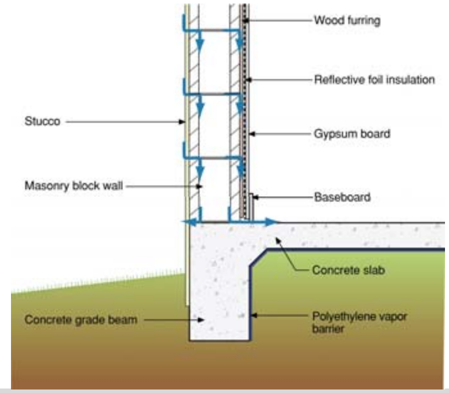


Boroscope Camera Examination

Water Penetration Through Stucco

Water Penetration Through Stucco

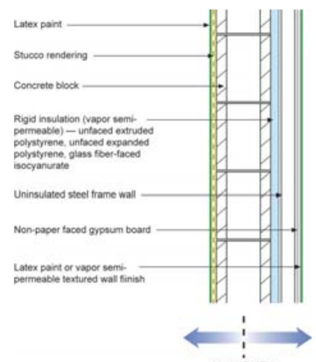
CMU-Stucco Wall Rain Penetration



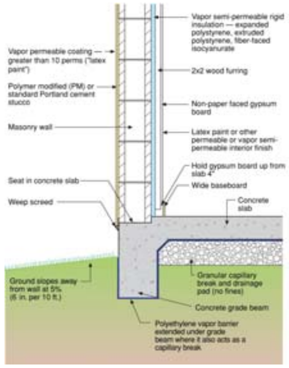
CMU-Stucco Wall Rain Penetration

- Water penetrates then cannot dry out

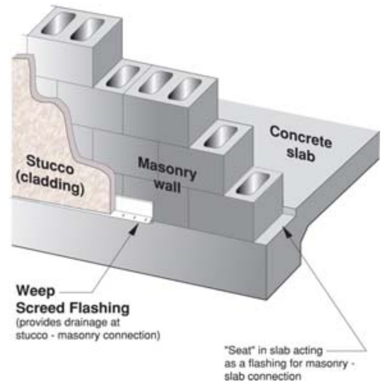
Recommended Stucco-CMU Assembly



Recommended Stucco-CMU Assembly



Stucco-CMU "Seat" in Slab Edge



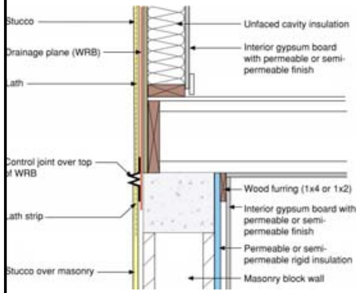
Stucco-CMU "Seat" in Slab Edge

Stucco-CMU Interior XPS Board

Frame-to-CMU Horizontal Joint

Frame-to-CMU Horizontal Joint

- Drained stucco to "mass" stucco wall connection



Frame-to-CMU Horizontal Joint (Old)

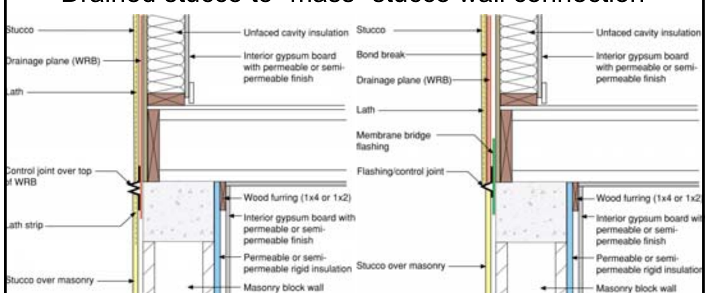
Frame-to-CMU Horizontal Joint (Old)

Frame-to-CMU Horizontal Joint (Old)

Frame-to-CMU Horizontal Joint (Old)

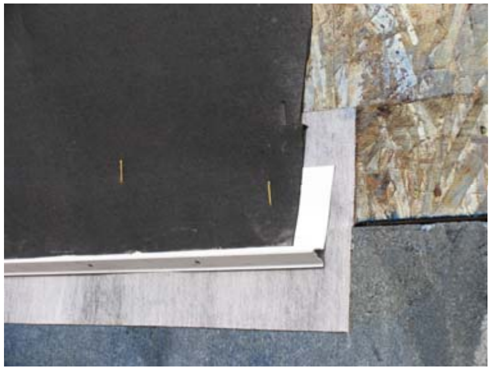
Frame-to-CMU Horizontal Joint

- Drained stucco to "mass" stucco wall connection

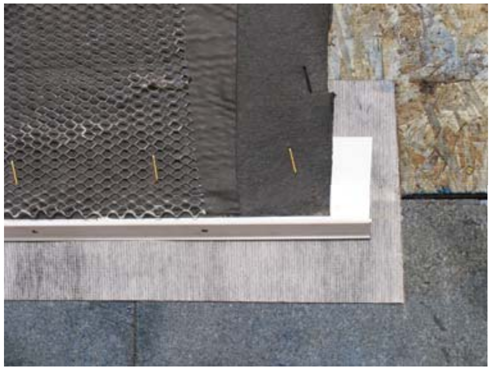


Frame-to-CMU Horizontal Joint (New)

Frame-to-CMU Horizontal Joint (New)



Frame-to-CMU Horizontal Joint (New)



Sweating Mechanicals-Vented Attics, Closets

Air Handlers in Attics

- Attics operate at outdoor dewpoint
- Hot humid climates-sweating

Sweating on Ductwork & Equipment

- Dripping, equipment longevity

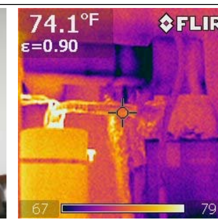
Sweating on Ductwork & Equipment

- Dripping, mold growth

Air Handlers In Garage/Garage Closet

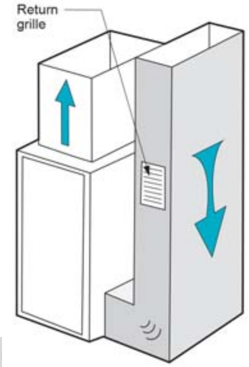
- Cooler than an attic
- Outdoor dewpoint (often)—combustion air duct?
- Sweating sometimes worse (cooler surfaces)

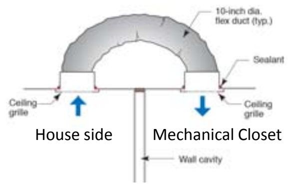
Sweating Problems Worsen?



Return Grille (Not Supply Grille)

- Make closet dewpoint lower, but not much colder





Backdrafting and code problems if gas water heater

Move Mechanicals Inside?

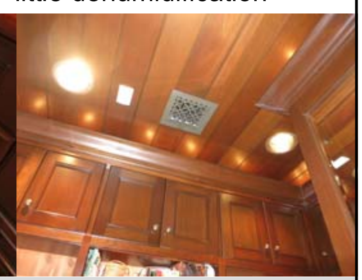
- Sweating where duct penetrates ceiling
- Same solution as garage mechanical closet
- Insulated mechanical closets (sound isolation) → worse
- With return grille opening, closet will be negative pressure

Ceiling Duct Penetration

- Negative pressure will suck out of hot-humid attic
- Not flex… rigid collar best seal

"Landlocked" Closets

- Dripping from ceiling
- Better attic insulation, cooler closet ceiling
- "Dewpoint stratification," little dehumidification



"Landlocked" Closets

- Add closet returns
- Undercut doors (return pathway)
- General humidity control measures (more later)

Building Science Corporation 2018-09 Monuments Builder Group 81

No Good Deed Goes Unpunished

- Air handlers inside
- Increase attic insulation
- Better windows
- Reducing cooling loads → cooling runs less → less dehumidification happens → moisture problems
- Higher ventilation rates (codes)
- Supplemental dehumidification: more later

Building Science Corporation 2018-09 Monuments Builder Group 82

Make-Up Air for Big Range Hoods

Building Science Corporation 2018-09 Monuments Builder Group 83

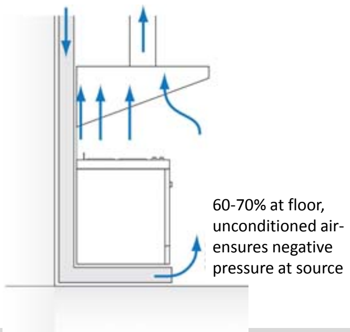
Why Makeup Air?

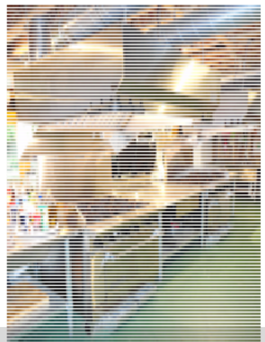
- Building code (M1503.4 Makeup Air Required when > 400 CFM)
- Backdrafting of combustion appliances & fireplaces
- Pull air from garage
- Whistling noises at windows & doors
- Motorized or gravity damper as option?

Building Science Corporation 2018-09 Monuments Builder Group 84

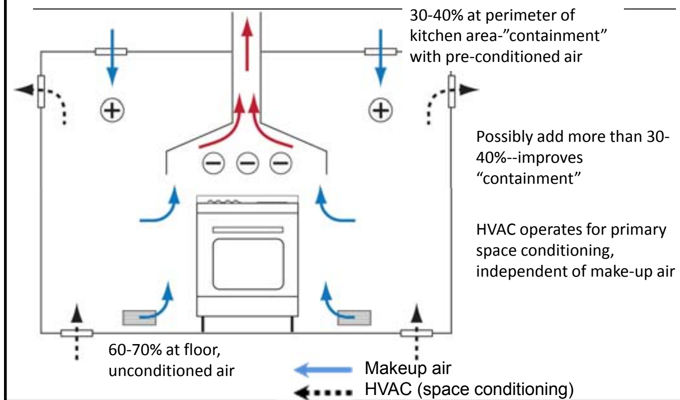
Make-Up Air Floor Level Supply

- Supply at floor, 60-70% unconditioned



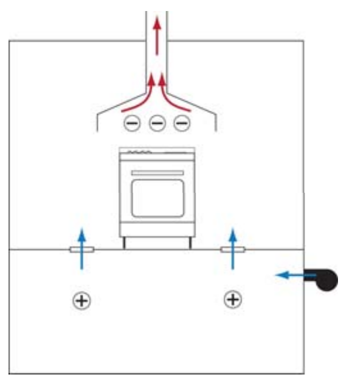


Makeup Air Sources



Smaller (~200 CFM) Make Up Air

- Basement acts as "plenum" or "mixing box"
- Make-up air "bled" into kitchen space
- Supply @ ~110% of exhaust hood airflow



Supplying Make-Up Air

- Commercial Kitchens (CA Energy Commission)

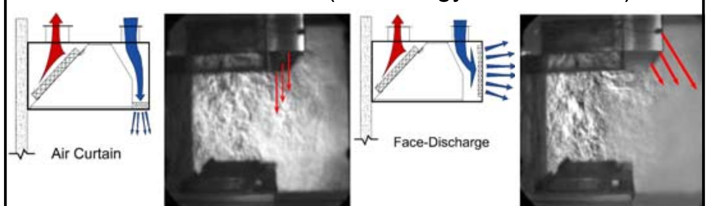
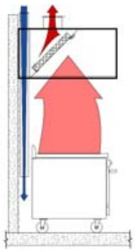


Figure 6. Schlieren image shows the thermal plume being pulled outside the hood by the air curtain.

Figure 7. Schlieren image shows the thermal plume being pulled outside the hood by a poorly engineered front face supply.

Supplying Make-Up Air

- Commercial Kitchens (CA Energy Commission)



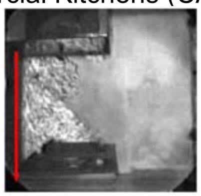


Figure 8. Schlieren image shows the thermal plume being pulled captured with backwall supply.

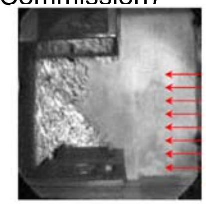


Figure 11. Schlieren image shows the plume being effectively captured when makeup air is supplied at low velocity from dis-placement diffusers.

At least 12" below cooking surface

No more than 60% of exhaust flow

Island-Style Range Hoods

Island-Style Range Hoods

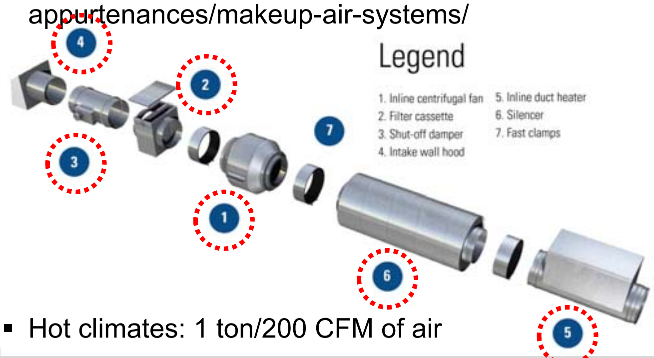
Range Hood at Wall

Range Hood at Wall

Make-Up Air at Toe Kicks

Off-the-Shelf Heated Make-Up Air

- http://www.fantech.net/product-range/fans-and-appurtenances/makeup-air-systems/



- Hot climates: 1 ton/200 CFM of air

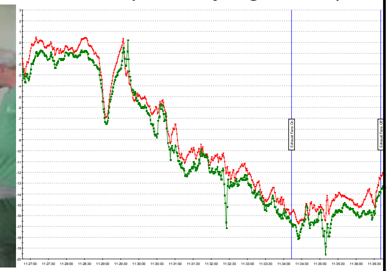
Off-the-Shelf Make-Up Air

- Interlock control with range hood
- Variable speed controller (if variable speed hood)
- Sizing heater (based on flow, outdoor Ts)

Make-Up Air for Fireplaces

Wood Fireplaces

- "Wood-powered exhaust fan"
- 400-600 CFM going up chimney (example below)
- Pressures/flow change with fire (start/dying down)



Wood Fireplaces

- Attempt at combustion air: 6" duct
- Minimal effectiveness
- Need bigger duct, fan drive… or open window

Wood Burning Fireplaces

Two types of fireplaces

Open Face

Airtight

Wood Burning Fireplaces

Open Face
- Exposed to interior space
- Draws combustion air from inside
- Chimney flue damper (iron usually, not well sealed)
- Higher risk to occupants and structure if operated incorrectly

Airtight
- Sealed combustion
- OA duct connected to sealed firebox with damper.
- No chimney flue
- Low risk to occupants and structure if operated incorrectly

Wood Burning Fireplace Challenges

- Makeup Air
  - How to supply makeup air in low leakage homes
  - Are intelligent controls necessary?
- Air Leaks (Open Face)
  - Leaky flue damper when not operating energy
  - Leaky fireplace assembly
- Other appliances that need makeup air?
  - Kitchen hood, clothes dryer

Wood Burning Fireplaces: Makeup Air

- Wood fireplace = 200-600 CFM
- Size makeup air duct according to flue?
- Fan to move makeup air?
  - Inline fan at makeup air duct
  - Exhaust fan at chimney cap
- How to operate makeup air?
- What about operator error:
  - Closing off makeup air too early? Can lead to re-entrainment of flue gases, CO poisoning
  - Startup problems can lead to smoke in house

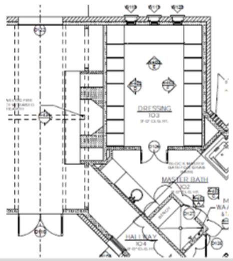
Wood Burning Fireplaces: Makeup Air

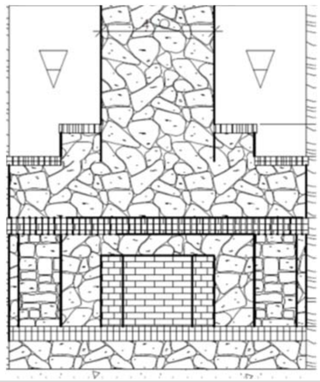
- ASHRAE says: you need a fan

An inoperative fireplace is completely at the mercy of indoor/outdoor pressure differences caused by winds, building stack effects, and operation of forced-air heating systems or mechanical ventilation. Thus, the complaint of smoking during start-up can have complex causes seldom related to the chimney. Increasingly in new homes and especially in high-rise multiple family construction, fireplaces of normal design cannot cope with mechanically induced reverse flow or shortages of combustion air. It is mandatory in these circumstances to treat and design a fireplace as a constantly operating mechanical exhaust system, with induced-draft blowers (mechanical-draft systems) that can overpower other mechanized air-consuming systems, and can develop sufficient flow to avoid smoking and excessive flue temperatures.

Wood Burning Fireplace Example

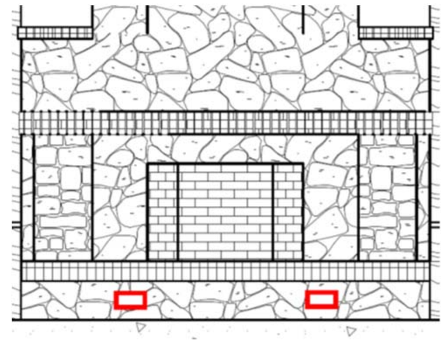
- Masonry Fireplace
- Land locked
- Open face





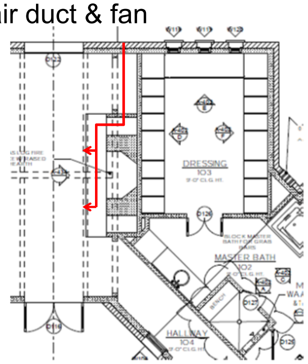
Outside air makeup

- Makeup air register location



Outside air makeup

- Makeup air duct & fan



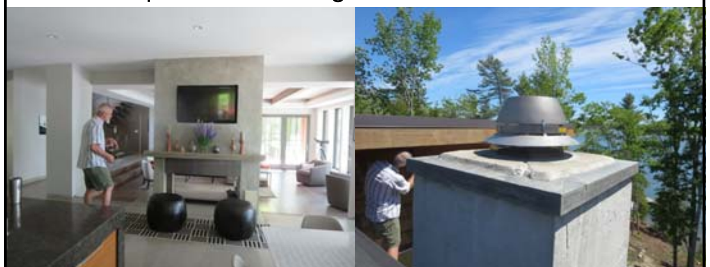
Sizing Make Up Air

- Calculate flue size based on open face of fireplace
- Supply airflow to achieve 0.8 feet per second (fps) velocity target
- Then start dialing in airflows
- More complicated with more fireplaces

- Chimney top fan ("pulling") possibly safer aproach

Wood Burning Fireplaces: Makeup Air

- Chimney top fans—effective solution, always out
- Issues: planning, access, noise complaints
- Still requires fine-tuning



Wood Burning Fireplace: Air Leaks

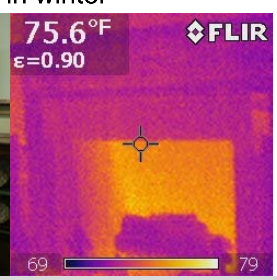
Air Leaks (Open Face)

- Flue damper must seal well
- One option is an inflatable bladder
- http://www.chimneyballoon.us/

Fireplace Condition	Results in cfm
Damper open / No Damper	1720
Glass Doors closed only	1323
Damper closed only	1470
Damper closed & Glass doors closed	1280
Chimney Balloon installed only	1250

Wood Burning Fireplace: Air Leaks

- 24/7/365 inside-to-outside hole
- Height of chimney worsens leakage problems
- Inward in summer, outward in winter



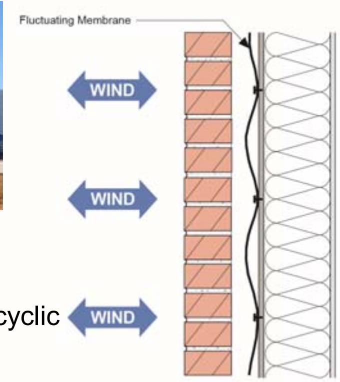
Housewraps vs. Self-Adhered vs. Fluid-Applied…

Housewrap (Residential)

Housewrap (Commercial)

Billowing Housewrap

- Is it really an air barrier (network airflow)?
- Potential damage from cyclic loading



Vapor-Impermeable Adhered Membrane

- Cold climate + no exterior insulation = danger

Vapor-Permeable Adhered Membrane

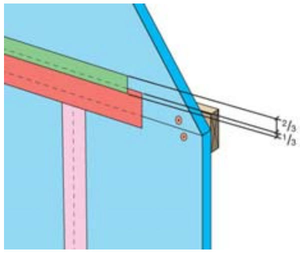
Self-Adhered Membranes

- Self-sealing
- Air leakage improvement; no blow-off/billowing
- No 'hidden path' water leakage/bypass
- Reverse laps not as critical

Taped Sheathings (WRB Surface)

- Fast dry-in
- Airtightness
- Reliance on adhesive vs. laps? Surface prep
- Rigid foam insulation too

Taped Joints (Foam Sheathing)



- Membrane-type flashing tape at joints
- Horizontals more important than verticals

Fluid-Applied WRBs

- “Housewrap in a can” (GBA Column)
- Continuous water control
- Airtightness
- Can be applied with air gun (paint sub)
- Issues: surface prep, application temperature, substrate condition, etc.

Reverse Lap Termination


- "Termination mastic" at reverse lap condition

Air Leakage, Blower Doors, and Spray Foam

Air Barrier Systems

- Function: to stop airflow through enclosure
- ABS can be placed anywhere in the enclosure
- Must be strong enough to take wind gusts (code requirement)
- Many materials are air impermeable, but most systems are not airtight

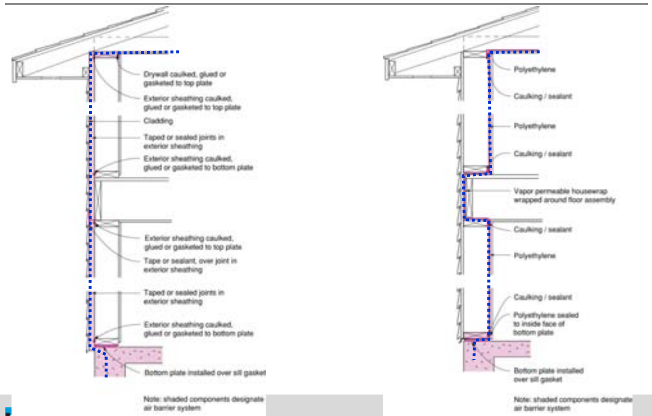
Why Not Build Air-Leaky?

- Code requirements (2012 IECC onward)
- Problems with "too tight"?
  - Typically a lack of air change/ventilation problem
  - Design and product solutions available
- Problems with air leaky
  - Unpredictable where leaks are, how big
  - Comfort complaints
  - Humidity problems
  - **Moisture damage (inward or outward air leakage)**

Air Barrier Systems: Requirements

- Continuous
  - primary need, common failure
- Strong
  - designed for full wind load
- Durable
  - critical component - repair, replacement
- Stiff
  - control billowing, pumping
- Air Impermeable
  - (may be vapour permeable)

Air Barriers: "Trace the line"

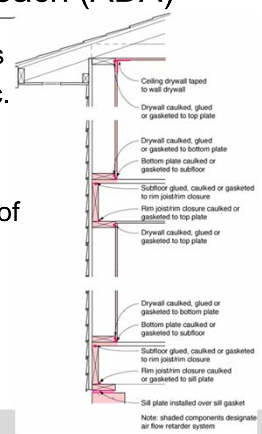


Polyethylene as Air/Vapor Barrier

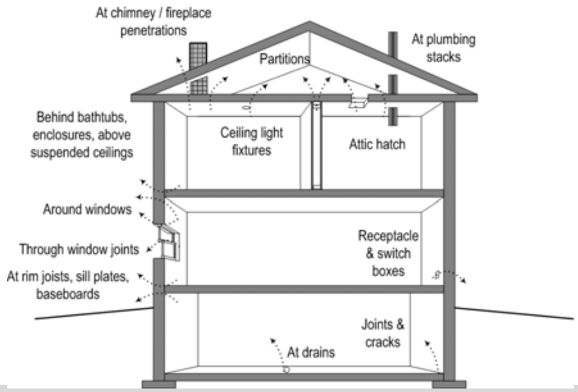
- Potential problems with AC, definitely not in South

The Airtight Drywall Approach (ADA)

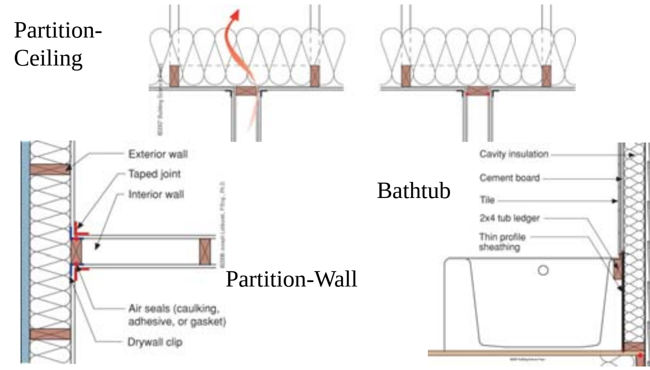
- Use drywall, framing members
- Seal with sealant, gaskets, etc.
- Is stiff, strong
- Often easier to ensure quality
- Widely applicable to all forms of commercial, residential
- Allows choice of vapor permeance



Typical Air Leakage Points



Attic and Wall Air Barrier Details

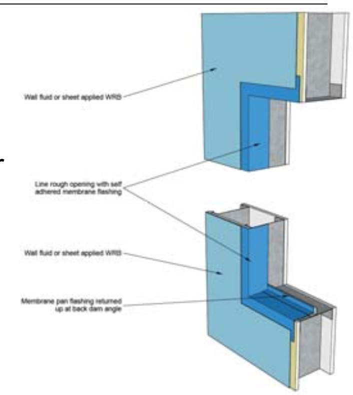


Air Sealing at Components

- E.g., windows and walls; other openings and penetrations
- Low expansion foam, membrane flashing tapes, sealants, etc.

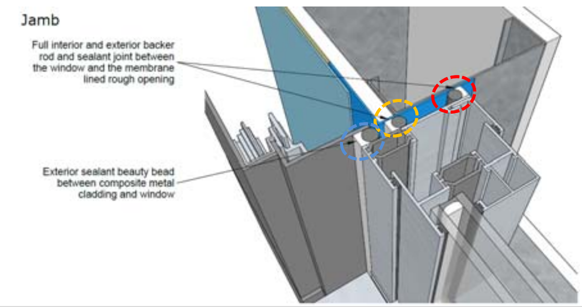
Window Air Sealing

- Air barrier “wraps” into window rough opening
- Seal window to rough opening “wrap”
- Tooled sealant & backer rod: excellent results

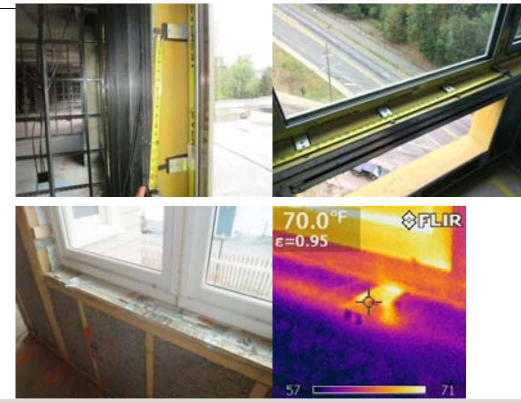


Window Air Sealing

- Seal window to rough opening “wrap”
- Air seal, weather seal, and “beauty bead”

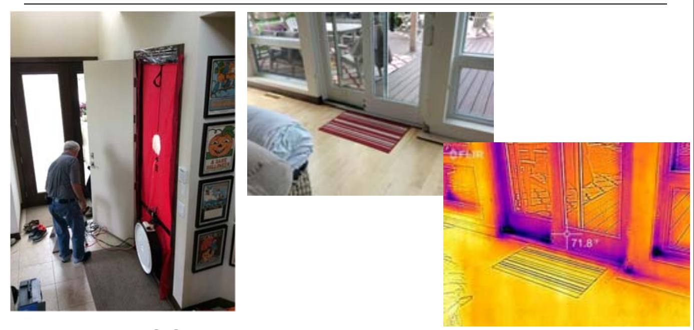


Window Air Sealing with Clips



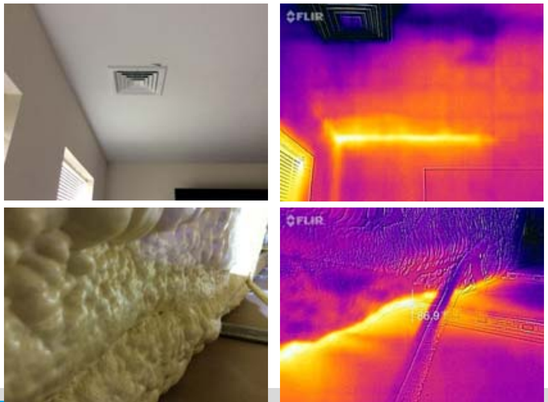
Window Air Sealing with Clips

Air Leakage Testing

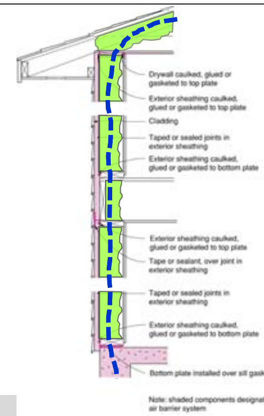


- 2009 IECC does not have testing requirement
- 2012 IECC onward requires 3 or 5 ACH 50

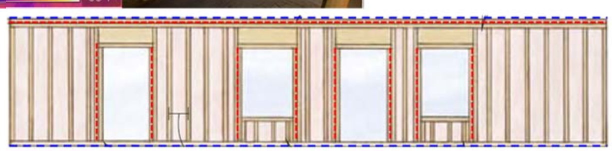
Air Leakage Testing



Spray Foam as an Air Barrier



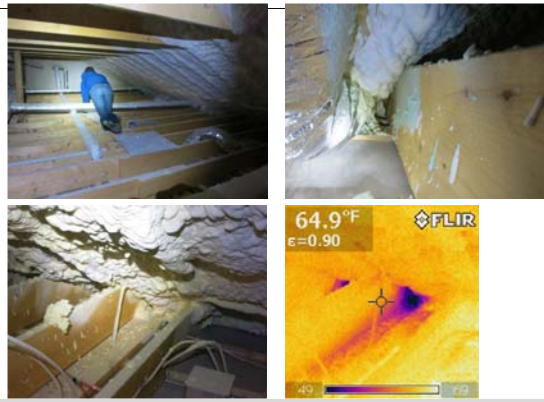
Spray Foam as an Air Barrier



- Spray foam doesn't air seal where it isn't there!
- Wood-to-wood connections

Spray Foam as an Air Barrier

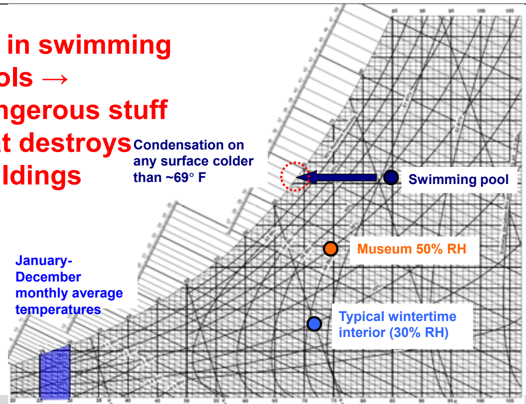
Spray Foam as an Air Barrier



Swimming Pools and Spas

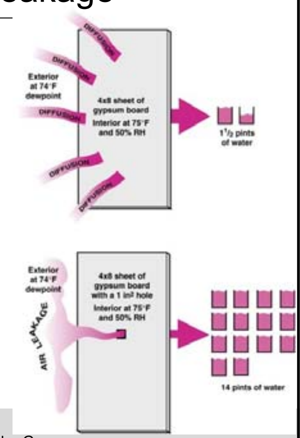
Swimming Pool Conditions

Air in swimming pools → dangerous stuff that destroys buildings

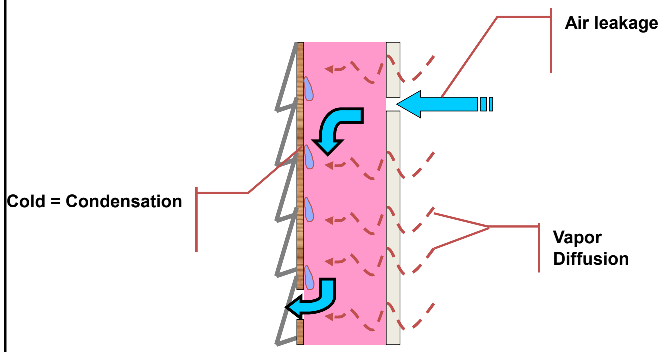


Vapor Diffusion vs. Air Leakage

- Vapor Diffusion
  - more to less vapor
  - no air flow
  - flow through tiny pores
- Air Convection
  - more to less air pressure
  - flow through visible cracks and holes
  - vapor is just along for the ride

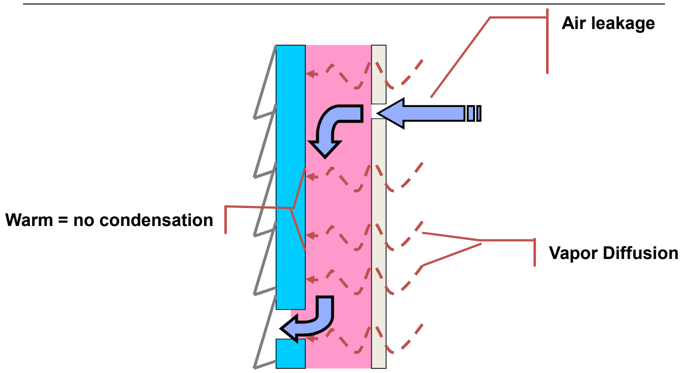


Wall w/o Insulated Sheathing

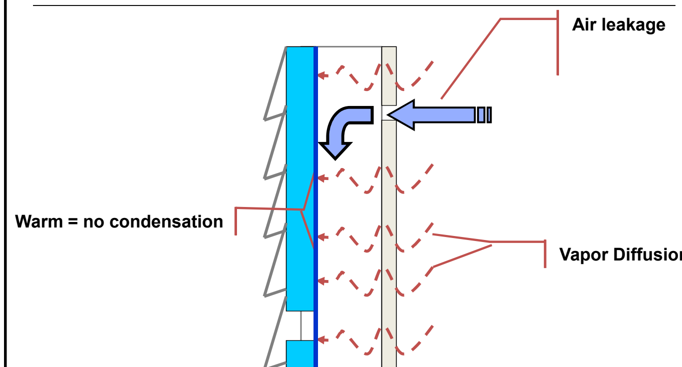


Frosting on Sheathing

Wall with Insulated Sheathing

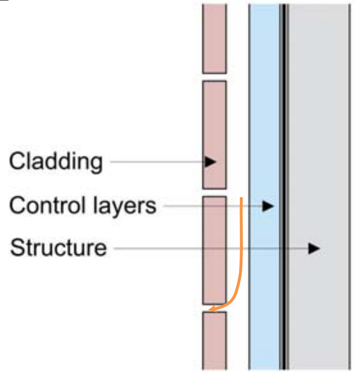


“Perfect Wall”



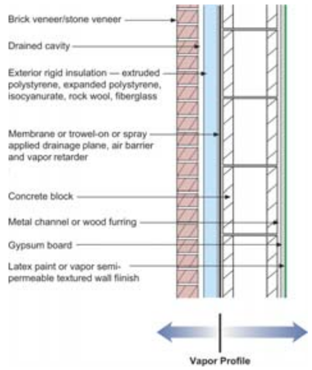
The Perfect Wall

- Structure (protected)
- Air-vapor barrier (“Control layers”)
- Insulation
- Ventilated gap (“Rainscreen”)
- Exterior cladding



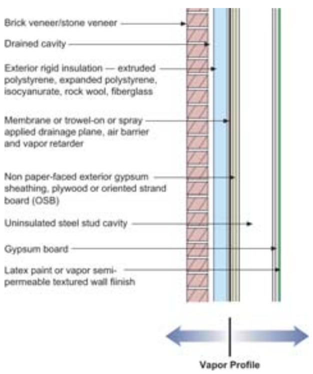
Building Science Corporation 2018-09 Monuments Builder Group 153

The “Perfect” Wall: Higher Performance



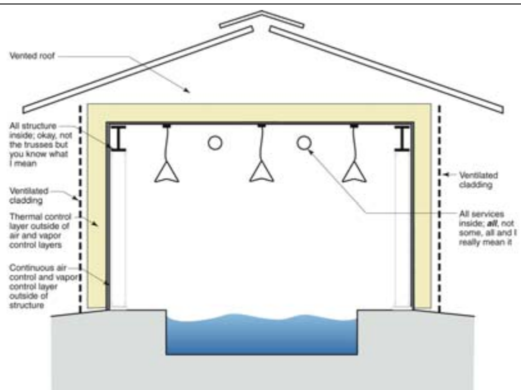
Building Science Corporation 2018-09 Monuments Builder Group 154

The Commercial Steel Frame Wall



Building Science Corporation 2018-09 Monuments Builder Group 155

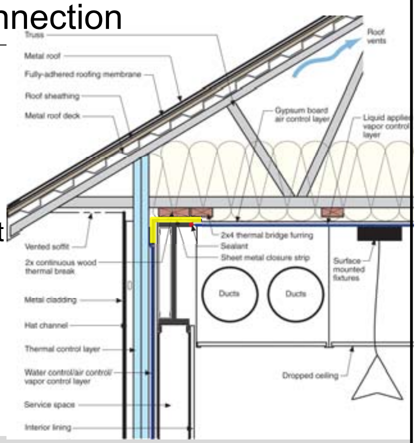
Conceptual Pool Enclosure



Building Science Corporation 2018-09 Monuments Builder Group 156

Roof-to-Wall Connection

- Perfect wall
- Vented roof
- All mechanicals inside shell
- Thermal bridging at steel truss
- Roof-to-wall air/ vapor barrier connection



Building Science Corporation 2018-09 Monuments Builder Group 157

Roof-to-Wall Air Barrier Connection

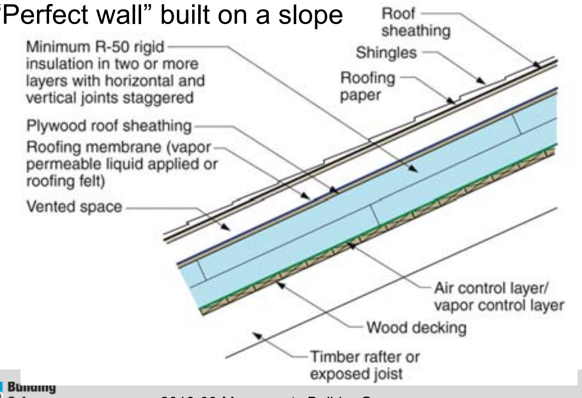
Building Science Corporation 2018-09 Monuments Builder Group 158

Interior & Exterior Air-Vapor Barrier

Building Science Corporation 2018-09 Monuments Builder Group 159

Cathedral Vented Roof

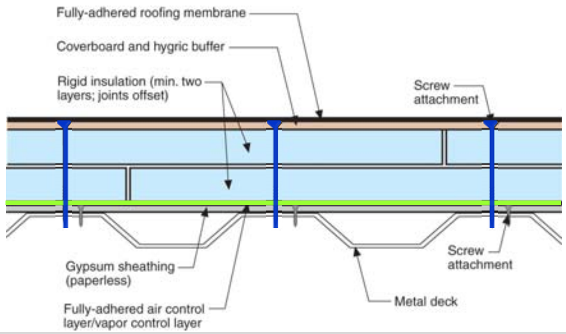
- "Perfect wall" built on a slope



Building Science Corporation 2018-09 Monuments Builder Group 160

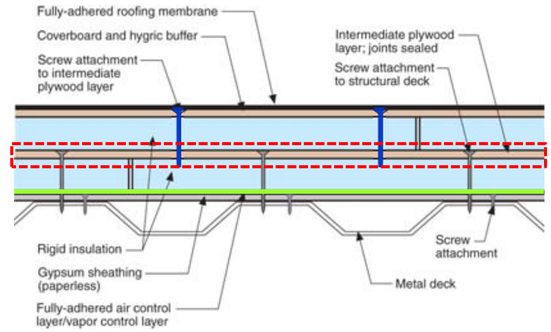
Low-Slope ("Flat") Roof

- Only works for Climate Zone 4 and warmer



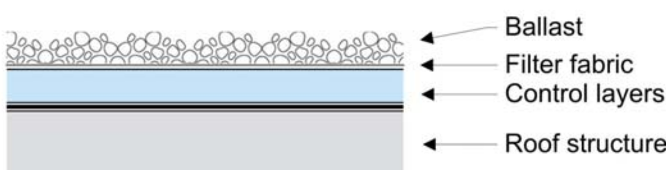
Low-Slope ("Flat") Roof

- For Climate Zone 5-ish



Inverted Membrane Roof

- Entirely safe: "perfect wall" as roof



Inverted Membrane Roof

- Entirely safe: "perfect wall" as roof
- Top side could be ballast, pavers, "green roof"

Case Study: Roof-Wall Air Barrier

- Academic pool building stripped, re-insulated, reclad
- Efflorescence staining in first winter


Case Study: Roof-Wall Air Barrier

- "Perfect wall"


Case Study: Roof-Wall Air Barrier

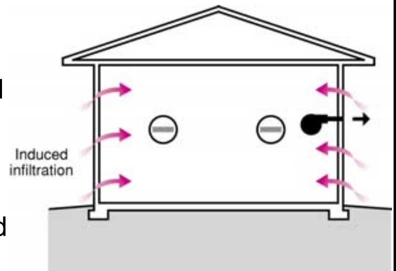
- Excellent roof (air-vapor barrier below)


Case Study: Roof-Wall Air Barrier




Run Pools at Negative Pressure

- Contains moisture (outside to inside air leakage)
- Contains odors (pool attached to rest of building)
- Tighter construction = smaller fan needed



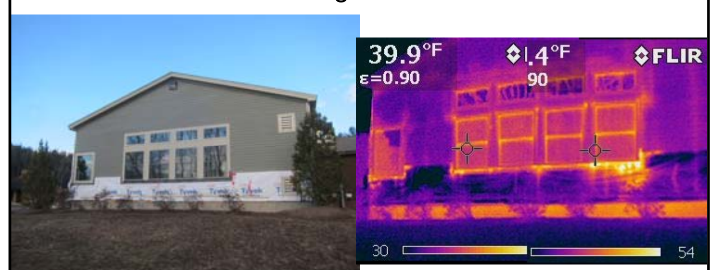
Case Study: Pressurized Pool

- Recently rebuilt NH resort pool

Case Study: Pressurized Pool

Case Study: Pressurized Pool

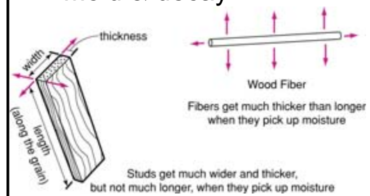
- Pool conditioning system improperly configured
- Pressurized pool + greater airtightness → concentrated air leakage condensation

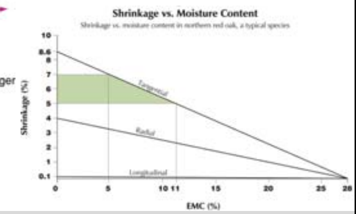


Wood Floors on Slabs

Wood Floors on Slabs

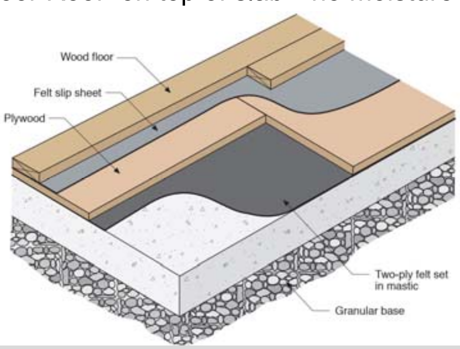
- Concrete + Water → No Problem
- Wood + Water → Problem
- Wood moisture movement
- Mold & decay





Wood Floors—Back in the Day…

- “Indoor Roof” on top of slab—no moisture

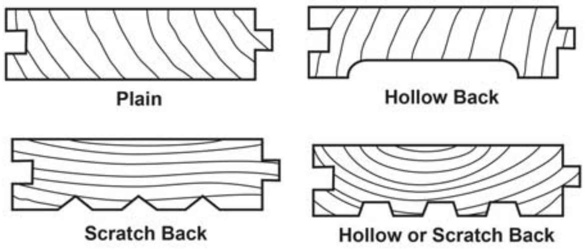


Wood Floors—Back in the Day…

- Bitumen, plywood, slip surface

Wood Flooring Profiles

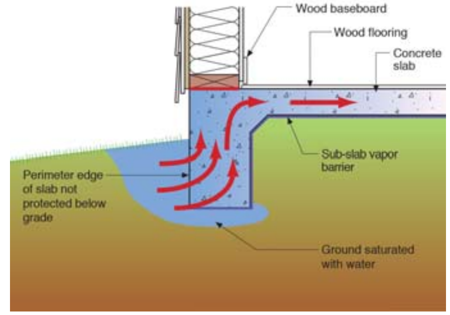
- Reduces curling due to differential seasonal moisture content at top and bottom



Building Science Corporation 2018-09 Monuments Builder Group 177

Slab Moisture Sources

- Exposed slab edge “wicks” from surrounding soil



Building Science Corporation 2018-09 Monuments Builder Group 178

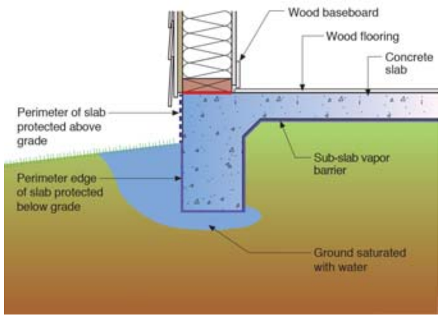
Slab Moisture Sources

- Can move moisture long distances inward

Building Science Corporation 2018-09 Monuments Builder Group 179

Slab Moisture Solution

- Protect with polyethylene at footing, slab coating

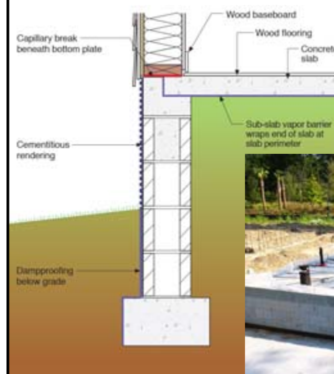


Building Science Corporation 2018-09 Monuments Builder Group 180

Slab Moisture Solution

- Protect with polyethylene at footing, slab coating

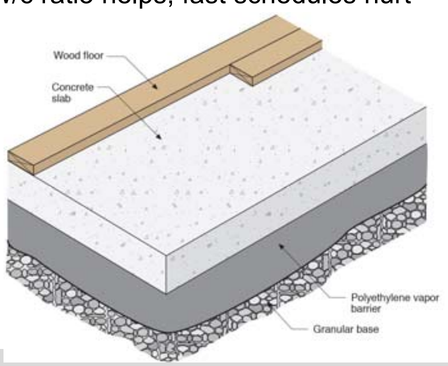
Stemwall Detail



- Slab protected by polyethylene
- Cement render on stemwall

Installation on Dry Slab

- Low w/c ratio helps; fast schedules hurt

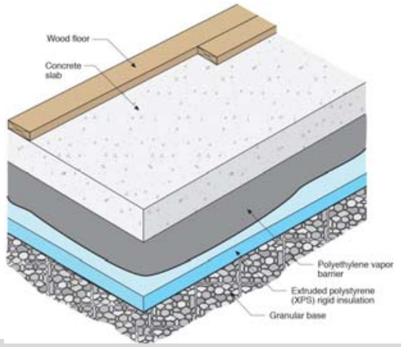


Built-In Slab Moisture

- Thickened slabs hurt (more concrete → more moisture)

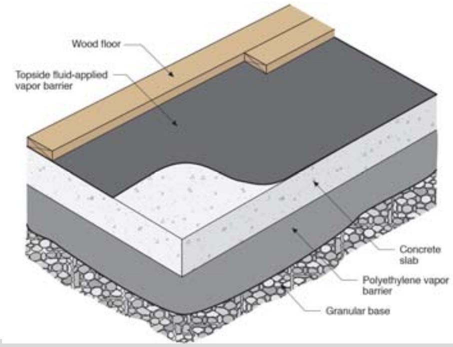
Insulated Dry Slab

- Polyethylene over XPS (not reversed)



Solution-Topside Vapor Barrier

- Fluid applied or self-adhered. Not polyethylene

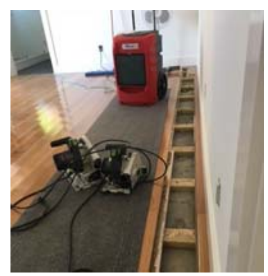


Case Study: Cupping Floor Maine

- Polyethylene below XPS
- Slab exposed through winter

Case Study: Cupping Floor Maine

- Floors cupping during finishing (sleepers)
- Slab clearly wet during demolition



Case Study: Cupping Floor Maine

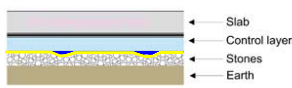
- High moisture levels on slab surface
- Previously wet cavity-corrosion

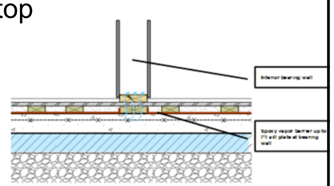

Case Study: Cupping Floor Maine

- Lower parts of slab 95%+ RH
- 4 months + of drying


Case Study: Cupping Floor Maine

- Solution option: force drying of sleeper cavity, then observe through next year
- Potential for "trapped" water
- Solution option: demolish floor, epoxy vapor barrier top coat
- Client chose latter option
- Drying might have been sufficient to solve problem





Slab Moisture and Low-Perm Floors

- Many floors are Class I (0.1 perm or less) vapor barriers: VCT, rubber-backed floor tile
- Concrete slabs are full of water when cast
- Sand "blotter layer" between polyethylene & slab makes things worse—permanent reservoir

Impermeable Floors on Wet Slabs

- Latex-based adhesives re-emulsify
- Bubbling of sheet vinyl composition flooring


Building Science Corporation 2018-09 Monuments Builder Group 193

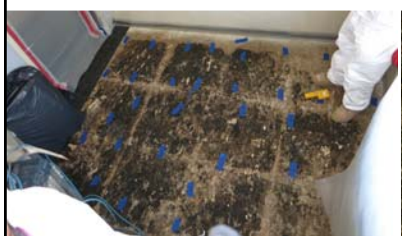
Case Study: Multi-Use Building RI

- Sleepers and Advantech on slab on grade
- Rubber-backed carpet tile, fine over basement


Building Science Corporation 2018-09 Monuments Builder Group 194

Case Study: Multi-Use Building RI

- Damage pattern matches seams of carpet tile
- High wood MCs: 18-25% typical




Building Science Corporation 2018-09 Monuments Builder Group 195

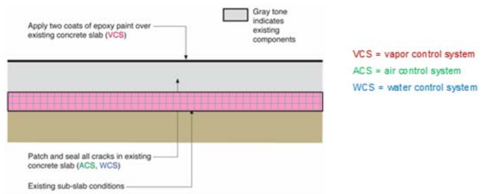
Case Study: Multi-Use Building RI

- Advantech damaged on top and bottom, wetter
- Slab RHs >98% at some spots

Building Science Corporation 2018-09 Monuments Builder Group 196

Case Study: Multi-Use Building RI

- *“AdvanTech® Flooring over Concrete Slabs”: “Slab Preparation: Cover the slab with a minimum 6 mil polyethylene sheeting”*
- Build back with epoxy coating on slab, or self-adhered membrane



Ventilation and Over-Ventilation

Ventilation Rates

- Ventilation rates are based on odor control
- Health science basis for ventilation rates is extremely limited
- Almost nothing cited applies to housing
- The applicable studies focus on dampness

Ventilation Rates over Time

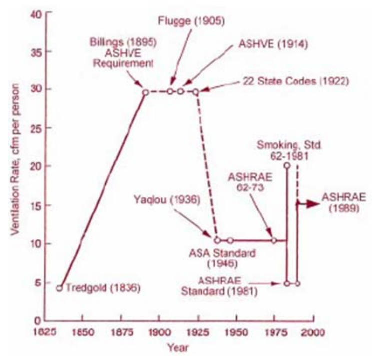


Figure 1: Minimum ventilating rate history.

Ventilation Rates vs. Odor Acceptance

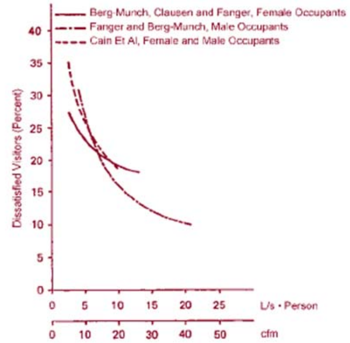


Figure 2: Odor acceptance.

Ventilation Rates and the Codes

House

2,000 ft^2
3 bedrooms
8 ft. ceiling
Volume: 16,000 ft^3

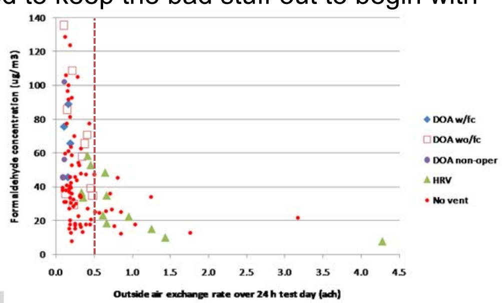
.35 ach	93 cfm
.30 ach	80 cfm
.25 ach	67 cfm
.20 ach	53 cfm
.15 ach	40 cfm

Ventilation Rates

62 - 73	5 cfm/person	20 cfm
	10 cfm/person	40 cfm
62 - 89	15 cfm/person	60 cfm
	0.35 ach	90 cfm
62.2 - 2010	7.5 cfm/person + 0.01	50 cfm
62.2 - 2013	7.5 cfm/person + 0.03	90 cfm

Interior Pollutants-Formaldehyde

- Under 0.5 ACH: no correlation w. levels
- Impractical to ventilate at much higher rates
- Need to keep the bad stuff out to begin with

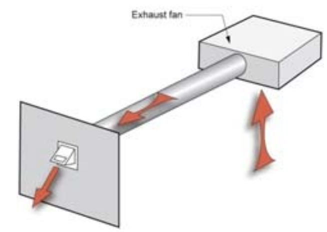


HRVs vs ERVs and Dehumidifiers

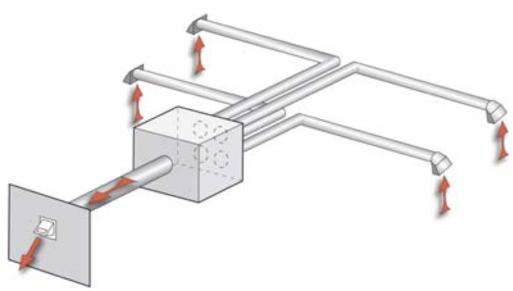
Why Mechanical Ventilation?

- Overventilation → energy, possible humidity problems
- Tighter construction → less air change
- Controlled mechanical ventilation to match occupancy

Single-Port Exhaust

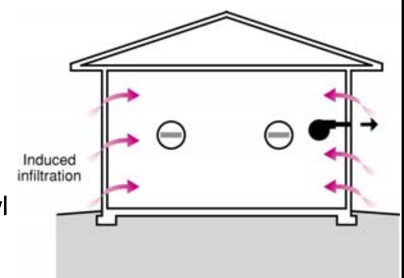


Multi-Port Exhaust

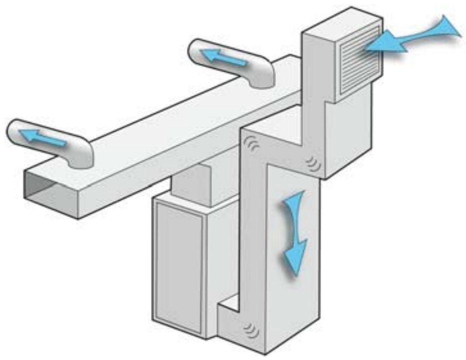


Exhaust-Only Ventilation

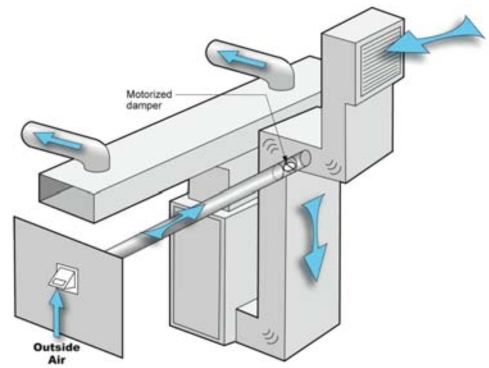
- Lowest cost
- Depressurizes building
- Draws air from wherever leaks are (unknown sources)
- Draws air from crawl spaces, basements, attics, garages…



Central-Fan Integrated Supply Ventilation

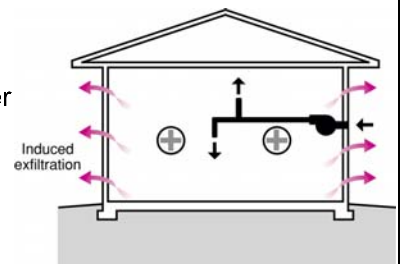


Central-Fan Integrated Supply Ventilation

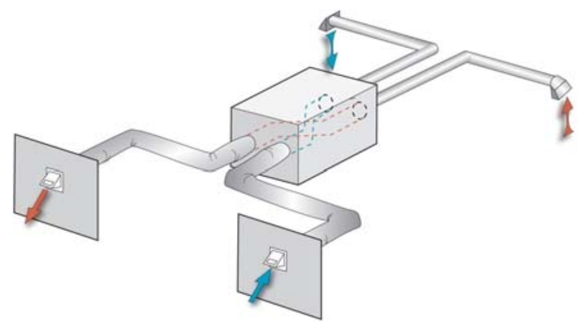


Supply-Only Ventilation

- Pressurizes building
- Draws air from known source
- Problems with tighter construction, multifamily

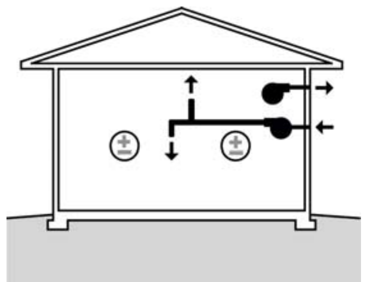


Balanced Ventilation (HRVs & ERVs)



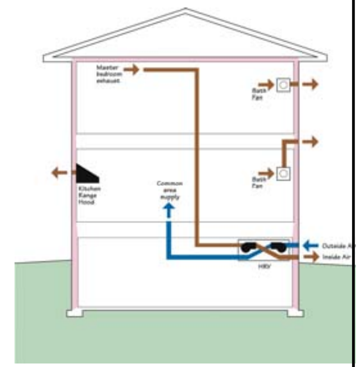
Balanced Ventilation (HRVs & ERVs)

- Building pressure neutral
- Draws air from known source
- Works with tighter construction, multifamily
- Heat recovery → energy performance



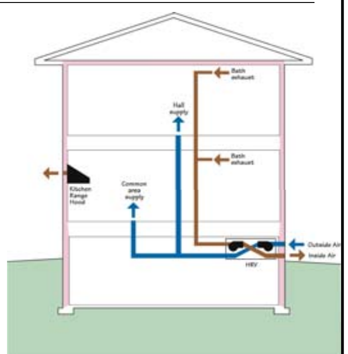
Single-Point HRV/ERV

- Draw from bedroom, supply to common area
- Bathrooms and kitchens on separate exhaust systems



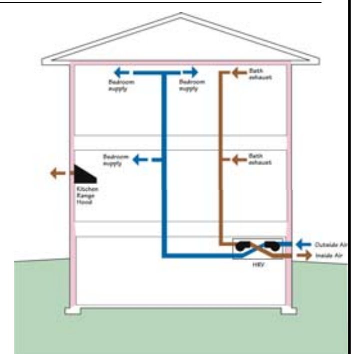
Multi-Point HRV/ERV

- Draw from bathrooms, supply to common area
- Kitchen on separate exhaust systems
- Or…



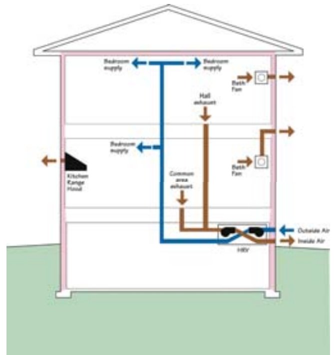
Multi-Point HRV/ERV

- Draw from bathrooms, supply to bedrooms
- Kitchen on separate exhaust systems
- Bedrooms are where pollutants are generated and concentrate!
- But don't “dump” on occupants



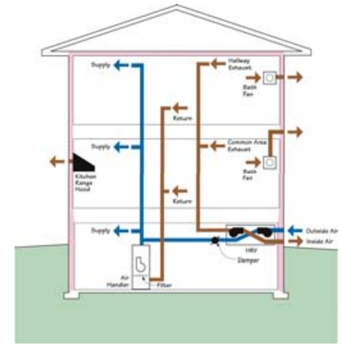
Multi-Point HRV/ERV

- Draw from common spaces, supply to bedrooms
- Kitchen and baths on separate exhaust systems



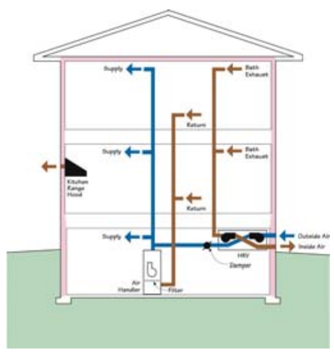
HVAC-Integrated HRV/ERV

- HVAC integration
  - Lower cost (less ductwork)
  - Good distribution of supply air
  - More complicated- interlocks
- Draw from common areas, supply to HVAC plenum
- Damper to avoid backdrafting



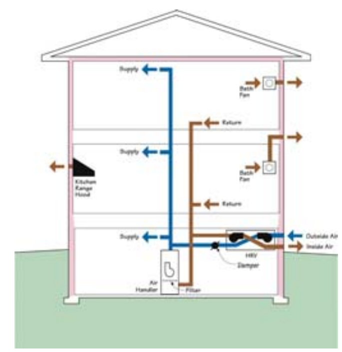
HVAC-Integrated HRV/ERV

- Draw from bathrooms, supply to HVAC supply plenum
- Damper to avoid backdrafting



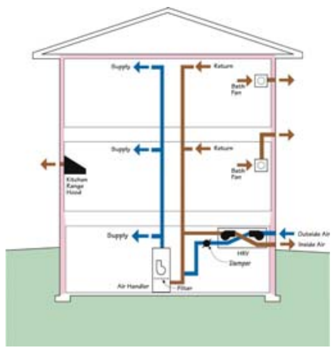
HVAC-Integrated HRV/ERV

- Draw from return plenum, supply to HVAC supply plenum
- Damper to avoid backdrafting
- Risks of pressure relationship problems



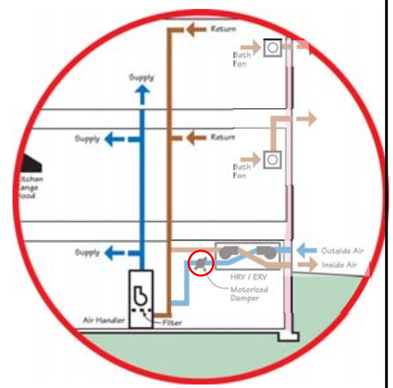
HVAC-Integrated HRV/ERV

- Draw from return plenum, supply to return plenum
- Damper to avoid backdrafting
- Risks of pressure relationship problems



HRV Induced Flow

- AHU running, HRV not running→ unintended airflow
- Overall air leakage + duct leakage issues
- Need motorized damper in addition to backdraft dampers



HRV/ERV Takeaways

- Supplying to bedrooms → outside air where pollutants are generated/concentrated
- Ductwork independent of HVAC system: simpler, fewer things to go wrong, but more expensive
- Multi-point ducted system better than single-point ducted system (and more expensive)
- HRV/ERV can do double duty as bath fan, but avoid long dumb runs
  - Bathroom exhaust via ERV recovers moisture—typically not a good thing

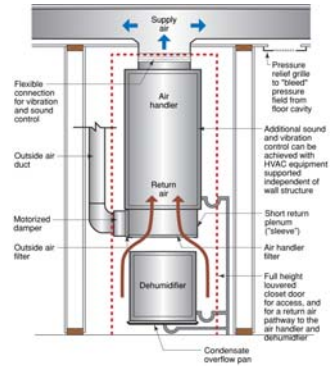
HRVs vs. ERVs

- Hot-humid and mixed-humid climates: ERV
- ERVs do not dehumidify
  - They only partly reduce the moisture load due to outdoor air humidity
- Cold climates: HRVs vs. ERVs
  - Recover or reject moisture?
  - Building size and occupancy
  - Large houses, low occupancy → ERV typical
- Do not over ventilate: HRV + overventilation = “too dry” complaints

Part-Load Humidity and Dehumidification

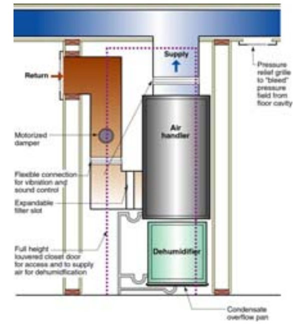
- Better enclosures/shells: less cooling load
  - Windows, shading, insulation levels, airtightness
- Less runtime → less dehumidification
  - "Shoulder" seasons often worst
- Oversized cooling equipment → poor dehumidification
  - Two stage/multi speed helps, but…
- High-efficiency HVAC → worse dehumidification
- Adding supplemental dehumidification

Adding Dehumidification (Closet AHU)



Adding Dehumidification (Closet AHU)

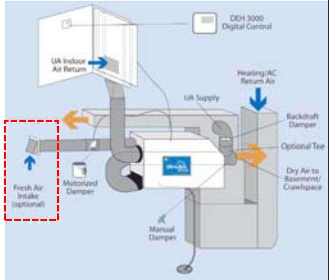
Adding Dehumidification (Closet AHU)



Adding Dehumidification (Closet AHU)

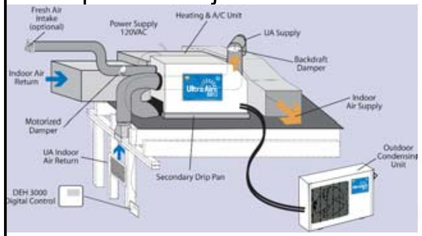
Dehumidifier Integrated with HVAC

- Ducted high efficiency units
- Dehumidify outside supply air option



Dehumidifier Integrated with HVAC

- Dehumidifiers add heat to indoors
  - Pros and cons
- Option to "reject" heat outdoors instead



Questions?

Kohta Ueno
kohta (at sign) buildingscience dot com

This presentation will be available at http://buildingscience.com/past-events

Document Resources

- Building Science Digest 014: Air Flow Control in Buildings
  http://www.buildingscience.com/documents/digests/bsd-014-air-flow-control-in-buildings
- Building Science Digest 104: Understanding Air Barriers
  http://www.buildingscience.com/documents/digests/bsd-104-understanding-air-barriers/
- Building Science Digest 105: Understanding Drainage Planes
  http://www.buildingscience.com/documents/digests/bsd-105-understanding-drainage-planes
- Building Science Digest 163: Controlling Cold-Weather Condensation Using Insulation
  https://buildingscience.com/documents/digests/bsd-controlling-cold-weather-condensation-using-insulation
- Building Science Insight 001: The Perfect Wall
  http://www.buildingscience.com/documents/insights/bsi-001-the-perfect-wall/
- Building Science Insight 003: Concrete Floor Problems
  https://buildingscience.com/documents/insights/bsi-003-concrete-floor-problems
- Building Science Insight 006: No Good Deed Shall Go Unpunished
  http://buildingscience.com/documents/building-science-insights/bsi-006-no-good-deed-shall-go-unpunished

Building Science Corporation 2018-09 Monuments Builder Group 233

Document Resources

- Building Science Insight 012: Balancing Act - Exhaust-Only Ventilation Does Not Work
  http://buildingscience.com/documents/building-science-insights/bsi-012-balancing-act-exhaust-only-ventilation-does-not-work
- Building Science Insight 029: Stucco Woes—The Perfect Storm
  http://buildingscience.com/documents/insights/bsi-029-stucco-woes-the-perfect-storm
- Building Science Insight 037: Mold in Alligator Alley
  http://buildingscience.com/documents/insights/bsi-037-mold-in-alligator-alley
- Building Science Insight 038: Mind the Gap, Eh!
  http://www.buildingscience.com/documents/insights/bsi-038-mind-the-gap-eh/
- Building Science Insight 055: In the Deep End
  http://www.buildingscience.com/documents/insights/bsi-055-in-the-deep-end/
- Building Science Insight 057: Hockey Pucks and Hydrostatic Pressure
  http://buildingscience.com/documents/insights/bsi-057-hockey-pucks-and-hydrostatic-pressure
- Building Science Insight 070: First Deal with the Manure and Then Don't Suck
  https://buildingscience.com/documents/insights/bsi-070-first-deal-with-the-manure
- Building Science Insight 082: Walking the Plank
  https://buildingscience.com/documents/insights/bsi082-walking-the-plank

Building Science Corporation 2018-09 Monuments Builder Group 234

Document Resources

- Building Science Insight 084: Forty Years of Air Barriers*—The Evolution of the Residential Air Barrier
  http://buildingscience.com/documents/insights/bsi-084-forty-years-of-air-barriers
- Building Science Insight 102: The Coming Stucco-Pocalypse
  https://buildingscience.com/documents/building-science-insights/bsi-102-coming-stucco-pocalypse
- Information Sheet 611: Balanced Ventilation Systems (HRVs and ERVs)
  http://buildingscience.com/documents/information-sheets/info-611-balanced-ventilation-systems
- Information Sheet 620: Supplemental Humidity Control
  http://buildingscience.com/documents/information-sheets/information-sheet-supplemental-humidity-control
- Research Report 0203: Relative Humidity
  http://www.buildingscience.com/documents/reports/rr-0203-relative-humidity/view
- Design Guide: Improving Commercial Kitchen Ventilation System Performance
  http://www.energy.ca.gov/reports/2003-06-13_500-03-034F.PDF

Building Science Corporation 2018-09 Monuments Builder Group 235

Document Resources

- Indoor Pool Building
  https://buildingscience.com/project/indoor-pool-building
- Mixed-Use Building
  https://buildingscience.com/project/mixed-use-building
- Pool and Recreation Facility
  https://buildingscience.com/project/pool-and-recreation-facility

Building Science Corporation 2018-09 Monuments Builder Group 236