Architectural & Engineering Design in Hot & Humid Climates

Indoor Mold and the Building Envelope Affects On Indoor Air Quality
Charleston, SC

Presented By

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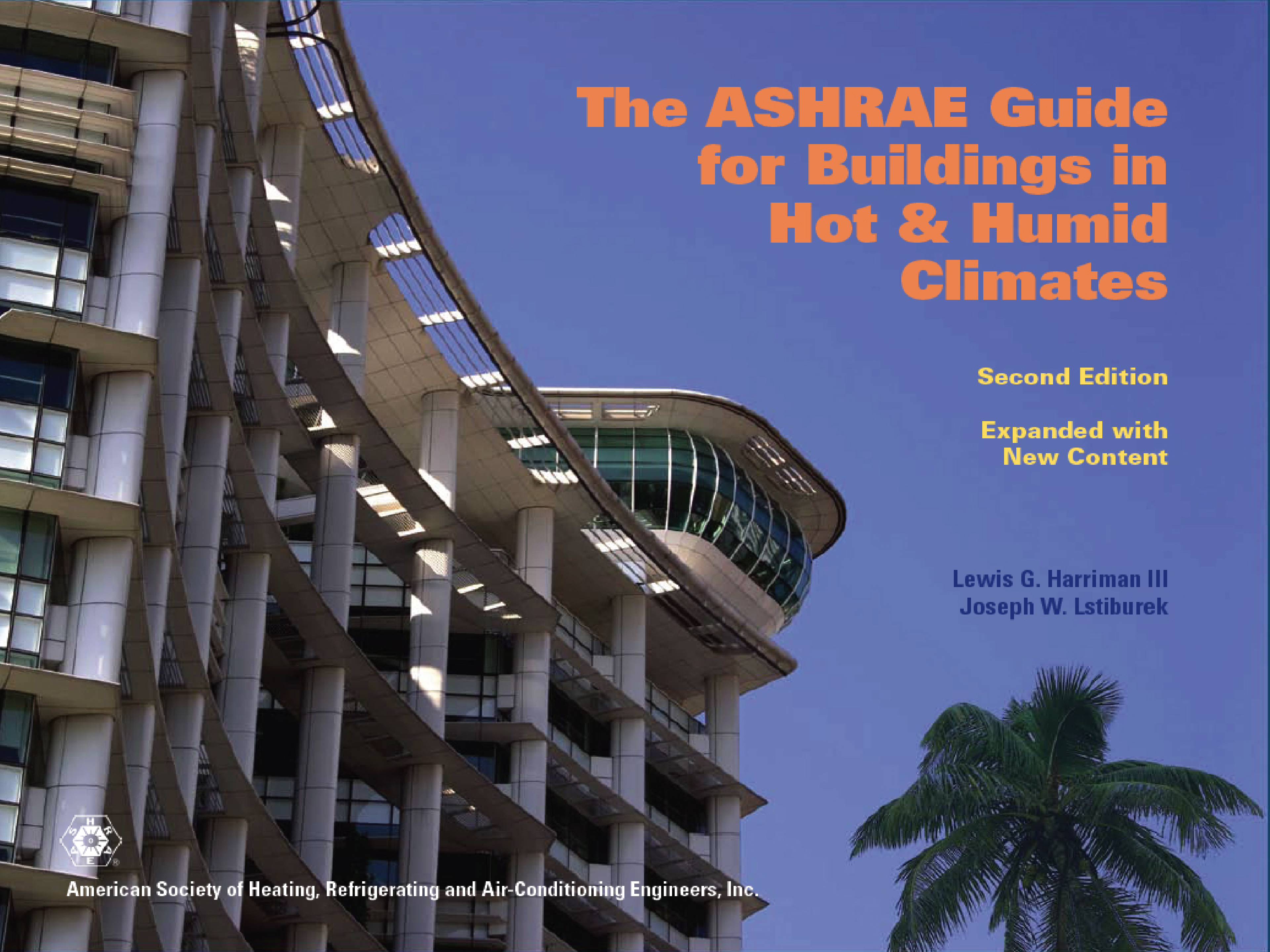


The ASHRAE Guide for Buildings in Hot & Humid Climates

Second Edition

Expanded with New Content

Lewis G. Harriman III
Joseph W. Lstiburek

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Designing Buildings

When we build let us think we build forever. Let it not be for present delight nor for present use alone. Let it be such work that our descendants will thank us for, and let us think, as we lay stone upon stone, that a time is to come when these stones will be held sacred because our hands have touched them, and that men will say, as they look upon the labor and wrought substance of them, "See! This our fathers did for us."

John Ruskin (1819 - 1900)

Indoor Environmental Quality
and
Indoor Air Quality

Indoor Environmental Quality

- Indoor environmental quality (IEQ) refers to the quality of a building's environment in relation to the health and wellbeing of those who occupy space within it. IEQ is determined by many factors, including lighting, air quality, and damp conditions.

Indoor Air Quality - EPA

- EPA definition: “a term referring to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants.”

Indoor Air Quality - ASHRAE

- ASHRAE definition: “air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority [80 percent or more] of the people exposed do not express dissatisfaction.”

History

- Tighter building construction
- Building materials and techniques have changed
- Technology produces indoor pollutants
- Technology and people have moved indoors together
- People spend up to 90% of their time indoors

Health

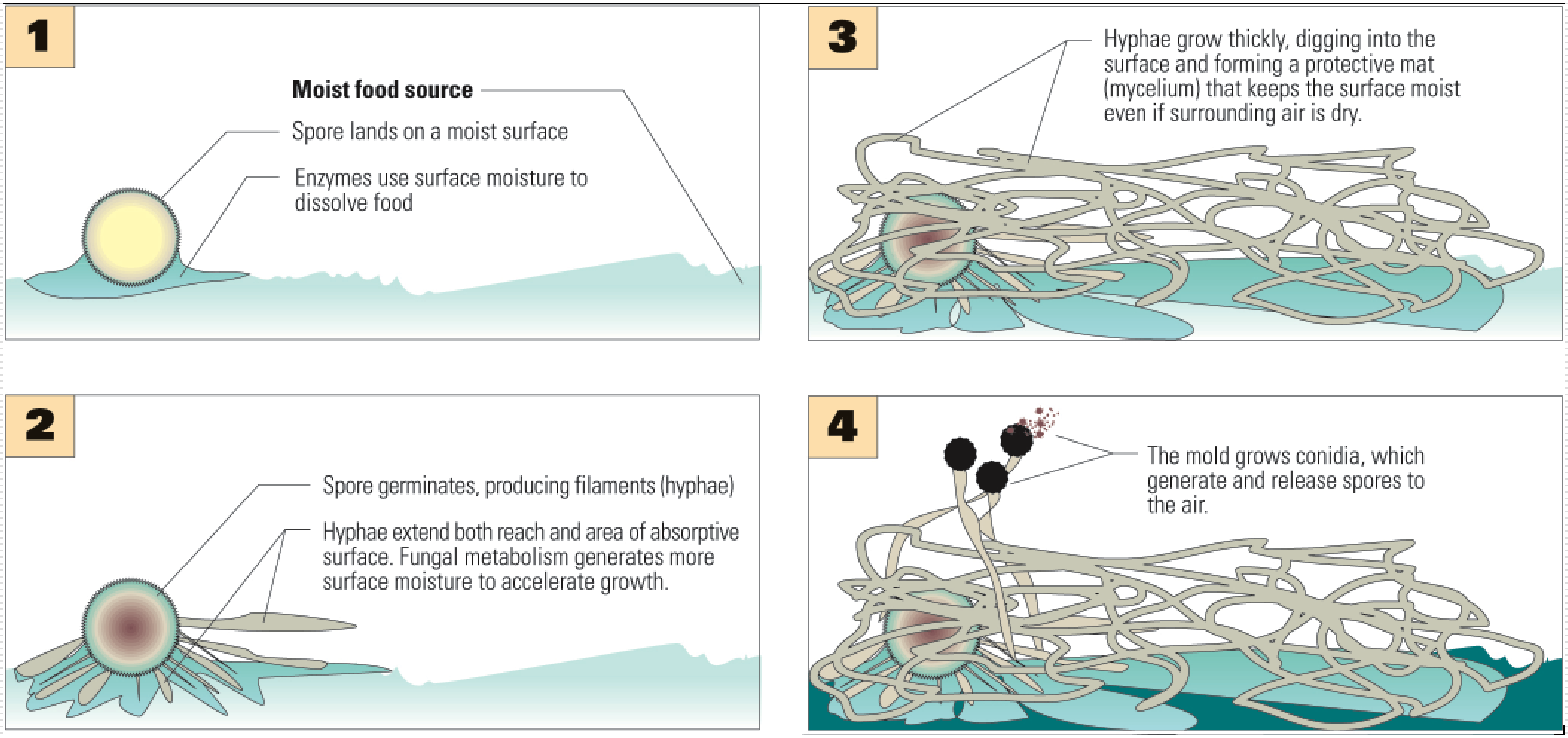
- Health standards are typically set for Occupational work settings, such as TLV's for an 8 hour work day. Reference EPA, OSHA, NIOSH, etc.
- Office vs. Occupational work settings
  - Contaminant source different
  - Extremely low contaminant levels

Comfort

- *Non-IAQ-Related*
  - *Lack of Control over*
    - *Work*
    - *Environment*
  - *Noise*
  - *Lighting*
- *IAQ-Related*
  - *Temperature*
  - *Humidity*
  - *Odors*
  - *Mold*

Mold Growth in Buildings

Mold Growth


1
Moist food source
Spore lands on a moist surface
Enzymes use surface moisture to dissolve food
2
Spore germinates, producing filaments (hyphae)
Hyphae extend both reach and area of absorptive surface. Fungal metabolism generates more surface moisture to accelerate growth.
3
Hyphae grow thickly, digging into the surface and forming a protective mat (mycelium) that keeps the surface moist even if surrounding air is dry.
4
The mold grows conidia, which generate and release spores to the air.

Mold Growth

- Enzymes on mold spore combine with surface moisture to dissolve food source… paper, wood, ceiling tile
- Osmotic pressure causes liquid nutrients to diffuse across spore wall allowing spore to absorb the nutrients
- Spore germinates producing filamentous hyphea
- Hyphea grows quickly creating mycelium mat
- Mold grows conidia which generates and releases spores into the air

mVOCs

- Product of metabolism
  - *Substrate*
  - *Environmental conditions*
- Changes with growth cycle
- Odorous
- Small concentration when compared to total building VOC load

Mycotoxins

- Secondary metabolites
- Particle association
  - *Spores*
  - *Mycelial fragments*
  - *Substrate*
- Concurrent production of multiple toxins
- Competition inhibition

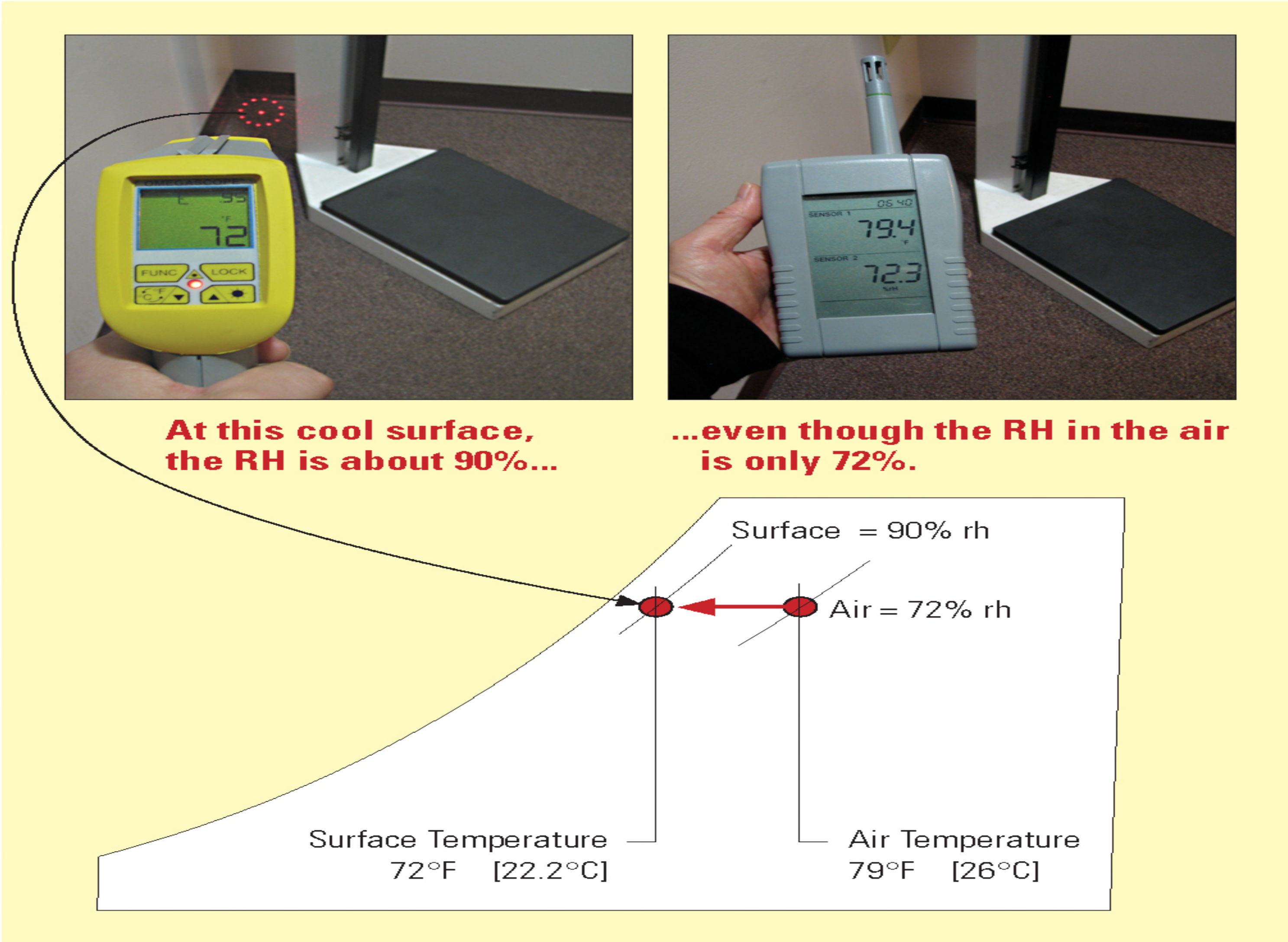
Production of Mycotoxins

- Fungal Species
- Strain dependent
- Environmental conditions
  - *Substrate*
  - *Temperature*
- Concurrent production of several toxins
- Growth does not signify presence

Water Activity

- Water activity indicates how much water is biologically available to fungus in its food source.
- Water activity of 0.8 refers to the amount of water absorbed into a material when the surrounding air is at 80% RH
- Water activity of a material is very different from the relative humidity of the material
- Mold growth is a risk when surface relative humidity stays above 85% for extended periods

Moisture Content and Surface Relative Humidity



Uncontrolled air flow

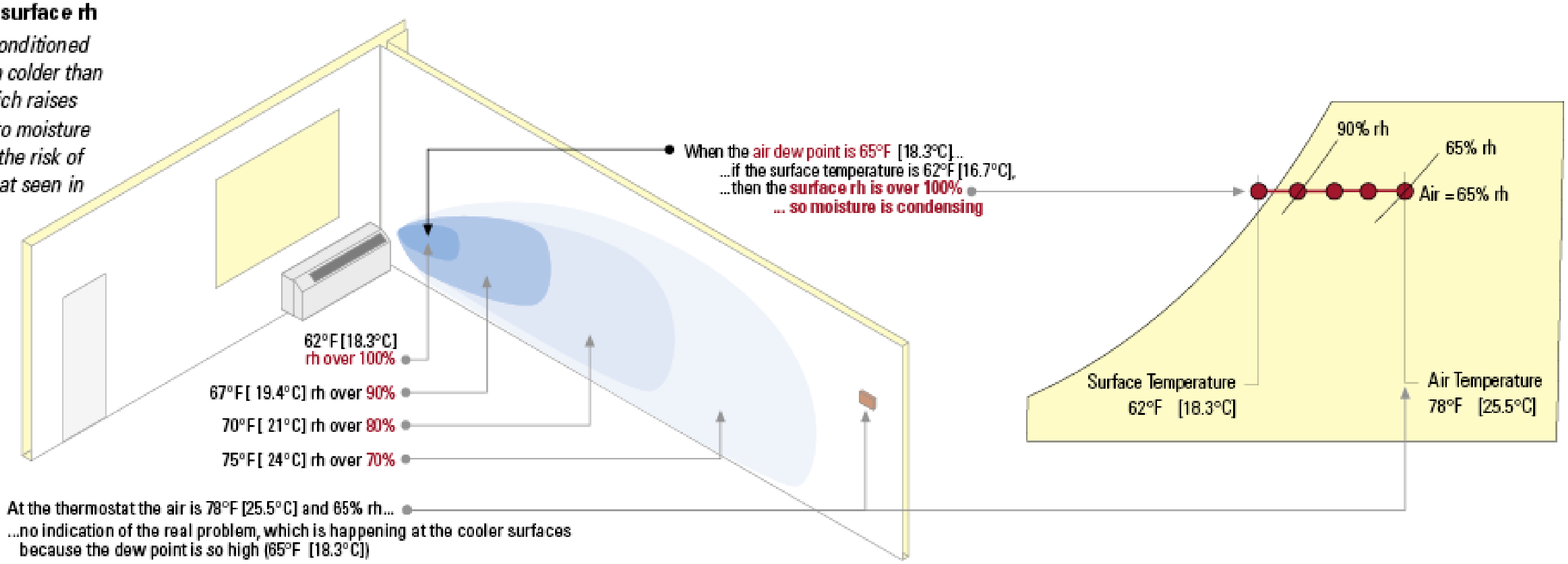
- Buildings which have never reported relative humidity above 65% still may have mold growth

Mold - It's the surface rh that counts.. So keep the dew point down, and things go well

Fig. 5.5

Cold surfaces = high surface rh

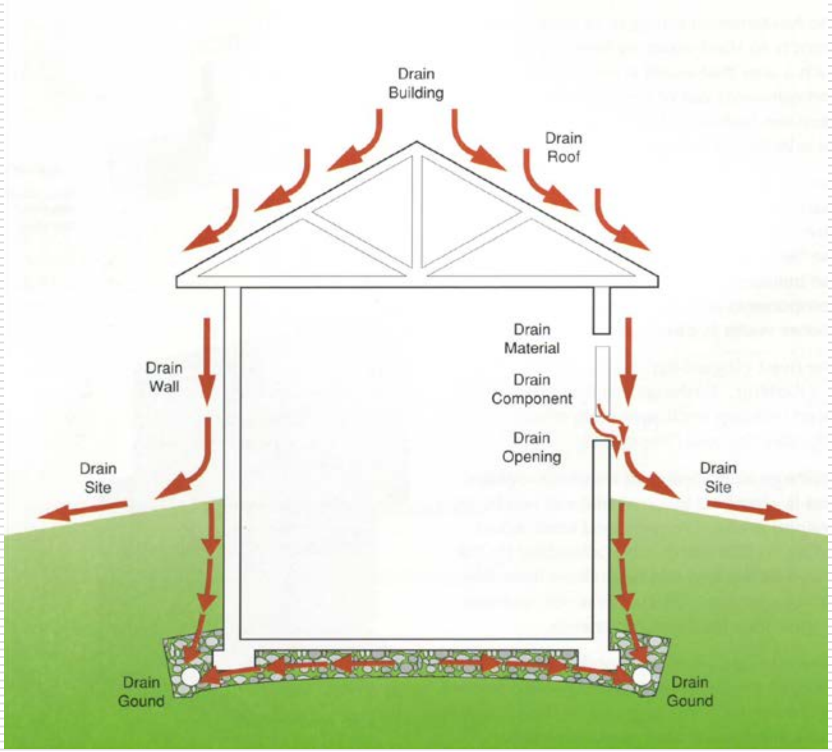
The surfaces in an air conditioned building are often much colder than the surrounding air, which raises the local rh, and leads to moisture absorption and then to the risk of mold growth such as that seen in figure 5.6.



Building Envelopes

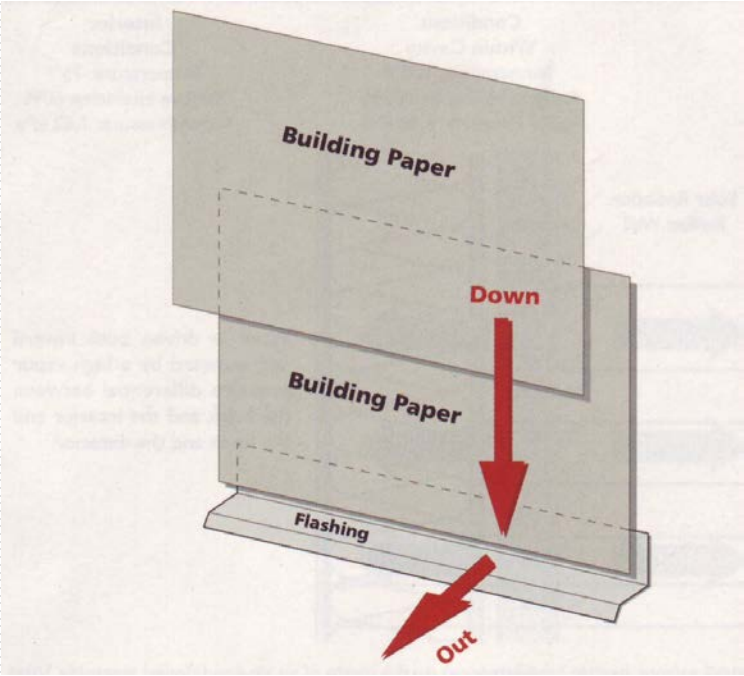
Drainage

- Drainage plane
- Drains water away from building
- Drainage is the key to water management



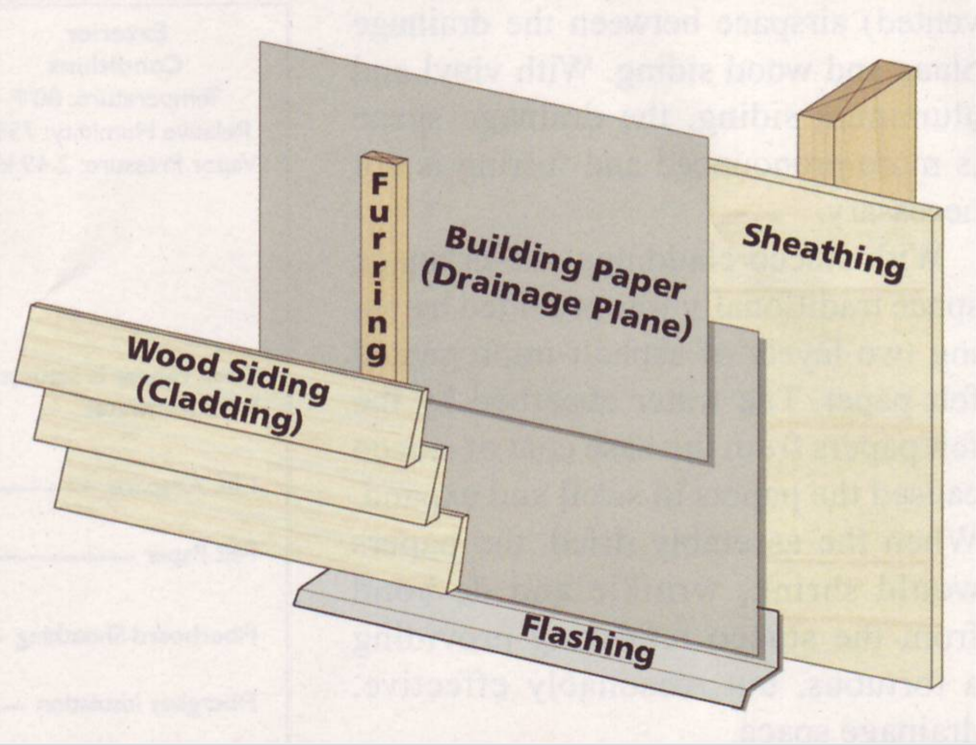
Application

- Install drainage plane so that water is not trapped
- Overlap building in “ship lap” fashion
- Drain water to flashing which directs water away from building



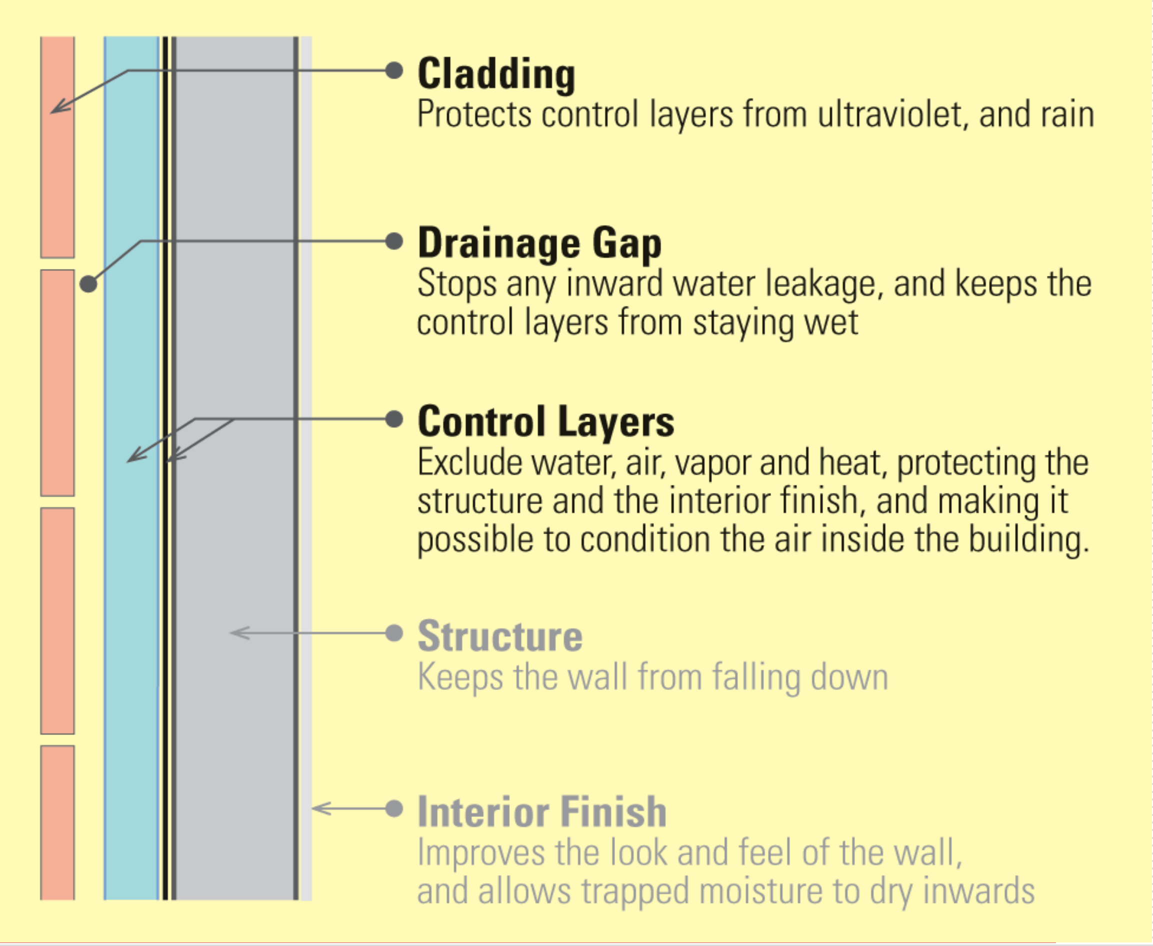
Application

- Provide air space between finish (cladding, stucco, etc) and drainage to drain water

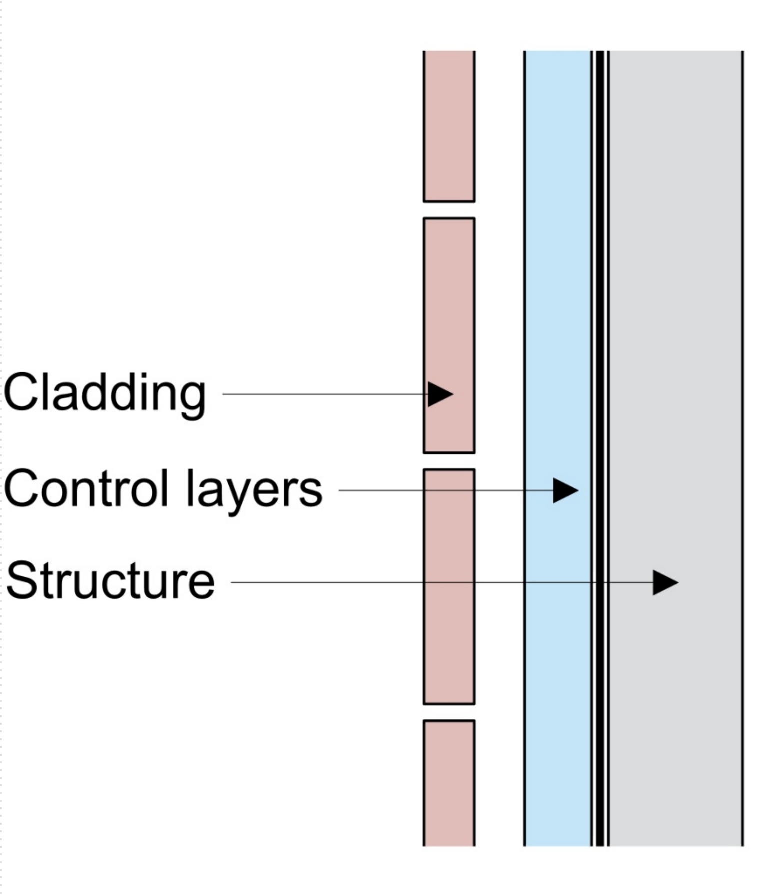


Application
The Perfect Wall

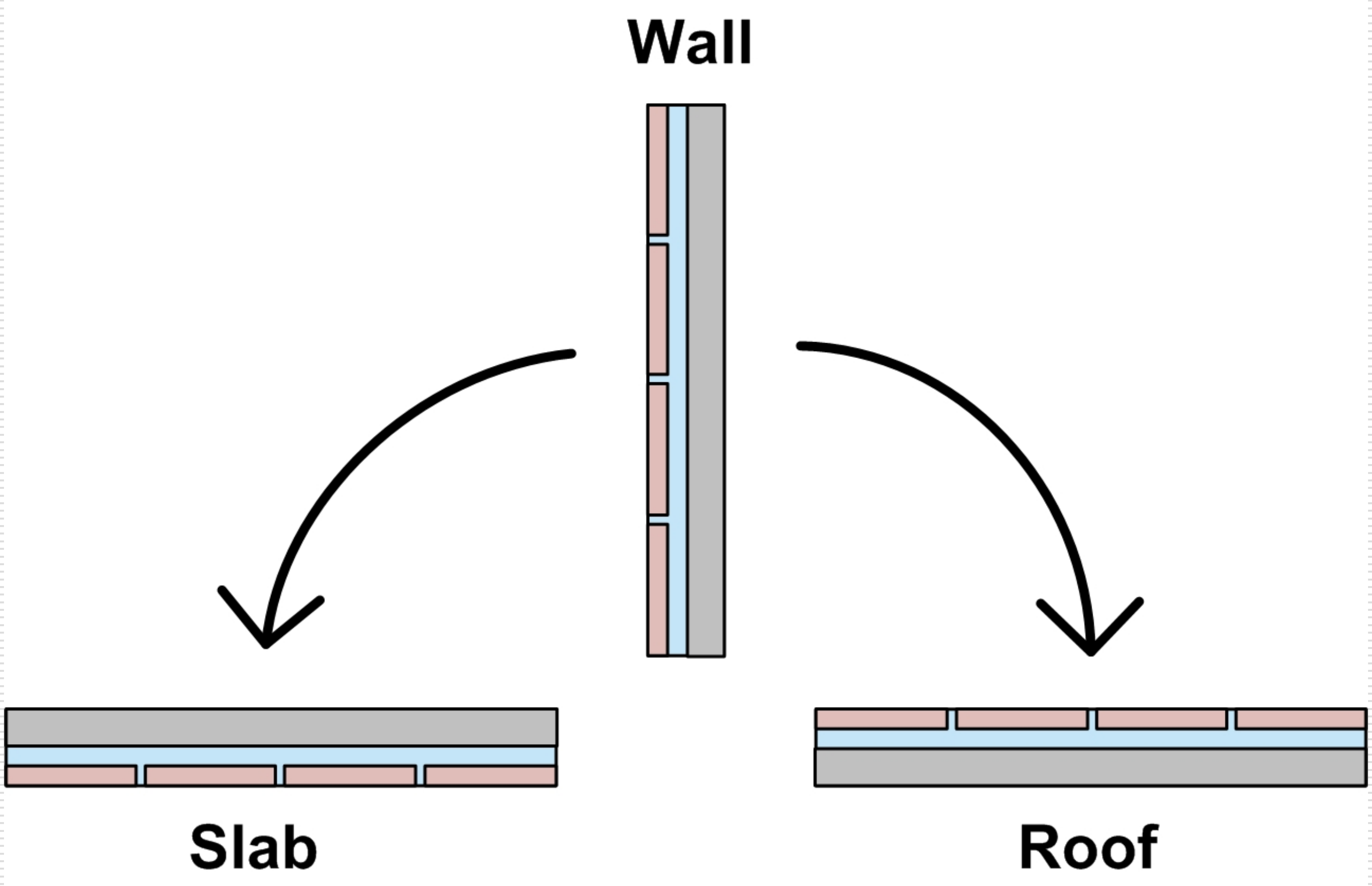
In concept, the perfect wall has the rainwater control layer, the air control layer and the vapor control layer all under the cladding, but all directly on the exterior of the structure. The cladding's functions include shedding rain, but it's principal purpose is to protect the control layers from ultraviolet radiation.



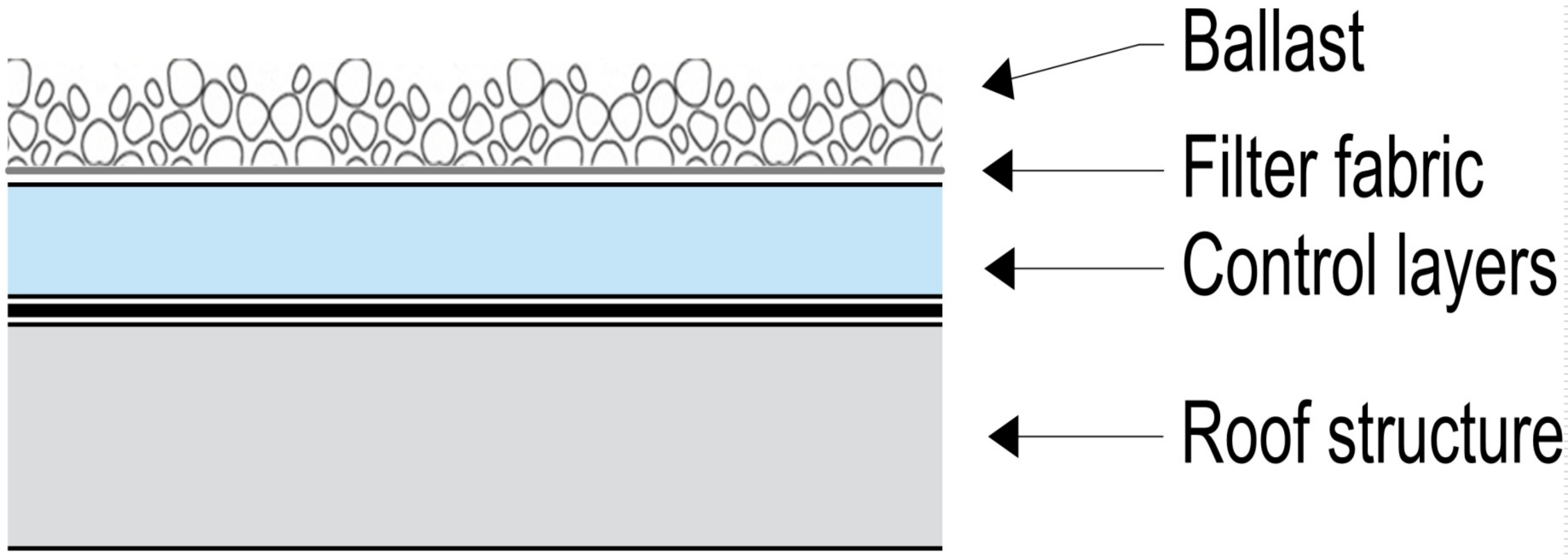
The Perfect Wall



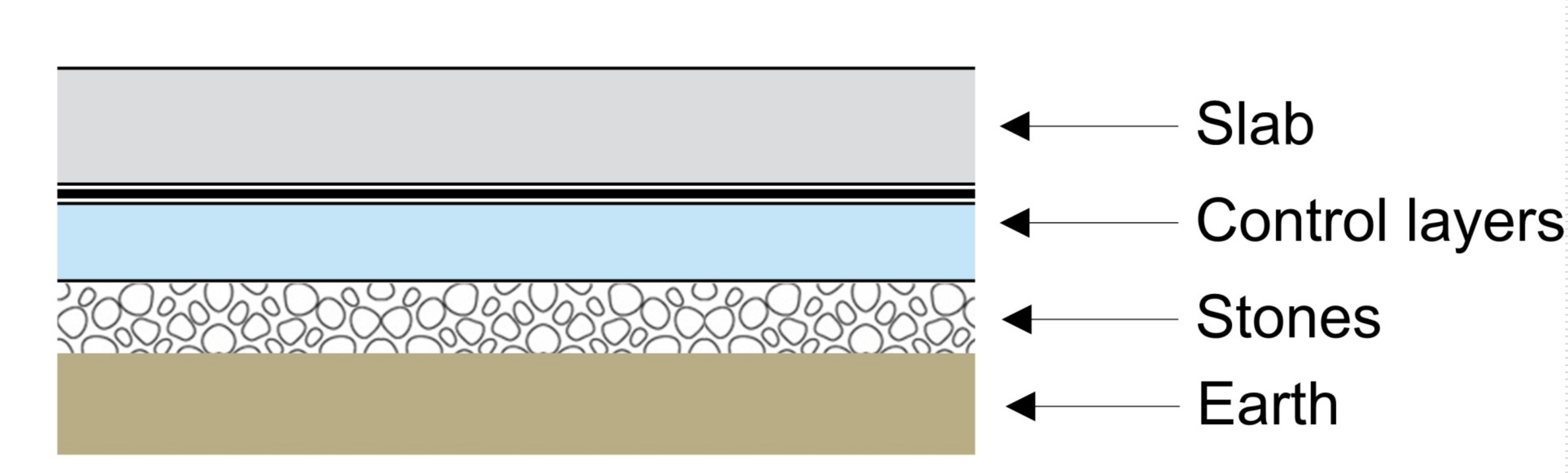
Perfect Wall – Slab - Roof



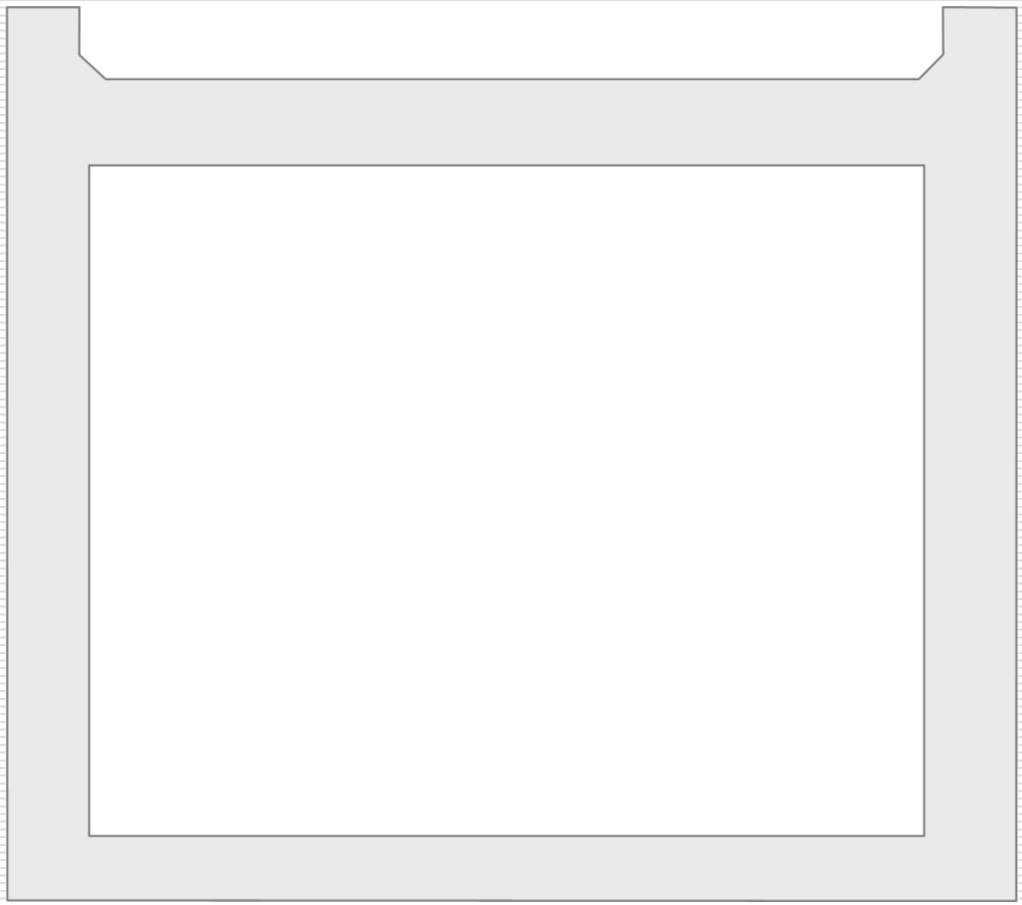
The Perfect Roof



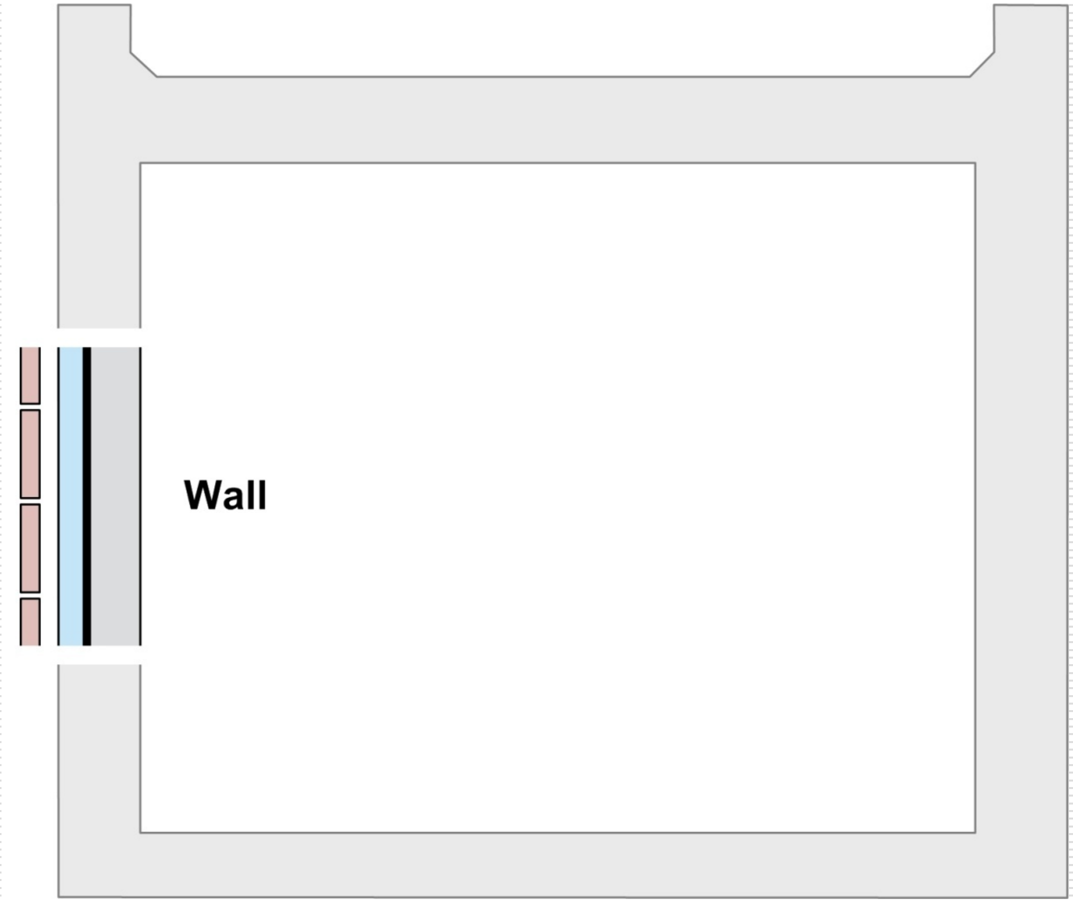
The Perfect Slab



The Perfect Building



The Perfect Building



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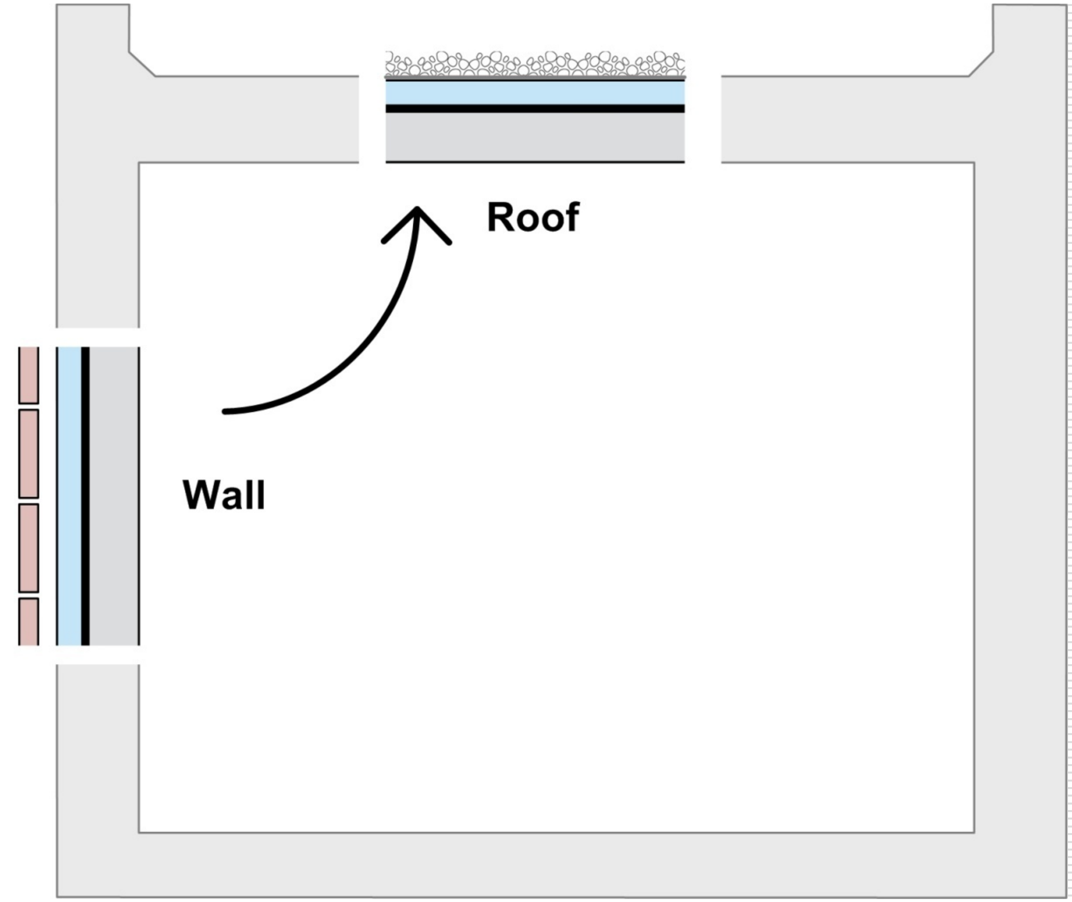
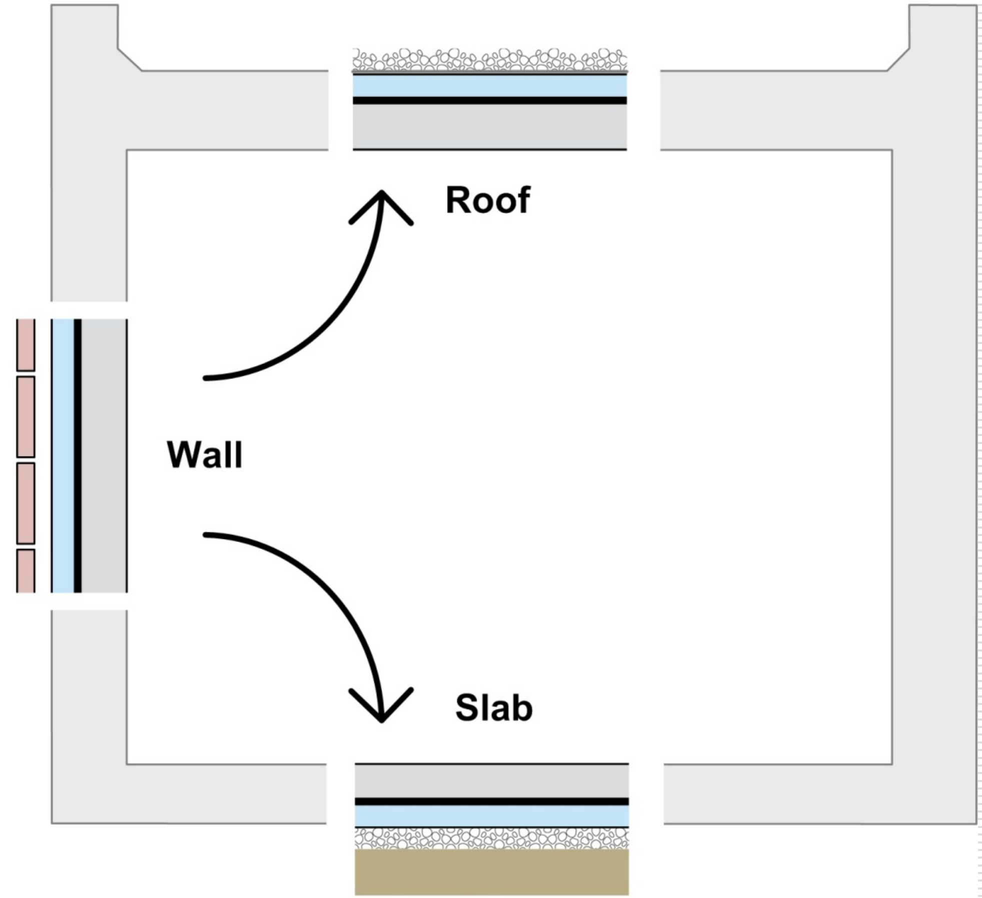
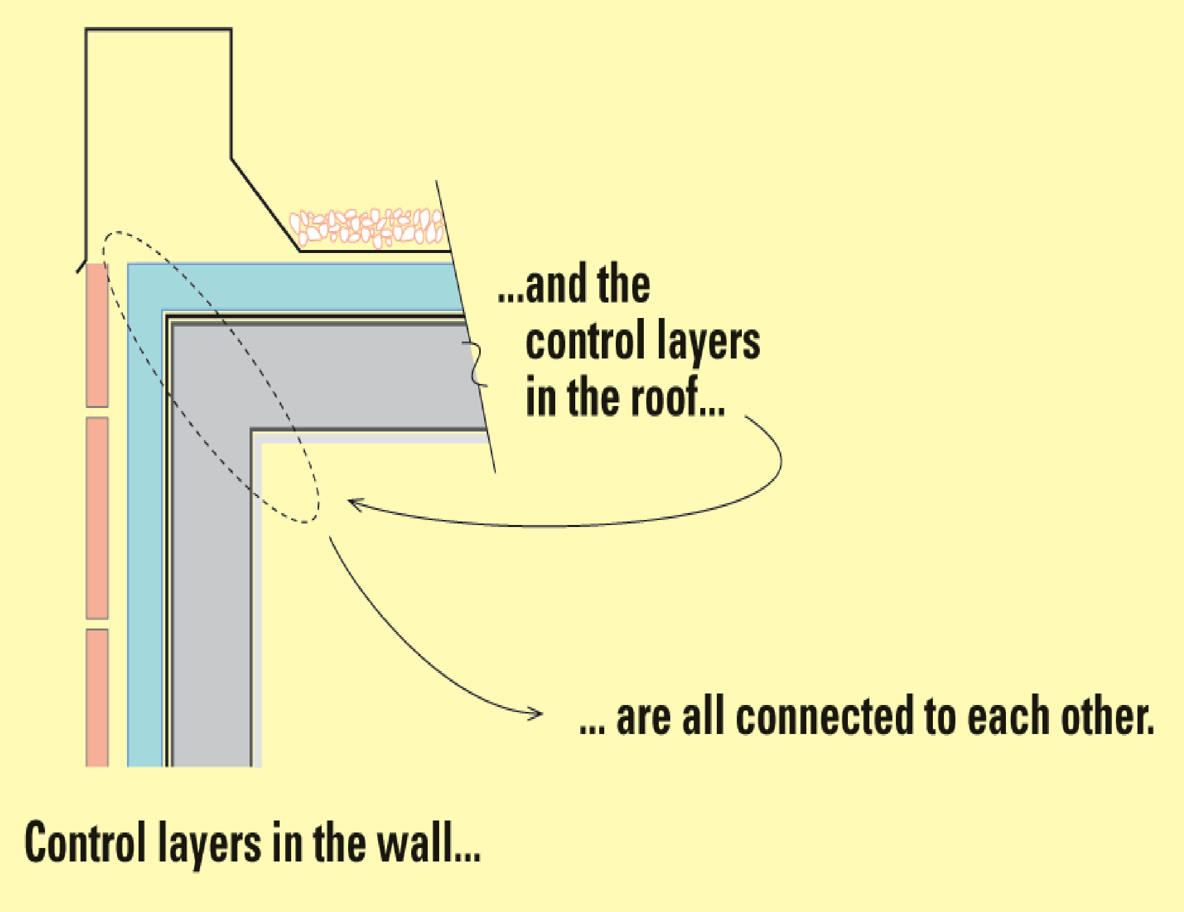


The Perfect Building

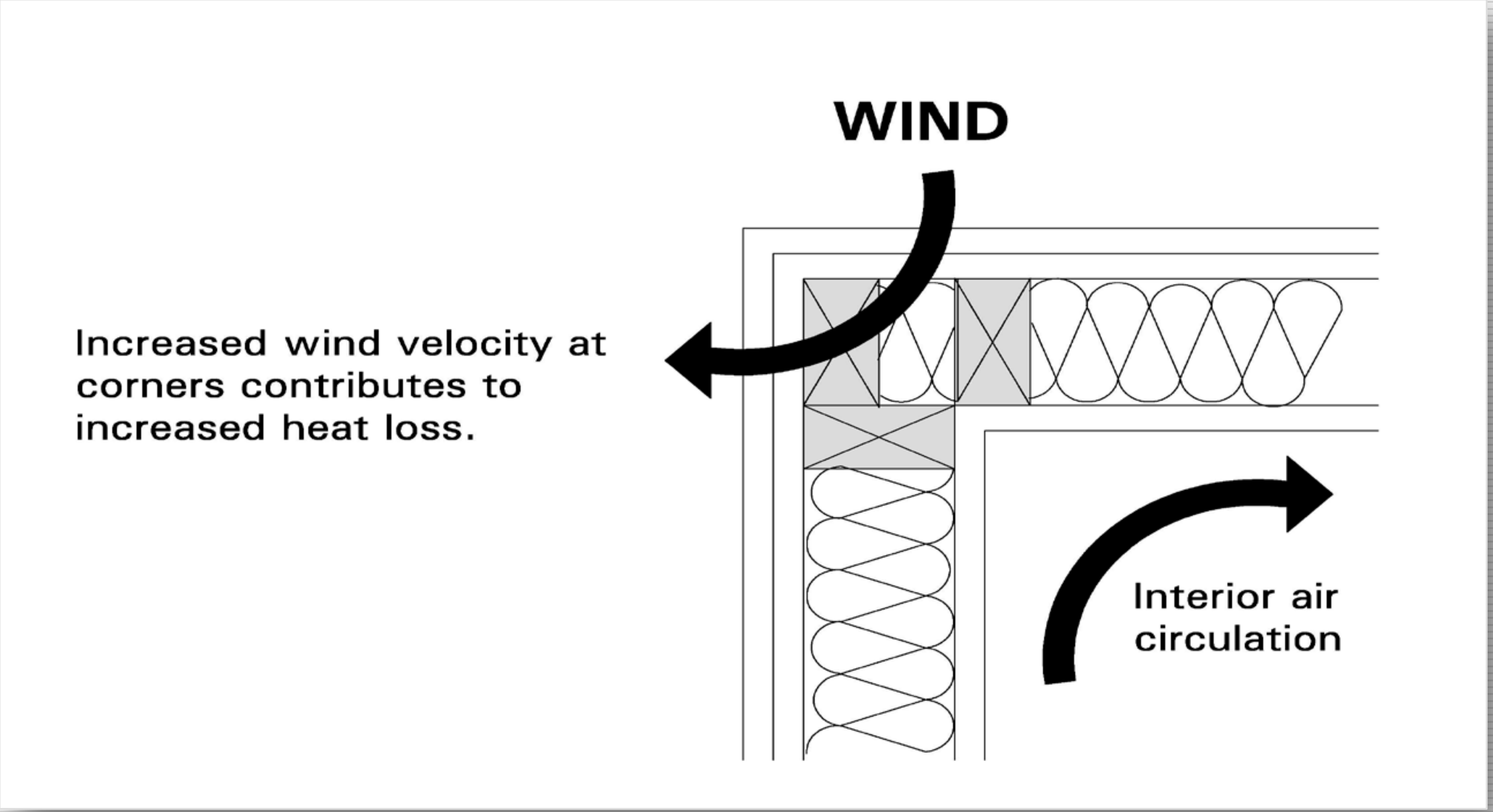


Application – Roof Wall Connection

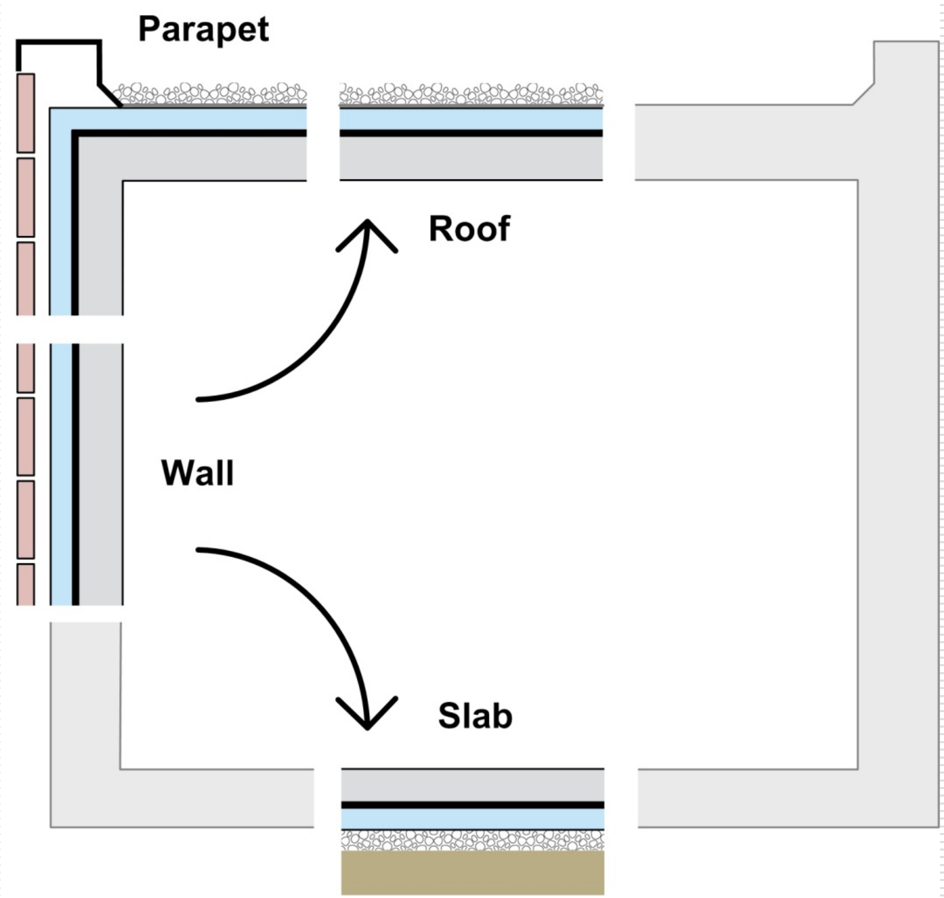
Notice the control layer for rain on the roof is connected to the control layer for rain on the walls. And the control layer for air is connected to the control layer for air on the wall, and so on.



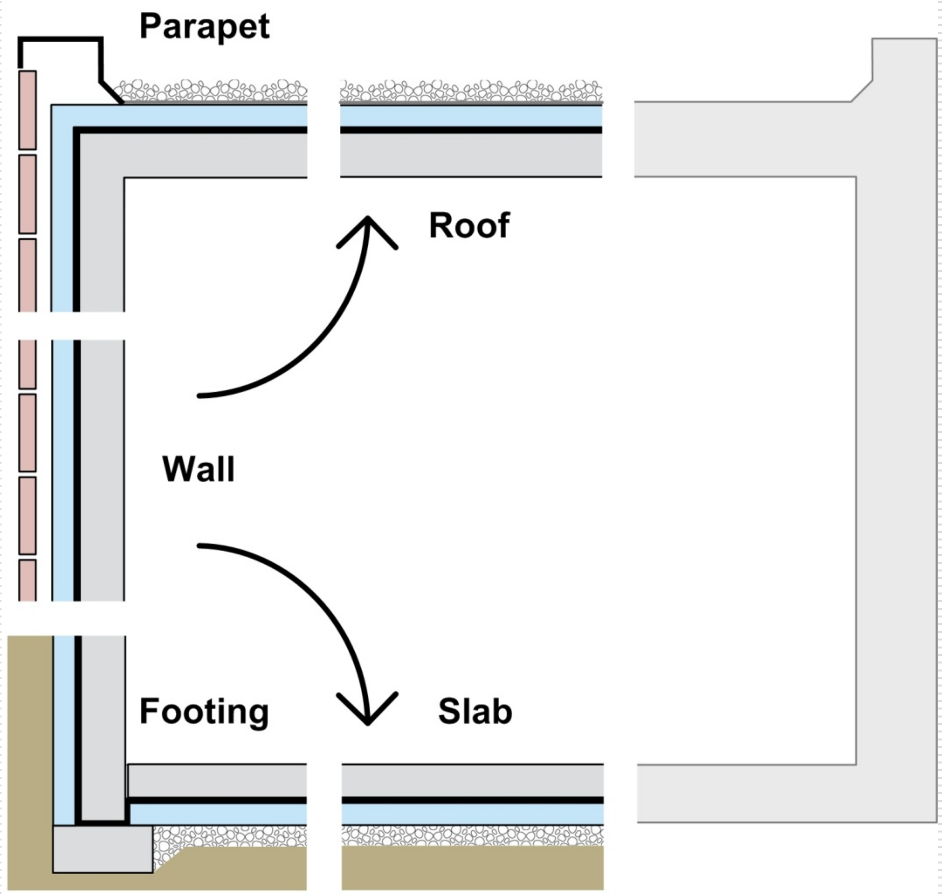
Heat & Moisture Gain Effects at Building Corners



The Perfect Building

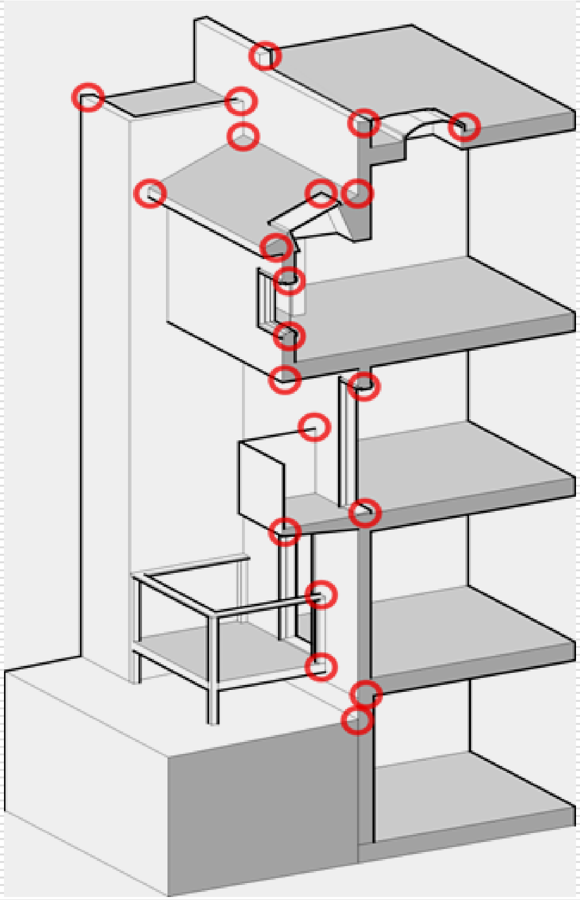


The Perfect Building



Enclosure Design: Details

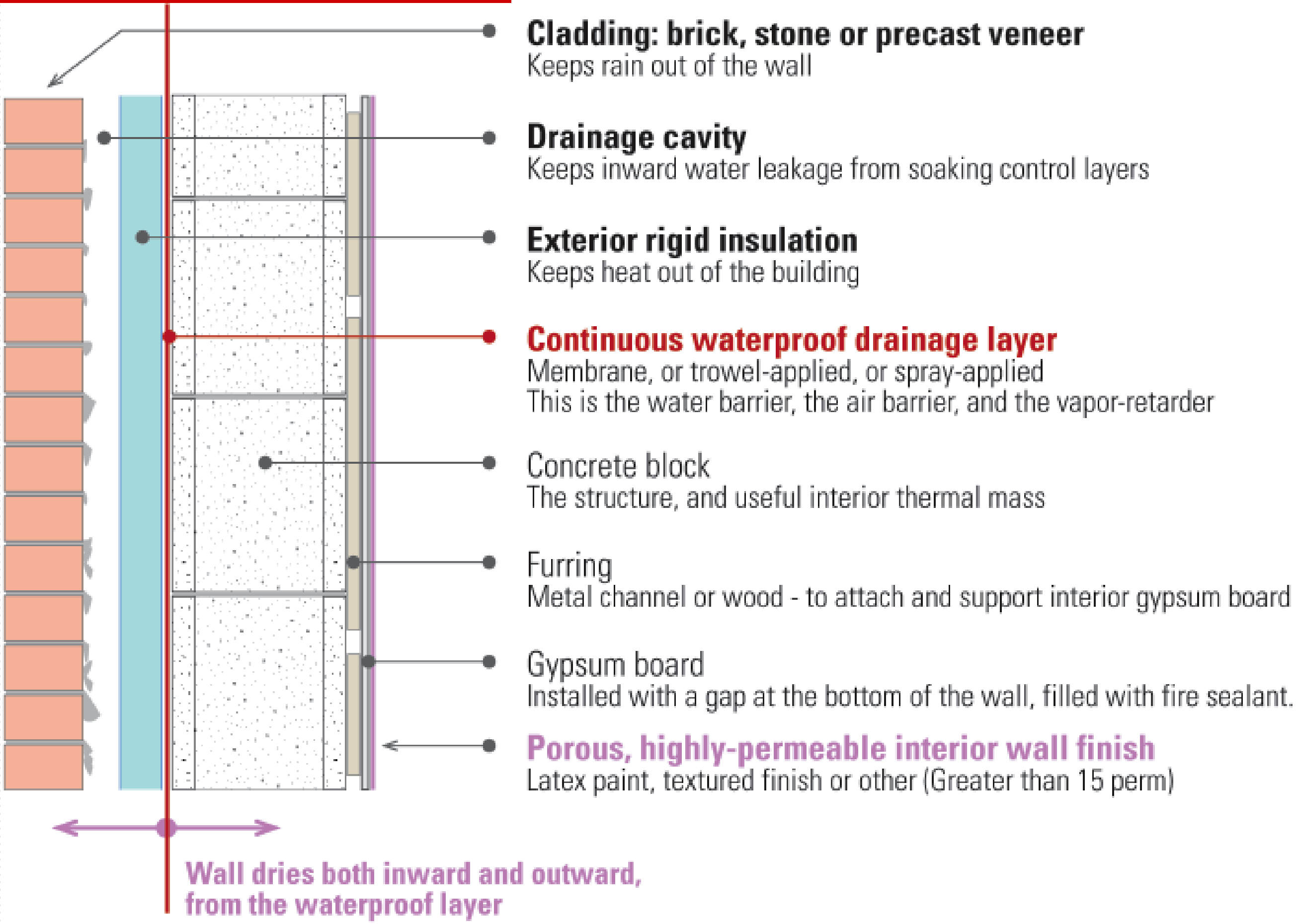
- Details demand the same approach as the enclosure.
- Scaled drawings required at each circle

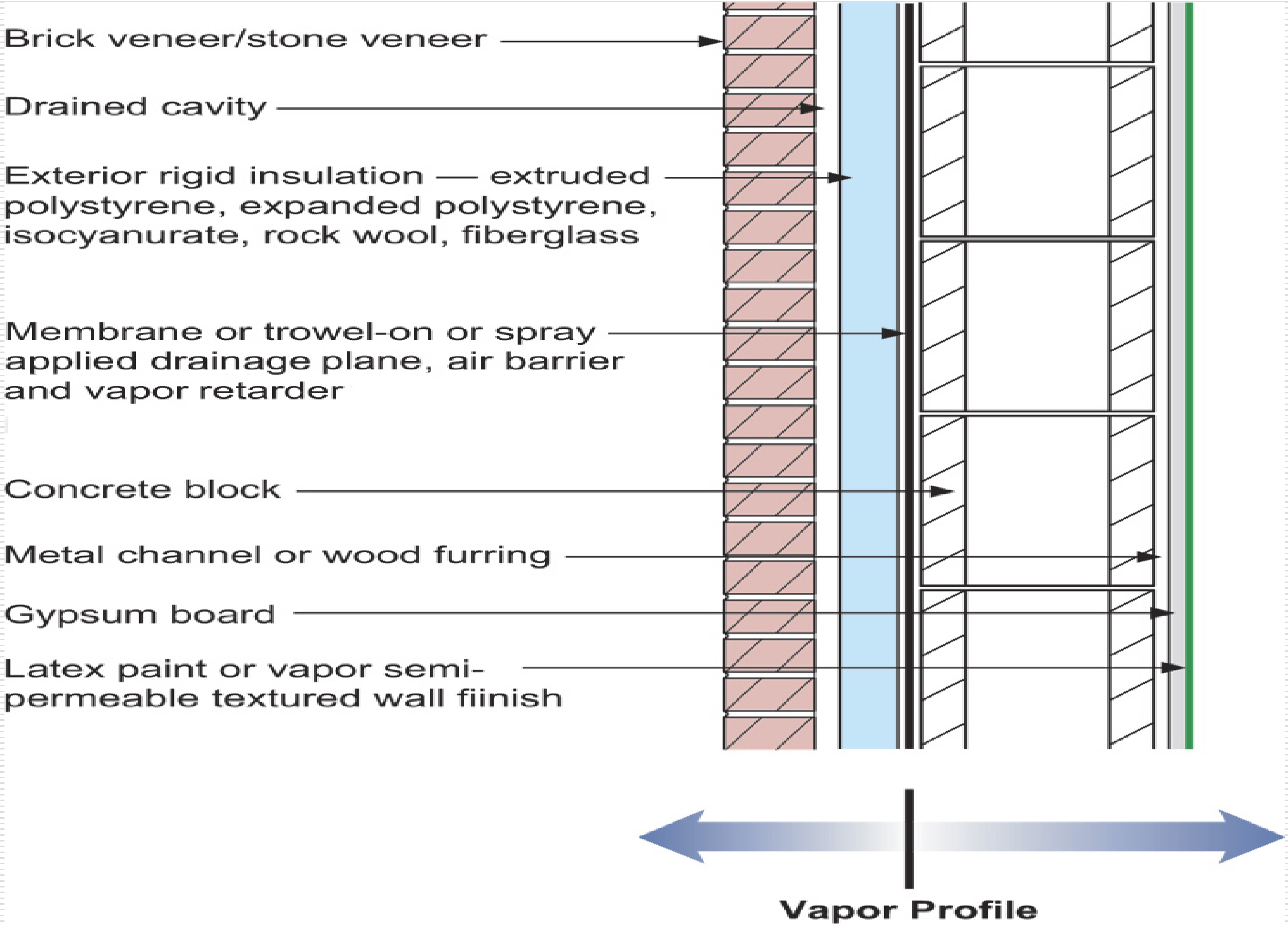


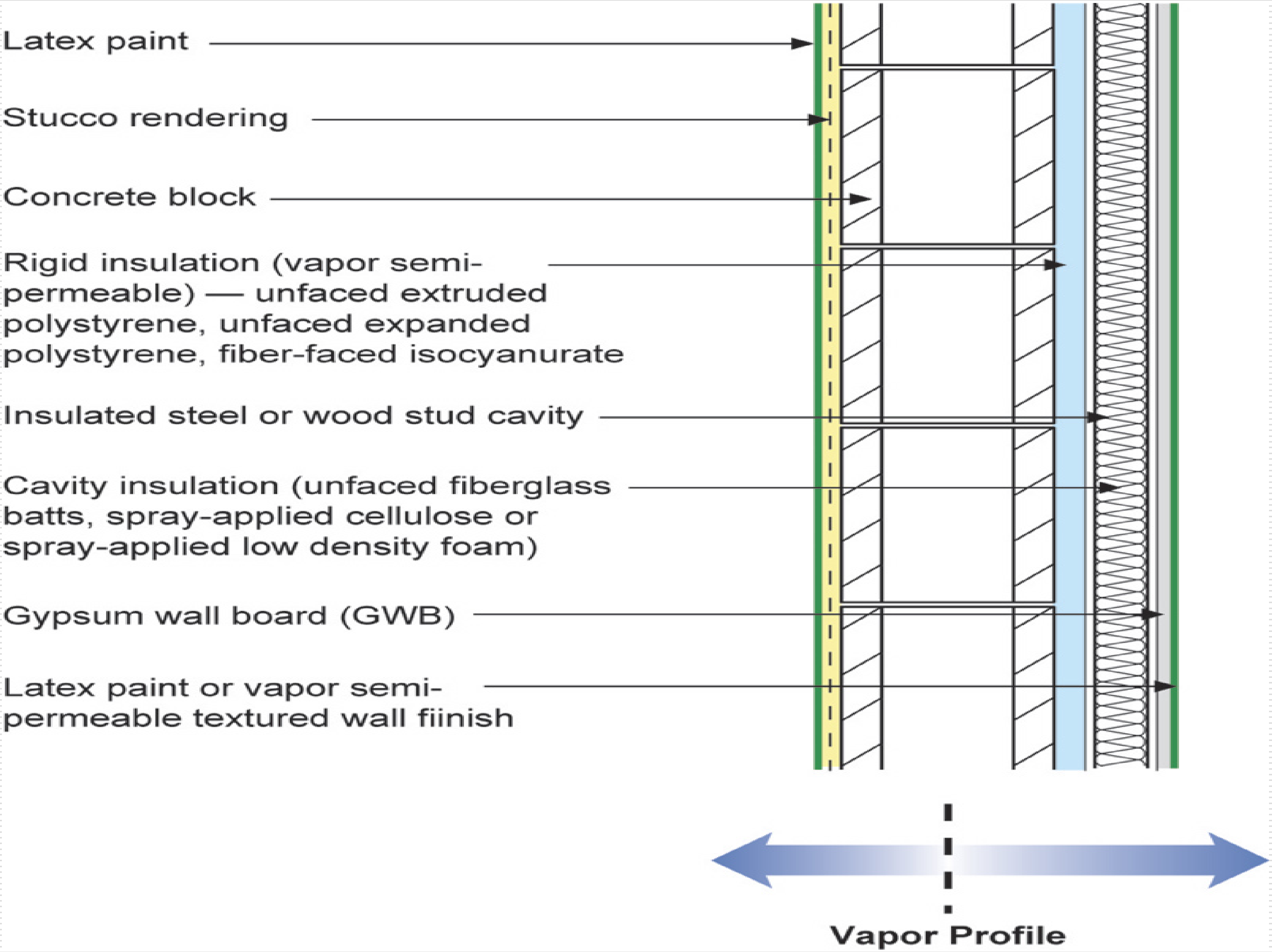
Envelope Applications

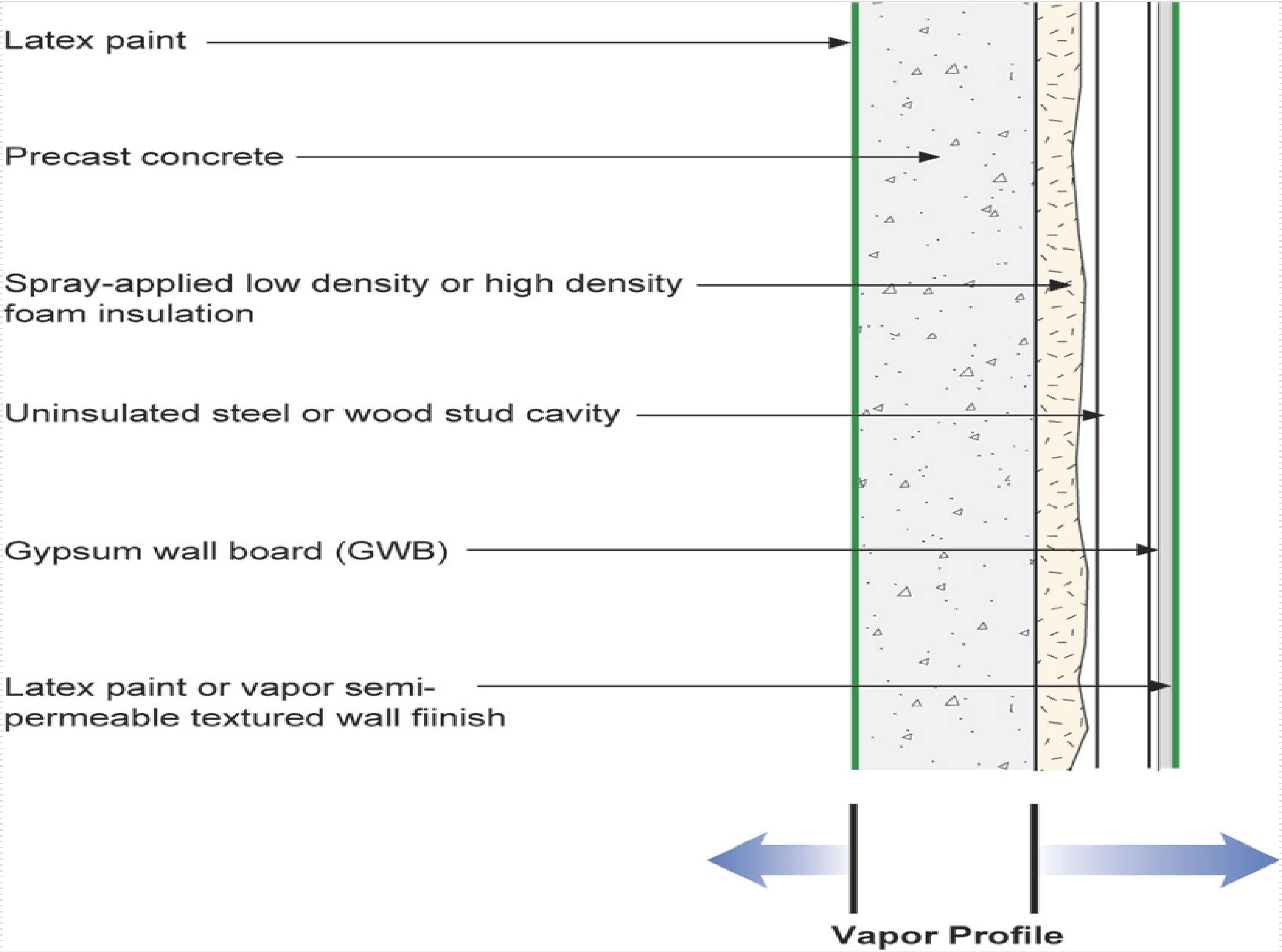
Application Institutional Wall

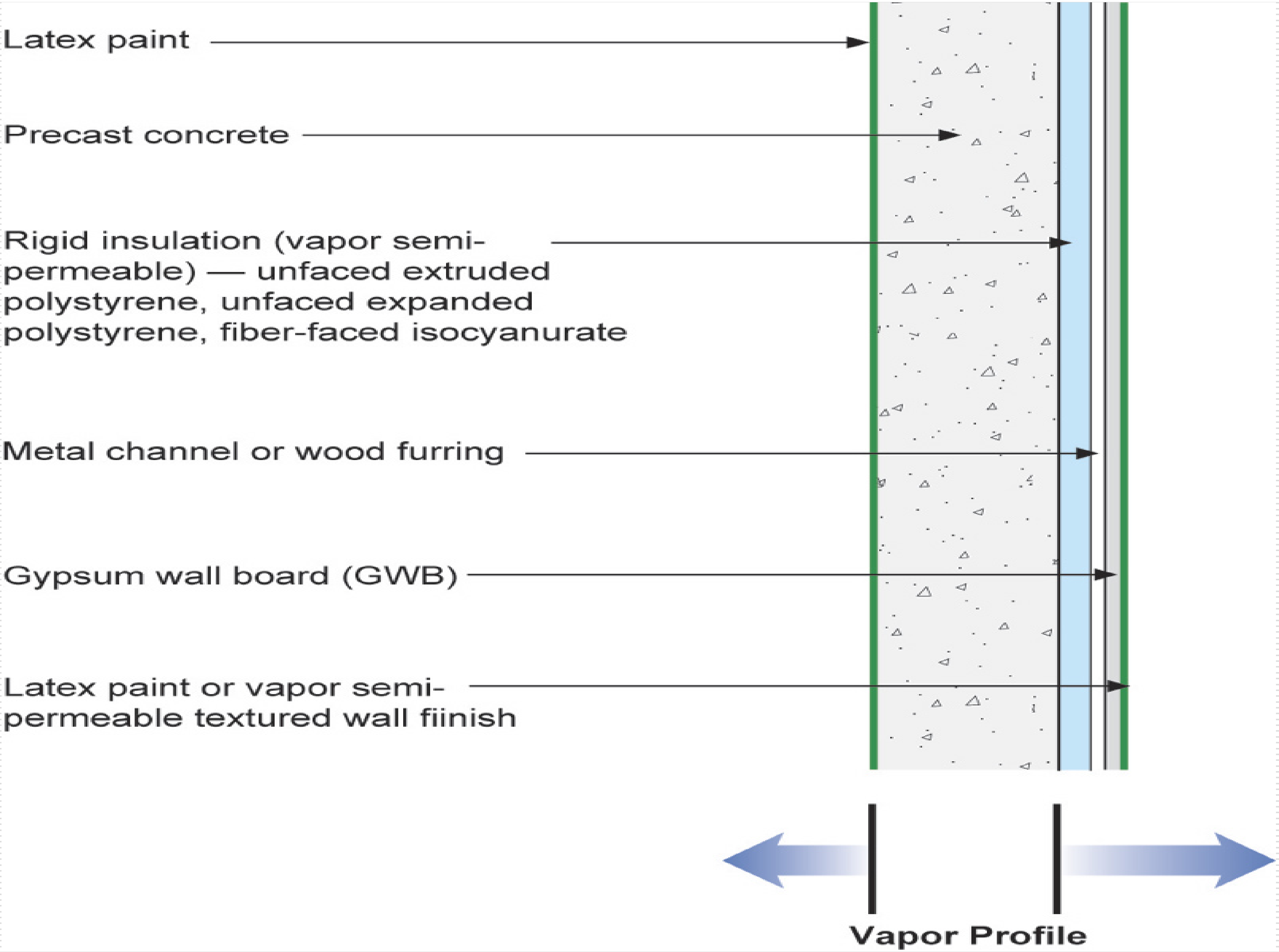
The best wall we build today. It works everywhere, in every climate zone. It costs more, but then, it's sustainable. It will pass from generation to generation.

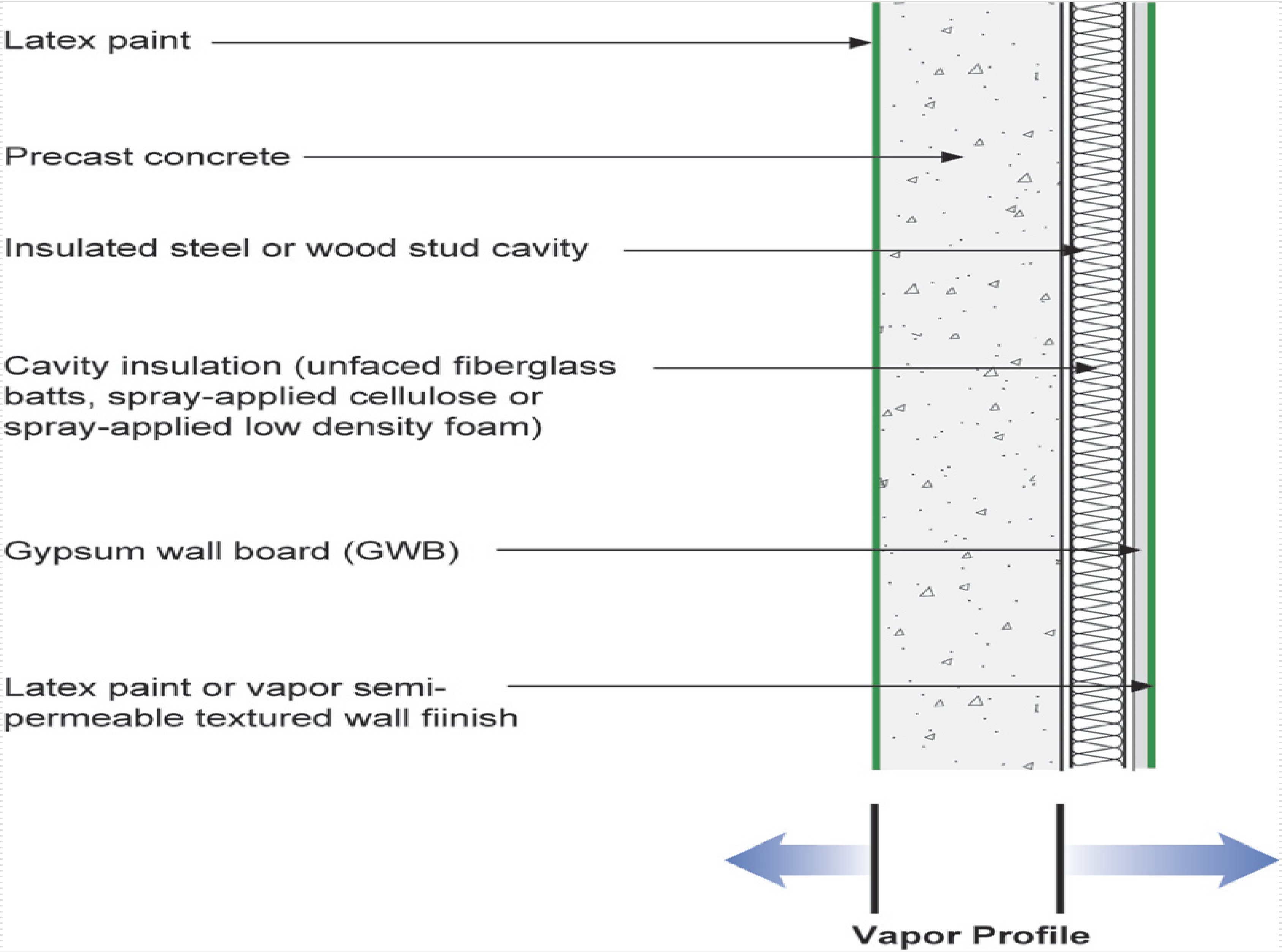



Brick veneer/stone veneer
Drained cavity
Exterior rigid insulation — extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass
Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder
Concrete block
Metal channel or wood furring
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile


Latex paint
Stucco rendering
Concrete block
Rigid insulation (vapor semi-permeable) — unfaced extruded polystyrene, unfaced expanded polystyrene, fiber-faced isocyanurate
Insulated steel or wood stud cavity
Cavity insulation (unfaced fiberglass batts, spray-applied cellulose or spray-applied low density foam)
Gypsum wall board (GWB)
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile

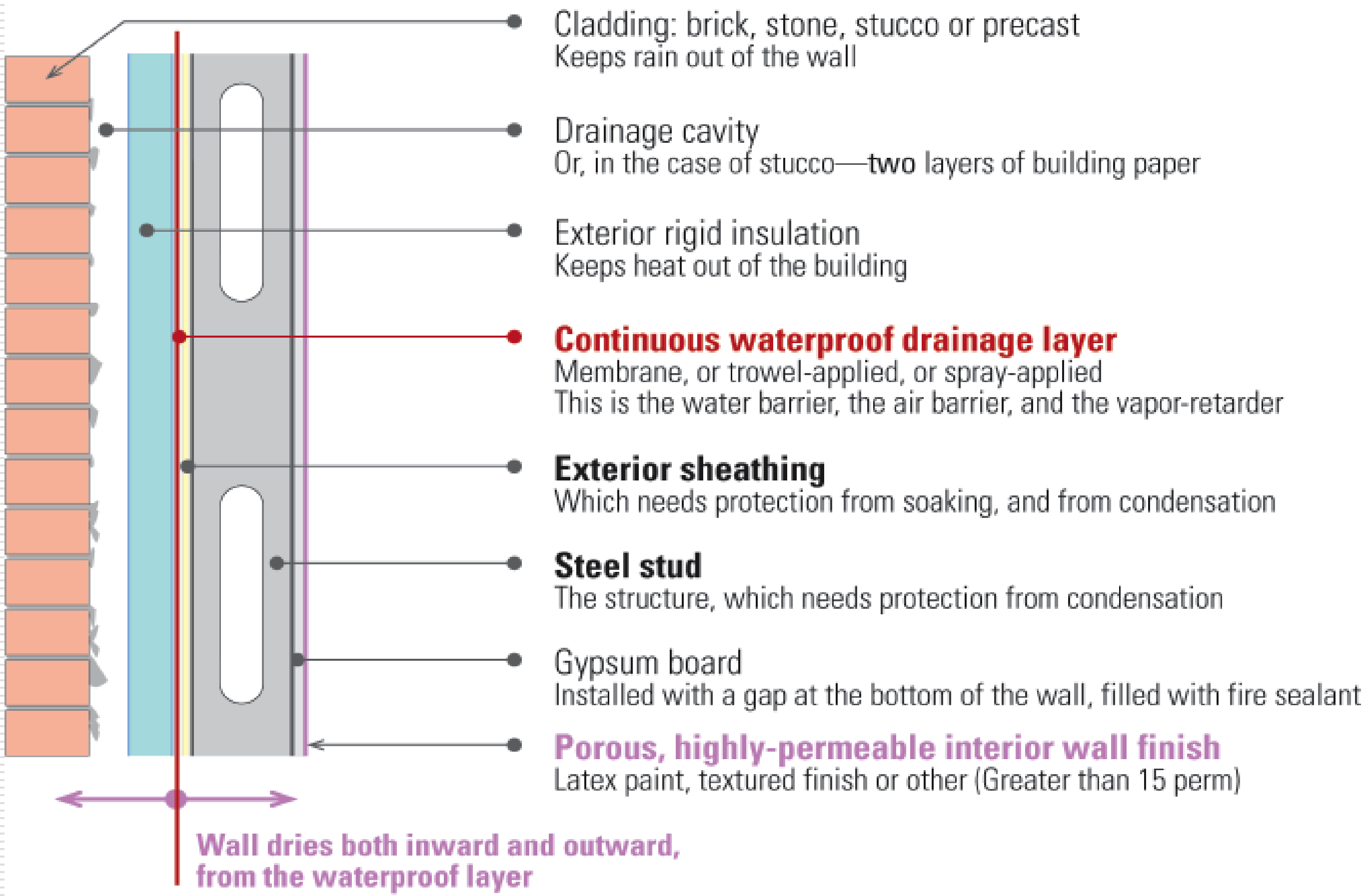

Latex paint
Precast concrete
Spray-applied low density or high density foam insulation
Uninsulated steel or wood stud cavity
Gypsum wall board (GWB)
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile

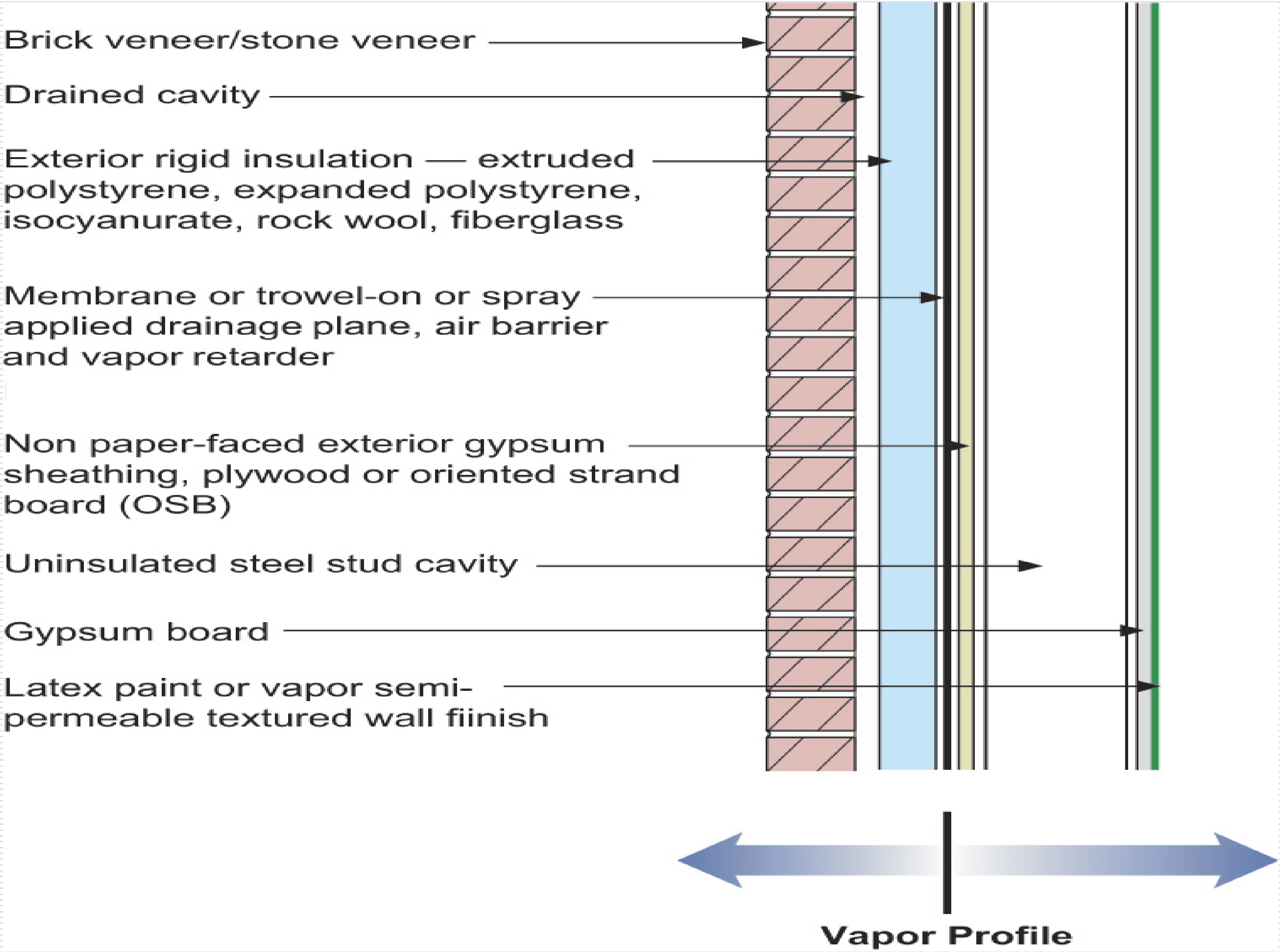

Latex paint
Precast concrete
Rigid insulation (vapor semi-permeable) — unfaced extruded polystyrene, unfaced expanded polystyrene, fiber-faced isocyanurate
Metal channel or wood furring
Gypsum wall board (GWB)
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile


Latex paint
Precast concrete
Insulated steel or wood stud cavity
Cavity insulation (unfaced fiberglass batts, spray-applied cellulose or spray-applied low density foam)
Gypsum wall board (GWB)
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile

Application Commercial Wall

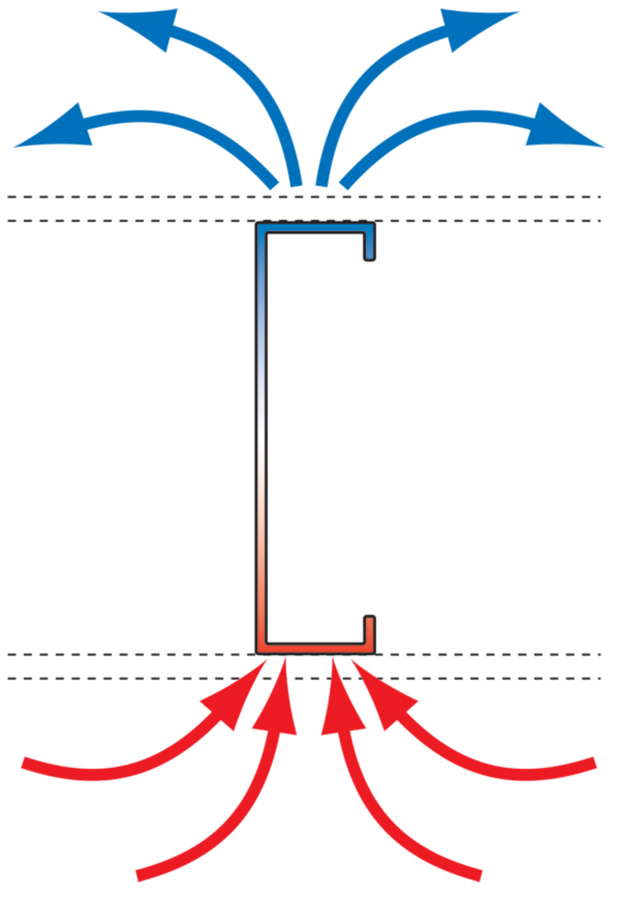
The almost-best wall we construct today. It's affordable. Actually, it's the cheapest wall that works, and it works in any climate zone.




Brick veneer/stone veneer
Drained cavity
Exterior rigid insulation — extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass
Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder
Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)
Uninsulated steel stud cavity
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile

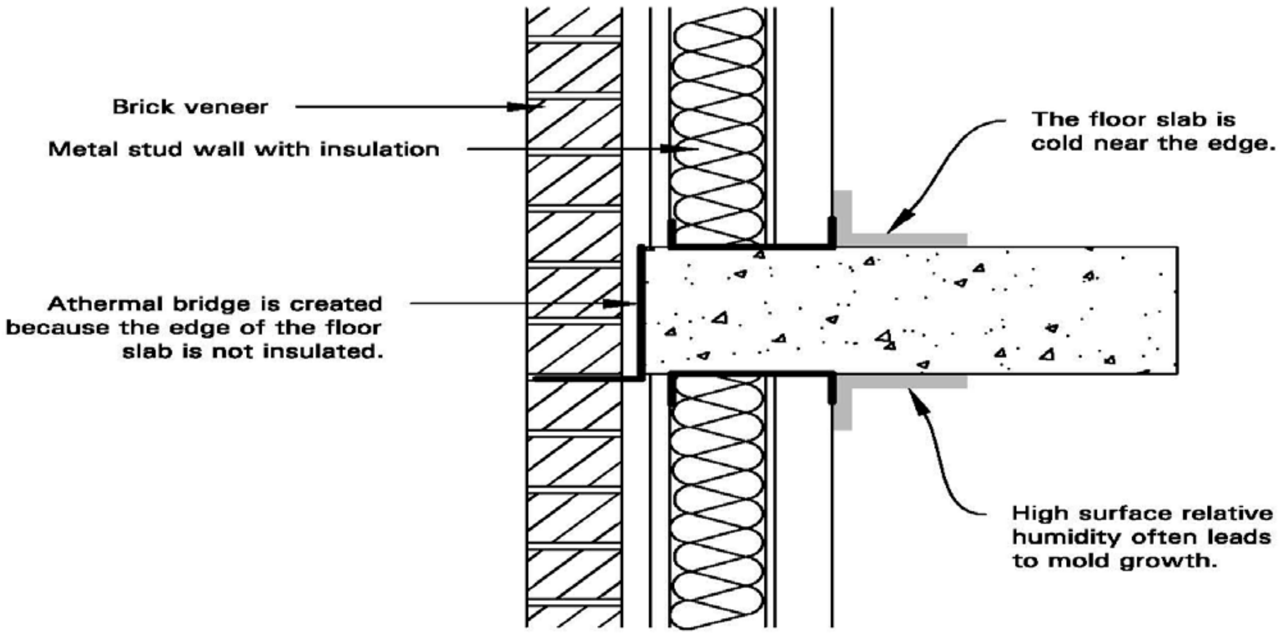
Thermal Bridging

Thermal Bridge



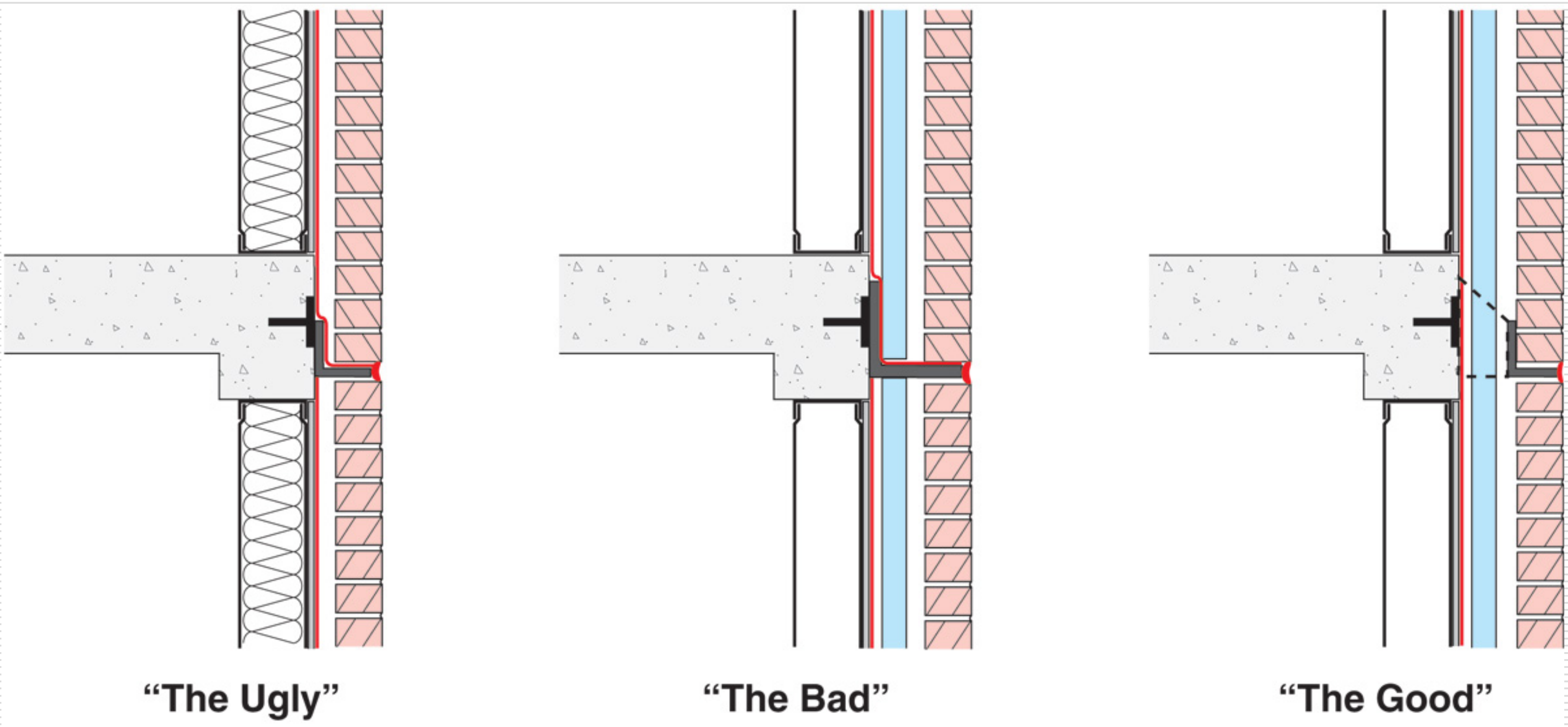
Thermal Bridge in Wall

Thermal Bridge at Wall / Floor Intersection

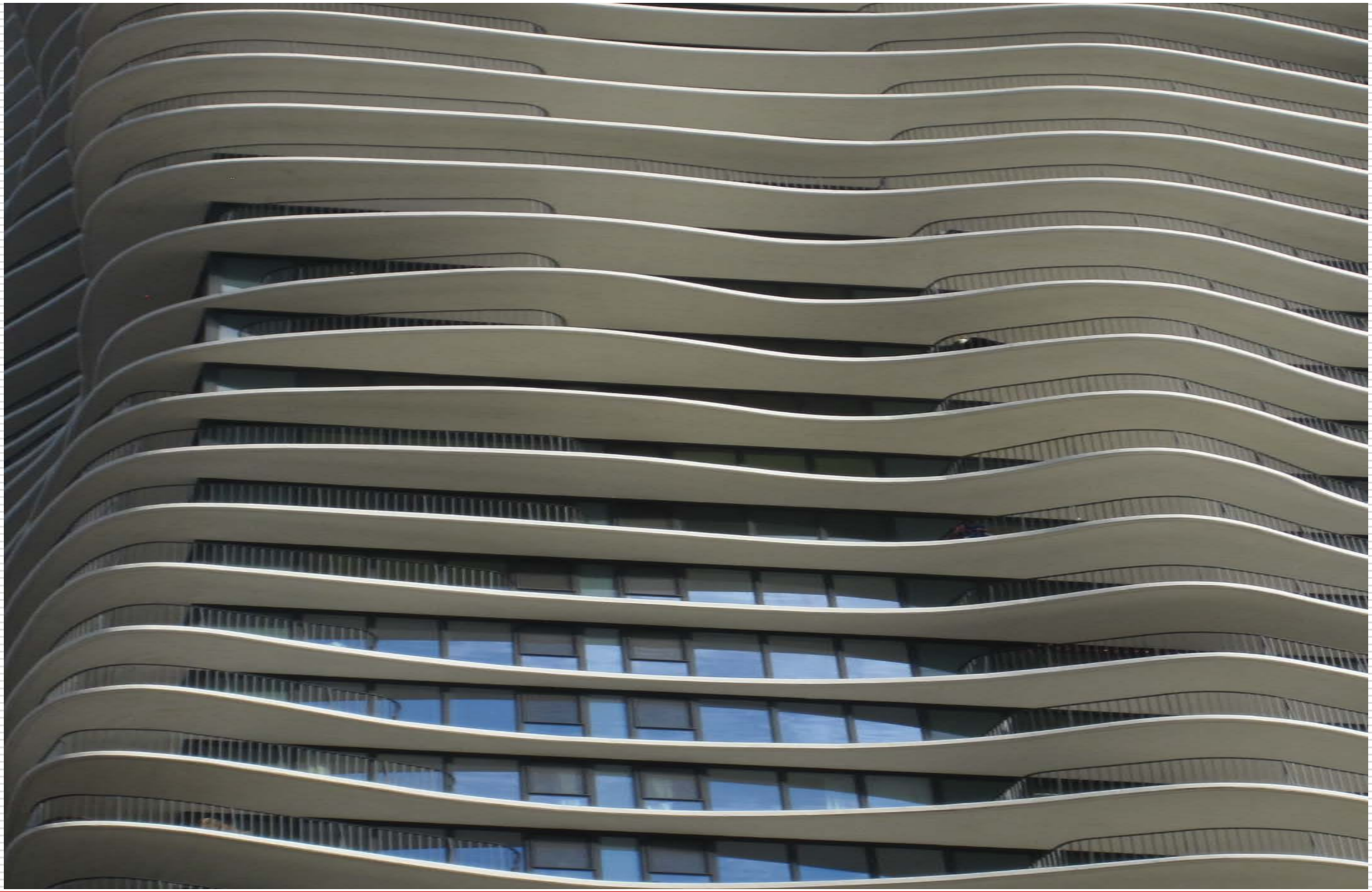


Thermal bridge at wall/floor intersection.

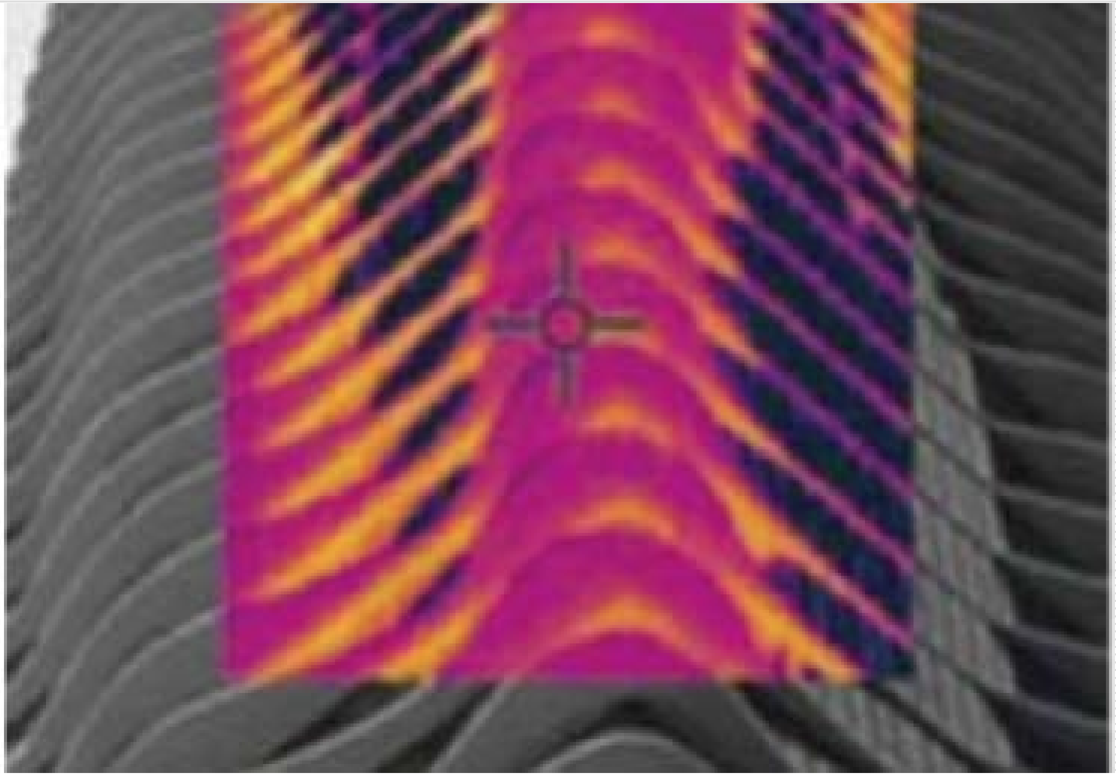
Thermal Bridge at Wall / Floor Intersection



Thermal Bridge



Thermal Bridge

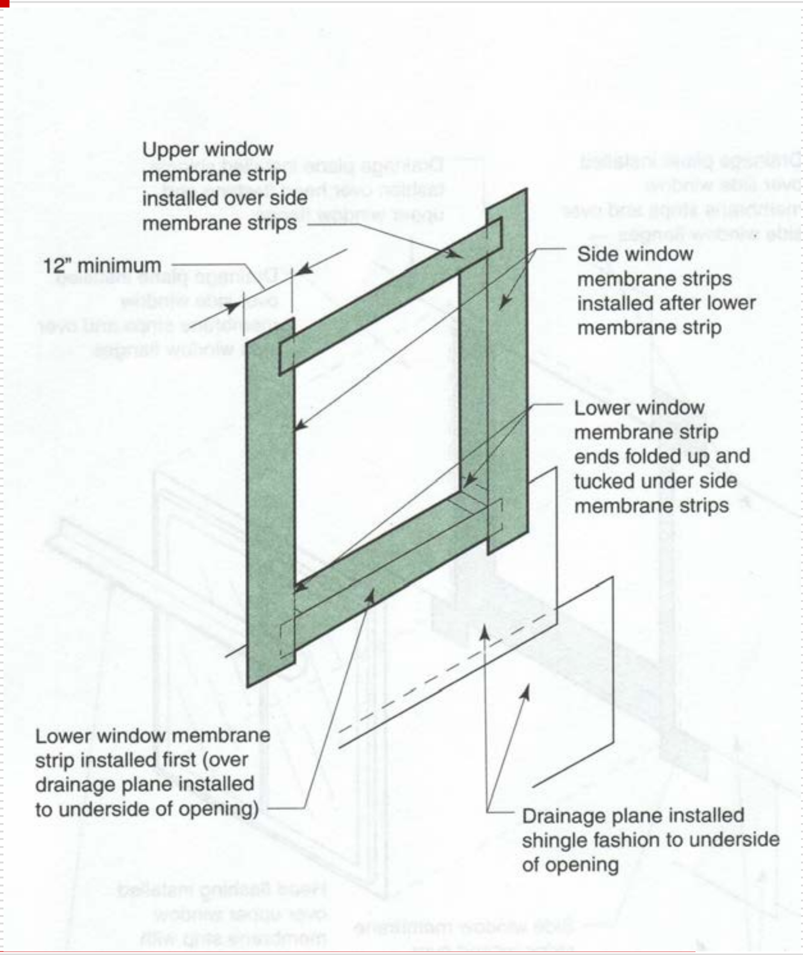


Moisture Intrusion

Water Management

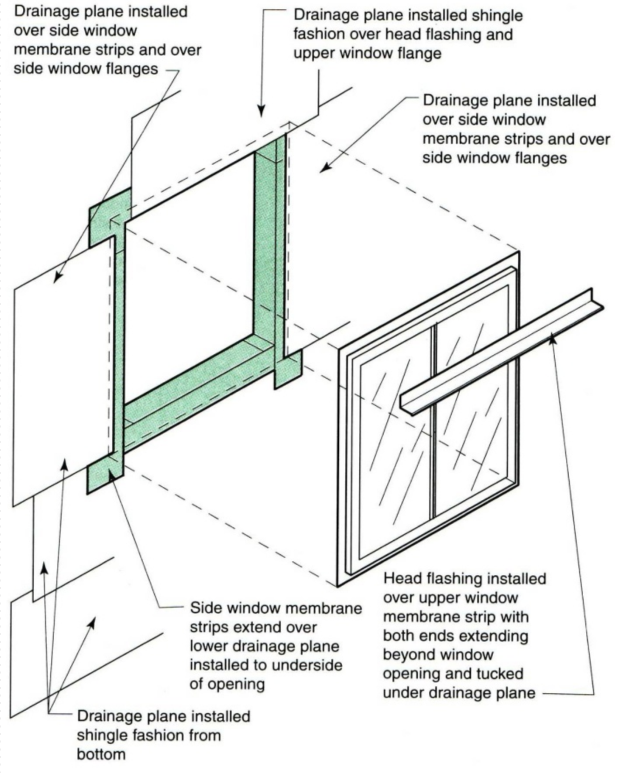
Water Management

- Water management for exterior windows requires proper placement of window flashing strips and drainage plane



Water Management

- Water management for exterior windows requires proper placement of window flashing strips and drainage plane
- Note placement of drainage plane under window



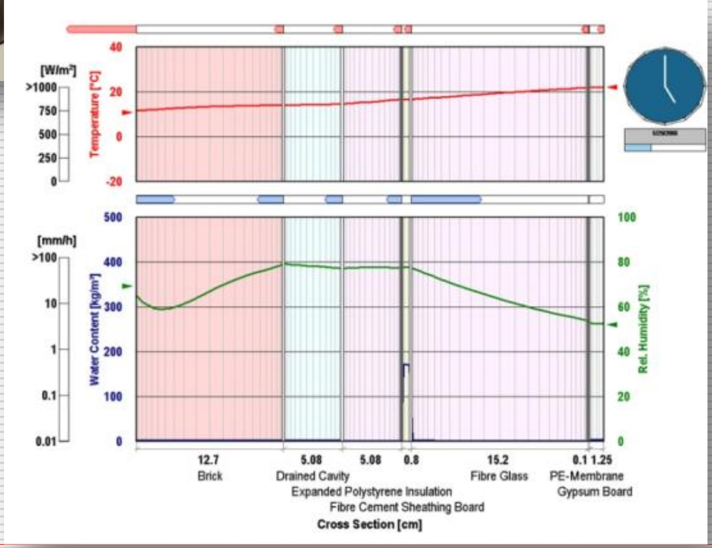
Water Management

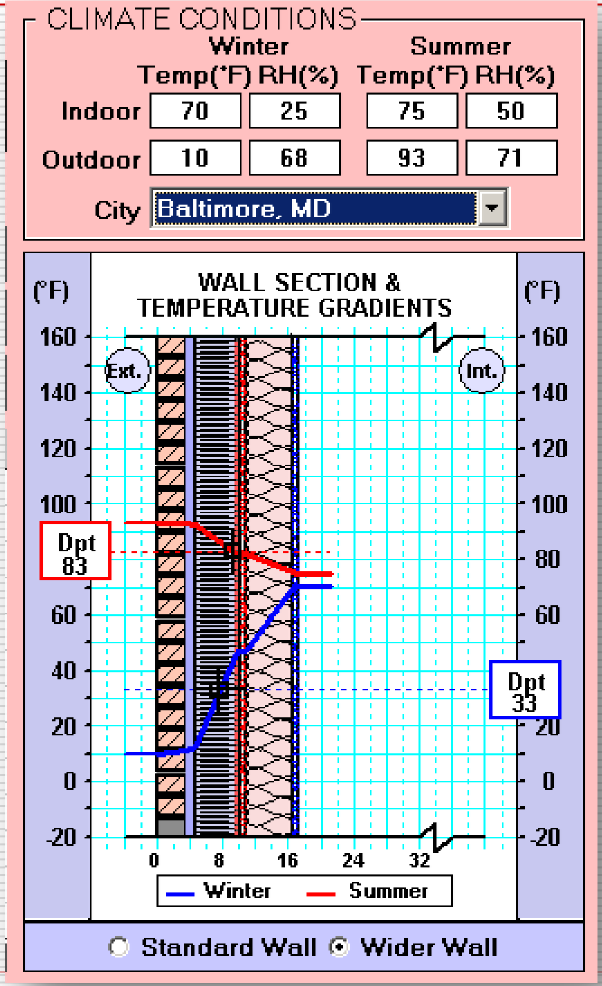
Water Management

Air, Vapor and Water Barrier – Peel & Stick

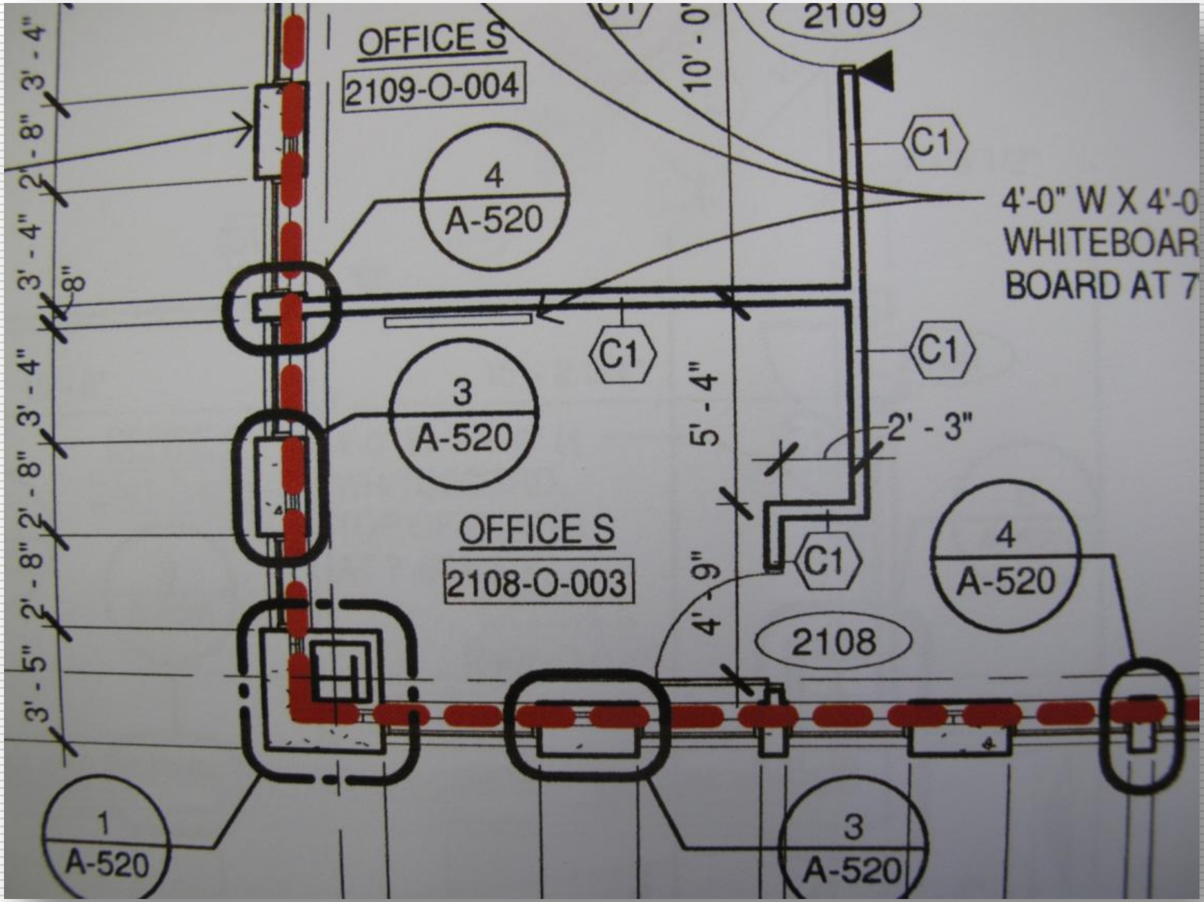
Air, Vapor and Water Barrier – Fluid Applied

Building Enclosure Design





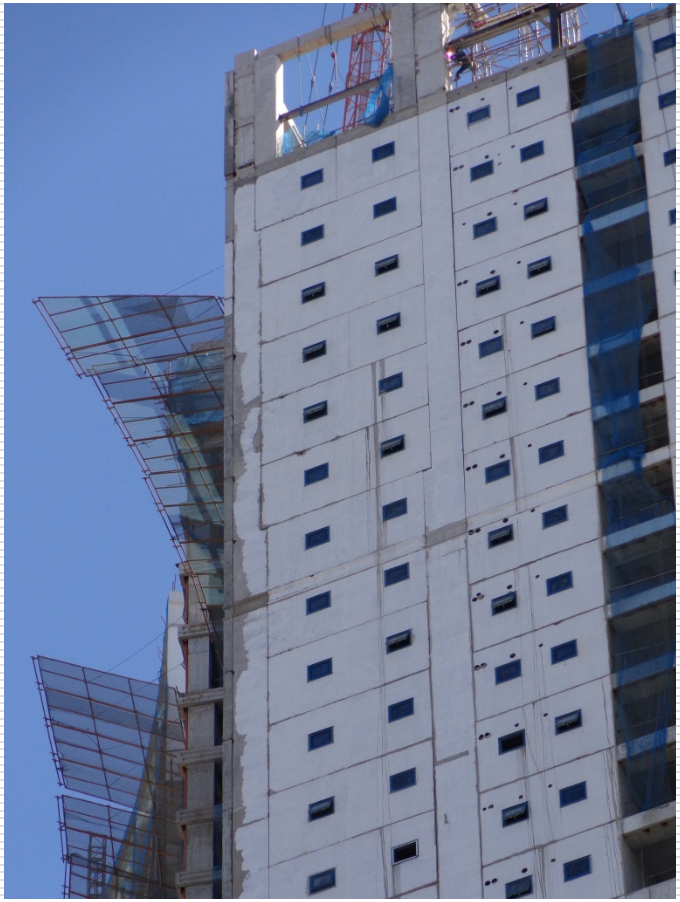
Enclosure Detail Design



Examples

Example

Current Construction



Example

Thermal Break

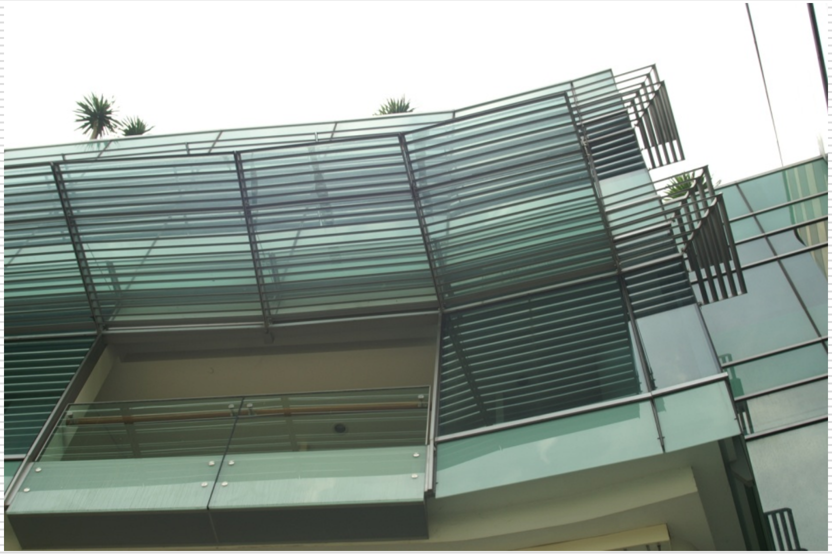
Example

Master Builder and Contemporary Builder

Example

Overhangs and Sills

Example



Window Shading

Building Envelope Commissioning

Building Envelope Commissioning BECx

National Institute of
BUILDING SCIENCES

NIBS Guideline 3-2006

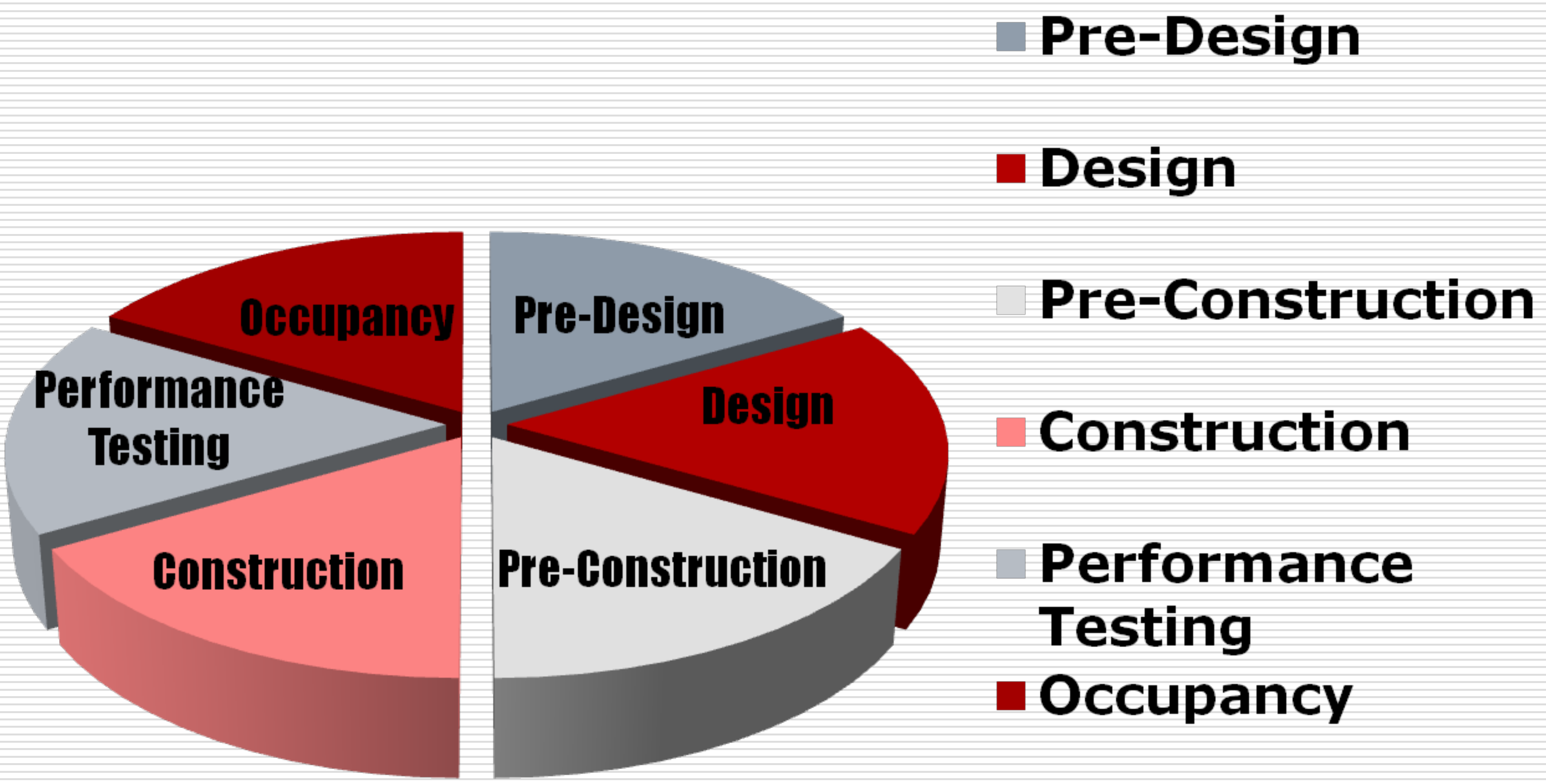
Exterior Enclosure
Technical Requirements
For the Commissioning Process

This Guideline is for Use with
ASHRAE Guideline 0-2005:
The Commissioning Process

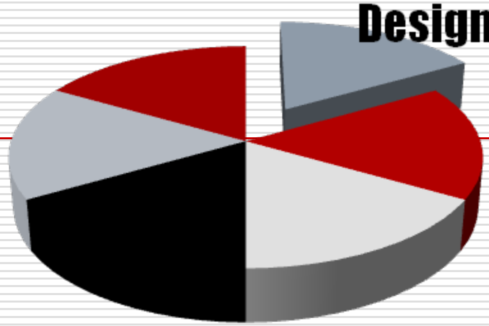
ASTM INTERNATIONAL

WK26027 - New Practice for Enclosure Commissioning

Building Envelope Commissioning BECx

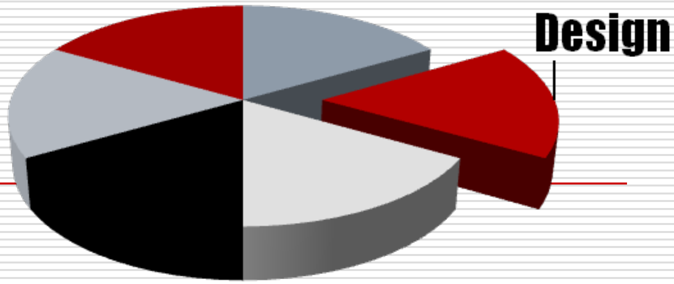


BECx Pre-Design

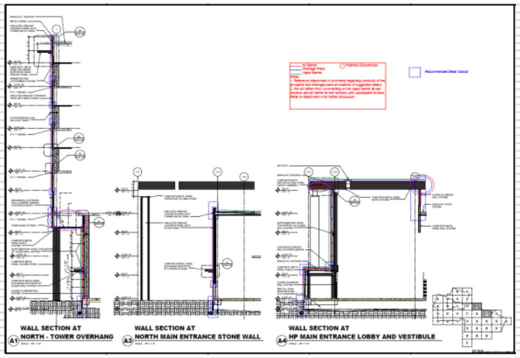


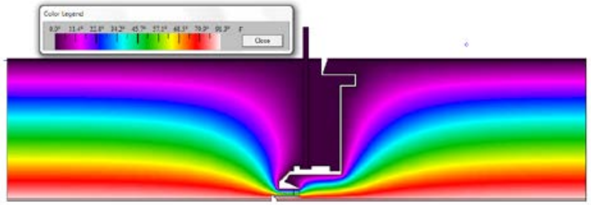
- BECxA Selection
  - Qualified
  - Independent, 3rd Party
- OPR
  - Moisture
  - Vapor
  - Thermal
  - Air
  - Other (Acoustic/Fire/Blast/ Structural)
- Scope and Budget
- BECx Plan

BECx Design

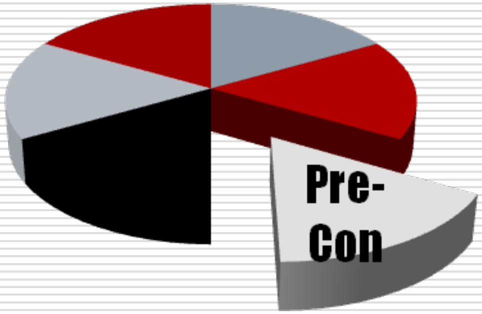


- Hygrothermal Modeling / Simulation
- Construction Document Review
  - OPR / BOD
  - Performance
  - Constructability
- Design Meetings
- BECx Specification
- Functional Performance Test Specification



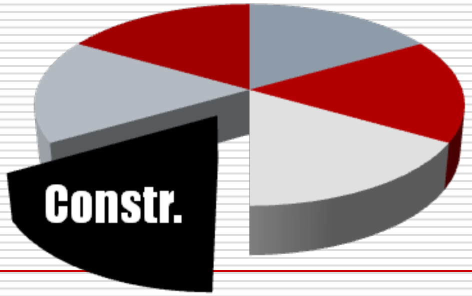


BECx Pre-Construction

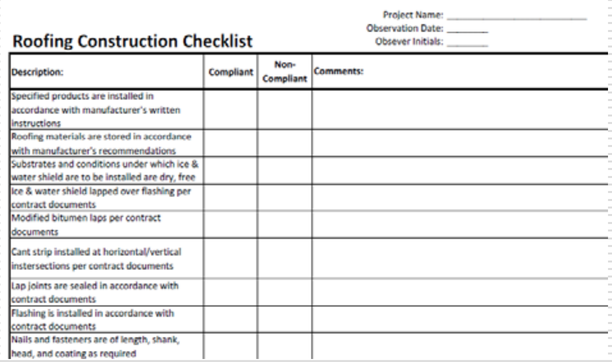


- Submittal / Shop Drawings Review
- Pre-Con Meetings
- Sequencing
- Mockup Functional Performance Test

BECx Construction



- Quality Assurance Observations – Ensure Construction meets:
  - OPR / BOD
  - Construction Documents
  - Manufacturer's Installation Requirements
  - Industry Standard of Care
- Site Meetings
- Checklists

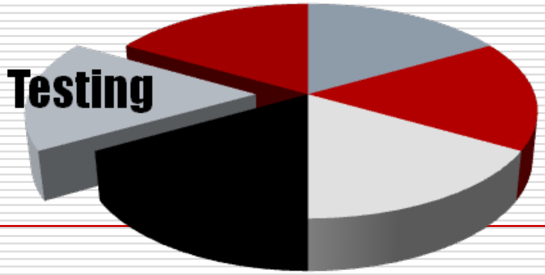


Project Name: ______
Observation Date: ______
Obsever Initials: ______

Roofing Construction Checklist

Description:	Compliant	Non-Compliant	Comments:
Specified products are installed in accordance with manufacturer's written instructions			
Roofing materials are stored in accordance with manufacturer's recommendations			
Substrates and conditions under which ice & water shield are to be installed are dry, free			
Ice & water shield lapped over flashing per contract documents			
Modified bitumen laps per contract documents			
Cant strip installed at horizontal/vertical intersections per contract documents			
Lap joints are sealed in accordance with contract documents			
Flashing is installed in accordance with contract documents			
Nails and fasteners are of length, shank, head, and coating as required			

BECx Testing



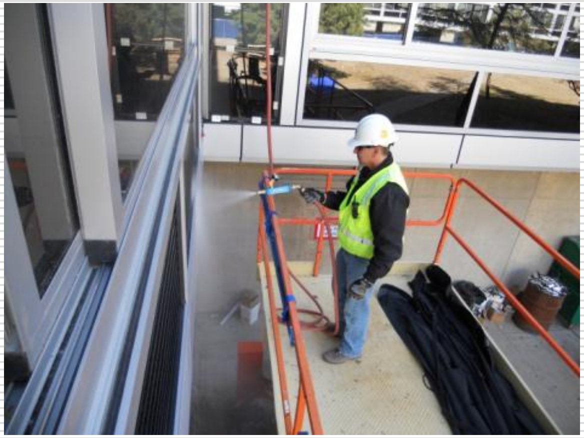
- Fenestration Testing
  - ASTM E1105 / E783 Water and Air Testing
  - AAMA 501.2 Water *Leakage* Testing
- Air Barrier Testing
  - ASTM E779 Whole Building Air Leakage (Quantitative)
  - ASTM E1186 Air Leakage Site Detection (Qualitative)
- Thermal Barrier Testing
  - ASTM C1060 Infrared Thermography
- Other
  - Roof Uplift (FM Global 1-52)
  - Adhesion

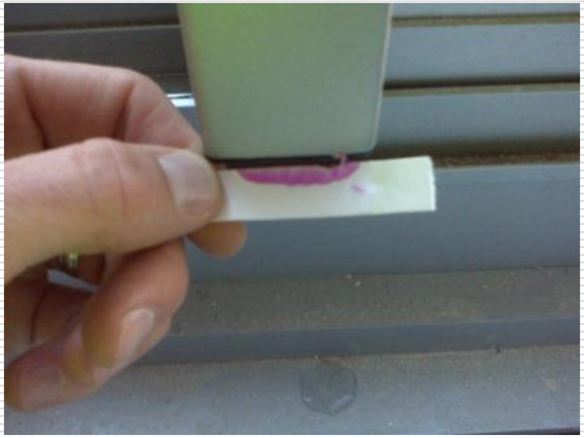
Fenestration / Moisture Barrier Testing

- **ASTM E1105: Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Curtain Walls and Doors by Uniform or Cyclic Static Air Pressure Difference**

Fenestration / Moisture Barrier Testing

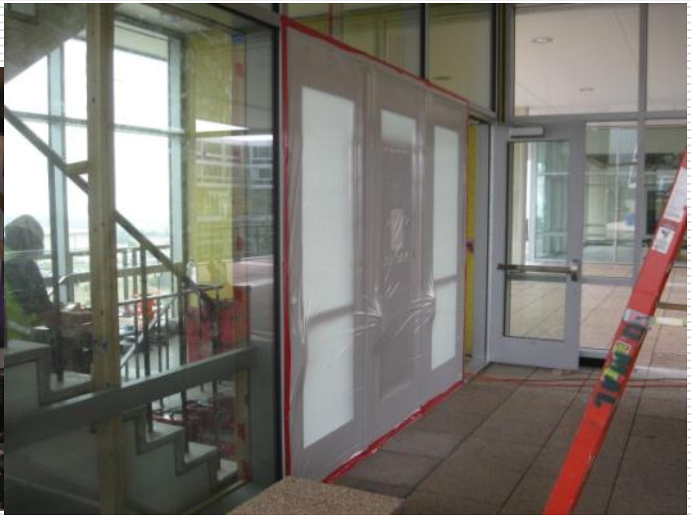
- AAMA 501.2 Testing: Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Slope Glazing Systems
- Implement field testing regimen throughout construction process (example: 25%, 50%, 75% and 100%)





Field Assembly Air Tightness Testing

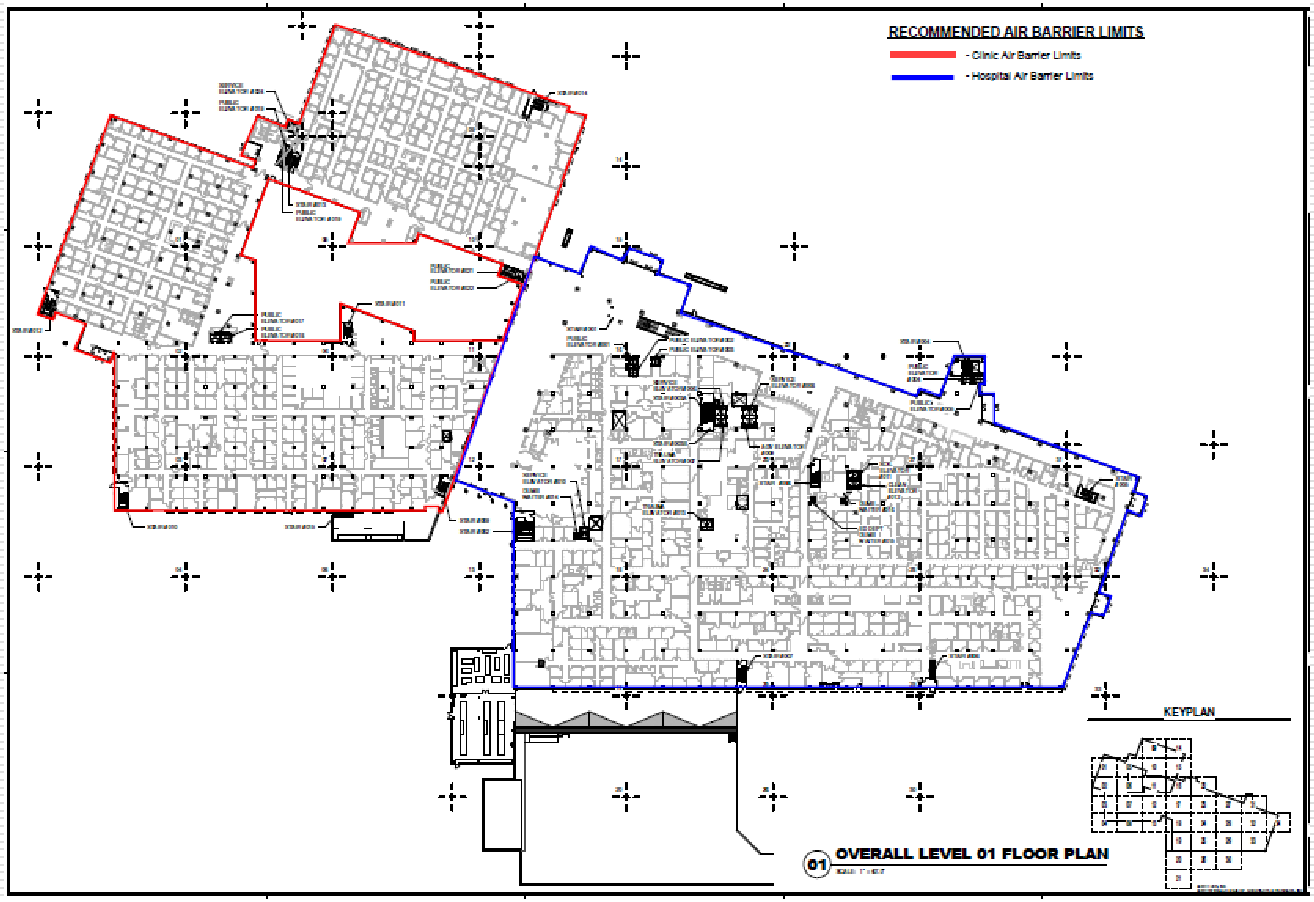
- ASTM E783: Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors



Whole Building Air Tightness Test

- ASTM E779: Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
- ASTM E1827: Standard Test Methods for Determining Air tightness of Buildings Using an Orifice Blower Door

Whole Building Air Barrier Testing

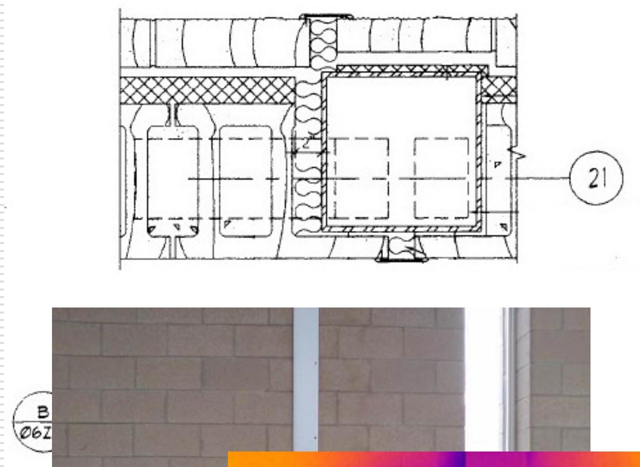


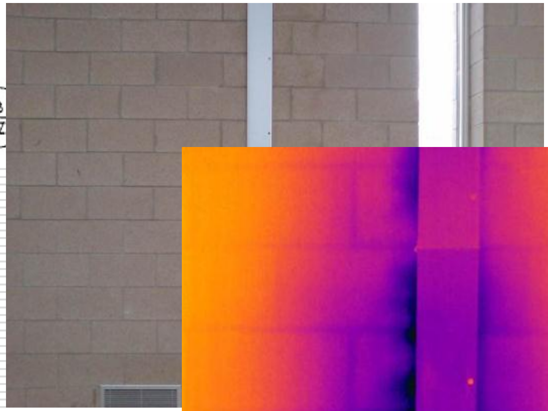
Whole Building Air Barrier Testing

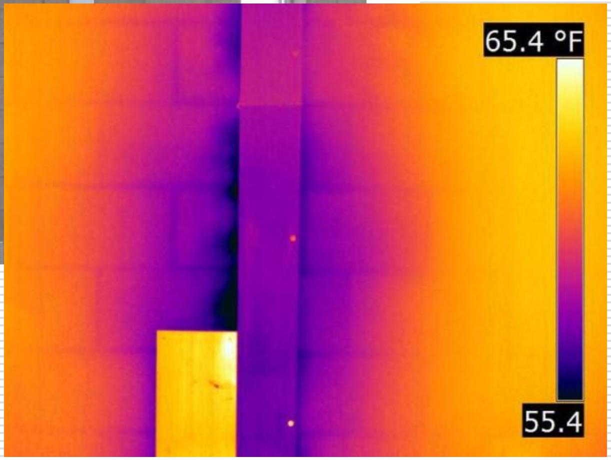
Description	Air Leakage (CFM/ft² at 75-Pa)	Percent *above* Max Allowable (0.25 CFM/ft² at 75-Pa) OR PASS
Pressurization	0.12	PASS
Depressurization	0.10	PASS
Average	0.11	PASS

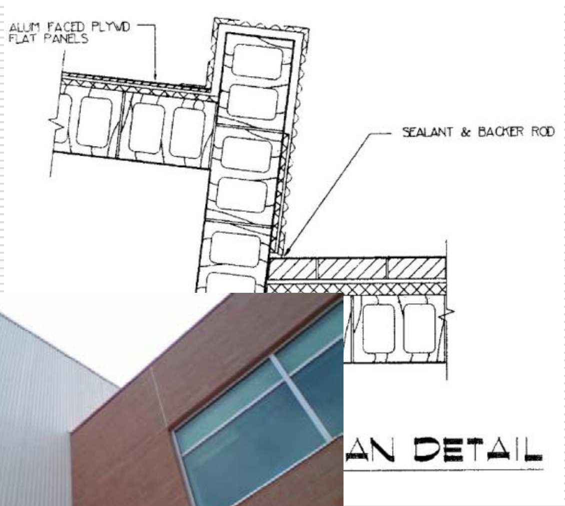
Figure 1 – Air Tightness Testing Results

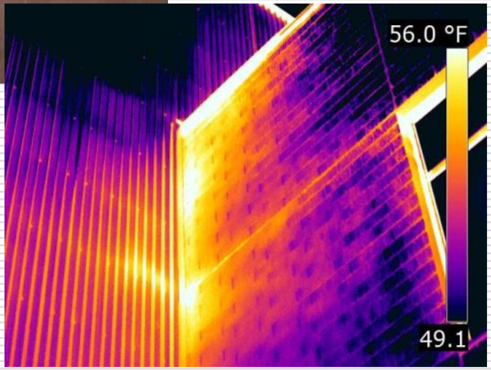
Expansion Joints & Dissimilar Interfaces



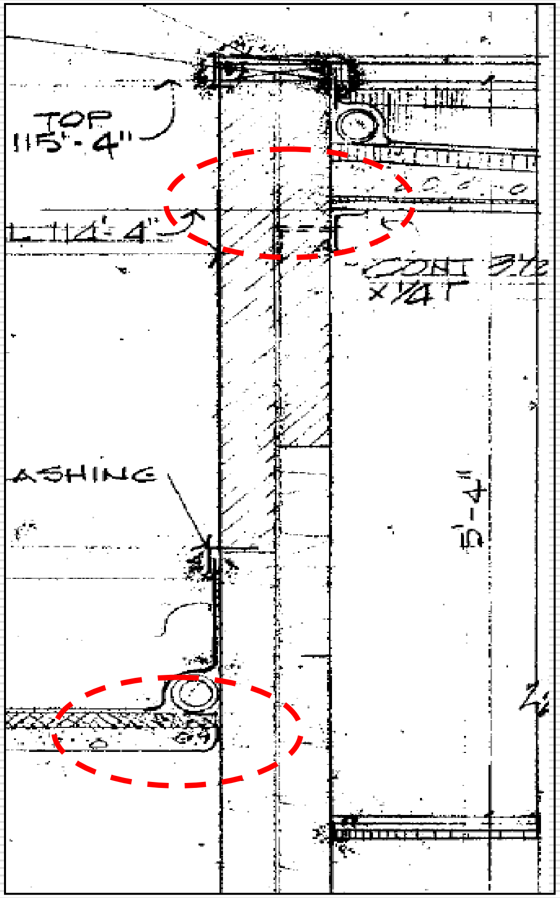




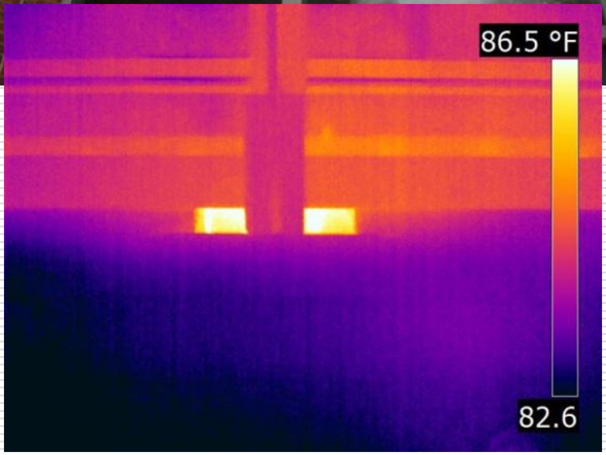


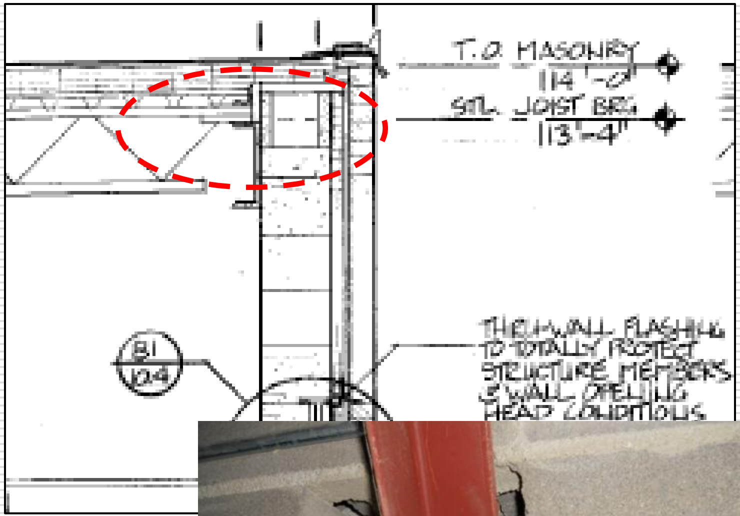


Roof Transitions/Rise Wall Expansion Joints



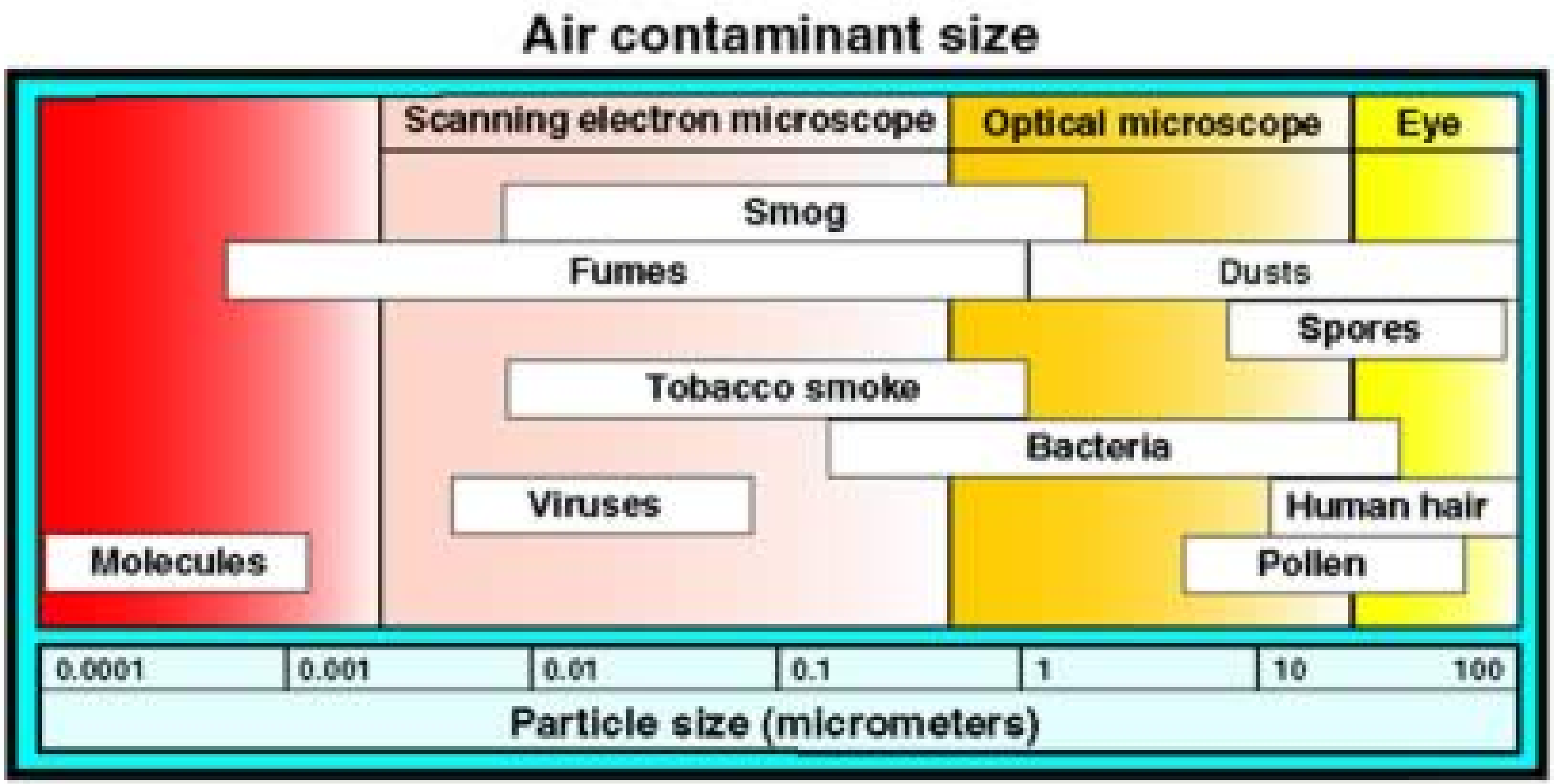
Beam Pockets





Ventilation and Infiltration

Ventilation and Filtration



Ventilation and Filtration

☐ASHRAE Standard 52.1

Measures arrestance, dust spot efficiency and dust holding capacity. *Arrestance* means a filter's ability to capture a mass fraction of coarse test dust and is suited for describing low 7 medium efficiency filters. Be aware that arrestance values may be high even for low efficiency filters and do not adequately indicate the effectiveness of certain filters for CBR protection. *Dust spot efficiency* measures a filters ability to remove large particles, those that tend to soil building interiors. *Dust holding capacity* is a measure of the total amount of a dust a filter is able to hold during a dust loading test.

Ventilation and Filtration

- ASHRAE Standard 52.2
  - Measures particle size efficiency (PSE). This newer standard is a more descriptive test which quantifies filtration efficiency in different particle size ranges for a clean and incrementally loaded filter to provide a composite efficiency value. It gives a better determination of a filter's effectiveness to capture solid particles as opposed to liquid aerosols. This standard rates particle size efficiency results as a MERV between 1 & 20. A higher MERV indicates a more efficient filter. Also this standard rates a minimum PSE in three size ranges for each of the MERV numbers.

Ventilation and Filtration

	ASHRAE 52.2			ASHRAE 52.1		Particle size range, µm	Applications
	Particle size range			Test			
MERV	3 to 10 µm	1 to 3 µm	.3 to 1 µm	Arrestance	Dust spot		
1	<20%	—	—	<65%	<20%	>10	residential light pollen, dust mites
2	<20%	—	—	65-70%	<20%		
3	<20%	—	—	70-75%	<20%		
4	<20%	—	—	>75%	<20%		
5	20-35%	—	—	80-85%	<20%	3.0-10	industrial, dust, molds, spores
6	35-50%	—	—	>90%	<20%		
7	50-70%	—	—	>90%	20-25%		
8	>70%	—	—	>95%	25-30%		
9	>85%	<50%	—	>95%	40-45%	1.0-3.0	industrial, Legionella, dust
10	>85%	50-65%	—	>95%	50-55%		
11	>85%	65-80%	—	>98%	60-65%		
12	>90%	>80%	—	>98%	70-75%		
13	>90%	>90%	<75%	>98%	80-90%	0.3-1.0	hospitals, smoke removal, bacteria
14	>90%	>90%	75-85%	>98%	90-95%		
15	>90%	>90%	85-95%	>98%	~95%		
16	>95%	>95%	>95%	>98%	>95%		
17	—	—	≥99.97%	—	—	<0.3	clean rooms, surgery, chem-bio, viruses
18	—	—	≥99.99%	—	—		
19	—	—	≥99.999%	—	—		
20	—	—	≥99.9999%	—	—		

Ventilation and Filtration

Table 3. Application of activated carbon impregnates [CBIAC 2001]

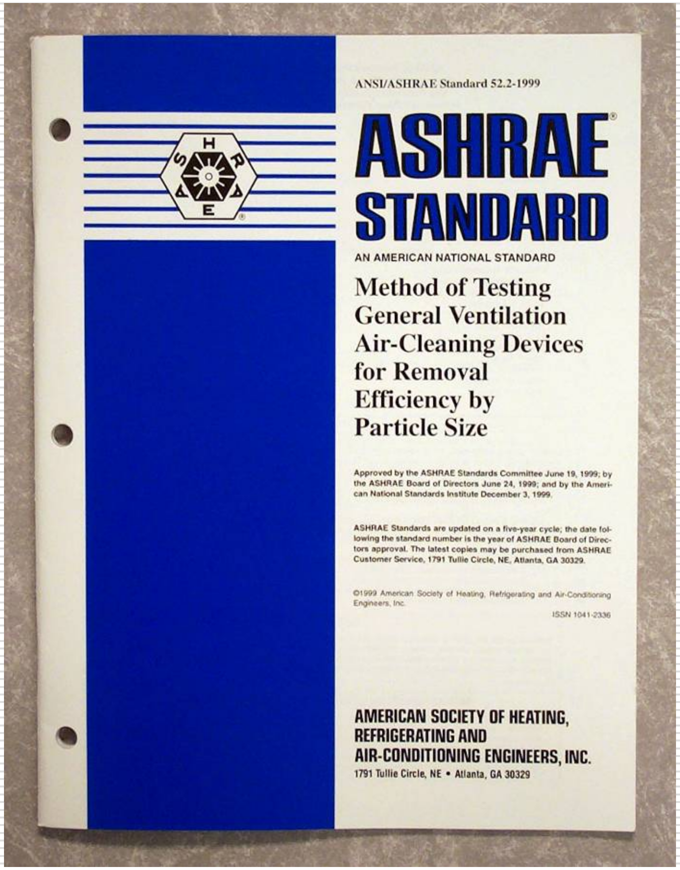
Impregnate	Chemical contaminant
Copper/silver salts	Phosgene, chlorine, arsine
Iron oxide	Hydrogen sulfide, mercaptans
Manganese IV oxide	Aldehydes
Phosphoric acid	Ammonia
Potassium carbonate	Acid gases, carbon disulfide
Potassium iodide	Hydrogen sulfide, phosphine, mercury, arsine, radioactive methyl iodide
Potassium permanganate	Hydrogen sulfide
Silver	Arsine, phosphine
Sulfur	Mercury
Sulfuric acid	Ammonia, amine, mercury
Triethylenediamine (TEDA)	Radioactive methyl iodide
Zinc oxide	Hydrogen cyanide

Ventilation and Filtration

- ASHRAE Standard 52.2
  - Measures particle size efficiency (PSE). This newer standard is a more descriptive test which quantifies filtration efficiency in different particle size ranges for a clean and incrementally loaded filter to provide a composite efficiency value. It gives a better determination of a filter's effectiveness to capture solid particles as opposed to liquid aerosols. This standard rates particle size efficiency results as a MERV between 1 & 20. A higher MERV indicates a more efficient filter. Also this standard rates a minimum PSE in three size ranges for each of the MERV numbers.

ASHRAE Std 52.2

- Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size



Building Pressurization

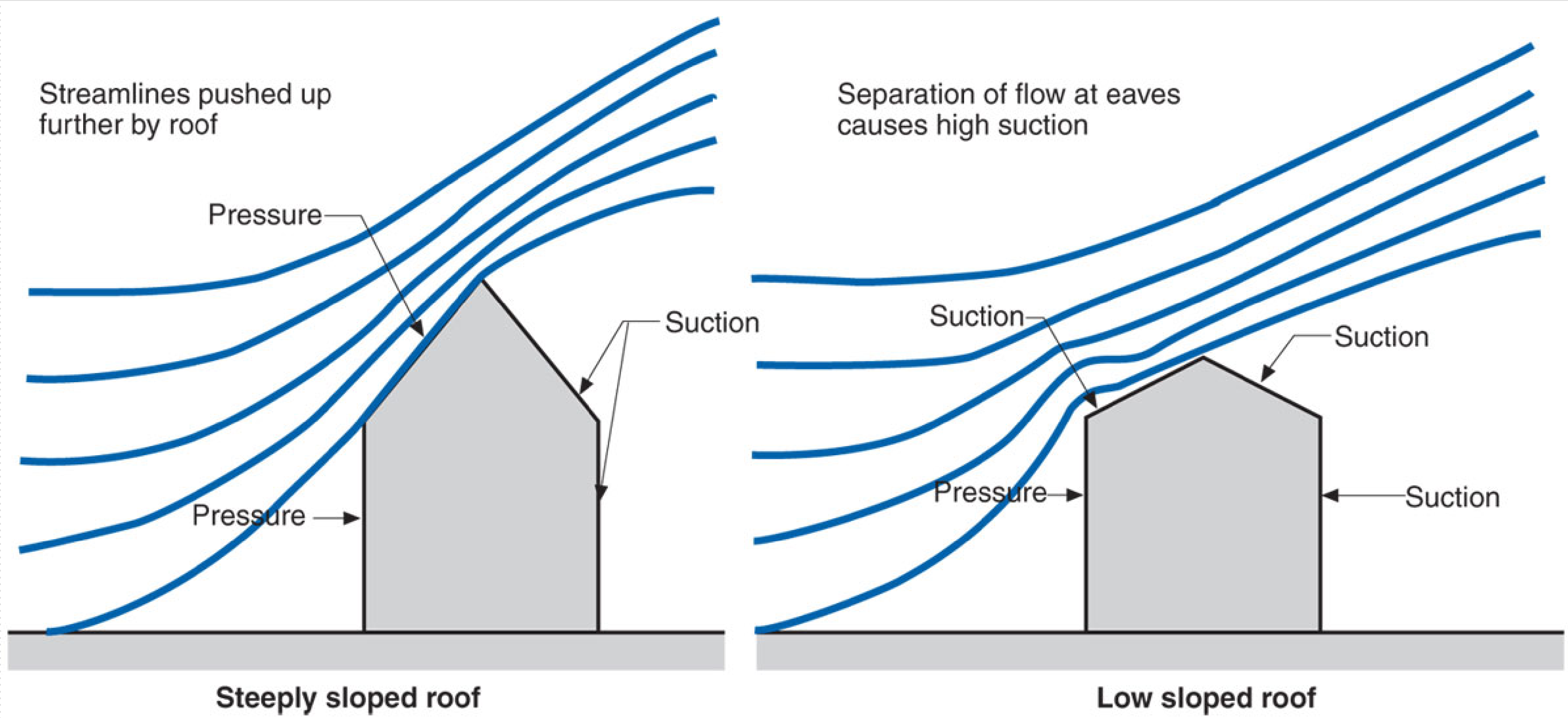
Air Barrier

- An air barrier is defined by the Air Barrier Association of America (ABAA) as an assembly to *"control the unintended movement of air into and out of a building enclosure."*

Infiltration & Exfiltration

- ASHRAE Fundamentals Chapter 16 & 26
  - Wind pressure, stack pressure and HVAC pressure
  - Air leakage rates
    - ASHRAE Std 180 requires 0.40 cfm/sq ft @ 75 pascals (0.30 in-wg)
    - ASHRAE Std 90.1 addendum will require 0.40 cfm/sq ft @ 75 pascals (0.30 in-wg)
    - ASTM E 779
    - US LEED 1.25 in^2 EfLA @ 4 Pa / 100 ft^2

Velocity Pressure on Envelope



Benefits of an air-tightness standard

- Reduced building heating and cooling costs
- Reduced building enclosure moisture problems
- Improved indoor air quality
- Improved acoustical isolation
- Isolates the indoor environment
- Sustainable, durable buildings

Air Tightness Standards

			cfm/ ft² [L/s*m²] at 75Pa
US	ASHRAE	0.40 cfm/ ft^2 at 75Pa	0.40/2.00
UK	TS-1Commercial Best Practice	5 $m^3/h/m^2$ at 50 Pa	0.36/1.82
US	LEED	1.25 in^2 EfLA @ 4 Pa / 100 ft^2	0.30/1.52
US	ASHRAE HOF Average	0.30 cfm/ ft^2 at 75Pa	0.30/1.52
UK	TS-1Commercial Tight	2 $m^3/h/m^2$ at 50 Pa	0.14/0.71
CAN	R-2000	1 in^2 EqLA @10 Pa /100 ft^2	0.13/0.66
US	ASHRAE HOF Tight	0.10 cfm/ ft^2 at 75Pa	0.10/0.51

Leakier

Tighter

For a 4 story building, 120 x 110 ft, n=0.65

Requirements for an Air Barrier System

- It must be continuous, with all joints made tight.
- The materials shall have an air permeability not to exceed 0.004 cfm/sf under a pressure differential of 0.3 in. of water. (Or 0.02 L/s/m2 @ 75 Pa)
- It shall be capable of withstanding positive and negative combined design, wind, fan and stack pressures on the envelope without damage or displacement, and shall transfer the load to the structure. It shall not displace adjacent materials under full load.

Requirements for an Air Barrier System

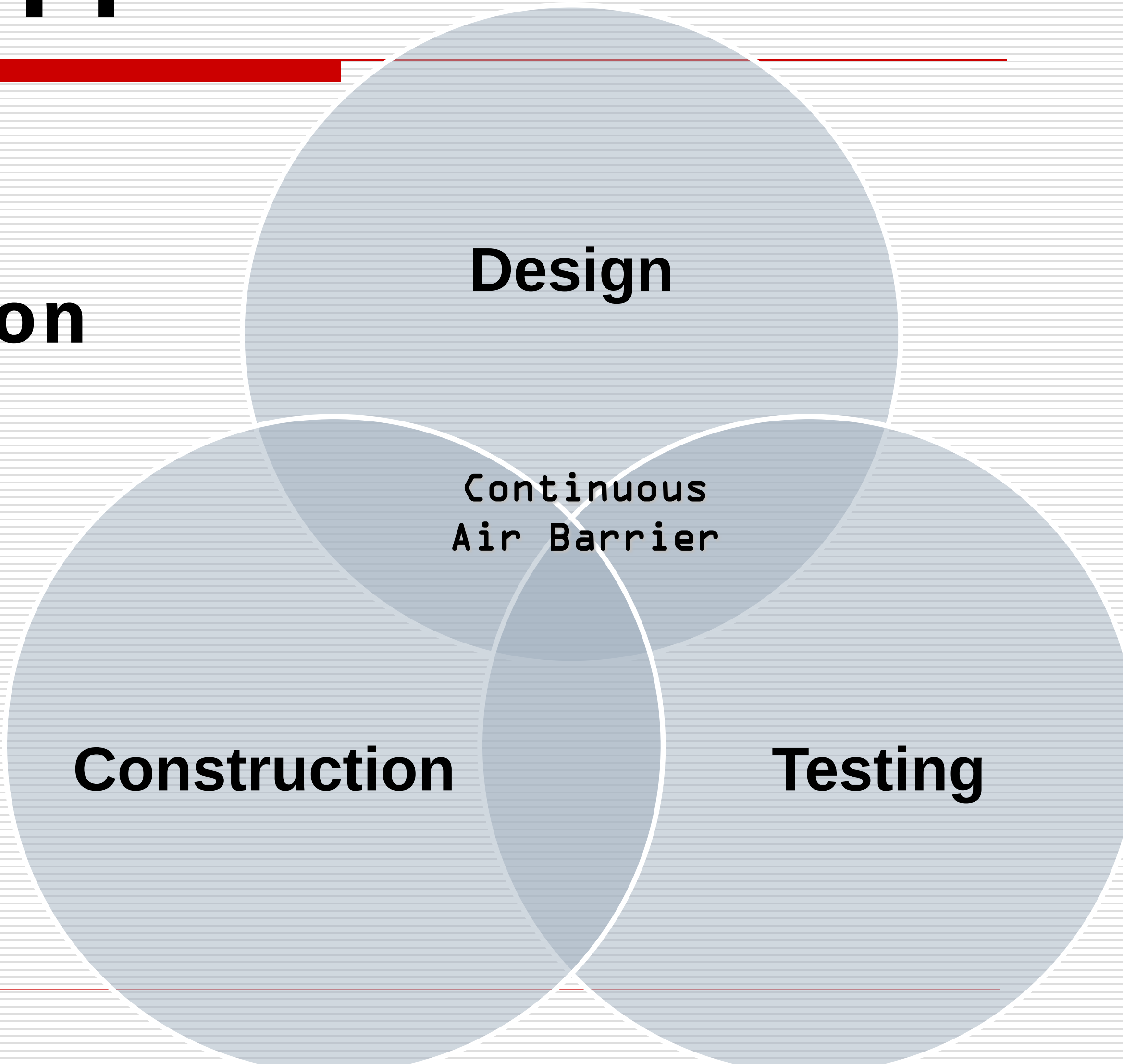
- It shall be durable or maintainable
- The air barrier shall be joined in an airtight and flexible manner to the air barrier of adjacent systems, allowing for the relative movement of systems due to thermal and moisture variations and creep. Connections shall be made between:
  - a) Foundations and walls
  - b) Walls and windows or doors
  - c) Different wall systems
  - d) Wall and roof
  - e) Walls, floor and roof across construction, control and expansion joints
  - f) Walls, floor and roof and utility, pipe and penetrations

Performance Verification

- **Demonstrate performance of the continuous air barrier for the opaque building envelope by the following tests:**
- ***(a) Test the completed building and demonstrate that the air leakage rate of the building envelope does not exceed 0.25 cfm/ft2 at a pressure differential of 0.3” w.g.(75 Pa) in accordance with ASTM E-779 (2003) and E-1827-96 (2002).***
- ***(b) Test the completed building using Infrared Thermography testing. Use infrared cameras with a resolution of 0.1deg C or better. Perform testing on the building envelope in accordance with ISO 6781:1983 and ASTM C1060-90(1997).***

Integrated Design Approach

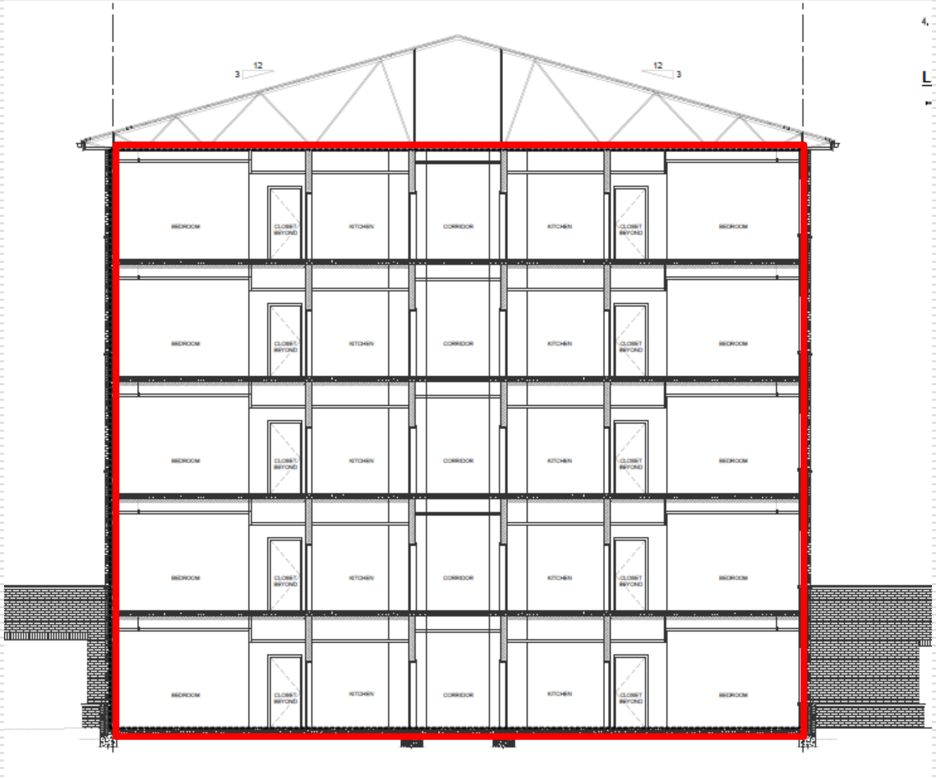
- Design
- Construction
- Testing



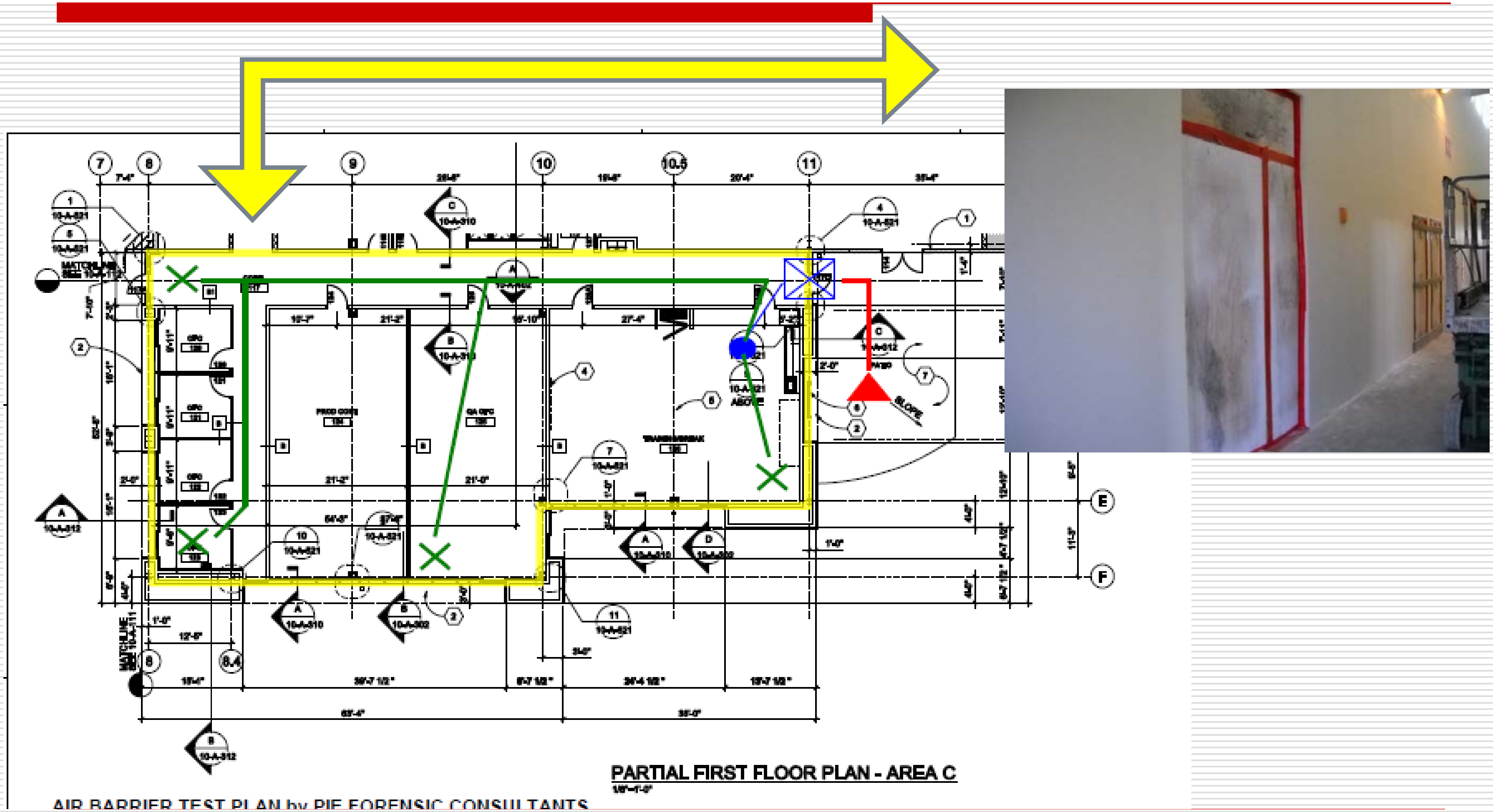
Common Design Omissions

- Air barrier limits and area not on drawings
- Properly locating the air barrier limits
- Insufficient information in specifications or drawings
- Critical detailing areas
- Missing & impractical details

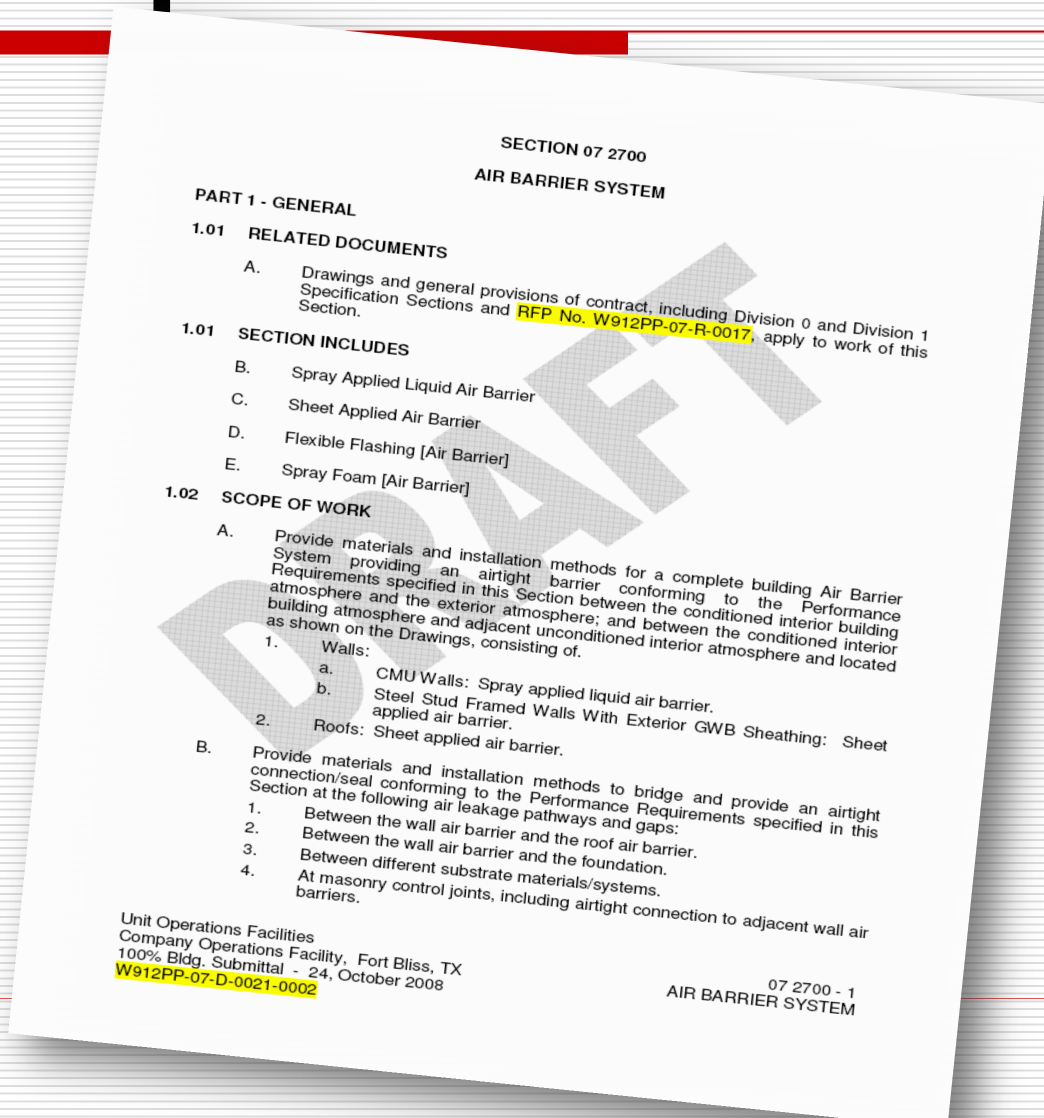
Use Actual Boundaries… Elevation View



Use Actual Boundaries… Plan View



Specifications



SECTION 07 2700

AIR BARRIER SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of contract, including Division 0 and Division 1 Specification Sections and RFP No. W912PP-07-R-0017, apply to work of this Section.

1.01 SECTION INCLUDES

B. Spray Applied Liquid Air Barrier

C. Sheet Applied Air Barrier

D. Flexible Flashing [Air Barrier]

E. Spray Foam [Air Barrier]

1.02 SCOPE OF WORK

A. Provide materials and installation methods for a complete building Air Barrier System providing an airtight barrier conforming to the Performance Requirements specified in this Section between the conditioned interior building atmosphere and the exterior atmosphere; and between the conditioned interior building atmosphere and adjacent unconditioned interior atmosphere and located as shown on the Drawings, consisting of.

1. Walls:
   a. CMU Walls: Spray applied liquid air barrier.
   b. Steel Stud Framed Walls With Exterior GWB Sheathing: Sheet applied air barrier.
2. Roofs: Sheet applied air barrier.

B. Provide materials and installation methods to bridge and provide an airtight connection/seal conforming to the Performance Requirements specified in this Section at the following air leakage pathways and gaps:

1. Between the wall air barrier and the roof air barrier.
2. Between the wall air barrier and the foundation.
3. Between different substrate materials/systems.
4. At masonry control joints, including airtight connection to adjacent wall air barriers.

DRAFT

Unit Operations Facilities
Company Operations Facility, Fort Bliss, TX
100% Bldg. Submittal - 24, October 2008
W912PP-07-D-0021-0002

07 2700 - 1
AIR BARRIER SYSTEM

Consistency Between Specs & Drawings

2.3 SELF-ADHERING SHEET AIR BARRIER (DRAWING DESIGNATION – AIR BARRIER)

A. Modified Bituminous Sheet: 40-mil- thick, self-adhering sheet consisting of 36 mils of rubberized asphalt laminated to a 4-mil- thick, cross-laminated polyethylene film with release liner on adhesive side and formulated for application with primer that complies with VOC limits indicated.

SECTION 072500 - WEATHER BARRIERS

PART 1 - GENERAL

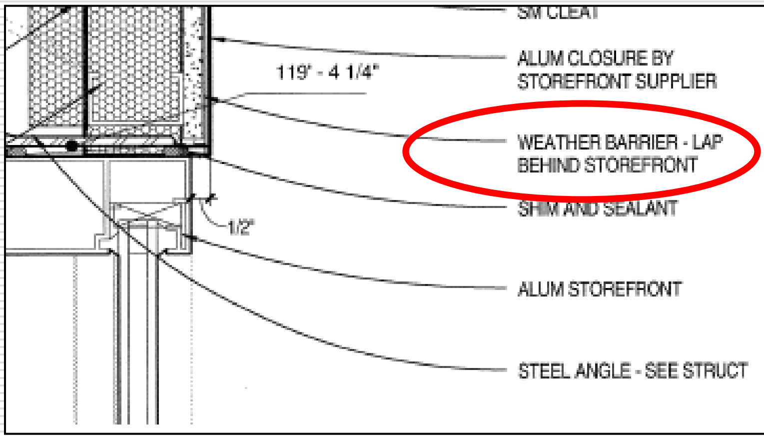
1.1 SUMMARY

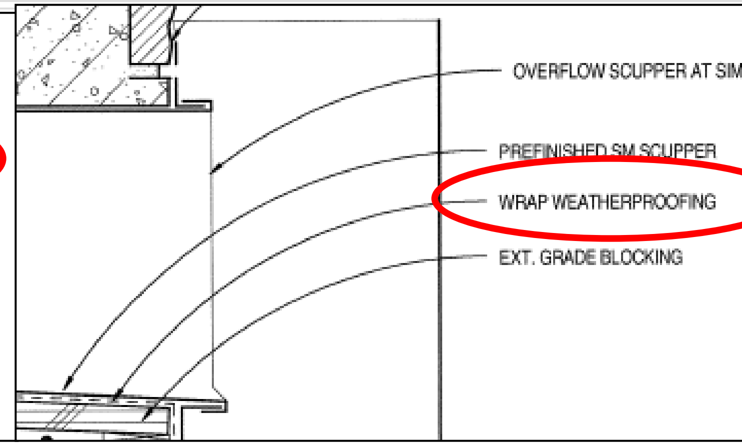
A. Section Includes:
1. Building wrap.
2. Flexible flashing.

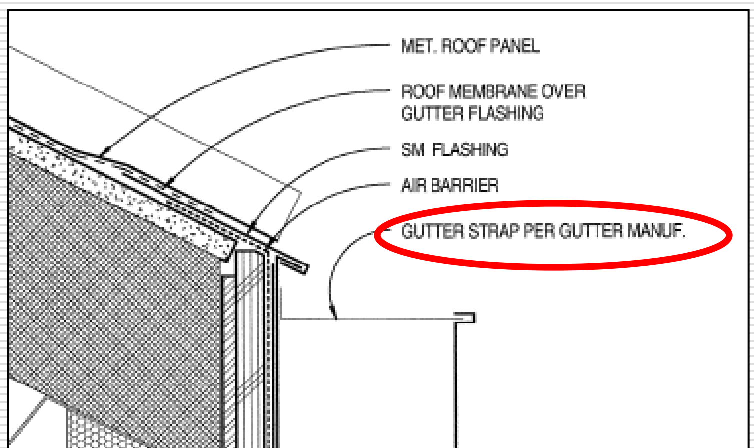
B. Related Requirements:

1. Section 061600 "Sheathing" for sheathing joint and penetration treatment.
2. Section 072713 "Modified Bituminous Sheet Air Barriers" for sheet air barrier.

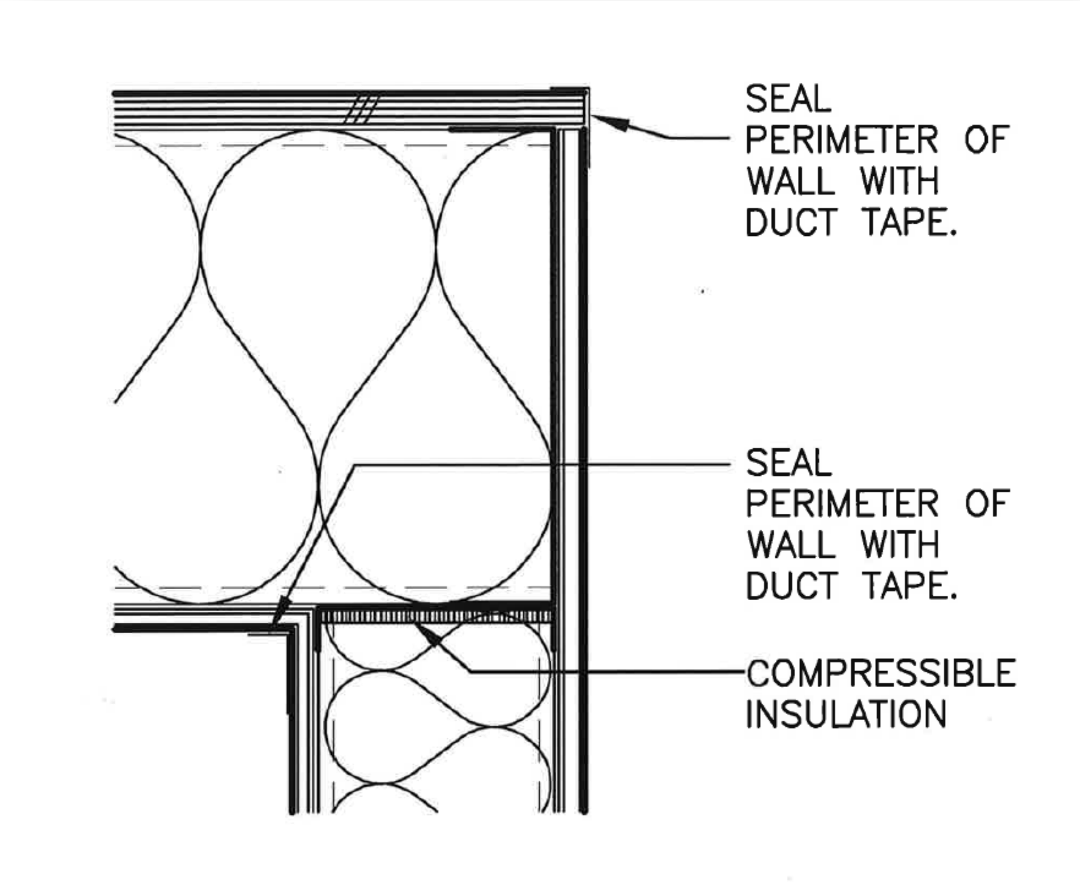
Consistency with Details







Details



SEAL PERIMETER OF WALL WITH DUCT TAPE.
SEAL PERIMETER OF WALL WITH DUCT TAPE.
COMPRESSIBLE INSULATION

Key Design Areas

- Floor Slab & Foundation / Exterior Wall Interface
- Wall / Roof Interface
- At Changes In Substrate Material / Construction
- Window, Louver and Door Perimeters
- Penetrations through the Building Envelope
- Control and Expansion Joints
- Relieving Angle / Wall Interface

Controlling Moisture in Commercial Buildings

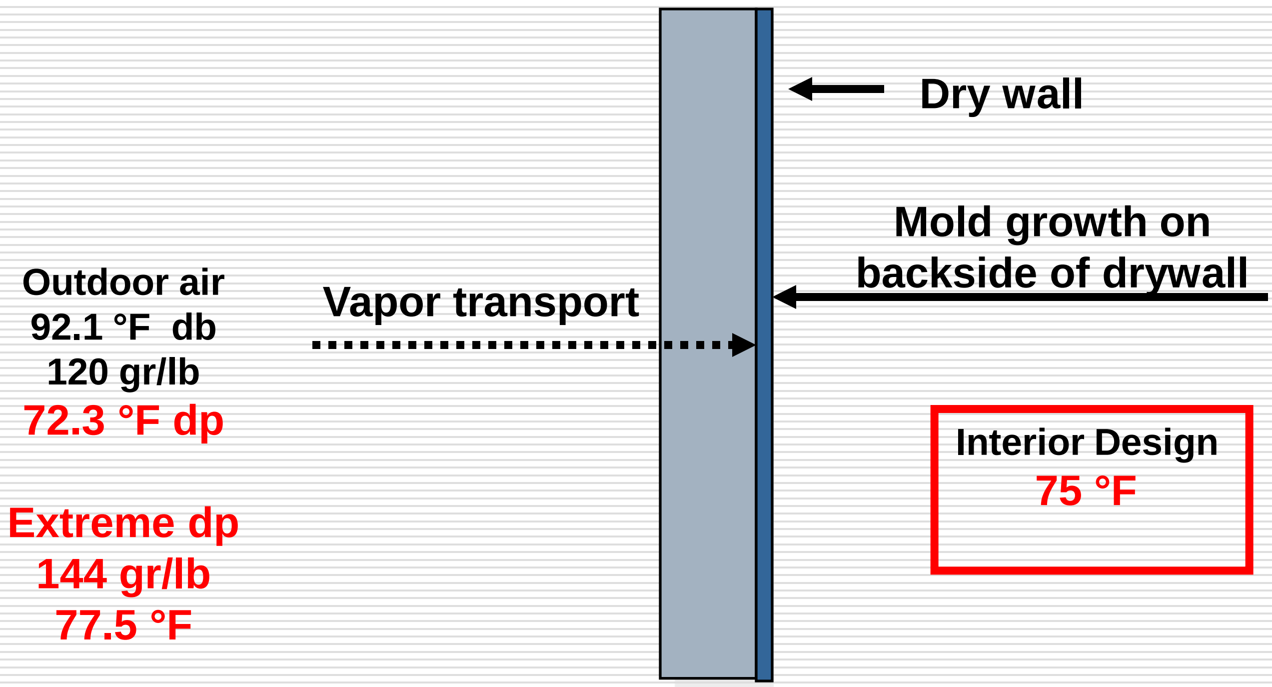
HVAC

THE MOISTURE PROBLEM

- Highest enthalpy occurs at peak dew point.. **NOT** peak dry bulb.. Charleston extreme DB w/ MCWB (1.0%) 92.1db/77.6wb, **120 gr/lb**, 72.3dp
- ASHRAE 2009 Fundamentals lists extreme DP with MCDB.... Charleston (1.0%) 77.5db/77.5dp (**144 gr/lb**) (83.3wb) ....

…poor performance at part load!!

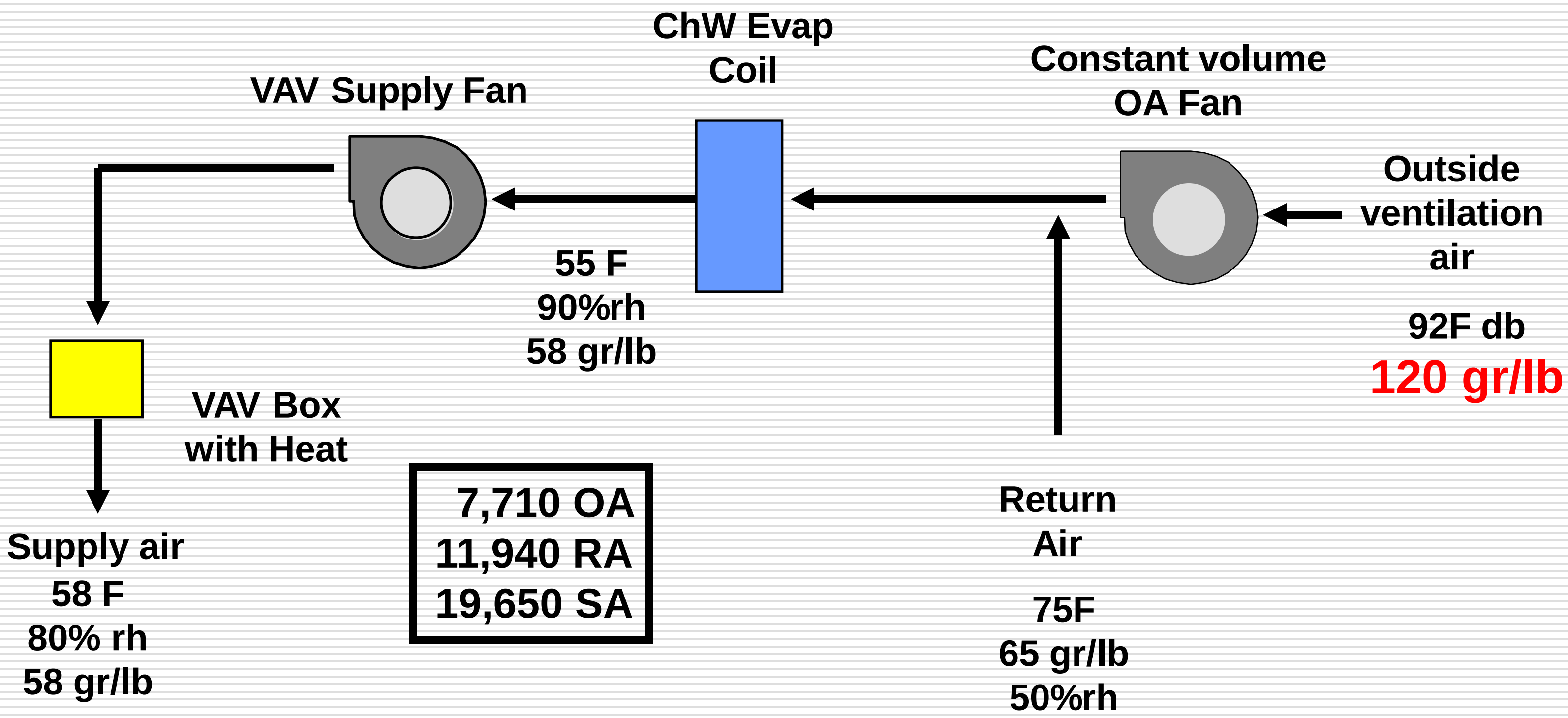
TYPES OF MOISTURE PROBLEMS

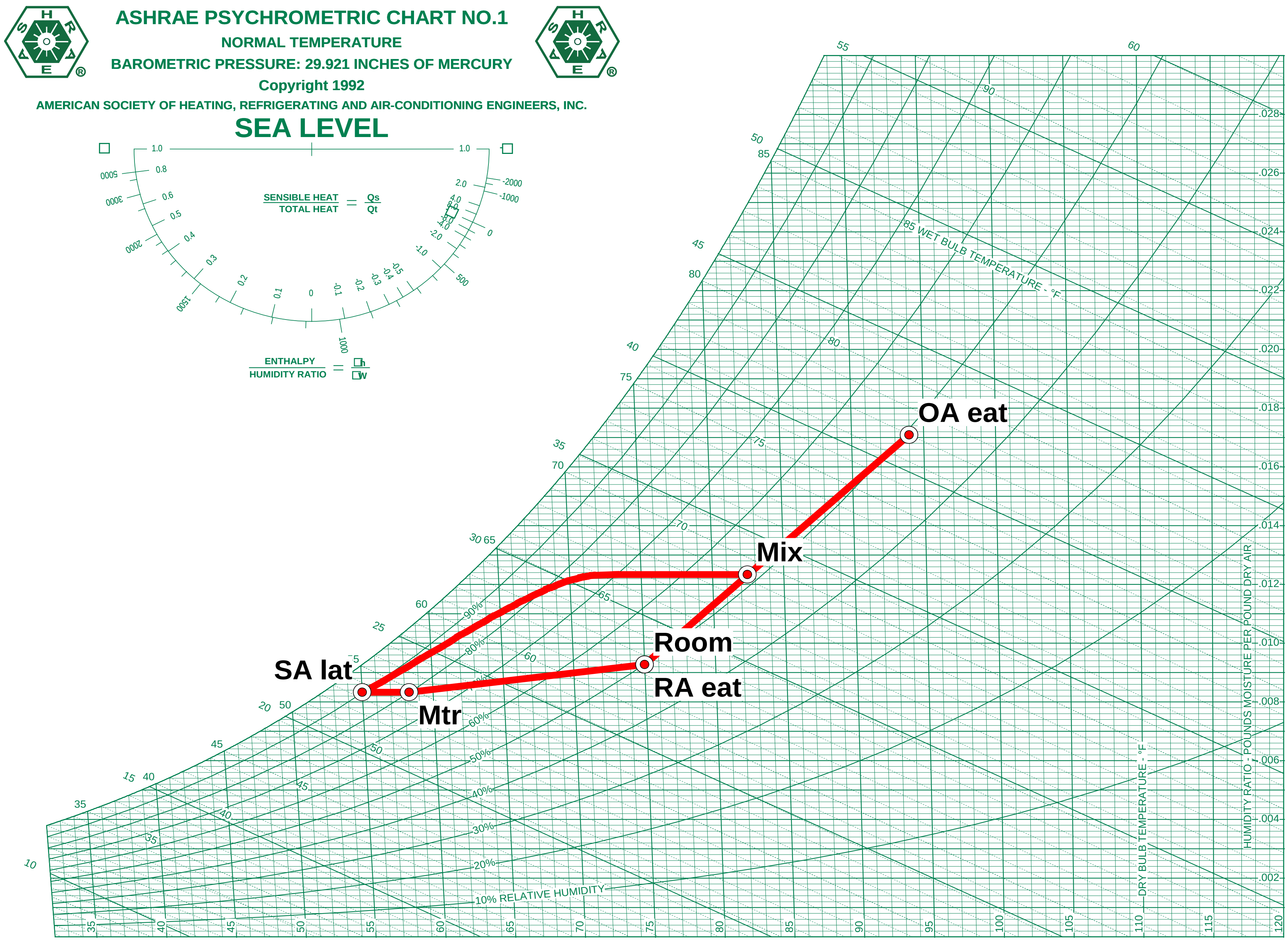


Building Envelope with poor vapor barrier

VAV AIR CONDITIONING

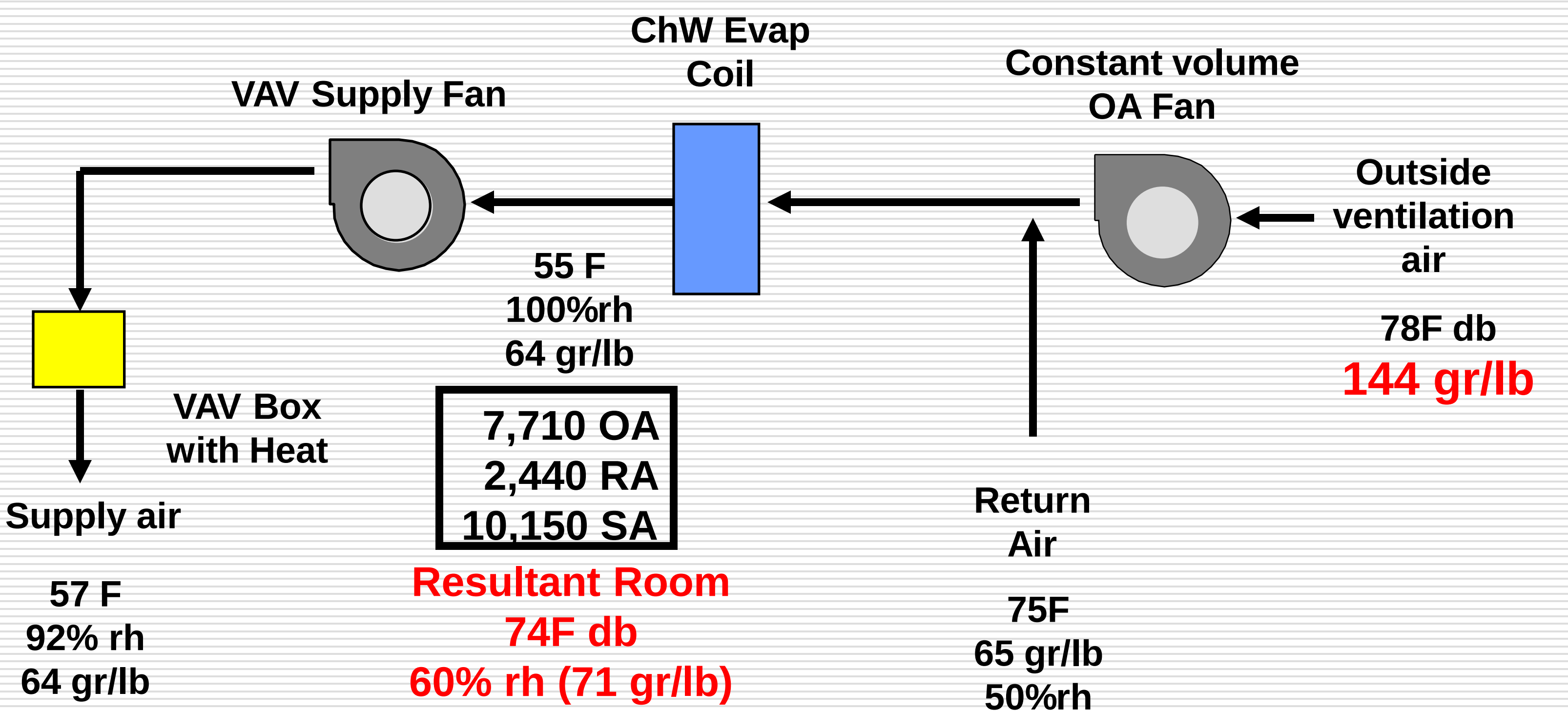
Full Load



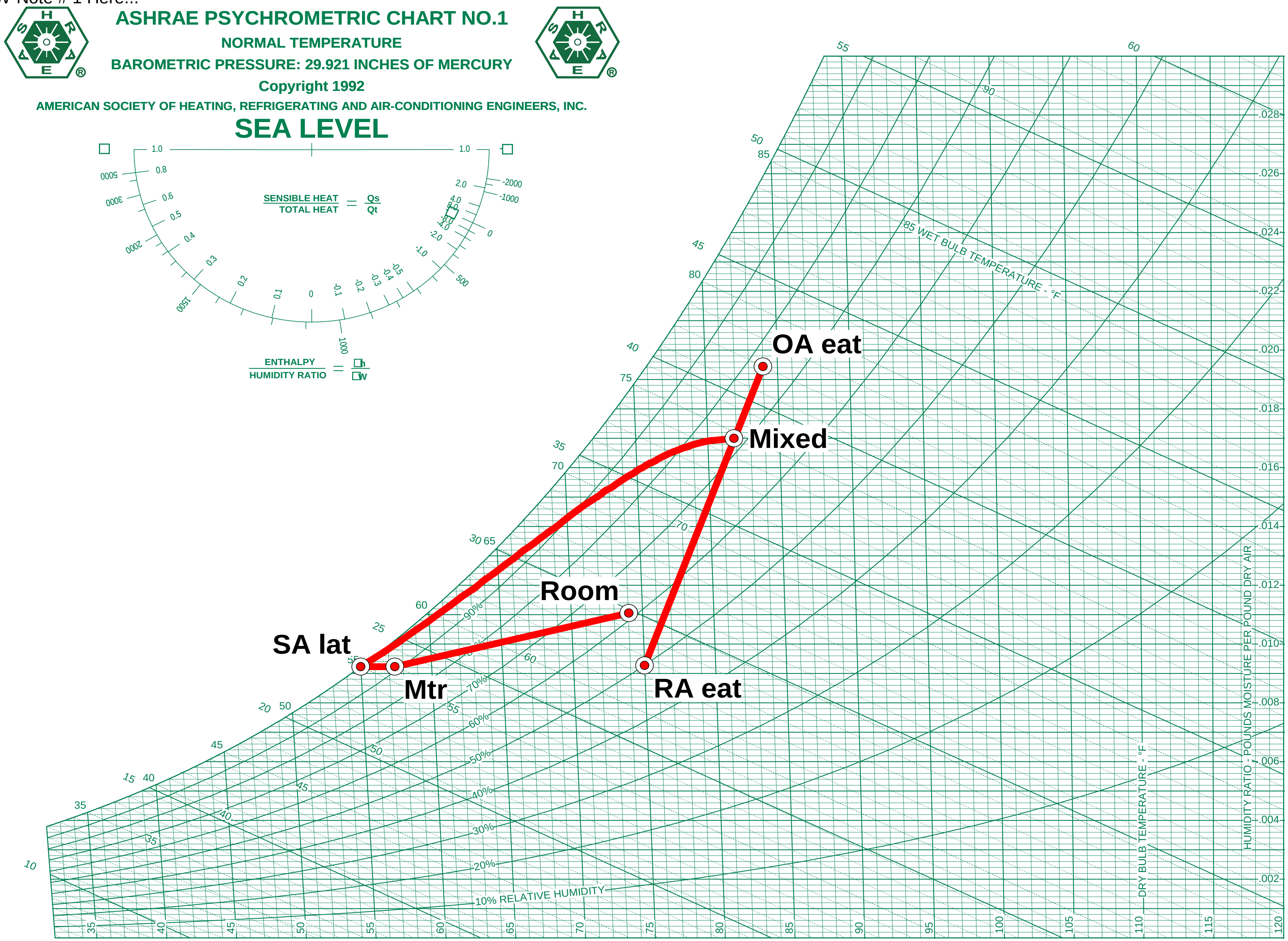

ASHRAE PSYCHROMETRIC CHART NO.1
NORMAL TEMPERATURE
BAROMETRIC PRESSURE: 29.921 INCHES OF MERCURY
Copyright 1992
AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
SEA LEVEL
SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO
85 WET BULB TEMPERATURE - °F
10% RELATIVE HUMIDITY
DRY BULB TEMPERATURE - °F
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
OA eat
Mix
Room
RA eat
SA lat
Mtr

VAV AIR CONDITIONING

Part Load



NEW Note # 1 Here...



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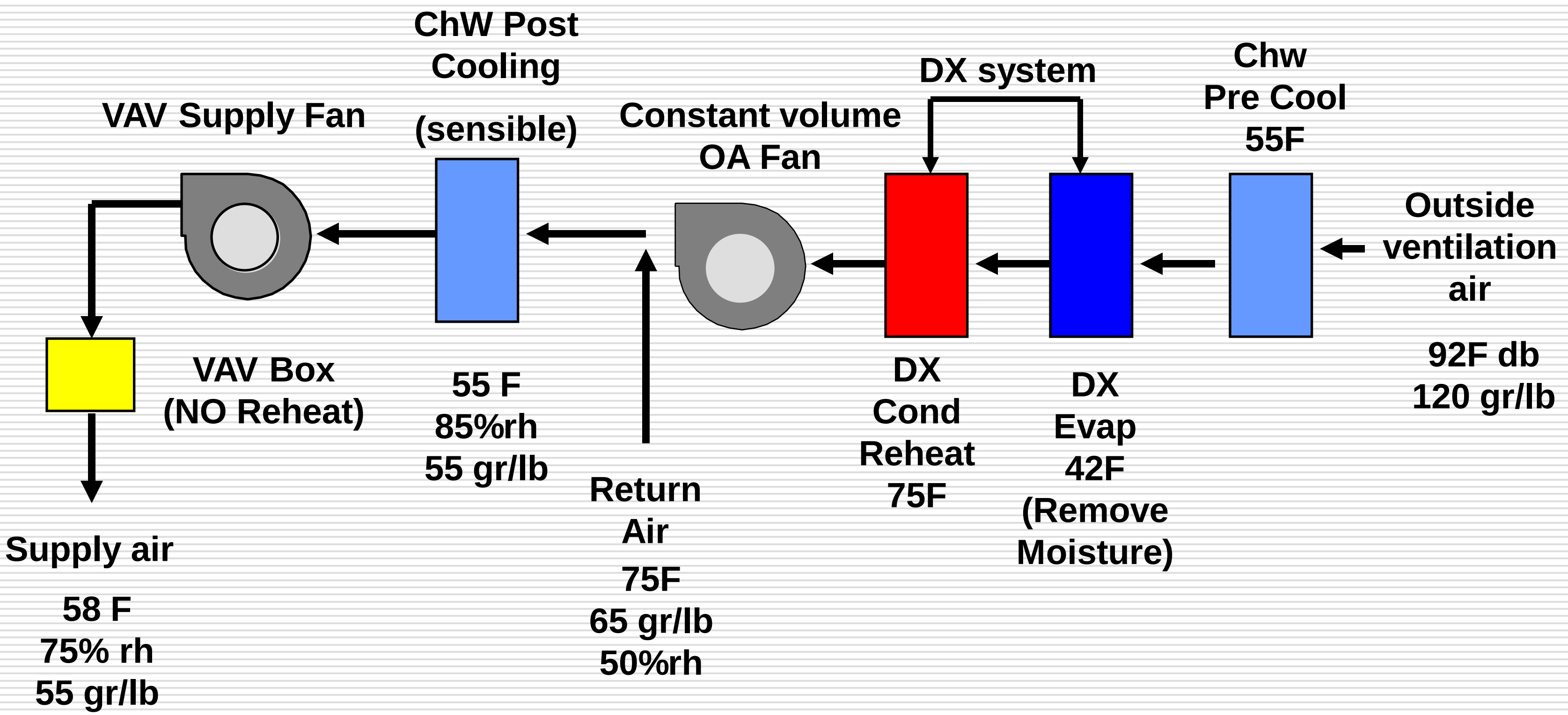
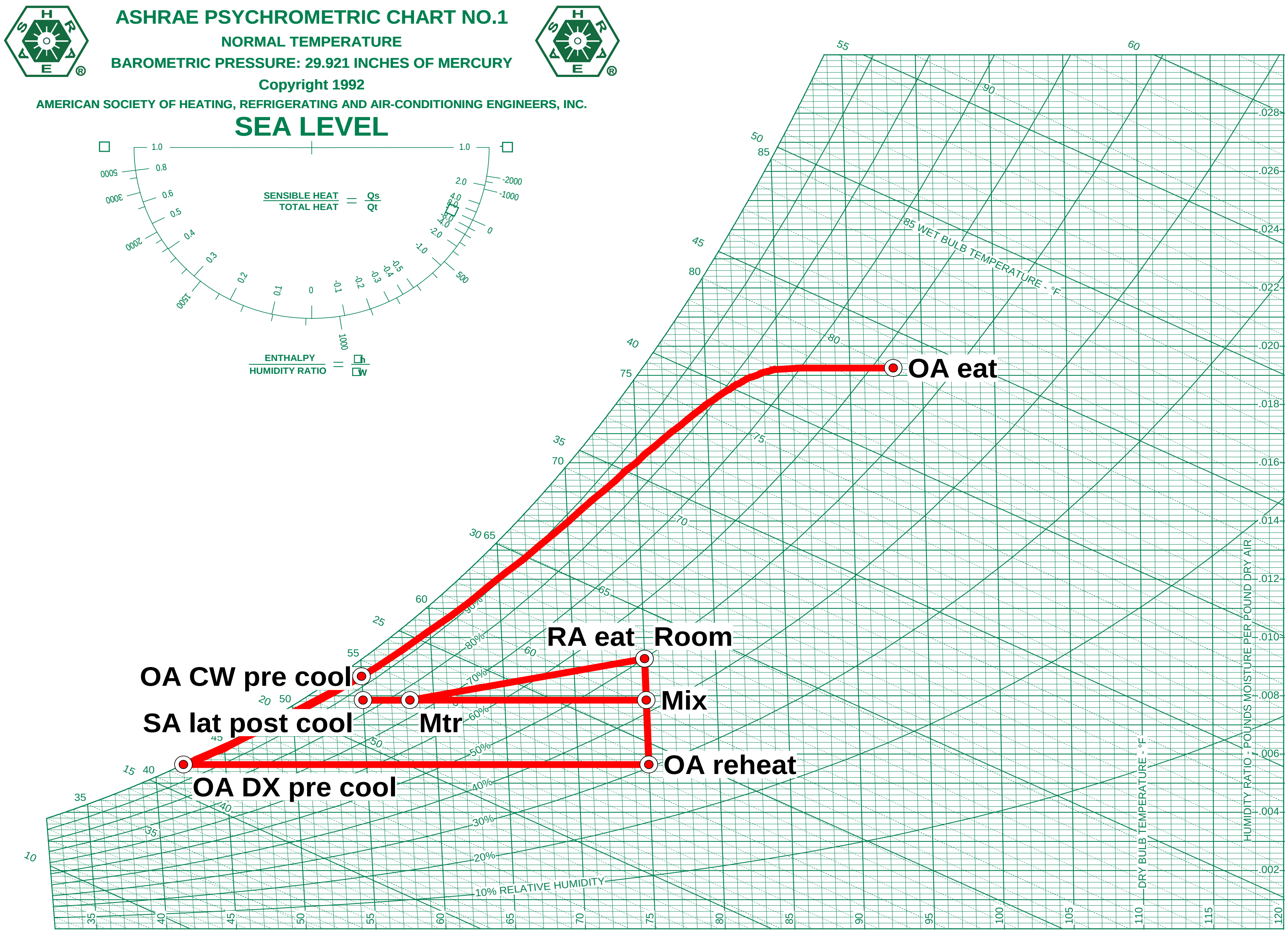
OA Pre Treatment with Post Cooling

Full Load

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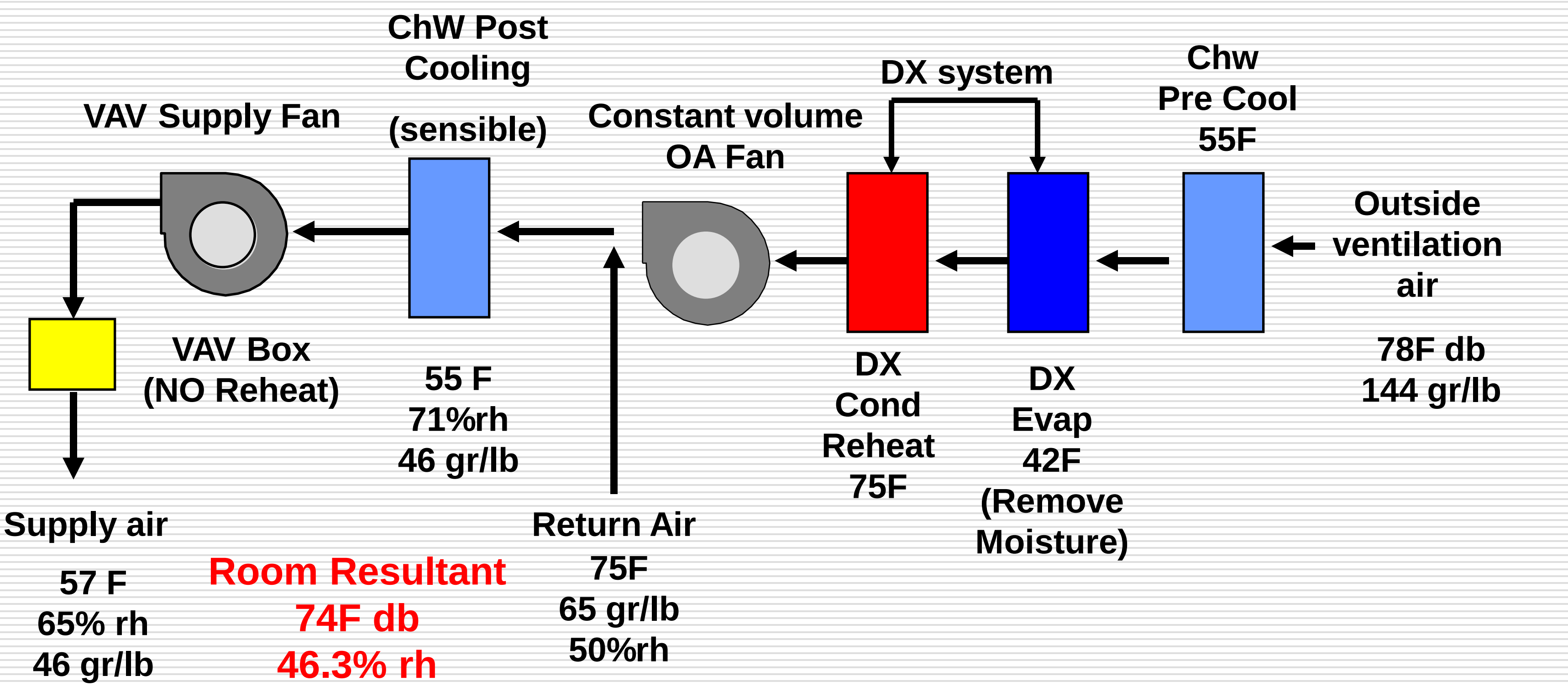
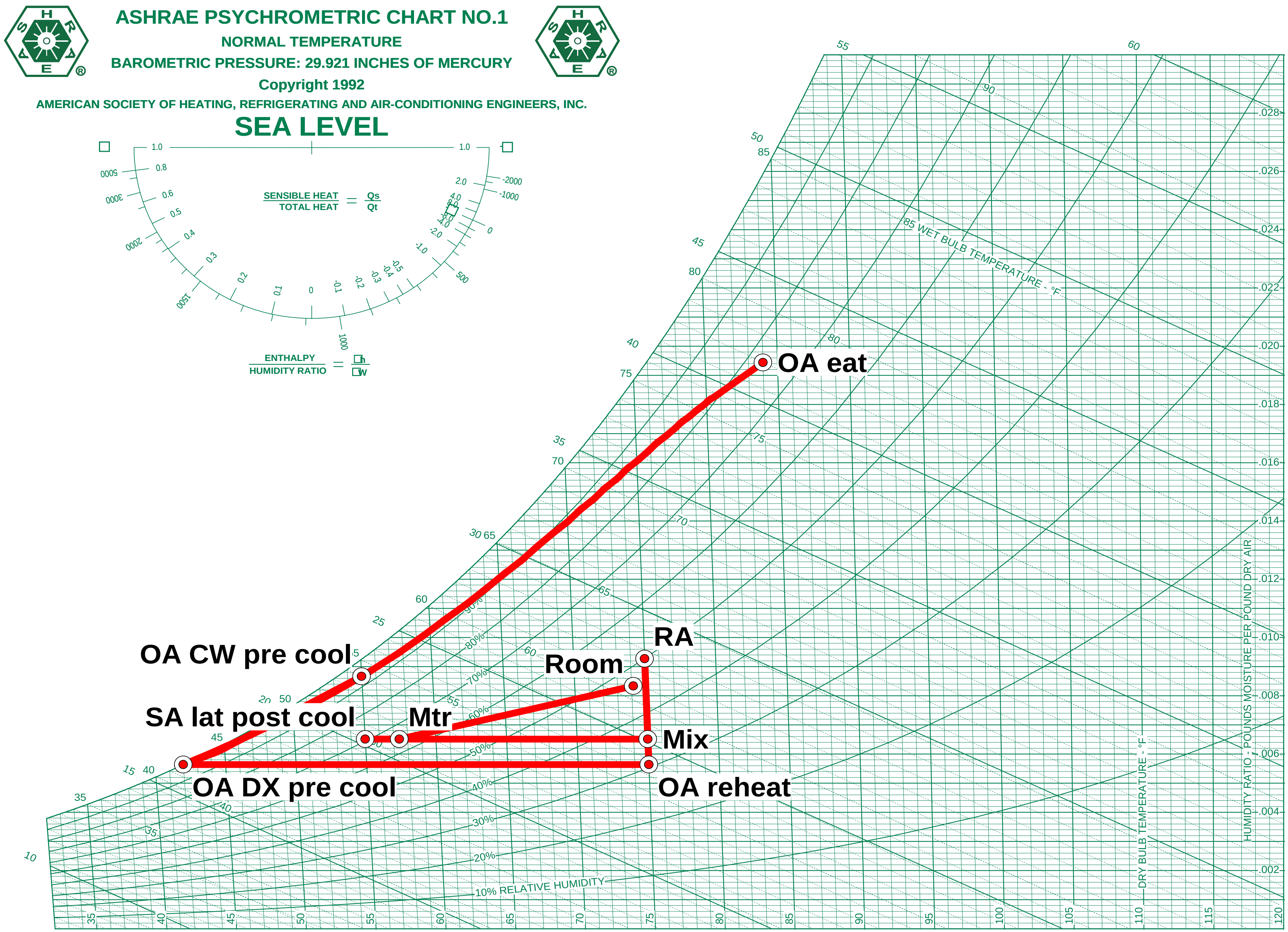
SEA LEVEL
SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO
85 WET BULB TEMPERATURE - °F
10% RELATIVE HUMIDITY
DRY BULB TEMPERATURE - °F
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
OA eat
RA eat
Room
OA CW pre cool
Mix
SA lat post cool
Mtr
OA reheat
OA DX pre cool

OA Pre Treatment with Post Cooling

Part Load




ASHRAE PSYCHROMETRIC CHART NO.1
NORMAL TEMPERATURE
BAROMETRIC PRESSURE: 29.921 INCHES OF MERCURY
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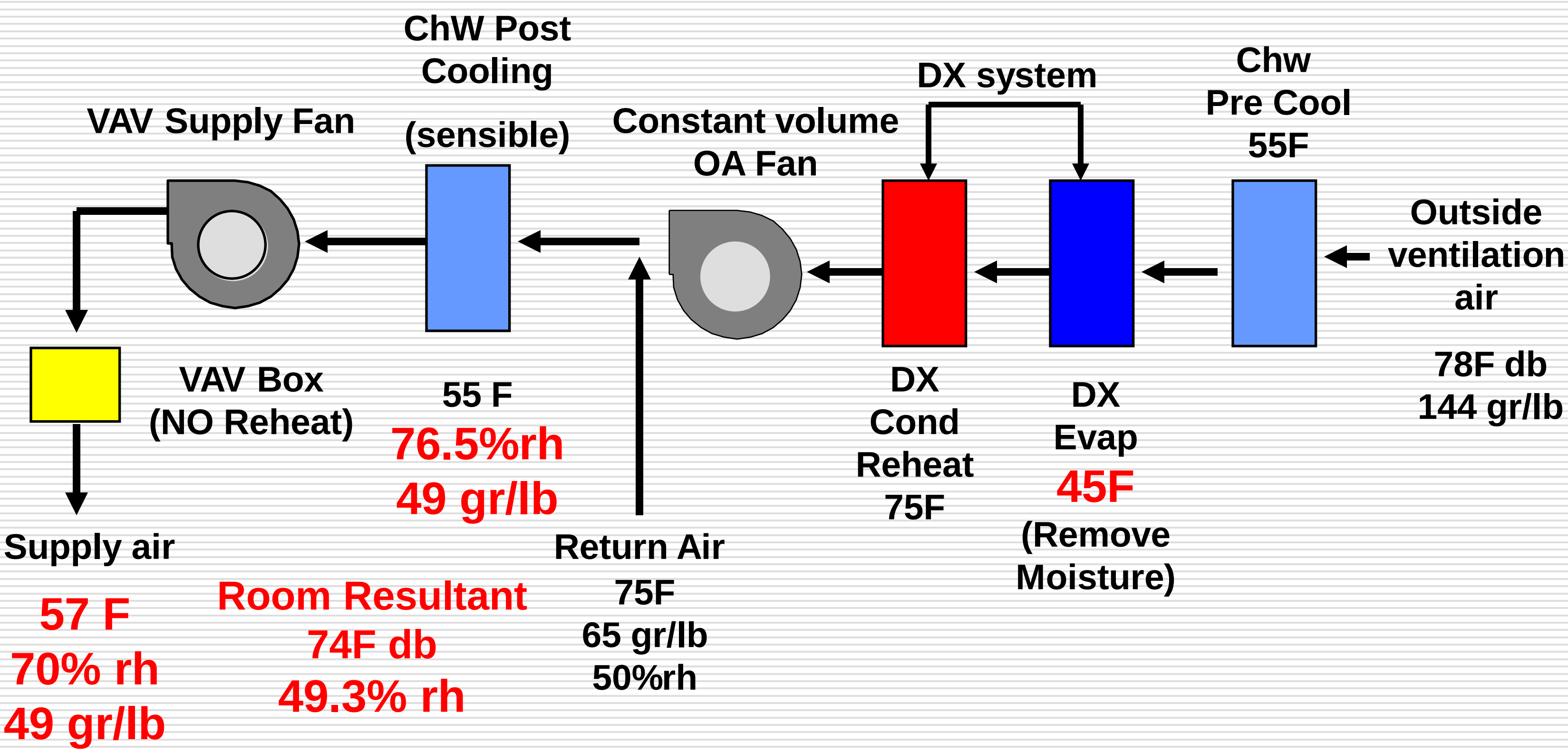
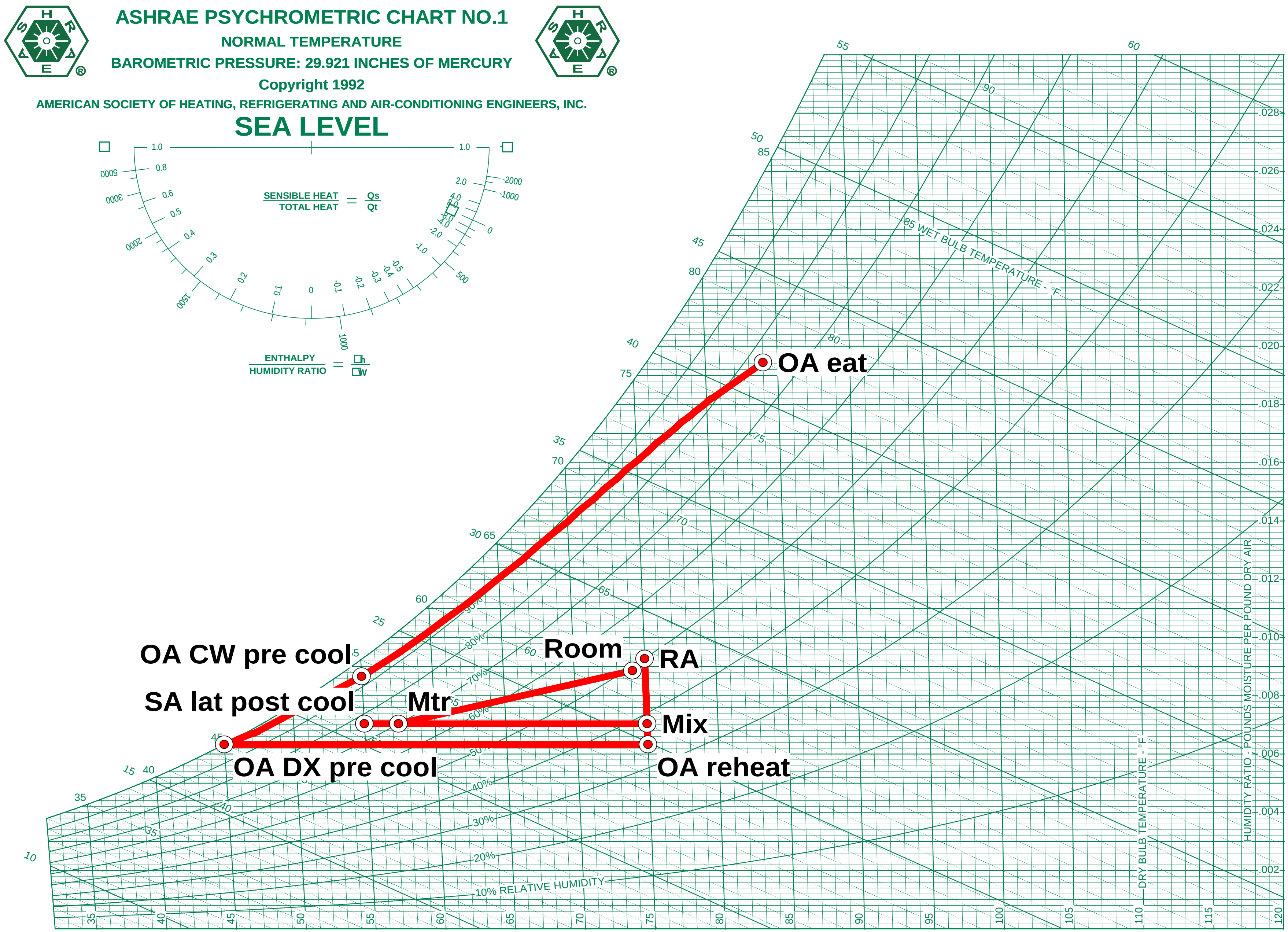
AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
SEA LEVEL
SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO = Δh / ΔW
85 WET BULB TEMPERATURE - °F
10% RELATIVE HUMIDITY
DRY BULB TEMPERATURE - °F
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
OA eat
OA CW pre cool
SA lat post cool
Mtr
Room
RA
Mix
OA DX pre cool
OA reheat

OA Pre Treatment with Post Cooling

Part Load – reset DX

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BAROMETRIC PRESSURE: 29.921 INCHES OF MERCURY
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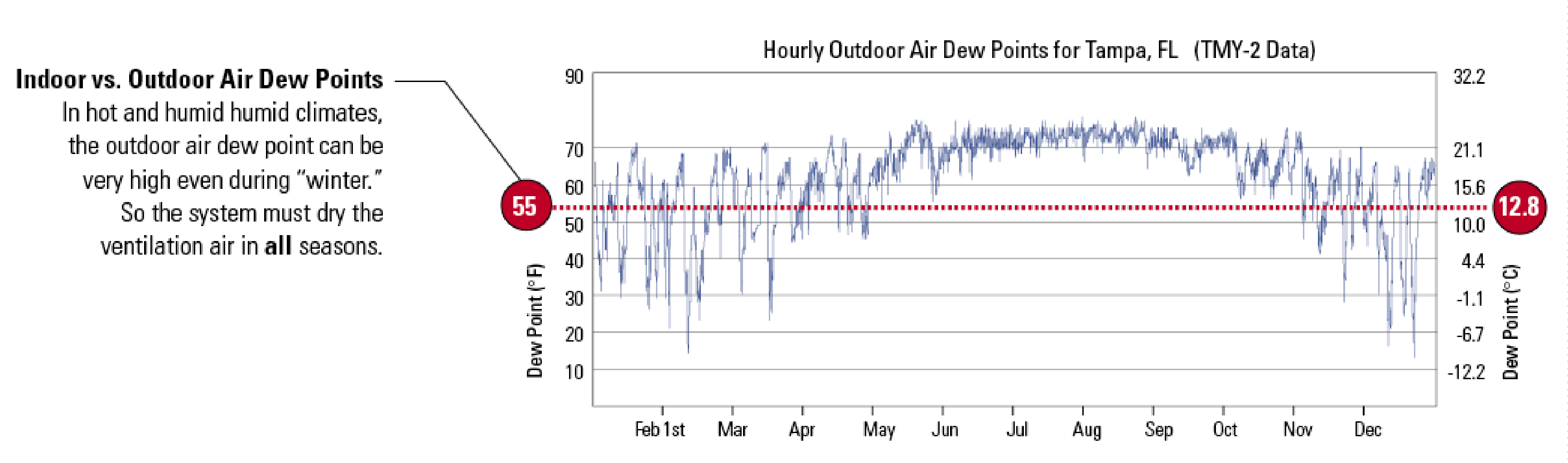
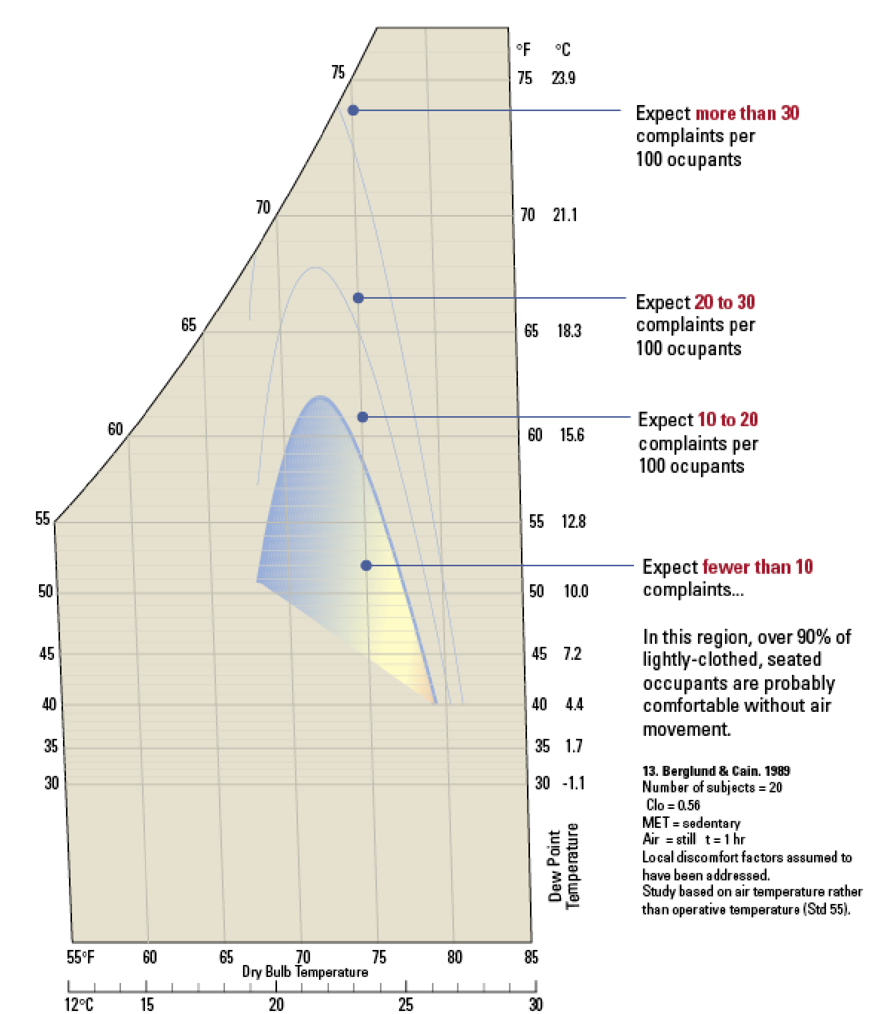
AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
SEA LEVEL
SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO
85 WET BULB TEMPERATURE - °F
10% RELATIVE HUMIDITY
DRY BULB TEMPERATURE - °F
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
OA eat
OA CW pre cool
SA lat post cool
Mtr
Room
RA
Mix
OA DX pre cool
OA reheat

Ventilation - If it's not dried… you're in trouble





Comfort - Keep the dew point under control, and comfort happens at warmer, more energy-efficient temperatures

Design Considerations

- It’s a system… not just a unit
  - The habitable space is a plenum
  - Uncontrolled air flow – ASHRAE Journal
- Don’t operate in a vacuum… it’s a team effort… Use integrated design approach and solutions
- Sequence of operation
- ***Control outside air at the source***
- Control condensation

SUMMARY

RISK MITIGATION

- Architectural
  - Effective flashing around all penetrations
  - Pan flashing under windows and doors
  - Drain water away from the building using effective drainage planes
  - Continuously sealed water & air barrier

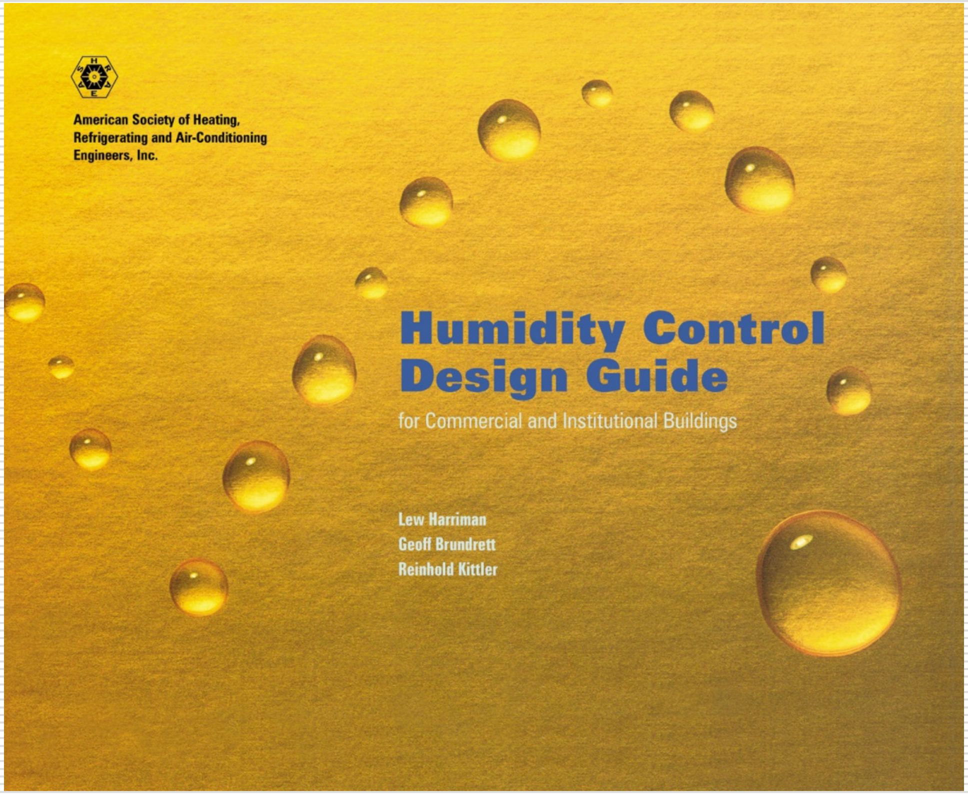
RISK MITIGATION

- Mechanical
  - Design dehumidification for peak outdoor dew point
  - All ventilation air dried to below building dew point
  - Control building dew point during unoccupied hours
  - Control ductwork air leakage

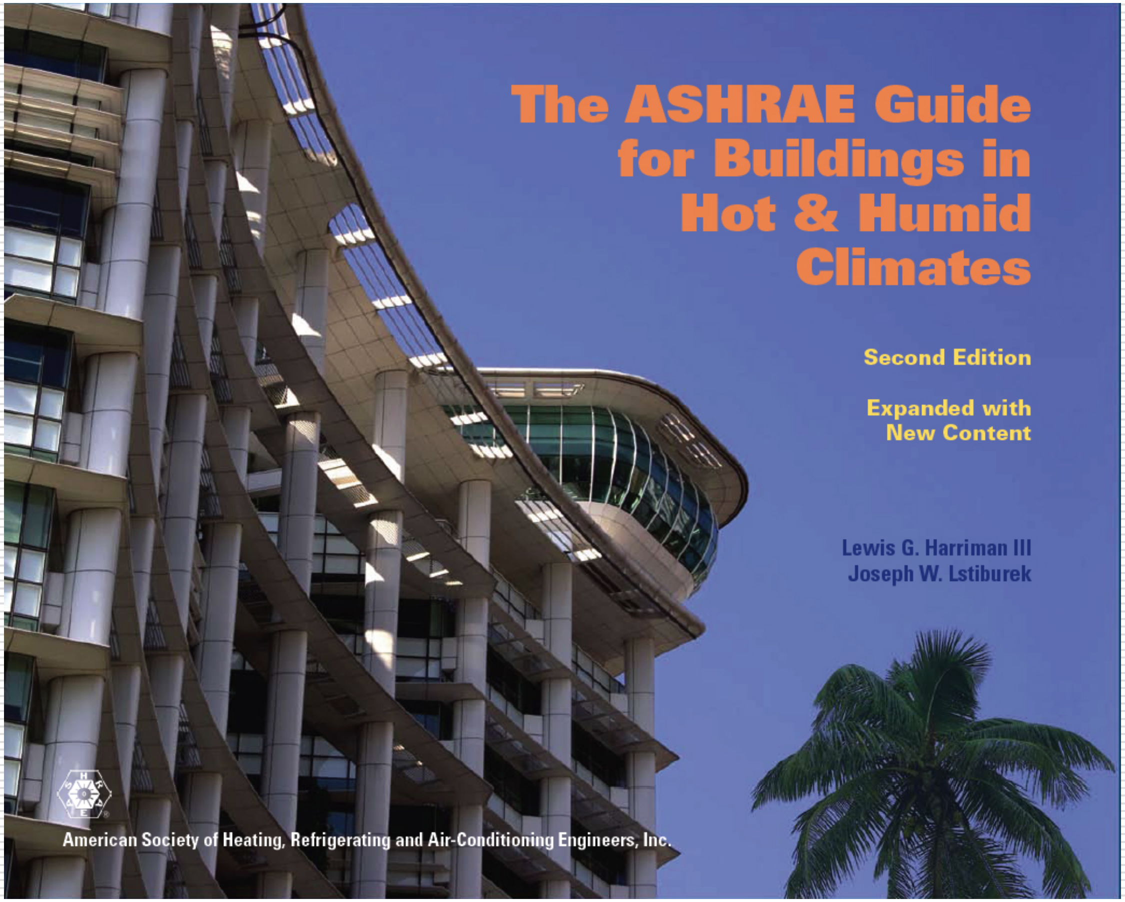
ASHRAE Standards and Publications

- **Humidity Control Design Guide**

  For Commercial and Institutional Buildings

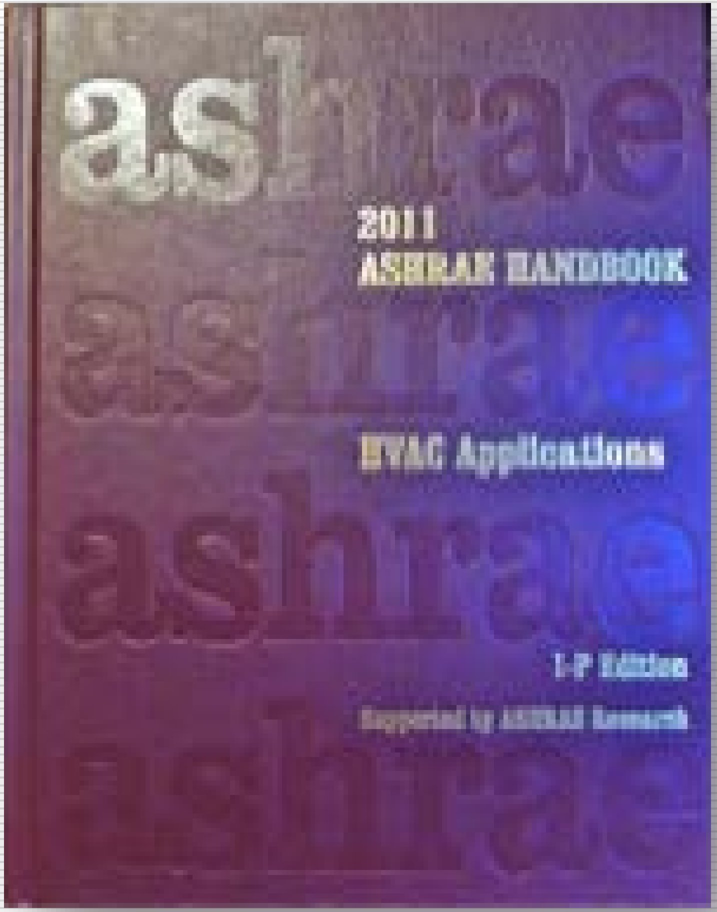


ASHRAE Standards and Publications



ASHRAE Standards and Publications

- ASHRAE Handbooks



Reference Publications

- Water in Buildings; An Architect's Guide to Moisture and Mold: William Rose, Ph.D, FAIA, FASHRAE
- Building Science for Building Enclosures: John Straube, Ph.D, P.Eng, & Eric Burnett, Ph.D., P.Eng
- Builder's Guide to Hot – Humid Climates: Joseph Lstiburek; Ph.D, P.Eng, FASHRAE
- Recognition, Evaluation, and Control of Indoor Mold: American Industrial Hygiene Association
- The JLC Guide to Moisture Control: Journal of Light Construction

Q & A