Water-Resistive Barriers,
Last Line of Defense

Laverne Dalgleish
ABAA

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Course #: RAiNA-CONF24-3

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RAINSCREEN ASSOCIATION IN NORTH AMERICA

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Presenter Bio

Laverne Dalgleish
ABAA, RAiNA

Laverne Dalgleish is the Chief Operating Officer for the Rainscreen Association in North America (RAiNA). As such, he works to champion energy conservation in buildings while educating the building owners and designers about the benefits of energy conservation such as durability, comfort, reduced maintenance, reduced HVAC equipment costs and the positive impact on the environment. Mr. Dalgleish travels across North America weekly to educate building owners and designers on the advantages of efficient and functional air barrier systems and rainscreen assemblies in buildings. His mission involves collaborating with standards development organizations, training and education groups, government policy departments, and quality assurance program developers within the construction industry.
Laverne Dalgleish also serves as the Executive Director of the Air Barrier Association (ABAA). Mr. Dalgleish chairs the ULC Thermal Performance in the Building Environment Standards Committee. He was the key developer of the ABAA Quality Assurance Program for installing air barrier systems in buildings. This program is based on ISO9000 and ISO 12576-2 but brings the ISO requirements together with practical applications for the air barrier industry.

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air barrier
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ABSTRACT

- There is a lot of misunderstanding about the differences between Air Barriers, Water-Resistive Barriers and Vapor Barriers. The definitions start out very simple but as you start to use them in the building envelope, it becomes very complicated. The presentation walks you through the process of understanding the differences between the barriers and then deals with how you select materials and how and where you would install the material in the building assembly.

LEARNING OBJECTIVES

- Define the four control layers
- Explain why a material meets a definition but it is not used to perform that function
- Determine how to identify a material properly
- List critical installation requirements
- Identify means for quality assurance

BUILDING ENVELOPE

BUILDING ENVELOPE

BUILDING MATERIALS

Materials have different:

- Heat flow (conduction)
- Air flow (convection and air permeance)
- Moisture flow (water absorption, vapor permeance)
- Durability

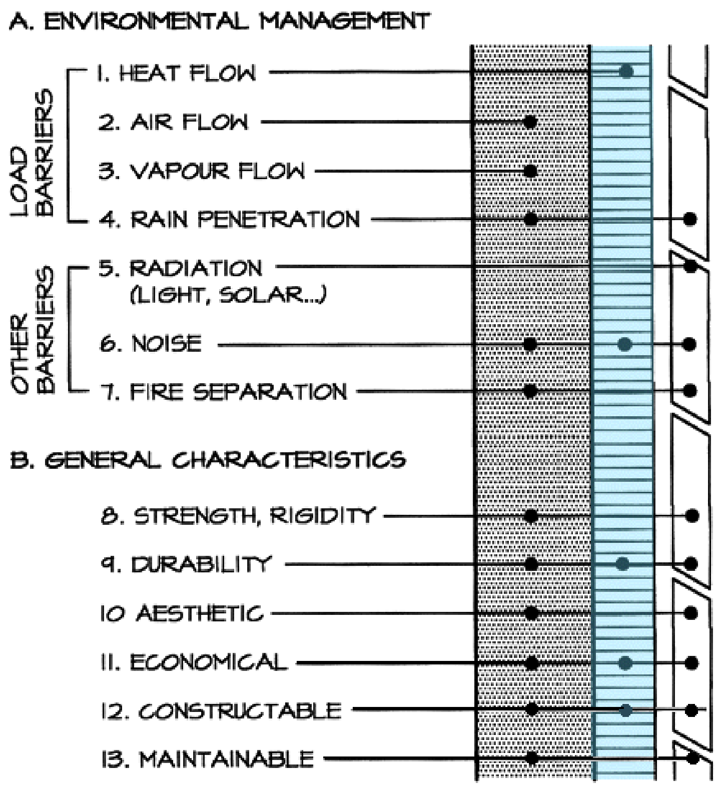
Environment – interior and exterior can change hour by hour

Why do we have moisture problems?

The four control layers must be considered together in the following order

1. Rain penetration (bulk water)
2. Air Flow (water vapor transport)
3. Heat Flow (keeps the assembly warm)
4. Vapor Flow (water vapor through the material)

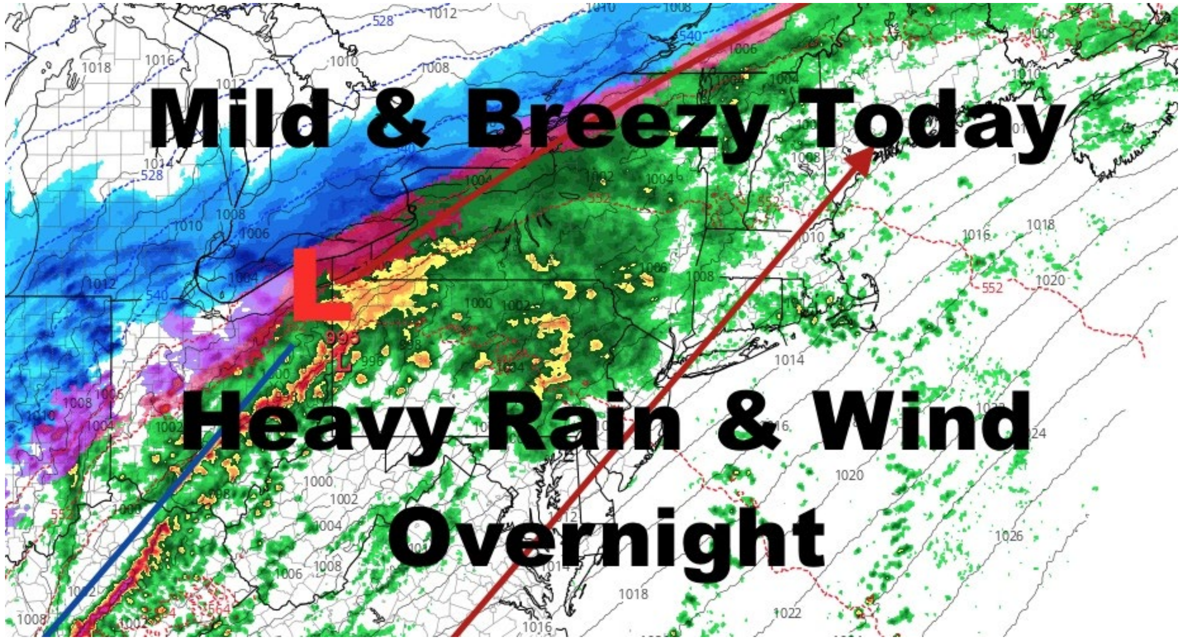
Yet we focus on the water vapor transmission of a single material



ENVELOPE REQUIREMENTS (PRIMARY FUNCTIONS)

Rain Penetration

- Cladding systems shed most of the water hitting the building assembly

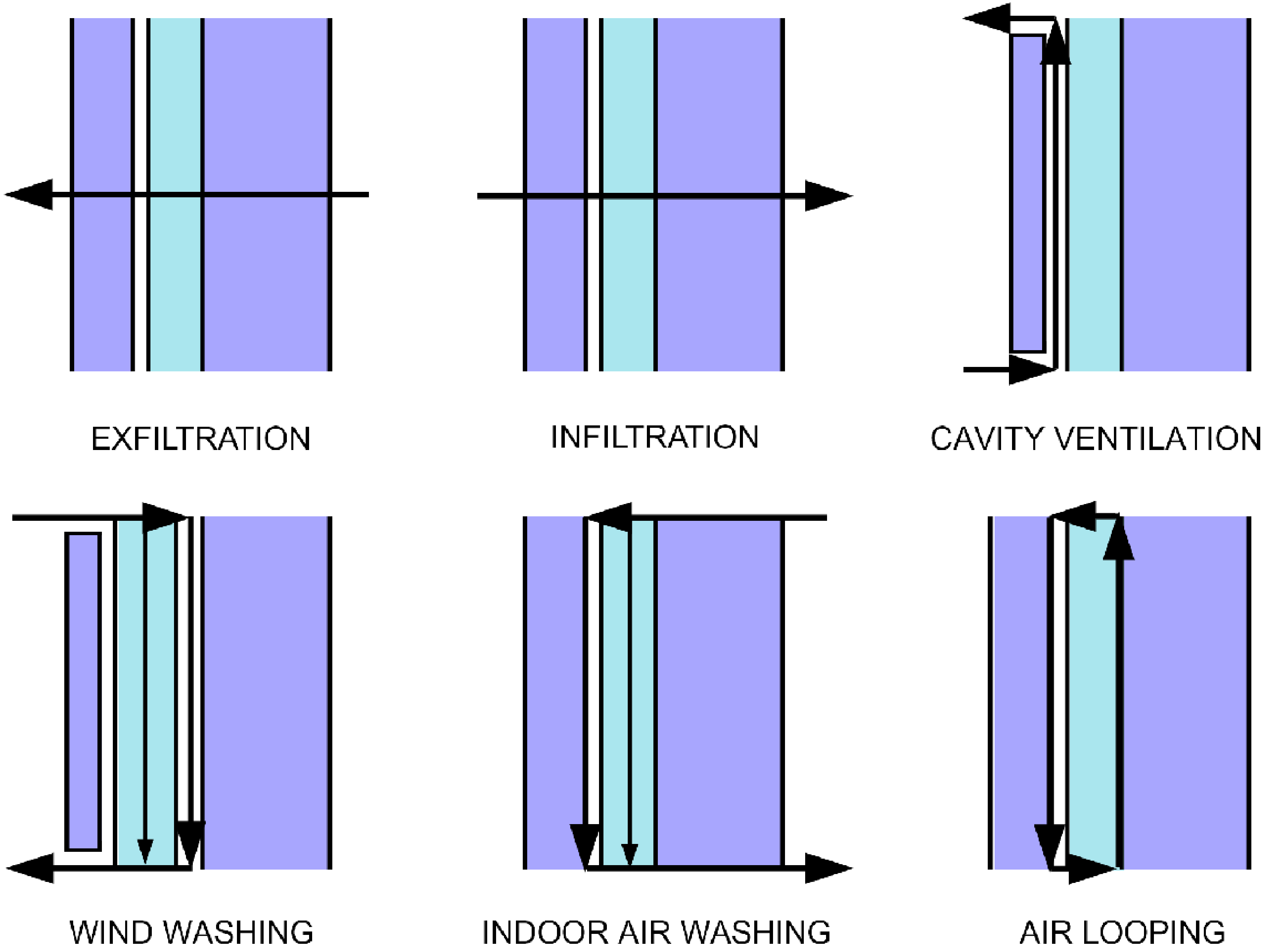


ASHRAE Standard 160 – 2% of water hitting the cladding will work its way into the wall assembly

AAMA Standard 501.1 test – you look for water on the interior of a building

Air Flow – Pressure differences

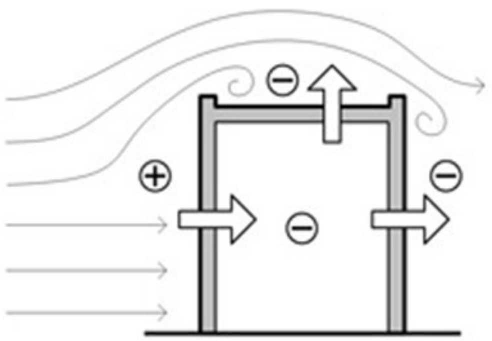
- Stack Effect
- Wind Effect
- Flue Effect
- Ventilation Effect

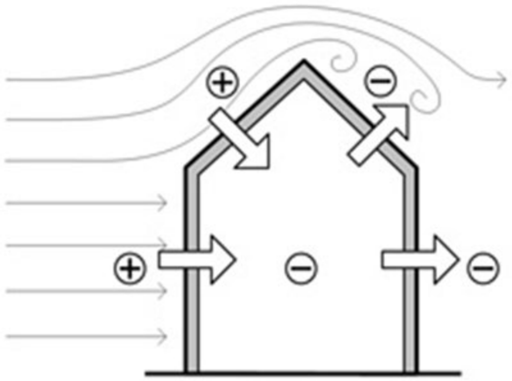

EXFILTRATION
INFILTRATION
CAVITY VENTILATION
WIND WASHING
INDOOR AIR WASHING
AIR LOOPING

•**Exfiltration (air outflow)**: air passes across an envelope component moving from inside the building component to the outdoors
•**Infiltration (air inflow)**: air passes across an envelope component from the outside of the building component to the inside
•**Cavity ventilation**: outdoor air flows along an air cavity at the exterior of the thermal insulation layer without washing or penetrating the insulation layer
•**Wind washing**: outdoor air permeates the thermal insulation layer and/or flows along the air layer behind
•**Indoor air washing**: indoor air permeates the thermal insulation layer and/or flows along the air layer behind
Air looping: buoyancy forces cause air to flow around and wash the thermal insulation layer filling the cavity

Air Flow – Wind Effect

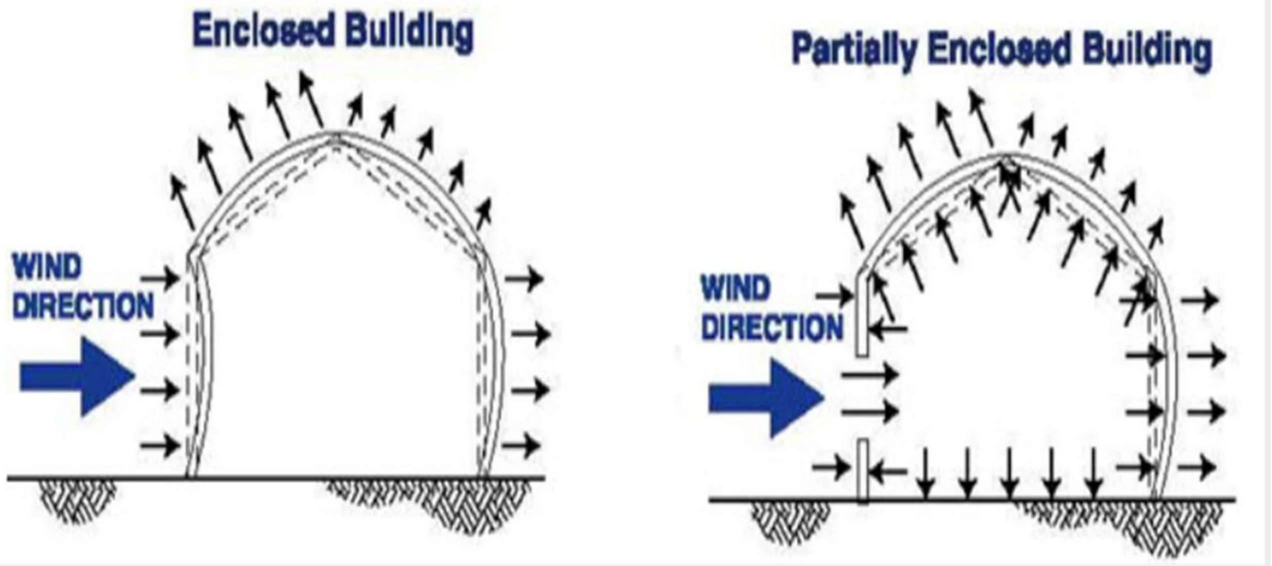
- Creates pressure differences





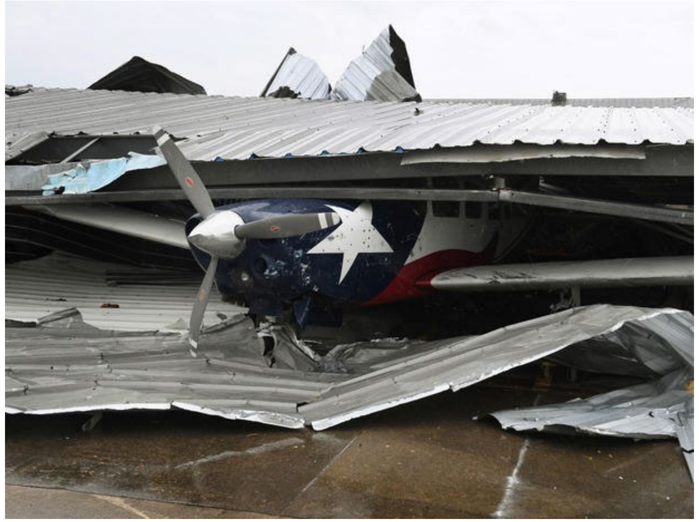
Infiltration and exfiltration at the same time

Infiltration can over pressurize the inside while wind uplift tries to suck the roof off



Air Flow – Wind Effect

- Creates pressure differences



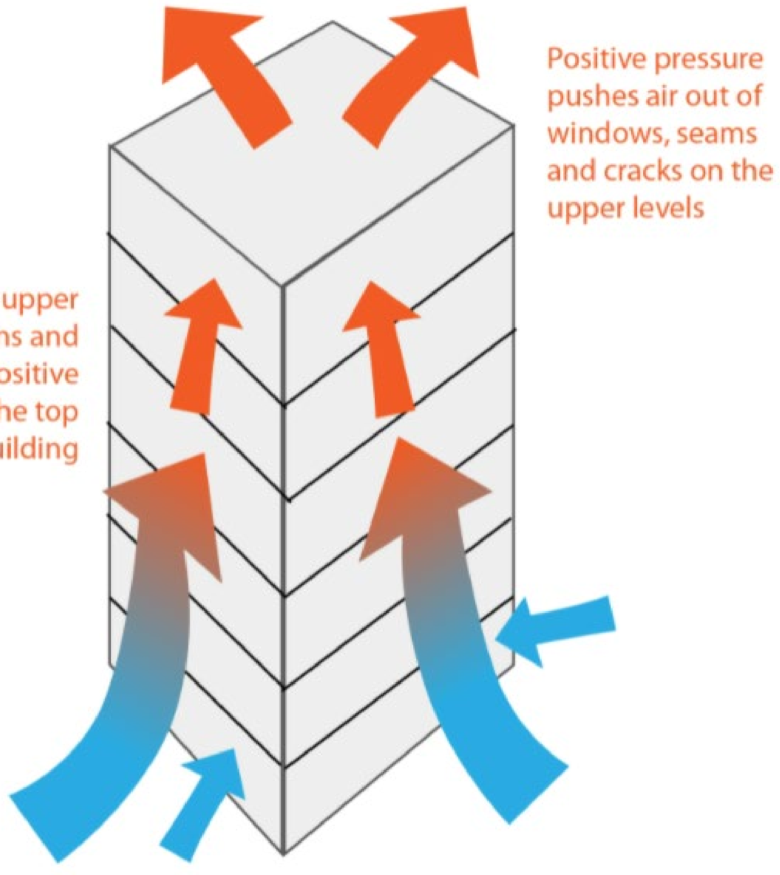
Air Flow – Wind Effect

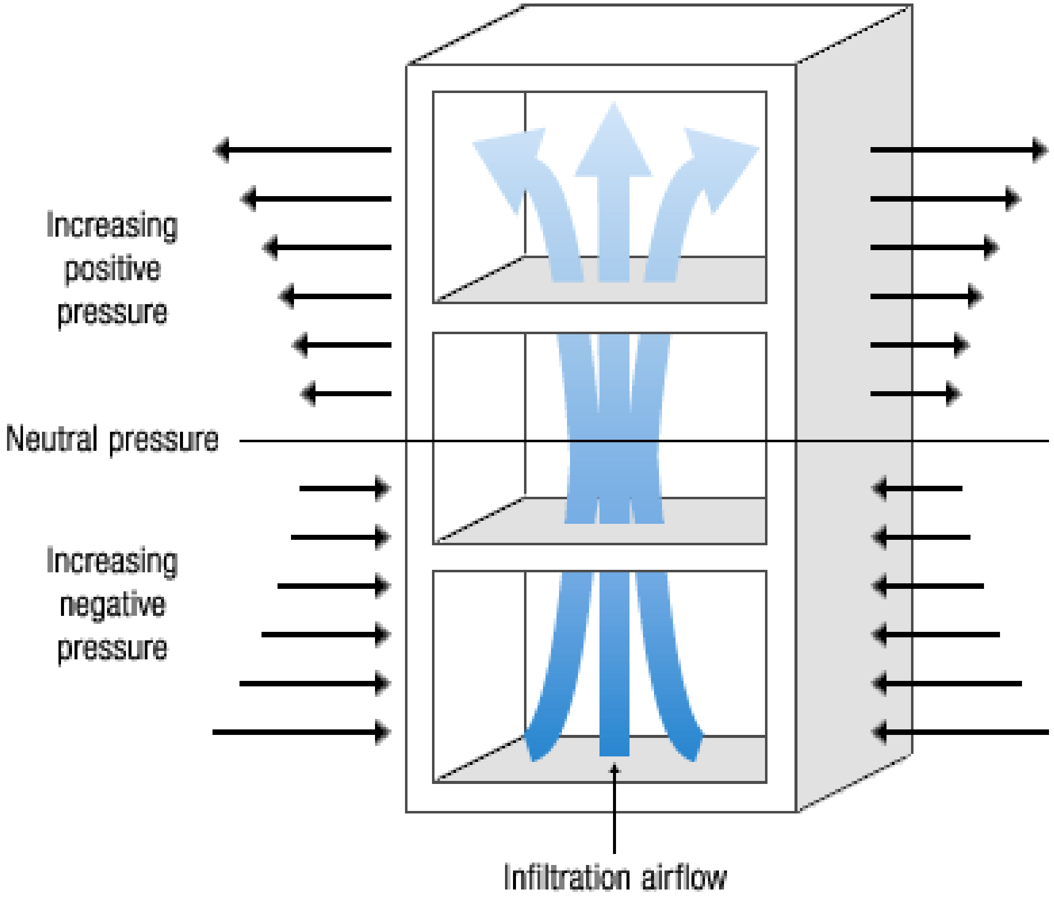
- Height of a building creates pressure differences

Maximum Building Height above grade (H), m	Cyclic $(P_2)^2$, Gust (P_3) Pressures, Pa	Sustained 1 in 50 hourly wind pressure (P_1), Pa					
		450	550	650	750	850	1000
ASTM E2357	P_2	660	800	950	1090	1240	1460
12	P_3	980	1200	1410	1630	1850	2180
20	P_2	720	880	1050	1210	1370	1610
	P_3	1080	1320	1570	1810	2050	2410
40	P_2	1340	1630	1930	2220	2520	2970
	P_3	2000	2440	2880	3320	3770	4430
60	P_2	1440	1770	2090	2420	2740	3220
	P_3	2160	2640	3120	3610	4090	4810
80	P_2	1530	1870	2220	2560	2900	3410
	P_3	2290	2800	3310	3820	4330	5090
100	P_2	1610	1960	2320	2670	3030	3560
	P_3	2400	2930	3460	3990	4530	5320
120	P_2	1630	2030	2400	2770	3150	3700
	P_3	2480	3040	3590	4140	4700	5520

Air Flow – Stack Effect (and Flue Effect)

- Creates pressure differences





Air Flow – Mechanical Effect

- Creates pressure differences

Mechanical Pressurization and Ventilation Effect

Fans draw air through a building

- Will create negative and positive pressures in a building
- Causes infiltration and ex-filtration through a building

Air Flow – Mechanical Effect

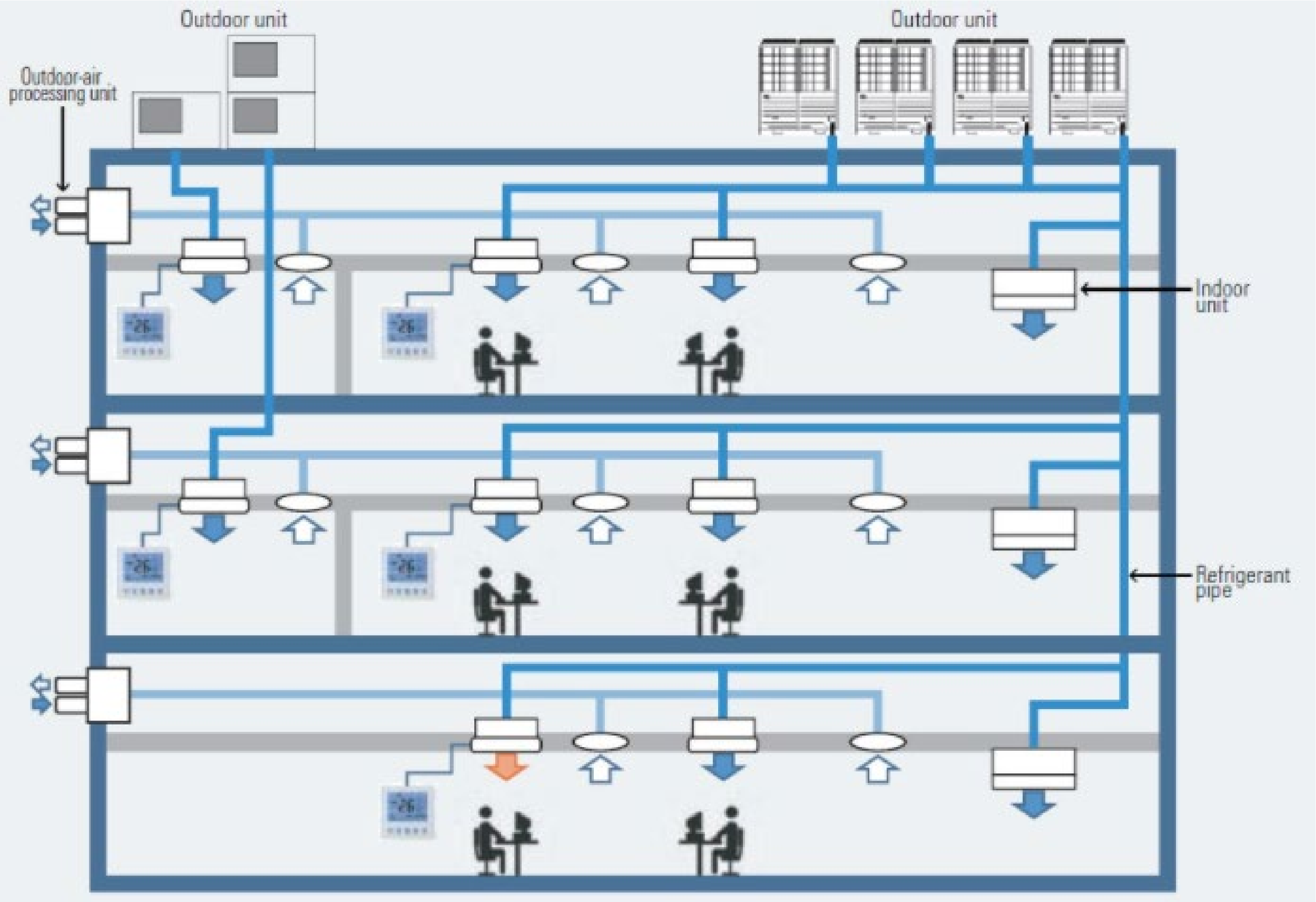
- Creates pressure differences

Mechanical Systems effect buildings by:

- Adding / removing heat
- Adding / removing moisture
- Creating different air pressures
- Moves air / heat / moisture from one part of the building / building component of another

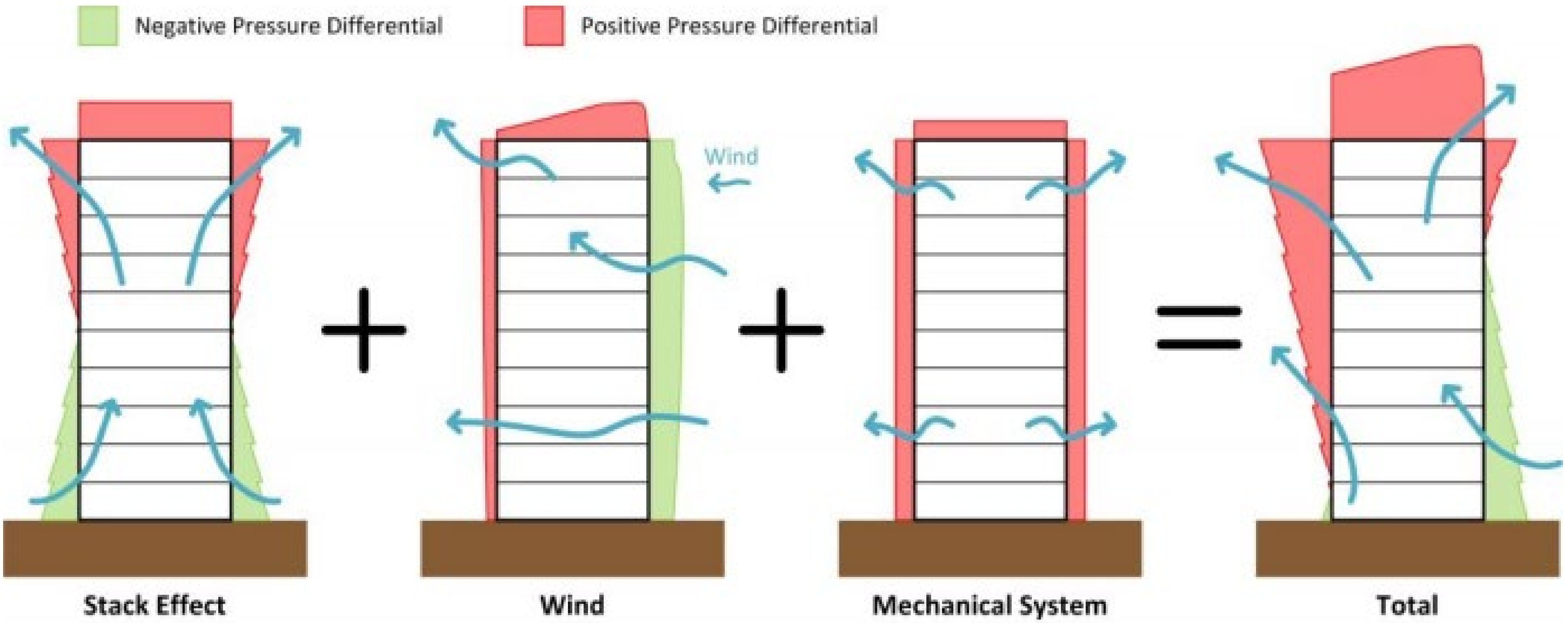
Air Flow – Mechanical Effect

- Creates pressure differences



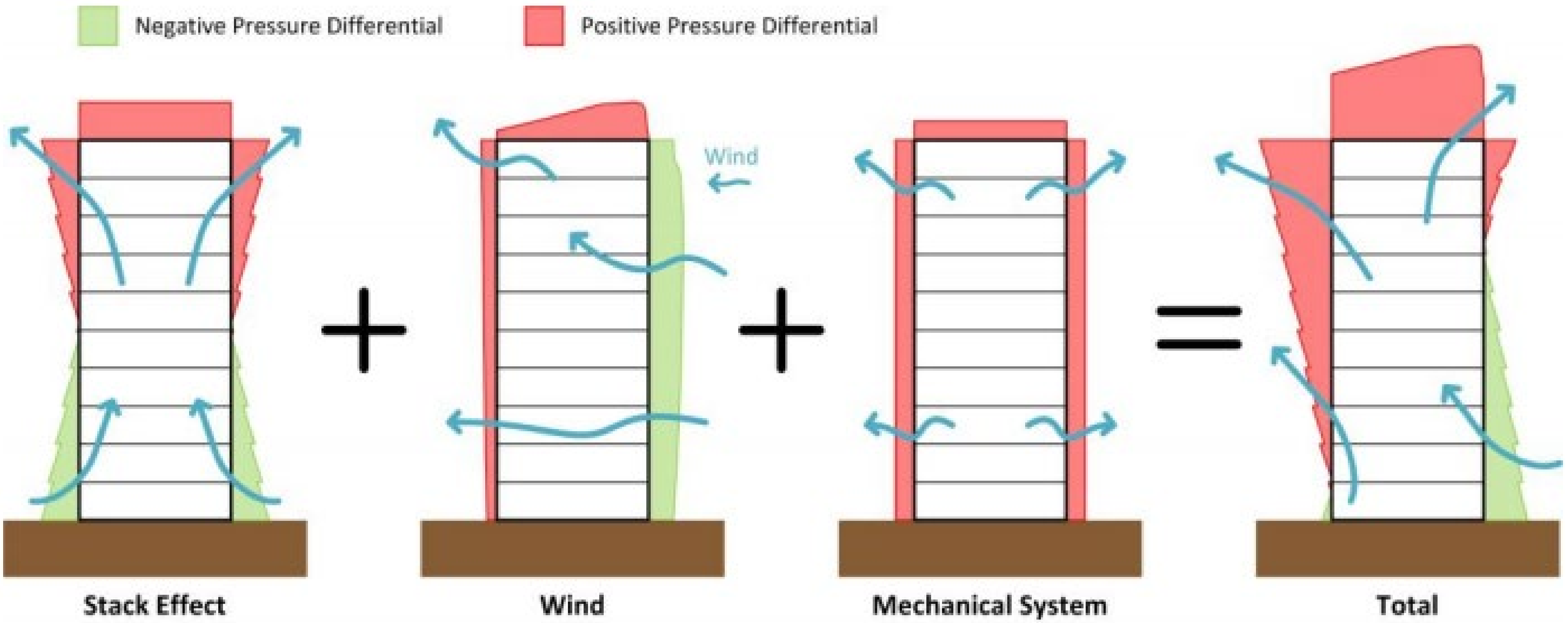
Air Flow – Composite Effect

- Creates pressure differences



Air Flow – Composite Effect

- Creates pressure differences



BUILDING SCIENCE

AIR FLOW

Who cares?

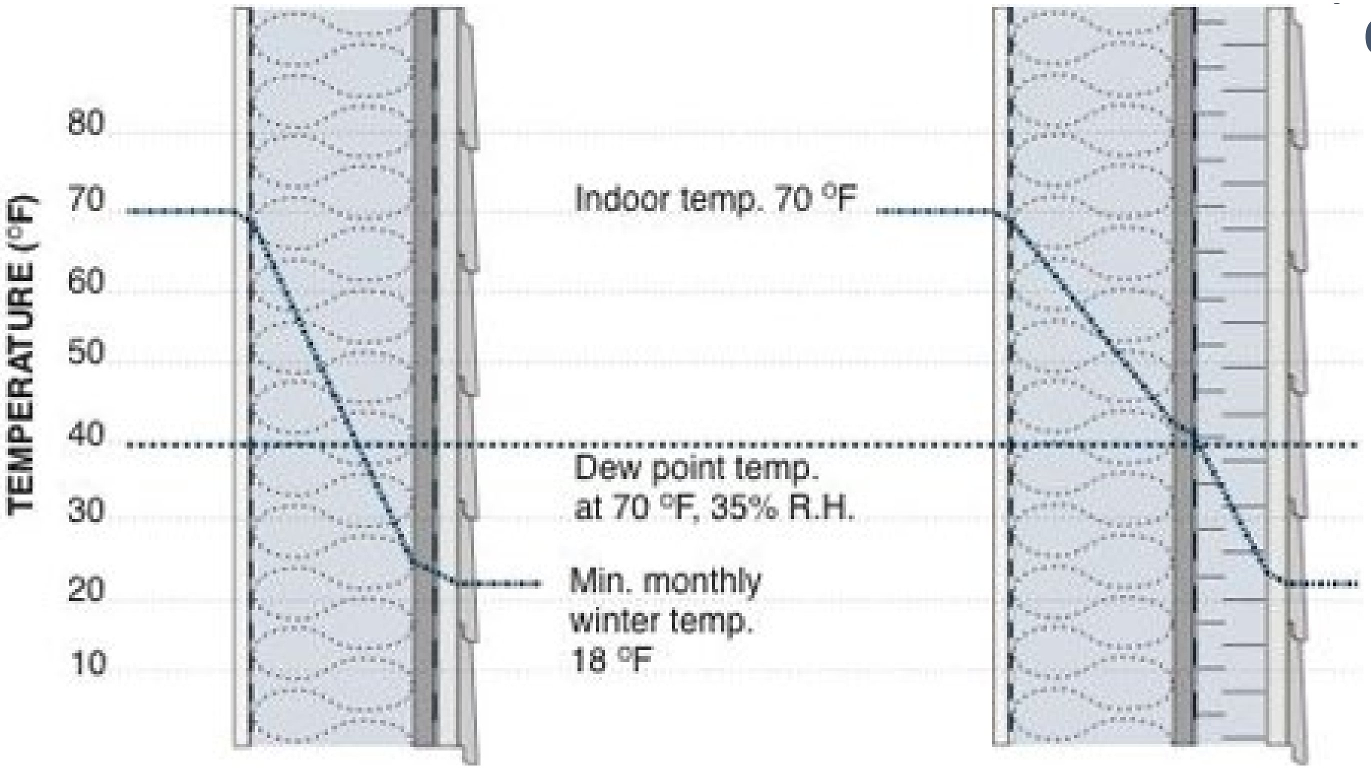
- Warm moist air transports a tremendous amount of moisture
- Energy savings

Moisture Movement – Comparing water vapor transmission through a material vs. air transport					
Location	Water vapor by air transport through a 1 in^2 hole in ounces/gallons		Water vapor transmission through 39" by 39" in of material ASTM E96 desiccant method Procedure A in ounces		
	Mid Rise	High Rise	5.7 ng (0.1 Perm)	57 ng (1.0 Perm)	570 ng (10 Perm)
Seattle, WA	5,543/34.64	18,120/113.25	0.166	1.66	16.6
San Francisco, CA	6,812/42.57	20,738/129.61	0.166	1.66	16.6
Chicago, IL	5,612/35.07	16,285/1010.78	0.166	1.66	16.6
Miami, FL	7941/49.63	17,577/109.86	0.166	1.66	16.6

Heat Flow – Changing the Dew Point

- Water vapor turns to liquid water

- The temperature where the relative humidity reaches 100% and the water vapor changes to liquid water

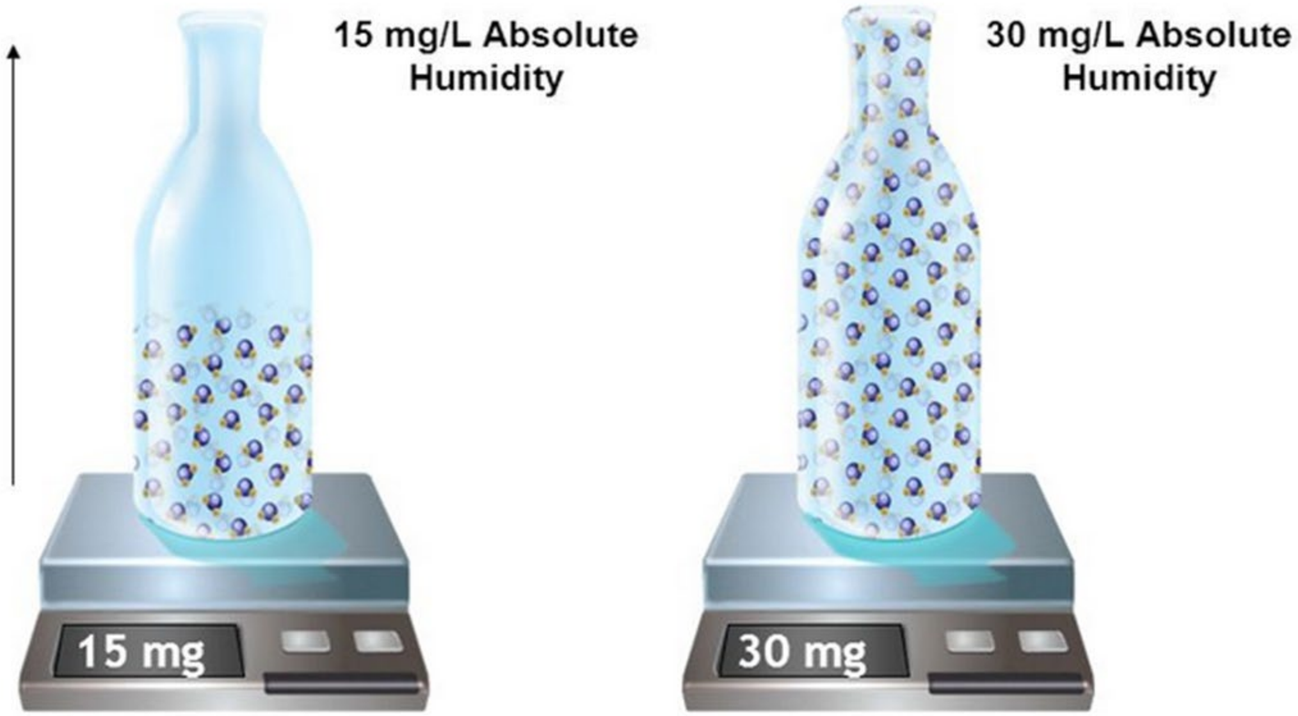


Heat Flow – Changing the Dew Point

- Water vapor turns to liquid

Heat Flow – Changing the Dew Point

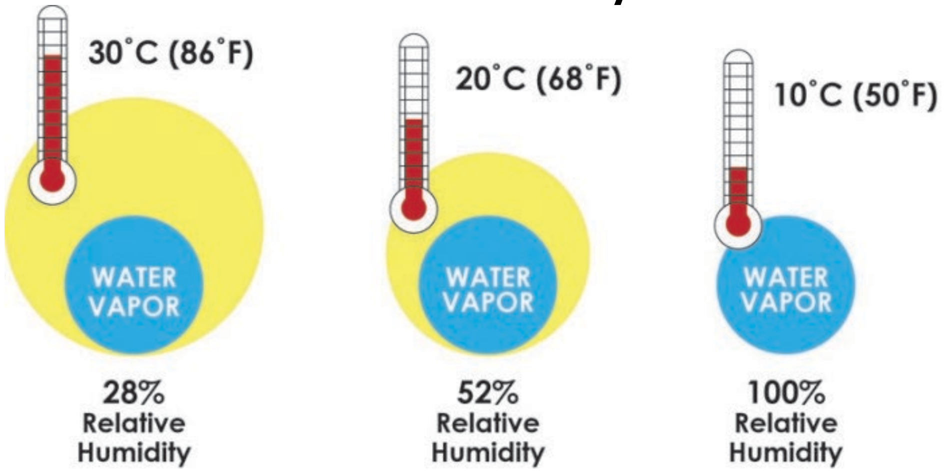
- Absolute humidity



- The amount of moisture in the air by weight – absolute humidity is not affected by temperature

Heat Flow – Changing the Dew Point

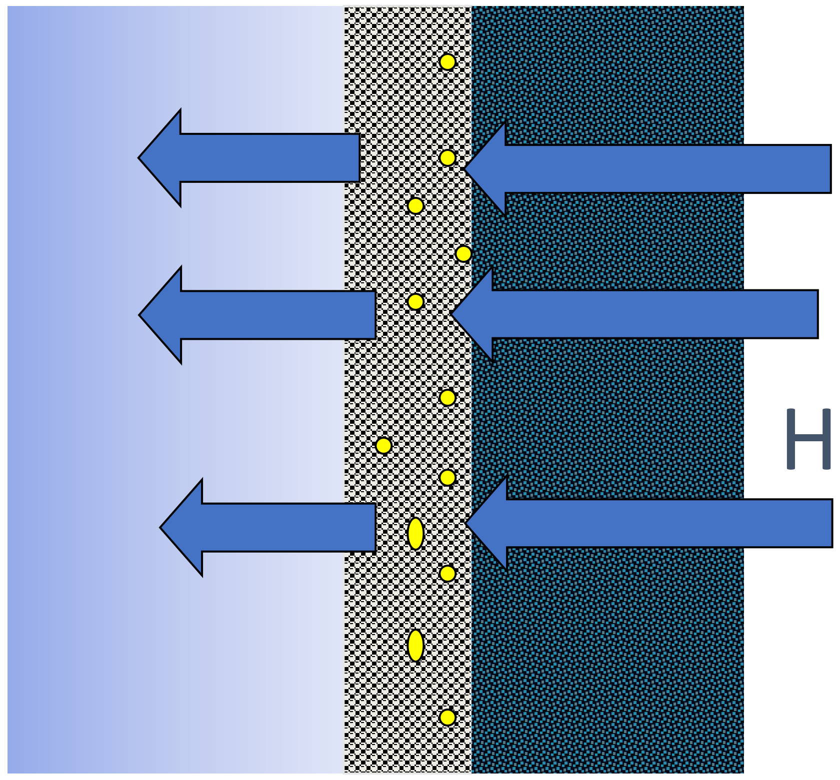
- Relative humidity



The amount of moisture in the air compared to the amount of moisture the air can hold at a specific temperature –

This will change as temperature changes even when the absolute humidity remains exactly the same

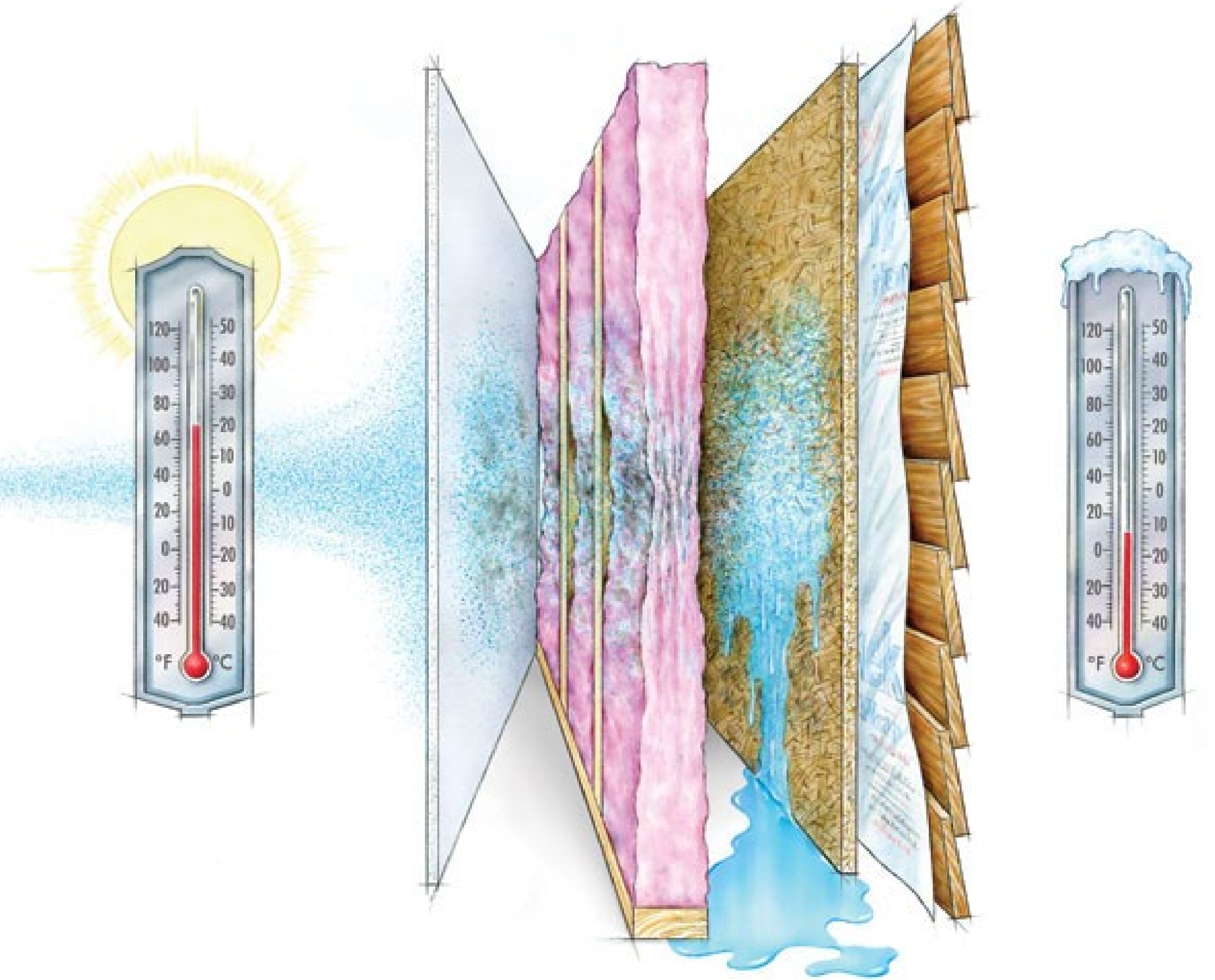
Water Vapor Flow – Very low and slow



Building Material

Water Vapor Flow – Very low and slow

- Relative humidity



Through a Material – Diffusion

- Use a vapor barrier / vapor retarder to protect building

Water Vapor Flow – Very low and slow

- Relative humidity

- A perm is equal to **57.2 nanograms meter^{-2} second^{-1} Pascal^{-1}** .
- Since there are 31,536,000 seconds in a year,
- 2985Pa of vapor pressure at saturation,
- 1,000,000,000 Ng per gram
- The vapor pressure for both the wet cup (100%-50%Rh) and dry cup (50%-0%RH) is 50% of the saturation vapor pressure or 1492Pa,
- The weight of water vapor going through one square meter of a **0.1 perm** (inch-pound) in a year would be 0.1*1492*31,536,000/1,000,000,000 or 4.71 grams (**0.166 ounces**).
- The weight of water vapor going through one square meter of a **1.0 perm** (inch-pound) in a year would be 1.0*1492*31,536,000/1,000,000,000 or 47.1 grams (**1.66 ounces**).
- The weight of water vapor going through one square meter of a 10 perm (inch-pound) in a year would be 10*1492*31,536,000/1,000,000,000 or 471 grams (**16.60 ounces**).

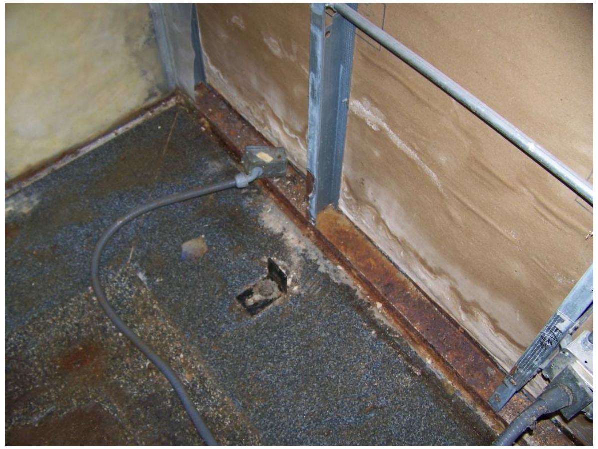
Water Vapor Flow – Same material – different atmospheres

Sampling of water vapor transmission rates (ABAA website for fluid-applied evaluated material) n = 11			
Fluid-Applied	Desiccant method ng	Water method ng	Difference
Min WVT Rate	0.572	0.572	0 percent
Max WVT Rate	1763	2830	61 percent
Mean WVT Rate	0.89	1.8	102 percent
Min Percent Difference	4.96	5.15	4 percent
Max Percent Difference	4.3	2034	47,202 percent
Mean Percent Difference	418	870	108 percent

BUILDING SCIENCE
MOISTURE FLOW

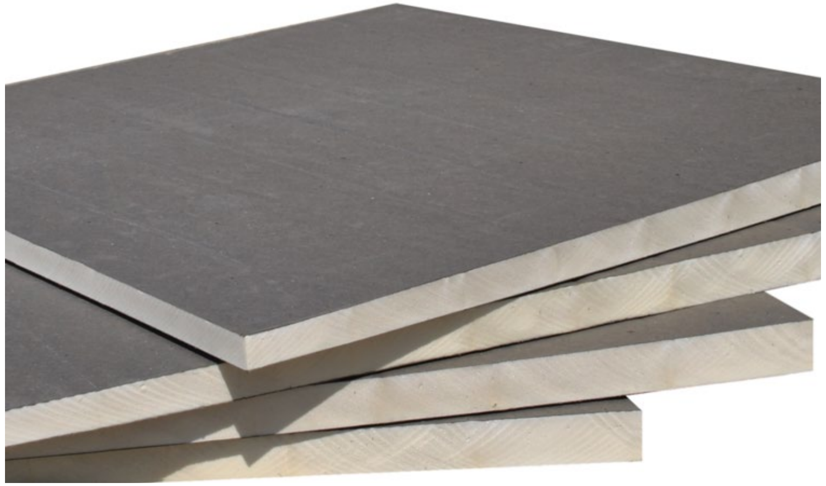
Water vapor condensing in the building envelope leads to problems:


MOLD

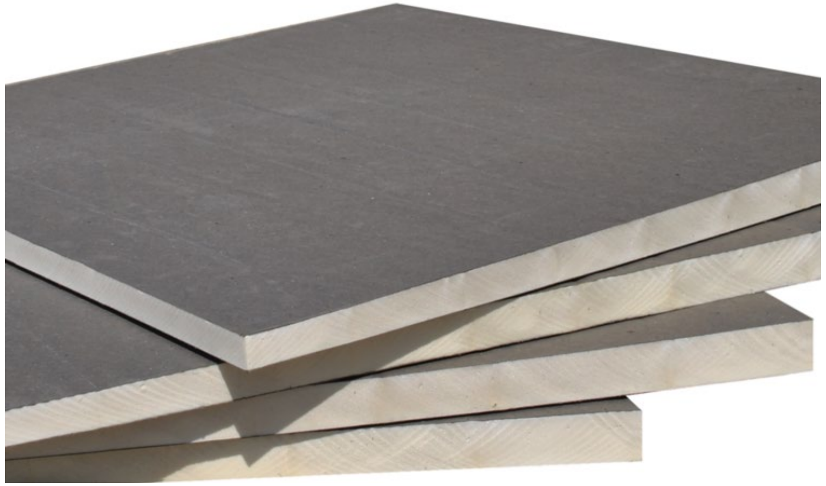

DAMAGE


WOOD ROT

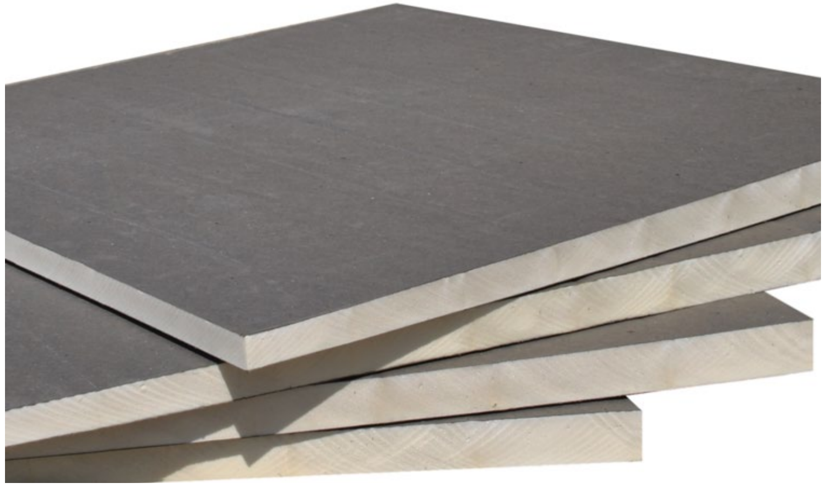
What is an Air Barrier?



What is a Vapor Retarder (Barrier)?



What is a Water-Resistive Barrier?



BUILDING SCIENCE

What is the main function of this material?

How can you tell?

BUILDING ENVELOPE

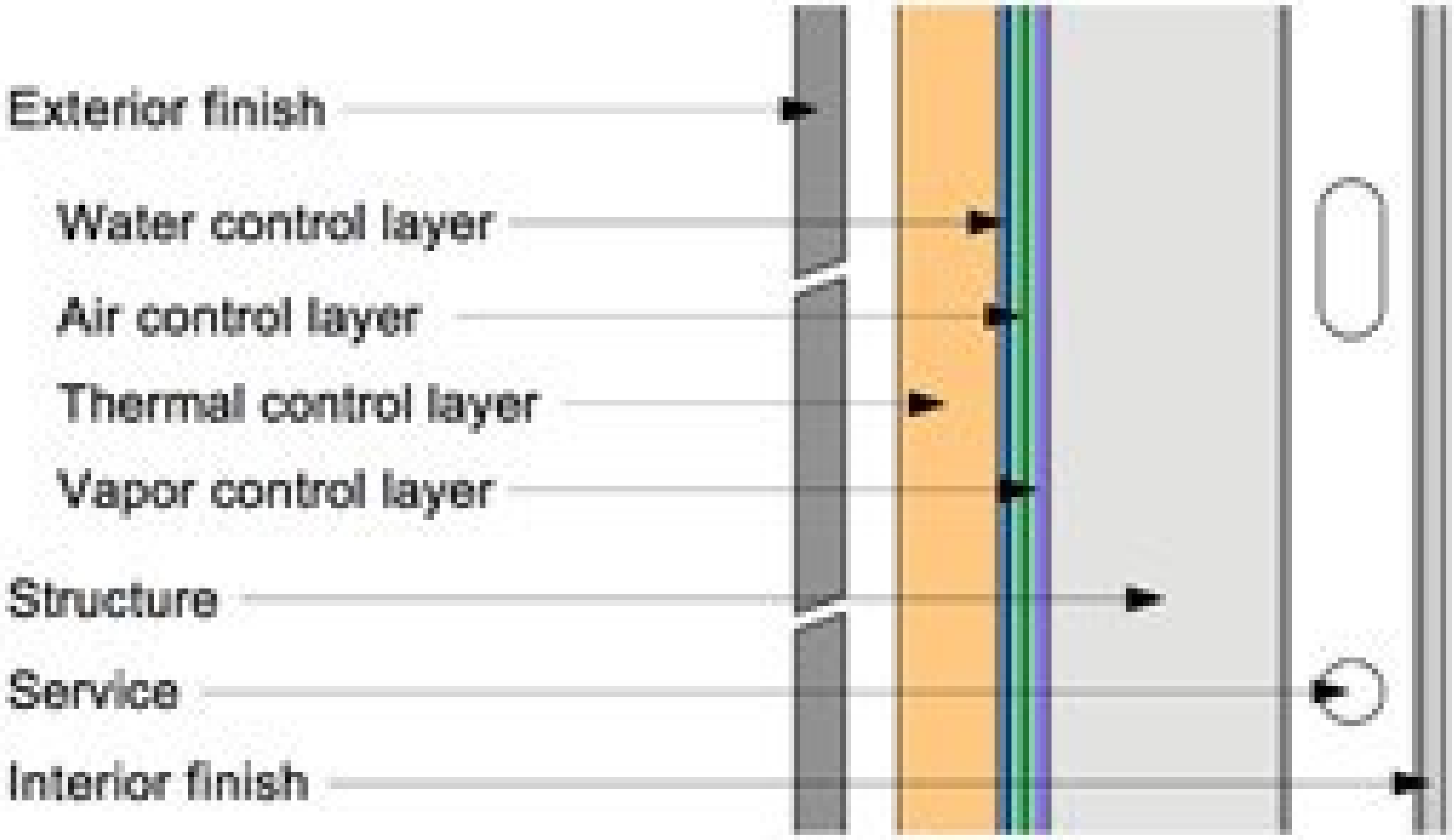
BUILDING MATERIALS

Materials have different:

- Heat flow (conduction)
- Air flow (convection and air permeance)
- Moisture flow (water absorption, vapor permeance)
- Durability

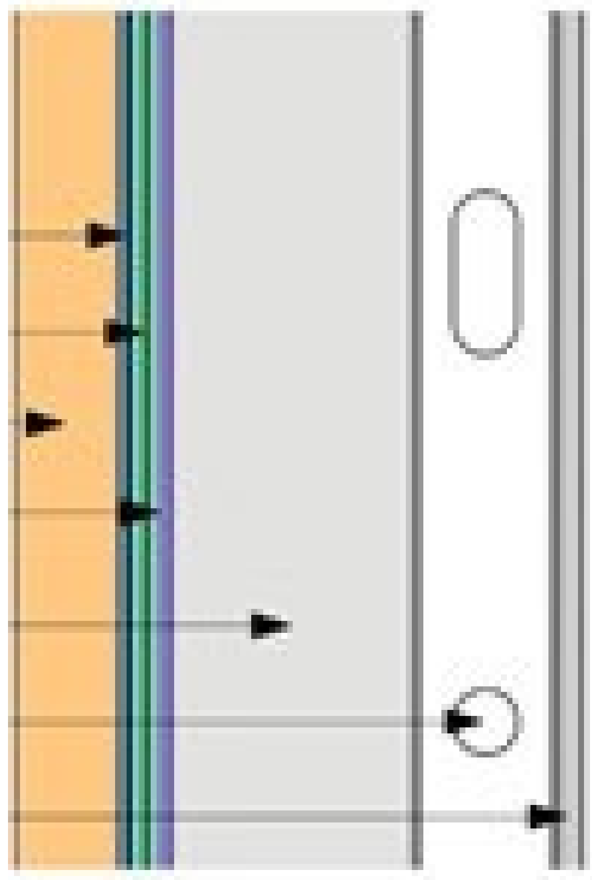
Environment – interior and exterior can change hour by hour

A Simple Wall Construction



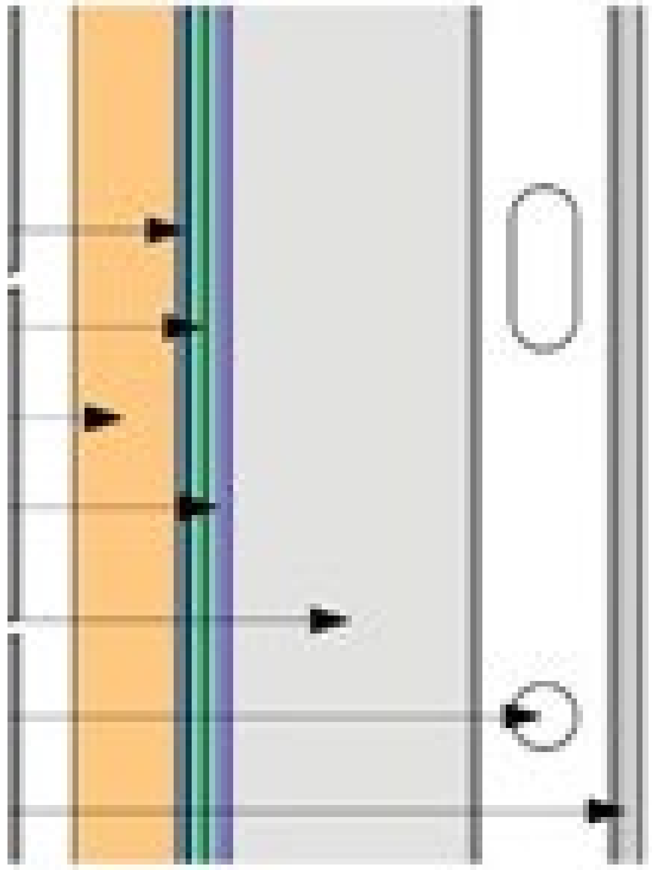
A Simple Wall Construction

- Exterior continuous insulation
  - Impacts the complete wall by changing the temperature gradient
  - Depending on the material, it could also be an air barrier, a water-restive barrier or vapor retarder



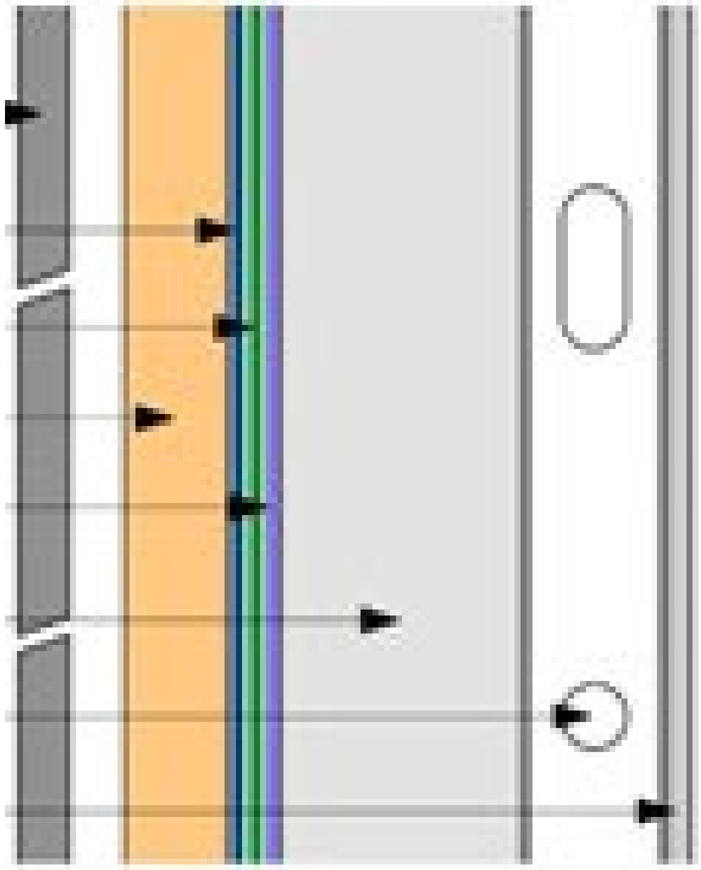
A Simple Wall Construction

- Airspace
  - Becoming an extremely important component is some wall assemblies
  - Allows water to drain from the wall and ventilation promotes drying
  - More insulation in a wall, the more important the cavity



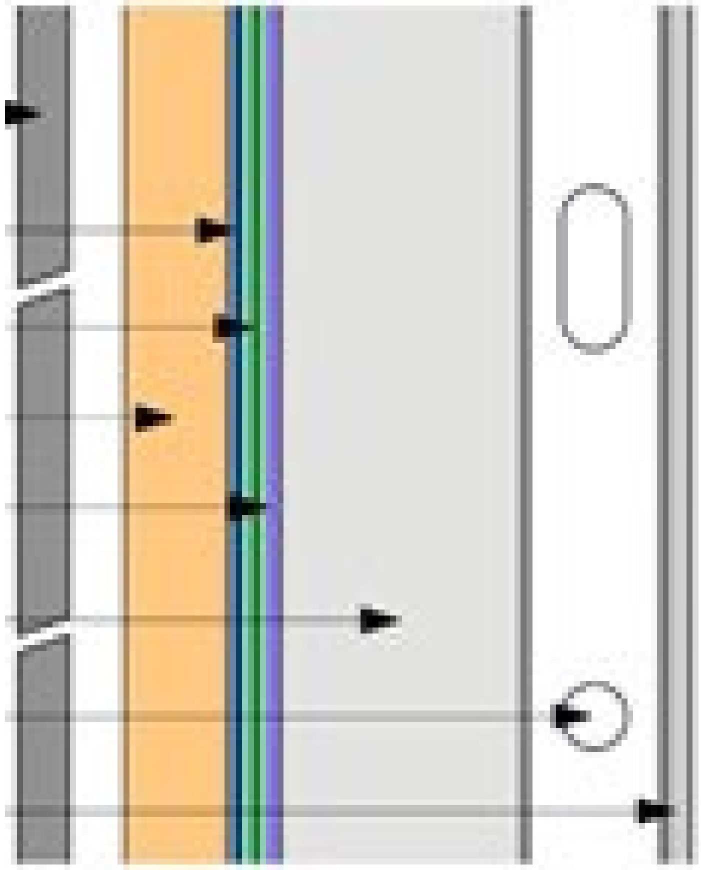
A Simple Wall Construction

- Exterior finish
  - The look of the building
  - Sheds much of the bulk water
  - Needs to be structurally
  - Attached which can put holes in the water-restive barrier, air barrier and thermal bridging in the insulation



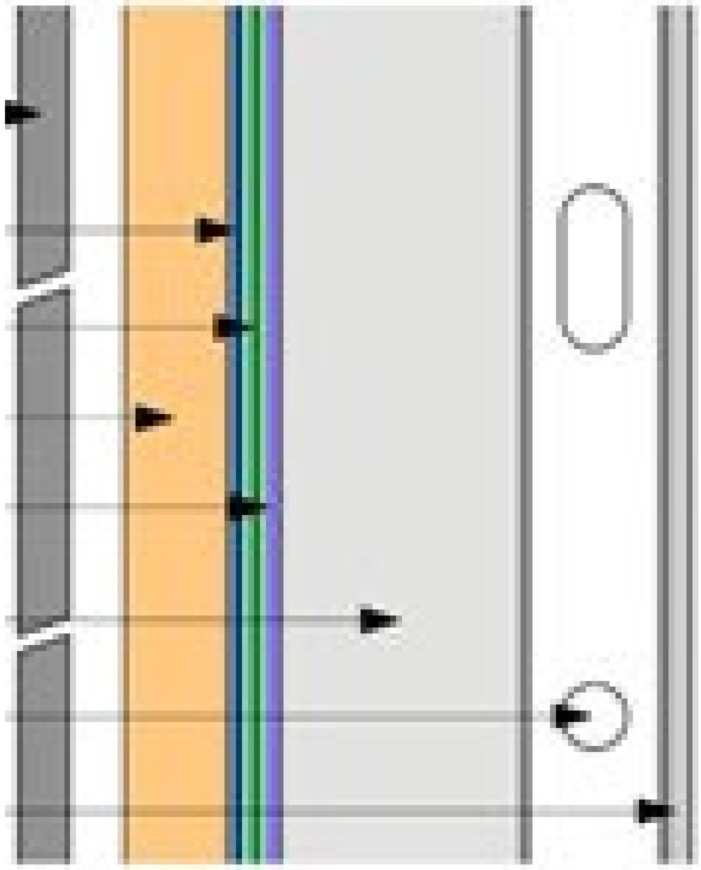
A Simple Wall Construction

- Simple wall construction
  - No building assembly is simple
  - Every layer in the assembly affects the other layers
  - One value engineered change notice can result in major damage to the building envelope



A Simple Wall Construction

- Simple wall construction
  - The design professional can do a great design of a building assembly, but it will only work as intended, if installed properly



INSTALLATION

TYPICAL AIR BARRIER MATERIALS

- Substrate Prep is key to all materials !

INSTALLATION

SELF ADHERED MEMBRANES – PROPER INSTALL

INSTALLATION

FLUID APPLIED MEMBRANES – PROPER INSTALL

INSTALLATION

BOARD STOCK– PROPER INSTALL

INSTALLATION

SPRAYED POLYURETHANE FOAM – PROPER INSTALL

INSTALLATION

COMMERCIAL BUILDING WRAP – POOR INSTALL

INSTALLATION

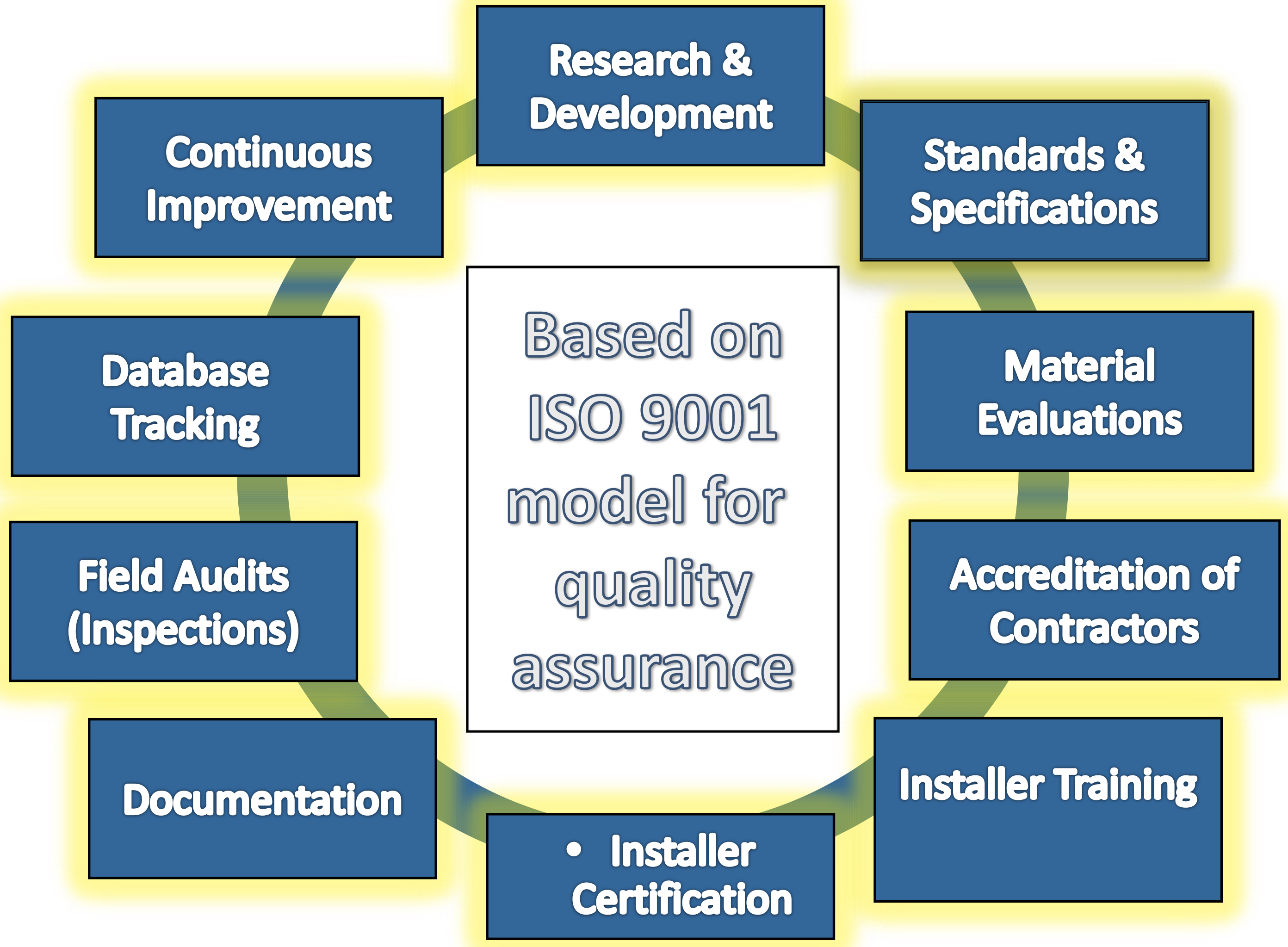
FACTORY BONDED MEMBRANES TO SHEATHING

- Proper Substrate Preparation
    - Product is substrate
    - Proper fastening to substrate with recommended fasteners
    - Priming of membranes over sheathing

QUALITY ASSURANCE

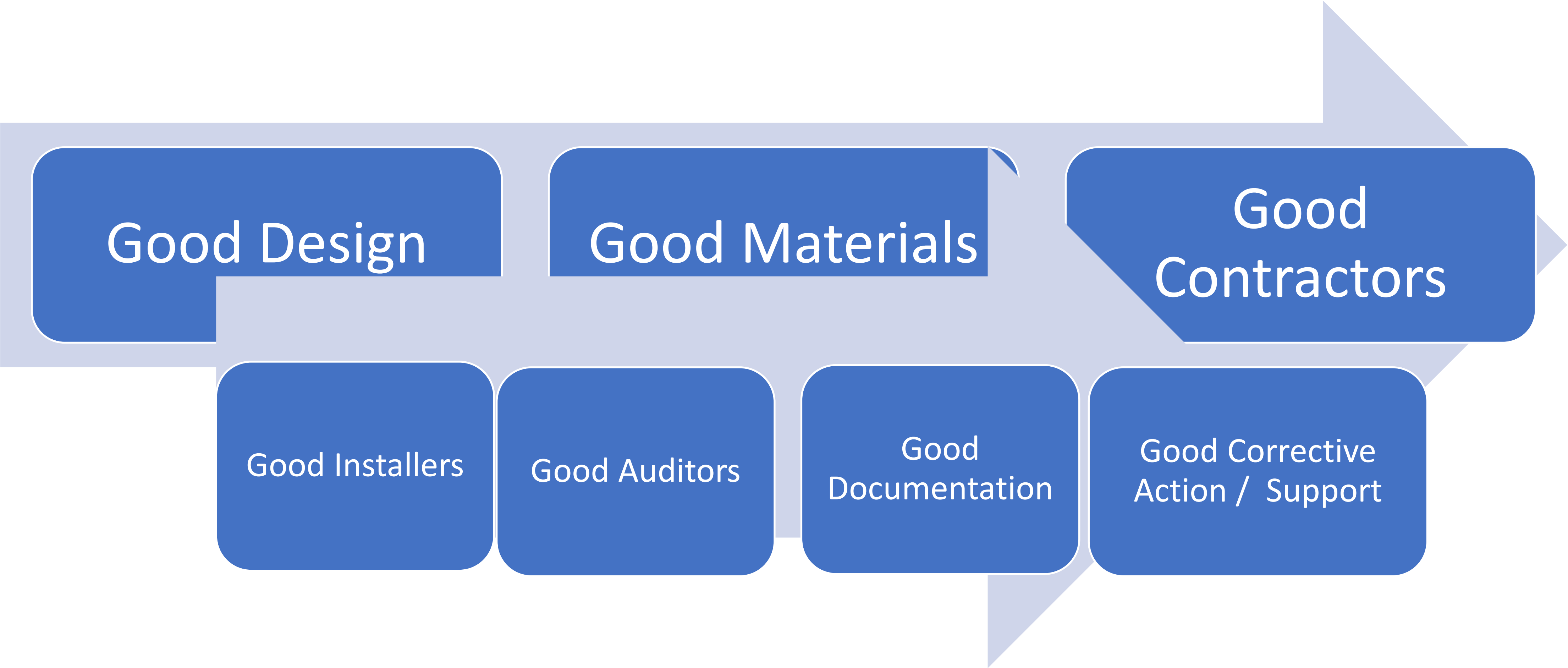
FOR AIR BARRIERS

Model for Site Quality Assurance



QUALITY ASSURANCE

FOR AIR BARRIERS



QUALITY ASSURANCE

FOR AIR BARRIERS

- Research
  - Credible and Scientific research on product performance, key installation parameters, durability

Field test

Sub-assembly tests

Material characterization

Sheathings

Non-insulating

Insulating

Sealants

Spray-applied foam

QUALITY ASSURANCE
FOR AIR BARRIERS

Standards and Specifications

- Material specifications; Project Specifications, Guide specification
- , whole building testing, auditing
- ASTM and ISO
- Quality Assurance Program


US Army Corps of Engineers®
Engineer Research and Development Center

air barrier abaa association of america

U.S. Army Corps of Engineers
Air Leakage Test Protocol for
Building Envelopes

Version 3 - May 11, 2012

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QUALITY ASSURANCE

FOR AIR BARRIERS

QUALITY ASSURANCE

FOR AIR BARRIERS

- Example of Material Evaluation
  - Standardized testing and performance criteria
  - Listed on website and in specifications

Identifying function of materials ABAA Material Specifications

- ABAA S0001, *Standard for Air and Water-Resistive Barriers – Medium Density Closed Cell Rigid Spray Polyurethane Foam – Material Specification*
- ABAA S0003, *Standard for Air Barrier Material - Light Density Open Cell Semi-Rigid Spray Polyurethane Foam - Material Specification*
- *ABAA S0005, Standard for Air Barrier Material – Non-Insulating Sheathing - Gypsum Based - Material Specification*
- ABAA S0006, *Standard for Air Barrier Material - Mechanically Fastened Engineered Polymer Film - Material Specification*
- ABAA S0007, *Standard for Air and Water-Resistive Barriers – Self-Adhered Sheet Membrane, Bitumen Based – Material Specification*
- ABAA S0008, *Standard for Air and Water-Resistive Barriers – Fluid Applied Membrane – Material Specification*
- ABAA S009, *Standard for Air and Water-Resistive Barriers Fluid Applied Coating – Material Specification*
- ABAA T00010*, Standard Method for Building Enclosure Airtightness Compliance Testing*
- ABAA S0011, *Standard for Air Barrier Material - Low Density Open Cell Rigid Spray Polyurethane Foam - Material Specification*
- ABAA S0012, *Standard for Air and Water-Resistive Barriers – Factory-Bonded Membranes to Sheathing – Material Specification*
- ABAA S00013, *Standard for Air and Water-Resistive Barriers – Mechanically Fastened Commercial Building Wraps – Material Specification*
- ABAA S0014, *Standard for Air and Water-Resistive Barriers – Rigid Cellular Thermal Insulation Board – Material Specification*

QUALITY ASSURANCE
FOR AIR BARRIERS

- Manufacturer Training / Support
  - Material evaluation requirements
  - Technical sessions
  - Technical support – salespeople, site people, research people

QUALITY ASSURANCE

FOR AIR BARRIERS

- Risk Management
  - Establish material performance requirements – research, field feedback, good building science
  - Develop standard material specifications which incorporate the material performance requirements
  - Manufacturer quality control with 3 party involvement – ISO 12576-1 System 4
  - Legally bind the manufacturer to produce material in accordance with the material specification

QUALITY ASSURANCE

FOR AIR BARRIERS

Contractor Accreditation

- Education
- Minimum standards (financial/insurance)
- Certified individuals (workers)
- Code of conduct
- Corrective Action / Defect resolution
- Internal quality control systems
- Accreditation can be lost for non-compliance (suspension, fines, cancellation)

QUALITY ASSURANCE

FOR AIR BARRIERS

Contractor Training / Support

- Business procedures
- Business development
- Quality control
- Quality Assurance
- Technical sessions

QUALITY ASSURANCE

FOR AIR BARRIERS

Installation Risk Management - Contractors

- Establish business performance requirements – technical knowledge, insurance, business licenses, workers compensation, safety plans, etc.
- Legally bind the contractor to do what is required – installation requirements, health and safety issues, contract requirements
- Constant monitoring – ISO 10002 and ISO 14020

QUALITY ASSURANCE

FOR AIR BARRIERS

Training of Installers

- Focused on application – Insulation installer, air barrier installer, window installer, etc.
- Classroom and **<u>hands on</u>**
- Practical applications

QUALITY ASSURANCE

FOR AIR BARRIERS

Certification of Installers

- Confirmation of knowledge, skills and abilities
- Experience in installation of various products
- Written test / field exam
- Certified by product type
- Code of conduct
- Can be lost
- ISO 17024 requirements critical

QUALITY ASSURANCE
FOR AIR BARRIERS

Trade Quality Control

- Internal check lists from daily reports
- Daily testing program for visual, adhesion, density, thickness, substrate
- Site Quality Assurance Administrator

QUALITY ASSURANCE

FOR AIR BARRIERS

Project Documentation

- Daily Job site reports by product
- Standardized Audit reports
- Corrective Action Documents
- Quality Assurance Program

QUALITY ASSURANCE

FOR AIR BARRIERS

air barrier
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	Fluid-Applied Air Barrier Assembly Audit Report
ABAA Assigned Audit Report #:	
Scheduled Project Audit X of X:	
Audit Date and Time:	
Project Name:	
Project Address:	
Auditor Name:	
ABAA Auditor Certification #:	
Phone #:	
Alternate Phone #:	
Accredited Contractor:	
Primary Contact:	
ABAA Contractor Member #:	
Phone #:	
E-mail Address:	
Certified Installer:	
ABAA Certification #:	
Expiry Date:	
Certified Installer:	
ABAA Certification #:	
Expiry Date:	
Registered Installer:	
ABAA Registration #:	
Expiry Date:	
Registered Installer:	
ABAA Registration #:	
Expiry Date:	
General Contractor :	
Primary Contact:	
Address:	
Office Phone #:	
Site Phone #:	
E-mail Address:	
Design Professional:	
Primary Contact:	
Address:	
Phone #:	
E-mail Address:	
Project Description:	

Field Audits

- Quality Control and Auditing – ISO 17020
- Intent is to help
- Identification of field issues which leads to modifying processes if required
- Standardized report / photo log
- Each report goes through internal QC
- Distribution: sub-trade, GC, architect, manufacturer

QUALITY ASSURANCE

FOR AIR BARRIERS

Information Management

- Improvement of key areas based on actual performance of system and key metrics
- Continuous improvement cycle
- Data on typical defects, adhesion, substrate issues

QUALITY ASSURANCE

FOR AIR BARRIERS

How do I get it ?

- You have to specify it, does not happen automatically
- Very specific language should be used in your specification / program requirements

QUALITY ASSURANCE

FOR AIR BARRIERS

Specification Language:

J. Manufacturer: Obtain primary ABAA Evaluated Materials from a single ABAA Evaluated Manufacturer regularly engaged in manufacturing specified self-adhered sheet air barriers. Obtain secondary materials from a source acceptable to the primary material manufacturer.

N. Field Quality Assurance: Implement the site Quality Assurance Program requirements used by ABAA. Cooperate with ABAA Auditors and any independent testing and inspection agencies engaged by the Owner. Do not cover the air barrier assembly until it has been inspected, tested and accepted.

QUALITY ASSURANCE
FOR AIR BARRIERS

B. Air Barrier Association of America Installer Audits: Cooperate with ABAA's testing agency. Allow access to work areas and staging. Notify ABAA in writing of schedule for Work of this Section to allow sufficient time for testing and inspection. Do not cover Work of this Section until testing and inspection is accepted. Arrange and pay for site inspections by ABAA to verify conformance with the material Manufacturer's instructions, the site Quality Assurance Program used by ABAA, and this section of the project specification.

1. Audits and subsequent testing shall be carried out at the following rate:
   a. Up to 10,000 ft^2 of air barrier contract requires one (1) audit.
   b. 10,001 – 35,000 ft^2 of air barrier contract requires two (2) audits.
   c. 35,001 – 75,000 ft^2 of air barrier contract requires three (3) audits.
   d. 75,001 - 125,000 ft^2 of air barrier contract requires four (4) audits.
   e. 125,001 – 200,000 ft^2 of air barrier contract requires five (5) audits.
   f. 200,001 ft^2 and over of air barrier contract requires six (6) audits.

QUALITY ASSURANCE

FOR AIR BARRIERS

How much does a field audit cost ?

- Audit Costs: $2,000
- Costs carried by accredited contractor
- ABAA has the costs in a calculator

QUALITY ASSURANCE

FOR AIR BARRIERS

How does the audit process work ?

- Project Report
- Project Starts: contractor QC
- Auditor engaged
- Audit reports
- Corrective Action (if applicable)
- Field Support
- Documentation Submission
- Final documentation review
- Project Close Out

BUILDING SCIENCE

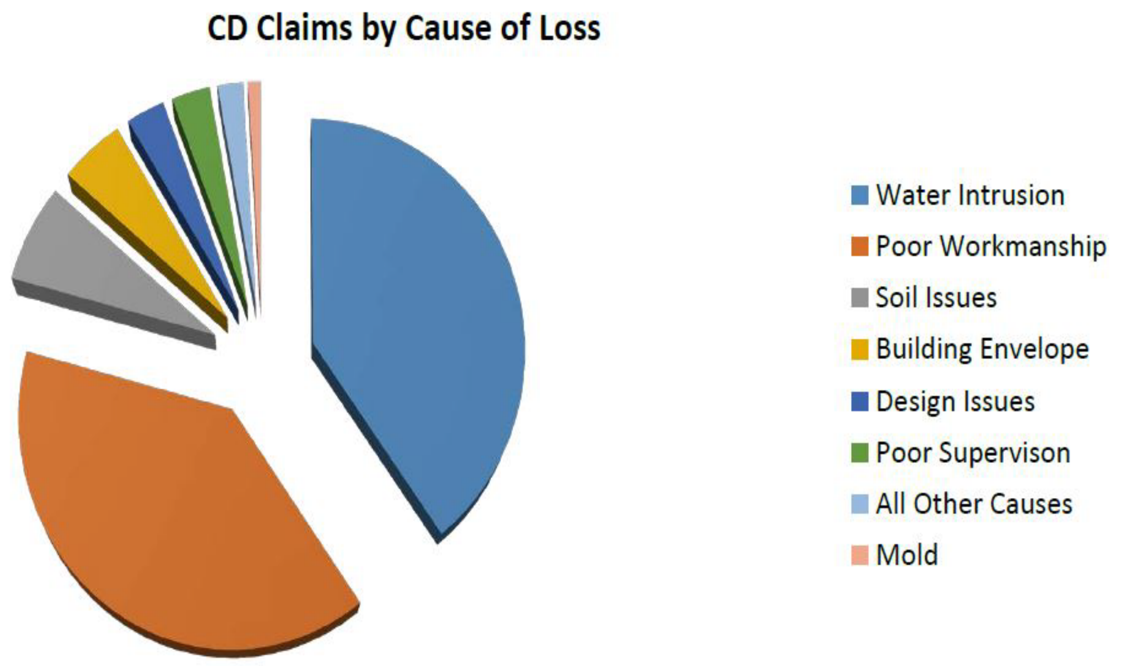
MOISTURE FLOW

Who cares?

- Poor workmanship also result in water intrusion – bulk and water vapor

Zurich Construction Defect claims study results

ZURICH



QUESTIONS??

air barrier
abaa
association of
america

This concludes The American Institute of Architects Continuing Education Systems Program

QUESTION & ANSWER PERIOD

RAINSCREEN ASSOCIATION
IN NORTH AMERICA

rainscreenassociation.org