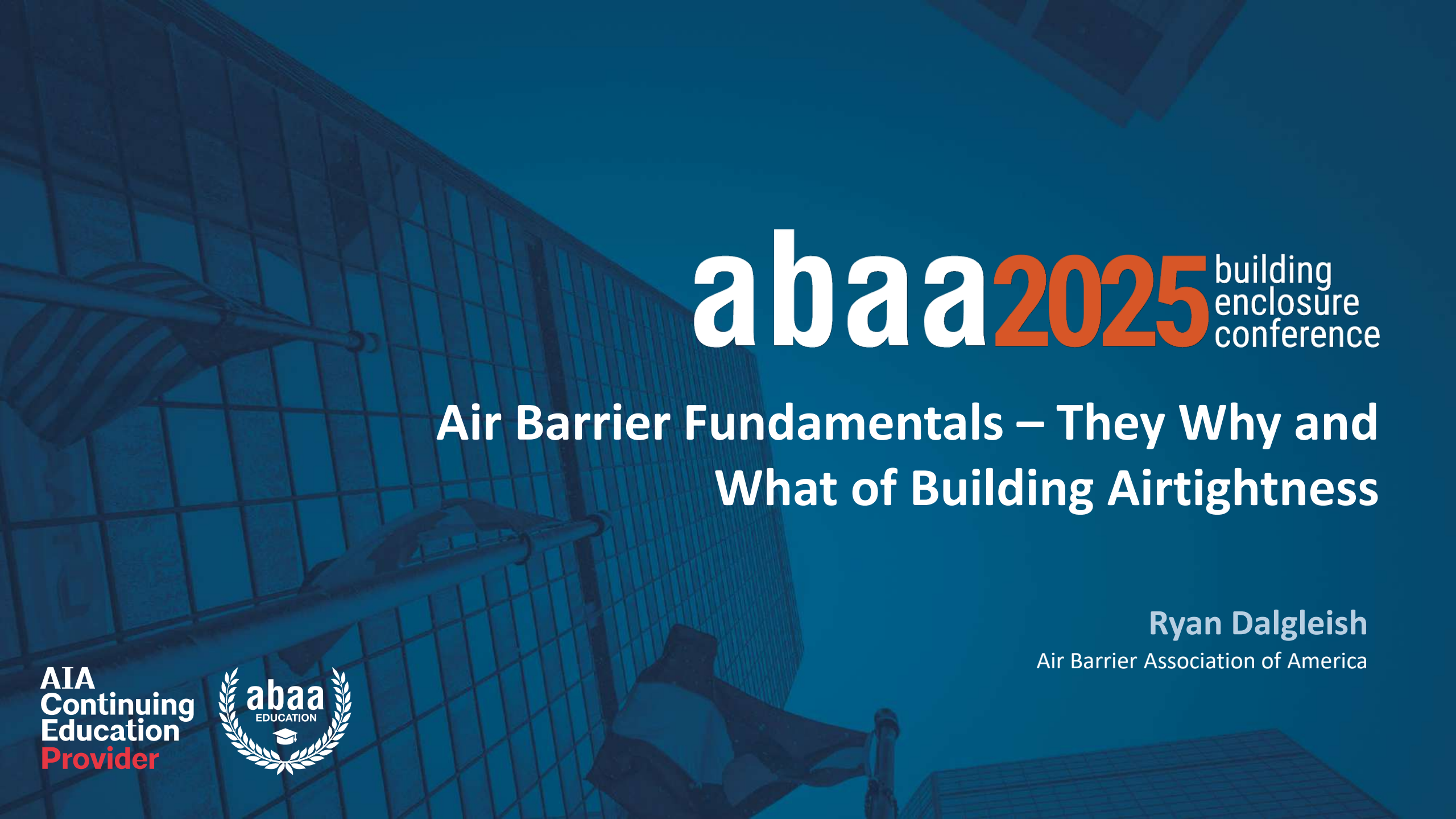


abaa 2025 building enclosure conference

Air Barrier Fundamentals – They Why and What of Building Airtightness

Ryan Dalgleish
Air Barrier Association of America

AIA Continuing Education Provider

abaa EDUCATION

Air Barrier Fundamentals – They Why and What of Building Airtightness

This foundational program will dive into why we are concerned about building airtightness and how air barriers impact all other components within the wall assembly. Once you have a good understanding of the "why", you appreciate how important these materials are and how the proper installation can have a huge impact on its performance and the ultimate success of any building. It's not just about air, it's about water too! We sometimes forget that an air barrier usually, if not all the time, does more than one thing.

Although boring to read, it is important to know building code requirements, along with what constitutes an air barrier material or system. Did you know that Peanut Butter can be an air barrier! Well, maybe it isn't, but it could be…. Are you intrigued?

abaa building enclosure conference

Ryan Dalgleish

Ryan has been involved in the building envelope and building performance areas of construction in both the commercial and residential sectors for over 25 years. Ryan acts in the position of Chief Operating Officer for the Air Barrier Association of America.

Ryan obtained credentials in Adult Education, Leadership and Organizational Excellence from the University of Manitoba and has been mentored and trained by some of the best building scientists in the world. Ryan is a certified Net Zero building instructor, teaches master builder courses to builders across the country and is a frequent speaker at various technical presentations dealing with the building enclosure to various building official associations, city departments, building enclosure councils and chapters of the American Institute of Architects, Construction Specifications Institute and a number of local home builder associations.

abaa EDUCATION

Learning Objectives

1. Describe the benefits or air barriers and the impacts on energy, moisture, sustainability and comfort
2. Understand Air Barriers in relation to the building enclosure
3. List performance requirements of Air Barrier materials, assemblies and systems
4. Understand building code requirements and gain knowledge in market forces driving energy efficient buildings

The Why of Airtightness

Is there really a benefit ?

WHY AIR BARRIERS

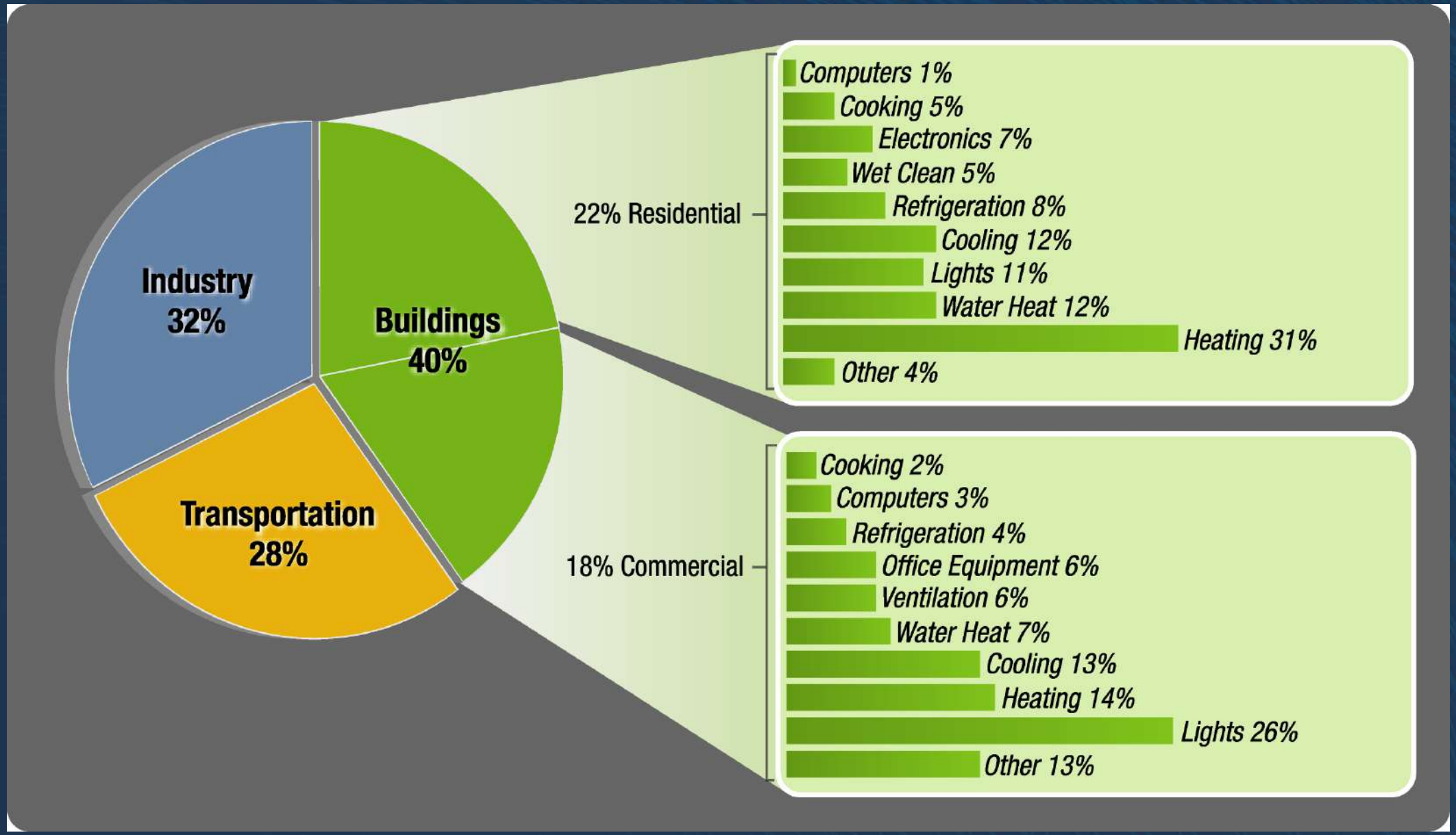
- Successfully shown to significantly reduce air leakage in a building for energy savings

https://www.airbarrier.org/technical-information/energy-savings-calculator/

- Part of a successful moisture management plan

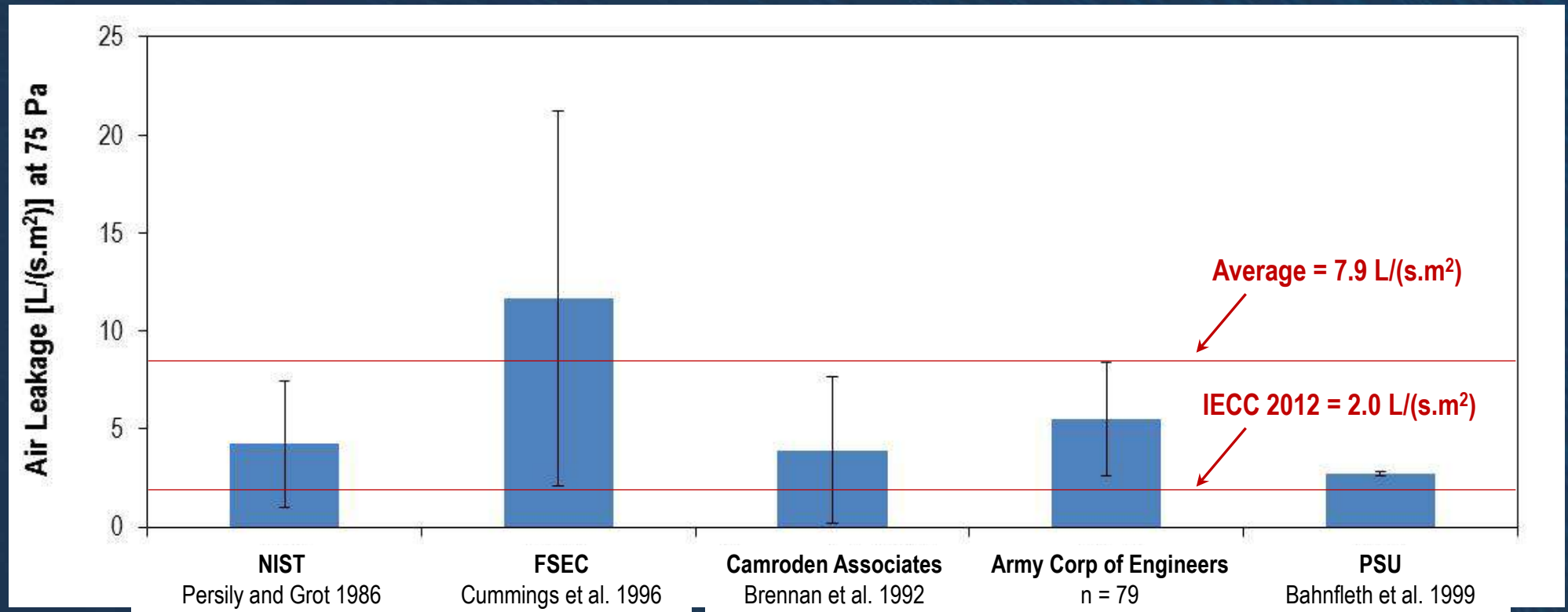
- Code requirement pretty much everywhere, except a little place that I have never heard of before in Texas

- Building Science helps us understand that we need to control water, air, vapor and thermal performance of the wall assembly



- 40% of total US prime energy expended
- 70% of all US electric energy used

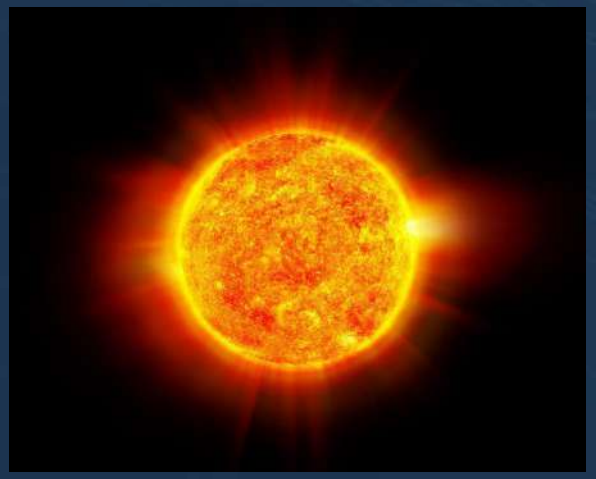
Air Leakage in Existing Buildings



NIST: National Institute of Standards and Technology
FSEC: Florida Solar Energy Center
PSU: Penn State University

BUILDING SCIENCE

- What are we actually trying to do ?



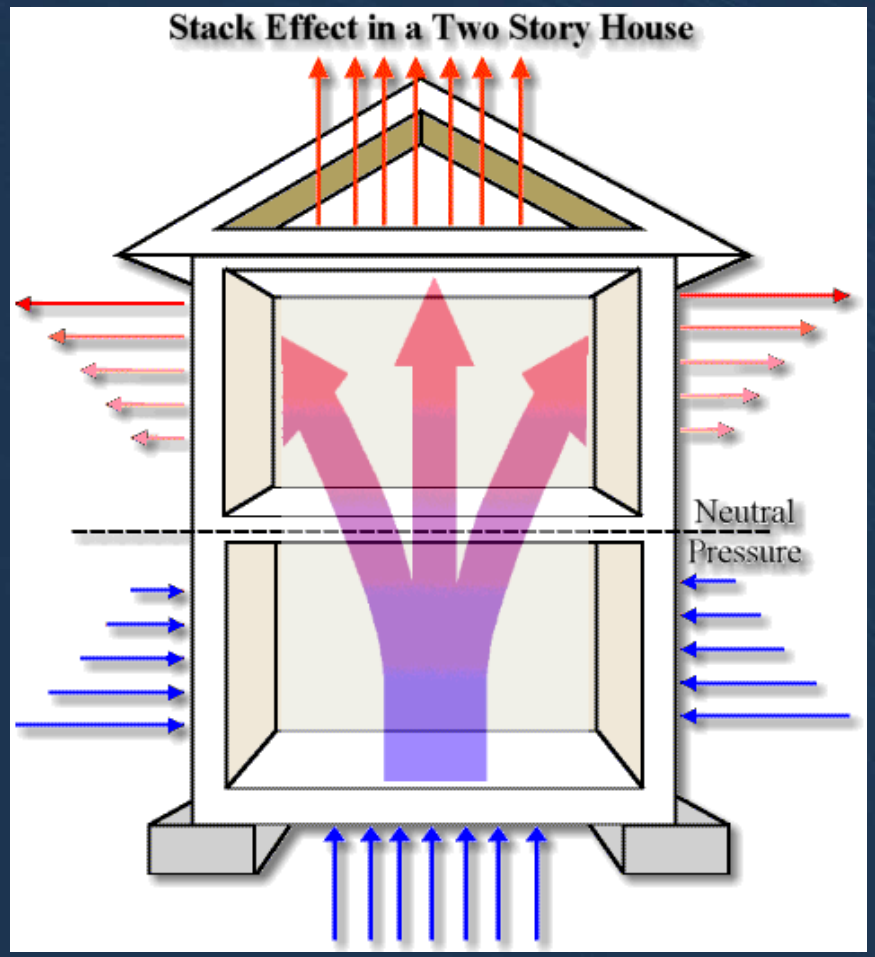
IMPROVE INSULATION

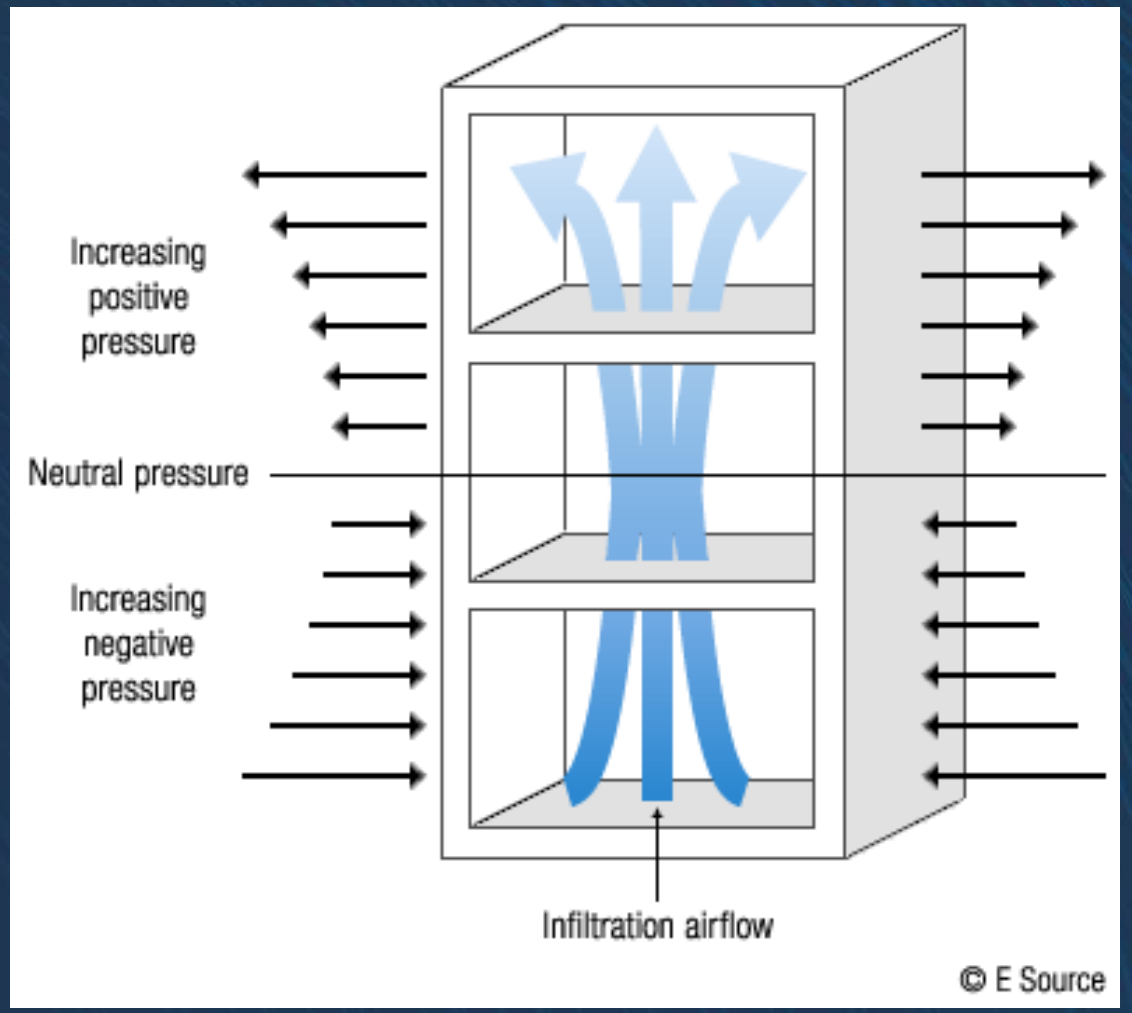
REDUCE MOISUTRE FLOW

REDUCE AIR FLOW

BUILDING SCIENCE

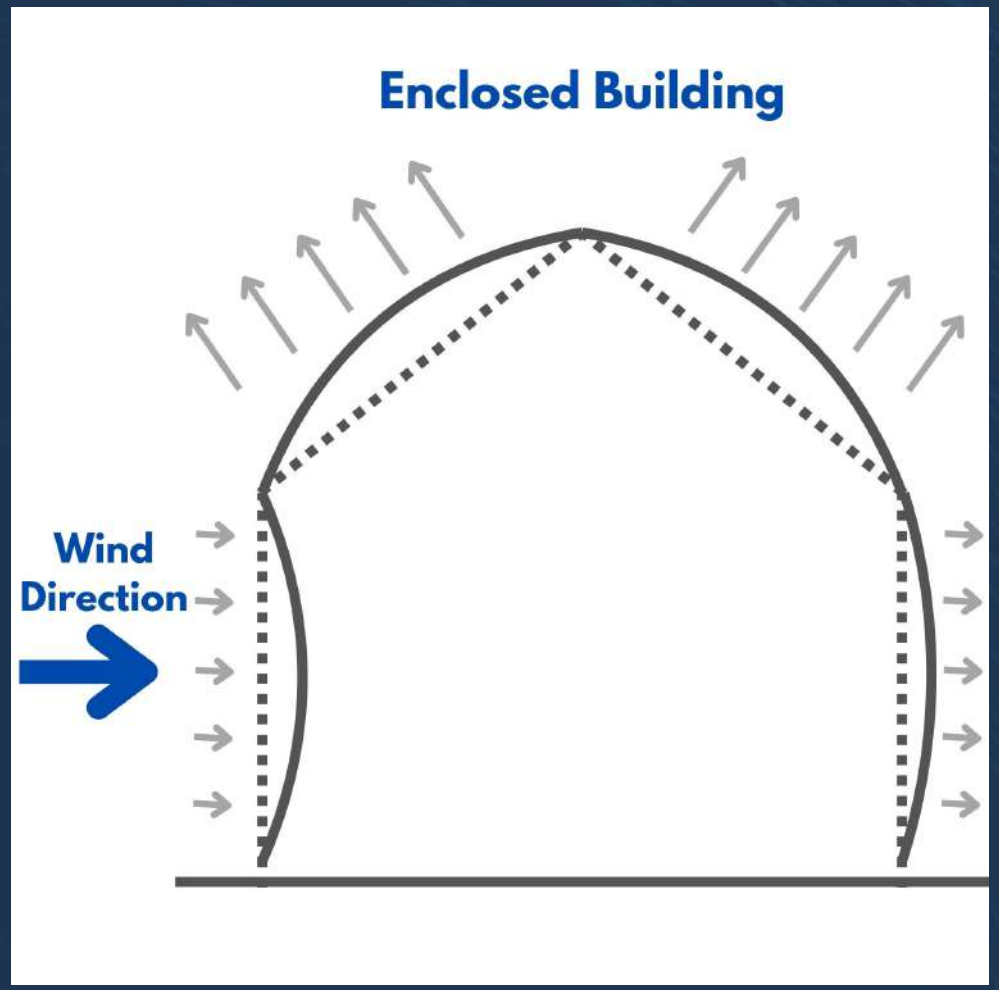
CONTROL AIR FLOW – STACK EFFECT

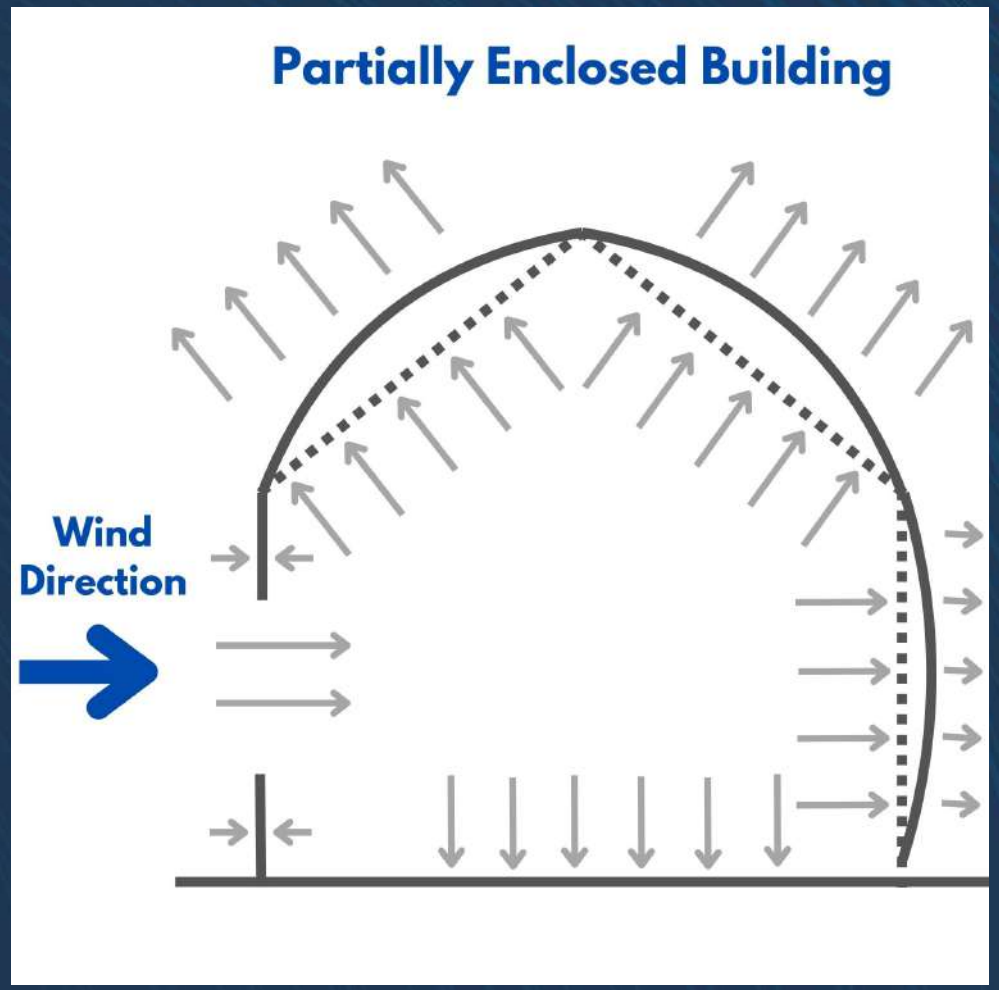




BUILDING SCIENCE

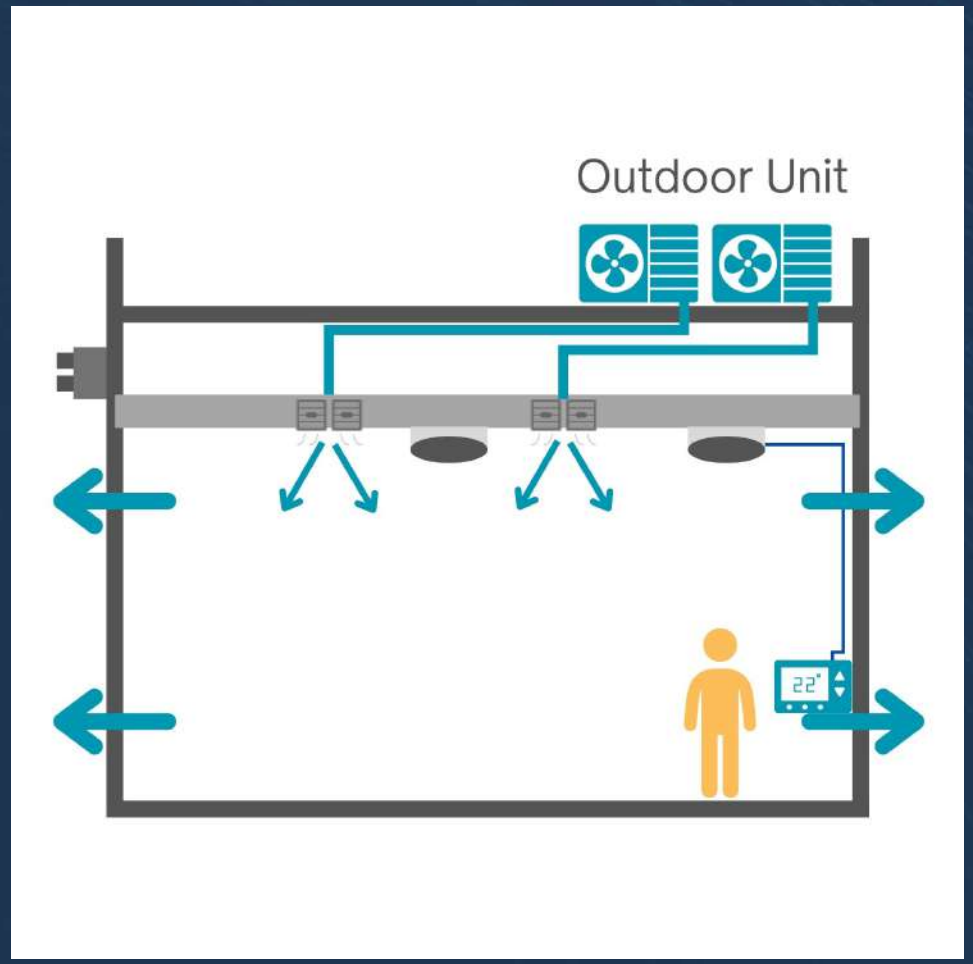
CONTROL AIR FLOW – WIND EFFECT

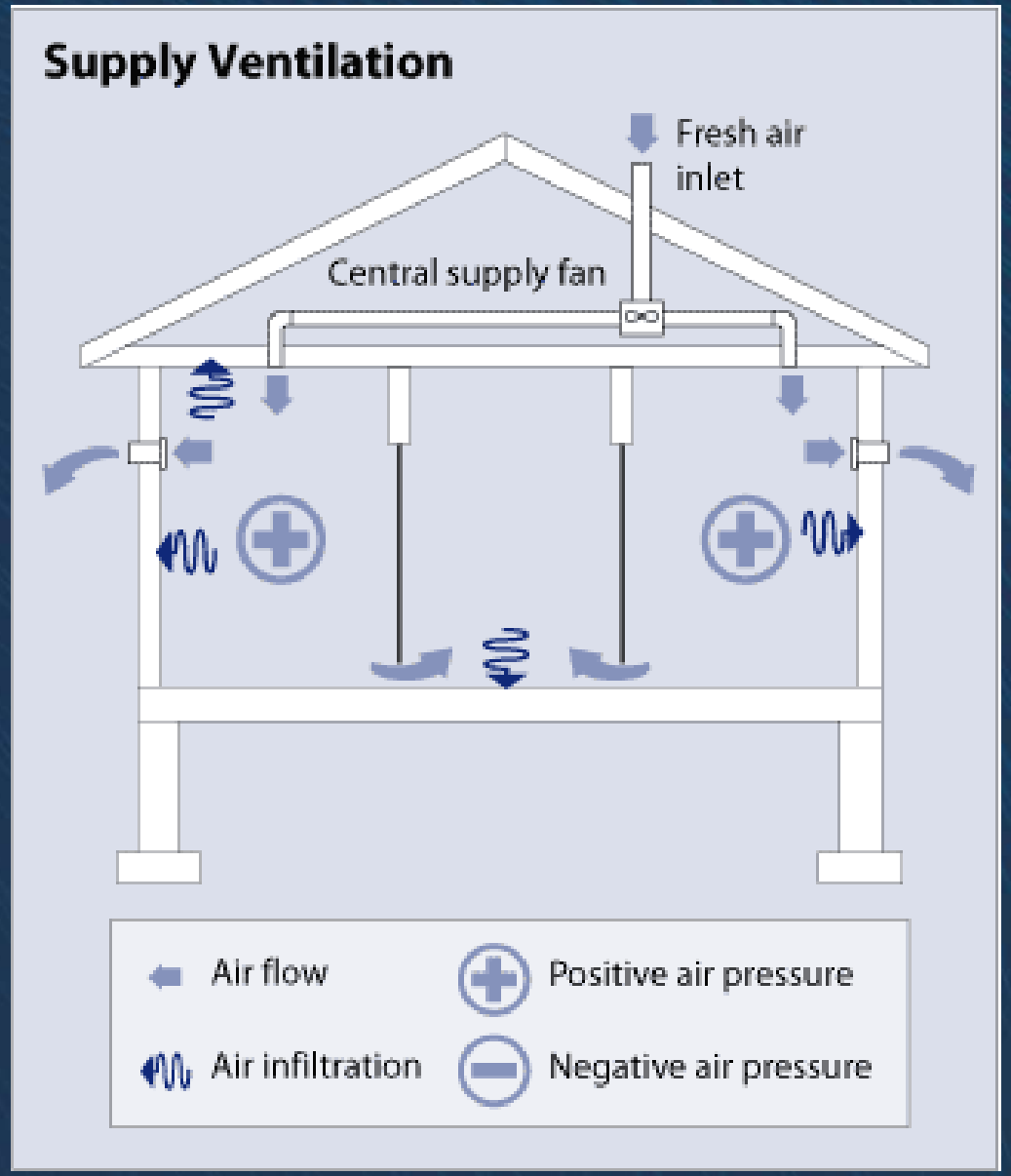




BUILDING SCIENCE

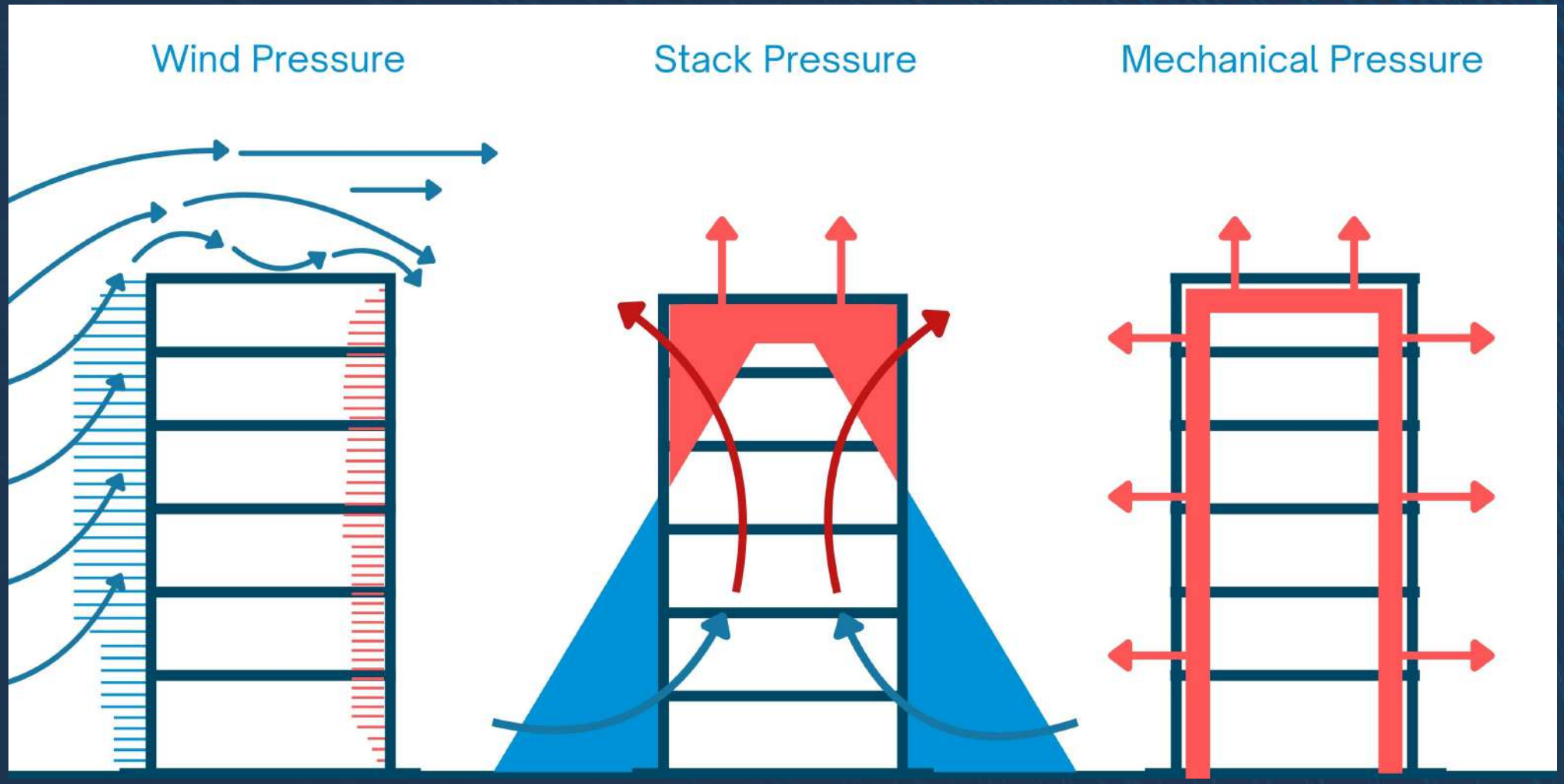
CONTROL AIR FLOW - MECHANICAL





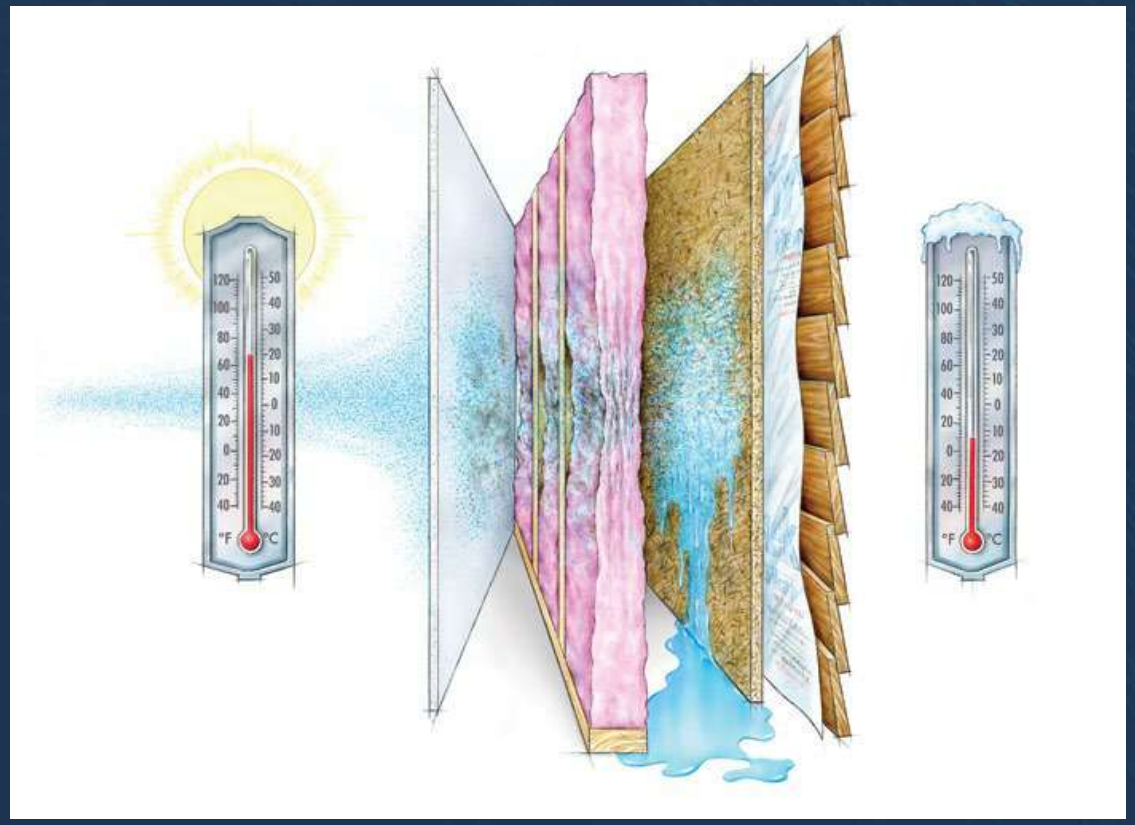
BUILDING SCIENCE

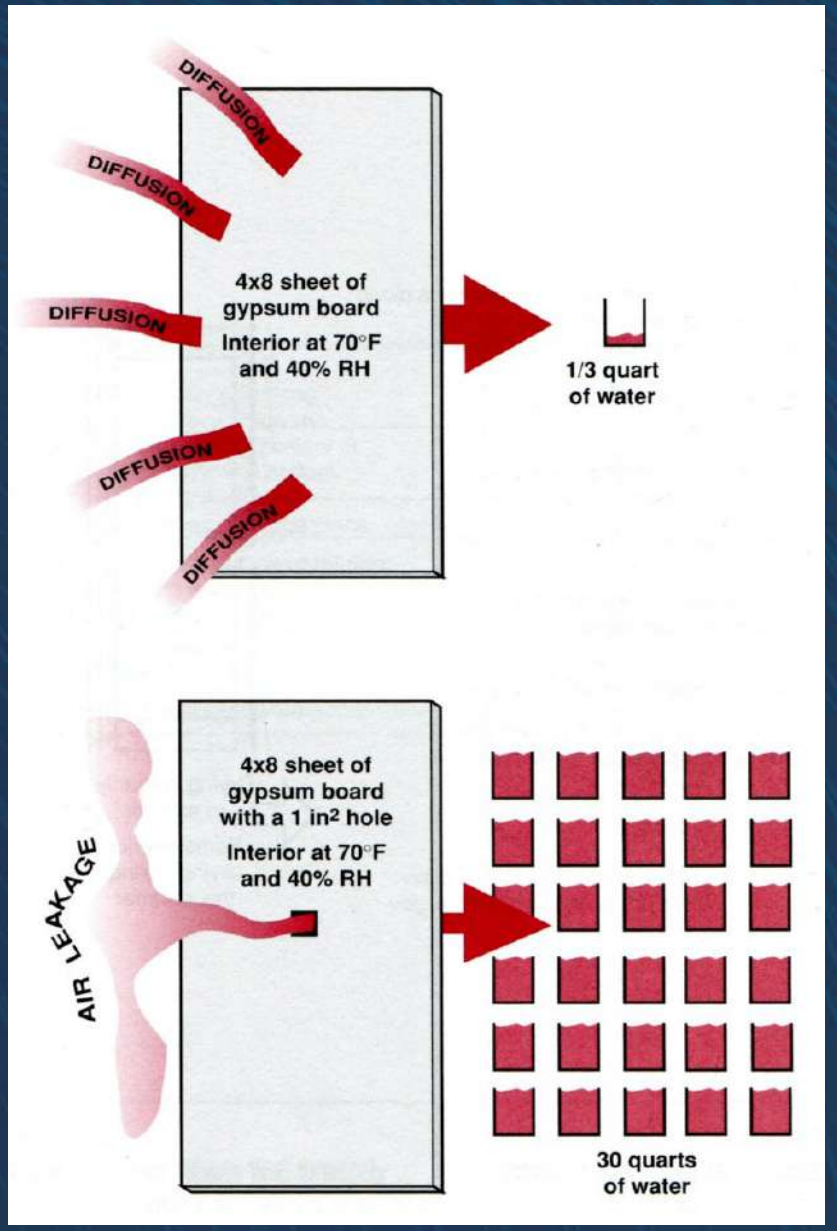
CONTROL AIR FLOW



BUILDING SCIENCE

MOISTURE FLOW – VAPOR DIFFUSION





BUILDING SCIENCE

MOISTURE FLOW – VAPOR DIFFUSION

Water Vapor Transmission

All materials have a water transmission rate. International Building Code says:

- **Class I: 0.1 perm or less (vapor barrier)**
- **Class II: 1.0 <perm ≤ 1.0 perm (vapor retarder)**
- **Class III: 10 <perm ≤ 10 perm (semi-permeable)**
- **Permeable 10.0 <perm**

BUILDING SCIENCE

MOISTURE FLOW – VAPOR DIFFUSION

BUILDING SCIENCE

MOISTURE FLOW – VAPOR DIFFUSION

Material Water Vapor Transmission Rate
0.1 Perm, 1.0 Perm, 10 Perms – How much water?

- Based on ASTM E96 Procedure A Desiccant method for one year
- A US perm is one grain of water vapor per hour per square foot per inch of mercury. In metric it is 57.2135 nanograms per second per meter squared per Pascal (57.213 $ng \cdot s \cdot m^2 \cdot Pa$).

BUILDING SCIENCE

MOISTURE FLOW – VAPOR DIFFUSION

Material Water Vapor Transmission Rate
0.1 Perm, 1.0 Perm, 10 Perms – How much water?

A **nanogram is one billionth of a gram.** To put this into perspective, a US penny weighs about 2.5 grams. So, take a penny and cut it into 2,500,000,000 pieces. Now take 57 or 58 pieces and now you have a weight equal to the weight of water that is considered one Perm.

BUILDING SCIENCE

MOISTURE FLOW – VAPOR DIFFUSION

10 Perms

1 Perm

0.1 Perm

BUILDING SCIENCE

MOISTURE FLOW – VAPOR DIFFUSION

Material Water Vapor Transmission Rate
0.1 Perm, 1.0 Perm, 10 Perms – How much water?

10 Perms

BUILDING SCIENCE

MOISTURE FLOW – VAPOR DIFFUSION

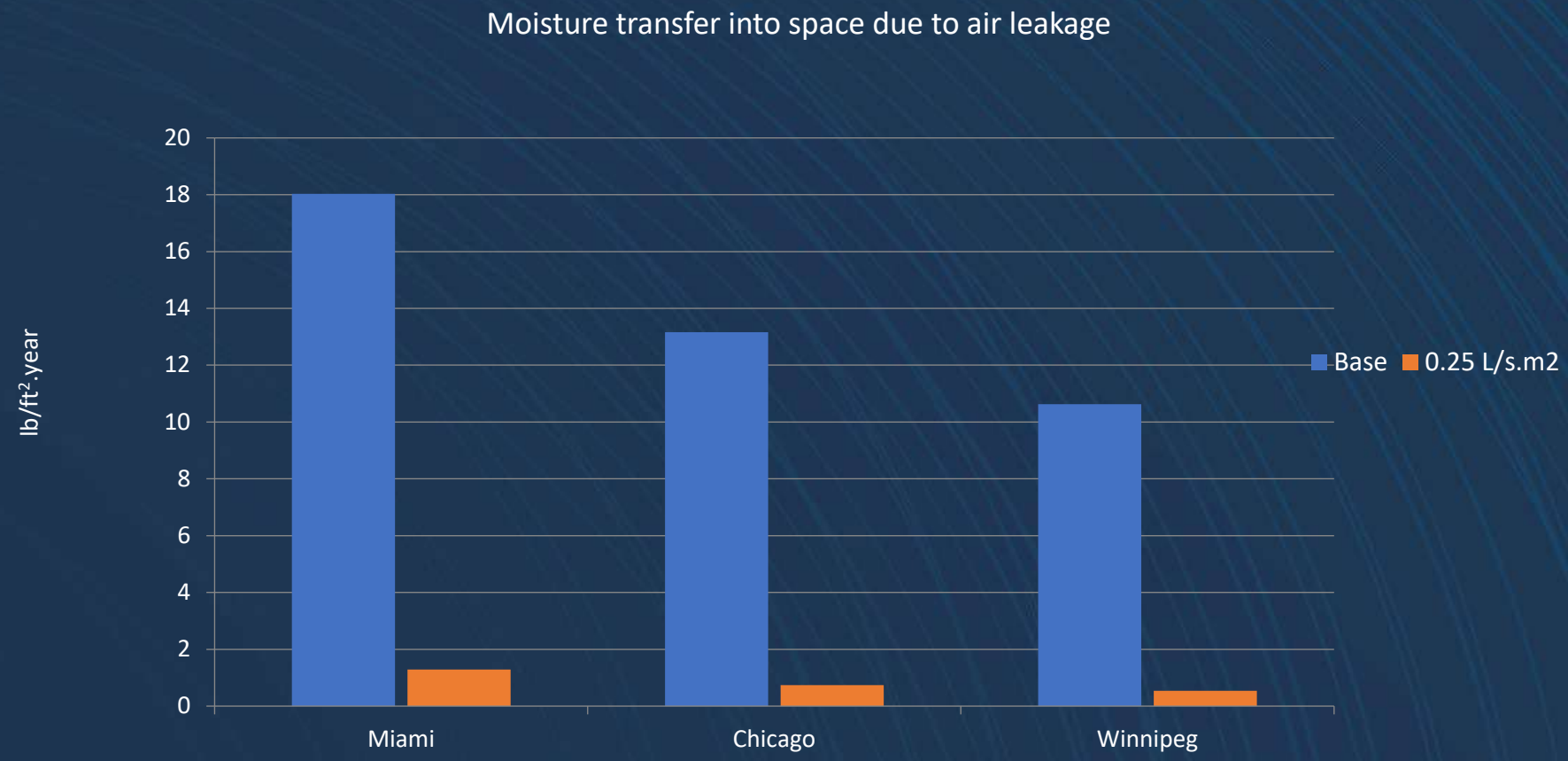
Material Water Vapor Transmission Rate
0.1 Perm, 1.0 Perm, 10 Perms – How much water?

1 Perm

AIR BARRIERS

AIR LEAKAGE IMPACTS ON MOISTURE

- Increase moisture with building enclosure



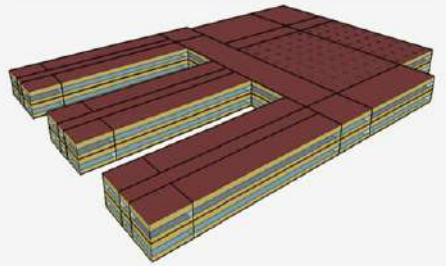
What keeps us up at night ?

Moisture

- Liquid water entry
- Moisture transport through air leakage

Infiltration Calculator Results

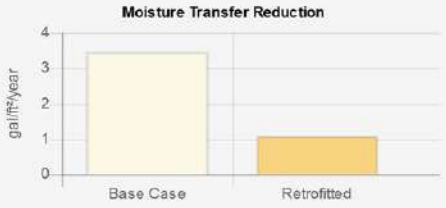
Building Type	School Secondary
Location	Boston MA USA
Floor Area	210900 ft²
Energy Price	Electricity 0.11$ /kWh, Natural Gas 11.03$ /1000 ft³



Leakage Rate		Equivalent Leakage Area	
Base Case	**Retrofitted Building**	**Base Case**	**Retrofitted Building**
1.07 CFM/ft² at 75 Pa	0.25 CFM/ft² at 75 Pa	100.63 ft²	23.49 ft²

Predicted Savings	Electricity	Natural Gas
Energy	31,869 kWh	2,550,773 ft³
Cost	$ 3,505.56	$ 28,135.02
Total Cost Savings	$ 31,640.58	

Moisture Transfer through the Wall Assembly due to Air Leakage	
Base Case	**Retrofitted Building**
3.48 gal/ft²/year	1.10 gal/ft²/year
734,385.29 gal/year	231,656.27 gal/year



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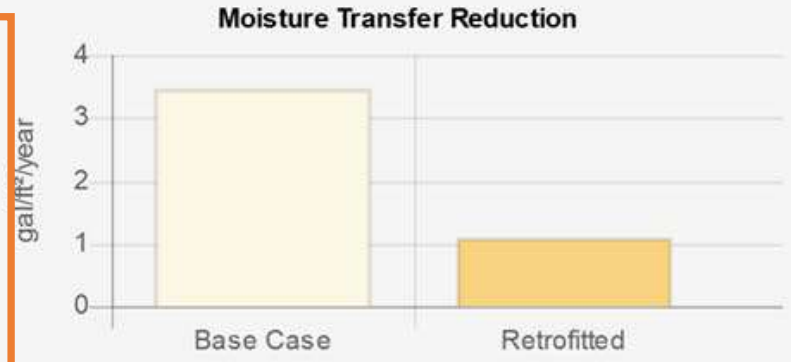
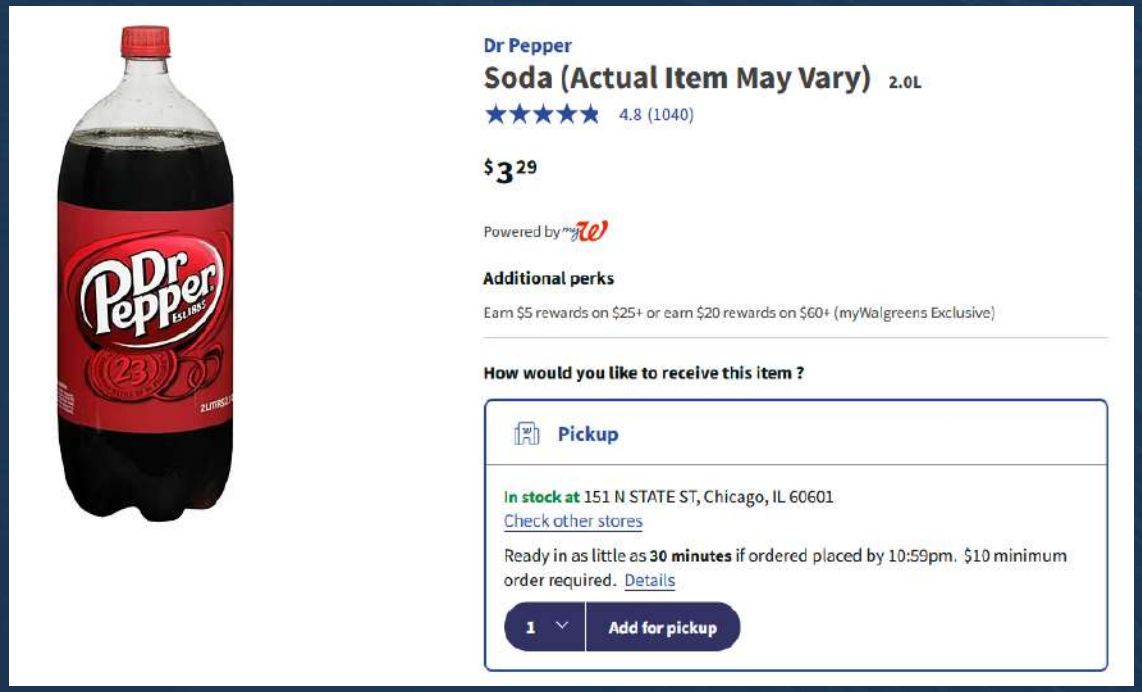




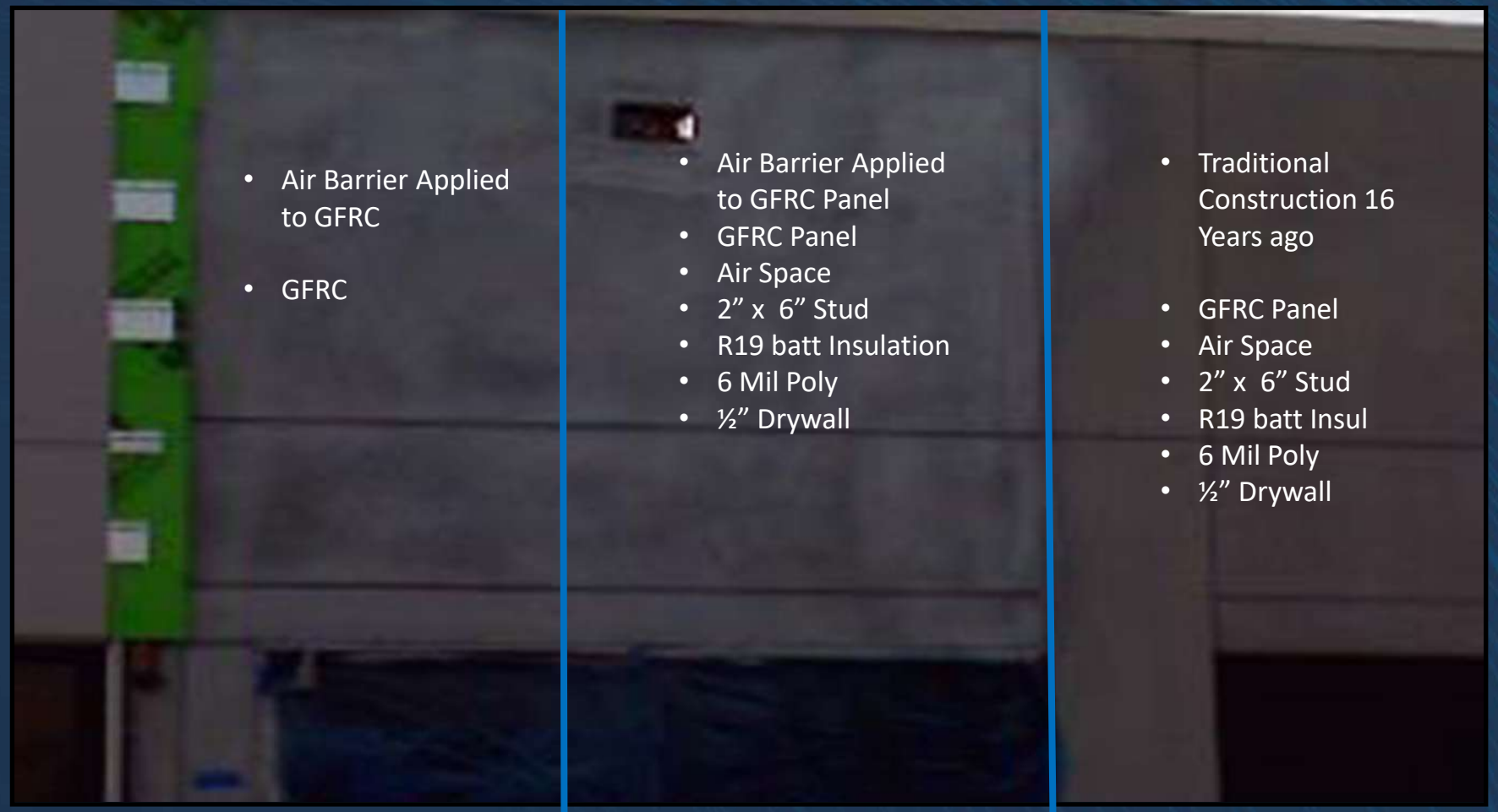
951,517 less 2L bottles of water going into your enclosure

Close to 1 less Olympic sized swimming pool of water not going into your enclosure

BUILDING SCIENCE

INSULATION PERFORMANCE

Outside Temperature = 15°F

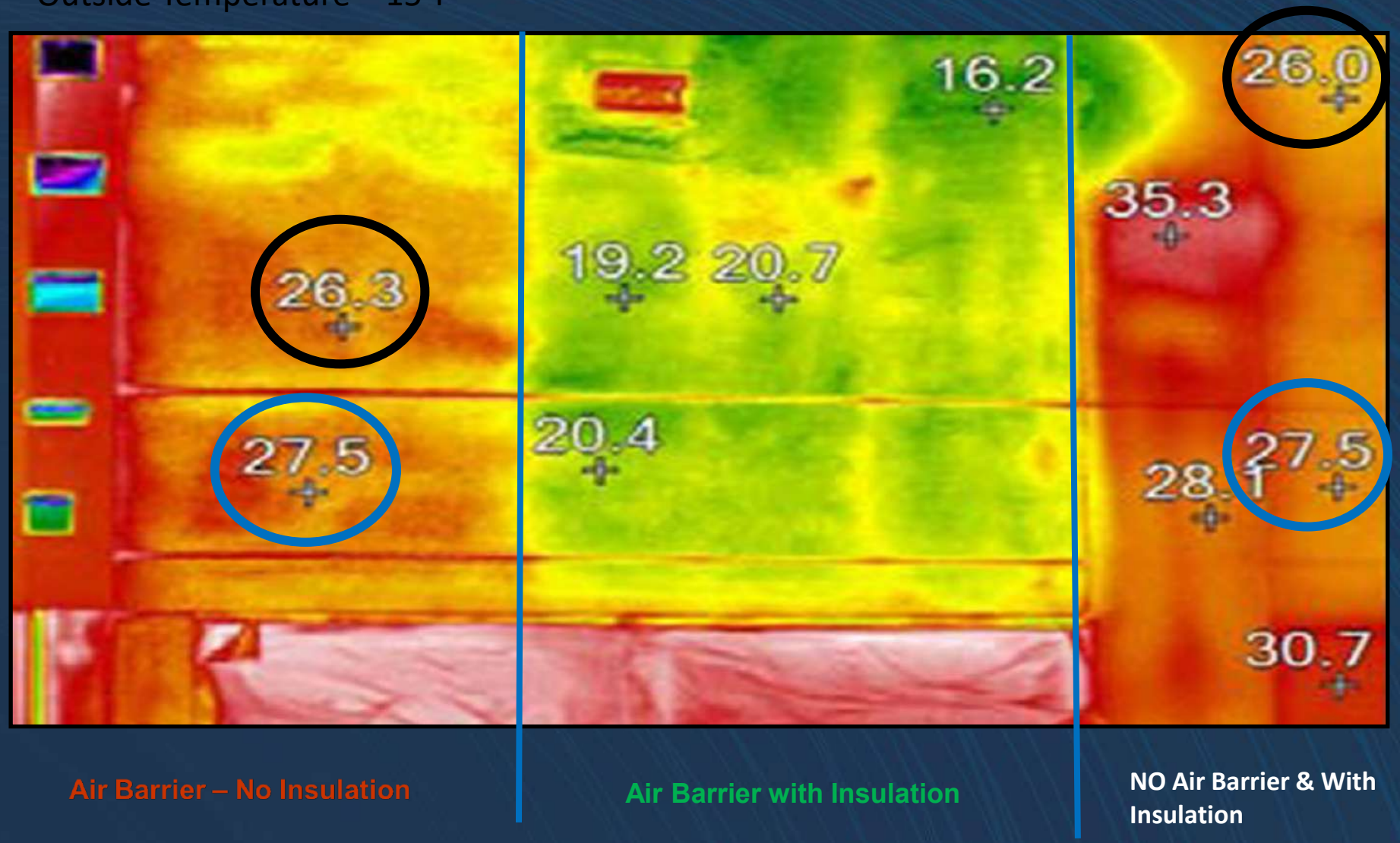


Air Barrier – No Insulation

Air Barrier with Insulation

NO Air Barrier & Insulation

Outside Temperature = 15°F



Air Barrier – No Insulation

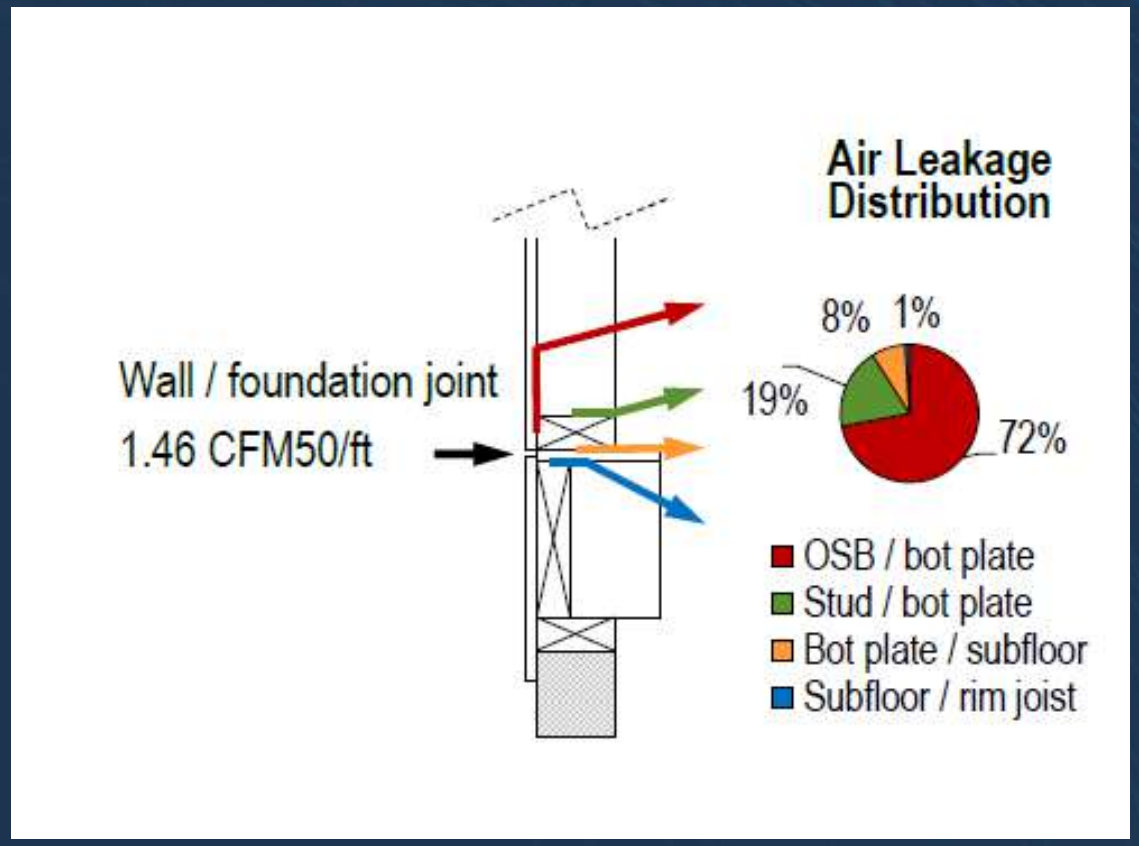
Air Barrier with Insulation

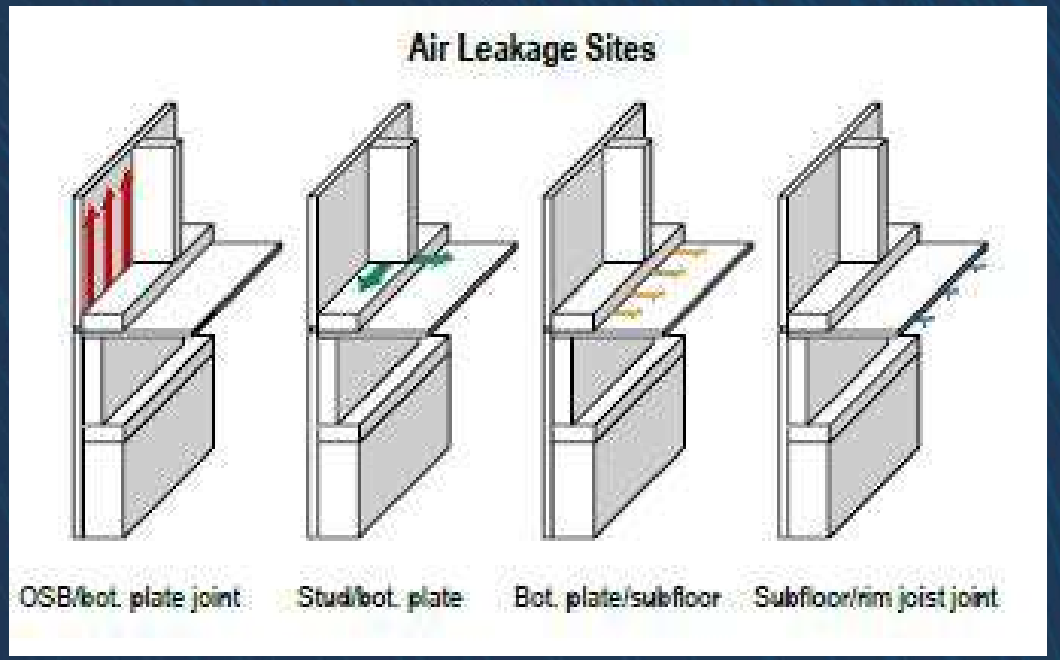
NO Air Barrier & With Insulation

AIR BARRIERS

AIR LEAKAGE IMPACTS ON THERMAL INSULATION

- Average 2,500 square foot house has more than ½ mile of cracks and crevices

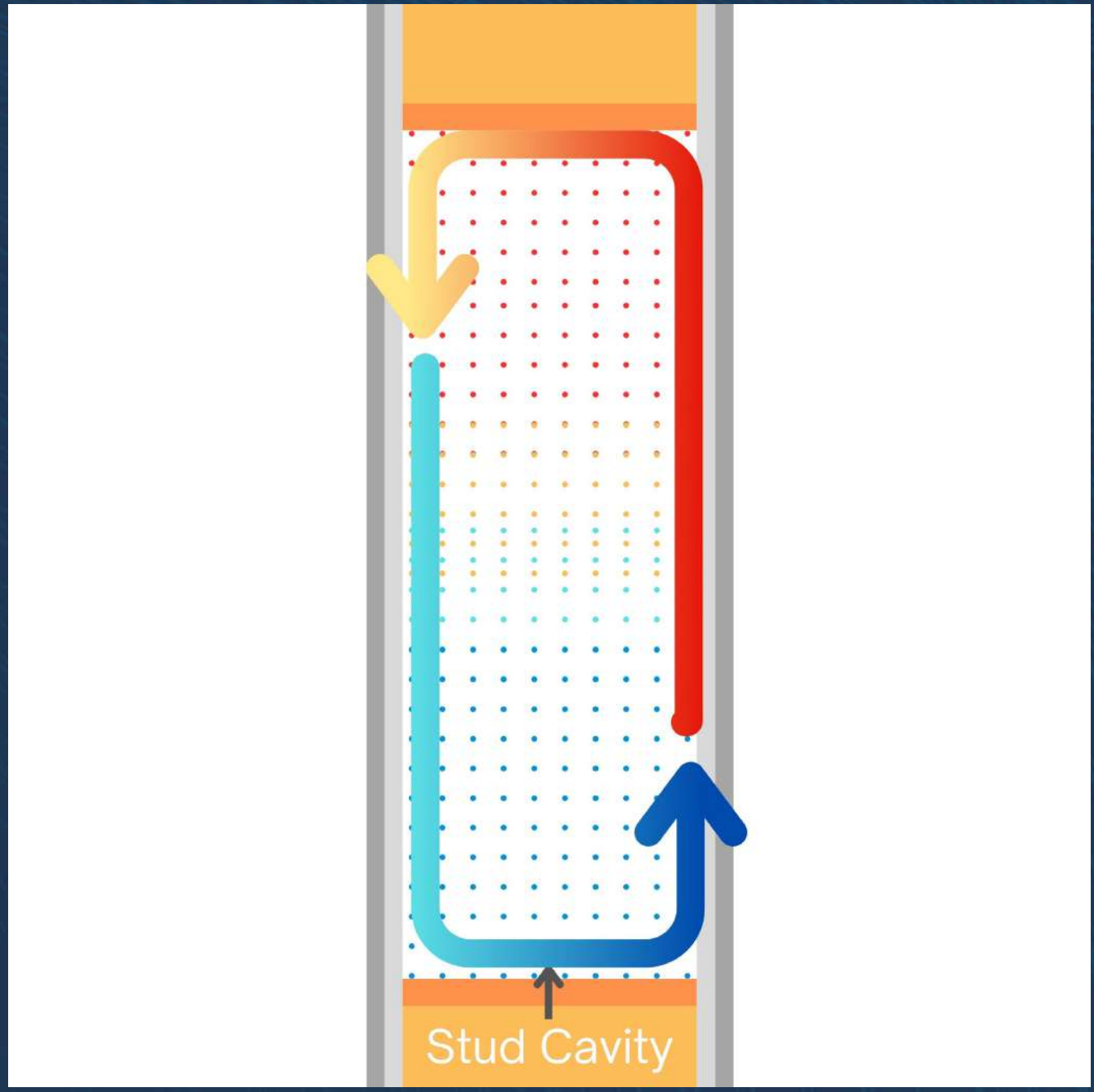




AIR BARRIERS

AIR LEAKAGE IMPACTS ON THERMAL INSULATION

- Airflow reduces thermal insulation through convective loops within the wall cavity



AIR BARRIERS

AIR LEAKAGE IMPACTS ON THERMAL INSULATION

- Wind-Washing through permeable insulations
  - Movement of unconditioned air around and through building

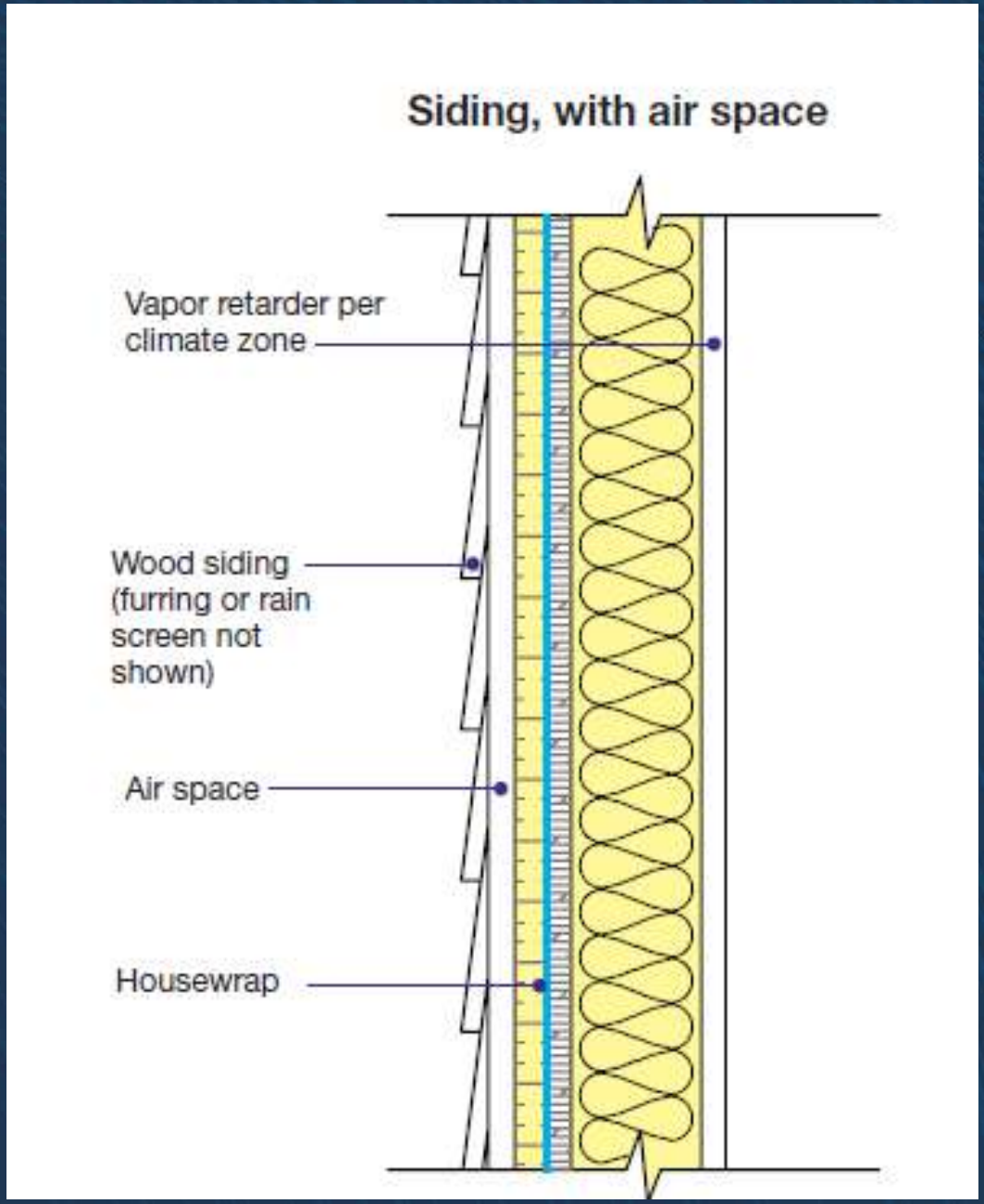
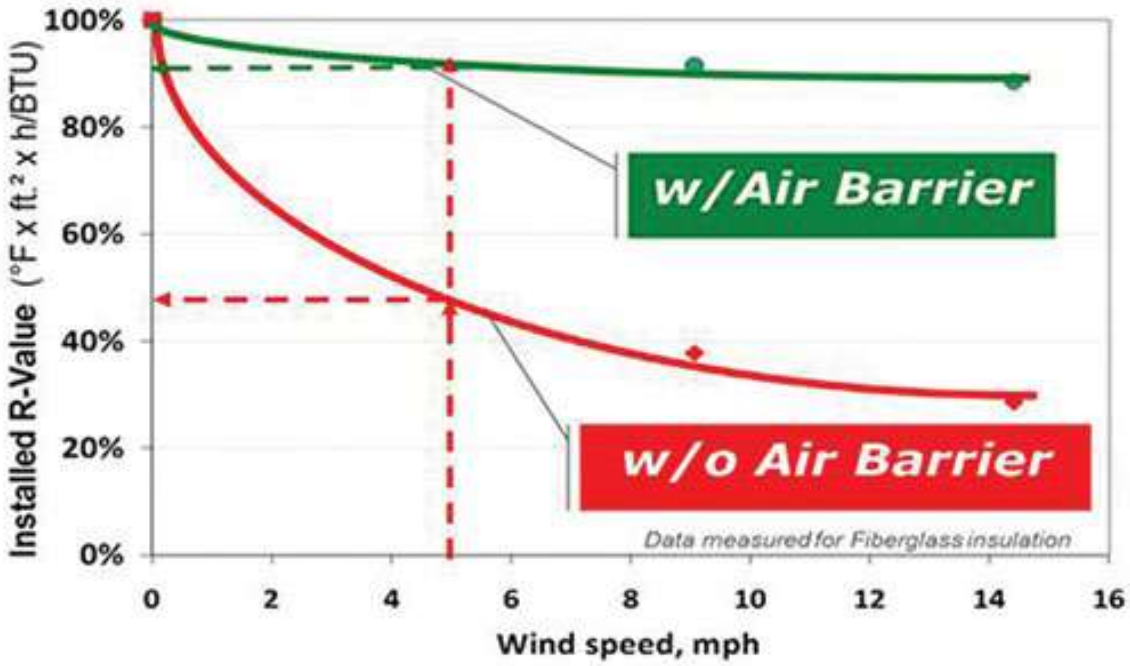


Photo courtesy of NYSERDA

AIR BARRIERS

AIR LEAKAGE IMPACTS ON THERMAL INSULATION

- Installed R-Value Decreases



Graph 1: Wind Washing Effect on Thermal Insulation Performance

Source: Impact of Airflow on the Thermal Performance of Various Residential Wall Systems utilizing a calibrated hot box, Thermal Envelopes VI/ Heat Transfer in Walls – Principles

Why do I need Quality for my Air Barrier Installation?

- Approximately 75% of Construction Defect Claims involve Water [1]

  - Air Barriers Perform the Water Resistive Barrier Function, along with airtightness layer to stop moisture transport

Why do I need Quality for my Air Barrier Installation?

BUILDING ENCLOSURE

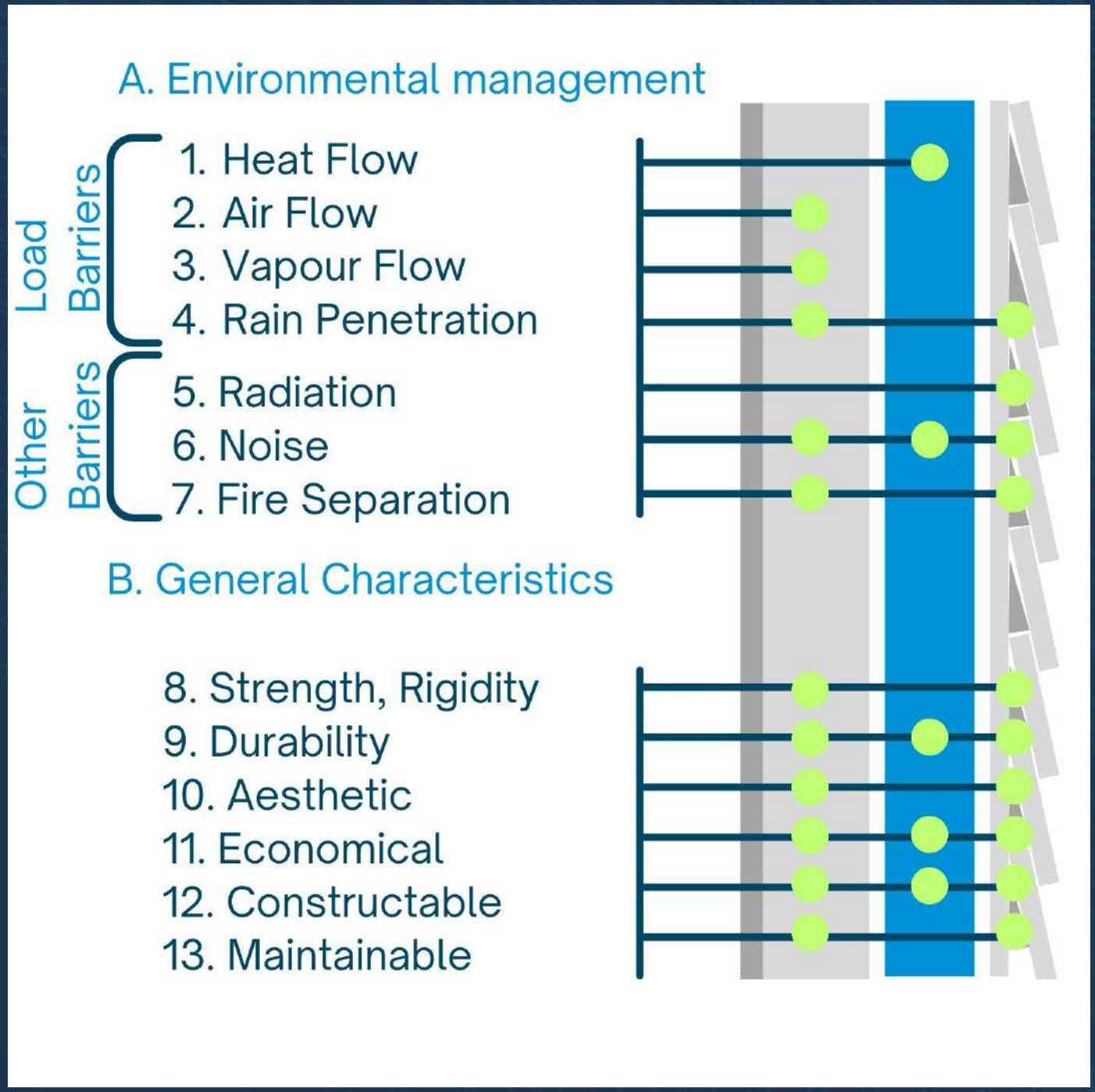
SYSTEMS APPROACH

Air Barriers cannot be dealt with without understanding that they are part of a wall assembly"

N.B. Hutcheon's CBD-48 - **Requirements for Exterior Walls**

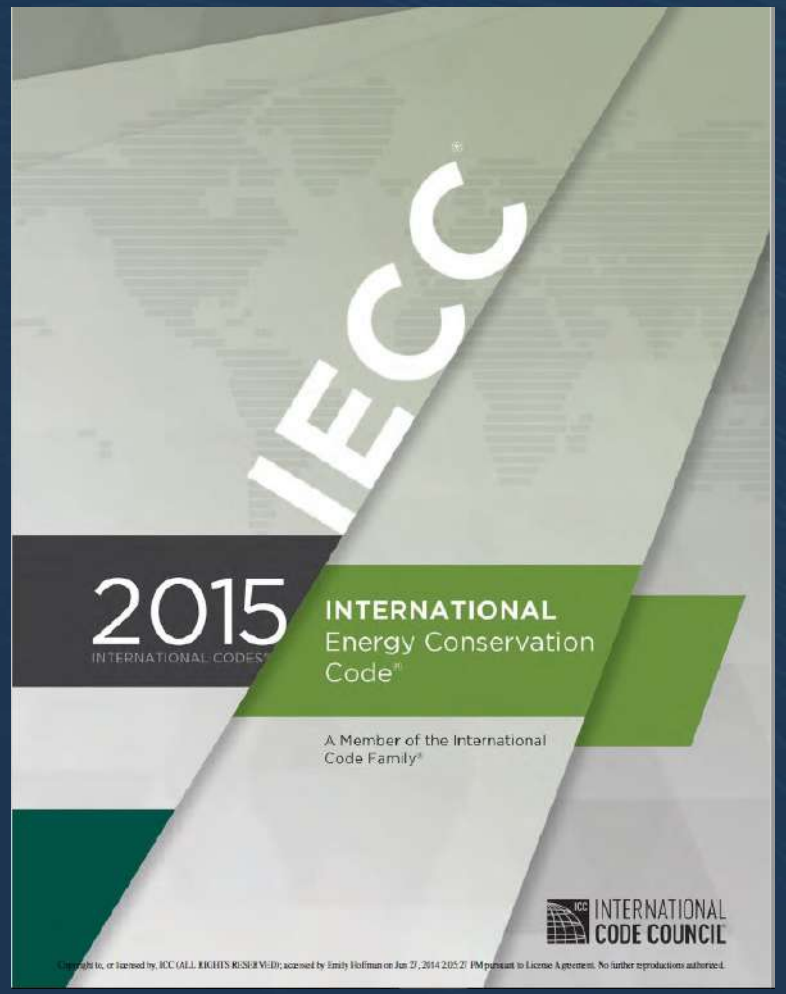
BUILDING ENCLOSURE

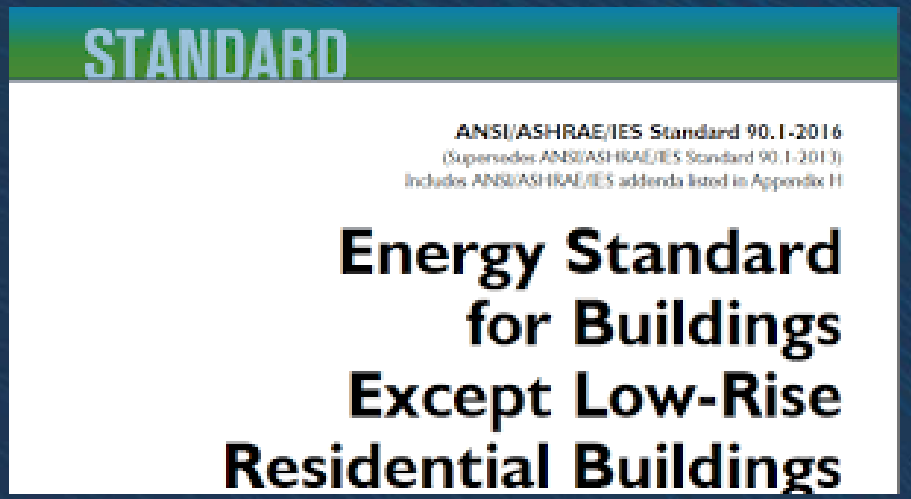
SYSTEMS APPROACH



Code Requirements

I fought the law and the law won

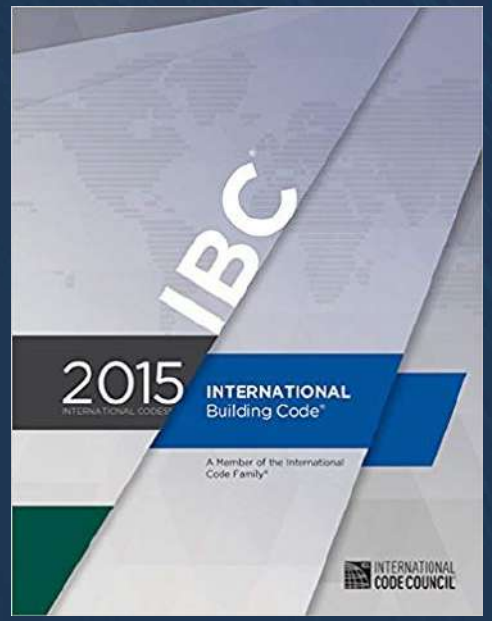


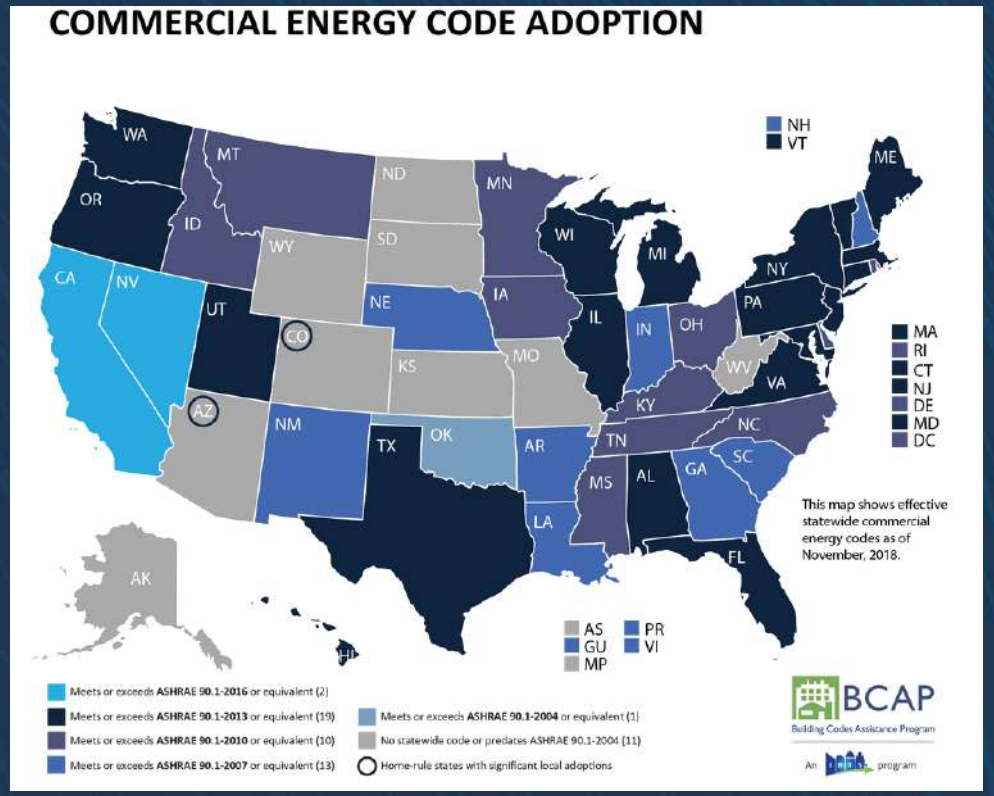


CODE REQUIREMENTS

CODE REQUIREMENTS

- 2021 International Energy Conservation Code –Air Barriers
- 2019 and current versions of ASHRAE 90.1 – Air Barriers
- International Building Code – Fire – NFPA 285
- Changes to State Codes



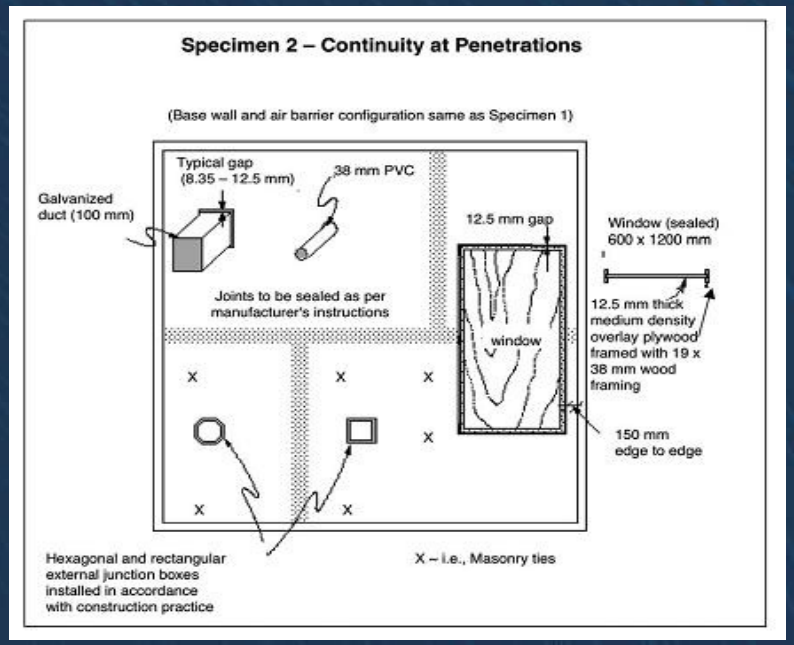


CODE REQUIREMENTS

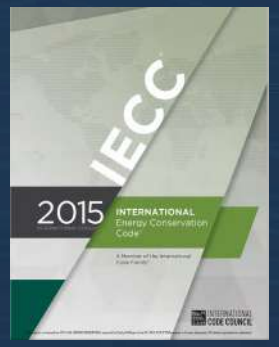
CODE COMPLIANCE OPTIONS – IECC 2015

Material

Assembly



System

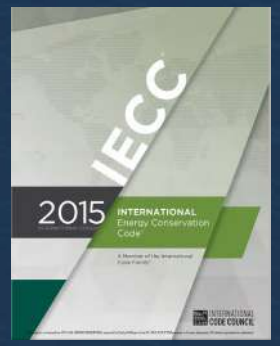


BUILDING CODES

INTERNATIONAL ENERGY CONSERVATION CODE

Material C402.5.1.2.1	Assembly C402.5.1.2.2	Building Test C402.4.1.2.3

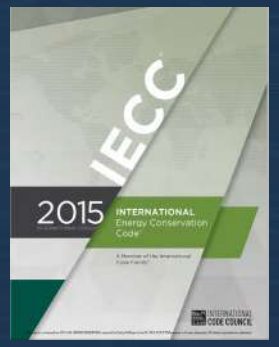
• ASTM 2178
• 0.004 cfm / ft^2
• List of 16 materials that are acceptable – *provided joints are sealed and installed as an air barrier*
	• ASTM 2357, 1677 or 283
	• 0.04 cfm / ft^2
	• List of 3 assemblies deemed to comply, if joints are sealed
	  • Concrete Masonry Walls (coated with block filler or two coats of a paint or sealant)
	  • Portland Cement / sand parge, stucco or plaster (min ½ inch)
		• ASTM 779
		• 0.40 cfm/ft^2
		• Or equivalent method approved by code official



BUILDING CODES

INTERNATIONAL ENERGY CONSERVATION CODE

Listed Materials that are acceptable – if joints sealed and installed as air barriers	
Plywood – thickness = or < 3/8 inch	Built-up roofing membrane
Oriented stand board = or < 3/8 inch	Modified Bituminous roof membrane
Extruded Polystyrene= or < ½ inch	Fully adhered single-ply roof membrane
Foil back Polyiso = or < ½ inch	Portland cement / sand / gypsum plaster = < 5.8
Closed Cell Spray Foam = or < 1 ½ inch	Cast-in-place and precast concrete
Open Cell Spray Foam = or < 4 ½ inch	Fully grouted concrete block masonry
Exterior/Interior Gypsum Board = or < ½	Sheet steel or aluminum
Cement board = or < ½	Solid or hollow masonry construction of clay or shale masonry units



BUILDING CODES

INTERNATIONAL ENERGY CONSERVATION CODE

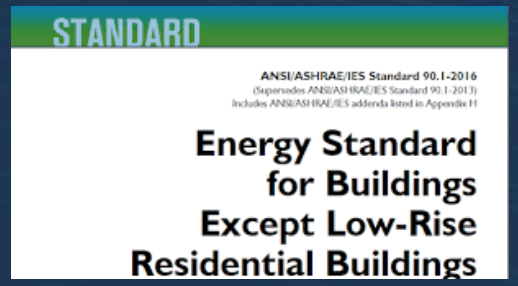
Construction – C402.5.1.1

- **Continuous** across joints and assemblies
- **Joints and seams to be sealed**
  - Changes in materials
  - Entire length and secured so as not to dislodge
  - Withstand pressure from wind/stack/mechanical
- Penetrations
  - Caulked, Gasketed, Sealed…withstand pressures
- Recessed light fixtures – certain air leakage rate – seal/gasket

1. The air barrier shall be continuous for all assemblies that are the thermal envelope of the building and across the joints and assemblies.

2. Air barrier joints and seams shall be sealed, including sealing transitions in places and changes in materials. The joints and seals shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair its ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation.

3. Penetrations of the air barrier shall be caulked, gasketed or otherwise sealed in a manner compatible with the construction materials and location. Joints and seals associated with penetrations shall be sealed in the same manner or taped or covered with moisture vapor-permeable wrapping material. Sealing materials shall be appropriate to the construction materials being sealed and shall be securely installed around the penetration so as not to dislodge, loosen or otherwise impair the penetrations' ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation. Sealing of concealed fire sprinklers, where required, shall be in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.



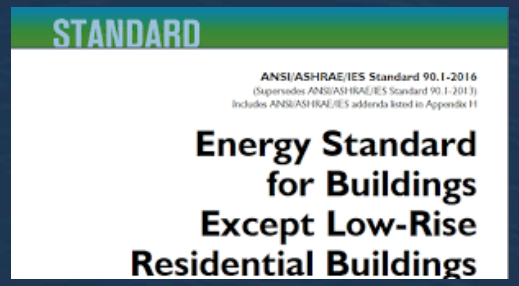
CODE REQUIREMENTS

ASHRAE 90.1 - 2016

- Very similar language to IECC 2016 – Section 5.4.3.1 - but some subtle differences
  - Reference to being continuous
  - Clearly identified on construction documents

5.4.3.1.1 Air Barrier Design. The air barrier shall be designed and noted in the following manner:

a. All air barrier components of each *building envelope* assembly shall be clearly identified or otherwise noted on *construction documents*.

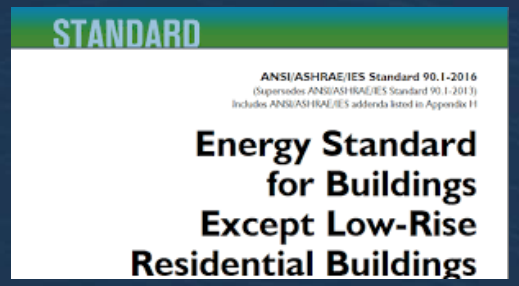


CODE REQUIREMENTS

ASHRAE 90.1 – 2016 – DIFFERENCES BOLDED/UNDERLINED (IECC 2015)

Material	Assembly	Whole Building Test
C402.5.1.2.1	C402.5.1.2.2	5.4.3.1.3 (a)

• ASTM 2178
• 0.004 cfm / ft^2
• List of **13** materials that are acceptable
	• ASTM 2357, 1677 or 283, **1680**
	• 0.04 cfm / ft^2
	• List of 3 assemblies deemed to comply, if joints are sealed
	  • Concrete Masonry Walls (coated with block filler or two coats of a paint or sealant)
	  • Portland Cement / sand parge, stucco or plaster (min ½ inch)
		• ASTM 779 or **ASTM E1827**
		• 0.40 cfm/ft^2 @ 0.3 in.
		• **Exceptions to requirements**



CODE REQUIREMENTS

ASHRAE 90.1 – 2016 (DIFFERENCES STRUCK OUT VS. IECC 2015)

Listed Materials that are acceptable – 13 (IECC is 16)	
Plywood – thickness = or < 3/8 inch	Built-up roofing membrane
Oriented stand board = or < 3/8 inch	Modified Bituminous roof membrane
Extruded Polystyrene= or < ½ inch	~~Fully adhered~~ single-ply roof membrane
Foil back Urethane = or < ½ inch	Portland cement / sand / gypsum plaster = < 5.8
Closed Cell Spray Foam = or < 1 ½ inch	Cast-in-place and precast concrete
~~Open Cell Spray Foam = or < 4 ½ inch~~	~~Fully grouted concrete block masonry~~
Exterior/Interior Gypsum Board = or < ½	Sheet steel ~~or aluminum~~
Cement board = or < ½	~~Solid or hollow masonry construction of clay or shale masonry units~~

CODE REQUIREMENTS

ASHRAE 90.1 – 2016 WHOLE BUILDING EXCEPTIONS

Whole Building Test
5.4.3.1.3 (a)

- ASTM 779 or **ASTM E 1827**
- 0.4 cfm/ft ^{2} @ 0.30 in.
- **Exceptions to requirements**

- Buildings over 50,000 sf of gross conditioned floor area – can be conducted on **less** than whole building (outlines what this means)
- If it is more than 0.4 cfm / ft ^{2}, but less than 0.6 cfm / ft ^{2}
  - Diagnostic evaluation (smoke tracer/Infrared)
  - Visual inspection
  - Seal leaks
  - Report on corrective action

CODE REQUIREMENTS

INTERNATIONAL BUILDING CODE - FIRE

NFPA 285 assembly test

- Exterior Wall Fire Performance due to things such as:
  - Foam Plastics
  - Combustible Exterior Claddings (EIFS, MCM, FRP, HPL)
  - Water Resistive Barriers (air barriers)

CODE REQUIREMENTS

INTERNATIONAL BUILDING CODE - FIRE

NFPA 285 assembly test

- Full Assembly Test with all exterior wall components
- Unable to “swap” out materials, unless engineering judgem letter accepted by AHJ
- Some assemblies passed and then failed once WRB was added
- Need to determine if NFPA test is required based on IBC if using combustible cladding or foam insulation – or look at non-combustible wall components for insulation and exterior cladding

CODE REQUIREMENTS

INTERNATIONAL BUILDING CODE - FIRE

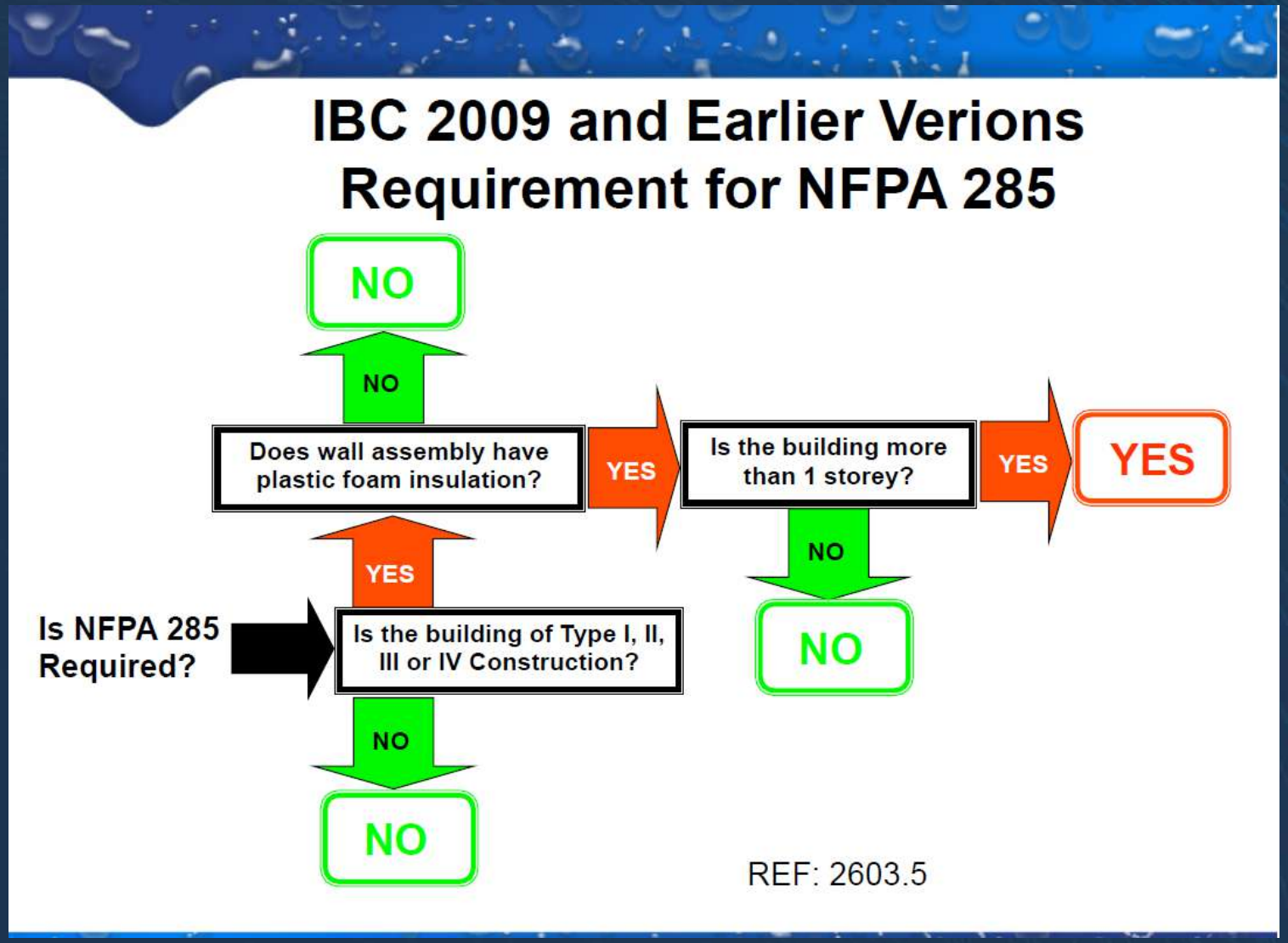


Photo courtesy of Carlisle

CODE REQUIREMENTS

INTERNATIONAL BUILDING CODE - FIRE

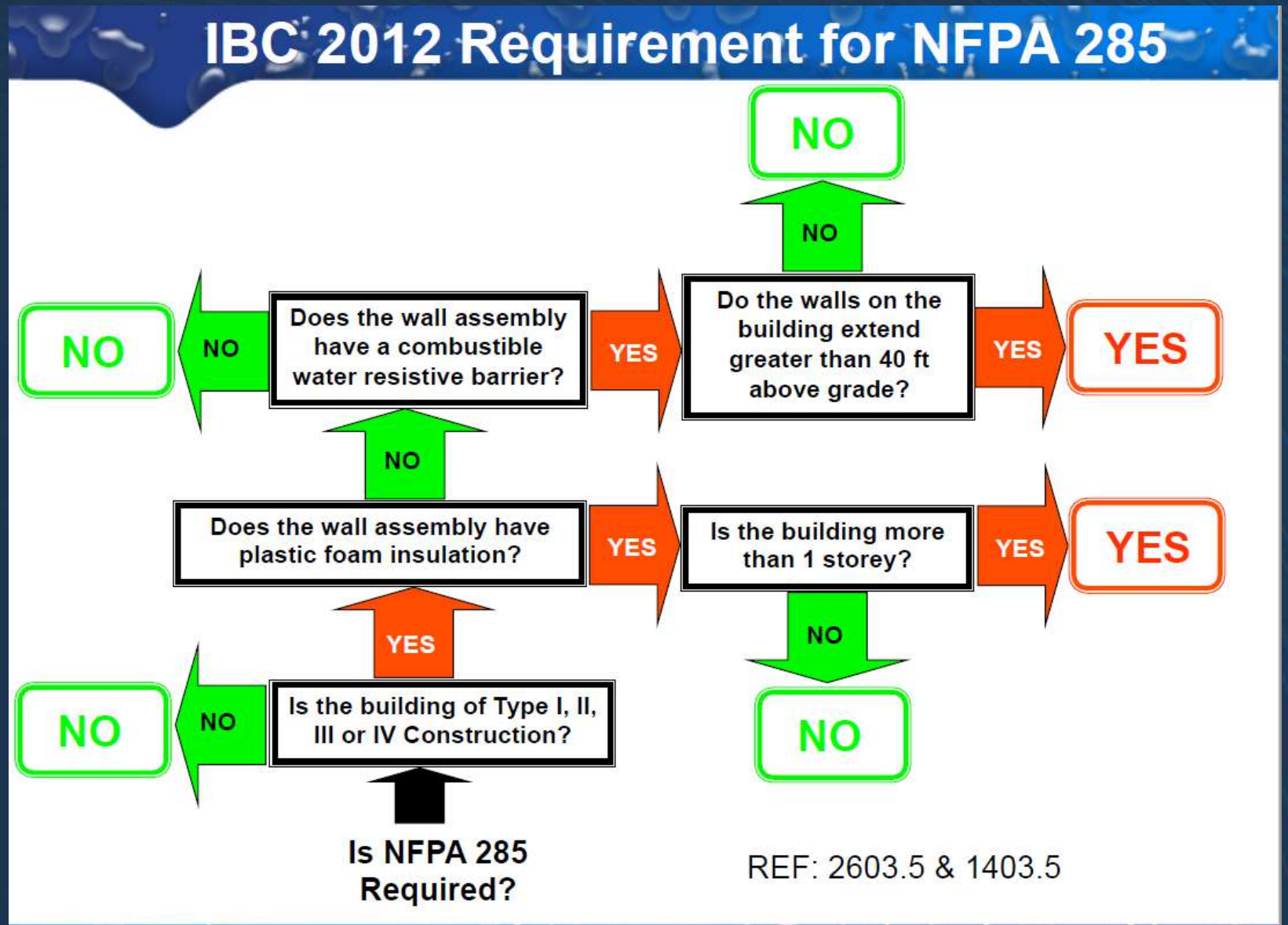


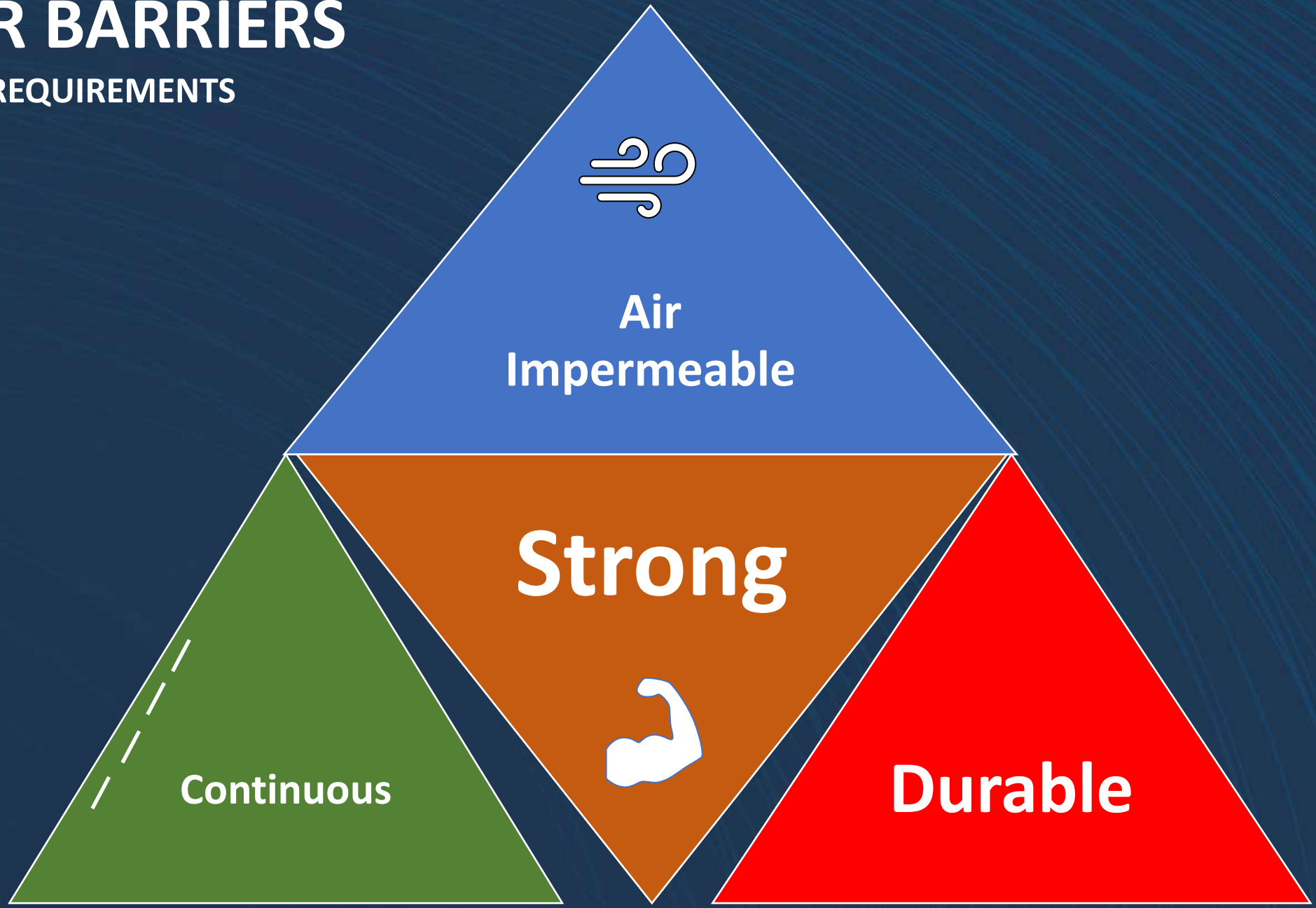
Photo courtesy of Carlisle

Air Barrier Materials

Can I use anything ?

AIR BARRIERS

KEY REQUIREMENTS



MATERIALS AND TEST METHODS

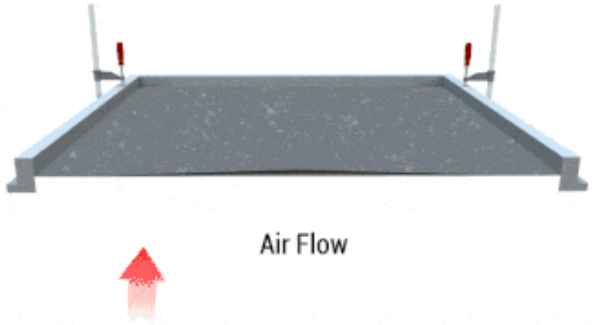
AIR BARRIERS

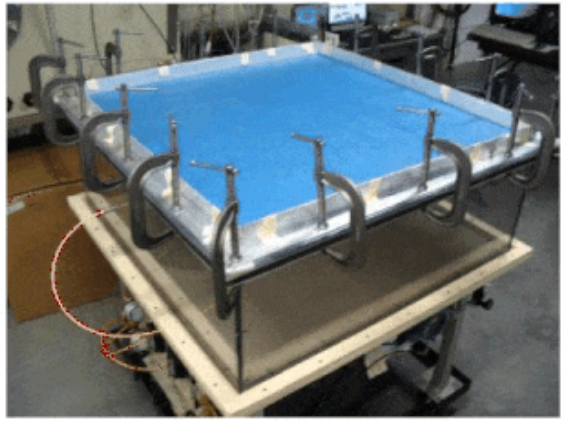
IMPERMEABLE MATERIAL

- A material that has been designated to provide the primary function of controlling the movement of air through a building assembly and when tested in accordance with ASTM E2178-01 and has a air permeance of less than:

  0.004 cfm/ft2 @ 1.56 lb/ft2

  0.02 L/s/m^2 @ 75 Pa

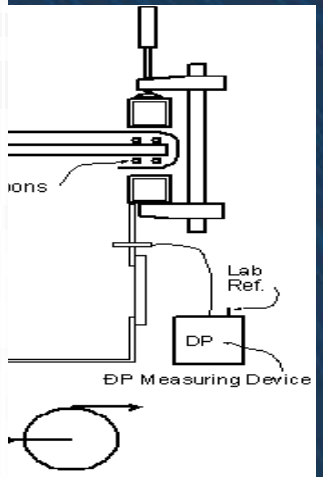




Actual 2178 test conducted with air barrier material

AIR BARRIERS

IMPERMEABLE MATERIAL



AIR BARRIERS

IMPERMEABLE MATERIAL

The test results are reported at 75 Pa, but the test pressures go up to 300 Pa

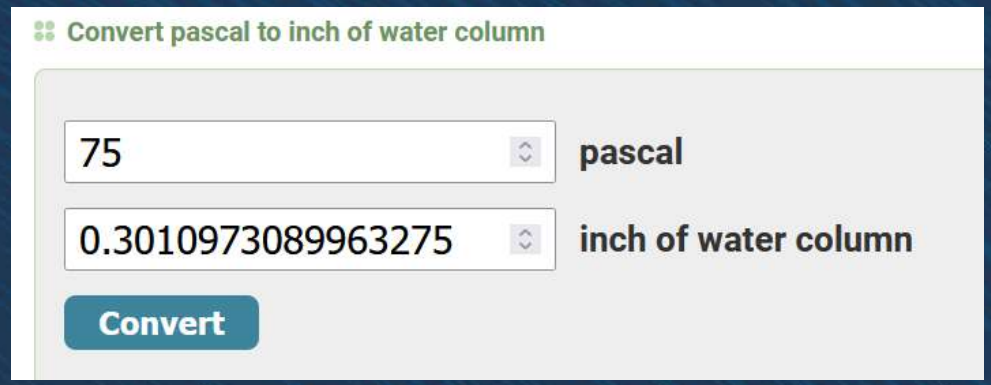
Do you know how much pressure 75 Pa is?

This is a very low level of pressure—about the same as the force exerted by a single sheet of paper spread over a square meter. To give you a familiar comparison, it's like a gentle breeze or a light tap.

Things you do not need to know!

Who is this Pascal Guy?

Blaise Pascal, a French mathematician, and physicist who made significant contributions to the study of fluids and pressure.



AIR BARRIERS

CONTINUOUS

- The air barrier shall be joined in an air-tight and flexible manner to the air barrier material of adjacent systems, allowing for the relative **movement** of systems due to **thermal and moisture** variations and creep. Connections shall be made between:
  - foundation and walls
  - walls and windows or doors
  - different wall systems
  - walls and roof
  - Interior floor wall and roof adjacent to unconditioned spaces
  - walls, floors, and roofs across construction, control and expansion joints

AIR BARRIERS

CONTINUOUS

- All penetrations of the air barrier and paths of air infiltration/exfiltration shall be made air-tight

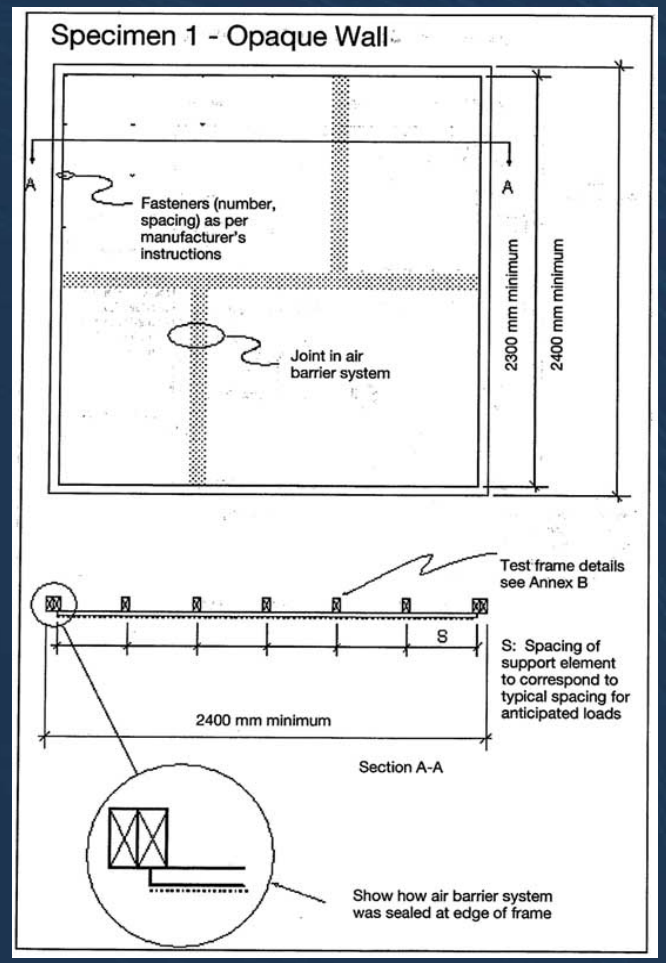
Remember:

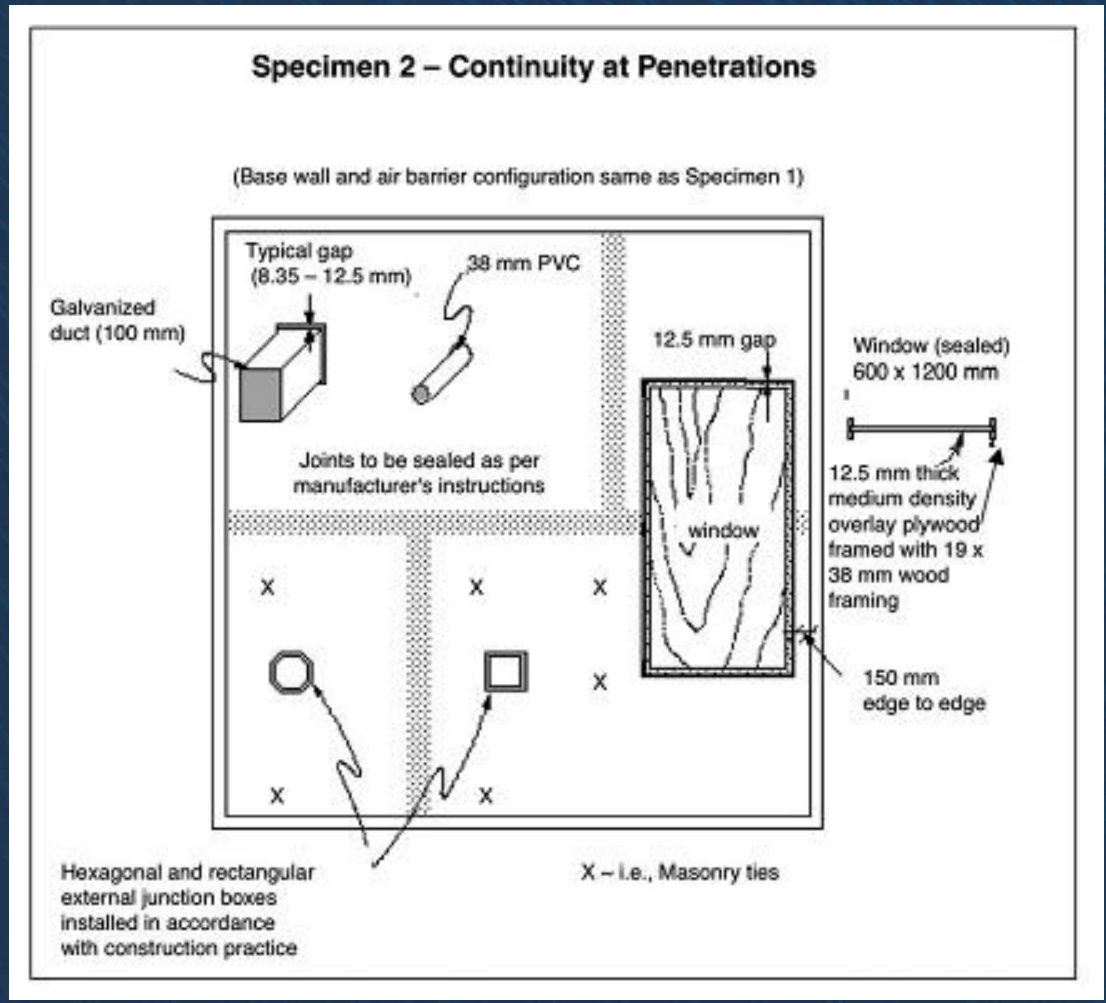
- Sequence of construction
- Before or after air barrier

AIR BARRIERS

CONTINUOUS

- ASTM 2357





AIR BARRIERS

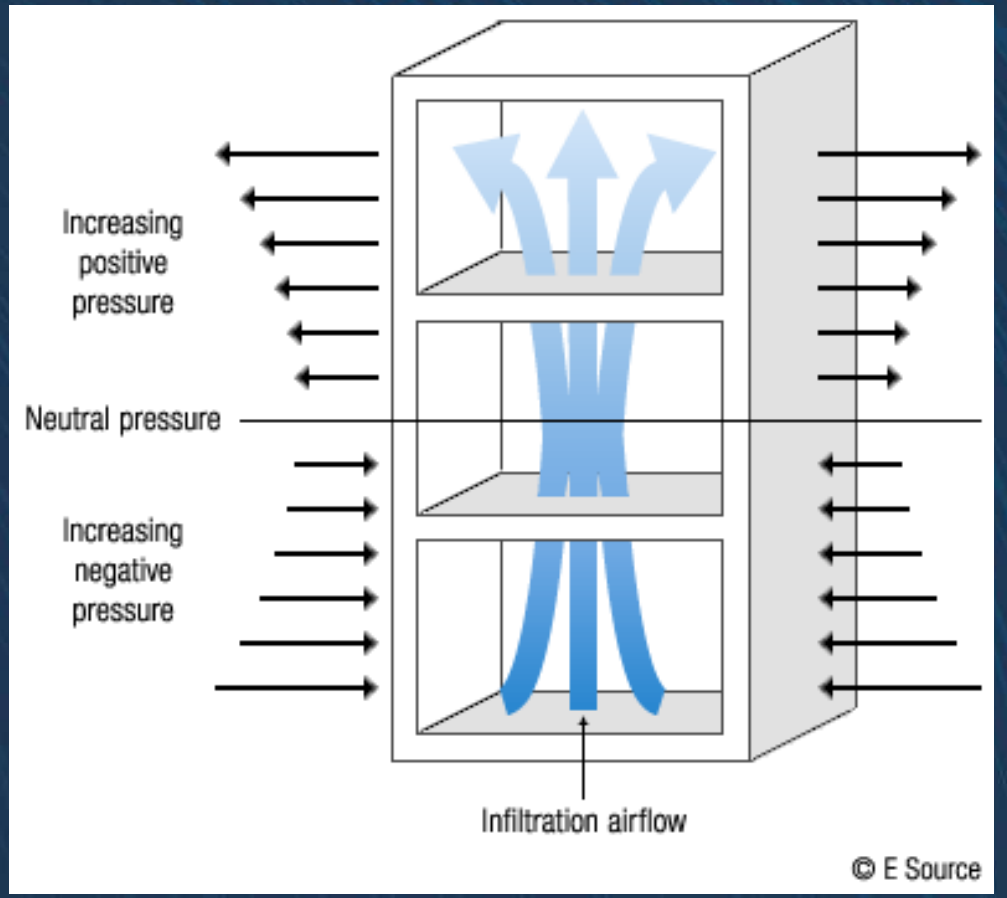
CONTINUOUS

- ASTM 2357

AIR BARRIERS

STRONG

- Withstand positive and negative loads due to wind, stack and mechanical pressures
- Not to displace other building enclosure components
- ASTM 2357 test method applies both positive and negative pressures to specimen to simulate wind gusts and pressures from stack and mechanical
- Result Reported at 75 Pa
- Pressures go up to 1,200 Pa



AIR BARRIERS

DURABLE

- Materials are typically installed as a non-maintainable components within the wall assembly
- Need to last the life of the enclosure and be resilient
- Durable to deal with moisture, temperature, building movement over the intended life span

AIR BARRIERS

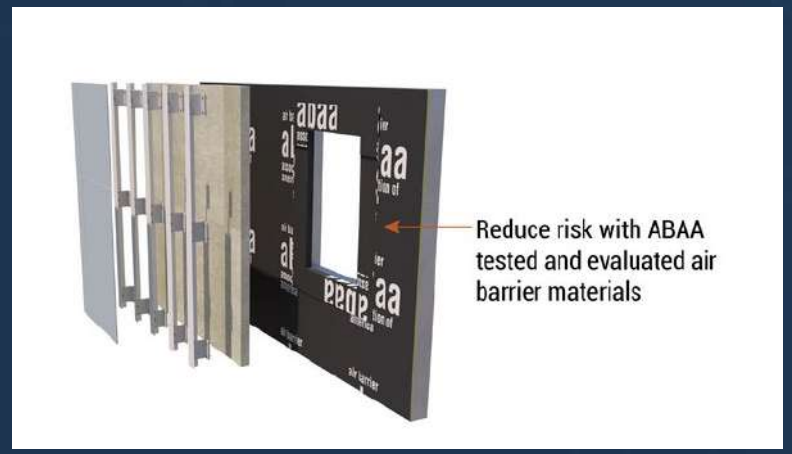
AIR LEAKAGE PERFORMANCE REQUIREMENTS

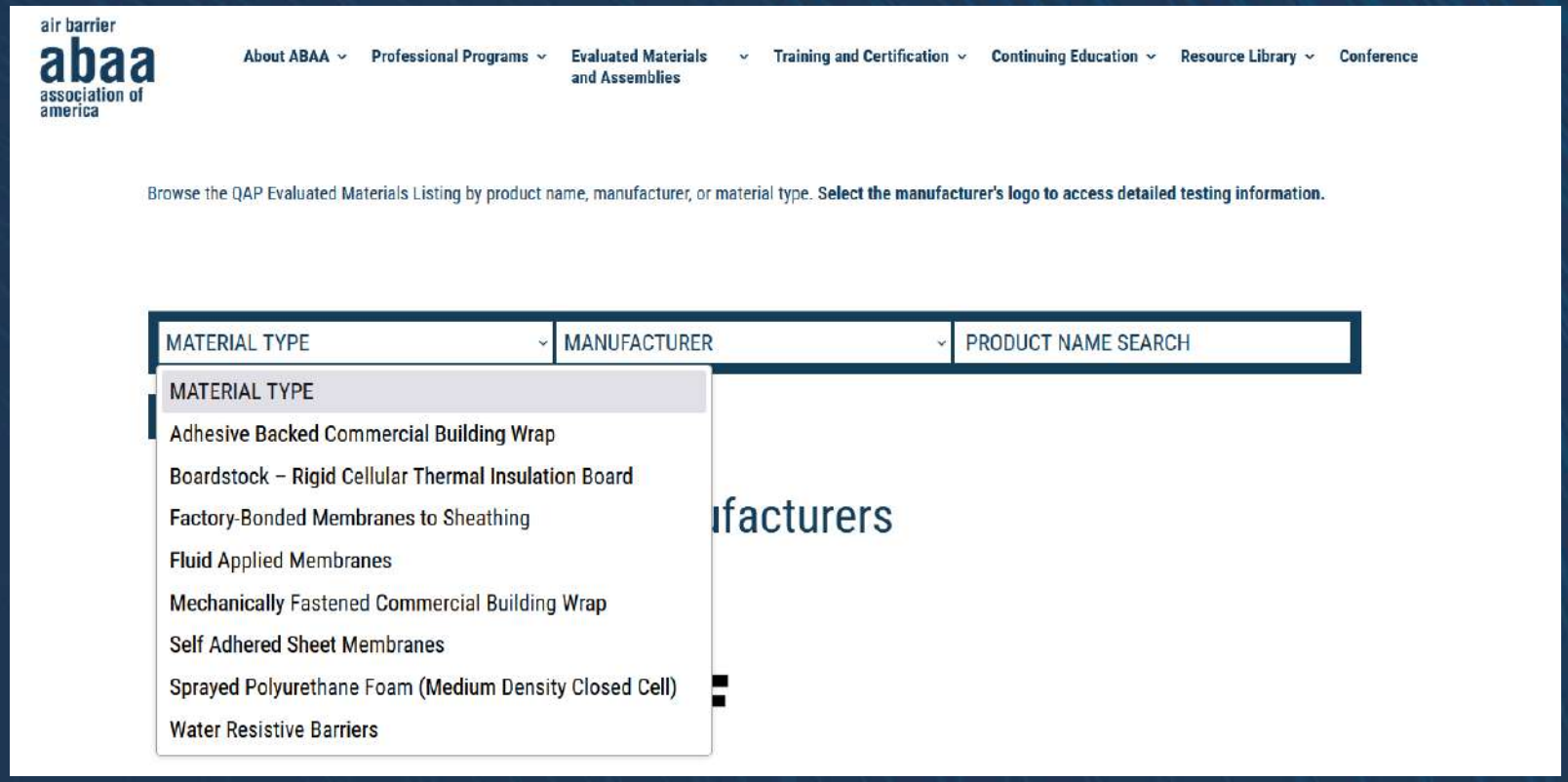
- Material - 0.004 CFM/ft²@ 1.56 lbs/ft² pressure difference (ASTM E 2178)
- Accessory – tapes, strips, caulking, etc - 0.004 CFM/ft²@ 1.56 lbs/ft² pressure difference (ASTM E 283)
- Component – windows, doors, skylights, etc. - 0.04 CFM/ft²@ 1.56 lbs/ft² pressure difference (ASTM E 283)
- Assembly (Wall assembly, roof assembly, foundation assembly)- 0.04 CFM/ft²@ 1.56 lbs/ft² pressure difference (ASTM E 2357)
- System (Whole Building) - 0.40 CFM/ft²@ 1.56 lbs/ft² pressure difference (ISO 9972, **ASTM E 779**, **ASTM 3158**, CGSB 149.10)

AIR BARRIERS

OTHER TEST CRITERIA ESTABLISHED BY ABAA

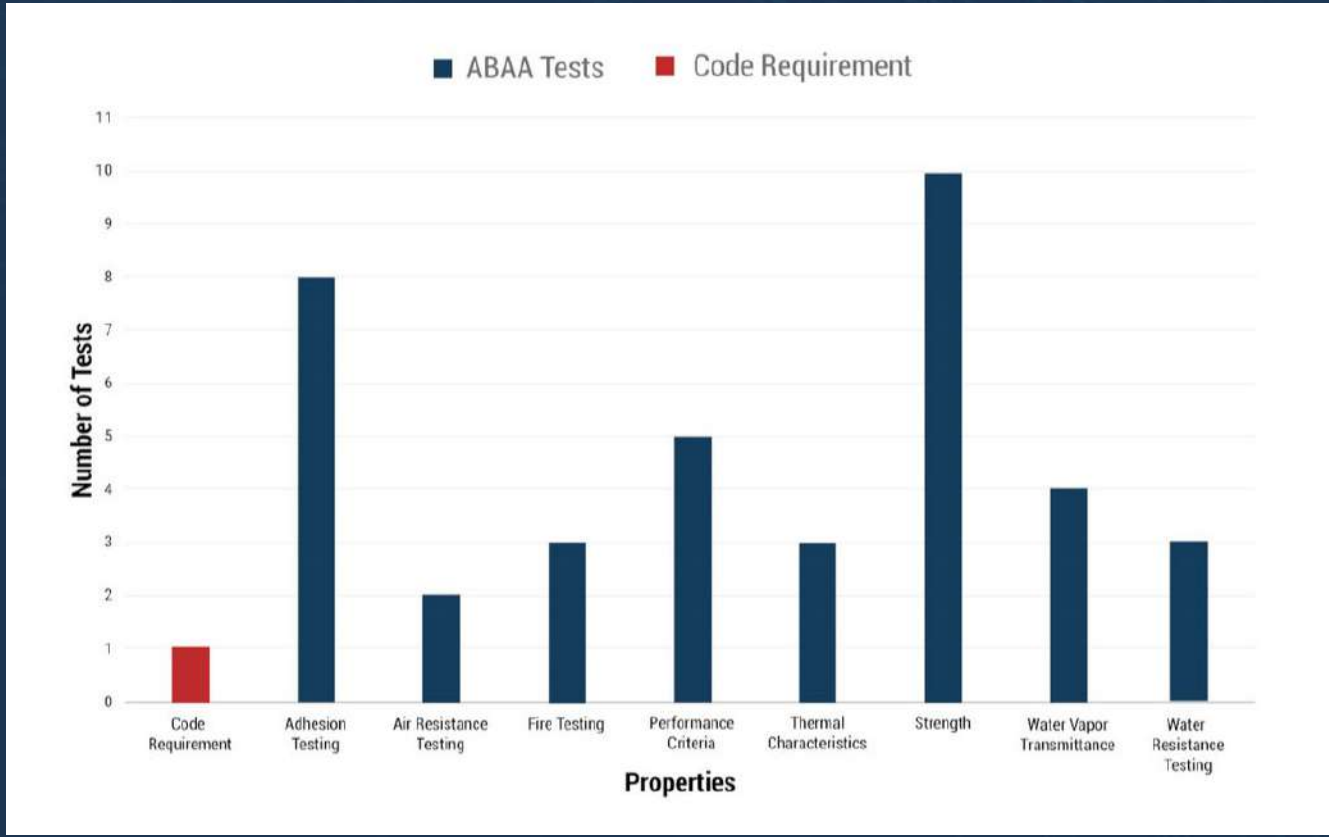
- Other test methods developed for each material type as part of ABAA evaluation process
- Currently developed for:





AIR BARRIERS

OTHER TEST CRITERIA ESTABLISHED BY ABAA



air barrier abaa association of america

ABAA S0008-2021

TABLE 1
REQUIREMENTS FOR PHYSICAL PROPERTIES

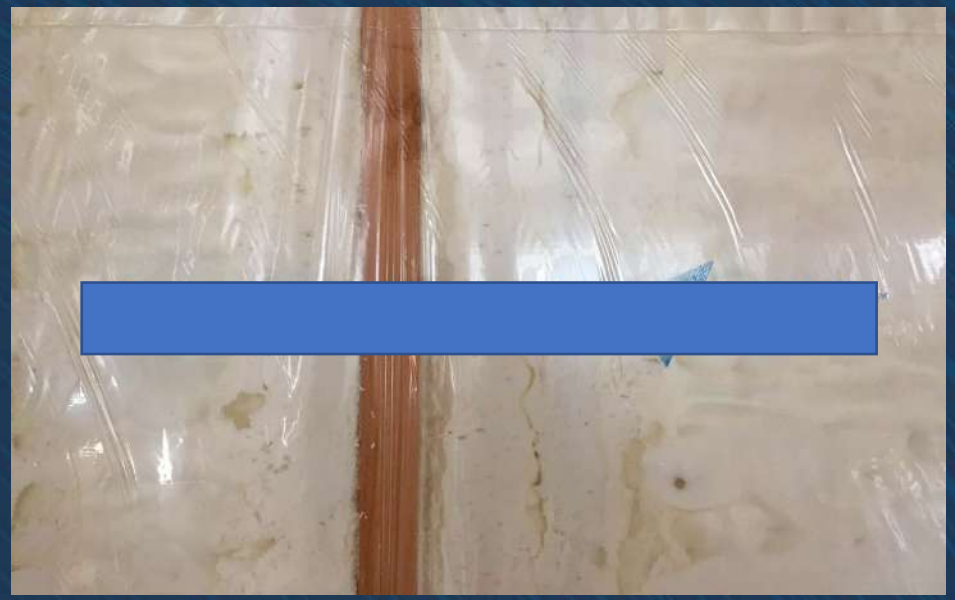
Property	Unit	Requirements		Test Method
		Min.	Max.	
Air Leakage Rate - Material	L/(s·m²) @ 75 Pa CFM/ft²@ 1.57 psf	- -	0.0200 0.0040	ASTM E2178
Air Leakage Rate - Fastener	L/(s·m²) @ 75 Pa CFM/ft²@ 1.57 psf	- -	0.0200 0.0040	ASTM E2178 with modified specimen
Alkali Resistance	visual	No deleteriou s effects	-	ASTM D543 Practice A Procedure 1
Elongation	%	200	-	ASTM D412 Method A Die C
Freeze-Thaw Resistance	visual	no surface changes	-	ASTM E2485 Method A
Fungi Resistance	%	no growth	-	ASTM C1338
Gap Bridging Ability	mm inch	Report temperature material were tested at and the maximum gap tested		ABAA T0004
Low Temperature Flexibility	visual	no surface changes	-	ASTM D522 Method B
Peel Adhesion	N/mm lb/inch	0.875 5.0	- -	ASTM C794
Pull Adhesion – For each substrate	kPa psi	110 16	- -	ABAA T0002
Surface Burning Characteristics Flame Spread Index	-	-	75	ASTM E84
Smoke Development Index	-	-	450	
Volatile Organic Compounds	ppm	Report		EPA 24
Water Vapor Absorption by Diffusion	%	Report		ASTM C1498
Water-Resistance in 100% Relative Humidity	visual	-	No change in color, blistering, etc.	ASTM D2247
Water Vapor Transmission Rate – water and desiccant method	ng/(Pa·s·m²) Perms	Report for both atmospheres		ASTM E96

AIR BARRIERS

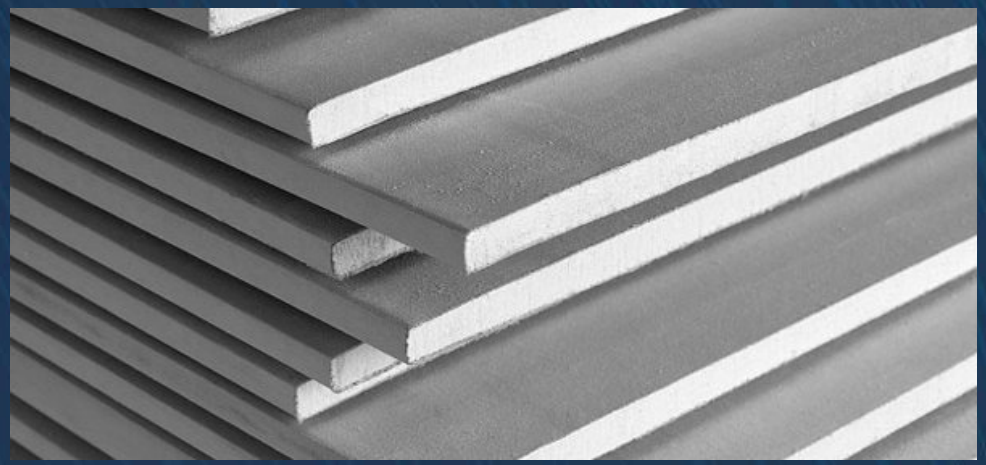
OTHER TEST CRITERIA ESTABLISHED BY ABAA

- Other evaluation criteria with no products evaluated:
  - Light Density Open Cell Semi-rigid spray polyurethane foam.
  - Non-insulating Sheathing Gypsum Based

The specific evaluation criteria for each material can be found on the ABAA website.



Interior Polymer Film



Non-Insulating Board Stock

Summary

Is ABAA just blowing a lot of hot air ?

Probably, but let’s Review

- Need to look at the building enclosure as a whole
- Focus on assemblies and systems, rather than single components
- Building Physics do not change, only how we design and build
- You can’t meet Net Zero effectively without a air tightness strategy.

Now what ?

Where can I go for help ?

Help Please !

- Evaluated Materials – ABAA Website
- 3-Part Guide Specification – ABAA website
- Education – Weekly Webinars – ABAA website
- Technical Articles – ABAA Website
- Social Media – LinkedIn, Instagram, Facebook.
- Site Quality Assurance – Spec ABAA QAP
- I just want to talk….. Give us a call or shoot us an email.

Contact Me:

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Ryan Dalgleish

abaa building enclosure conference