Building and Testing Airtight Buildings

IMPACT AND LESSONS LEARNED

APEGBC Airtightness in Buildings Seminar

June 21, 2017

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RDH BUILDING SCIENCE

Outline

- → Air Barrier Design
- → House versus High-rise
- → Where We're At – Measured Performance
- → Impact of Testing
- → Codes & Standards

Air Barrier Design

5 Requirements for an Air Barrier

#1: Continuity

→ Must be continuous between all enclosure elements, from above to below grade, walls to windows and doors, roof & everything in between

→ Relies on more than one material

→ Compatibility of adjoining materials critical for long term sealing

5 Requirements for an Air Barrier

#2: Air Impermeability

→ Materials must be resistant to flow or air at pressures experienced in the building

→ Air barrier materials of less than 0.02 L/s·m² (0.004 cfm/ft²) @ 75 Pa

→ Air barrier systems of less than 0.2 L/s·m² (0.04 cfm/ft²) @ 75 Pa

→ Most materials & systems easily meet requirements

Most CMU is not an airtight material by code definition unless coated

5 Requirements for an Air Barrier

→ Peanut Butter (brand unknown) – 20 mils

→ 0.0041 cfm/ft² @ 75 Pa – More than twice as tight as Tyvek!

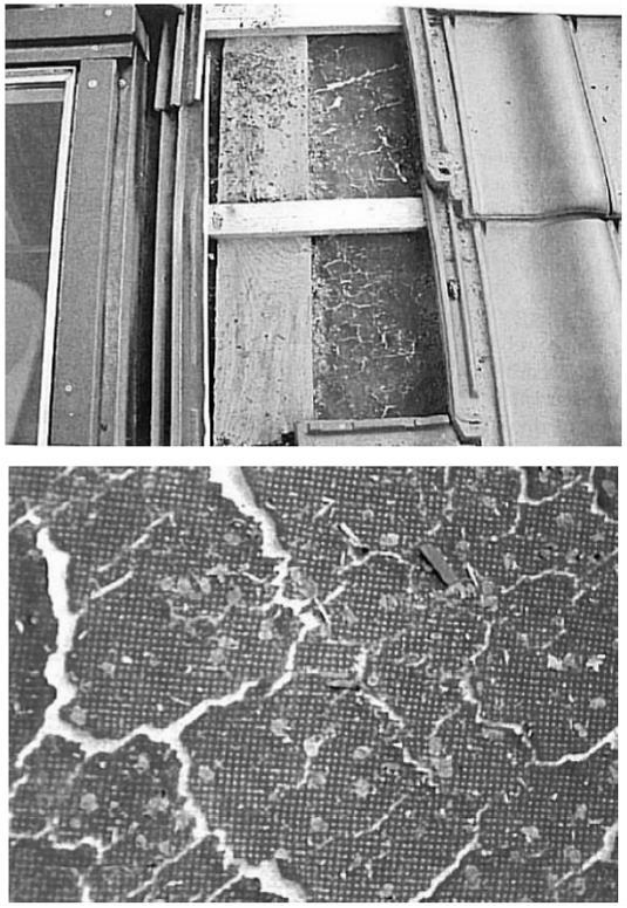
5 Requirements for an Air Barrier

#3: Durability

→ Air Barrier System must be durable enough to last as long as the enclosure assembly that it is installed into

→ Must be able to take stresses due to assembly/material movement

→ Must not degrade due to high or low temperatures, moisture, chemicals, contaminants, UV (if exposed) during construction & in-service



Untried air barrier membrane product from Europe – failed due to heat aging effects in roof assembly

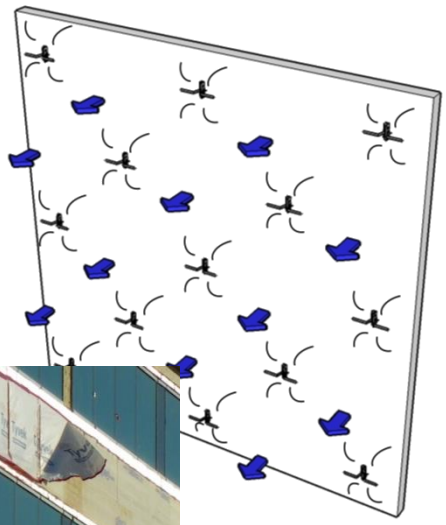
5 Requirements for an Air Barrier

#4: Strength

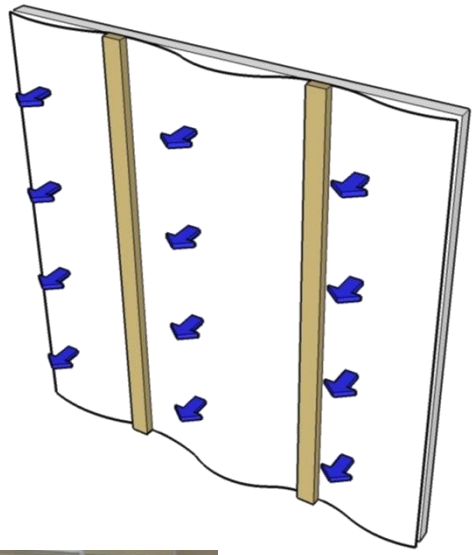
→ Air barrier systems must be designed for the structural wind & resulting building pressure loads

→ Joints and fasteners often critical, especially for flexible unadhered membrane systems

→ Adhesion of tapes/sealants critical to performance & are often the strength limiting component



5 Requirements for an Air Barrier



#5: Stiffness

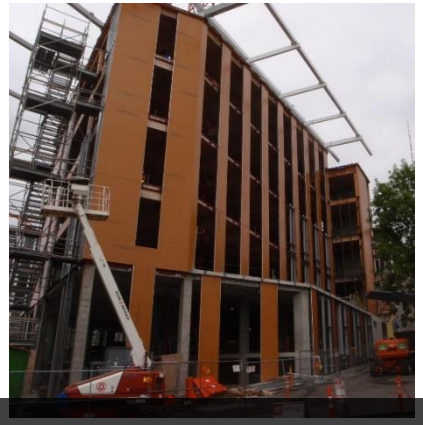
→ Air barrier system must be stiff enough so that deformations do not change the air-permeance or lead to damage

→ One-side supported sheet membranes create challenges

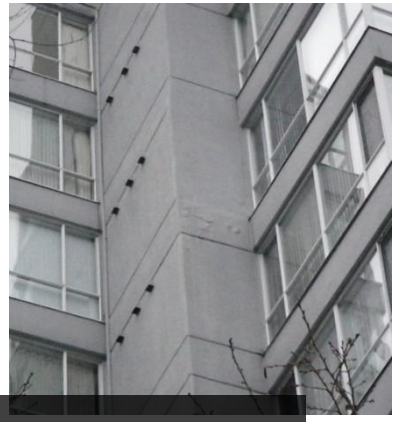
Many Air Barrier Systems Available

Loose Sheet Applied Membrane – Taped Joints & Strapping

Sealed Gypsum Sheathing – Sealant Filler at Joints

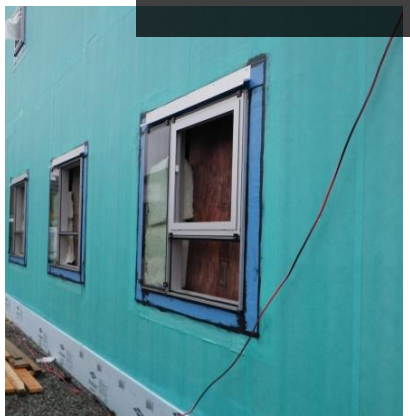


Liquid Applied Sealants/Membranes

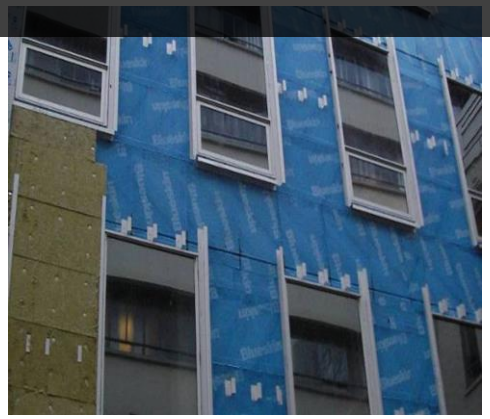


Mass Walls (concrete)

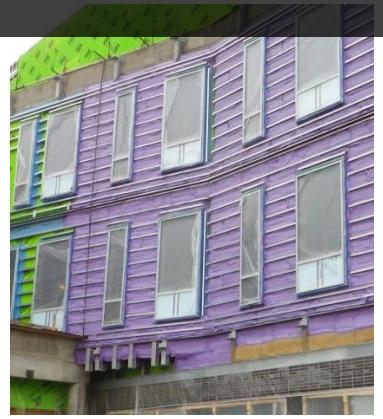
BUT, IT'S THE DETAILS THAT MATTER



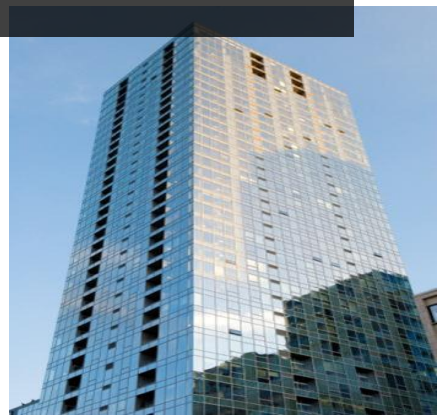
Self-Adhered vapor permeable membrane



Self-Adhered vapor impermeable membrane

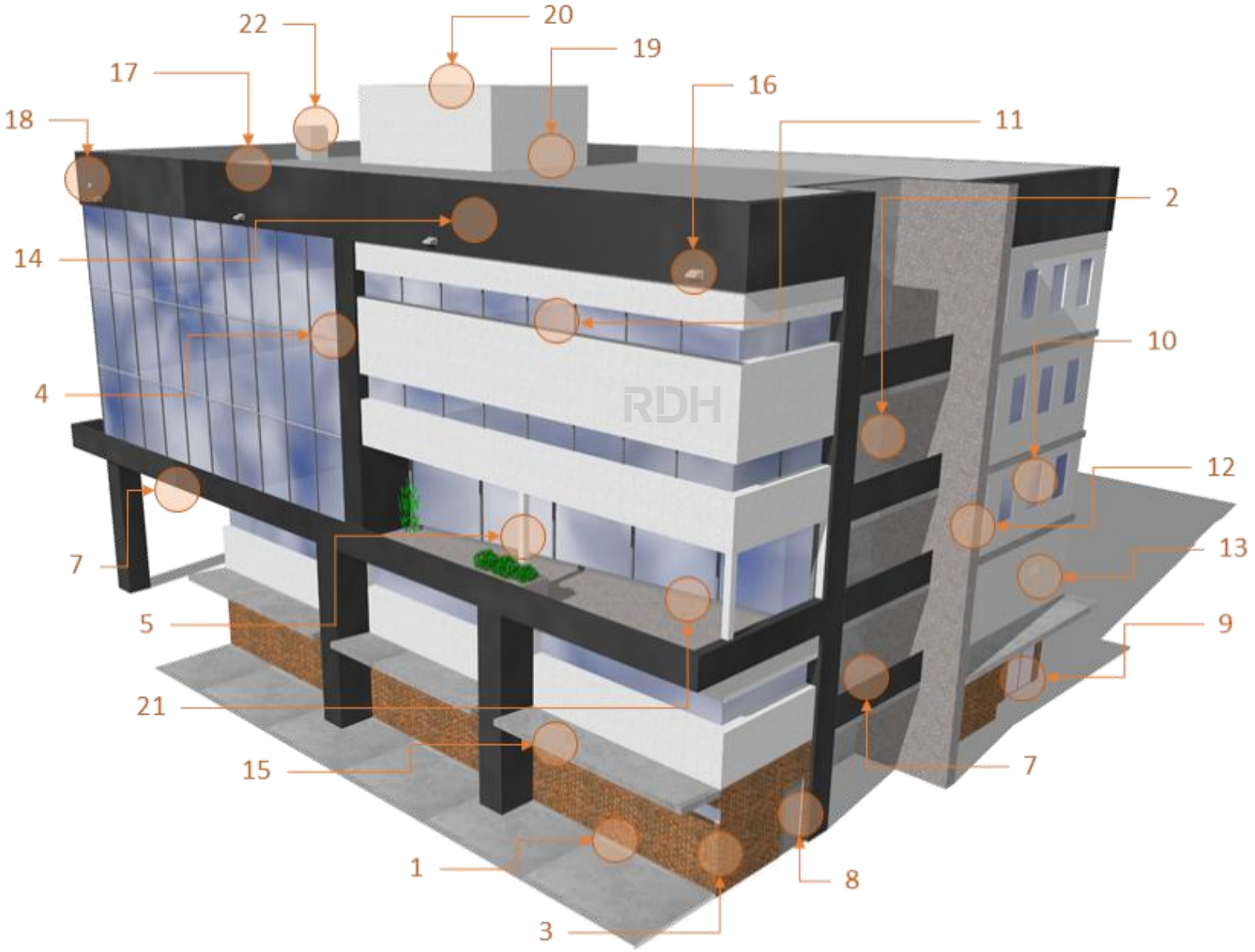


Sprayfoam



Curtainwall, window-wall & glazing systems

Only As Strong As Weakest Detail



Only As Strong As Weakest Detail

Materials **Components** **Accessories**

Whole Building Airtightness

Context - Other Jurisdictions

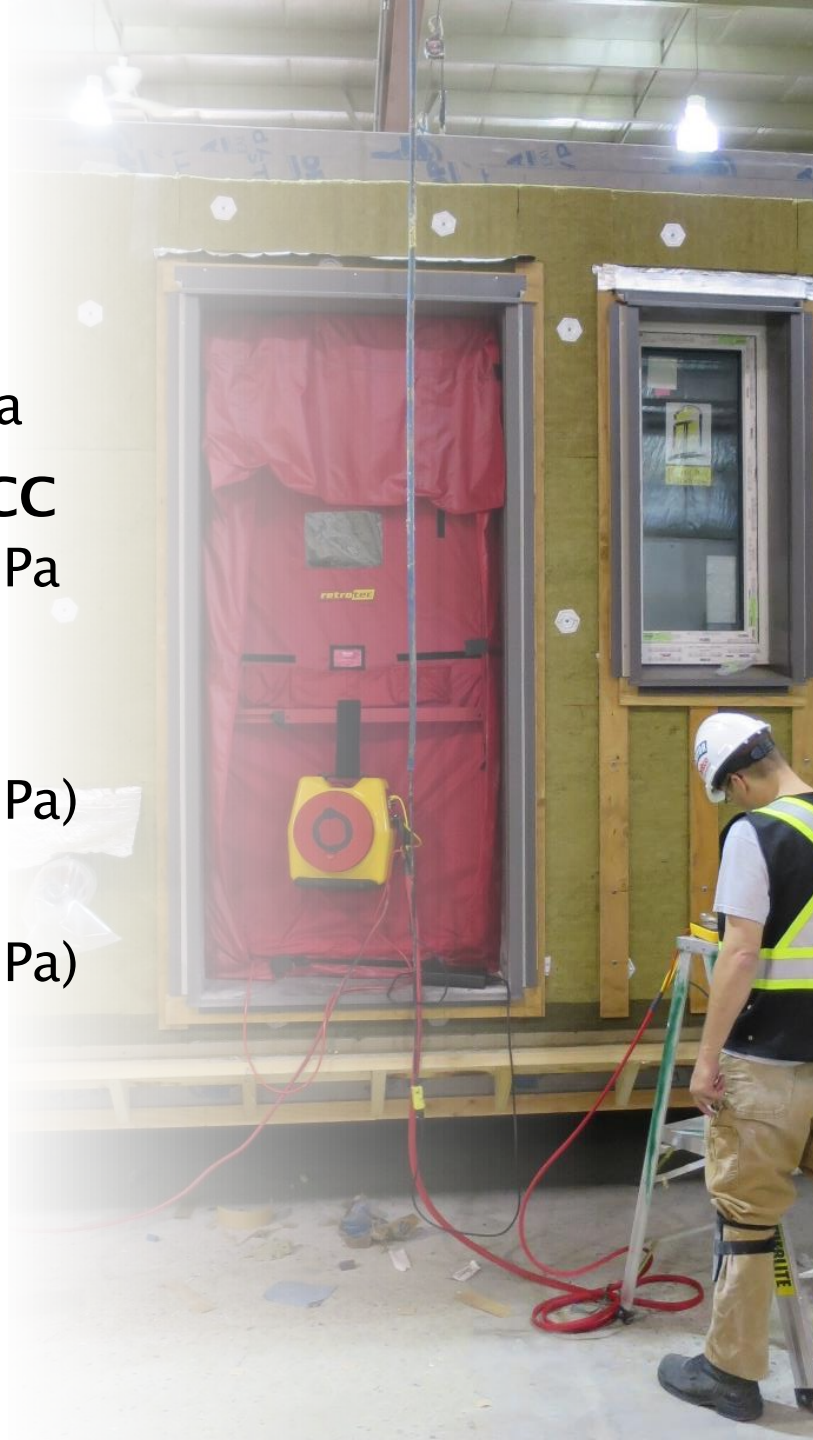
→ **Washington State & Seattle, ABAA Target, GSA, IBC/IECC Option**
< 2.0 L/(s·m²) [0.40 cfm/ft²] @ 75 Pa

→ **US Army Corps of Engineers & IGCC**
< 1.26 L/(s·m²) [0.25 cfm/ft²] at 75 Pa

→ **Passive House**
0.6 ACH50
(~0.60 L/(s·m²) [0.12 cfm/ft²] at 75 Pa)

→ **LEED, 6-sided apartment test**
(~1.25 L/(s·m²) [0.25 cfm/ft²] at 50 Pa)

→ **UK (AATMA) Large Buildings**
~0.70 to 1.75 L/(s·m²) at 75 Pa
[~0.14 to 0.34 cfm/ft² at 75 Pa]



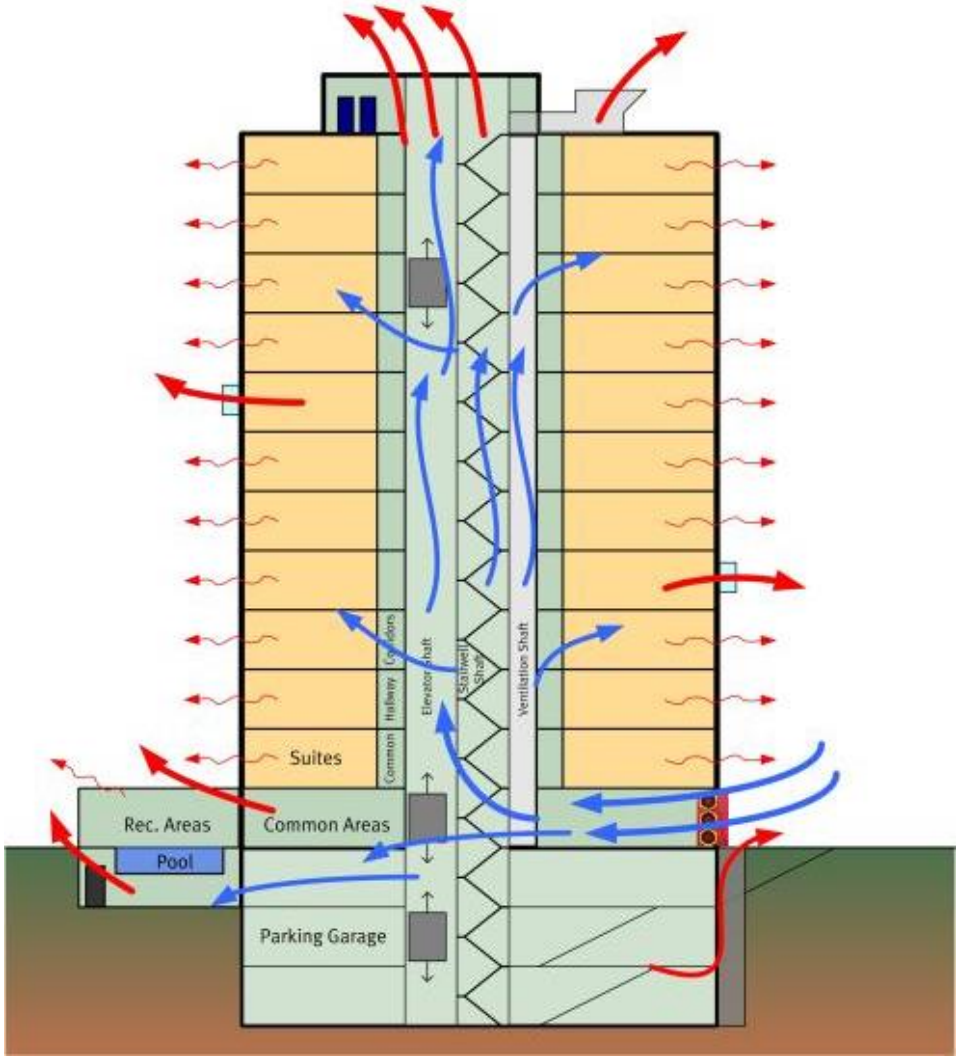
Airtightness Testing: House versus High-rise

Test Methods and Procedures

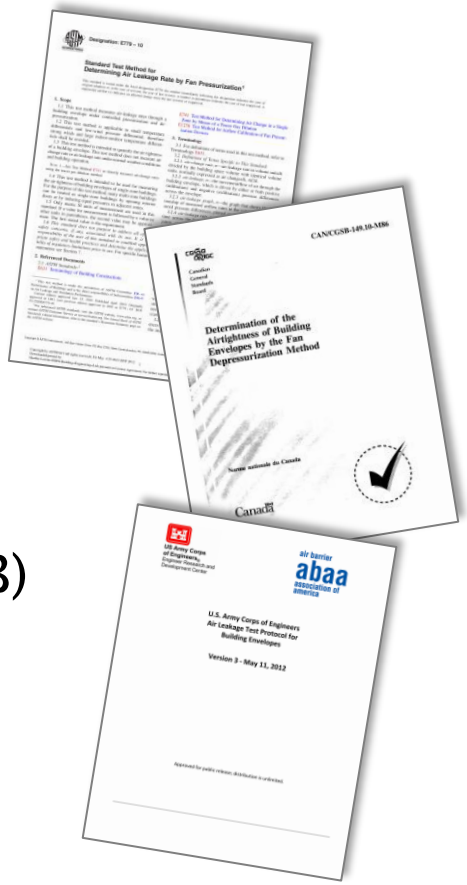
→ Most common airtightness test methods are based on similar fundamental principles

→ Fans are used to create a pressure difference across the building enclosure

→ Airflow rate through the fan at specific pressure difference(s) recorded



Standards & Qualifications



Many Standards Exist

→ CGSB 149.10 & 149.15

→ ASTM E 779 & ASTM E 1827 (blower door)

→ US Army Corps of Engineers

→ Air Barrier Association of America (ABAA)

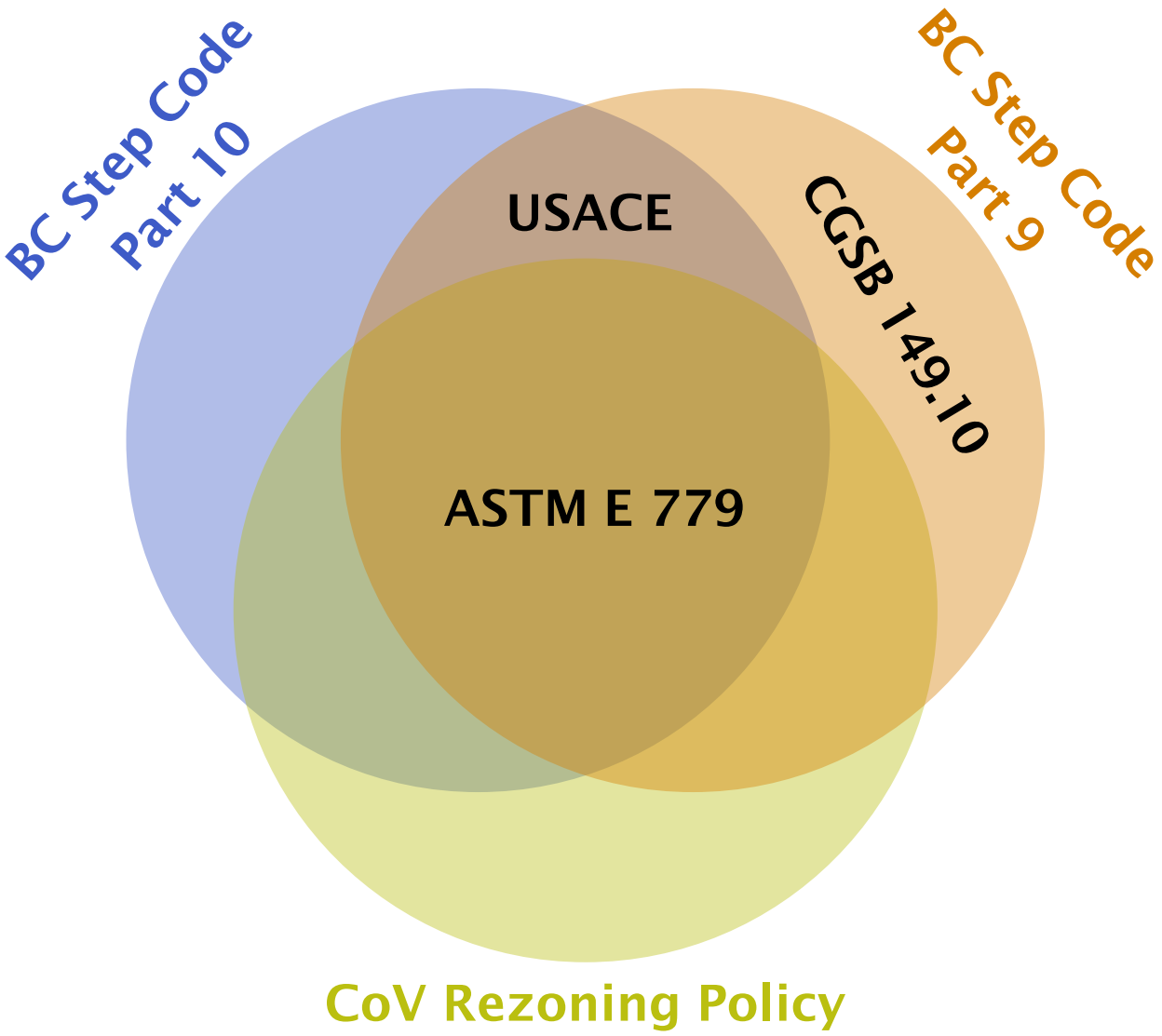
→ National Environmental Balancing Bureau (NEBB)

→ Airtightness Testing and Measurements Association (ATTMA) in the UK

Not Many Qualification Programs Exist

→ NEBB Building Enclosure Testing Certified Professional

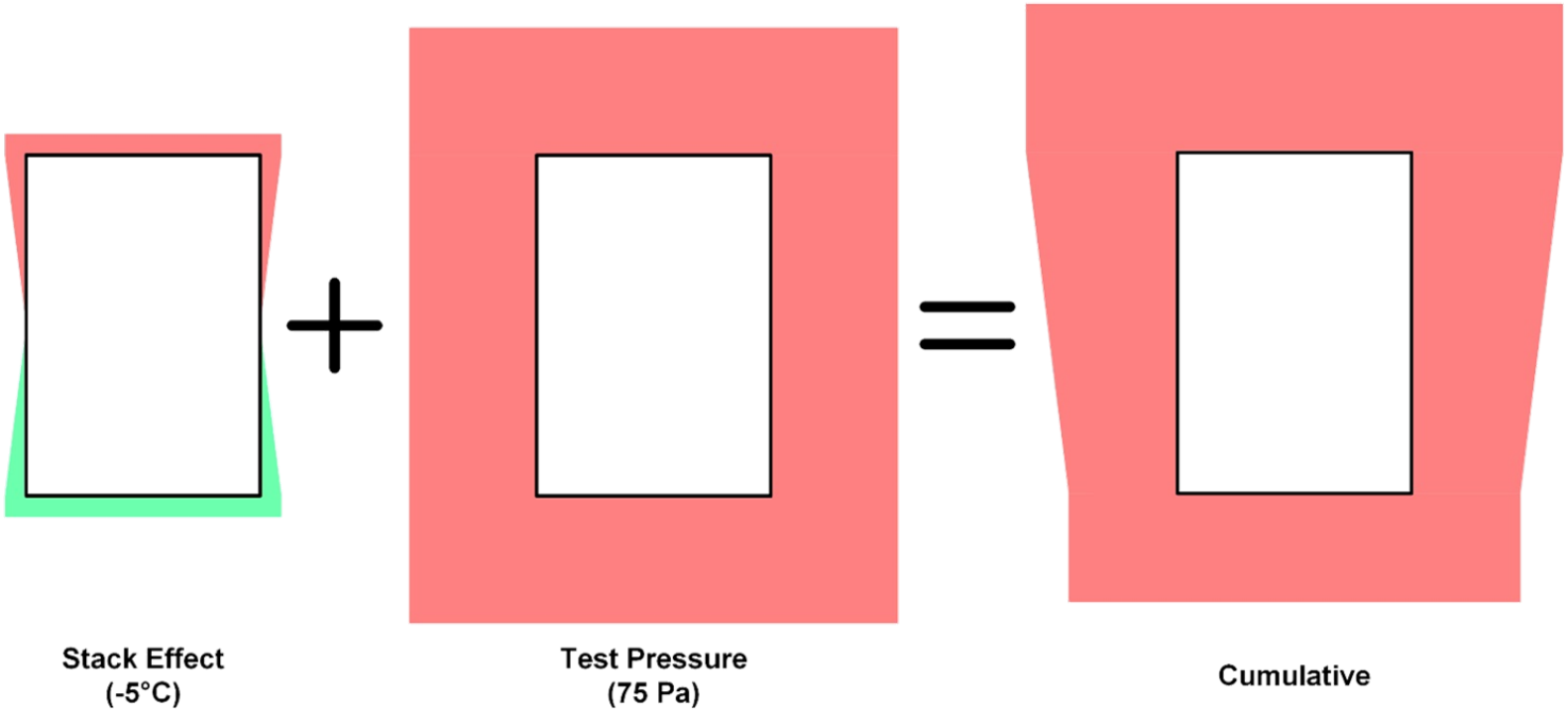
Airtightness Testing Standards



Test Methods and Procedures

→ Fan induced pressures must exceed building pressures to mitigate noise in data and potential for error

→ More difficult for large buildings than for houses



Test Methods and Procedures

→ More than just a bigger house test

How do you get here to seal these?

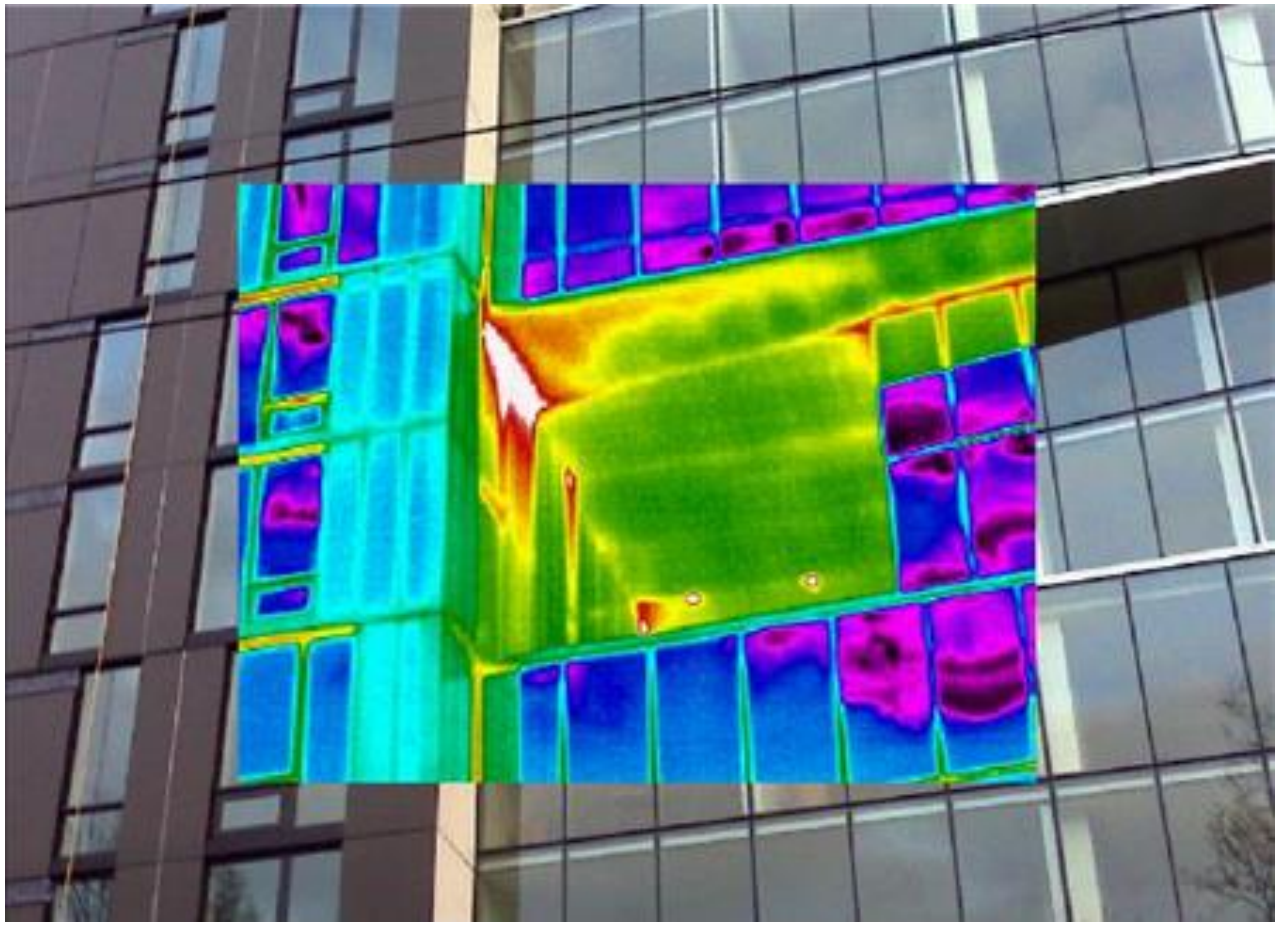

Lots of Gear…
800-765-5811
RDH

Test Methods and Procedures

- → Testing may be difficult for buildings which are:
  - → Large
  - → Tall
  - → Air-leaky and/or
  - → Compartmentalized

- → It may be more feasible to test smaller sections
  - → Floor-by-Floor
  - → Suite-by-Suite

Finding the Leaks – Infrared Thermography



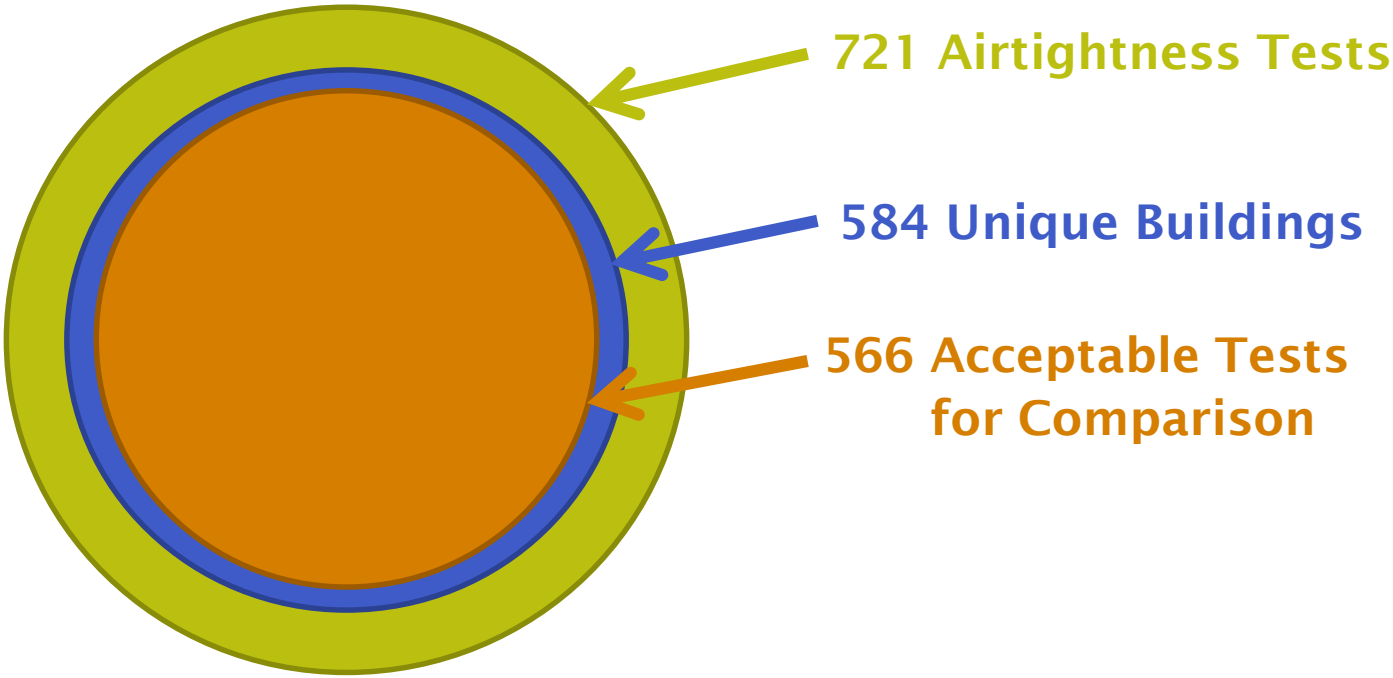
Finding the Leaks – Smoke Tracer

Measured Performance

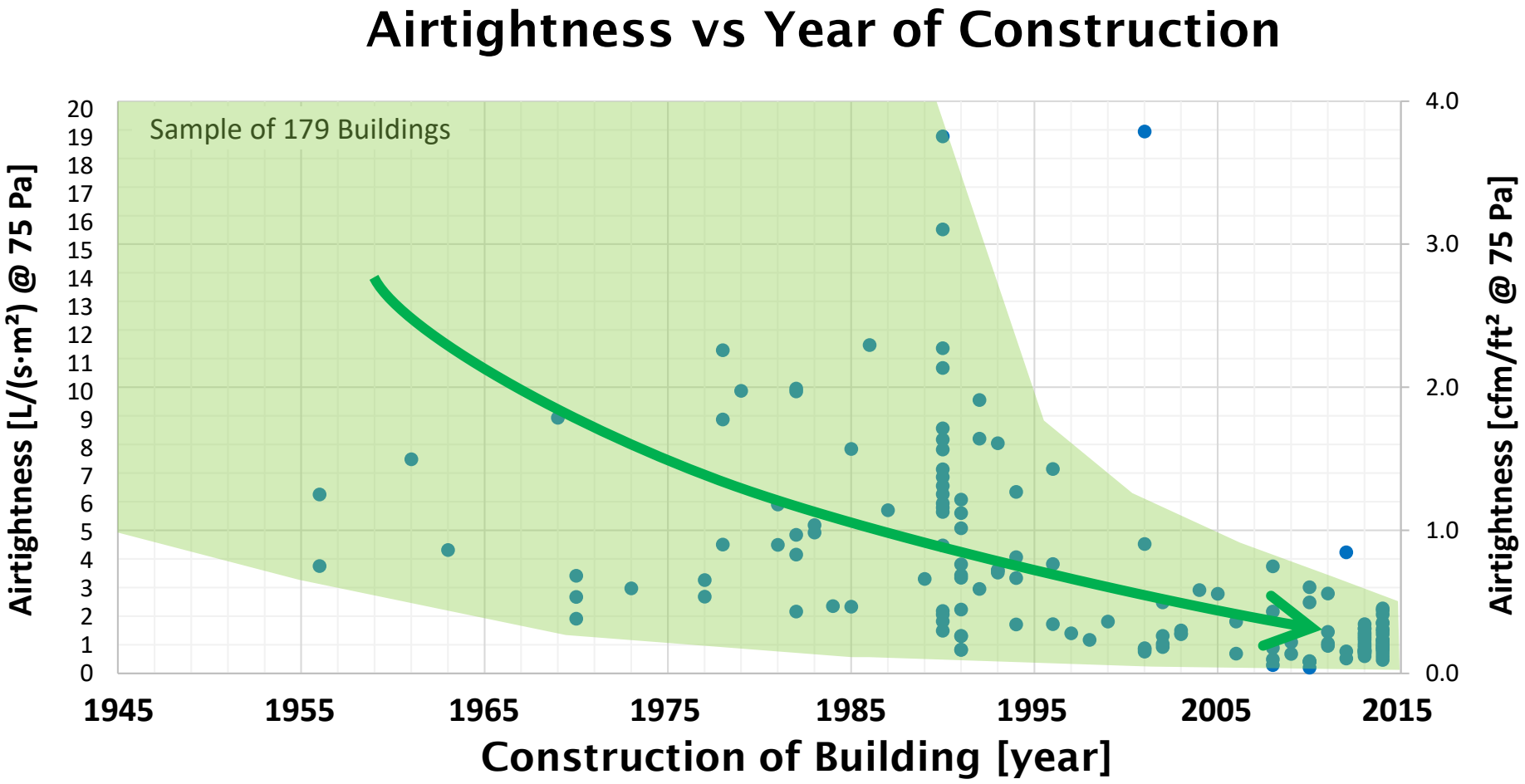
Where We're At – The Numbers

→ Airtightness testing data was compiled in a database from the following sources:

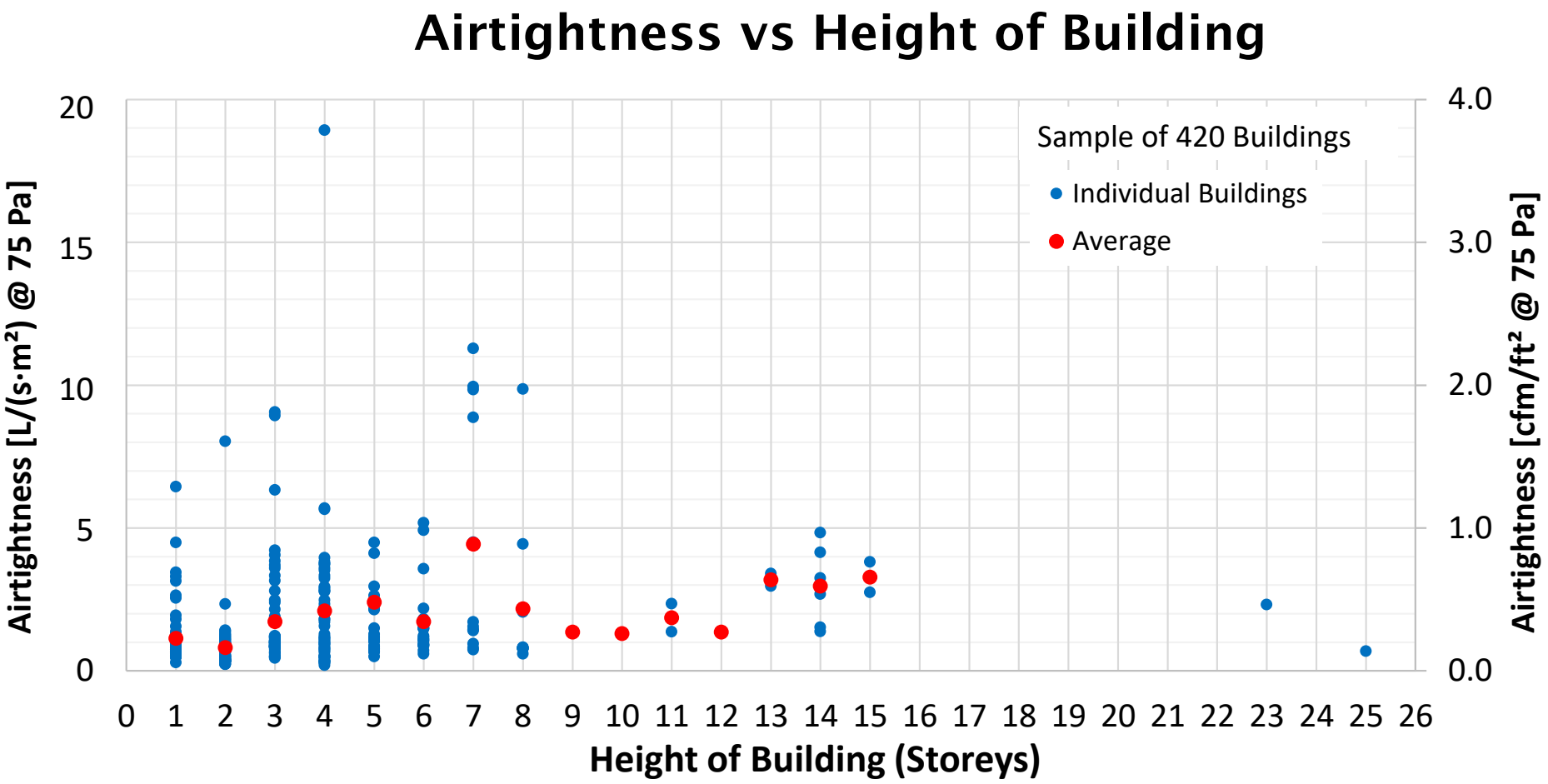
- → Published literature
- → Industry members
- → Unpublished data provided by the project team



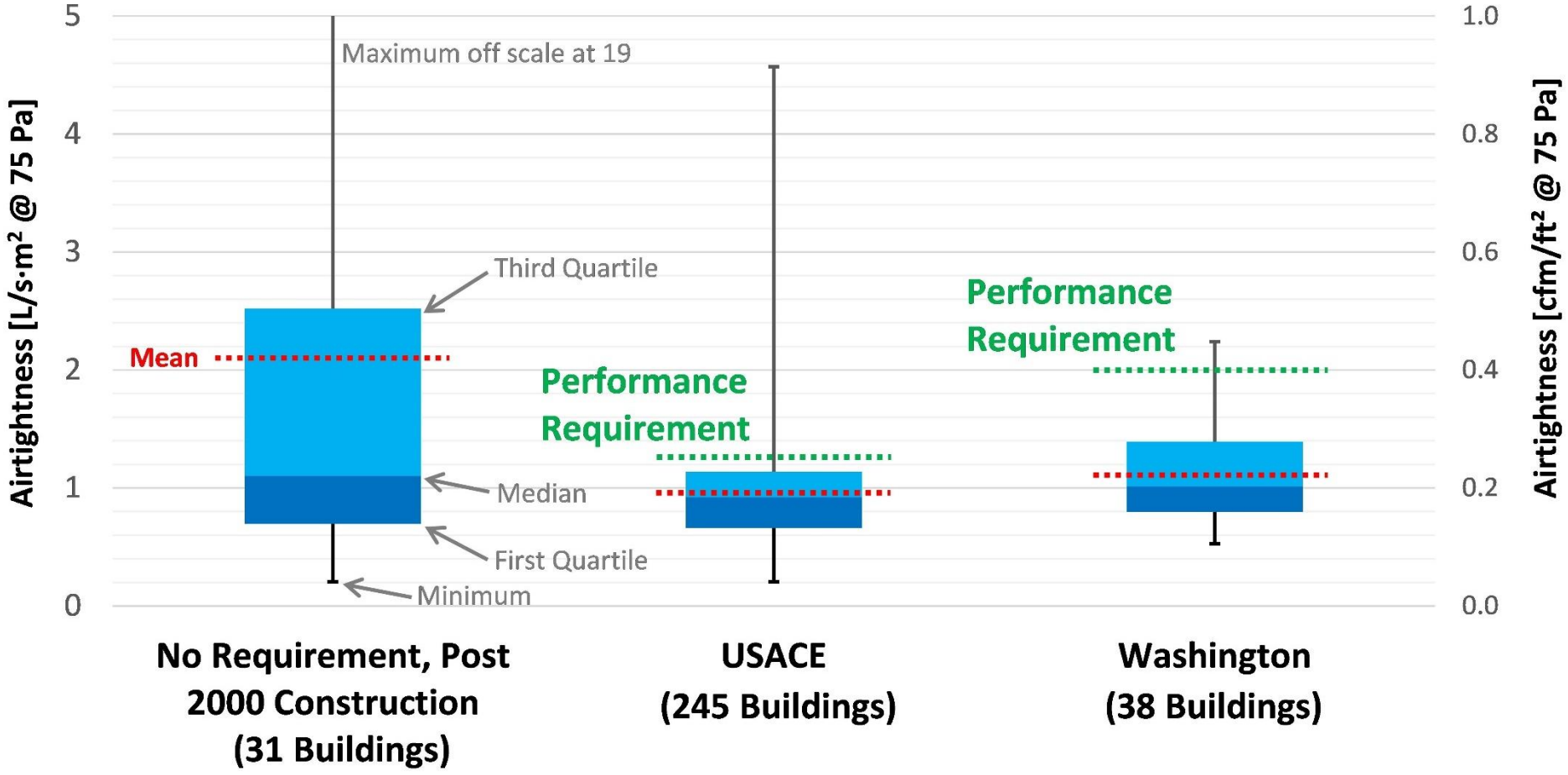
Where We're At – The Numbers



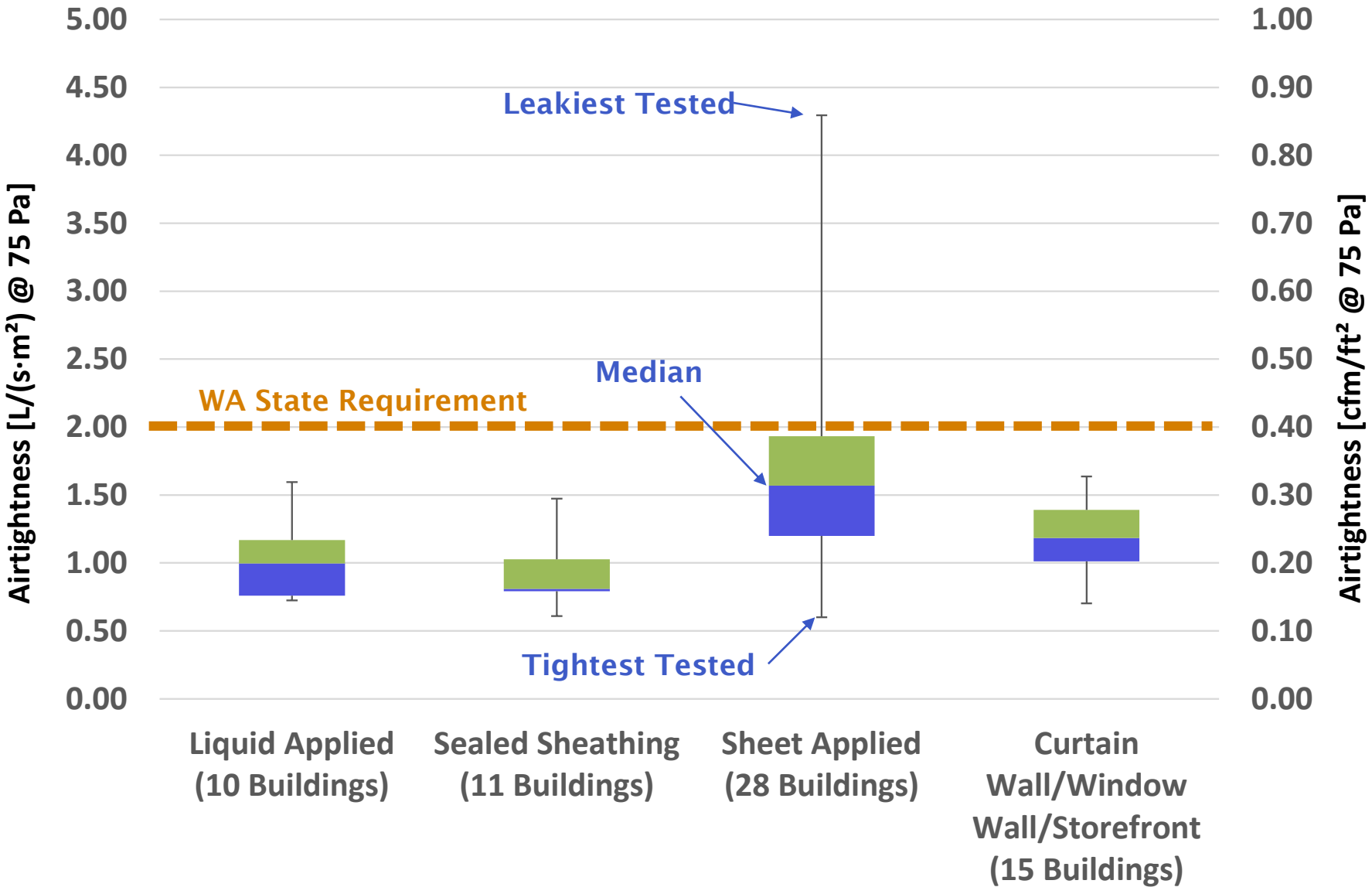
Where We're At – The Numbers



Impact of Requirements



Performance of Air Barrier Systems

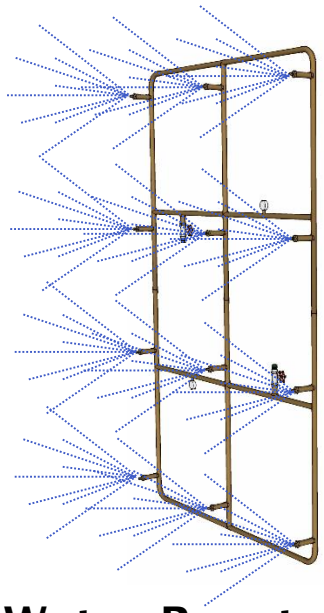


Impact of Testing

The Life of a Building

Other On-Site M&V Measures

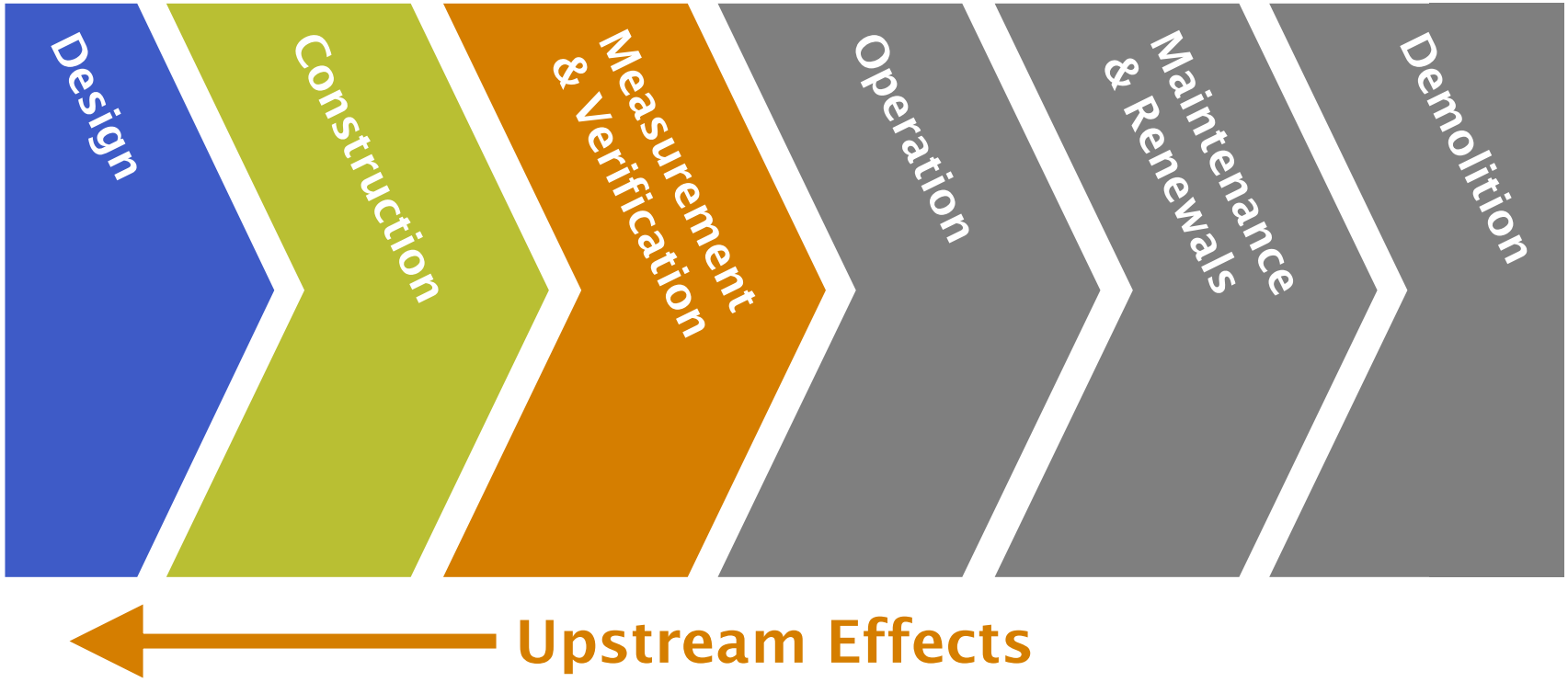
Commissioning of Fire Safety Systems



Water Penetration Testing of Windows

Balancing of HVAC Systems

The Life of a Building



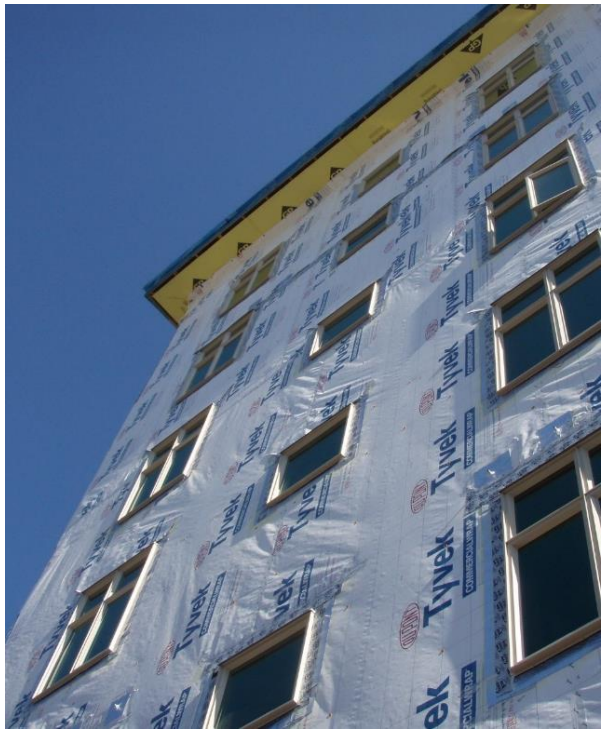
Material Selection

Assembly Design

Quality Control

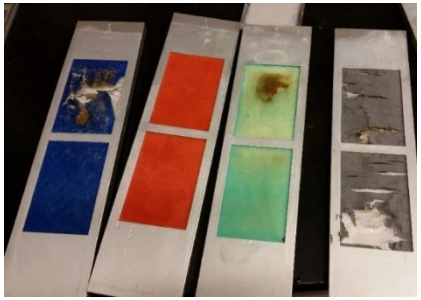
Changes in Air Barrier System Selection

→ Seeing shifts from **Mechanically Attached** to **Self-Adhesive** & **Liquid Applied** membranes

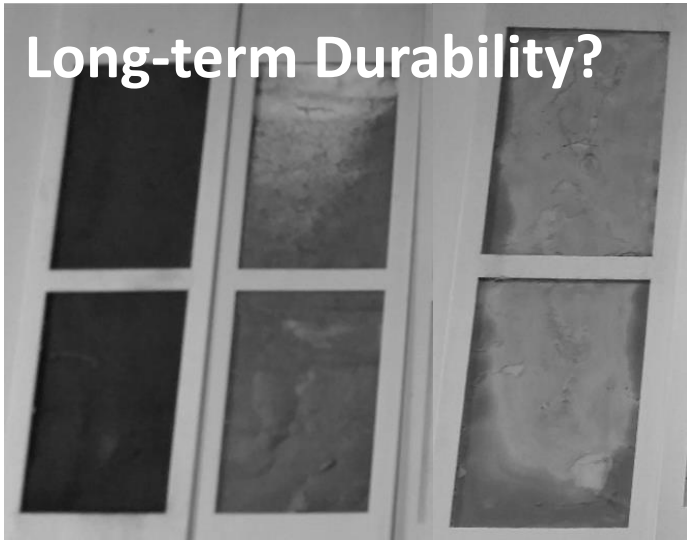


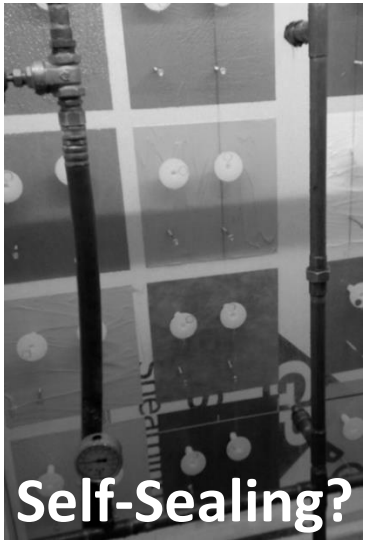
New AB/WRB Materials

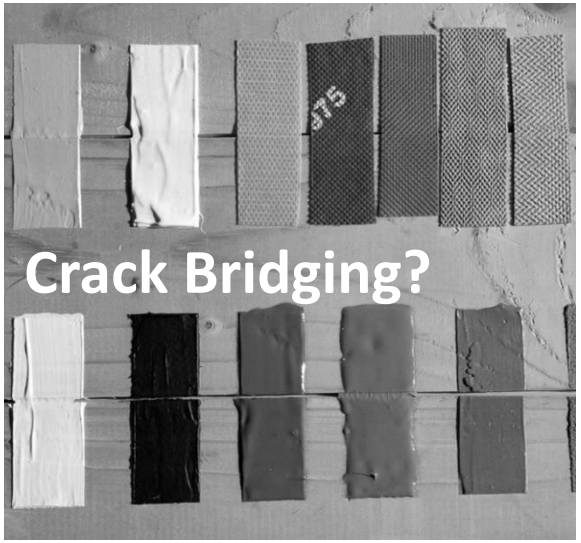
→ Many new self-adhered and liquid applied vapour permeable sheathing membranes available on the market



Lessons Learned So Far…

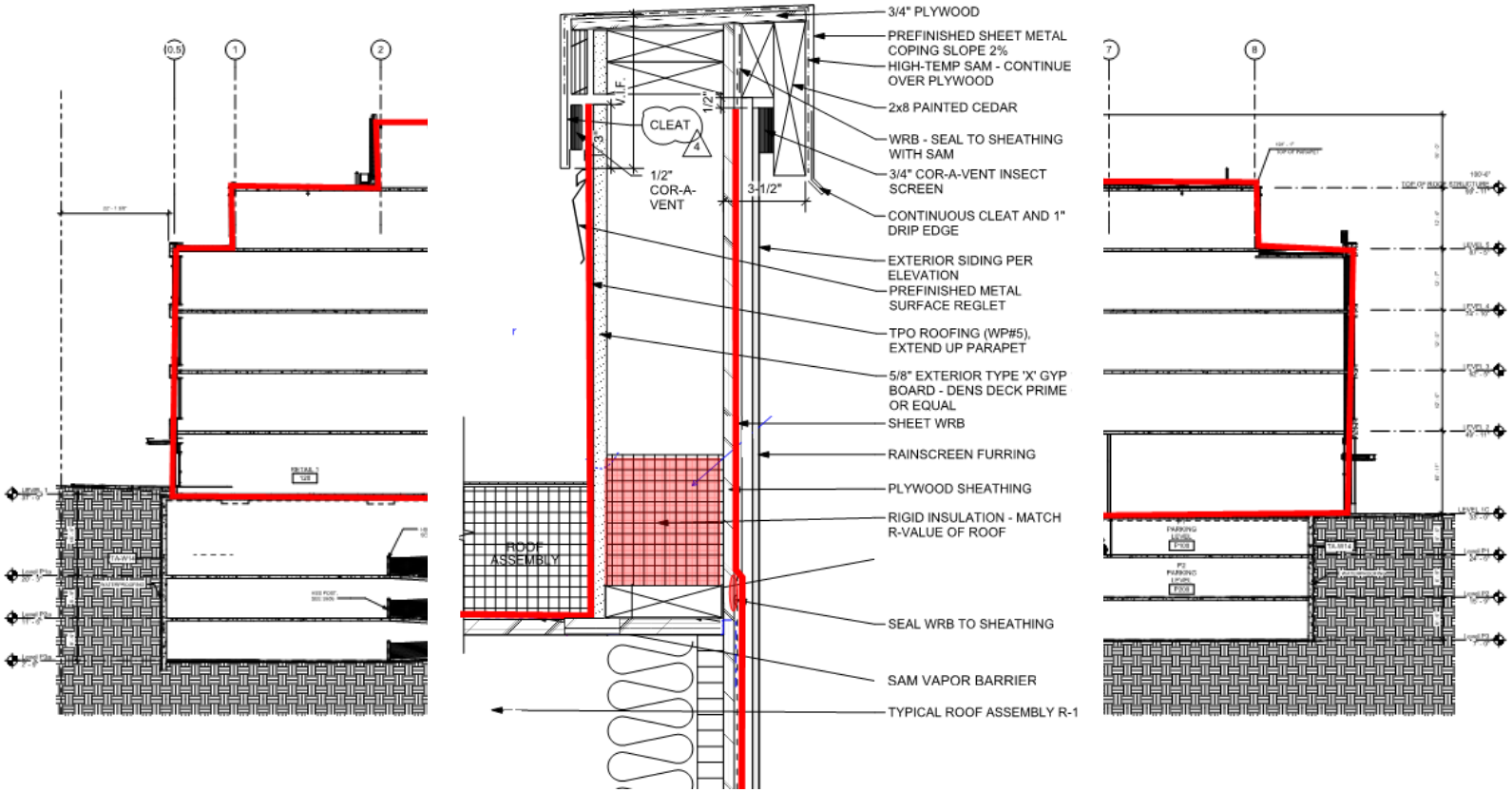






Changes in Design

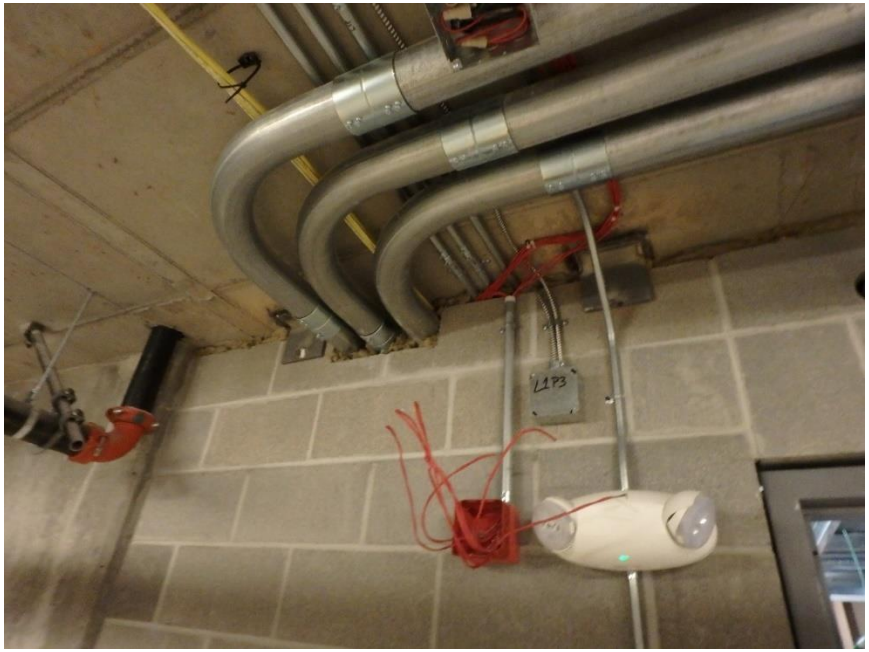
→ Clear identification of air barrier on all drawings both at whole building and detail level



Changes in Design

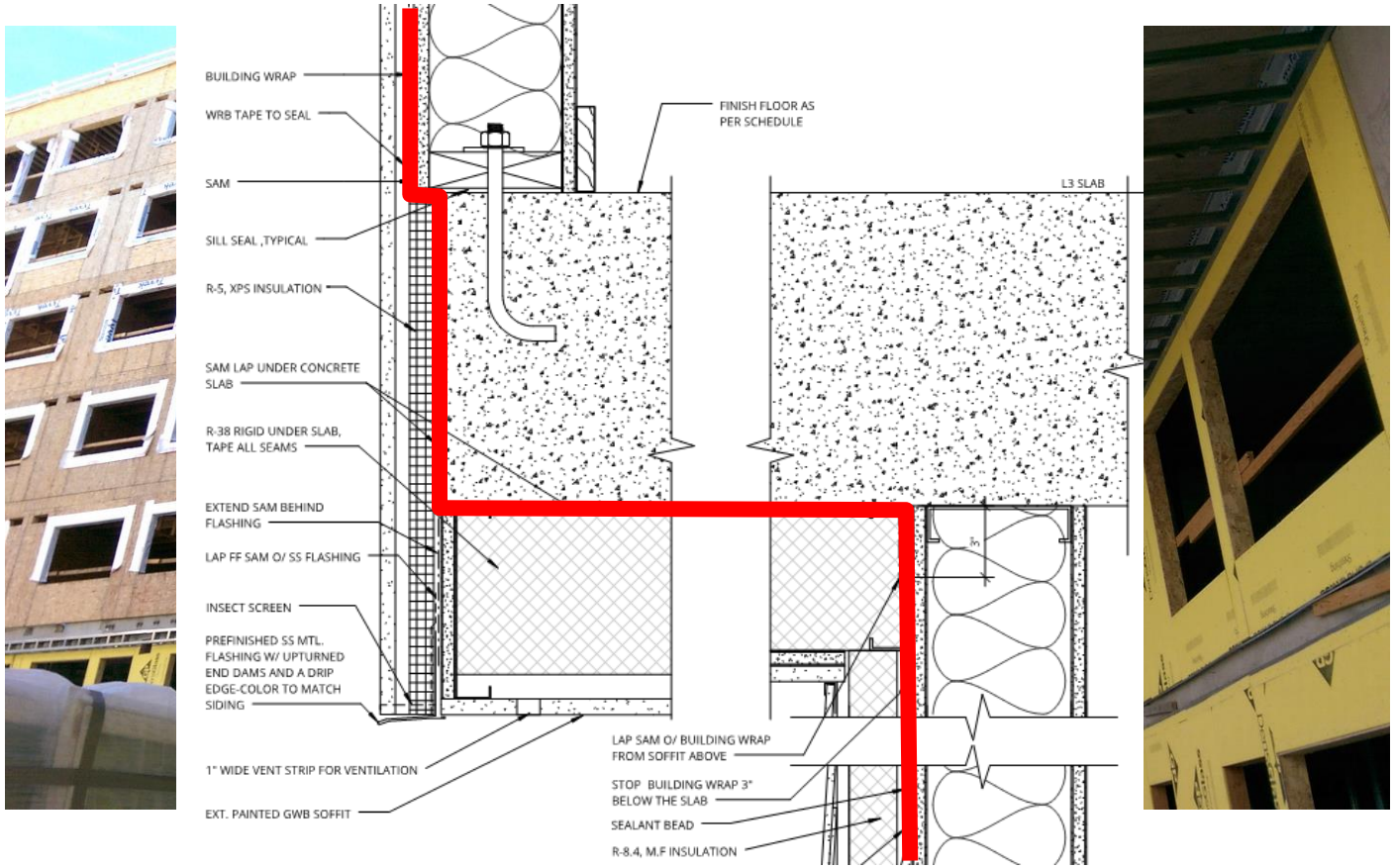
→ It's not the details you have, it's the details you don't have

- → Fluted decks are often a challenge
- → Don't forget interior smoke seals that are part of air barrier



Changes in Construction Practice

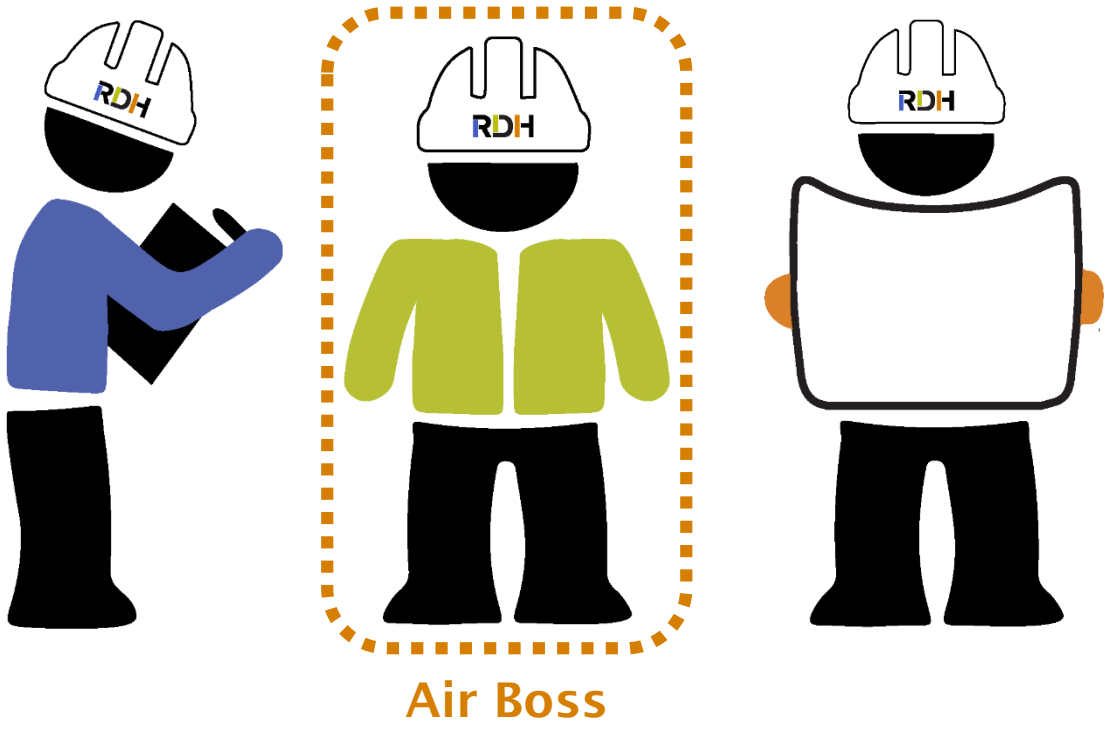
→ Sequencing when different trades comes together is a significant consideration for achieving airtightness



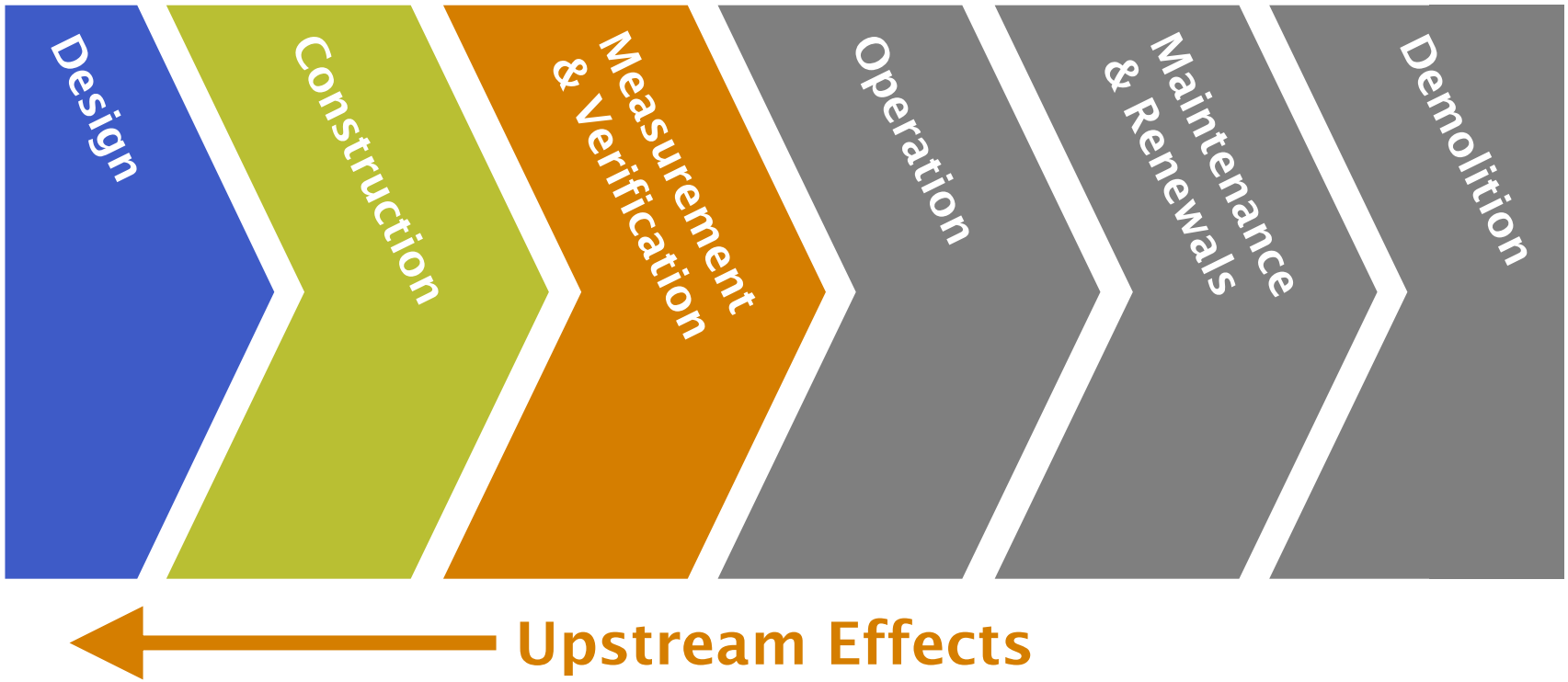
Changes in Quality Control

→ Noticeable improvements as soon as somebody cares – specific people designated to look at air barrier

→ Coordination between all team members essential



The Life of a Building

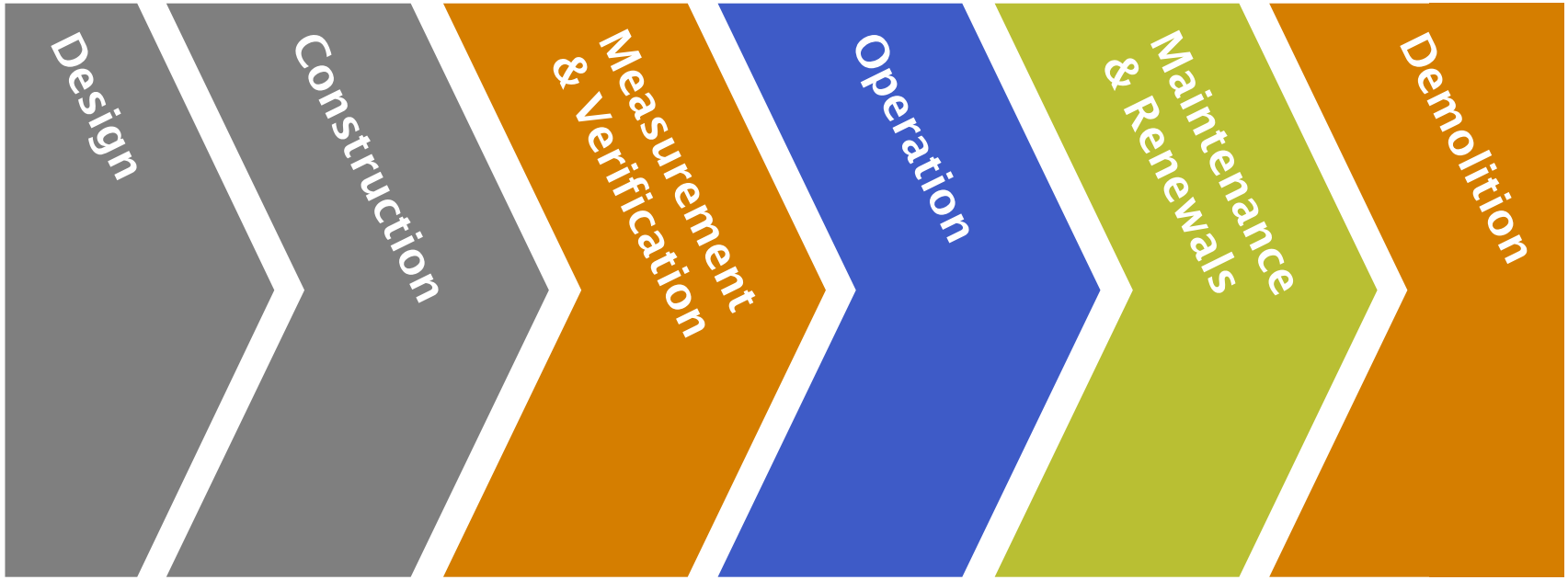


Material Selection

Assembly Design

Quality Control

The Life of a Building



Downstream Effects

Energy Consumption

Indoor Air Quality

Acoustics

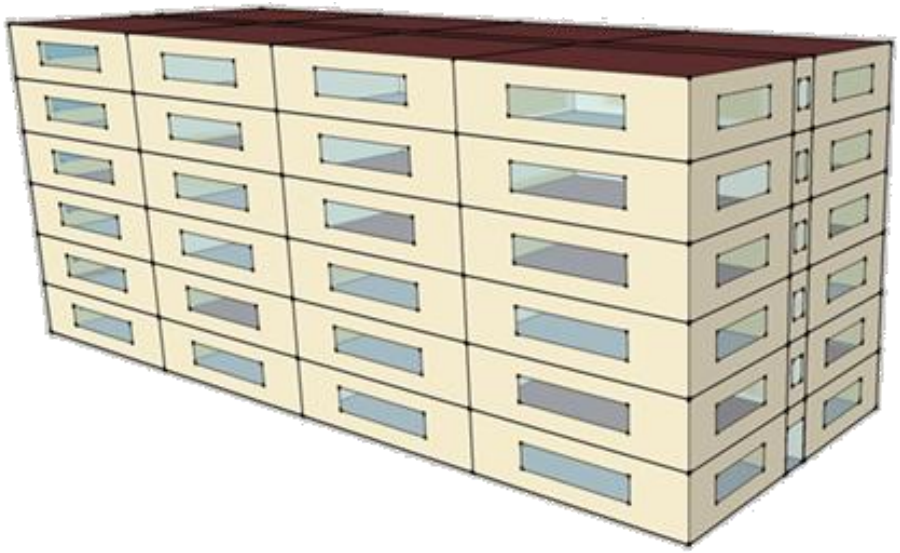
Durability

Impact on Energy Consumption – Case Study

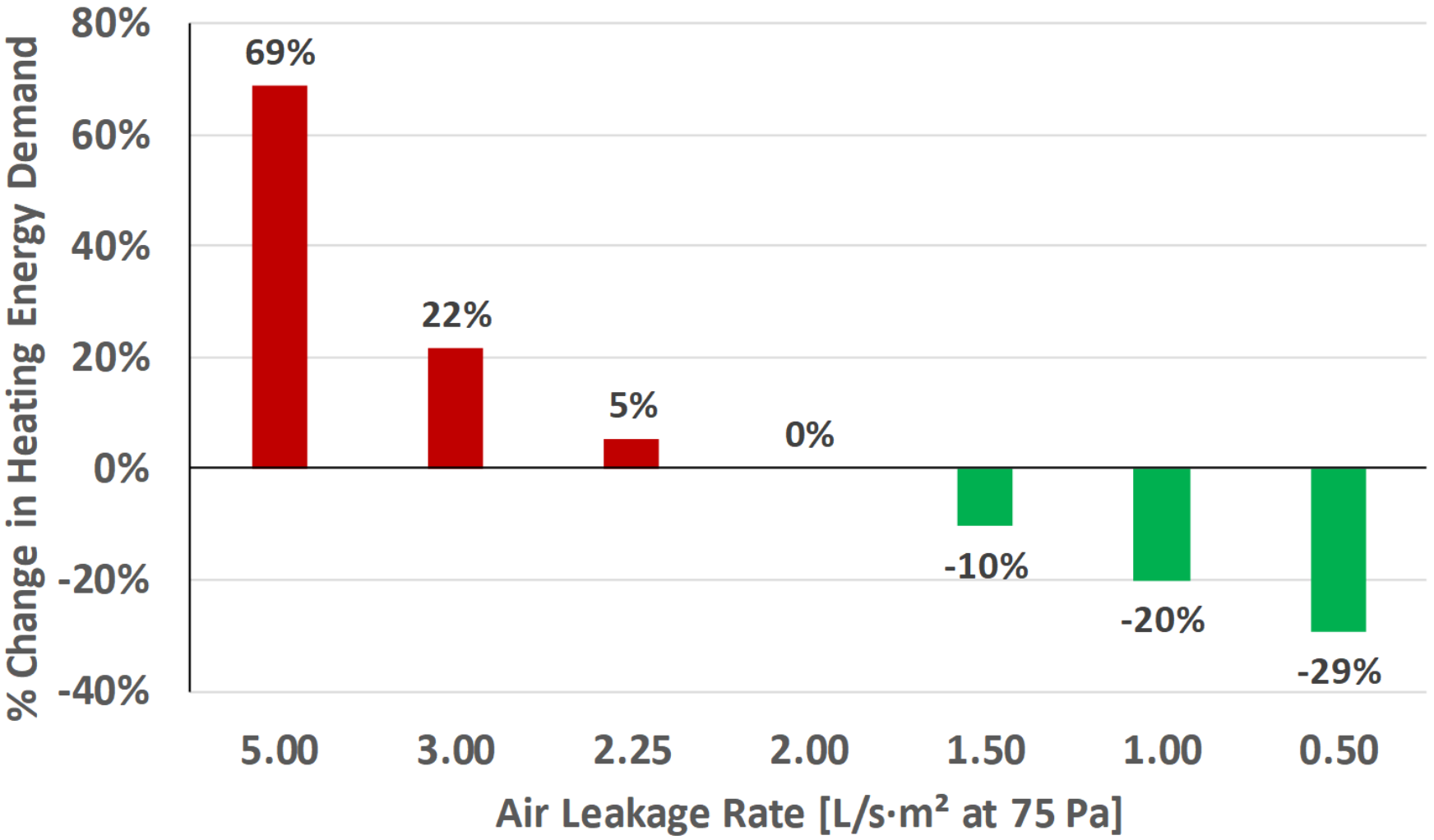
→ 6-storey 4,700 m² wood-frame multi-unit residential building

→ Energy Efficient
- › R-25 walls and U-0.27 windows
- › 60% efficient HRV

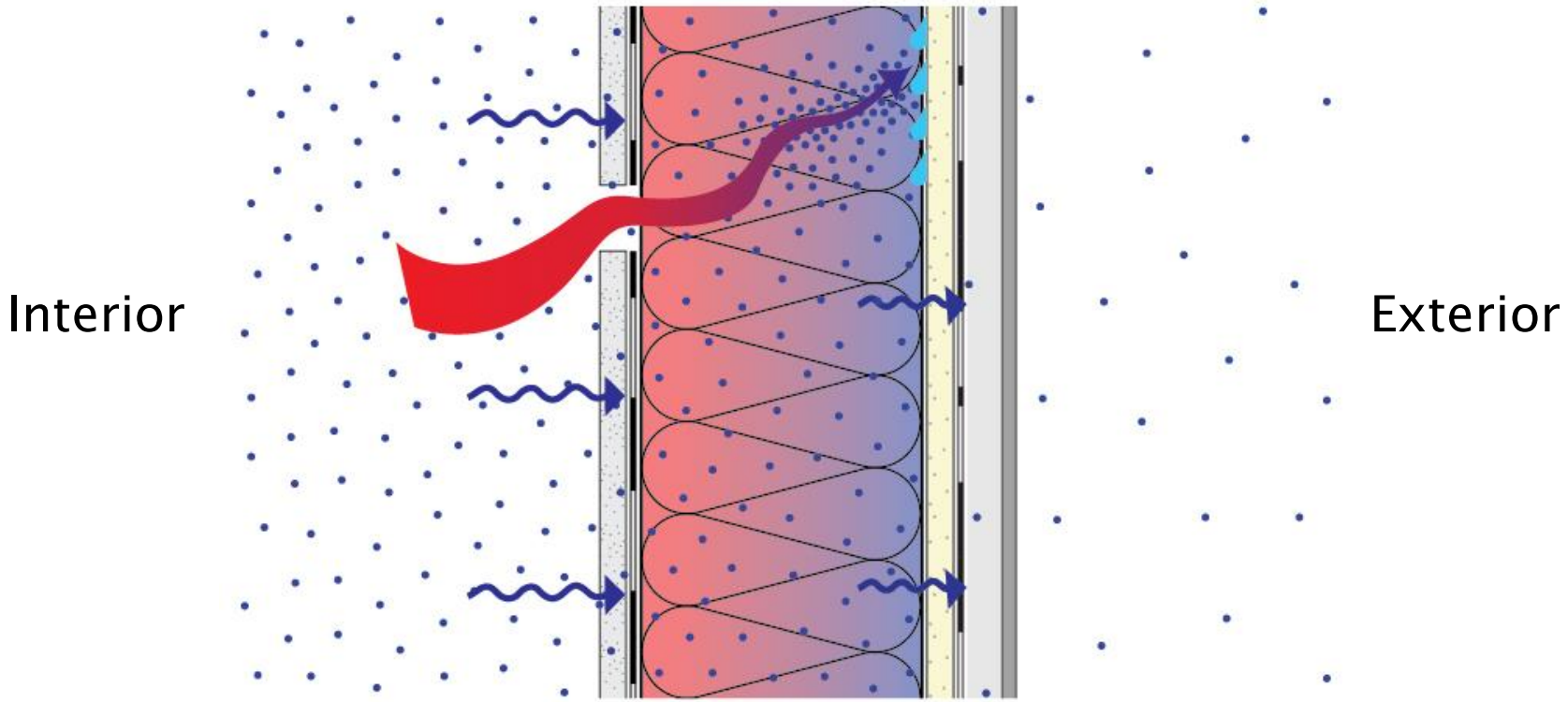
→ Modelled in Vancouver (ASHRAE Climate Zone 4)



Impact on Energy Consumption – Case Study



Impact on Durability - Air Leakage Condensation

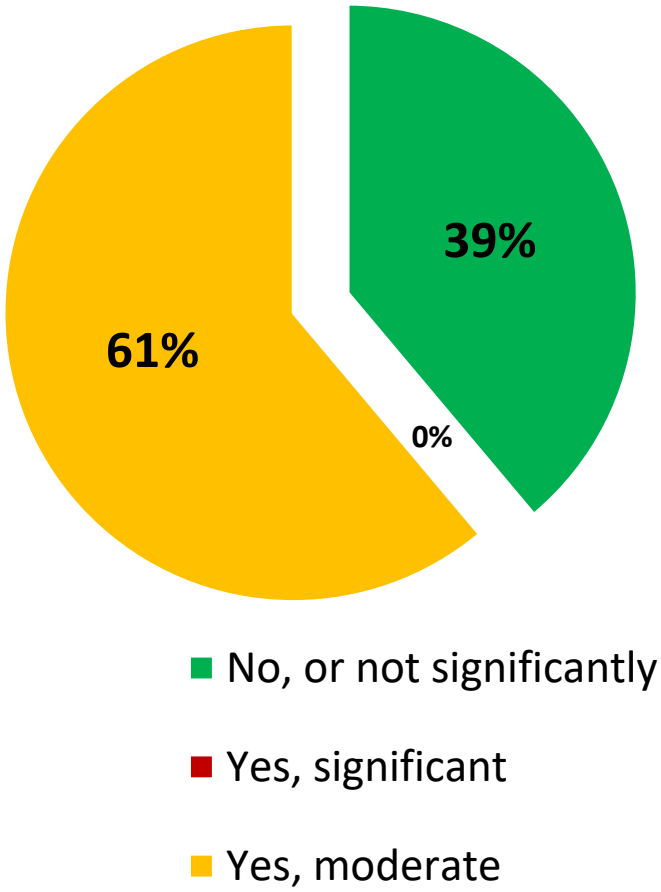


Impact on Durability

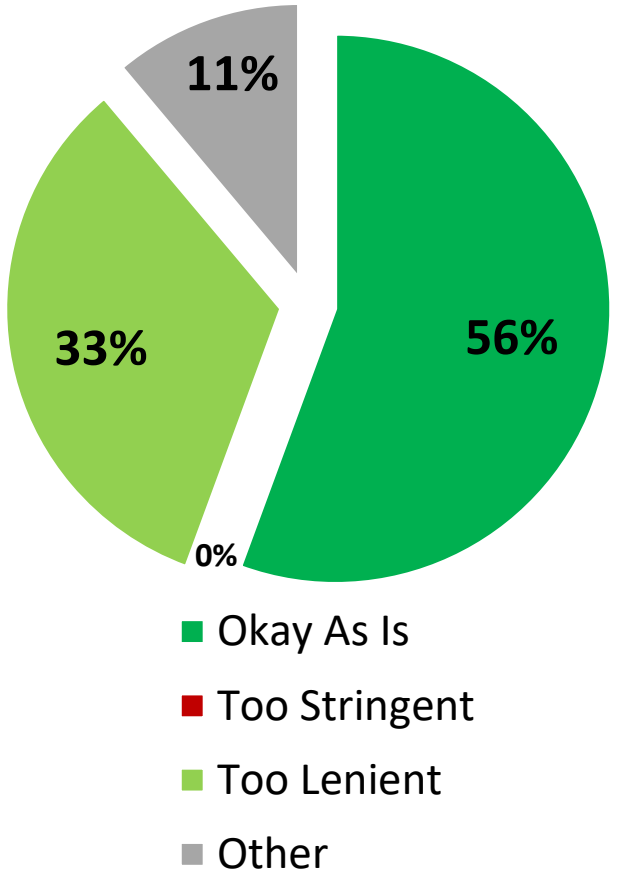
Details, Details, Details!

Impact of Requirements

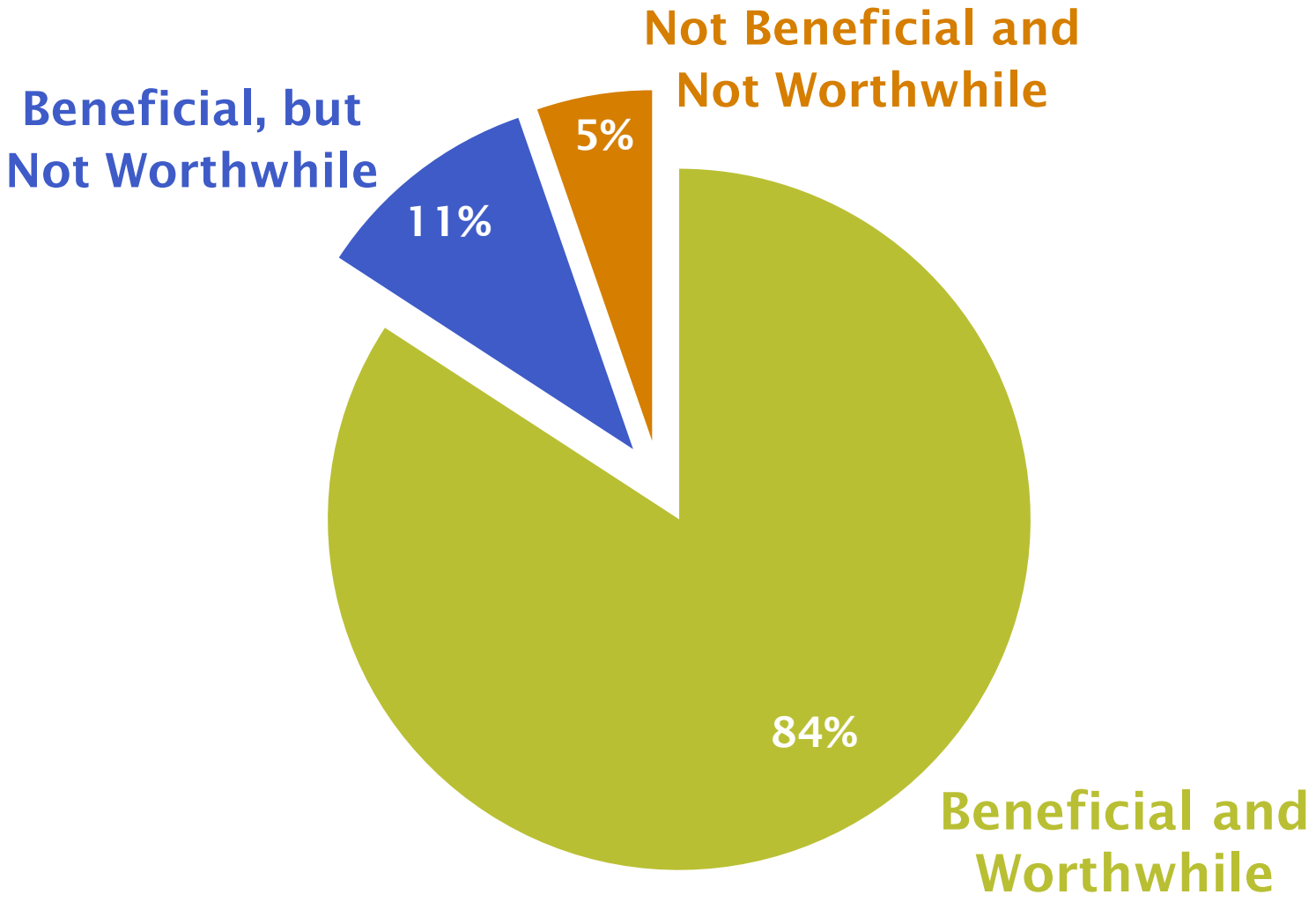
Does airtightness requirement increase cost?



Opinions of the Current Airtightness Target
(< 0.40 cfm/ft² at 75 Pa)
[< 2.0 L/s·m² at 75 Pa]



Impact of Requirements



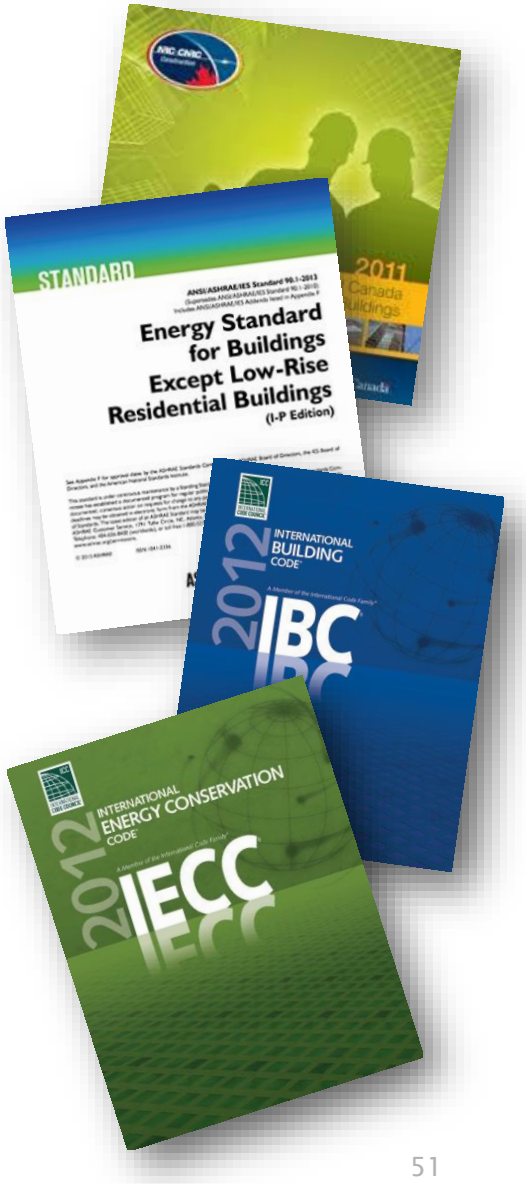
BC/Vancouver Codes

Context - Other Jurisdictions

→ What's in other codes?

→ NBC, NECB, ASHRAE 90.1, IBC, and IECC:

- Something like: *The building envelope shall be designed and constructed with a continuous air barrier system.*
- Some material requirements
- No testing requirements (though sometimes is an option)



Airtightness in BC Codes

→ **BC Building Code** (as of April 7, 2017)

- → Part 9 Buildings
  - › Whole building airtightness testing required
  - › Performance Requirement
    - – Step 1 = None
    - – Step 2 = 3.0 ACH_{50}
    - – Step 3 = 2.5 ACH_{50}
    - – Step 4 = 1.5 ACH_{50}
    - – Step 5 = 1.0 ACH_{50}
  - › Except Step 1, measured airtightness result to be reflected in the energy model
- → Part 3 Buildings (Part 10)
  - › NECB or ASHRAE 90.1 is still an option, Step Code is new option
  - › Whole building airtightness testing required for all Steps
  - › Except Step 1, measured airtightness result to be reflected in the energy model

Airtightness in BC Codes

→ City of Vancouver

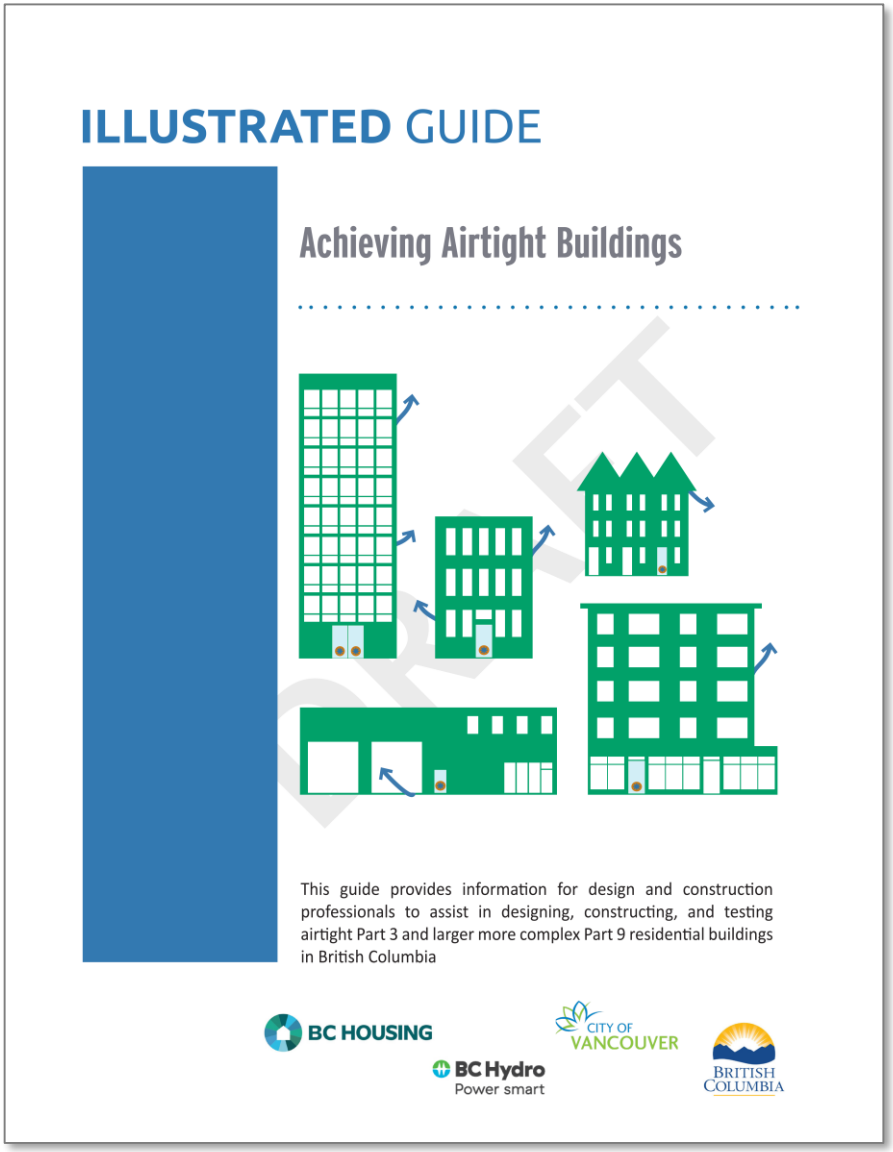
- → Part 9: 1- & 2-family Dwellings
  - › Testing to achieve 3.5 ACH_{50}
- → Green Buildings Policy for Rezonings (as of May 1, 2017)
  - › Testing & reporting required
  - › Target is 2.0 L/s · m² at 75 Pa

(3) Airtightness Testing

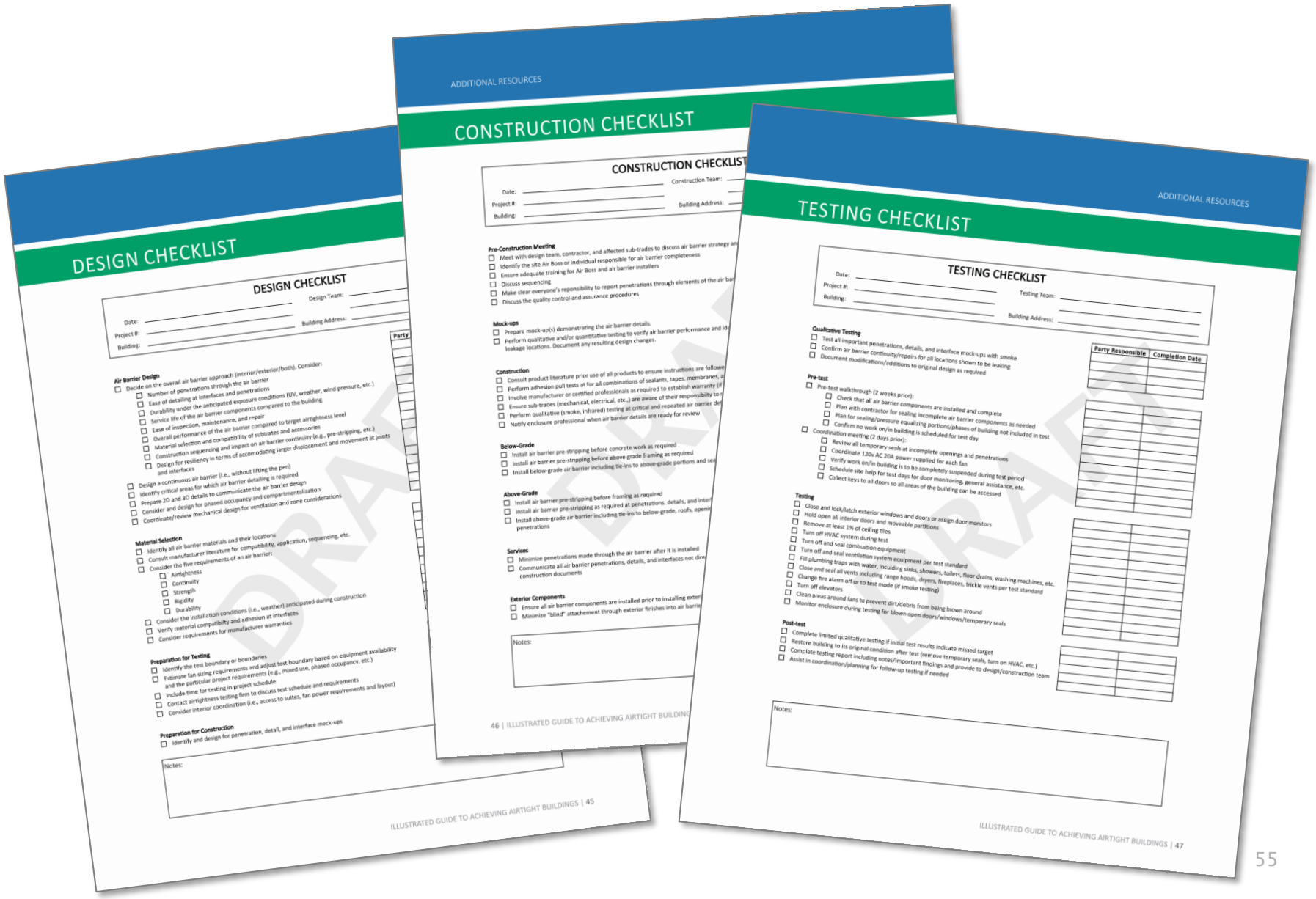
Whole-building airtightness for each building is to be tested and reported, and all buildings are to be designed and constructed with the intention of meeting an air-leakage target of 2.0 L/s*m² @75 Pa (0.40 cfm/ft² @ 0.3"w.c.), or sealed according to good engineering practice.

Buildings that fail to achieve the airtightness target must find and seal the sources of air leakage (using techniques such as visual inspection, smoke testing, and/or thermal imaging), and then re-test the building. If the building is still unable to meet the target, a lessons learned report must be provided for public use that includes the findings of a visual air barrier inspection, any air leaks found and sealed, likely remaining sources of air leakage and why they could not be readily sealed, and recommendations for future buildings to achieve the target.

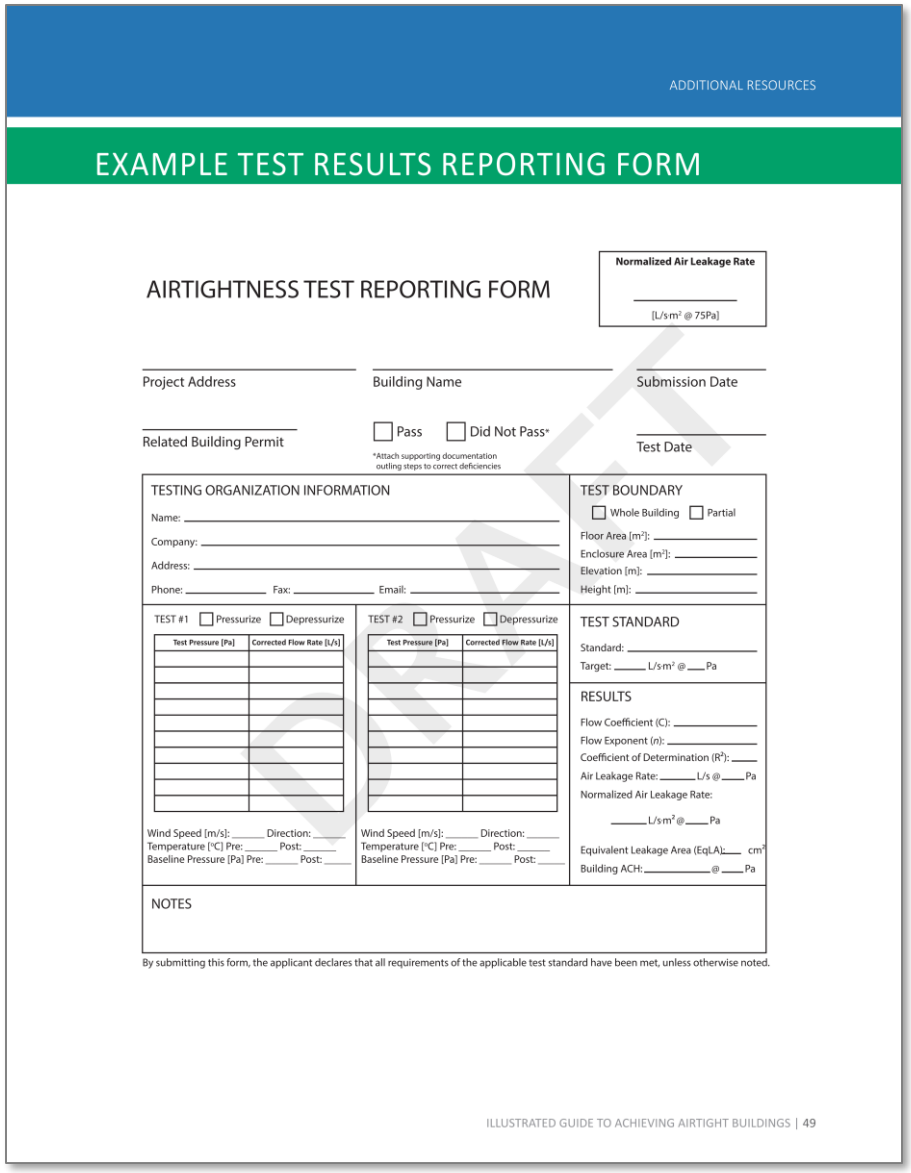
Guide to Achieving Airtight Buildings



Guide to Achieving Airtight Buildings



Guide to Achieving Airtight Buildings



EXAMPLE TEST RESULTS REPORTING FORM

AIRTIGHTNESS TEST REPORTING FORM

Normalized Air Leakage Rate

_____

[L/s·m² @ 75Pa]

Project Address _____ Building Name _____ Submission Date _____

Related Building Permit _____ ☐ Pass ☐ Did Not Pass* _____ Test Date

*Attach supporting documentation outling steps to correct deficiencies

TESTING ORGANIZATION INFORMATION

Name: _____

Company: _____

Address: _____

Phone: _____ Fax: _____ Email: _____

TEST BOUNDARY

☐ Whole Building ☐ Partial

Floor Area [m²]: _____

Enclosure Area [m²]: _____

Elevation [m]: _____

Height [m]: _____

TEST #1 ☐ Pressurize ☐ Depressurize

Test Pressure [Pa]	Corrected Flow Rate [L/s]

Wind Speed [m/s]: _____ Direction: _____

Temperature [°C] Pre: _____ Post: _____

Baseline Pressure [Pa] Pre: _____ Post: _____

TEST #2 ☐ Pressurize ☐ Depressurize

Test Pressure [Pa]	Corrected Flow Rate [L/s]

Wind Speed [m/s]: _____ Direction: _____

Temperature [°C] Pre: _____ Post: _____

Baseline Pressure [Pa] Pre: _____ Post: _____

TEST STANDARD

Standard: _____

Target: _____ L/s·m² @ ____ Pa

RESULTS

Flow Coefficient (C): _____

Flow Exponent (*n*): _____

Coefficient of Determination (R^2): _____

Air Leakage Rate: _____ L/s @ ____ Pa

Normalized Air Leakage Rate:

_____ L/s·m² @ ____ Pa

Equivalent Leakage Area (EqLA): ____ cm²

Building ACH: _____ @ ____ Pa

NOTES

By submitting this form, the applicant declares that all requirements of the applicable test standard have been met, unless otherwise noted.

DRAFT

Bulletin Airtightness Requirements

Standard	Buildings Where Testing is Required	Mandatory Target?	Airtightness Performance Target	Referenced Test Standard
ASHRAE 90.1-2016	All (except low-rise residential) for possible compliance path	Yes[1]	2.0 L/s·m² @ 75 Pa	ASTM E779, ASTM E1827
BC Building Code (2017)	Part 9 Residential	Yes (except Step 1)	Varies[2]	CAN/CGSB 149.10, ASTM E779, USACE
	Part 3 buildings	No[3]	Max TEDI/EUI[4]	ASTM E779, USACE
Vancouver Building By-Law (2014)	Part 9 Residential (1- & 2-family dwellings)	Yes[5]	3.5 ACH_{50}	None
Vancouver Green Building Policy for Rezonings (2017)	Near Zero Emission Buildings (Passive House)	No	0.6 ACH_{50} (if Passive House)	EN 13829 / ISO 9972
	Low Emission Green Buildings	No	2.0 L/s·m² @ 75 Pa	ASTM E779 or equivalent
EnerGuide 15.1 (2015)	Part 9 Residential	No	None	CAN/CGSB 149.10-M86
Energy Star® Homes 12.6 (2015)	Part 9 Residential Attached	Yes	3 ACH_{50} or 1.32 L/s·m² @ 50 Pa	CAN/CGSB 149.10-M86
	Part 9 Residential Detached	Yes	2.5 ACH_{50} or 0.93 L/s·m² @ 50 Pa	CAN/CGSB 149.10-M86
Energy Star® MFHR 1.0 (2015)	Part 3 Residential (Suite)	Yes	1.5 L/s·m² @ 50 Pa[6]	ASTM E779 2010, ASTM E1827
IECC (2012)	Part 3 Commercial[7,8] for possible compliance path	Yes[1]	2.0 L/s·m² @ 75 Pa	ASTM E779 or equivalent
	Part 9 Residential[9]	Yes	3 ACH_{50}	None
IGCC (2012)	All buildings	Yes	1.25 L/s·m² at 75 Pa	None

Discussion + Questions

FOR FURTHER INFORMATION PLEASE VISIT

→ www.rdh.com

→ www.buildingsciencelabs.com

OR CONTACT ME

→ Lorne Ricketts - lricketts@rdh.com

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