The Building Science of Air

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RDH Building Science Ltd.

RDH

Introduction: About RDH

- **Building Enclosure** Engineering Firm with over 150 staff across 6 offices on west coast of Canada & US - Projects North America Wide
- We are Engineers, Architects, Technologists, Project Managers, Contractors, Researchers
- We are all about Making Buildings Better
  - New Construction
  - Existing Buildings
  - Forensics
  - Energy Efficiency & Policy
  - Practical Research, Education & Guidelines

Air and the Built Environment

- → Obviously……..air is everywhere
  - → And is critical to our existence

- → But …….
  - → Air can move energy, moisture, pollutants
    - › All of which we want to control in our homes

- → If we don't control it, our buildings will be unhealthy, inefficient, uncomfortable and will decay prematurely

Myths and Frequently Asked Questions

→ What's the difference between an air barrier and a vapour barrier?

→ Can a building be too air tight?

→ Should a building be able to 'breathe'?

→ Why does interior RH matter?

→ How does ventilation reduce RH?

The Building Enclosure

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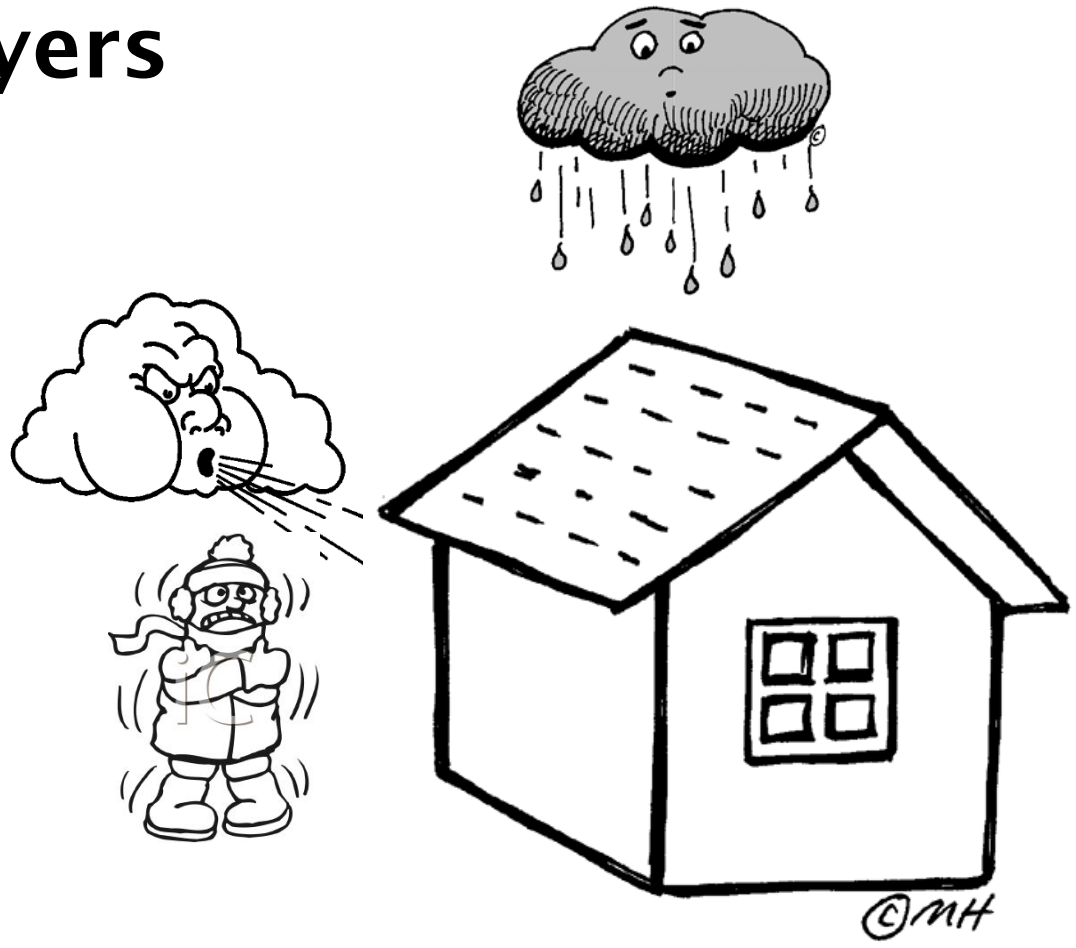
Functional Layers

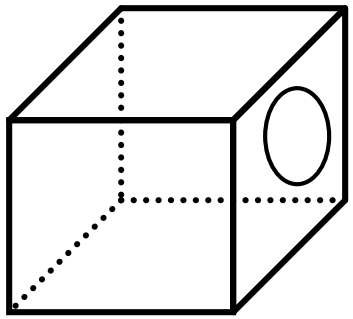
- Water Control
- Air Control
- Thermal Control
- Vapour Control



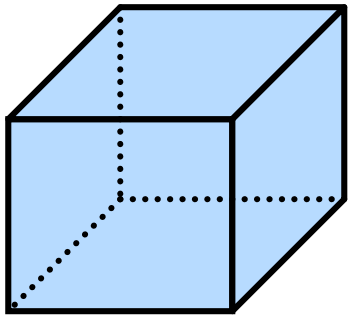
Fundamentals: Air-leakage and Pressure

→ For Air-Leakage to occur, need a pressure difference across the building enclosure or within an enclosure

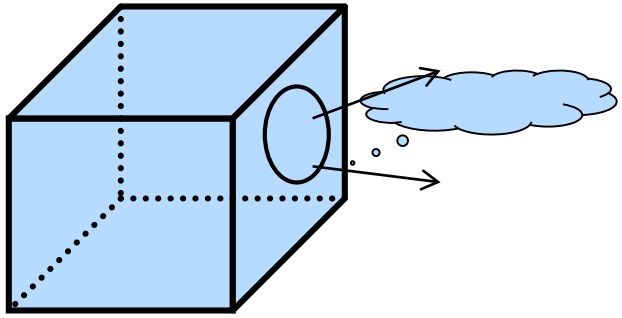
→ Amount of air-leakage depends on the pressure (the load) and air-tightness of the enclosure (size of holes)



No pressure, no flow



No hole, no flow



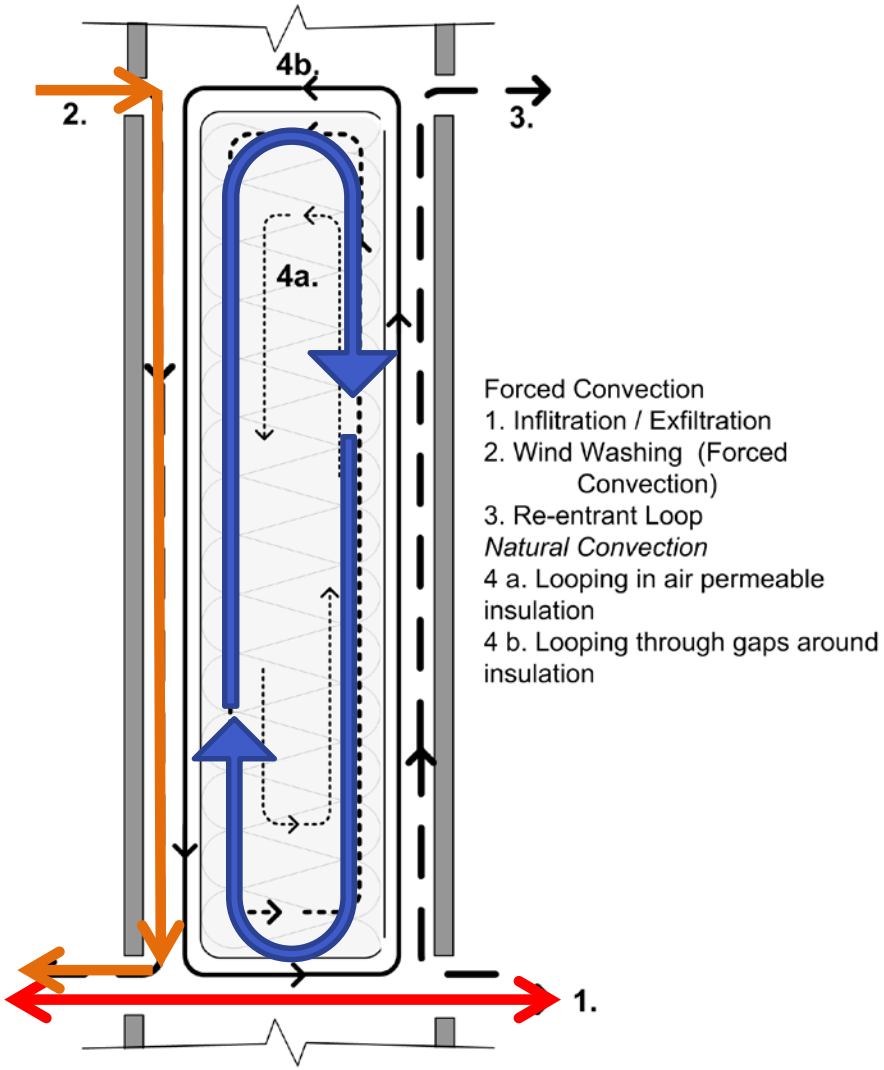
It takes BOTH pressure and a hole for there to be flow.

Air Movement and the Building Enclosure

→ Air Leakage

→ Wind washing

→ Convective Loops



Air Barriers vs Vapour Barriers

- Air Barrier –
  - Stops air flow
    - may or may not allow water vapour to pass through
  - Needs to have no holes
  - More is better

- Vapour Barrier (Retarder)–
  - Slows water vapour flow
    - may or may not allow air to pass through
  - Does not need to completely stop water vapour
  - Holes are OK
  - No more than 1

Controlling Air Flow – The Air Barrier System

- Needed in all building types and climate zones
- Can be a system of **many materials & components**
- Primary design and construction considerations are: **details, ease of installation and material compatibility** are
- Can by placed anywhere within the enclosure*

Why is Air Leakage Control Important?

1. **Prevent condensation** within the building enclosure

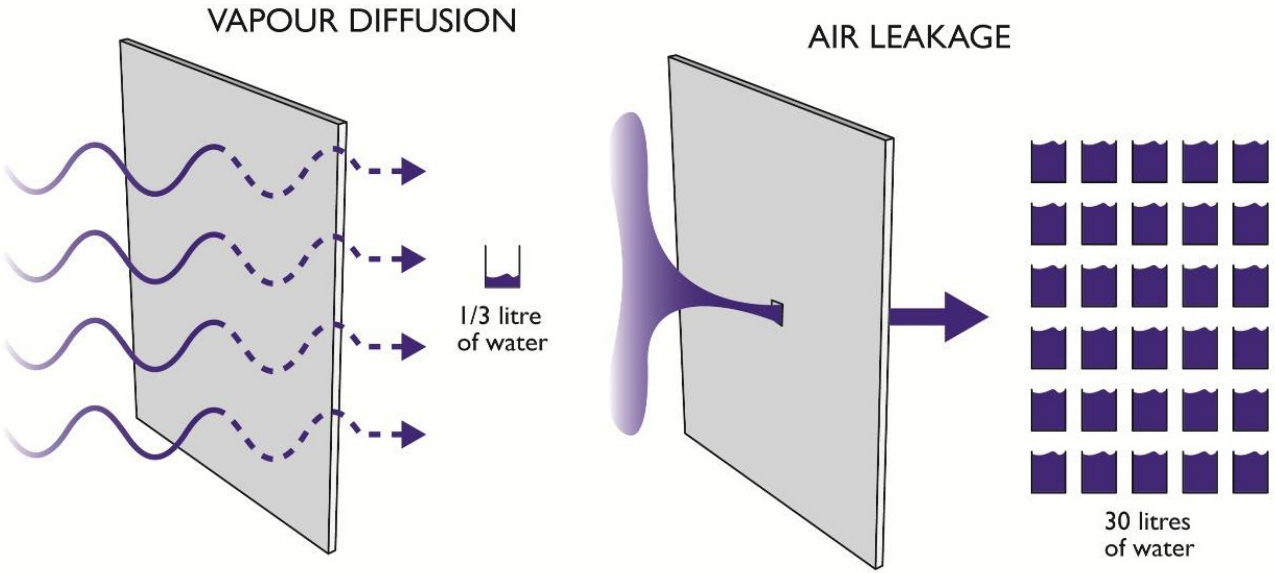
2. **Control heat loss** through the enclosure

3. **Maintain indoor air-quality** within the building

1) Air Leakage Condensation

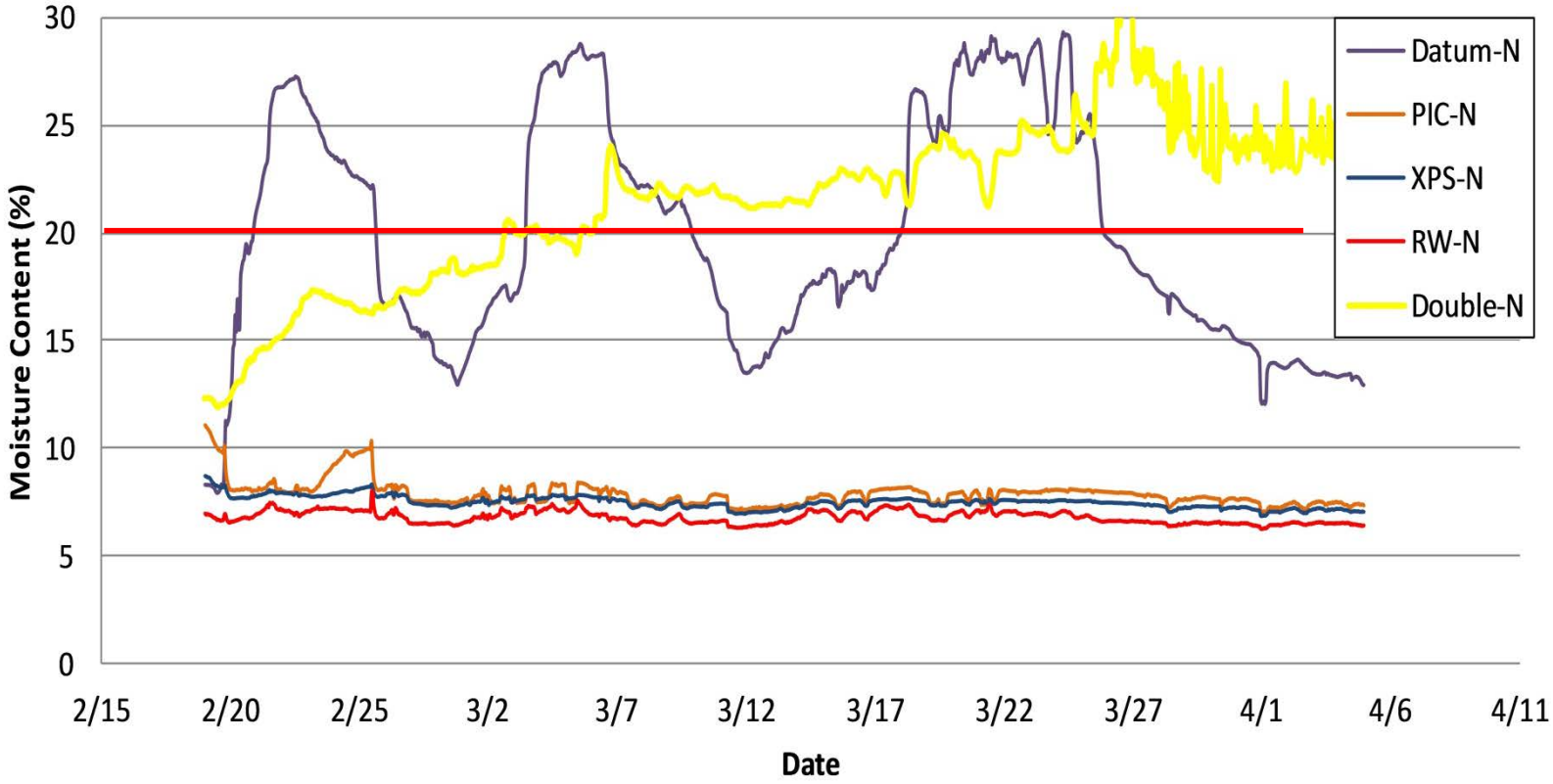
- Air leakage can deposit 10 to 100 times more condensation than vapour flow can

  Controlling air leakage is much more difficult and more important than controlling vapour flow



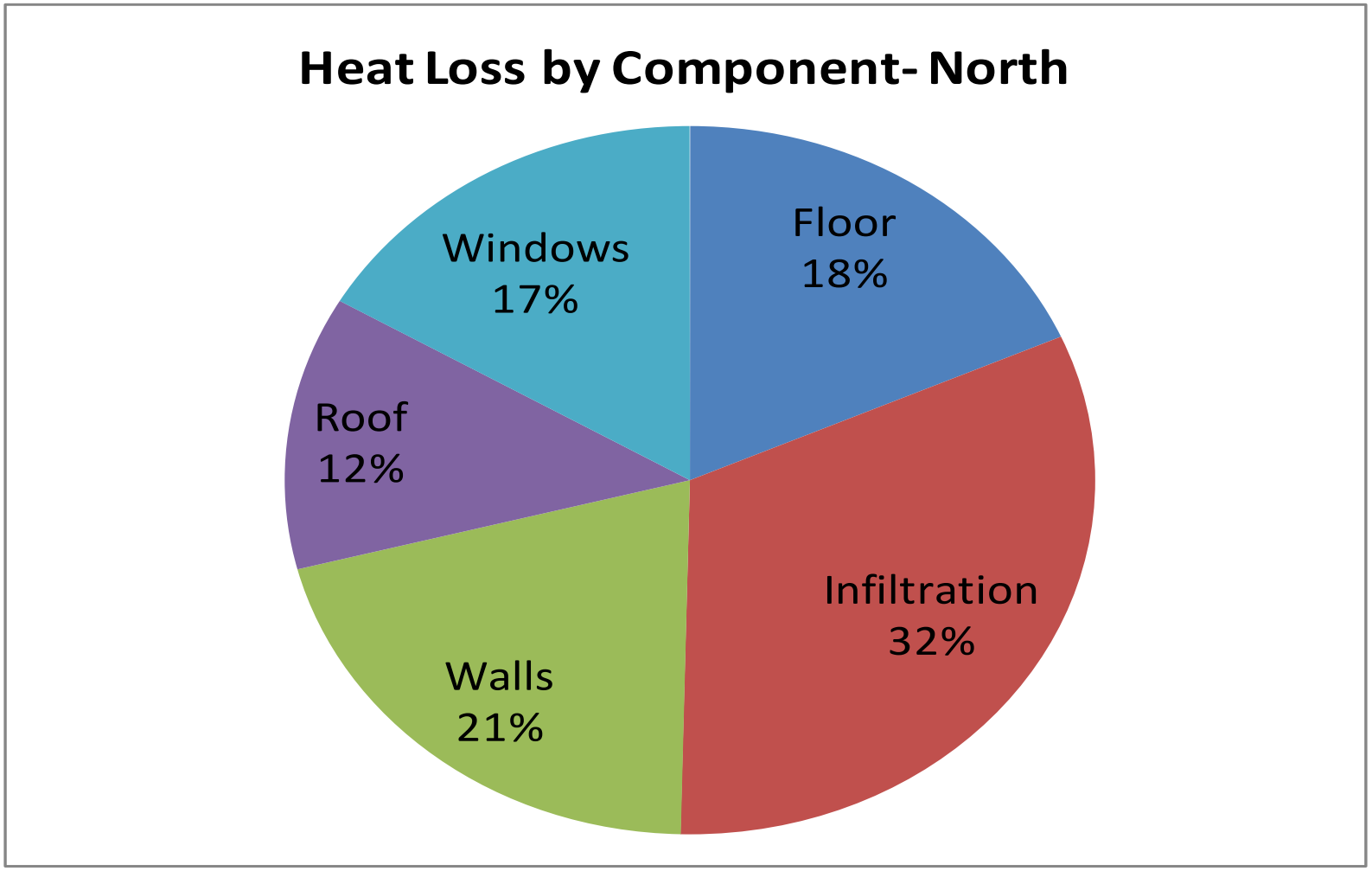
The amount of water vapour transported by Air-leakage is more than an order of magnitude than that typically moved by vapour diffusion

Air Leakage Condensation: Field Testing



Air Leakage Condensation: Forensic Investigations

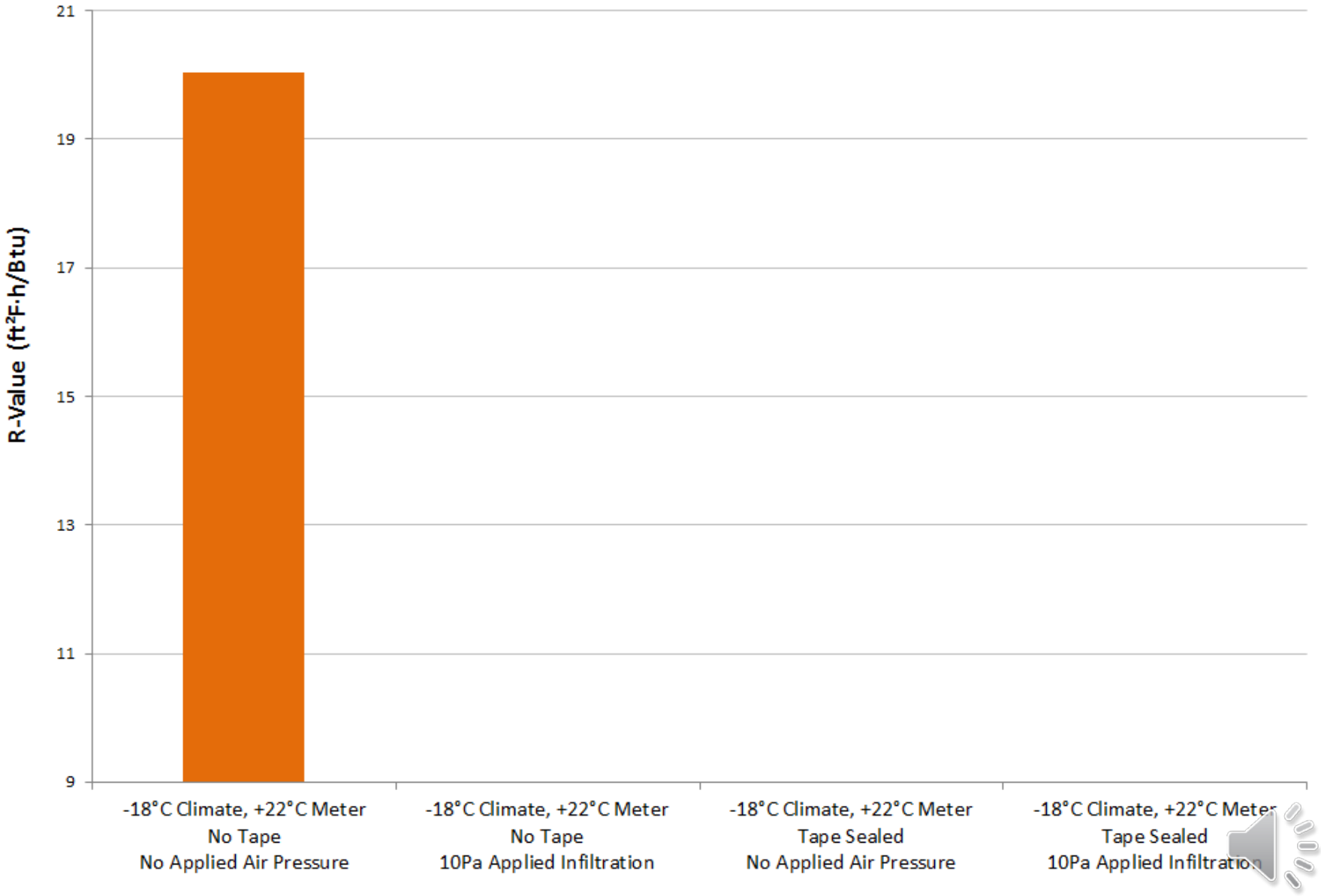
2) Air Leakage and Energy



(Huange et al., 1999)


1
2
3
4
5
6


gaps in the air barrier
ZIP system
7/16" ROOF AND WALL SHEATHING


R-Value (ft²F·h/Btu)
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-18°C Climate, +22°C Meter
No Tape
No Applied Air Pressure
-18°C Climate, +22°C Meter
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10Pa Applied Infiltration
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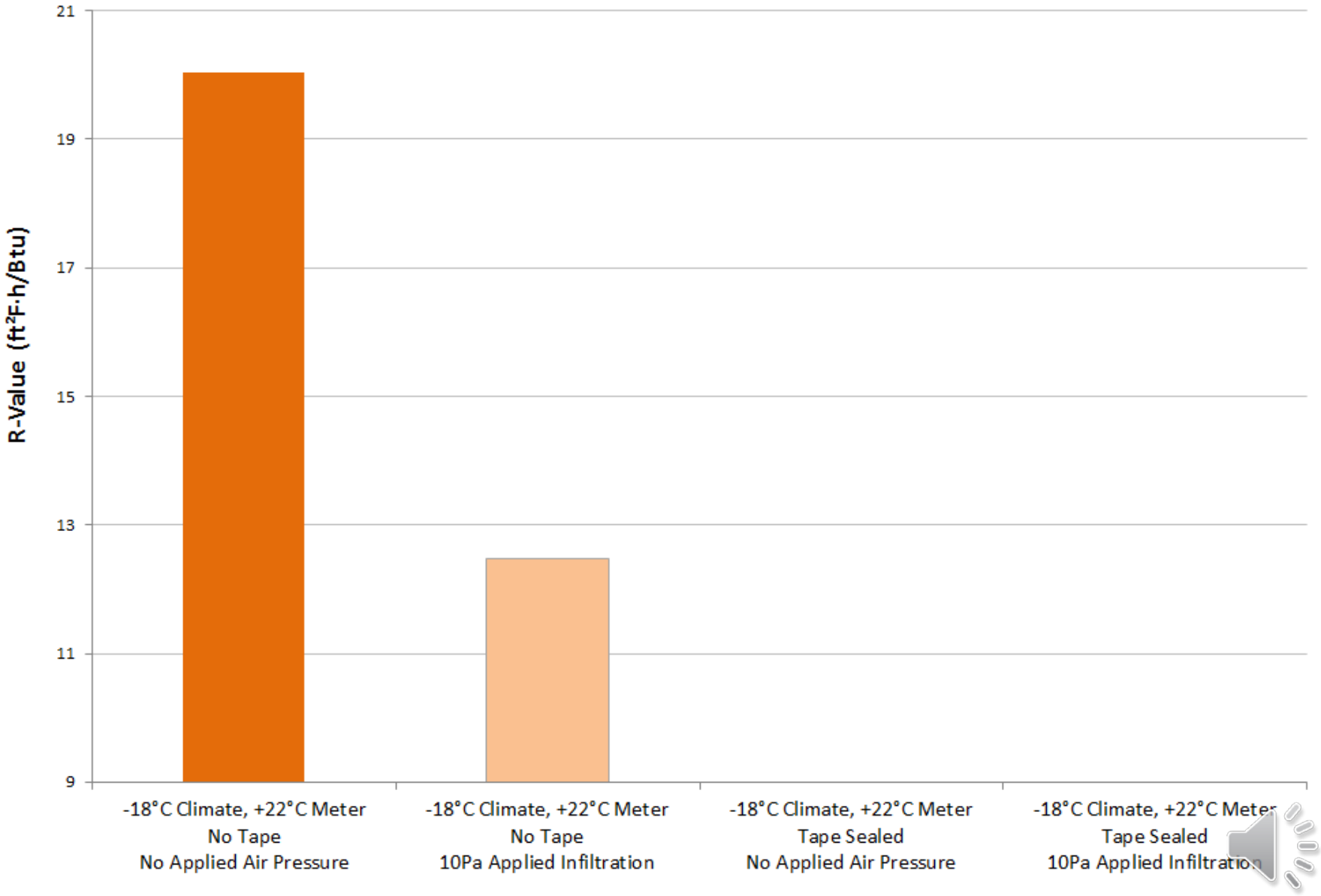
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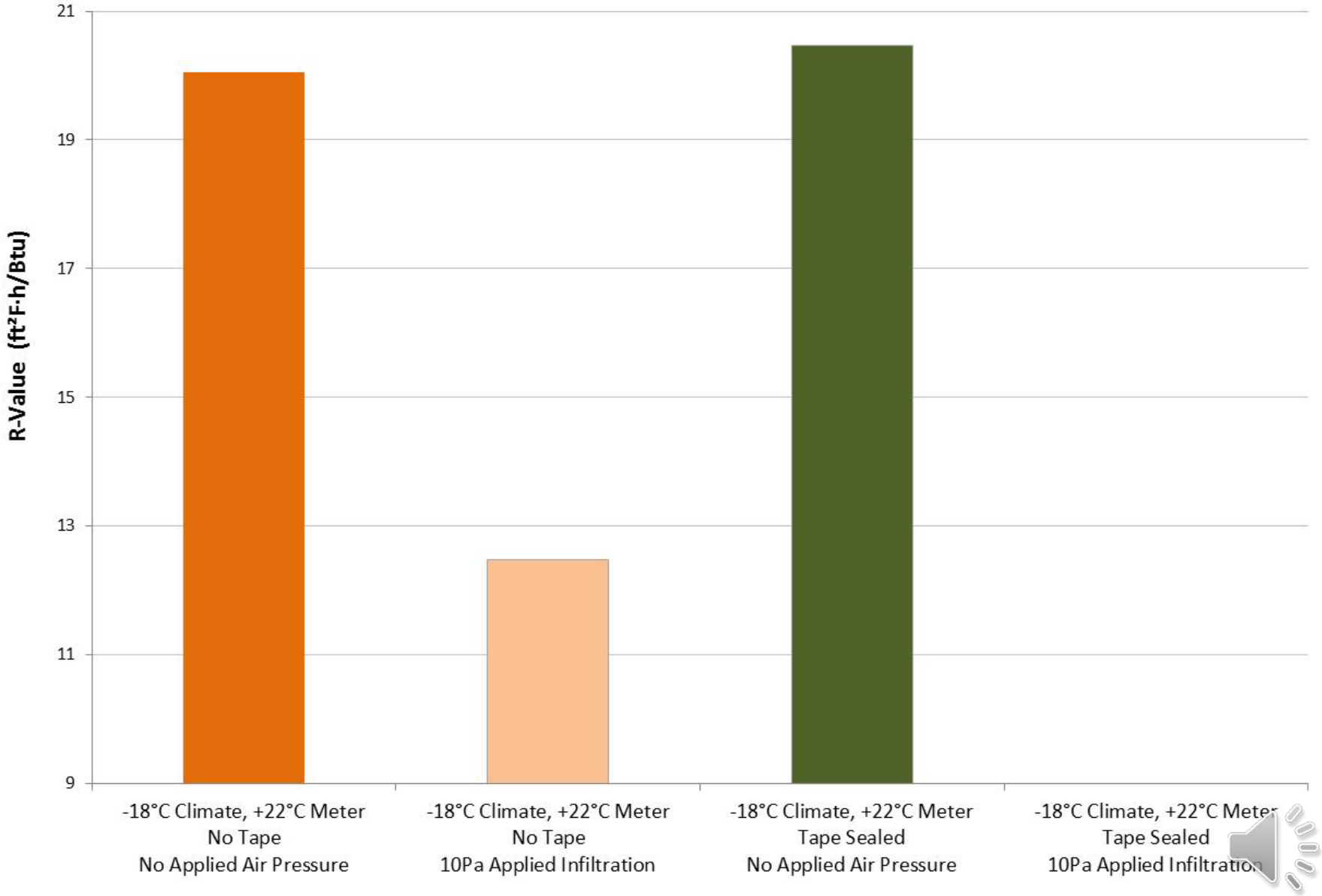
seal the gaps in the air barrier
ZIPsystem
7/16" ROOF AND WALL SHEATHING
AdvanTech Flooring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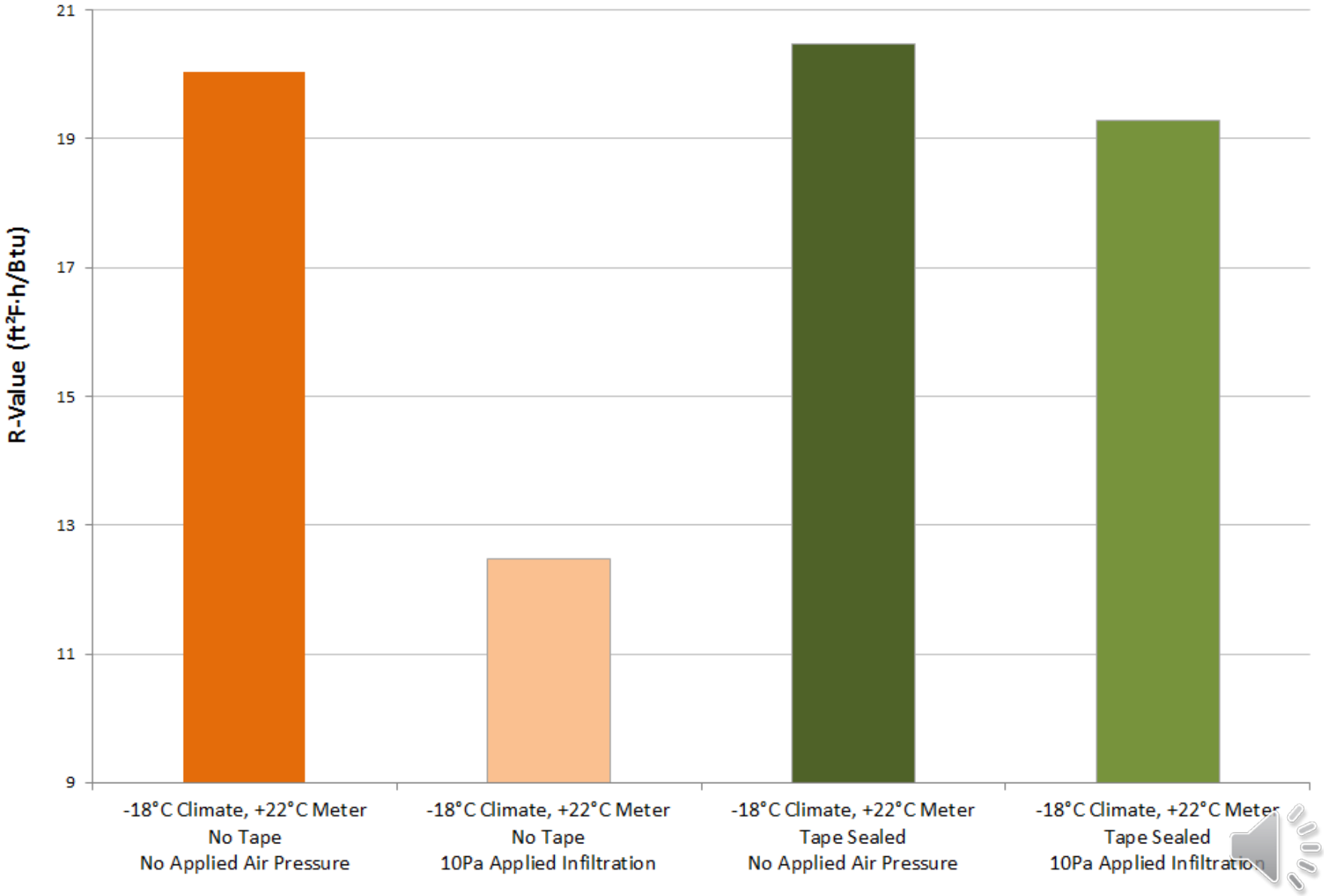
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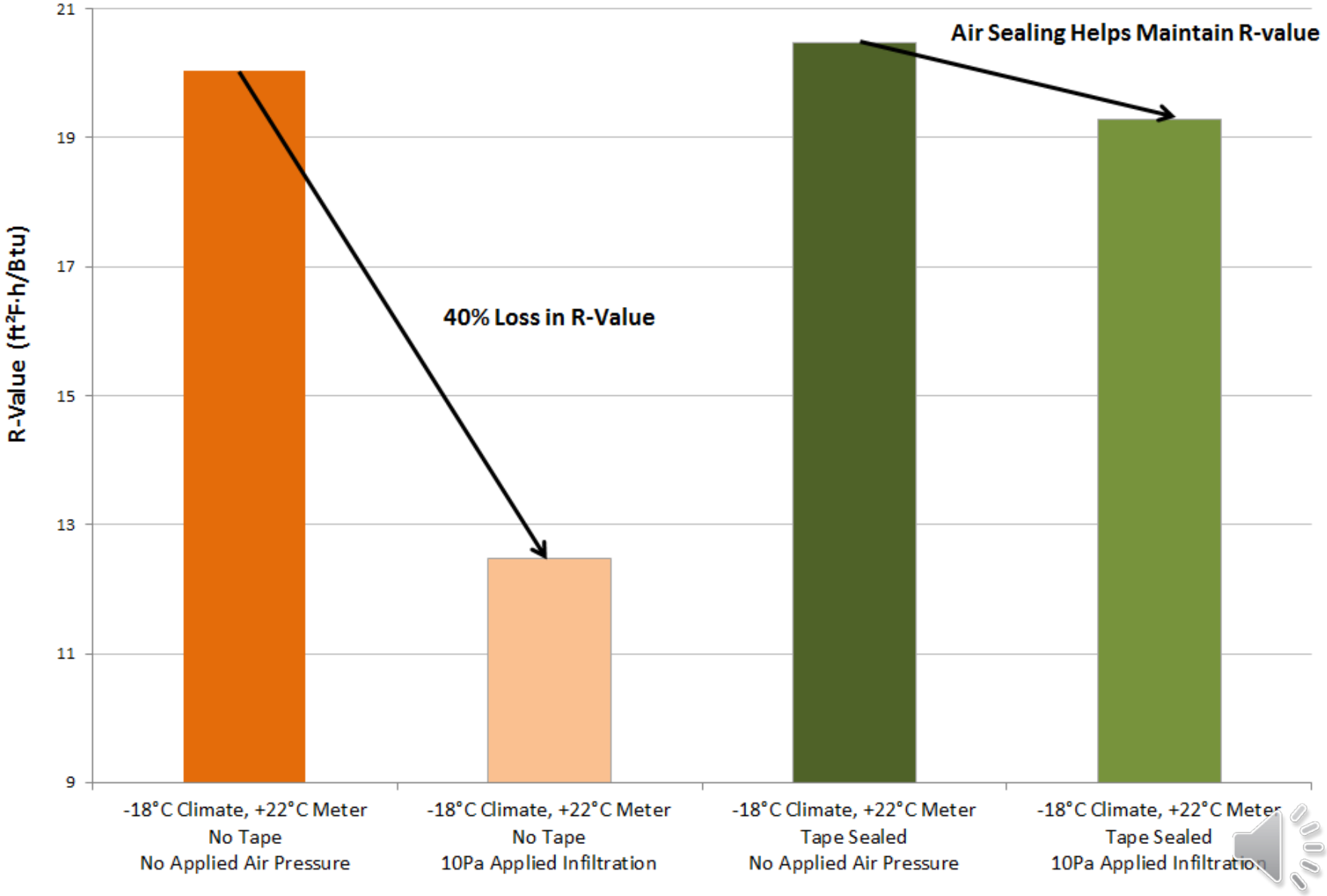
Air Sealing Helps Maintain R-value
40% Loss in R-Value
R-Value (ft²F·h/Btu)
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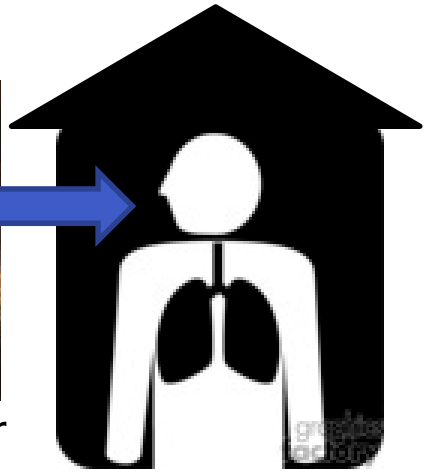
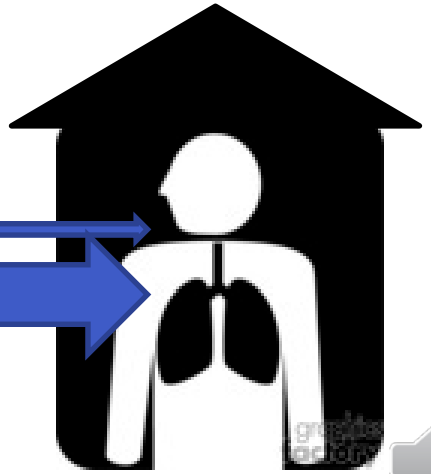
3) Air Tightness and Interior Air Quality

Good air quality



Good air tightness

Mould?
Radon?



Poor air tightness

Requirements for Air Barrier Systems

#1: Air Impermeability

#2: Continuity

#3: Durability

Requirements for an Air Barrier

#1: Air Impermeability

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

→ Is a referenced building code requirement

→ Most materials & systems easily meet requirements

Requirements for Air Barrier Systems

#2: Continuity

→ Air pressure finds flaws

→ The joints and transitions of the materials are key!!!!!

→ Consider the air barrier **system**

→ Redundancy is good

Requirements for Air Barrier Systems

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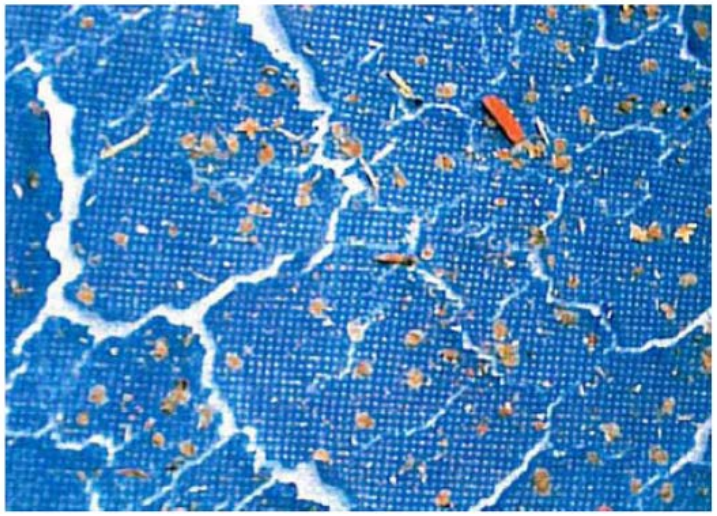
#3: Durability

→ durable enough to last as long as the enclosure assembly

→ Must be able to take stresses due to assembly, material movement, wind pressures etc.

→ Must not degrade due to high or low temperatures, moisture, chemicals, contaminants, UV

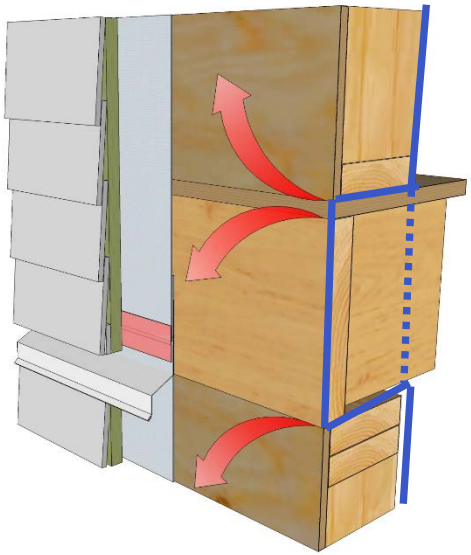


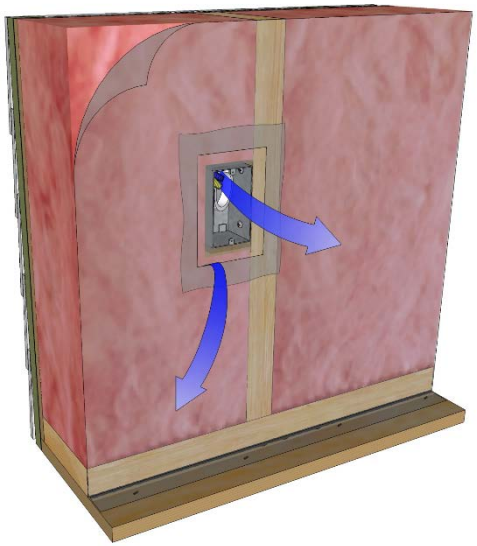
Untried air barrier membrane product from Europe – failed due to heat aging effects in roof assembly

Air Barrier: Where Should it Go?

Traditionally – **Interior** poly acts as air barrier

- → Difficult to make continuous
  - › Transition at floor rim joist
  - › Transition at ceiling plane
  - › Penetrations at electrical outlets, plumbing and HVAC penetrations



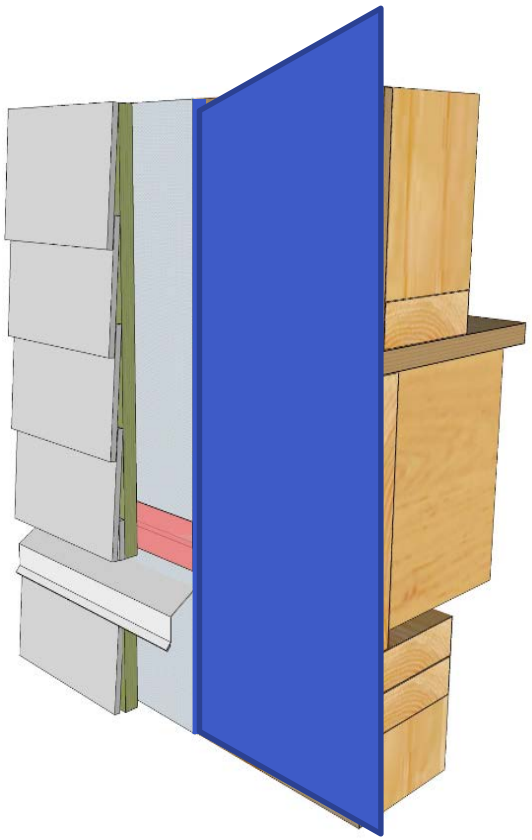


Air Barrier: Where Should it Go?

Exterior Air Barrier

More effective exterior to the structure

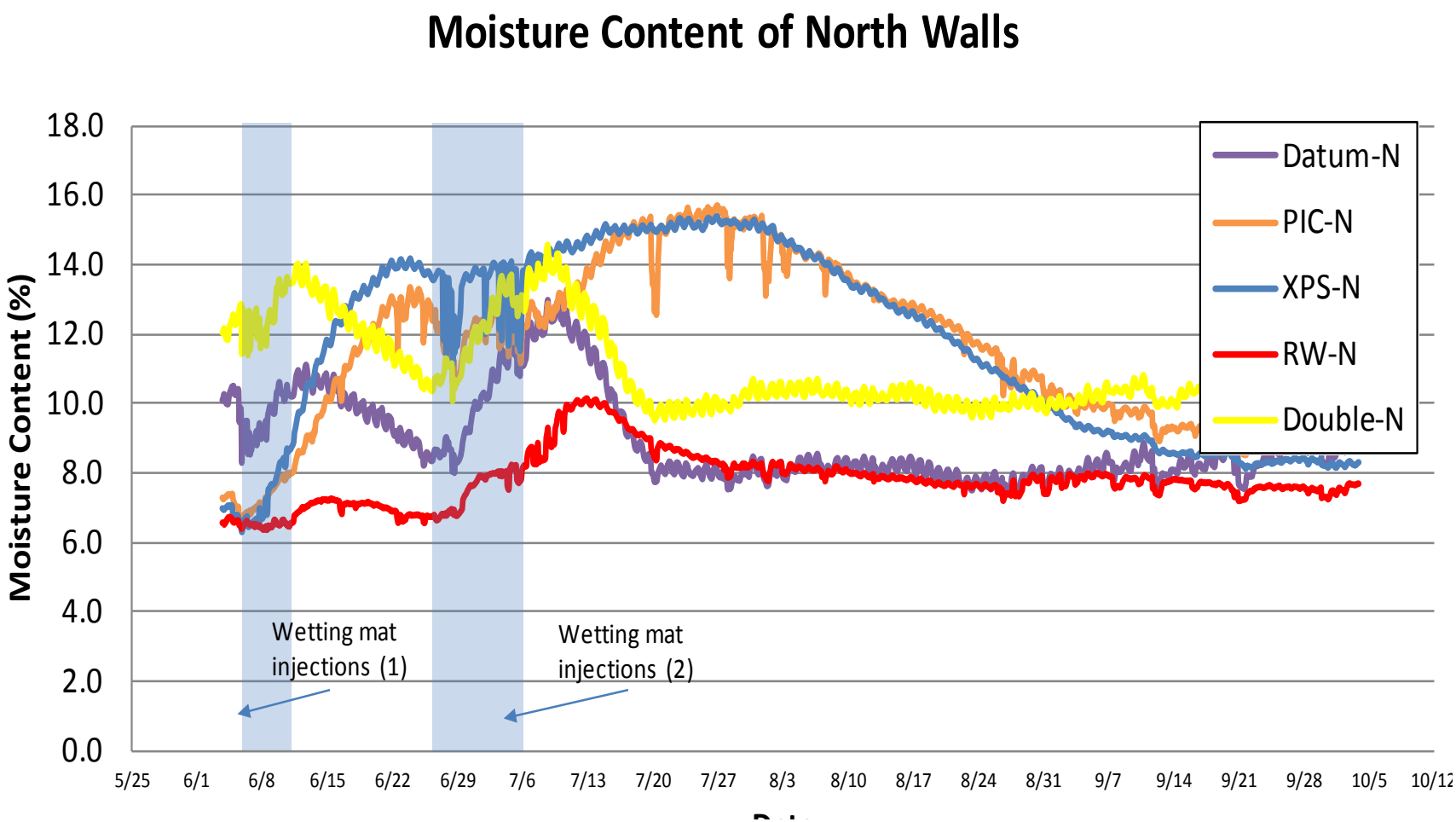
- Easier to make it continuous
  - › Utilize strength and stiffness of sheathing
  - › Transition across rim joist area
  - › Avoid many electrical, plumbing and HVAC penetrations
  - › Potential transition issues at ceiling level
  - › Potential for cold side vapour barrier
    - – Exterior Insulation can be a solution



Considerations for Exterior Air Barriers

- → Air barrier materials should be selected carefully to not negatively affect durability
- → Watch vapor permeance of air barrier materials on "cold" side of insulation

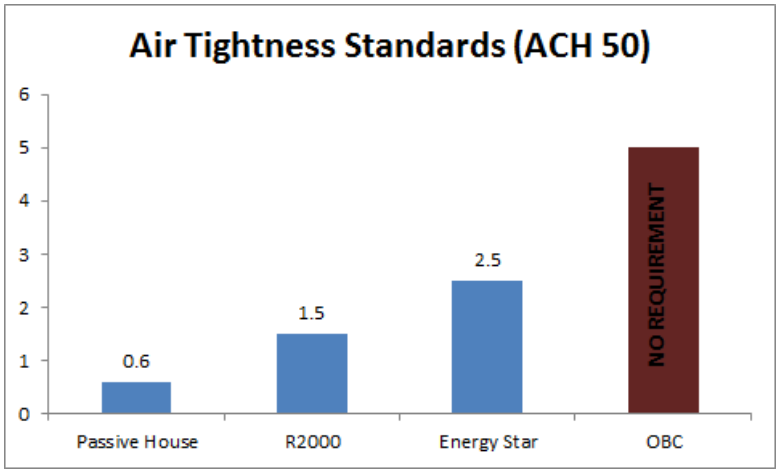
Considerations for Exterior Insulation



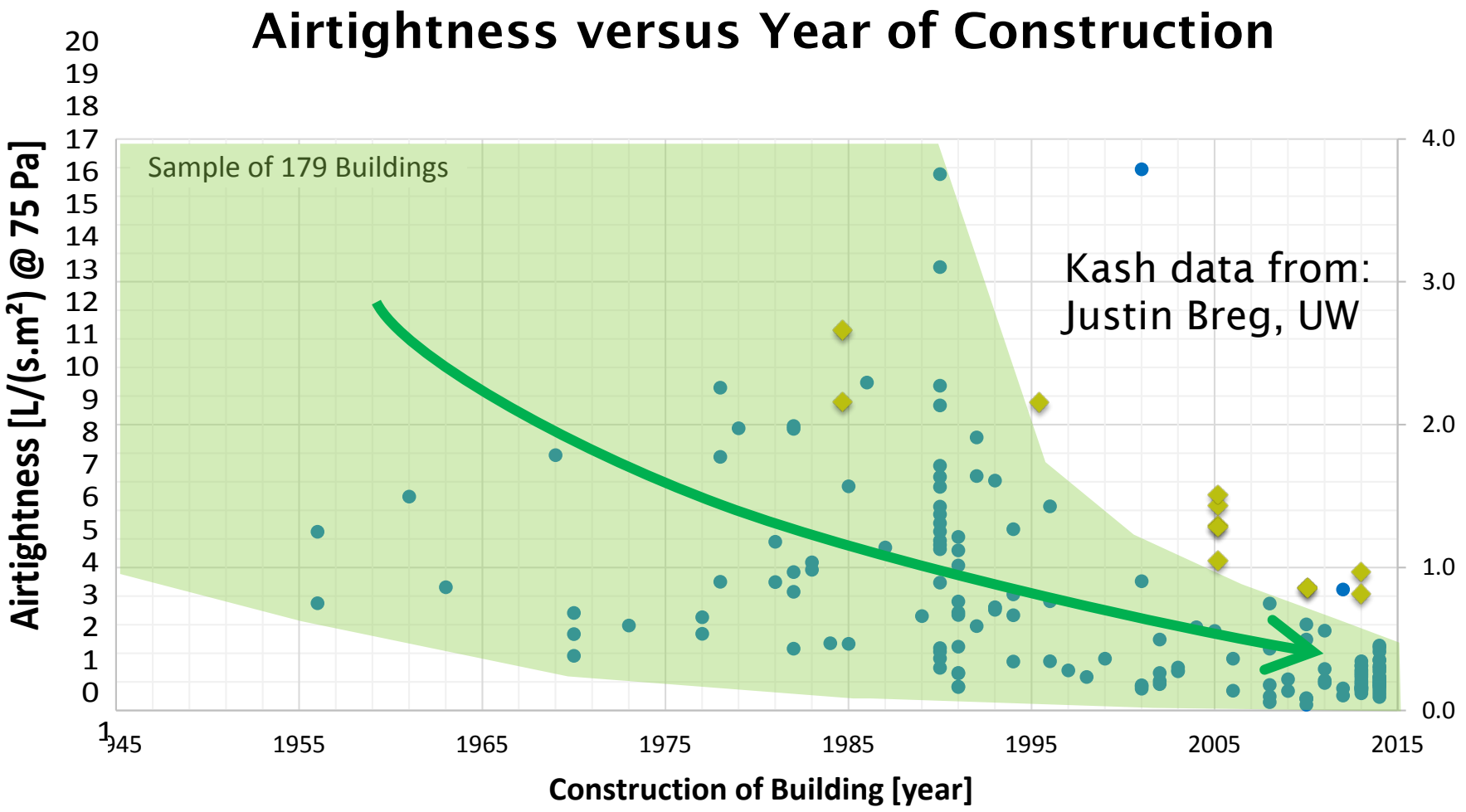
Measuring Air Tightness

→ Blower Door Testing

→ How tight should it be?

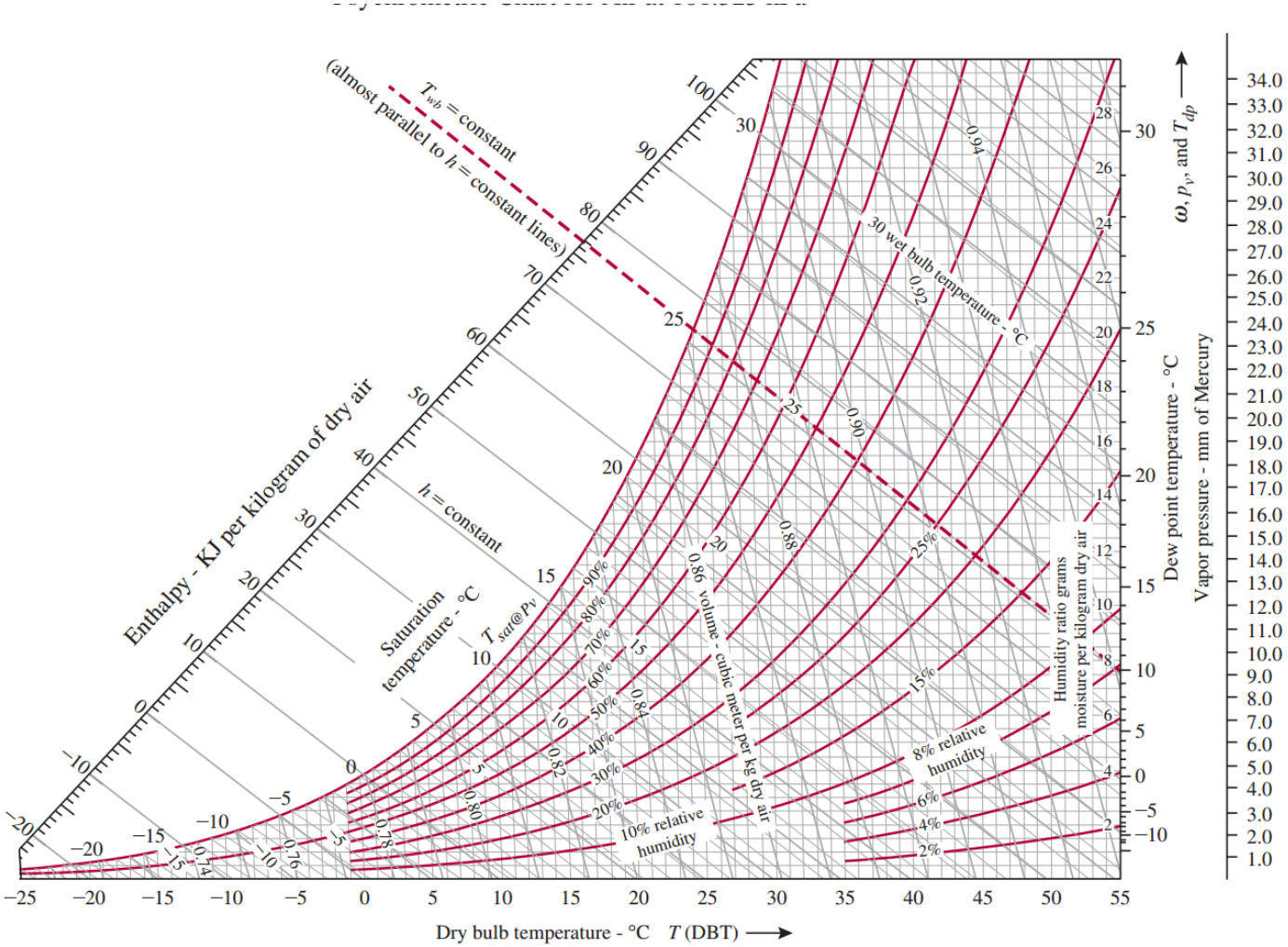


Buildings are Becoming More Airtight



Interior Relative Humidity

→What is RH?



Interior Relative Humidity

→ Moisture generation activities

- Breathing
- Drying cloths
- Baths/Showers
- Cooking/boiling water

Interior Relative Humidity

→ Moisture in building materials

› Construction moisture

› Rain Leaks/Condensation

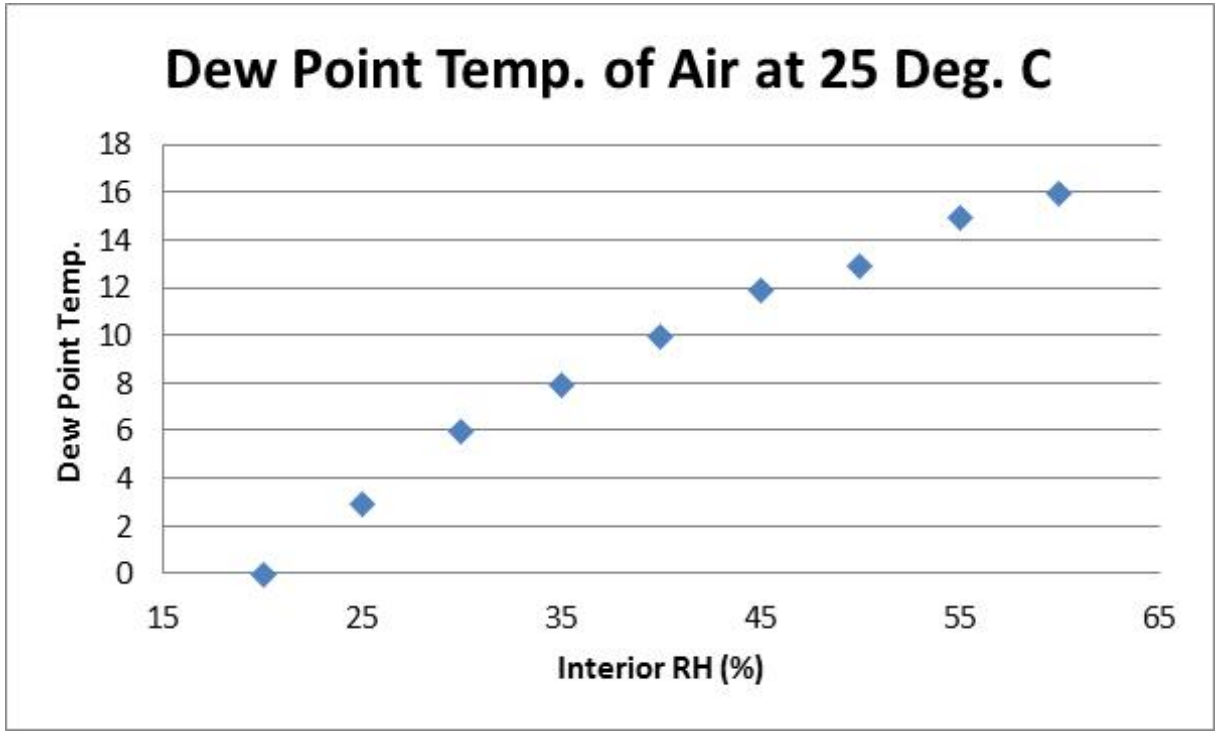
› Flooding

Interior RH- Why does it matter?

Dew point temperature

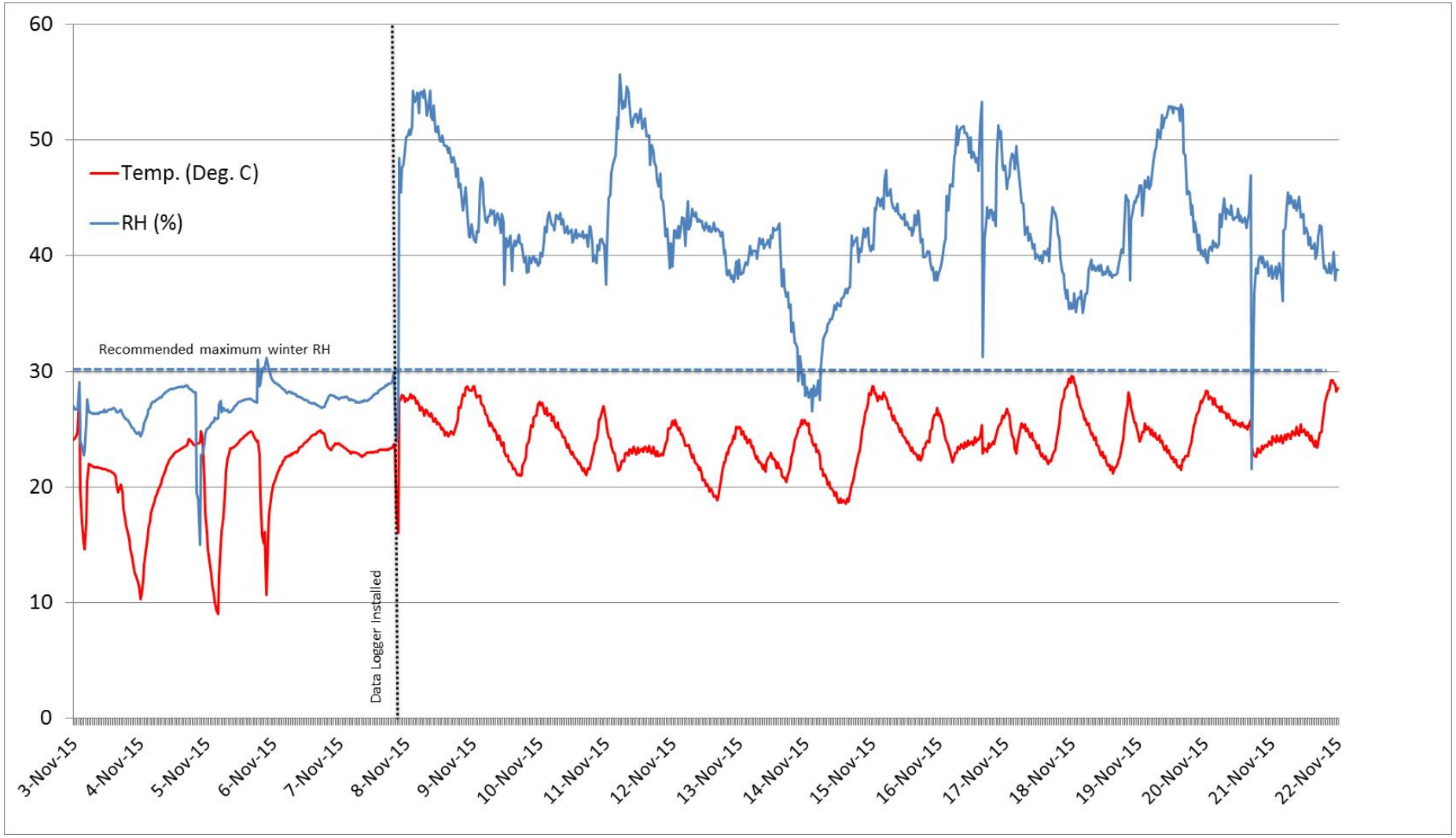
→ Surface temperature at which condensation occurs

→ Is directly related to air temperature and RH

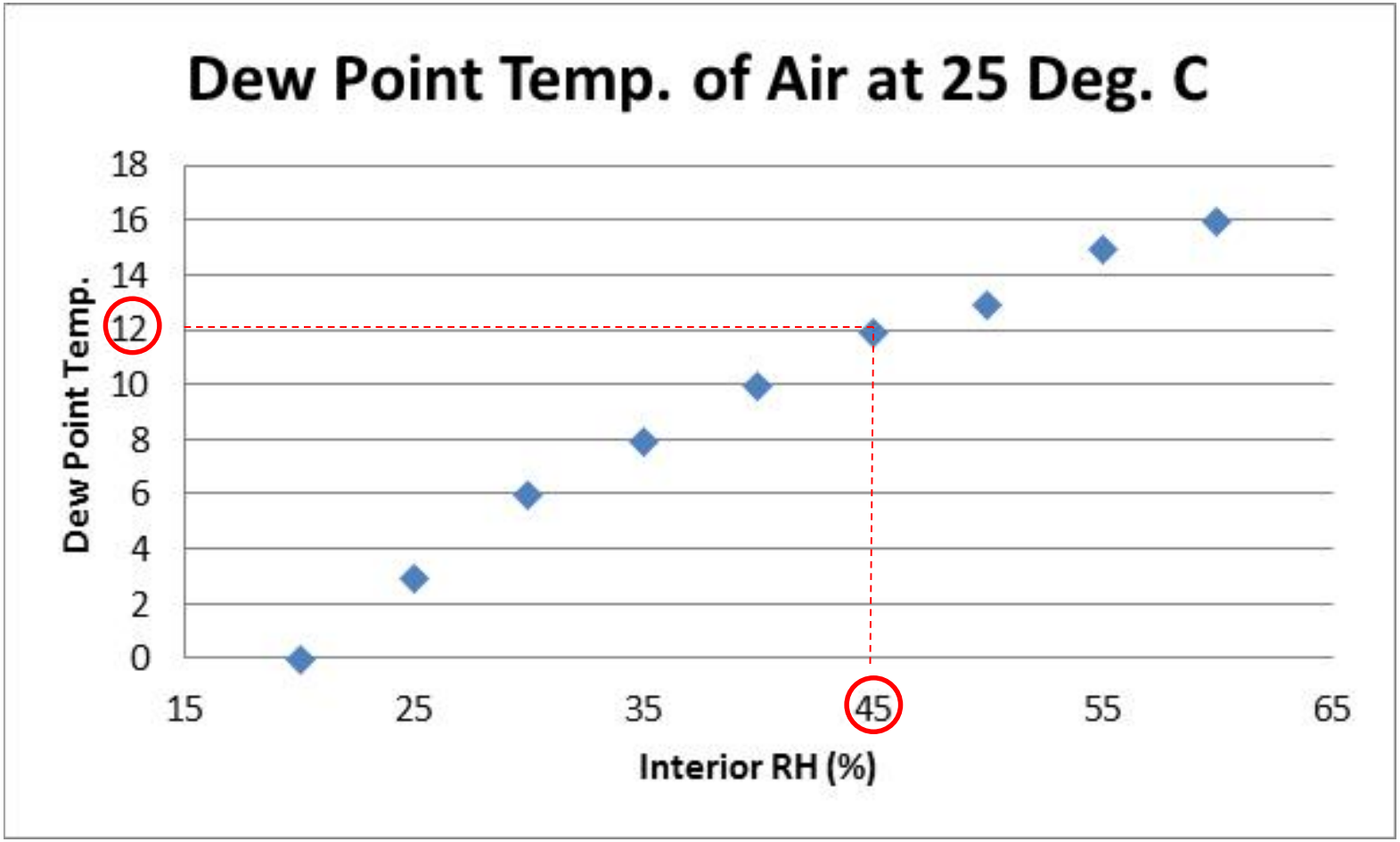


Typical (?) Interior RH Conditions

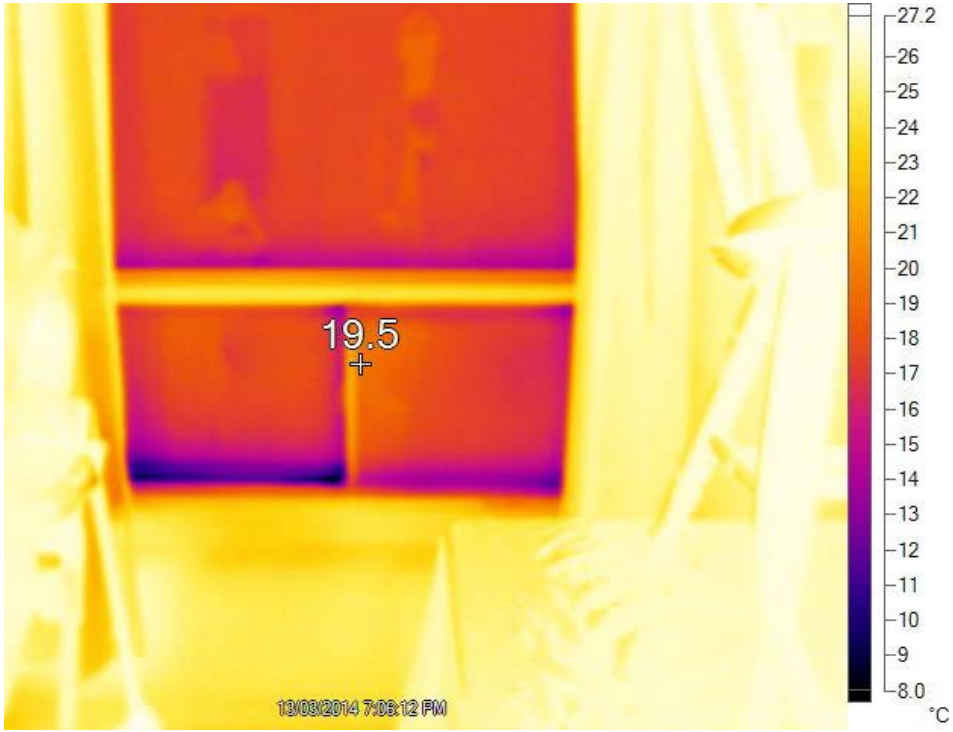
Kash data from:
Justin Breg, UW



Interior RH and Dew Point

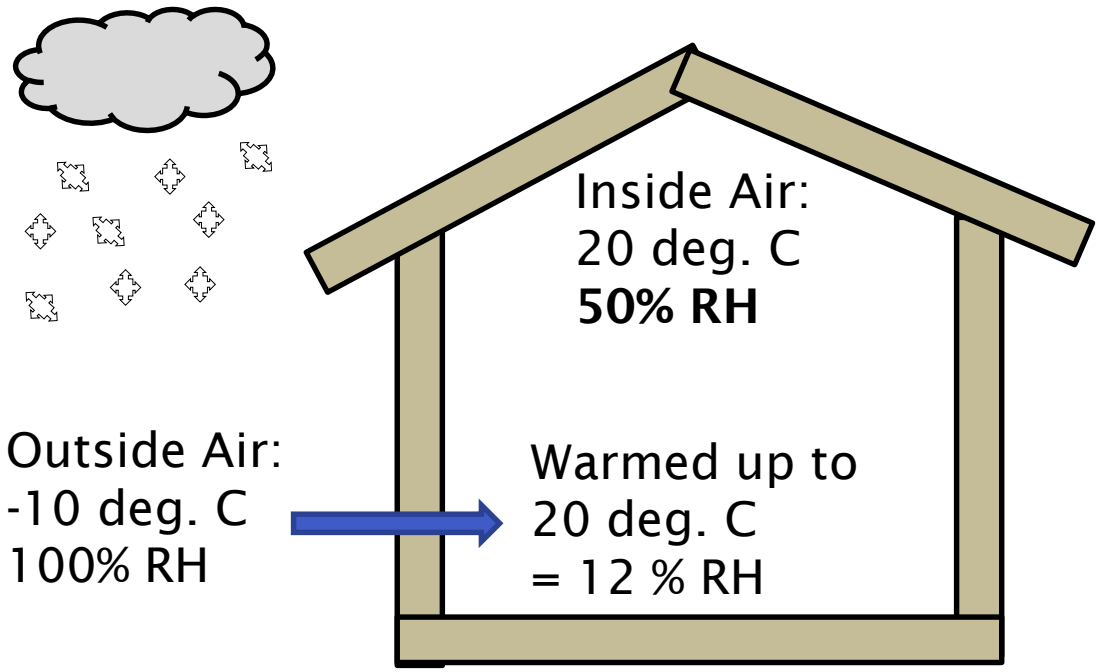


Surface Condensation



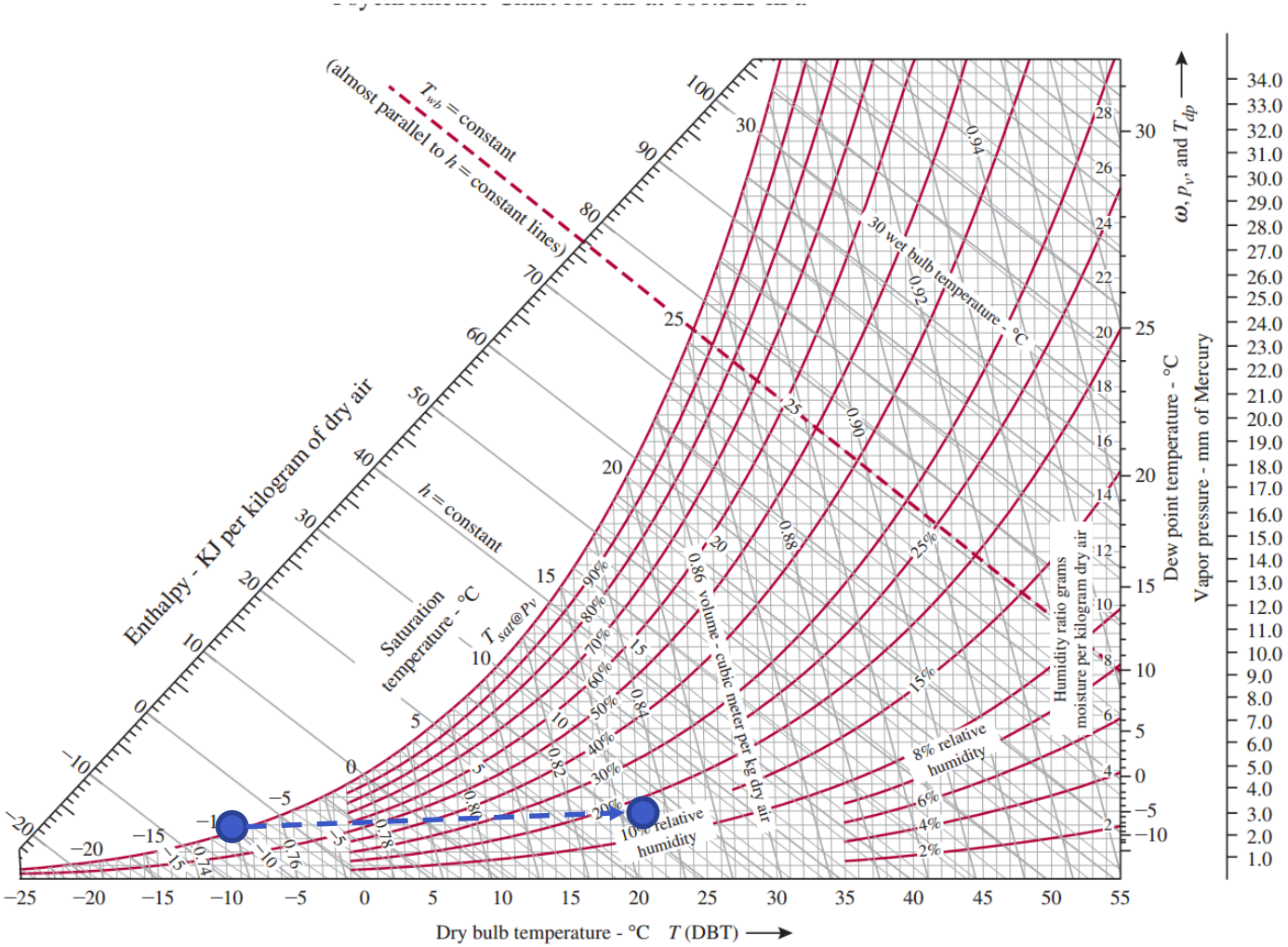
Controlling Interior Relative Humidity

- Mechanical Ventilation
  - Controlled exchange of interior air with exterior air



Controlling Interior Relative Humidity

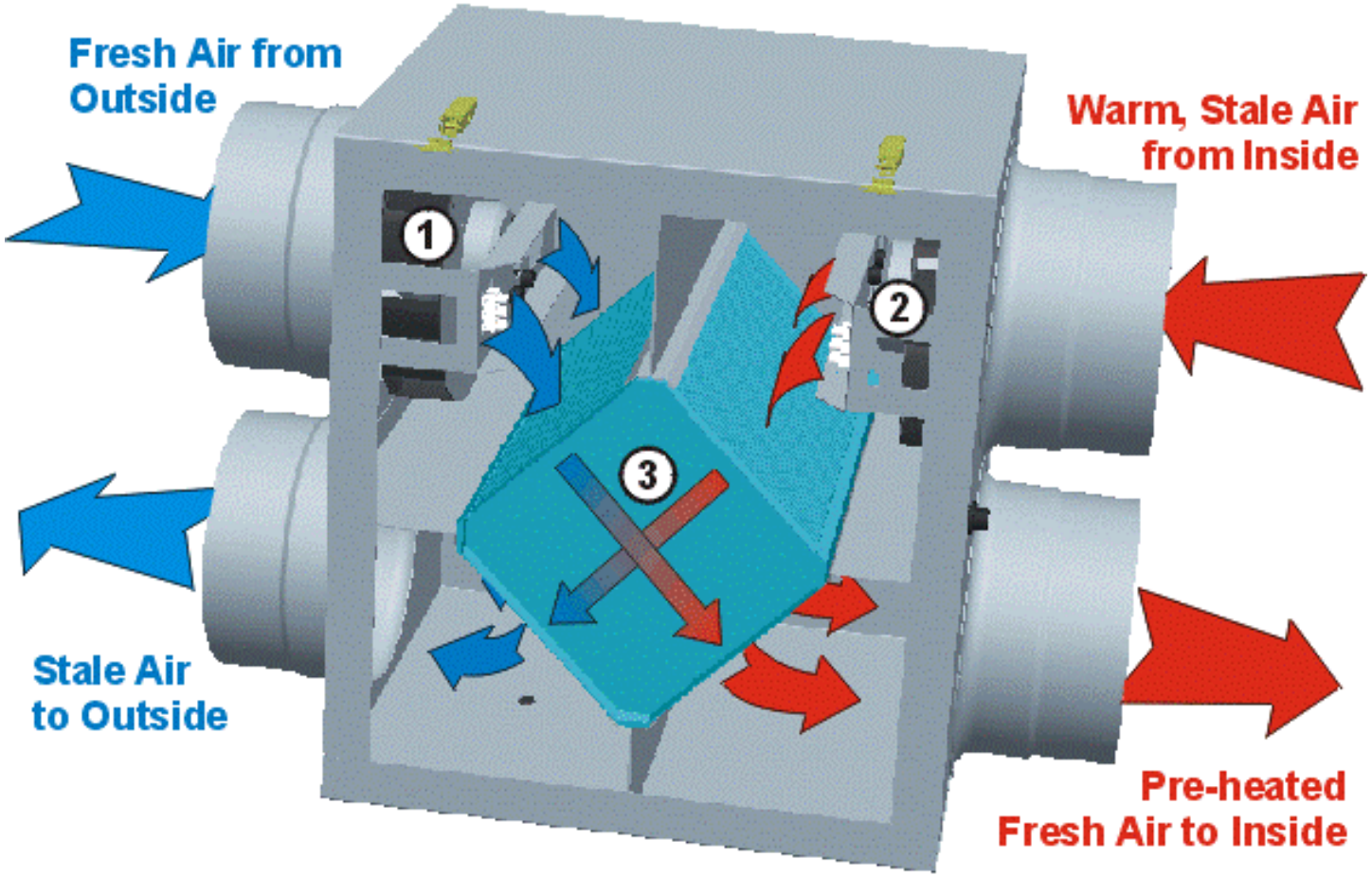
→This thing again?



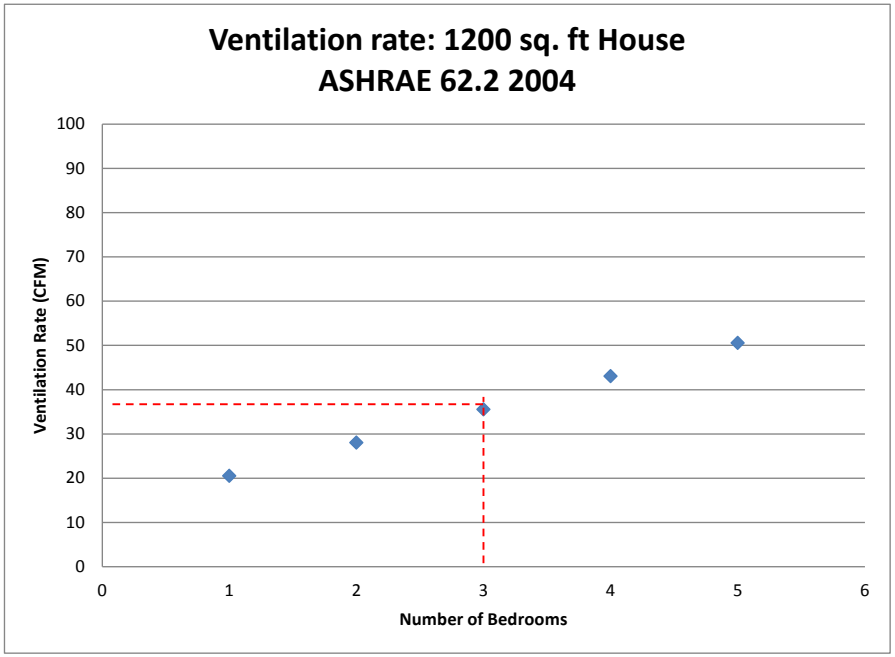
Ventilation

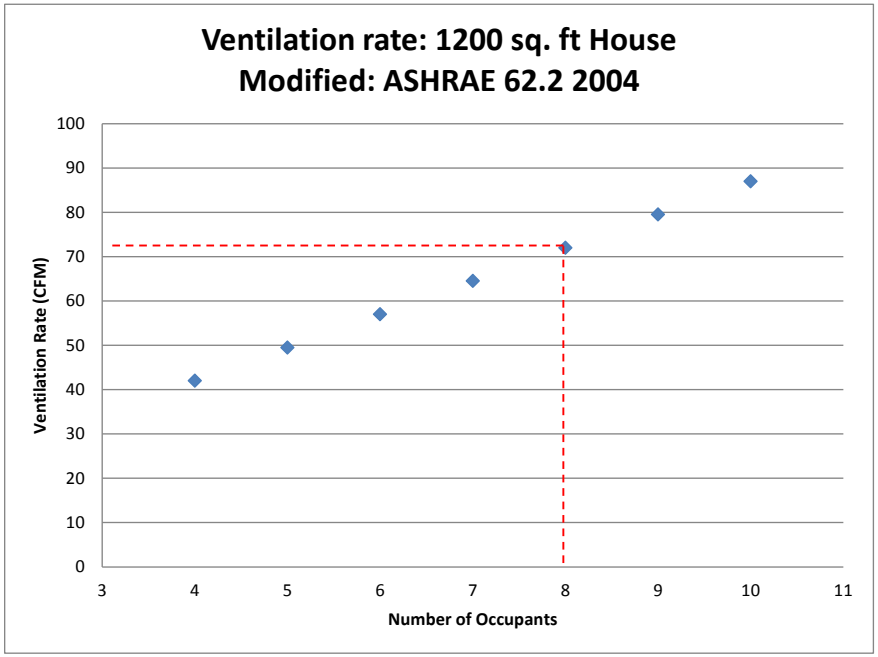
- → Natural Ventilation
  - → Windows, stack vents
  - → Unreliable and inconsistent
- → Mechanical Ventilation
  - → Trading energy for IAQ and humidity control
  - → Trading complexity for effectiveness
- → Supply only
- → Exhaust only
- → Balanced - HRV

Heat Recovery Ventilator



Ventilation Rates





Summary

- Air-tightness is critical for creating comfortable, durable, efficient and healthy homes……especially in cold, wet and windy environments
  - An air tightness standard should be specified for all new construction and also considered in all renovations
  - Compliance through blower door testing

- Ventilation is critical for controlling relative humidity and indoor air quality
  - A practical ventilation standard should be developed and specified for all new construction and extended to existing buildings

Myths and Frequently Asked Questions

→What's the difference between an air barrier and a vapour barrier?

1) Air barrier is more important
2) Air barrier must be nearly flawless
3) Air barrier can go anywhere in the assembly

Myths and Frequently Asked Questions

- → Can a building be too air tight?
  - → NO
  - → The tighter the better
  - → Controlling air flow is key to:
    - › Indoor air quality
    - › Building durability
    - › Energy efficiency

Myths and Frequently Asked Questions

→Should a building be able to 'breathe'?

- → NO – not through the building enclosure
- → Mechanical system should be used to control the amount and quality of air
- → BUT – the enclosure should be able to dry in one direction

Myths and Frequently Asked Questions

→Why does interior RH matter?

- → The RH effects the dew point
- → The dew point effects if condensation occurs
- → The dew point effects how much condensation occurs

Myths and Frequently Asked Questions

- How does ventilation reduce interior RH?
  - Expels warm moist air
  - Brings in cold air and when it warms up, produces dry air

Questions?????

→ Thanks for your time!