Building Air Tightness Requirements

Code Requirements for Commercial and Multifamily Building Air-Tightness Testing

Presented by:
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Building Science Specialist

Agenda

- Background on Airtightness
  - Code Requirement
  - Compliance Matrices
  - Air Flow Dynamics
- Materials, Assemblies, Systems
  - Airtight Drywall Approach?
- Common Issues
  - Design
  - Construction
- Air Barrier Testing
  - Test Data & Reporting
- Diagnostics

City of Fort Collins Ordinance

ORDINANCE NO. 019, 2014,
OF THE COUNCIL OF THE CITY OF FORT COLLINS
AMENDING CHAPTER 5, ARTICLE II, DIVISION 2, OF THE CODE
OF THE CITY OF FORT COLLINS FOR THE PURPOSE OF
REPEALING THE *2009 INTERNATIONAL ENERGY CONSERVATION CODE (IECC)*
AND ADOPTING THE *2012 INTERNATIONAL*
ENERGY CONSERVATION CODE, WITH AMENDMENTS

WHEREAS, since 1924, the City has reviewed, amended and adopted the latest

ORDINANCE NO. 039, 2014
OF THE COUNCIL OF THE CITY OF FORT COLLINS
ESTABLISHING REGULATIONS FOR THE CULTIVATION OF MARIJUANA

WHEREAS, on November 6, 2012, Colorado voters approved an amendment to Article XVIII, Section 16 of the Colorado Constitution (Amendment 64), that legalizes, under Colorado law, the personal use, possession and limited cultivation of recreational marijuana for adults

(~~7~~6) No marijuana cultivation activity shall result in the emission of any gas, vapors, odors, smoke, dust, heat or glare that is noticeable at or beyond the property line of ~~the~~ a single-family dwelling at which the cultivation occurs, or beyond any commonly-shared wall of a dwelling unit in a two-family, multi-family, or single-family attached dwelling at which the cultivation occurs.

City of Fort Collins Building Code Protocol for *New Multifamily Building Air Tightness Testing* (Effective August 1, 2014)

Application

This protocol can be used to meet the air barrier testing requirement for **any stacked multifamily building** built under the current City of Fort Collins amended residential or commercial I-Codes, replacing the whole building air barrier test. It **does not apply to attached-single-family dwellings** such as duplexes and townhomes.

Compliance Requirements

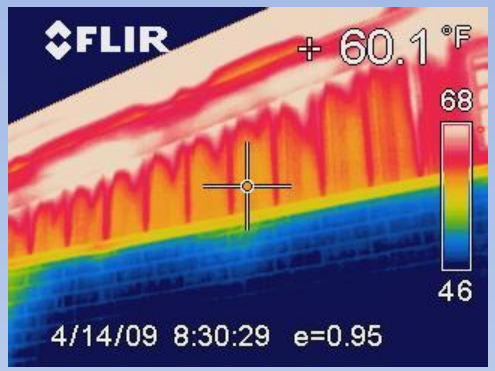
- Apartment exterior air barrier must be continuous and unbroken, separating the conditioned space of the building from the exterior and any unconditioned spaces or mechanical rooms within the building.
- Units must be compartmentalized to minimize uncontrolled pathways for smoke and other indoor air pollutants to transfer between units. Walls, ceilings and floors that separate each apartment from neighboring apartments, corridors, common space, trash chutes, utility chases, floors above and below, stairwells and elevator shafts must be air sealed by sealing all penetrations in walls, ceilings, floors and chases. Weather-strip all doors that lead to common hallways.
- It is highly recommended that the contractor provide access for the tester to visually inspect air barrier components as each building reaches pre-drywall stage, so as to help ensure units pass the tests.
- **The maximum air leakage rate** at 50 Pascal test pressure **shall not exceed 0.30 CFM50/square foot** of unit enclosure surface area (the total surface area of all walls, floors and ceiling).

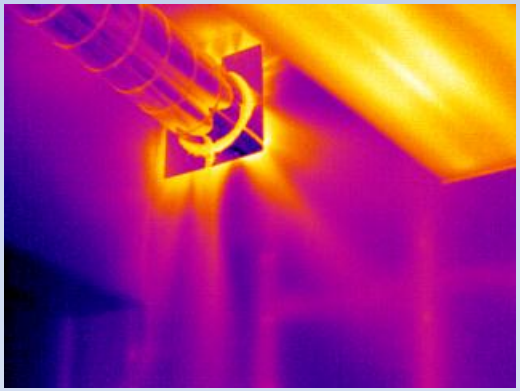
Unit Sampling

- When the air barrier is completed, tester must select a minimum of 20% of the units in each building to test, including at least one of each unit type and approximately an equal number of units on each floor level.
- Each of these units must be tested and pass without a failure. If a failure occurs, items causing the failure must be diagnosed, corrected, and the unit must be re-tested until it passes. A minimum of at least two additional units of this type in the same building must also be tested and pass.

Why Air Barriers?

- Energy conservation
  - Reduce heating and cooling loads
  - EPACT 2005 / EISA 2007
    - 30% reduction over ASHRAE 90.1-2004 by 2012
    - Net zero by 2030 (Executive Order 13514)
- Mechanical System Sizing/Operation
  - Designing / Modeling Infiltration Loads
- Moisture and mold control
  - Water vapor transport via air movement
  - Very costly to remediate
  - Politically volatile
- Pollutant transport (IAQ)
  - Example: TEMF facilities - Fumes
- Microclimate Conditioning
- Sound/Acoustics

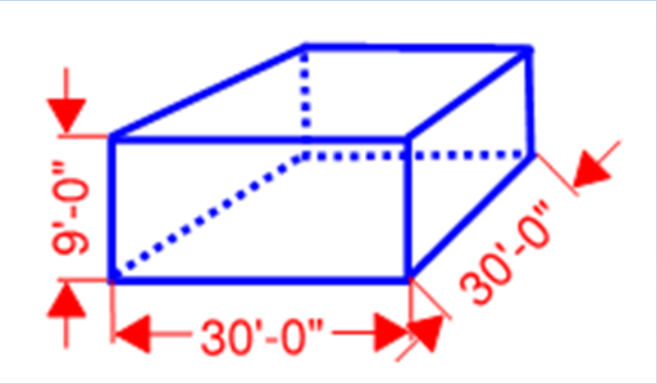




Air Barrier Requirements

Allowable Leakage Rate = 0.30 cfm/ft^2 @ 50-Pascal

- Multifamily Protocol
- Based on Unit Surface Area
- Unit Envelope Area = 2,880ft^2



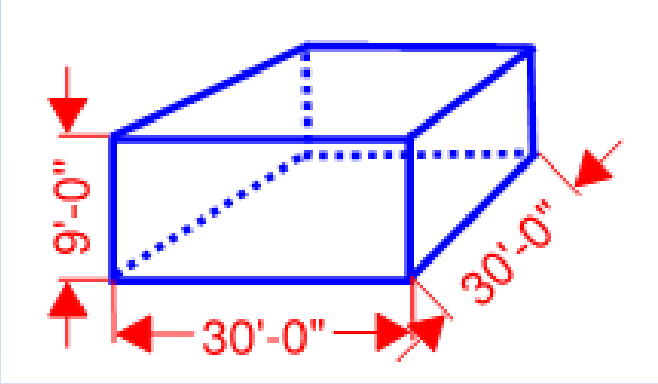
6 sides of the box!

Allowable Leakage = (0.30 cfm/ft^2)(2,880 ft^2) = **864 CFM**

Air Barrier Requirements

Allowable Leakage Rate = 3ACH @ 50Pa

- Small Commercial Alternative
- Based on Volume
- ACH50 = CFM@50Pa x 60(min/hr) / Volume

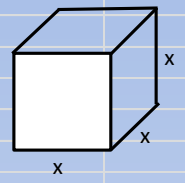


6 sides of the box!

Allowable Leakage = 8,100 x 3ACH50 / 60(min/hr) = **405 CFM**

ACH@50 vs. CFM/FT²@50

ACH	3
ALR (cfm/ft²)	0.3



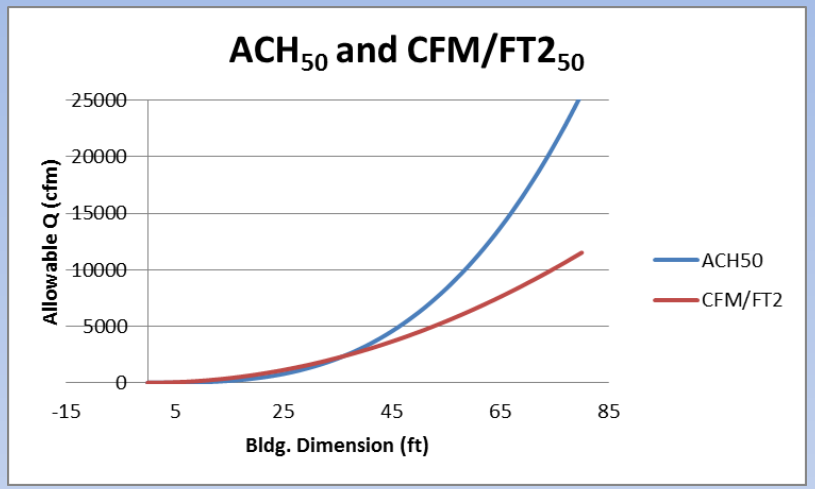
$V = x^3$

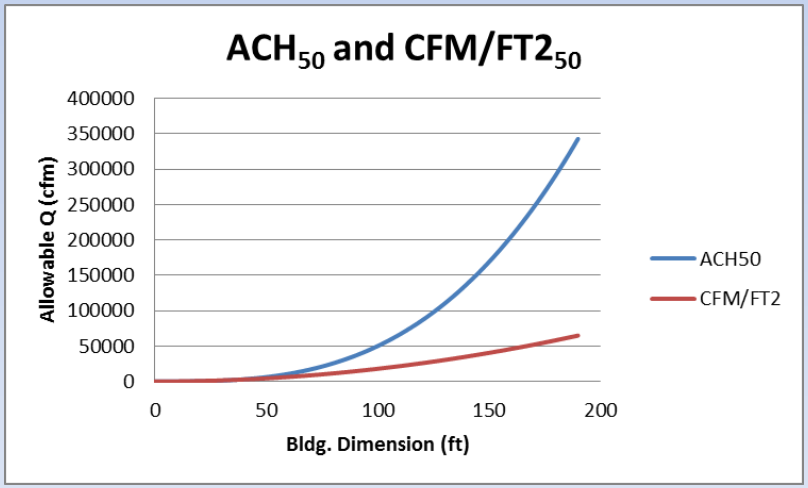
$A_s = 6x^2$

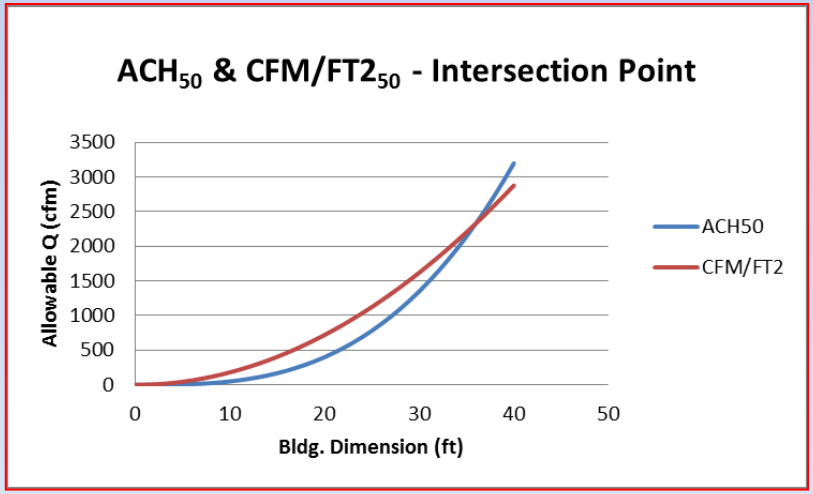
$ACH = \frac{60Q_{50}}{V}$

$ALR = \frac{Q_{50}}{A_S}$

x (ft)	GSF (ft²)	ACH_{50} (cfm)	$CFM/Ft2_{50}$ (cfm)
0	0	0	0
1	1	0.05	1.8
2	4	0.4	7.2
3	9	1.35	16.2
4	16	3	29
5	25	6	45
6	36	11	65
7	49	17	88
8	64	26	115
9	81	36	146
10	100	50	180
11	121	67	218
12	144	86	259







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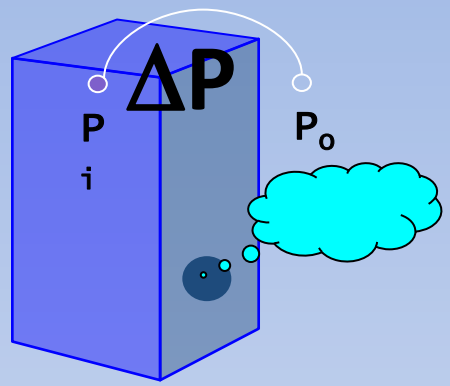
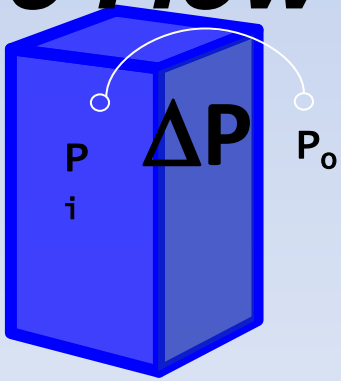
Air Leakage Needs:

1. **Driving Force**
2. **Pathway**



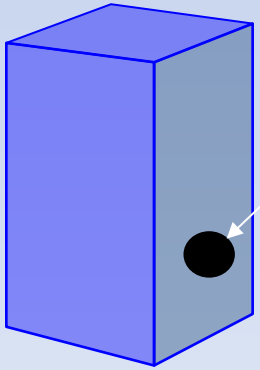
No pathway:

No Flow



No Δ Air Pressure:

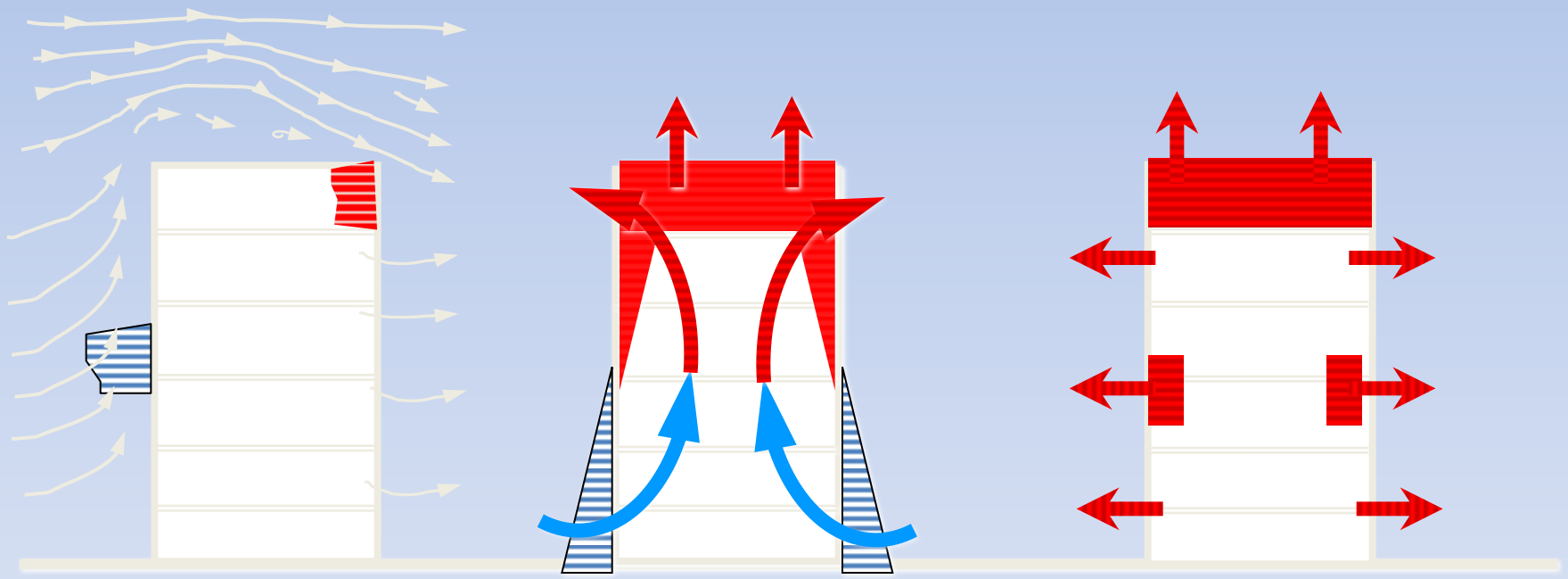
No Flow



Pathway
(Unintended Opening)

Sources of ΔP

There are 3 main sources of ΔP:



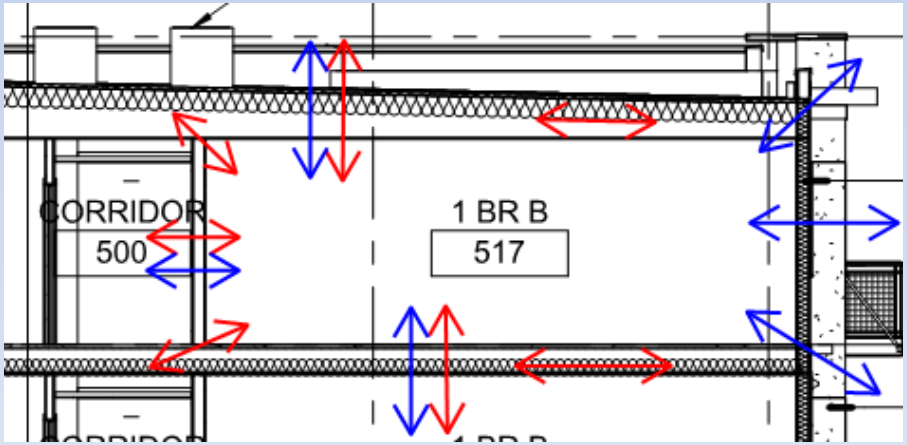
Wind Pressure

Stack Pressure

Mechanical Pressure

Compartmentalized Air Leakage

- Reducing Driving Force and Pathway
- Infiltration & Ventilation - Francisco & Palmiter 1994
- Replaces Whole Building Testing
- 20% of units – one of each type & equally sampled on each floor
- Failure – Retest until passing, plus additional **two**.
- Surface area location & percent of air leakage



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What is an air barrier?

- Big Picture

Materials → Assemblies → Systems

ASTM E 2178

ASTM E 2357

ASTM E 779 / USACE / IGCC / GSA P100 / City of Fort Collins / Etc.

- Materials: 0.004 cfm/ft^2 @ 75 Pa
- Assemblies: 0.04 cfm/ft^2 @ 75 Pa
- Whole Bldg: Varies by Building Type

What qualifies as an AB material?

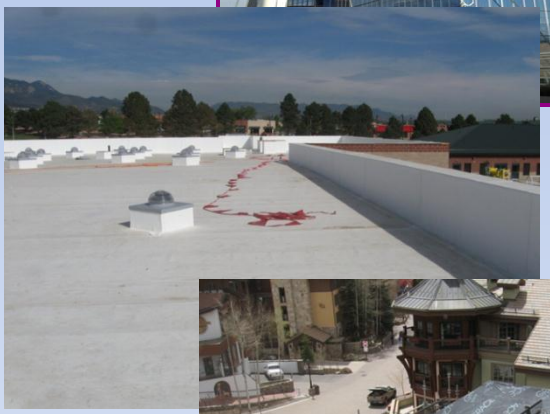
- Self-adhering membranes
- Some Building Wraps
- Fluid-applied waterproofing / air barrier

What qualifies as an AB material?

- Precast & Cast-in-place Concrete
- Extruded Polystyrene (XPS) or Foil Faced Polyisocyanurate Rigid Insulation
- Polyethylene Film

What qualifies as an AB material?

- Glass & Metal (storefronts / curtain wall / fenestrations)
- Fully adhered roof membranes (TPO, EPDM, Modified, Built-up, etc.)
- Fully Adhered Butyl or Modified Asphalt Underlayments



What qualifies as an AB material?

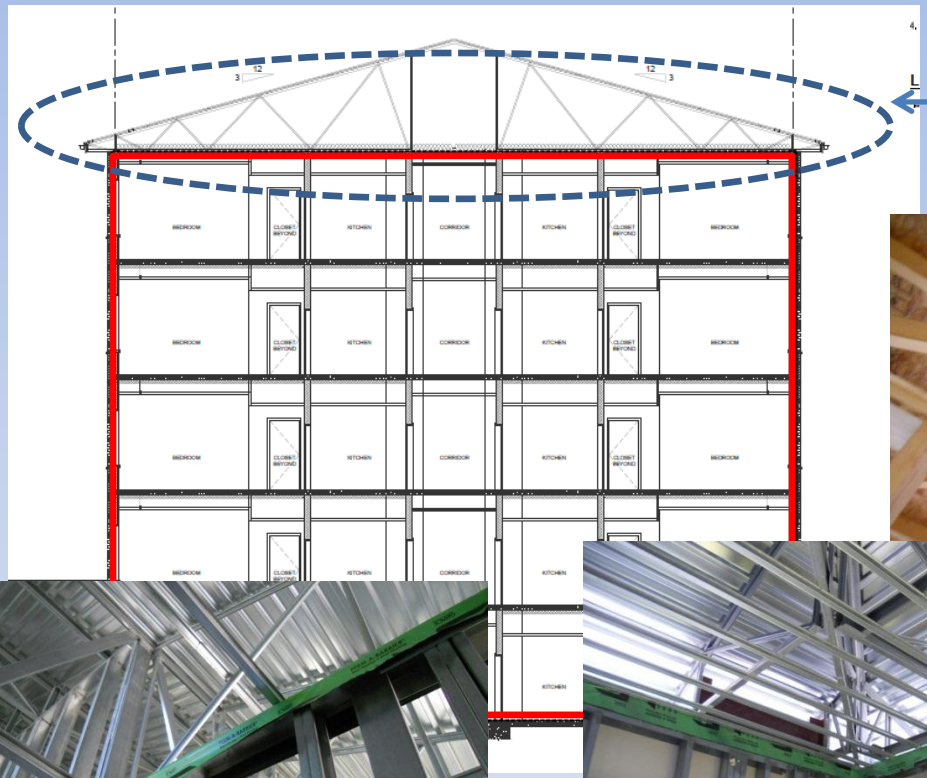
- Pre-Engineered Metal Buildings?
- Spray foam (closed cell, medium density, 3.5" thickness minimum, with max 2" lifts)?

What about CMU?

- Uncoated concrete block has an air permeance of 0.4 to 1.2 cfm/ft^2 @ 75-Pa (100-300 times the requirement of 0.004)
- Fluid-applied air barrier coating, self-adhering membranes, spray foam or other air barrier materials should be used over CMU to qualify as an air barrier.
- What about fully grouted or painted (test results)?

What about vented roofs?

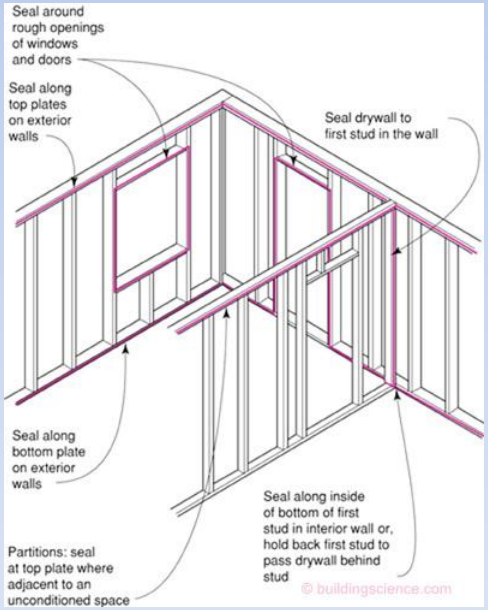
- Solution → Design the plane of air tightness to be at the uppermost ceiling.

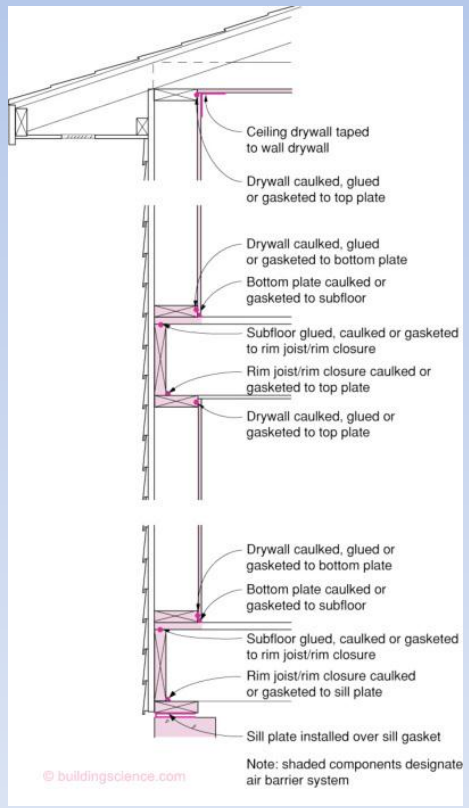


Roof is still vented, and air tight barrier is maintained at ceiling.

Airtight Drywall Approach to Compartmentalization?

- Exterior / Interior Gypsum Sheathing (min. 5/8”)





Detail Images: Building Science Corp

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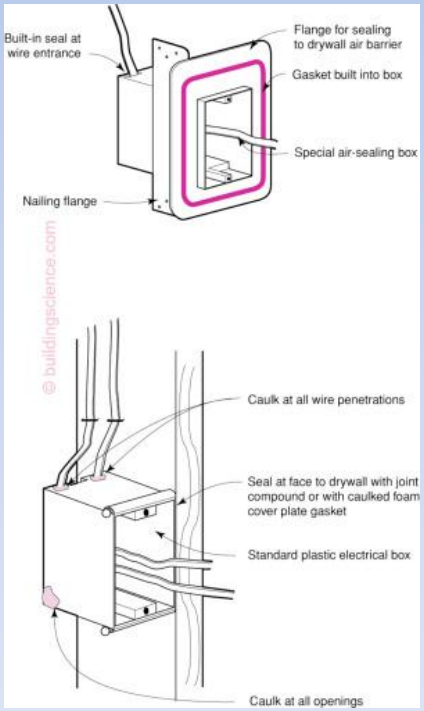

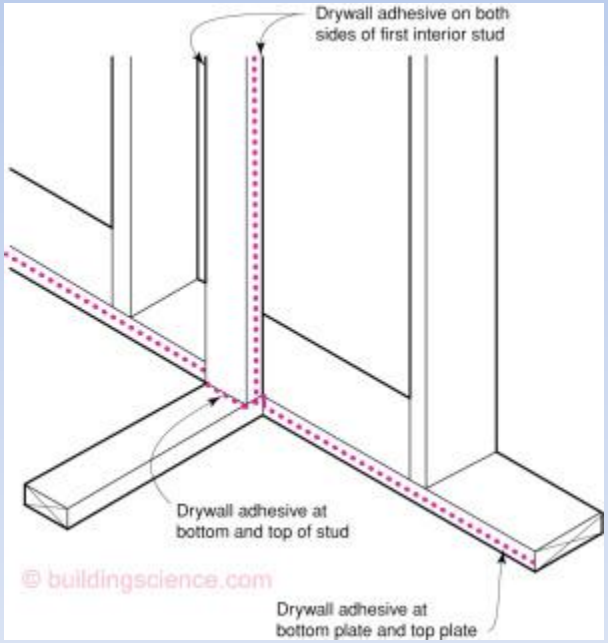

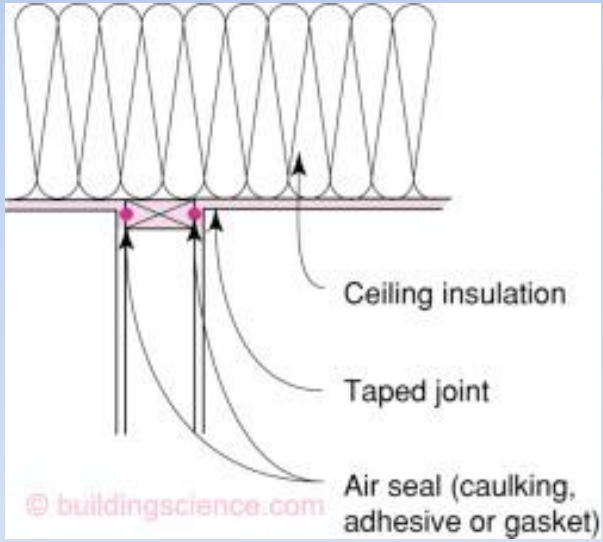

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Airtight Drywall Approach to Compartmentalization?

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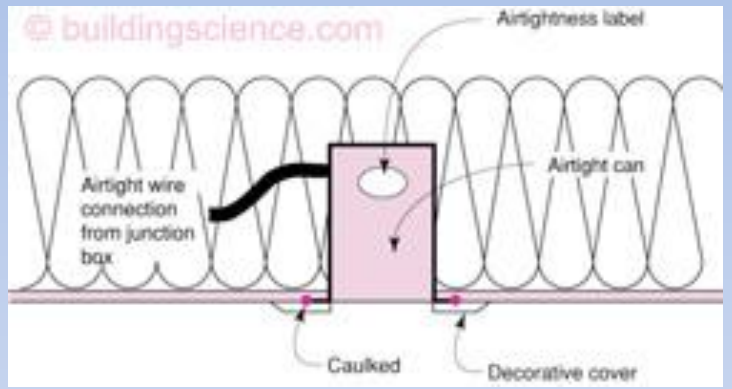
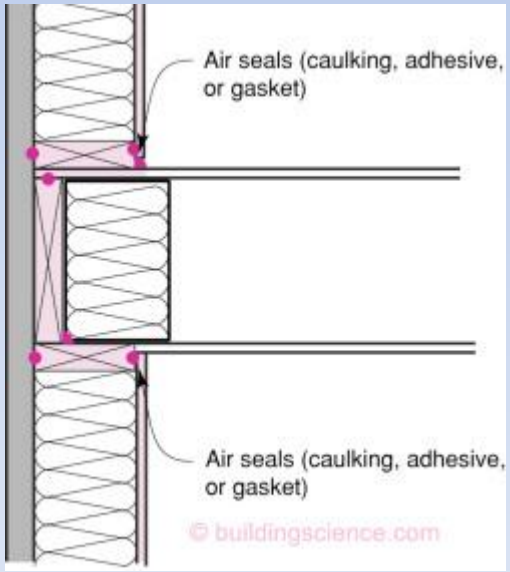
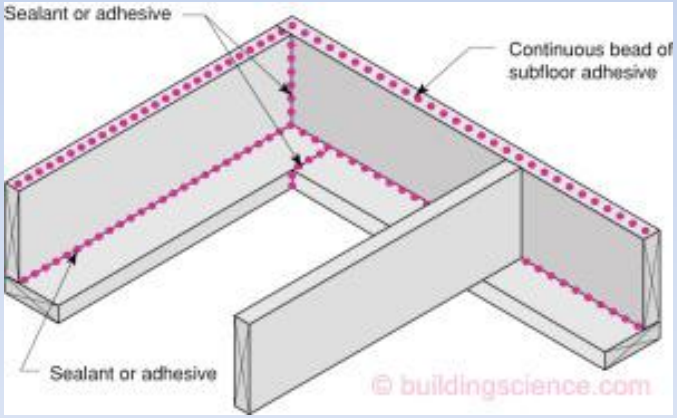






Detail Images: Building Science Corp

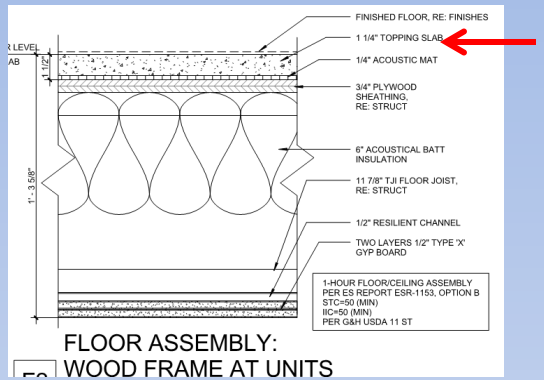
Airtight Drywall Approach to Compartmentalization?

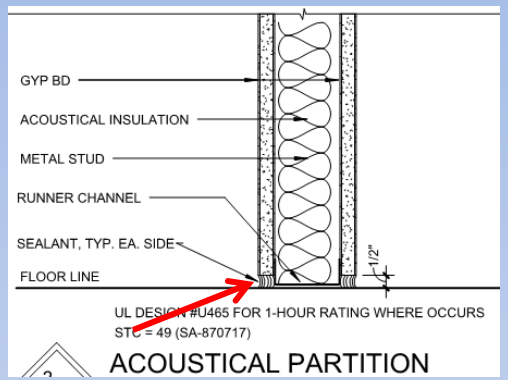
- Connections Inflexible
- Not Continuous
- Is a Sacrificial Layer
- Doesn’t Minimize the Number of Penetrations
- Is Not Vapor Intelligent (Exterior Condition.)

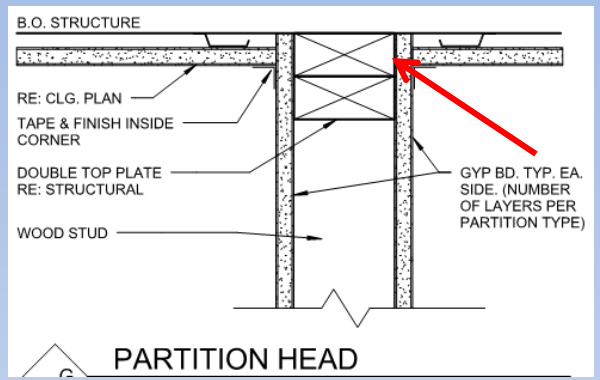
Typical Design Issues & Omissions

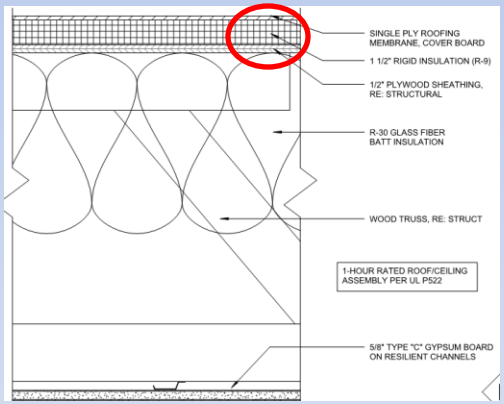
- Air barrier limits and area not on drawings
- Properly locating the air barrier limits
- Insufficient information in specifications or drawings
- Critical detailing areas
- Missing & impractical details (Constructability/Construction Sequencing)
- **DOR omitted from any responsibility on MF Testing Protocol.**

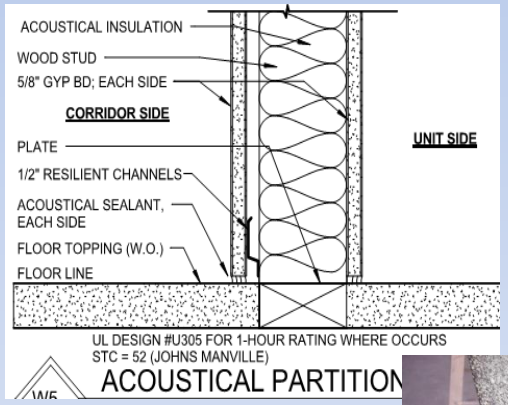
Detailing Common Walls

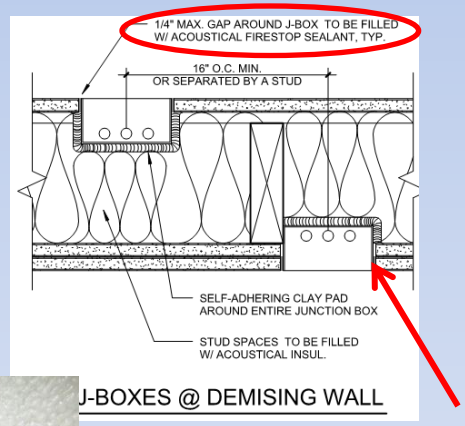


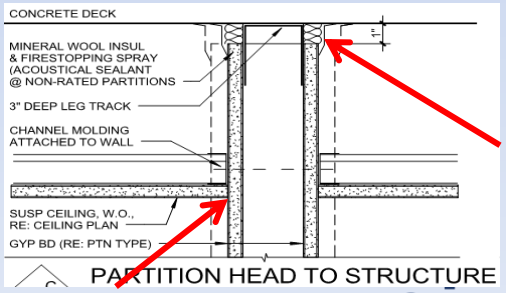












Unit Pathways – Metal Framed & Concrete Decks

- Top Wall Plates at Attic Interfaces
- Discontinuities at Common Walls
- Deck Flutes?
- Through-Floor Penetrations

Unit Pathways – Metal Framed & Concrete Decks

- Wall Penetrations
- Plumbing / Electrical / Mechanical?
- Through-Floor Penetrations

Unit Pathways – Wood Framed & Wood Decks

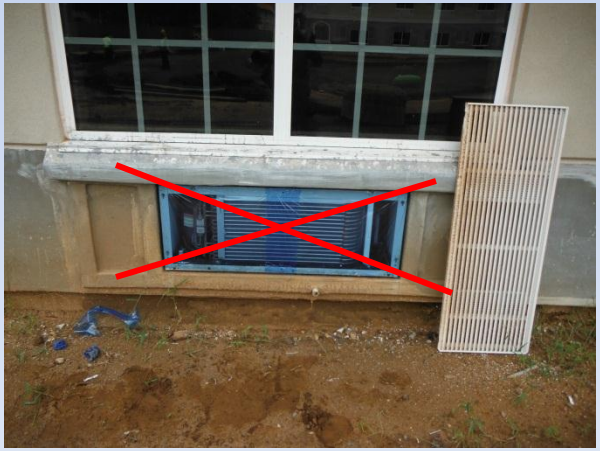
- Vented Attics
- Shed Roofs
- Partition Wall Interface to Attic

Unit Pathways – Wood Framed & Wood Decks

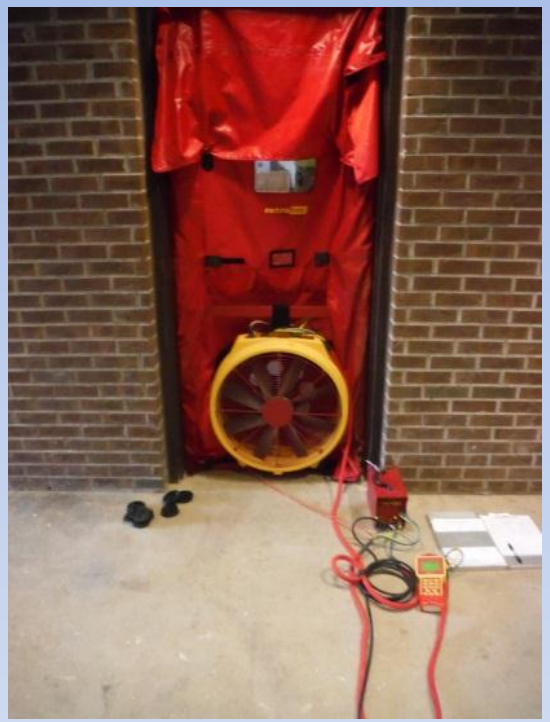
- Cantilevers
- Soffits
- Bottom of Wall

Buildings Tested in “Closed” Condition ASTM E 1827

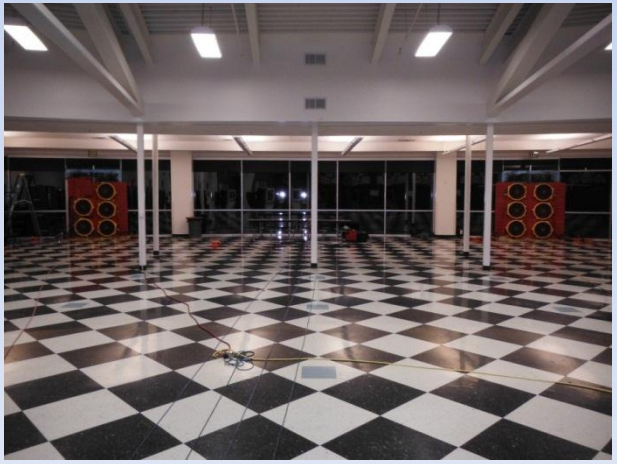
Units Tested in “Closed” Condition Mortgage Industry National HERS Standards, Item 802.2



Air Barrier Testing



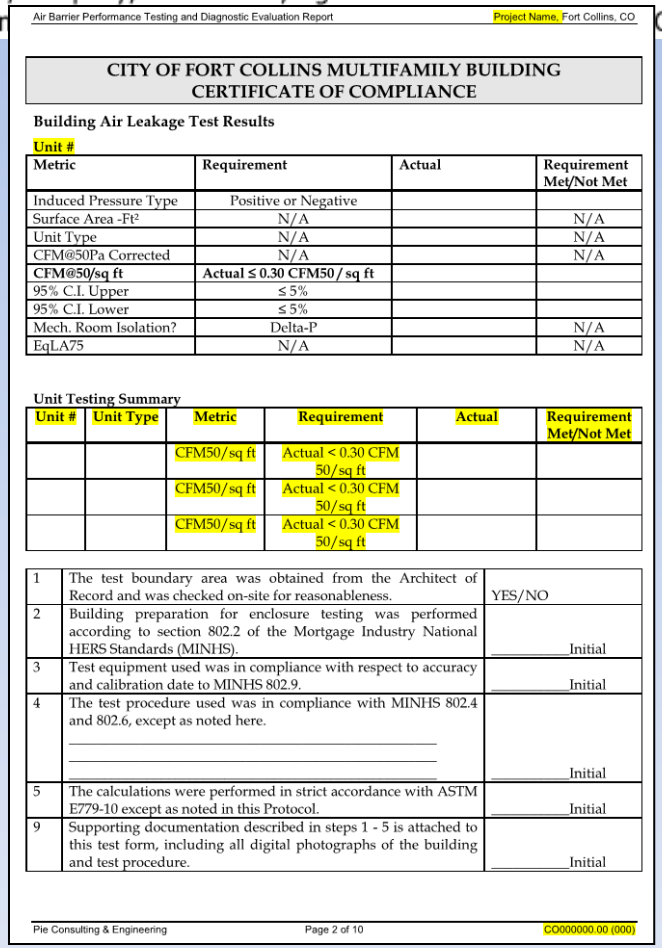
- Testing per Mortgage Industry National HERS Standards, Section 802
- Multipoint recording (8 points between 60Pa – 15Pa) (802.4 & 802.6)
- One direction (positive or negative pressure)
- Software Compliant with ASTM E 779-10, Section 9
- Equipment Calibration (802.9)



Test Data & Reporting

Test Report Submittal Requirement (to the Building Department)

- Building information including address and unit type data: enclosure surface area of each unit type, and the # and type of each unit per building that were tested.
- Testing results summarized in table reporting:
  - Building and unit numbers.
  - Unit results including: corrected CFM50, percent uncertainty at 95% confidence level, CFM50/sf unit enclosure area, mechanical compartment pressure WRT unit core, each test pass/fail result.
- Tester information: name, company, certification, signature and date
- Test reports shall be subm… Occupancy.



Air Barrier Performance Testing and Diagnostic Evaluation Report — Project Name, Fort Collins, CO

CITY OF FORT COLLINS MULTIFAMILY BUILDING CERTIFICATE OF COMPLIANCE

Building Air Leakage Test Results

Unit #

Metric	Requirement	Actual	Requirement Met/Not Met
Induced Pressure Type	Positive or Negative		
Surface Area -Ft²	N/A		N/A
Unit Type	N/A		N/A
CFM@50Pa Corrected	N/A		N/A
CFM@50/sq ft	**Actual ≤ 0.30 CFM50 / sq ft**		
95% C.I. Upper	≤ 5%		
95% C.I. Lower	≤ 5%		
Mech. Room Isolation?	Delta-P		N/A
EqLA75	N/A		N/A

Unit Testing Summary

Unit #	Unit Type	Metric	Requirement	Actual	Requirement Met/Not Met
		CFM50/sq ft	Actual < 0.30 CFM 50/sq ft		
		CFM50/sq ft	Actual < 0.30 CFM 50/sq ft		
		CFM50/sq ft	Actual < 0.30 CFM 50/sq ft		

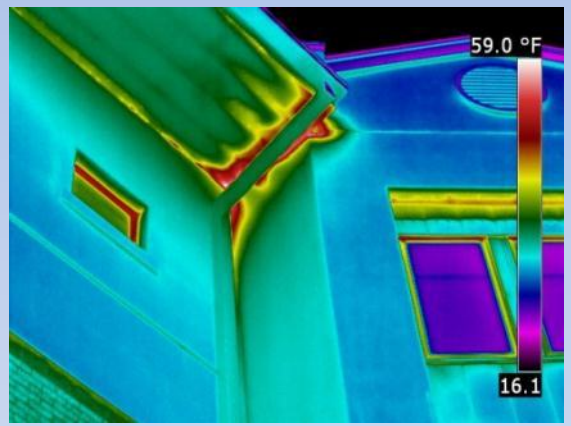
1	The test boundary area was obtained from the Architect of Record and was checked on-site for reasonableness.	YES/NO
2	Building preparation for enclosure testing was performed according to section 802.2 of the Mortgage Industry National HERS Standards (MINHS).	_____Initial
3	Test equipment used was in compliance with respect to accuracy and calibration date to MINHS 802.9.	_____Initial
4	The test procedure used was in compliance with MINHS 802.4 and 802.6, except as noted here. _____ _____ _____	_____Initial
5	The calculations were performed in strict accordance with ASTM E779-10 except as noted in this Protocol.	_____Initial
9	Supporting documentation described in steps 1 - 5 is attached to this test form, including all digital photographs of the building and test procedure.	_____Initial

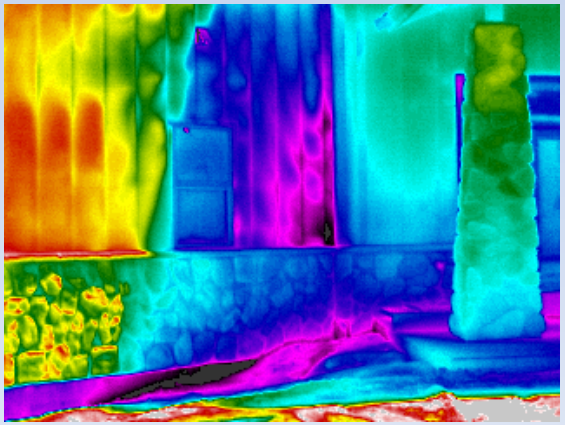
Pie Consulting & Engineering — Page 2 of 10 — CO000000.00 (000)

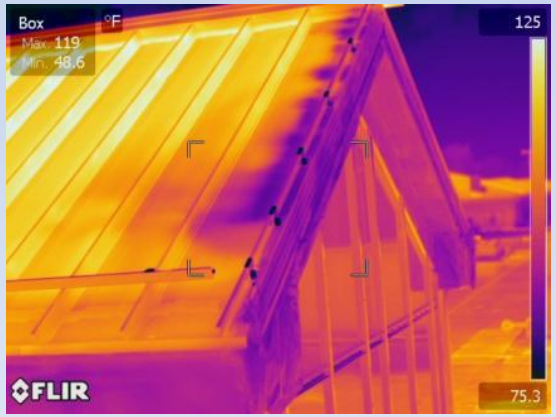
Failure to Plan, is a Plan to …

Air Tightness Testing Diagnostics

- ASTM E1186: Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems







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Question & Answer

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