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BUILDING ENCLOSURE CONFERENCE

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2022

MAY 10-11

Understanding Air Barrier Assembly Testing

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DuPont Performance Building Solutions

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Learning Objectives

1. Understand the standard test methods and specifications referenced in codes.
2. Understand the test method protocols of assembly air leakage assessment.
3. Understand the test method protocols of assembly water resistance assessment.
4. Understand the durability considerations included in assembly air and water test methods.

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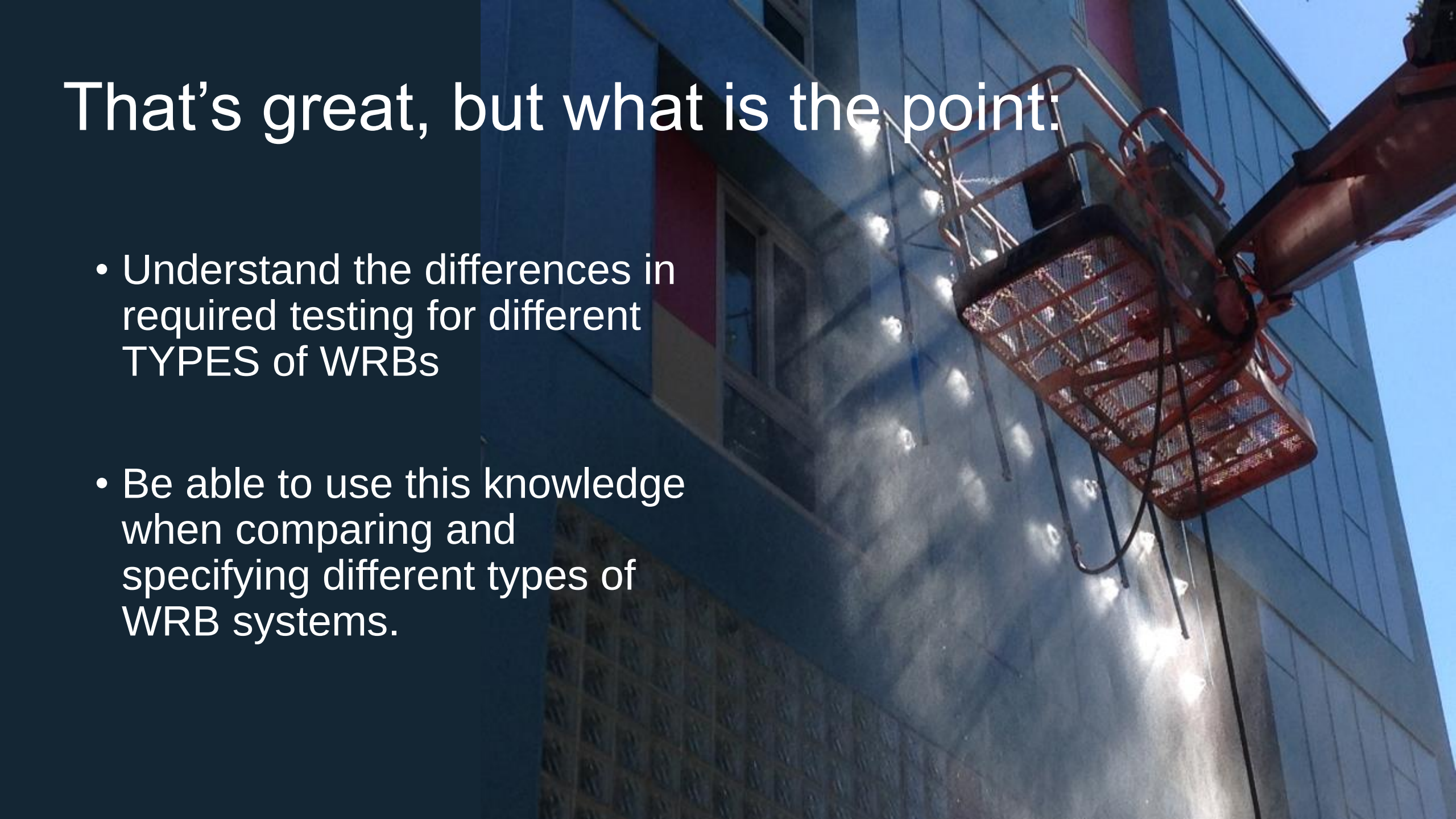
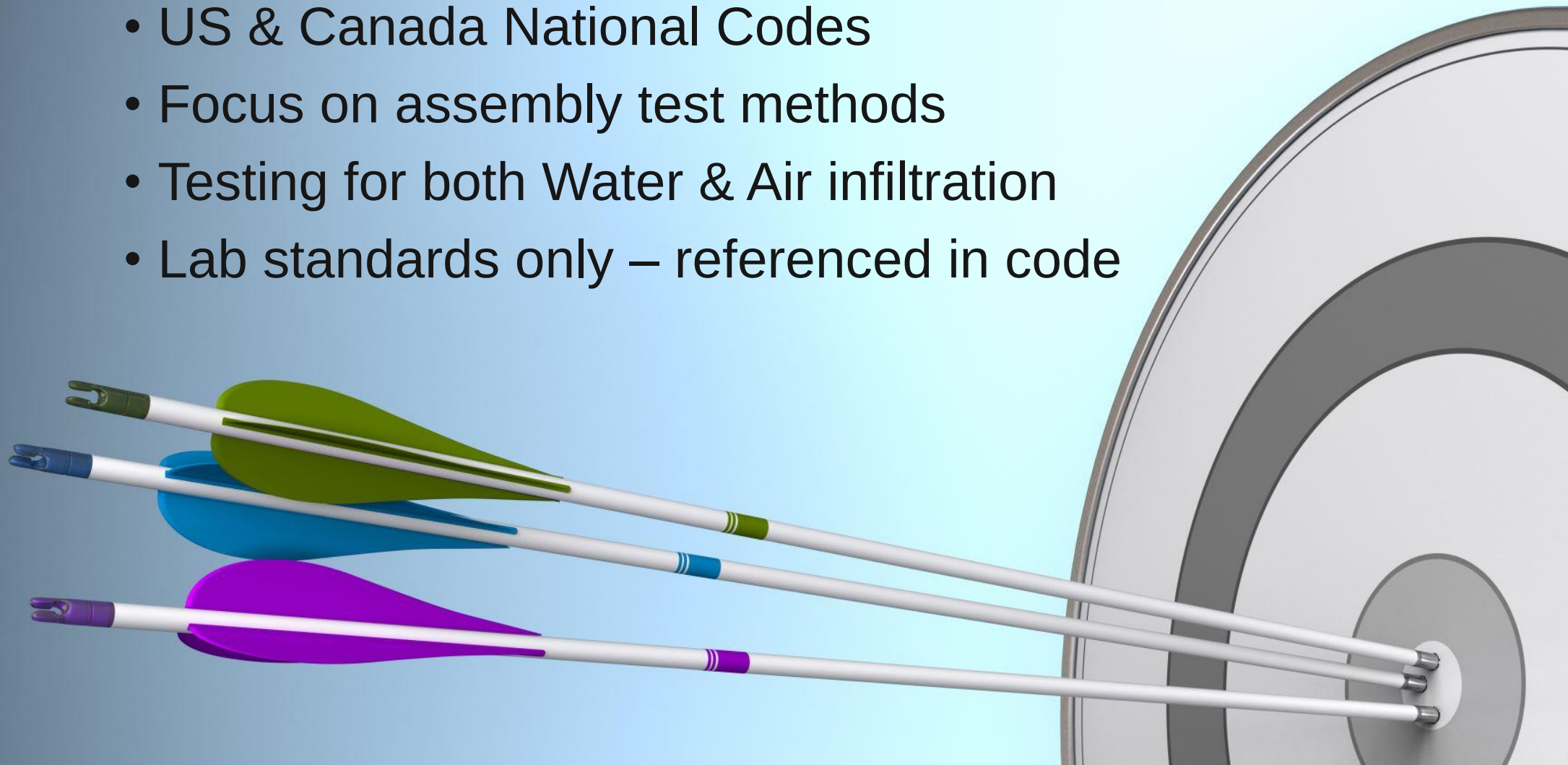
That’s great, but what is the point:

- Understand the differences in required testing for different TYPES of WRBs
- Be able to use this knowledge when comparing and specifying different types of WRB systems.



Scope

- US & Canada National Codes
- Focus on assembly test methods
- Testing for both Water & Air infiltration
- Lab standards only – referenced in code



Air Barriers

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2021 IECC §C402.5.1.2

- **Materials** (ASTM E2178 @ 75 Pa):
  ≤ 0.004 CFM / ft^2 of wall

- **Assemblies:**
  ≤ 0.04 CFM / ft^2 of wall

- **Whole Building** (ASTM E779 @ 75 Pa):
  0.25 – 0.4 CFM/ft^2

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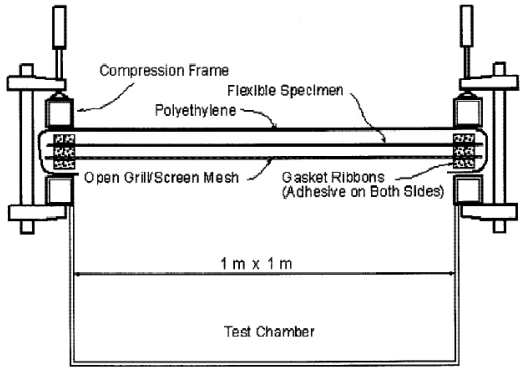
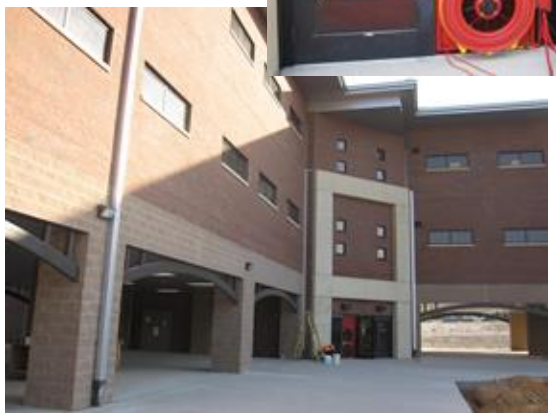
Air Barrier Testing

Material
ASTM E2178



Assembly
ASTM E2357

Whole Building
ASTM E779

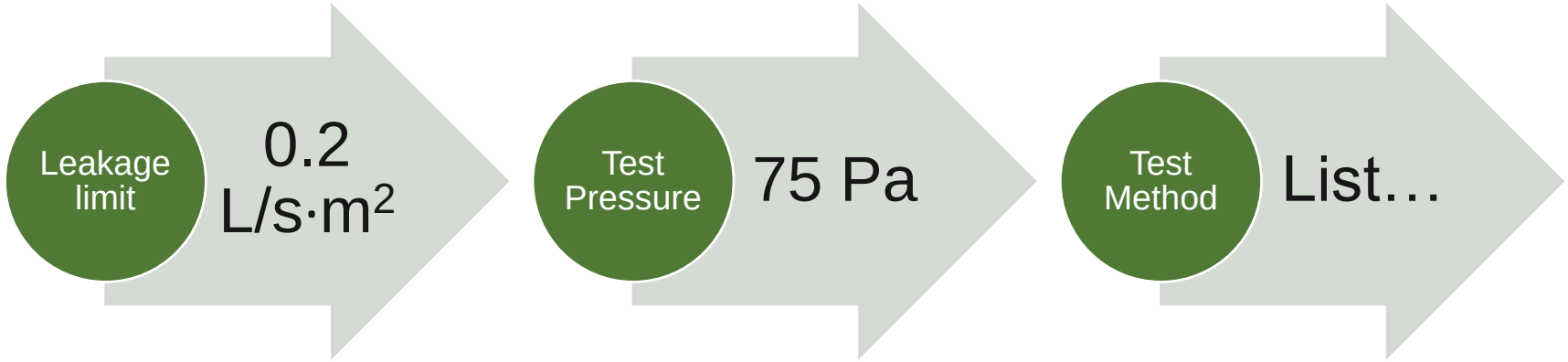


IECC Chapter 4 (2021)

C402.5.1.4 – Assemblies of materials and components with an average air leakage not greater than **0.04 cfm/ft² (0.2 L/s·m²)**

under a pressure differential of **0.3 in. of water gauge (w.g.) (75 Pa)**

when tested in accordance with **ASTM E2357, ASTM E1677, ASTM D8052 or ASTM E283** shall comply with this section.



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Test Method Toolbox

Air infiltration: ASTM E283

Wind Pressure Loading: ASTM E330

ASTM E283 Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Skylights, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

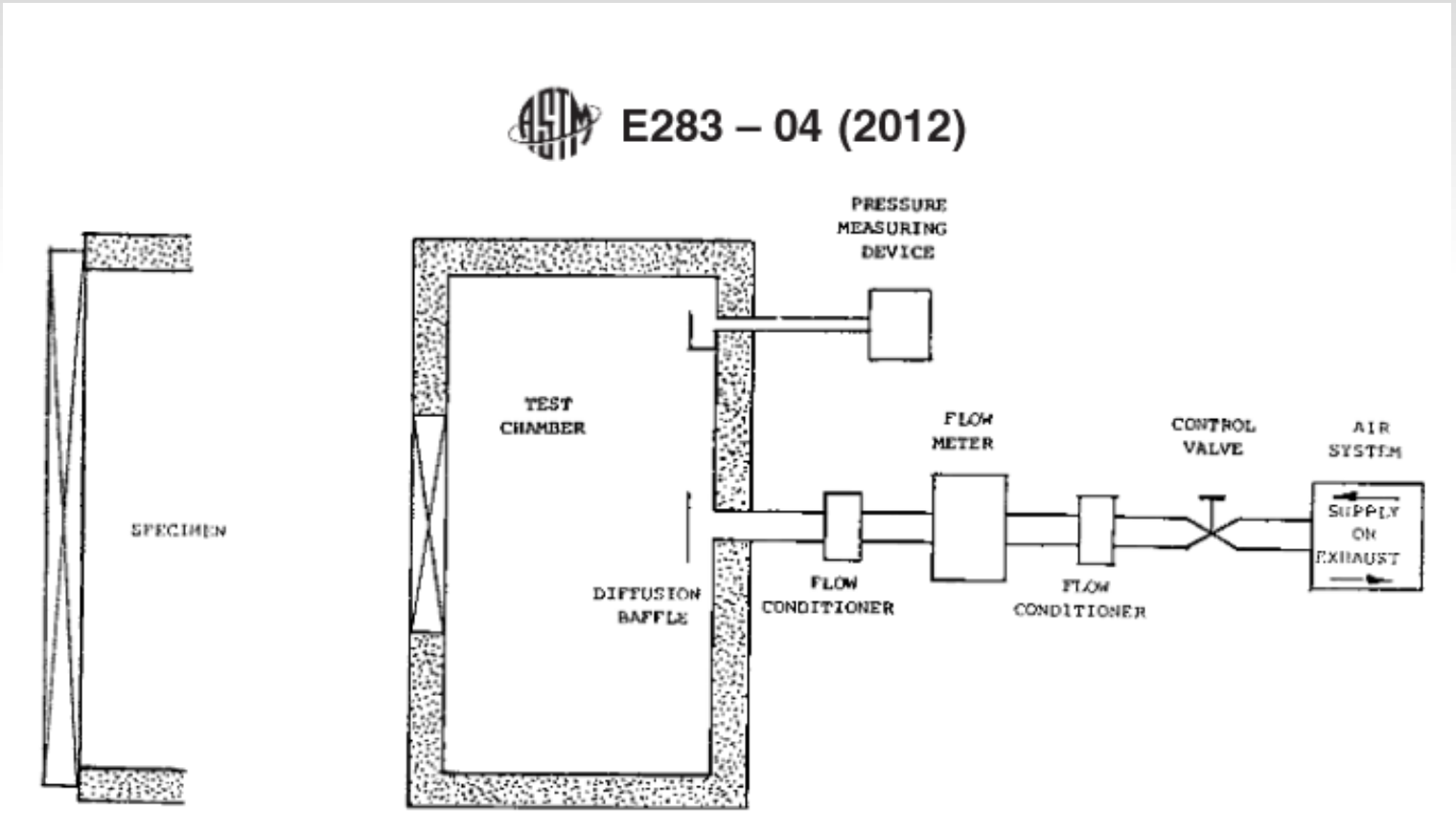

FIG. 1 General Arrangement of the Air Leakage Apparatus

Default pressure called out at 75 Pa (1.56 psf)

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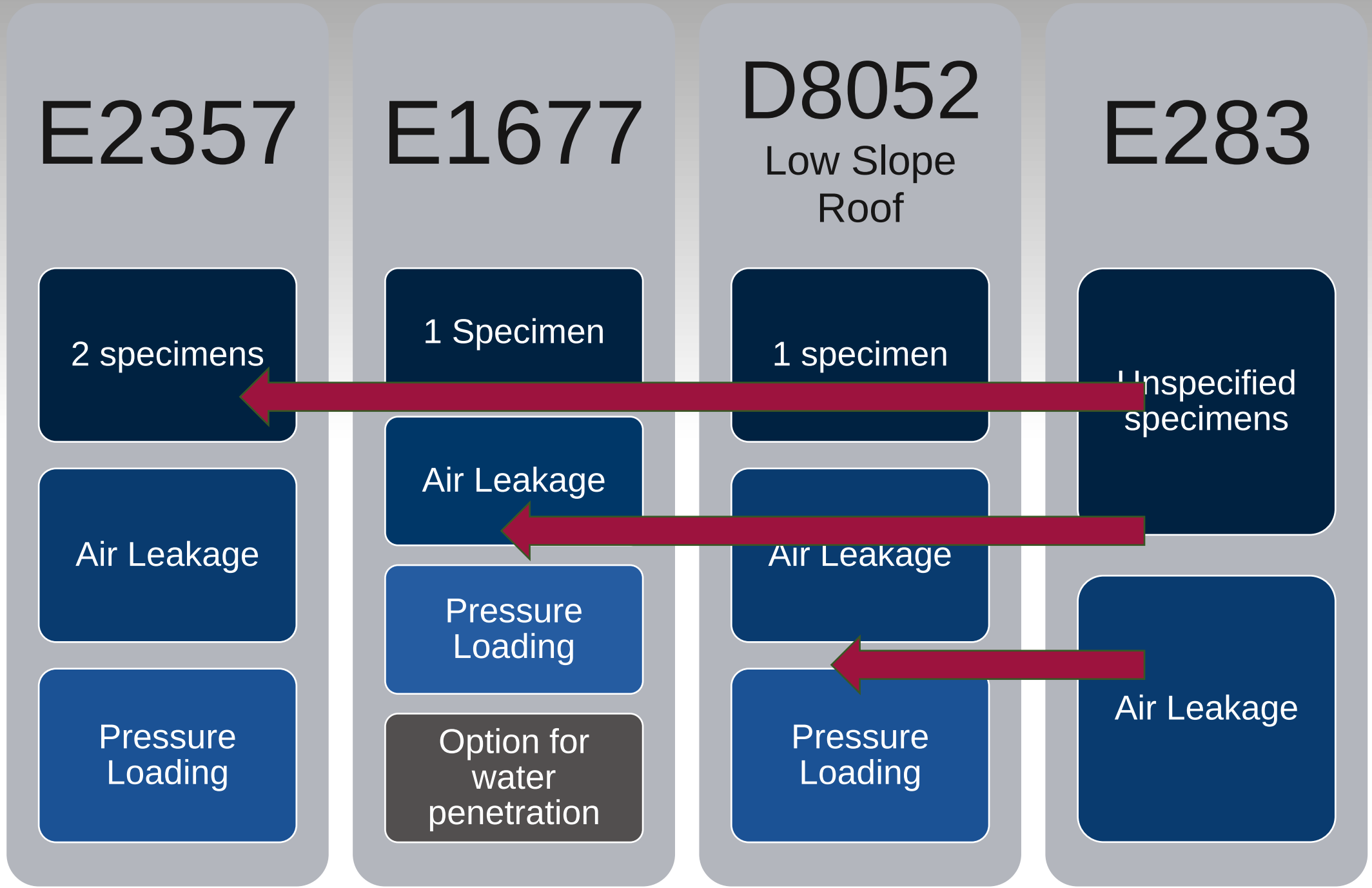
Air Leakage Test Pressures and Pass/Fail Criteria



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ASTM E330 Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference

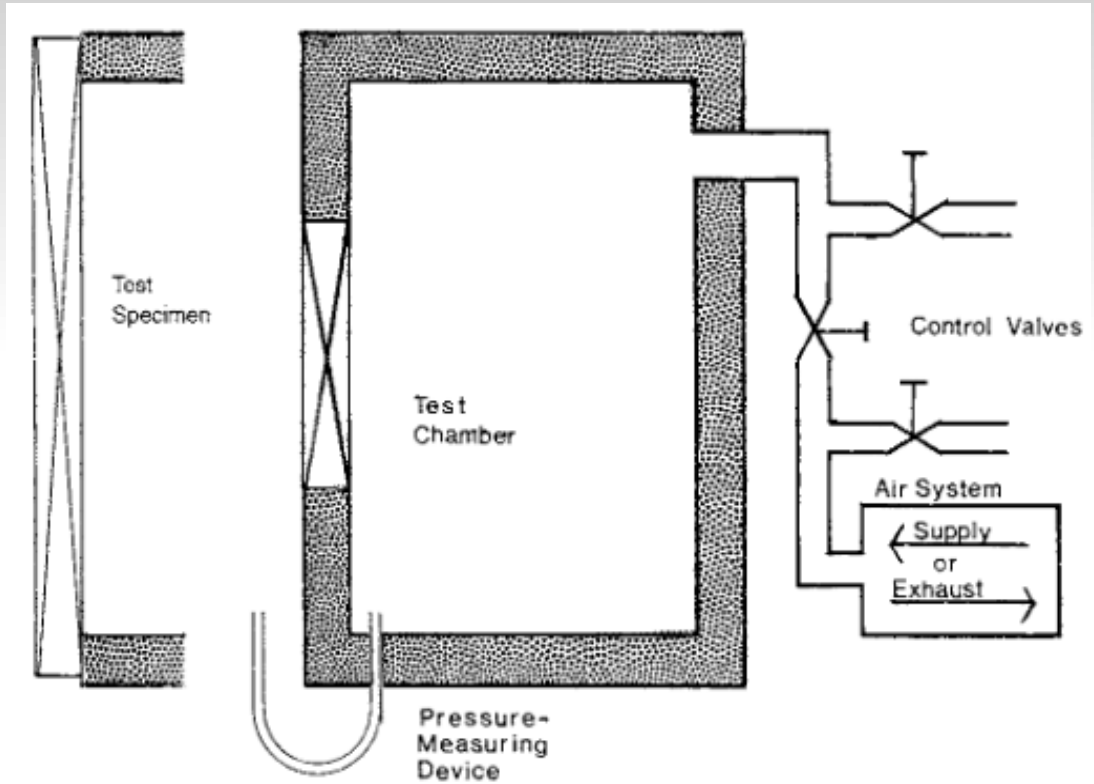

FIG. 1 General Arrangement of Testing Apparatus

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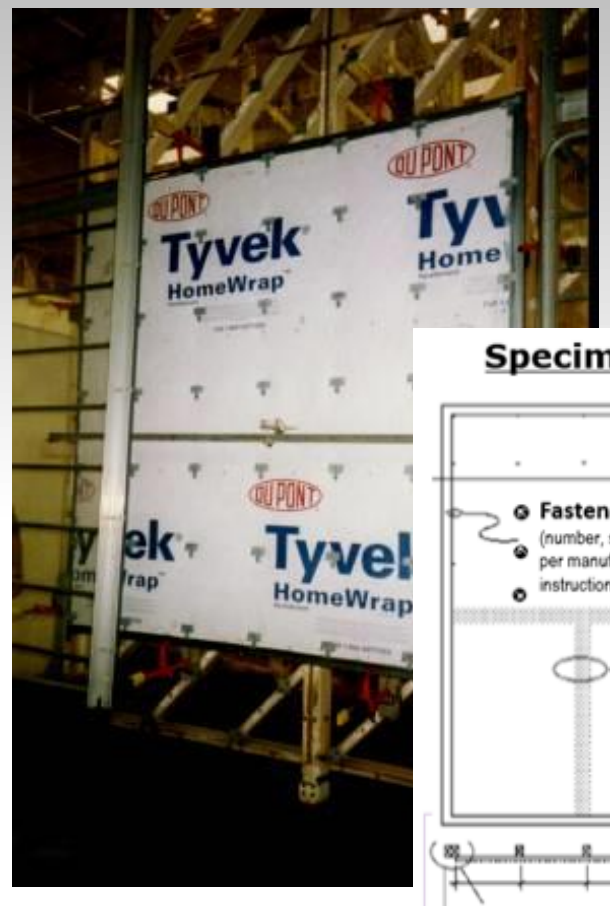
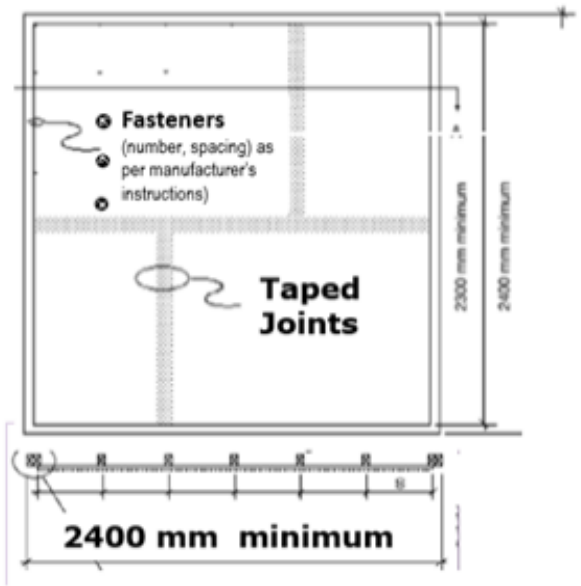
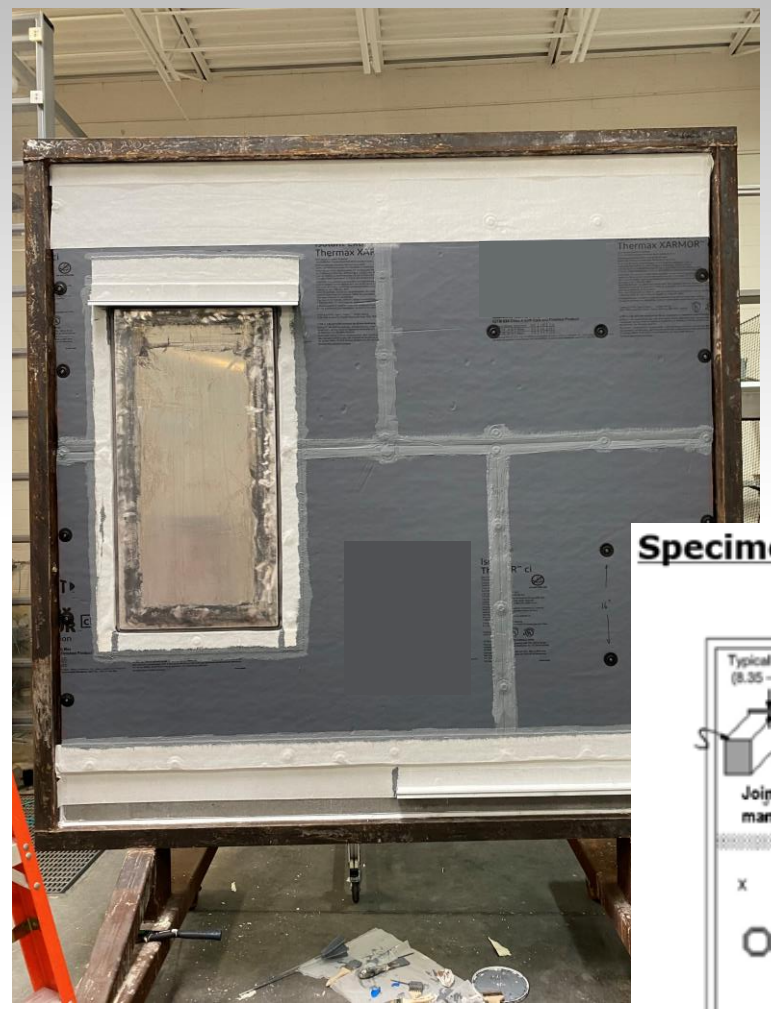
Testing per this method referred to as Wind Pressure Conditioning in E2357 or even Structural Loading

Define the Test Specimen

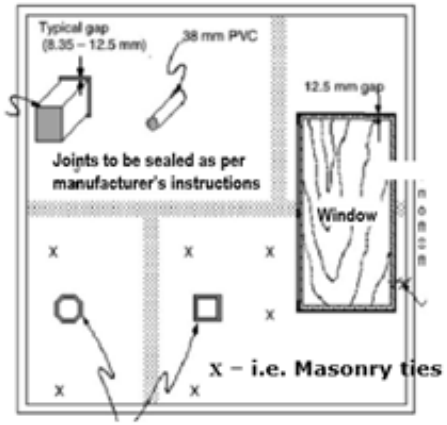


Specimen 1 – Opaque wall





Specimen 2 – Continuity at Penetrations



Hexagonal and rectangular external junction boxes installed in accordance with construction practice

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ASTM E1677: Two Air Barrier Classifications

Standard Specification for Air Barrier (AB) Material or Assemblies for Low-Rise Framed Building Walls

Performance Properties	AB Classifications	
	Type I	**Type II**
Air leakage As tested by E283	**< 0.06 cfm/ft² @ 75 Pa**	
Structural Integrity As tested by E330	**2 in. H_20 or 500 Pa (65 mph) for 1 hr in each direction**	
Water Resistance As tested by E331	No penetration during 15 min. of simulated wind driven rain at 0.11 H2) or 27 Pa (15 mph)	Not required
Water Vapor Permeance As tested by E96A	**Measured**	

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ASTM E1677 vs. ASTM E2357

	ASTM E1677-19	ASTM E2357-18
Number of Test Specimen and configuration	One Specimen: Opaque Wall (8 x 8-ft walls) (fasteners to simulate wood siding or brick ties required)	Test two of the three Specimens (8 x 8 -ft walls): 1 – Opaque Wall 2 – Wall with penetrations 3 – Wall-Foundation Interface
Conditions for Air Leakage Testing	**<u>Five Test Pressures:</u>** • 75Pa (1.56 psf, 25 mph) • two pressures below 75 Pa • two pressures above 75 Pa Air leakage results are reported at 75Pa ***(Positive & negative pressures)***	**<u>Seven Test Pressures:</u>** +/- 25Pa (0.56 psf, 15 mph) +/- 50Pa (1.04 psf, 20 mph) +/- 75Pa (1.56 psf, 25 mph) +/- 100Pa (2.09 psf, 30 mph) +/- 150Pa (3.24 psf, 35 mph) +/- 250Pa (5.23 psf, 45 mph) +/- 300Pa (6.24 psf, 50 mph) ***(Positive & negative pressures)***
Pressure Loading Schedule	Sustained loads up to +/- 500 Pa (10.4 psf, 65 mph) ***(Positive & negative pressures)***	1 - Sustained, +/- 600Pa (12.5 psf, 71 mph) 2 - Cyclic, +/- 800 Pa (16.7 psf, 82 mph) 3 - Gust, +/- 1200 (25 psf, 100 mph) ***(Positive & negative pressures)***

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2015 Canadian NBC Part 5, section 5.4*

5.4.1.2. Air Barrier System Properties

…

3) The air barrier system shall be continuous
   a) across construction, control and expansion joints,
   b) across junctions between different building assemblies, and
   c) around penetrations through the building assembly

4) The structural design of air barrier systems installed in assemblies subject to air pressure loads shall comply with Article 5.1.4.1 and Subsection 5.2.2.

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*Updates coming in next version will change requirements to call out specific testing per CAN/ULC-S742 or whole building testing

CAN/ULC-S742 Loading Table

TABLE 1
SUSTAINED (P_1), CYCLIC (P_2) AND GUST (P_3) WIND PRESSURE DIFFFERENCES
(Reference: Clause 6.3.3.3)

Maximum Building Height above grade (H), m	Sustained 1 in 50 hourly wind pressure differences (P_1), Pa					
	450	550	650	750	850	1000
12	P_2 660 P_3 980	P_2 800 P_3 1200	P_2 950 P_3 1410	P_2 1090 P_3 1630	P_2 1240 P_3 1850	P_2 1460 P_3 2180
20	P_2 720 P_3 1080	P_2 880 P_3 1320	P_2 1050 P_3 1570	P_2 1210 P_3 1810	P_2 1370 P_3 2050	P_2 1610 P_3 2410
40	P_2 1340 P_3 2000	P_2 1630 P_3 2440	P_2 1930 P_3 2880	P_2 2220 P_3 3320	P_2 2520 P_3 3770	P_2 2970 P_3 4430
60	P_2 1440 P_3 2160	P_2 1770 P_3 2640	P_2 2090 P_3 3120	P_2 2420 P_3 3610	P_2 2740 P_3 4090	P_2 3220 P_3 4810
80	P_2 1530 P_3 2290	P_2 1870 P_3 2800	P_2 2220 P_3 3310	P_2 2560 P_3 3820	P_2 2900 P_3 4330	P_2 3410 P_3 5090
100	P_2 1610 P_3 2400	P_2 1960 P_3 2930	P_2 2320 P_3 3460	P_2 2670 P_3 3990	P_2 3030 P_3 4530	P_2 3560 P_3 5320
120	P_2 1630 P_3 2480	P_2 2030 P_3 3040	P_2 2400 P_3 3590	P_2 2770 P_3 4140	P_2 3450 P_3 4700	P_2 3700 P_3 5520

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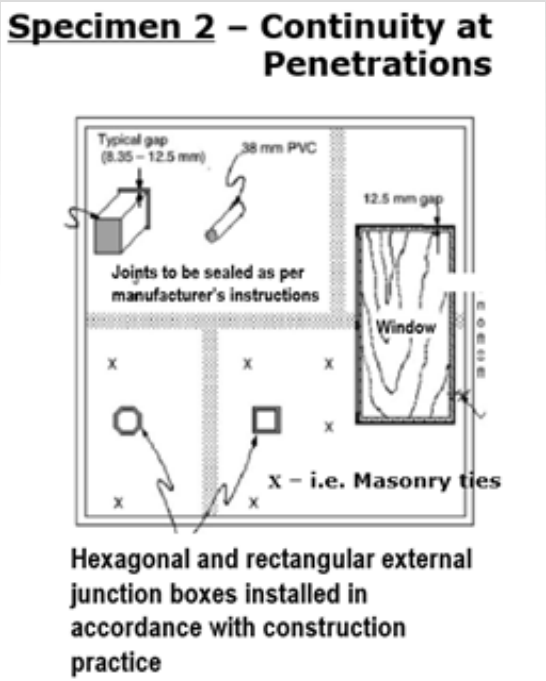
CAN/ULC-S742 Standard for Air Barrier Assemblies - Specification

Test Specimens prepared in accordance with ASTM E2357



- ASTM E283 at 5 pressures
- 0.05 to 0.2 L/s·m^2 @ 75 Pa

Air Leakage Rate

Wind Pressure Loading

- ASTM E330
- Pressures defined in standard

- ASTM E283 (ambient)
- ASTM E1424 (cold)

Air Leakage Rate

Water-Resistive Barriers

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Water Barrier Code Requirements – IBC 2021

1403.2 Water-resistive barrier

Not fewer than one layer of water-resistive barrier material shall be attached to the studs or sheathing, with flashing as described in Section 1404.4, in such a manner as to provide a continuous water-resistive barrier behind the exterior wall veneer.

Water-resistive barriers shall comply with one of the following:

1. No. 15 felt complying with ASTM D226, Type 1
2. ASTM E2556, Type I or II
3. ASTM E331 in accordance with Section 1402.2
4. Other approved materials installed in accordance with the manufacturer's installation instructions

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ASTM E2556 – Type I and II

Standard Specification for Vapor Permeable Flexible Sheet Water-Resistive Barriers Intended for Mechanical Attachment

Performance Properties	Minimum Performance Requirements	
	Type I	**Type II**
Water Resistance As tested by (a) D779, (b) Water Resistance Ponding Test or (c) AATCC 127	(a) 10 min. minimum. (b) No water penetrate membrane in 120 mins	(a) 60 min. minimum (b) n/a (c) No leakage at 55 cm after 5 hours
Water Vapor Permeance As tested by E96A	290 ng/(Pa·s·m^2) (5 perms) minimum	

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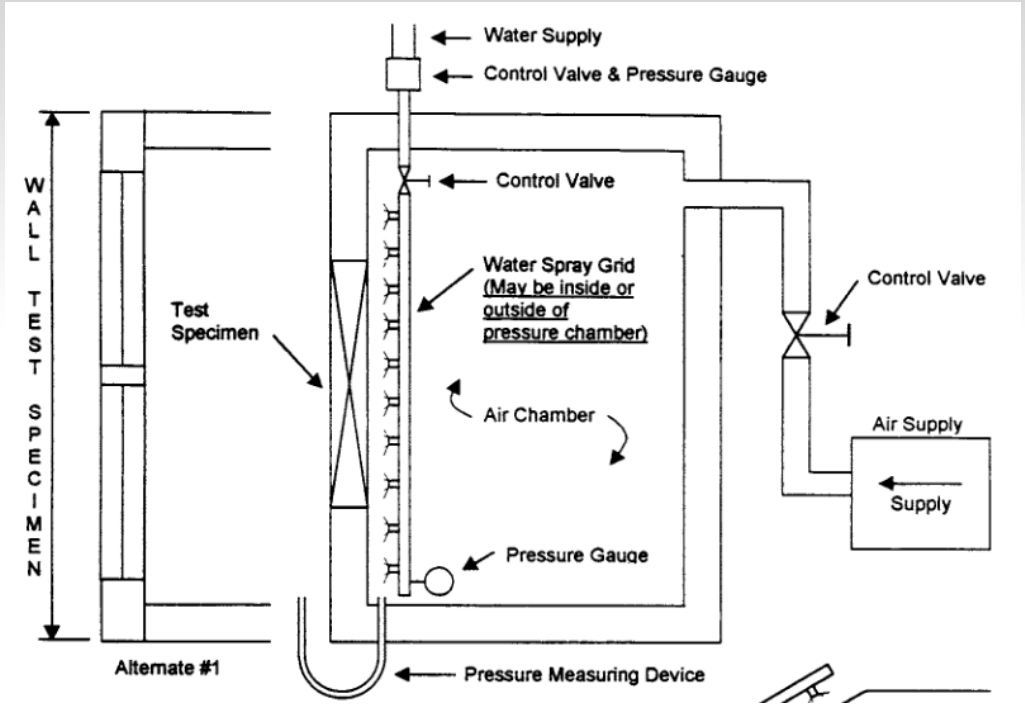
Test Method Toolbox

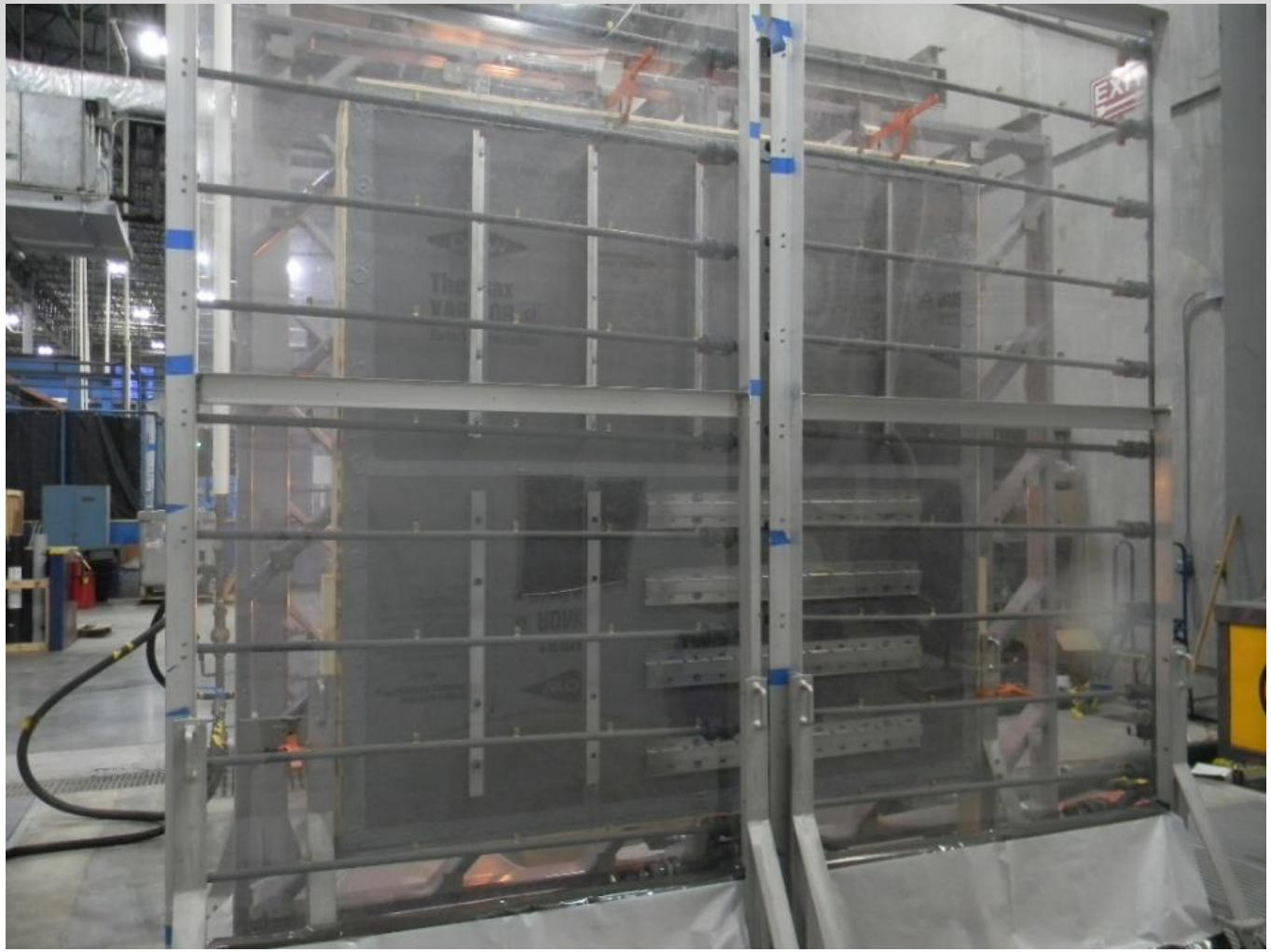
Air infiltration: ASTM E283

Water Penetration: ASTM E331

Wind Pressure Loading: ASTM E330

ASTM E331 Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference





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ICC Acceptance Criteria

- An optional way to verify that new and innovative building products comply with code requirements
- Require the use of third-party testing on properties covered by the report
- Different acceptance criteria for different products

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Common WRB Acceptance Criteria

- **AC 38** Acceptance Criteria for Water-Resistive Barriers
- **AC 71** Acceptance Criteria for Foam Plastic Sheathing Panels Used as Weather-Resistive Barriers
- **AC 212** Acceptance Criteria for Water-Resistive Coatings Used as Water-Resistive Barriers over Exterior Sheathing
- **AC 310** Acceptance Criteria for Water-Resistive Membranes Factory-Bonded to Wood-Based Structural Sheathing, Used as Water-Resistive Barriers
- **AC 382** Acceptance Criteria for Laminated Fibrous Board Sheathing Material Used as a Water-Resistive Barrier

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AC Criteria WRB Testing Comparison

AC Criteria	Applies to	Water Penetration Test Method	Conditioning
AC 38	Felt, mechanically fastened, self-adhering	No assembly testing for water	Limited to Type VB constructions and dwellings built under the IBC
AC 71	Foam Plastic Sheathing	E331	• None on assembly, only on small samples
AC 212	Coatings over Exterior Sheathing	E331	• Transverse loading per ASTM E1233 Proc. A • Racking per E72 • Restrained environmental cycling
AC 310	Membranes Factory-bonded to Wood-based Structural Sheathing	E331	• Transverse loading per ASTM E1233 Proc. A • Racking per E72 • Restrained environmental cycling
AC 382	Laminated Fibrous Board Sheathing	E331	• Transverse loading per ASTM E1233 Proc. A • Racking per E72 • Restrained environmental cycling

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Test Method Toolbox

Air infiltration: ASTM E283

Water Penetration: ASTM E331

Wind Pressure Loading: ASTM E330

Conditioning Testing

- **Racking: ASTM E72**
- **Transverse Loading: ASTM E1233**
- **Thermal Cycling: ASTM E2264 (Method A)**

Conditioning & Durability Considerations

Structural Racking (ASTM E72)

Standard Test Methods of Conducting Strength Tests of Panels for Building Construction

½ inch net deflection without hold-downs or 1/8-inch net defelction with hold downs

Transverse Loading (ASTM E1233)

Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Cyclic Air Pressure Differential

Specified deflection in accordance with code Table 1604.3 Deflection Limits (ranges from 1/360 to 1/120 for exterior walls)

Thermal Cycling (ASTM E2264)

Standard Practice for Determining the Effects of Temperature Cycling on Fenestration Products

Method A, Level 1 calls for durability cycles ranging from 0F to 150F.

AC Criteria WRB Testing Comparison

AC Criteria	Applies to	Water Penetration Test Method	Test Criteria	Conditioning
AC 38	Felt, mechanically fastened, self-adhering	No assembly testing for water		
AC 71	Foam Plastic Sheathing	E331	6.24 psf (0.297 kN/m2) for 2 hours	• None on assembly, only on small samples
AC 212	Coatings over Exterior Sheathing	E331	2.86 psf (127 Pa) for 15 minutes	• Transverse loading per ASTM E1233 Proc. A • Racking per E72 • Restrained environmental cycling
AC 310	Membranes Factory-bonded to Wood-based Structural Sheathing	E331	2.86 psf (127 Pa) for 15 minutes	• Transverse loading per ASTM E1233 Proc. A • Racking per E72 • Restrained environmental cycling
AC 382	Laminated Fibrous Board Sheathing	E331	2.86 psf (127 Pa) for 15 minutes	• Transverse loading per ASTM E1233 Proc. A • Racking per E72 • Restrained environmental cycling

Example: AC 212

ASTM E331
- Water infiltration under negative pressure
- 137 Pa (2.86 psf) for 15 mins

→

ASTM E1233 Procedure A
- Transverse Loading (structural)

→

ASTM E72
- Racking
- ½ inch net deflection without hold-downs

↓

Restrained Environmental Cycling
- 5 cycles of:
- Water spray 24 hours
- Radiant heat 24 hours

→

ASTM E331
- Water infiltration under negative pressure
- 137 Pa (2.86 psf) for 15 mins

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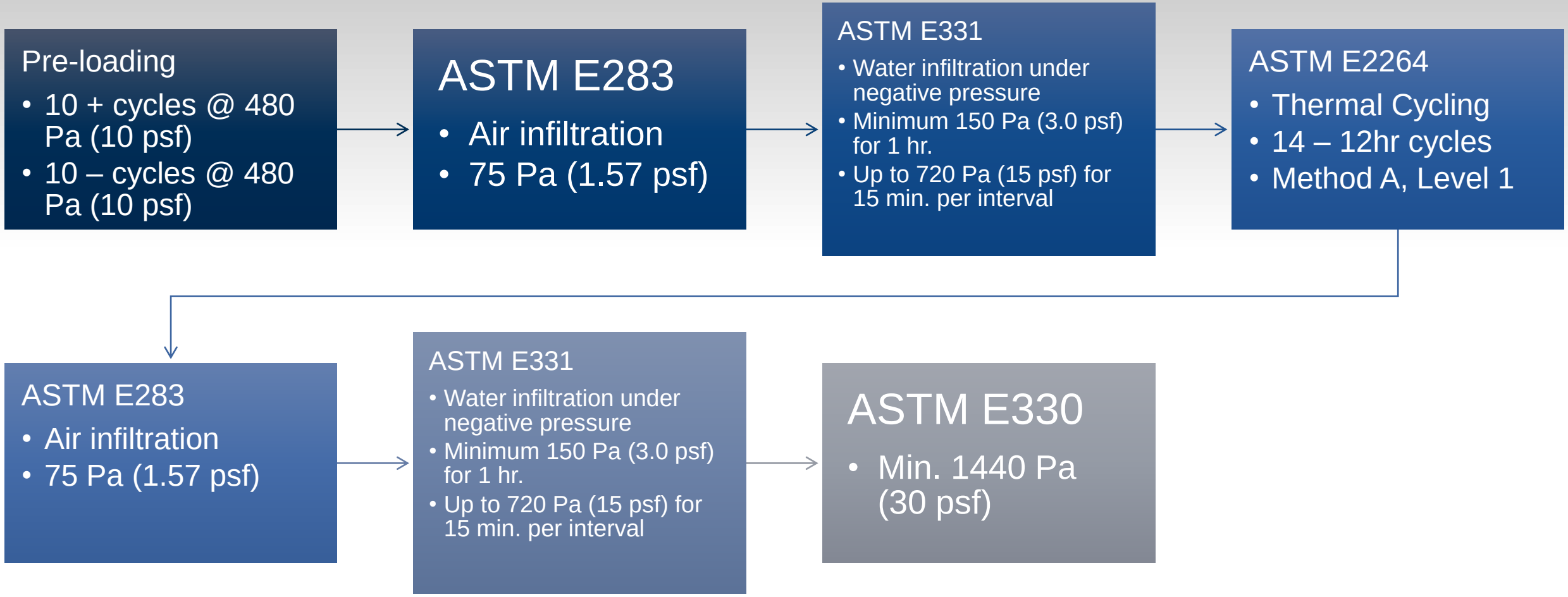
Example: AAMA 504



Example: Combining Air and Water-Resistive Barrier Testing Together

ASTM E283
- Air infiltration
- Pressures up to 300 Pa (6.24 psf)

ASTM E331
- Water infiltration under negative pressure
- 300 Pa (6.24 psf) for 2 hrs.
- Up to 720 Pa (15 psf) for 15 min. per interval

ASTM E2357
- Wind pressure conditioning
- Also referred to as structural cycling

ASTM E283 & E331
- Repeat air and water infiltration testing
- Only hold each water pressure for 15 minutes

ASTM E2264
- Thermal Cycling
- Method A, Level 2

ASTM E283 & E331
- Repeat air and water infiltration testing
- Only hold each water pressure for 15 minutes

ABAA and Codes

- Adding air barriers to the IBC and IRC in addition to just the IECC
- Increasing use of whole building testing and decreasing air leakage measurement level requirements
- Working with local and state codes in additional to the national codes
- Increasing requirements found in ASHRAE 90.1 and 189.1 which are then adopted into the code language

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Conclusions

- Air and Water-Resistive Barriers are all tested differently depending on material type and what standards they claim to meet
- Understanding what to expect of a tested material is important
- It is important to add conditioning and durability testing to the same assembly that is tested for air and water to better understand long-term performance.

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