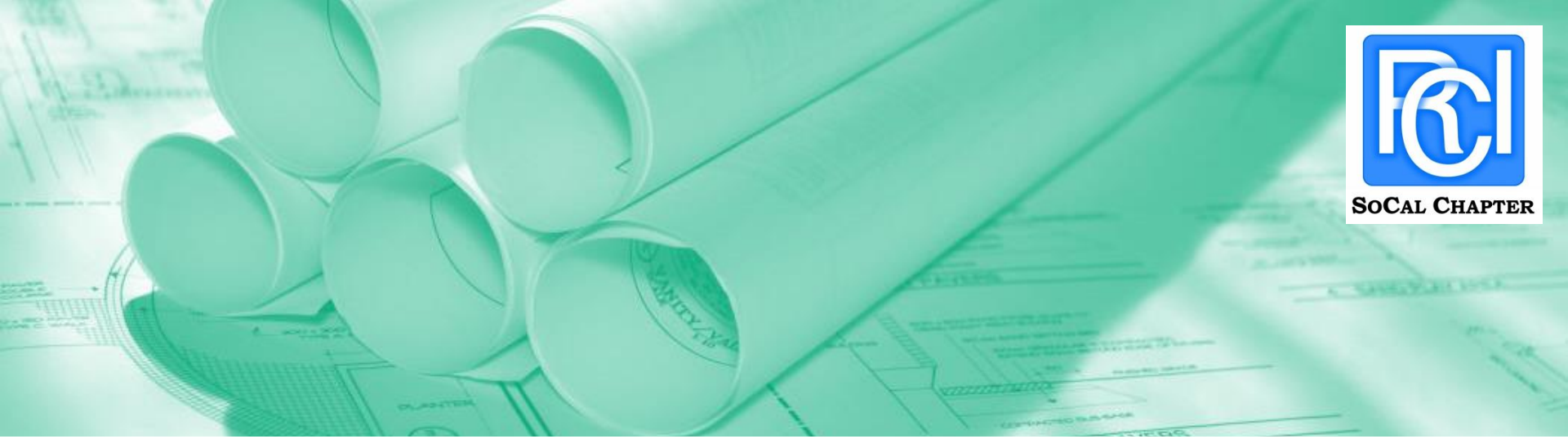

SoCal Chapter

Air Barrier Assemblies and Continuous Insulation

Presented by:
Karim Allana, P.E.
Allana Buick & Bers, Inc.

January 26 & 27, 2015

15th Annual Hawaii Winter Workshop
Roofing, Waterproofing, and Exterior Walls
Westin Maui Resort and Spa Ka'napali, HI

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Making Buildings Perform Better

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Best Practice

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SoCal Chapter

Karim P. Allana, PE, RRC, RWC

- **Education:** B.S., Civil Engineering, Santa Clara University
- **Registration:** P.E., Civil Engineering, California, Washington, Nevada, and Hawaii
- **Certification:** Registered Roof Consultant (RRC), Roof Consultants Institute, and Registered Waterproofing Consultant (RWC)
- **Overview:**
  - CEO and Senior Principal at Allana Buick & Bers.
  - Former Turner Construction Employee (Project Engineering and Superintendent)
  - Over 37 years experience providing superior technical standards in all aspects of building technology and energy efficiency.
  - Principal consultant in forensic investigations of building assemblies, failure analysis, evaluation and design of building infrastructure and building envelope evaluation and design.
  - Expert in all aspects of building envelope technology.
  - Completed numerous new construction, addition, rehabilitation, remodel and modernization projects for public and private sector clients.
  - Specialization in siding, roofing, cement plaster, wood, water intrusion damage, window assemblies, storefronts, below grade waterproofing, energy efficiency, solar engineering and complex building envelope and mechanical assemblies.

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ABBAE Firm Overview

- Allana Buick & Bers (ABBAE) is an Architectural Engineering firm specializing in Building Envelope Systems
- ABBAE is one of the 5 largest building envelope consultants in the country
- ABBAE has over 33 years of experience & over 12,500 projects
- ABBAE is also a leading Forensic Defect firm with hundreds of forensic projects (litigation)
- Locations – 16 offices across California, Nevada, North Carolina, Oklahoma, Oregon, Texas, Virginia, Washington, Colorado and Hawaii

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Staff & In-House Expertise

- Licensed Professional Engineers – Civil, Structural, and Mechanical
- Registered Architects
- Building Enclosure Commissioning Process Providers (BECxPs)
- Registered Building Envelope Consultant (RBEC)
- Registered Roofing Consultants (RRCs)
- Registered Waterproofing Consultants (RWCs)
- Registered Exterior Wall Consultant (REWCs)
- Registered Roof Observers (RROs)
- Certified Exterior Insulation and Finish System (EIFS) inspectors
- Curtain Wall Specialists
- ICC Certified Building Inspectors
- Quality Assurance Monitors
- Water Testing Experts
- Leak Investigation and Diagnosis Experts
- Infrared Imaging and Nuclear Moisture Scanning Experts

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ABBAE Building Expertise

- Building Envelope Systems
  - Roofing Systems
    - High-Slope/Low-Slope Roofs
    - Green/Garden Roofs
    - Drainage Systems
    - Pedestrian Plazas
  - Exterior Wall Systems
    - Wall Cladding/Siding/GFRC/pre-cast
    - EIFS/cement plaster/stucco
    - Sheet Metal Flashings
  - Windows and Glazing Systems
    - Punched Windows
    - Curtain Wall/Window Wall Systems
    - Sliding Glass Doors
    - Skylights
- Building Envelope Systems (cont'd)
  - Roofing & Waterproofing Systems
    - Deck/Balcony/Lanai Waterproofing
    - Podium Waterproofing
    - Pool/Spa Deck Waterproofing
    - Above-Grade/Below-Grade Waterproofing
    - All types of low and steep sloped roofing
  - Commissioning BECx
    - OPR/BOD/Commissioning Plan
- Mechanical/HVAC Systems
  - HVAC design
  - Plumbing systems
  - Commissioning and testing

SoCal Chapter

ABBAE Core Services

- Consulting and third-party peer review services
- Engineer of record for building envelope systems
- Contract administration services
- Inspection services (usually direct with owner)
- Air and water performance testing
- Mock-up design, observation, and testing
- Building assessments and forensic investigations
- Litigation support and expert witness services
- Educational seminars with AIA credits

SoCal Chapter

Today's Objectives

- Discuss Air Barrier Principles
- Review Air Barrier Code Requirements
- Outline Air Barrier Benefits
- Air Barrier Design Considerations
- Why the Need for Continuous Insulation?
- Continuous Insulation Design Considerations

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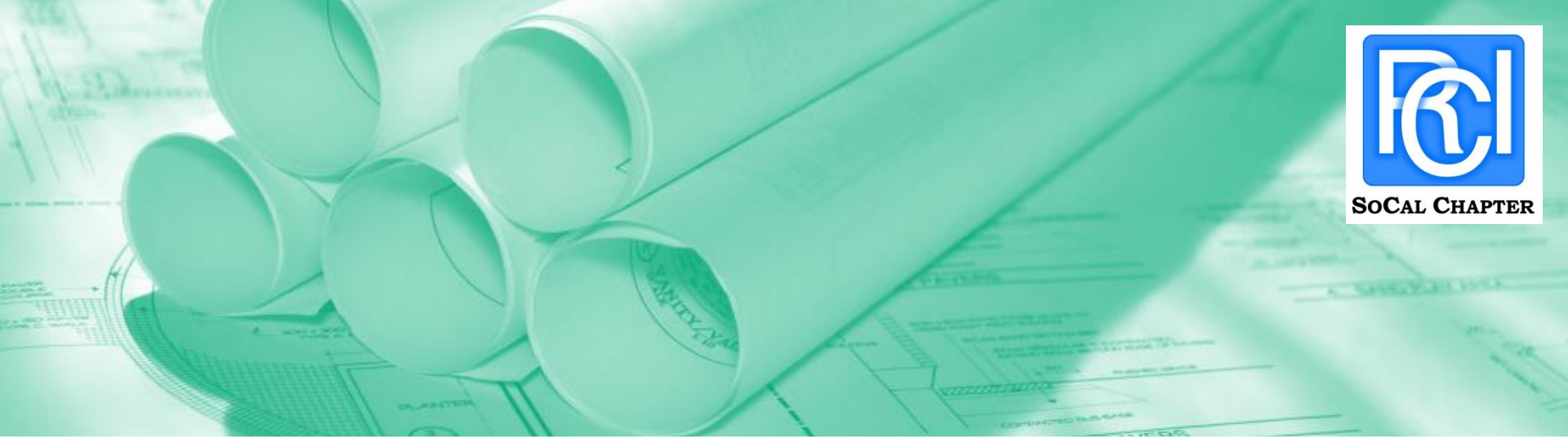

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Air Barrier Principles

Air Barrier Defined

"A combination of interconnected materials and assemblies joined and sealed together to provide a continuous barrier to air leakage through the building envelope that separates conditioned from unconditioned space, or that separates adjoining conditioned spaces of different occupancies or uses."

-2013 CA Title 24 Part 6

"A system of materials combined to form continuous control of the air leakage of a building."

-Air Barrier Association

"Air barriers define the location of the pressure boundary of the building enclosure."

-Joseph Lstiburek

SoCal Chapter

Why is Air Important to Talk About?

Air Infiltration Brings…

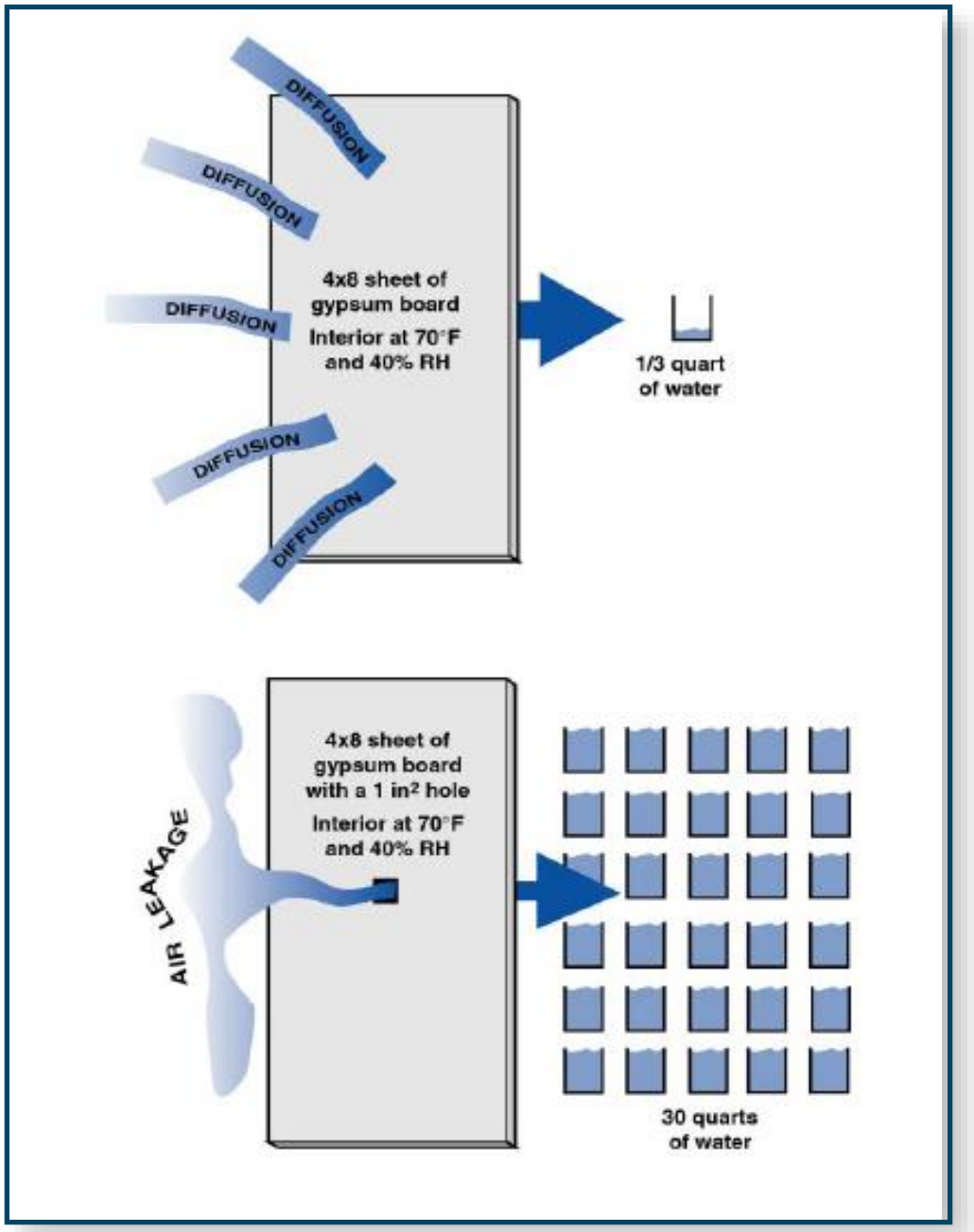
- Water Vapor = Potential Damage
- Heated or Cooled Air = Energy Loss

SoCal Chapter

DIFFUSION

VS.

AIR LEAKAGE



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How Does Air Leakage Occur

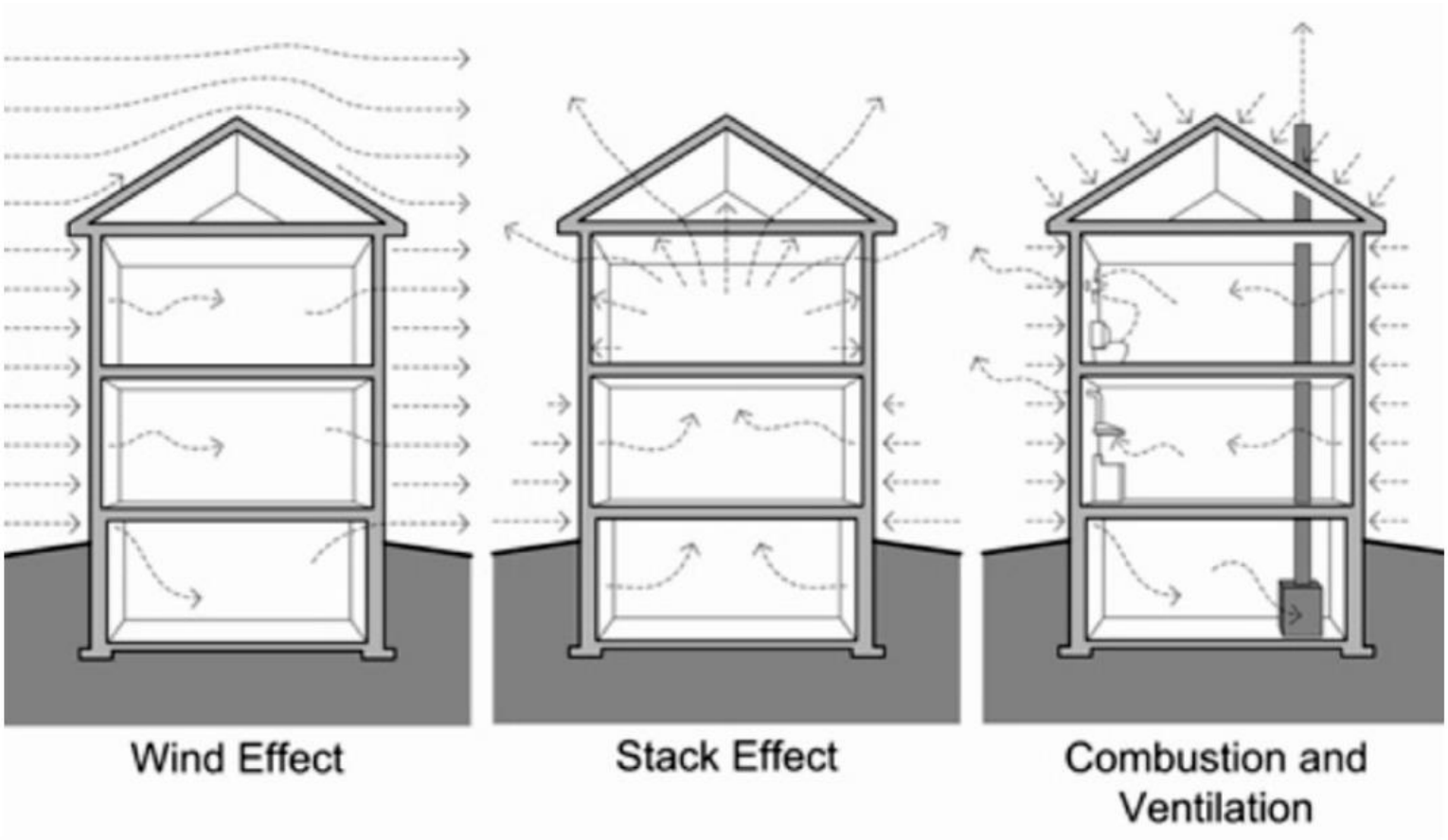


Figure 1: Examples of infiltration. Image courtesy: Building Science Corporation, www.buildingscience.com

SoCal Chapter

Material vs. Assembly vs. System

Air Barrier Material Testing Requirements

ASTM E2178-11 Standard Test Method for *Air Permeance* of Building Materials.

< 0.02 L/(s•m^2) @ 75 Pa (0.004 cfm/ft^2 @ 1.57 lb/ft^2)

Air Barrier Assembly Testing Requirements

ASTM E2357-11 Standard Test Method for Determining *Air Leakage* of Air Barrier Assemblies

<0.2 L/(s•m2) @ 75 Pa (0.04 cfm/ft2 @ 1.57 lb/ft2)

Air permeance is the amount of air/moisture that migrates through a material, whereas…

Air leakage is the air that passes through holes or gaps

SoCal Chapter

Material vs. Assembly vs. System

Air Barrier System Testing Requirements

ASTM E779-10: Standard Test Method for Determining Air Leakage Rate by Fan Pressurization

Title 24, Part 6 - Energy Code Requires

< 0.40 cfm/ft^2 @ 1.57 lb/ft^2

US Army Corps of Engineers Requires

< 0.25 cfm/ft^2 @ 1.57 lb/ft^2

ASTM E1827-11: Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door

ASTM E283-04: Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

****Testing can be done by Unit(s), Floor(s) or Building. If air barrier testing is planned by unit, detailing and continuity needs to be by unit.*

SoCal Chapter

Diagnostic Testing of Air Barriers

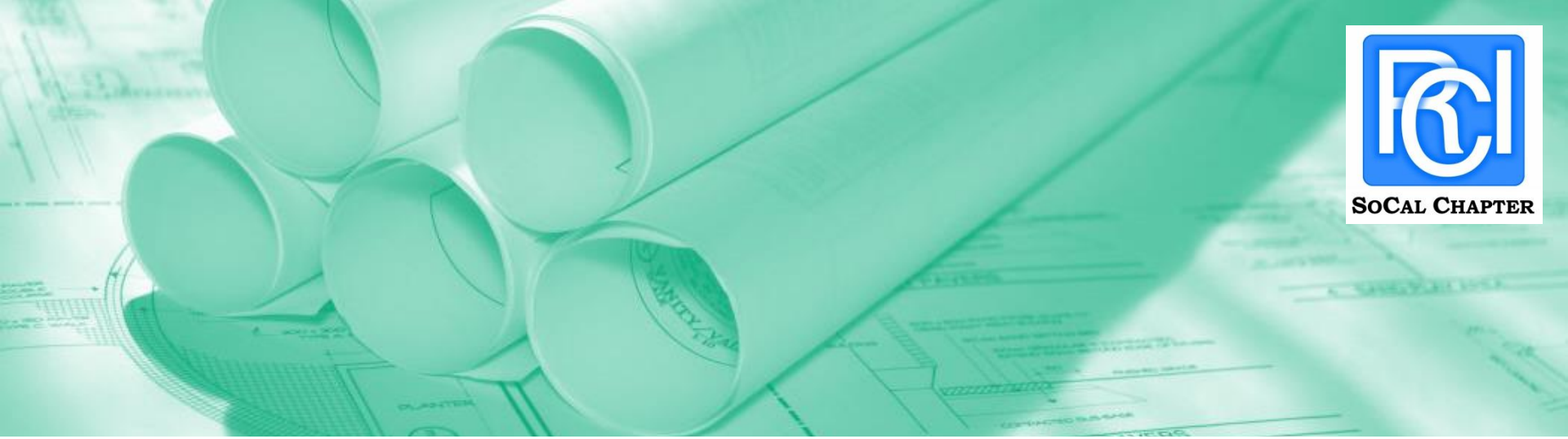
Air Barrier System Diagnostic Testing

- ASTM C1060-11a: Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings

- ASTM E1186-09: Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

Qualitative vs. Quantitative Testing

SoCal Chapter



SoCal Chapter

IECC and CA Title 24 Air Leakage and Air Barrier Requirements

Air Leakage Requirements by Code

Air Barrier Requirements (loosely defined, no testing)

- ✓ *2006 IECC (International Energy Conservation Code)*
- ✓ *2012 California Title 24 – Residential Requirements*
- ✓ *State Energy Code Amendments (Georgia, Minnesota, Rhode Island, California, New York)*

Air Barrier Requirements (defined air leakage, testing)

- ✓ *ASHRAE 90.1-2010 – Reference Code*
- ✓ *2009 IECC*
- ✓ *2012 IECC*
- ✓ *2012 California Title 24 – Commercial Requirements*
- ✓ *2012 IgCC (International Green Construction Code)*

SoCal Chapter

ASHRAE 90.1 - 2010

Building Envelope Requirements – Section 5.4.3.1

Qualitative requirement

> *"The following areas of the building envelope shall be sealed, caulked, gasketed, or weather-stripped to minimize air leakage:*

a. joints around *fenestration* and *door* frames
b. junctions between *walls* and foundations, between *walls* at building corners, between *walls* and structural *floors* or *roofs*, and between *walls* and *roof* or *wall* panels
c. openings at penetrations of utility services through *roofs*, *walls*, and *floors*
d. site-built *fenestration* and *doors*
e. building assemblies used as ducts or plenums
f. joints, seams, and penetrations of vapor retarders
g. all other openings in the *building envelope*

Quantitative requirement: NONE

Testing Requirement: NONE

SoCal Chapter

ASHRAE 90.1 - 2010

<u>Fenestration and Door Requirements – Section 5.4.3.2</u>

Qualitative requirement: NONE

Quantitative requirement:

Shall not exceed 1.0 cfm/ft^2 for glazed swinging doors

Shall not exceed 0.4 cfm/ft^2 for all other fenestration

Testing Requirement:

In accordance with NFRC 400

Exceptions:

Field Fabricated fenestration and doors

Garage Door air leakage can be determined via ANSI/ DASMA 105 as and alternate compliance test method.

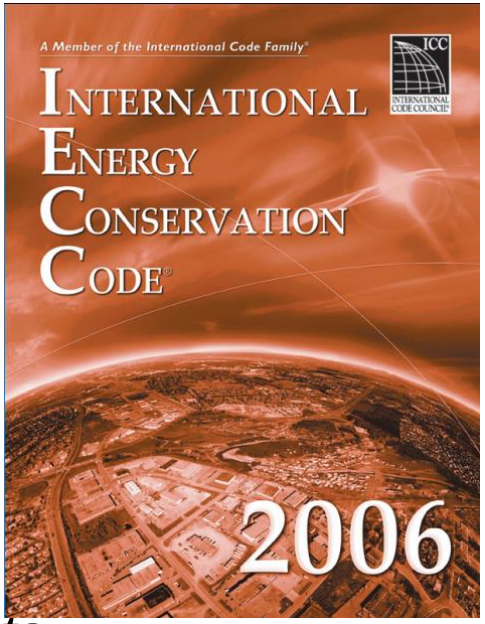
SoCal Chapter

2006 IECC

STATE ADOPTIONS

- ✓ *Alaska, Tennessee*
- ✓ *Maui County**
- ✓ *Honolulu County**
- ✓ *Hawaii County**

**Have independent and separate amendments*



Air Barrier Overall Requirements

1. *Residential vs. Commercial requirements*
2. *General, non-quantative building envelope requirements*
3. *Testing of the building envelope air barrier not required*
4. *Quantified air leakage limitations for fenestration and doors with testing requirements.*
5. *Not climate zone dependent*

SoCal Chapter

2006 IECC

Building Envelope Requirements – 402.4 RESIDENTIAL

Qualitative requirement:

"The building thermal envelope shall be durably sealed to limit infiltration. The sealing methods between dissimilar materials shall allow for differential expansion and contraction. The following shall be caulked, gasketed, weatherstripped or otherwise sealed with an air barrier material, suitable film or solid material:

1. All joints, seams and penetrations.
2. Site-built windows, doors and skylights.
3. Openings between window and door assemblies and their respective jambs and framing.
4. Utility penetrations.
5. Dropped ceilings or chases adjacent to the thermal envelope.
6. Knee walls.
7. Walls and ceilings separating a garage from conditioned spaces.
8. Behind tubs and showers on exterior walls.
9. Common walls between dwelling units.
10. Other sources of infiltration.

Quantitative requirement: I

Testing Requirement: NONE

Exceptions: NONE

SoCal Chapter

Air Leakage Units

Air Changes per Hour: (ACH50)

A measure of the air volume added to or removed from a space (normally a room or house) divided by the volume of the space.

Air Leakage Rate: (Cfm/ft^2 @ 75 Pa; L/s per m^2)

A measure of the air volume that can pass through a specified area at a specified pressure. The area used (building envelope area or effective leakage area) varies by

code.

Building Envelope Area:

A measure of the square footage of the building envelope

Effective Leakage Area:

A measure of the square footage of the pressure boundary.

Pressure Boundary:

The location of the air barrier within the building envelope.

SoCal Chapter

2006 IECC

<u>Fenestration and Door Requirements – 402.4.2 RESIDENTIAL</u>

Qualitative requirement: NONE

Quantitative requirement:

- *Windows, skylights and sliding glass doors shall not exceed 0.3 cfm/ft^2*
- *Swinging doors shall not exceed 0.5 cfm/ft^2*

Testing Requirement:

- *In accordance with NFRC 400*

Exceptions:

- *Site-built windows, skylights and doors*

SoCal Chapter

2006 IECC

Building Envelope Requirements – 502.4.3 COMMERCIAL

Qualitative requirement:

Shall meet ASHRAE 90.1 or according to 502.4.3:

502.4.3 Sealing of the building envelope. Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials spanning joints between construction materials shall allow for expansion and contraction of the construction materials.

Quantitative requirement: NONE

Testing Requirement: NONE

Exceptions: NONE

SoCal Chapter

2006 IECC

Fenestration and Door Requirements – 502.4 COMMERCIAL

Qualitative requirement: NONE

Quantitative requirement:

Same as Residential requirements for windows and doors

Curtain wall, storefront glazing and commercial-glazed swinging entrance doors and revolving doors shall not exceed 0.3 cfm/ft^2 at 75Pa.

Testing Requirement:

In accordance with NFRC 400 for windows and doors

In accordance with ASTM E283 for curtain wall and storefront

Exceptions:

Site-built windows, skylights and doors

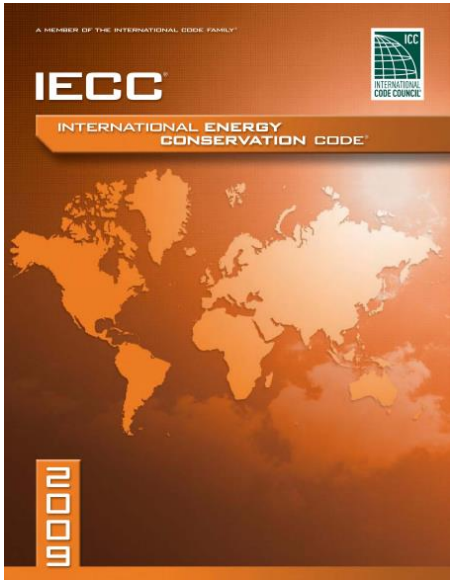
SoCal Chapter

2009 IECC

STATE ADOPTIONS

- ✓ *24 States (Florida, New York, Texas)*
- ✓ *State of Hawaii**
- ✓ *Kauai County**

**Has independent and separate amendments*



Air Barrier Overall Requirements

1. *Residential building envelope air barrier requirements become quantitative (kinda)*
2. *Residential building envelope air barrier requires testing or visual inspection of air barrier AND insulation*
3. *Commercial requirements and Residential Fenestration requirements remain the same as 2006 IECC*

SoCal Chapter

2009 IECC

Building Envelope Requirements – 402.4 RESIDENTIAL

Qualitative requirement: 402.4.1:

Same as 2006 IECC with 2 additional items

1. Rim joist junction

2. Attic access openings

Quantitative requirement: 402.4.2.1:

Air leakage below 7 air changes per hour (ACH50) at 50Pa (7 ACH50). Similar to 0.34-0.40 CFM/SF^2

Testing Requirement: 402.4.2.1 and 2:

If visual inspection of the air barrier and insulation is completed by a third party and according to Table 402.4.2, Testing Requirement is waived.

If no visual inspection, test according 402.4.1 with a blower door at 50 Pa

Exceptions: NONE

SoCal Chapter

2009 IECC

Fenestration and Door Requirements – 402.4 RESIDENTIAL and 502.4 COMMERCIAL

No change from 2006 IECC

Building Envelope Requirements – 502.4.3 COMMERCIAL

No change from 2006 IECC

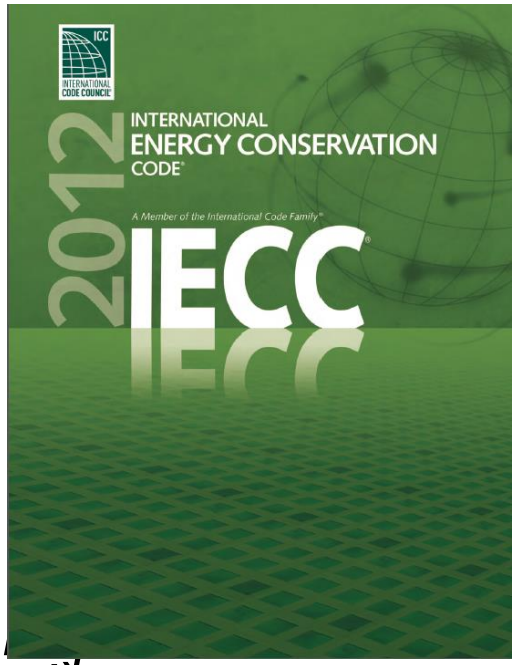
SoCal Chapter

2012 IECC

2012 IECC

- ✓ *16 States*
  - ✓ *Washington**
  - ✓ *Oregon**

**Has independent and separate amendments*

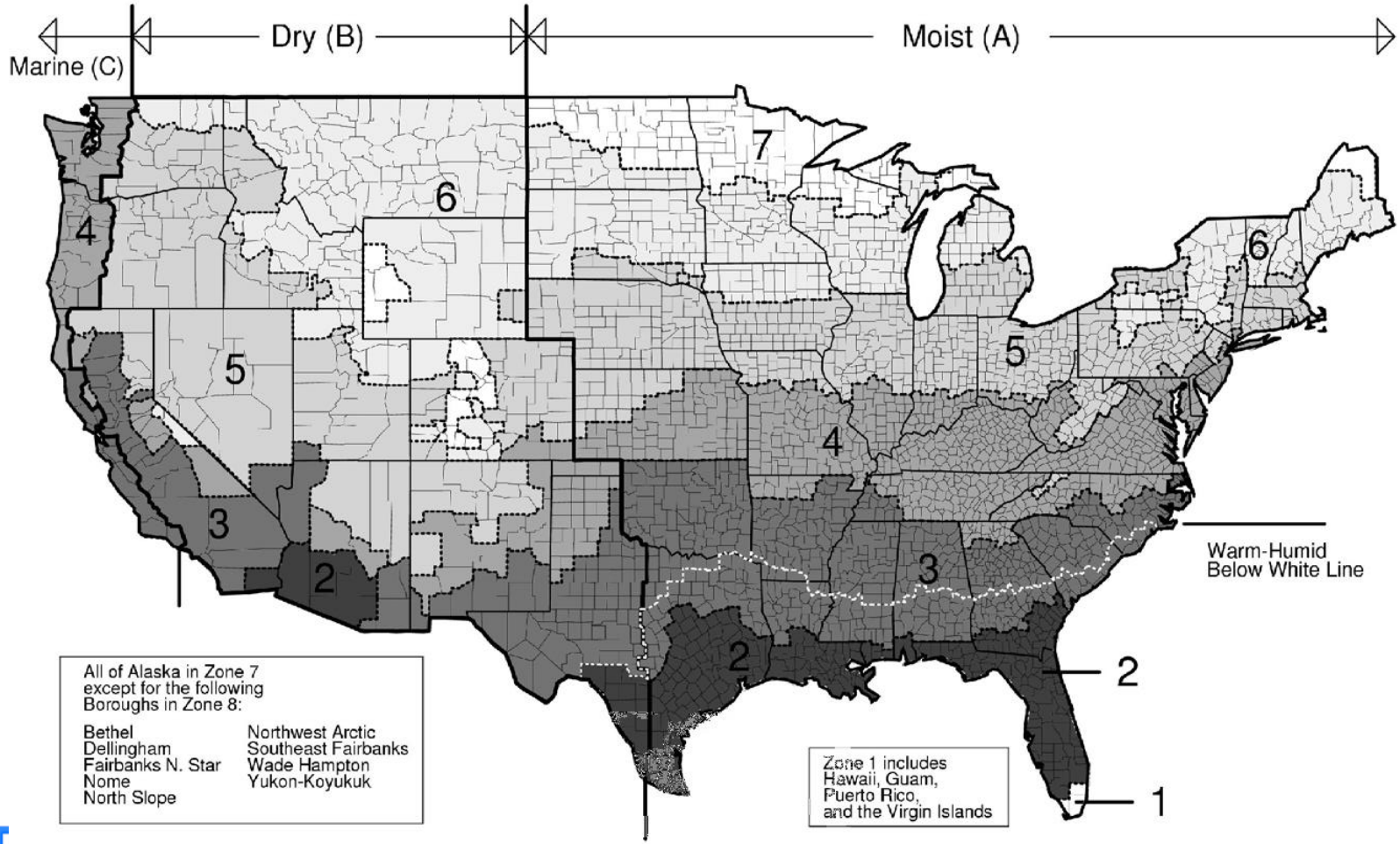


Air Barrier Overall Requirements

1. *New - CLIMATE ZONE BASED*
2. *Residential building envelope air barrier [illegible] become quantitative. (Not kinda anymore!)*
3. *Residential building envelope air barrier requires testing AND visual inspection of air barrier and insulation*
4. *Commercial building envelope requirements for Climate Zones 4-8. Compliance options defined.*
5. *Residential and Commercial Fenestration Requirements remain unchanged.*

SoCal Chapter

Mainland Zone Map



SoCal Chapter

2012 IECC *Table R402.4.1.1:*

Building Envelope Requirements – 402.4 RESIDENTIAL

Qualitative requirement:

Air Barrier and Insulation Requirements

Wall Requirements

Garage Separation Requirements

TABLE R402.4.1.1
AIR BARRIER AND INSULATION INSTALLATION

COMPONENT	CRITERIA[a]
Air barrier and thermal barrier	A continuous air barrier shall be installed in the building envelope. Exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed. Air-permeable insulation shall not be used as a sealing material.
Ceiling/attic	The air barrier in any dropped ceiling/soffit shall be aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop down stair or knee wall doors to unconditioned attic spaces shall be sealed.
Walls	Corners and headers shall be insulated and the junction of the foundation and sill plate shall be sealed. The junction of the top plate and top of exterior walls shall be sealed. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier. Knee walls shall be sealed.
Windows, skylights and doors	The space between window/door jambs and framing and skylights and framing shall be sealed.
Rim joists	Rim joists shall be insulated and include the air barrier.
Floors (including above-garage and cantilevered floors)	Insulation shall be installed to maintain permanent contact with underside of subfloor decking. The air barrier shall be installed at any exposed edge of insulation.
Crawl space walls	Where provided in lieu of floor insulation, insulation shall be permanently attached to the crawlspace walls. Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.
Shafts, penetrations	Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed.
Narrow cavities	Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled by insulation that on installation readily conforms to the available cavity space.
Garage separation	Air sealing shall be provided between the garage and conditioned spaces.
Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be air tight, IC rated, and sealed to the drywall.
Plumbing and wiring	Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation that on installation readily conforms to available space shall extend behind piping and wiring.
Shower/tub on exterior wall	Exterior walls adjacent to showers and tubs shall be insulated and the air barrier installed separating them from the showers and tubs.
Electrical/phone box on exterior walls	The air barrier shall be installed behind electrical or communication boxes or air sealed boxes shall be installed.
HVAC register boots	HVAC register boots that penetrate building thermal envelope shall be sealed to the sub-floor or drywall.
Fireplace	An air barrier shall be installed on fireplace walls. Fireplaces shall have gasketed doors.

a. In addition, inspection of log walls shall be in accordance with the provisions of ICC-400.

SoCal Chapter

2012 IECC

Building Envelope Requirements – 402.4 RESIDENTIAL

Quantitative requirement: 402.4.1.2: *More Restrictive than 2009*

Climate Zones 1-2: Air leakage below 5 air changes per hour (ACH) at 50Pa (5 ACH50 or 0.25 CFM/SF^2).

Climate Zones 3-8: Air leakage below 3 air changes per hour (ACH) at 50Pa (3 ACH50 0.15 CFM/SF^2).

Testing Requirement: 402.4.1.2:

Test according 402.4.1.2 air leakage requirements with a blower door at 50 Pa. Where required by the Code Official, provide a results report.

Visual inspection may be required by Code Official

Exceptions: NONE

SoCal Chapter

2012 IECC

Fenestration and Door Requirements – 402.X RESIDENTIAL

Quantitative requirement: 402.4.1.2: *More Restrictive than 2009*

Testing Requirement: 402.4.1.2:

Exceptions: NONE

SoCal Chapter

2012 IECC

Building Envelope Requirements – C402.4 COMMERCIAL

Qualitative requirements:

LOTS and LOTS and LOTS…..

C402.4 Air leakage (Mandatory). The thermal envelope of buildings shall comply with Sections C402.4.1 through C402.4.8.

C402.4.1 Air barriers. A continuous air barrier shall be provided throughout the building thermal envelope. The air barriers shall be permitted to be located on the inside or outside of the building envelope, located within the assemblies composing the envelope, or any combination thereof. The air barrier shall comply with Sections C402.4.1.1 and C402.4.1.2.

Exception: Air barriers are not required in buildings located in Climate Zones 1, 2 and 3.

cont'd

2012 IECC

Building Envelope Requirements – C402.4 COMMERCIAL

Qualitative requirement, cont'd

C402.4.1.1 Air barrier construction. The *continuous air barrier* shall be constructed to comply with the following:

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. Air barrier penetrations shall be sealed in accordance with Section C402.4.2. 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. Recessed lighting fixtures shall comply with Section C402.4.8. Where similar objects are installed which penetrate the air barrier, provisions shall be made to maintain the integrity of the air barrier.

Exception: Buildings that comply with Section C402.4.1.2.3 are not required to comply with Items 1 and 3.

SoCal Chapter

2012 IECC

Building Envelope Requirements – C402.4 COMMERCIAL

Quantitative requirements: Material Requirements:

Air Permeability less than 0.004cfm/ft^2 OR listed in C402.4.1.2.1 below:

1. Plywood with a thickness of not less than $^3/_8$ inch (10 mm).
2. Oriented strand board having a thickness of not less than $^3/_8$ inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than $^1/_2$ inch (12 mm).
4. Foil-back polyisocyanurate insulation board having a thickness of not less than $^1/_2$ inch (12 mm).
5. Closed cell spray foam a minimum density of 1.5 pcf (2.4 kg/m^3) having a thickness of not less than $1^1/_2$ inches (36 mm).
6. Open cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m^3) and having a thickness of not less than 4.5 inches (113 mm).
7. Exterior or interior gypsum board having a thickness of not less than $^1/_2$ inch (12 mm).
8. Cement board having a thickness of not less than $^1/_2$ inch (12 mm).
9. Built up roofing membrane.
10. Modified bituminous roof membrane.
11. Fully adhered single-ply roof membrane.
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than $^5/_8$ inch (16 mm).
13. Cast-in-place and precast concrete.
14. Fully grouted concrete block masonry.
15. Sheet steel or aluminum.

cont'd

SoCal Chapter

2012 IECC

Building Envelope Requirements – C402.4 COMMERCIAL

Quantitative requirements, cont'd:

Assembly Requirements:

Air Permeability less than 0.04cfm/ft^2 OR listed in C402.4.1.2.2 below:

Whole Building Requirements:

Air leakage rate shall not exceed 0.40 cfm/ft^2 at 75 Pa

Excep

1. Concrete masonry walls coated with one application either of block filler and two applications of a paint or sealer coating;
2. A Portland cement/sand parge, stucco or plaster minimum $^1/_2$ inch (12 mm) in thickness.

cont'd

SoCal Chapter

2012 IECC

Building Envelope Requirements – C402.4 COMMERCIAL

Testing Requirements:

Whole Building Test in accordance with ASTM E779 or an equivalent method approved by the code official

Exceptions: Commercial Buildings in Climate Zones 1, 2 or 3.

SoCal Chapter

2012 IECC

Building Envelope Requirements – C402.4 COMMERCIAL

Qualitative requirement:

C402.4 Air leakage (Mandatory). The thermal envelope of buildings shall comply with Sections C402.4.1 through C402.4.8.

C402.4.1 Air barriers. A continuous air barrier shall be provided throughout the building thermal envelope. The air barriers shall be permitted to be located on the inside or outside of the building envelope, located within the assemblies composing the envelope, or any combination thereof. The air barrier shall comply with Sections C402.4.1.1 and C402.4.1.2.

Exception: Air barriers are not required in buildings located in Climate Zones 1, 2 and 3.

SoCal Chapter

cont'd

2012 IECC

Fenestration and Door Requirements C402.4.3 COMMERCIAL

More restrictive from 2006/2009 IECC

2006/2009 – 0.3 cfm

TABLE C402.4.3
MAXIMUM AIR INFILTRATION RATE FOR FENESTRATION ASSEMBLIES

FENESTRATION ASSEMBLY	MAXIMUM RATE (CFM/FT²)	TEST PROCEDURE
Windows	0.20 [a]	AAMA/WDMA/ CSA101/I.S.2/A440 or NFRC 400
Sliding doors	0.20 [a]	
Swinging doors	0.20 [a]	
Skylights – with condensation weepage openings	0.30	
Skylights – all other	0.20 [a]	
Curtain walls	0.06	NFRC 400 or ASTM E 283 at 1.57 psf (75 Pa)
Storefront glazing	0.06	
Commercial glazed swinging entrance doors	1.00	
Revolving doors	1.00	
Garage doors	0.40	ANSI/DASMA 105, NFRC 400, or ASTM E 283 at 1.57 psf (75 Pa)
Rolling doors	1.00	

For SI: 1 cubic foot per minute = 0.47L/s, 1 square foot = 0.093 m^2.

a. The maximum rate for windows, sliding and swinging doors, and skylights is permitted to be 0.3 cfm per square foot of fenestration or door area when tested in accordance with AAMA/WDMA/CSA101/I.S.2/A440 at 6.24 psf (300 Pa).

SoCal Chapter

2014 California Title 24

- SECTION 110.7 – Mandatory Requirements to Limit Air Leakage

- *"All joints, penetrations and other openings in the building envelope that are potential sources of air leakage shall be caulked, gasketed, weather stripped, or otherwise sealed to limit infiltration and exfiltration."*

  - *<u>This requirement applies to ALL buildings Residential and Commercial.</u>*

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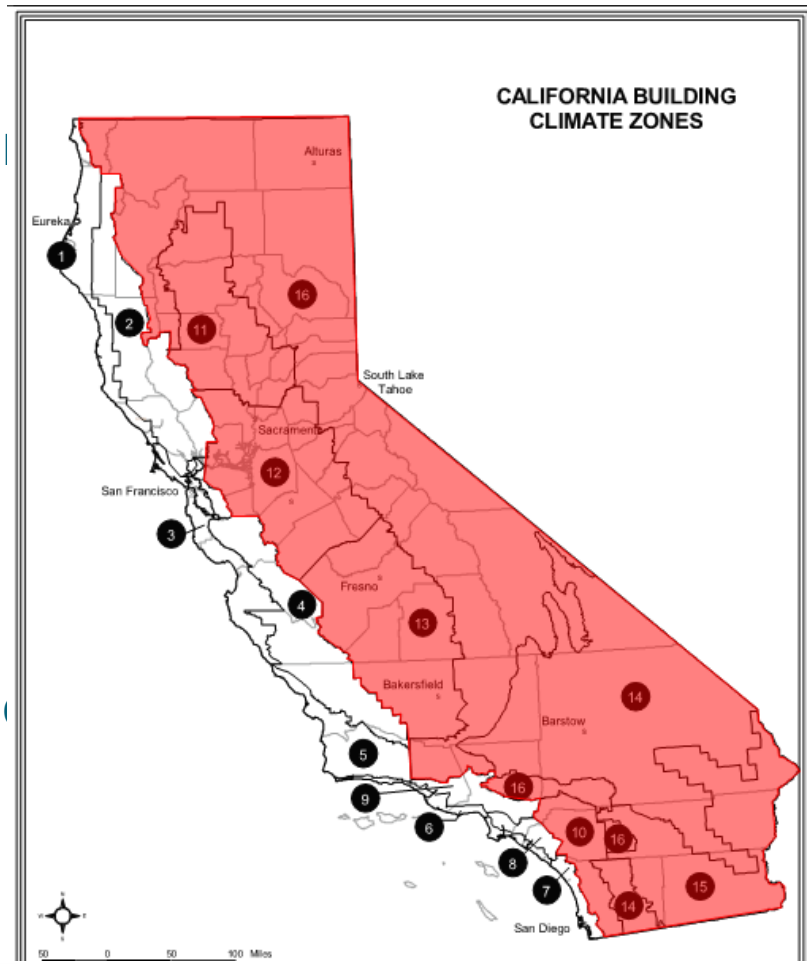
2014 California Title 24

- RESIDENTIAL –
- No additional requirements (Except110.7)
- (Less restrictive than 2012 IECC)

- NON-RESIDENTIAL –
- Section 140.3(a)9 - Table 140.3-B
- Limited to Non-residential Buildings.
- High Rise Residential Excluded
- Hotels/ Motels Excluded
- (Less restrictive than 2012 IECC)
- Limited Climate Zones
- Only Zones 10-16 required
- (More restrictive than 2012 IECC)

SoCal Chapter

Title 24 Where Air Barriers are Required



Climate Zones

10 Riverside, San

11 Redding

12 Sacramento

13 Fresno, Bakersfield

14 Barstow, Palmdale

15 Palm Springs

16 Pasadena*

* Some cities span

Zones! Check the zipcode before you design!

SoCal Chapter

Title 24 Air Barrier Requirements

- To meet the requirement of TABLE 140.3-B, all buildings shall have a continuous air barrier that is designed and constructed to control air leakage into, and out of, the building's conditioned space.
- The air barrier shall be sealed at all joints for its entire length and shall be composed of:
  - ✓ Materials,
  - ✓ Assemblies
  - ✓ Buildings
- That comply with ASTM air barrier testing requirements.

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Title 24 Air Barrier Material Requirements

- **Same as IECC 2012 (except where and what type of building)**

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Air Barrier Assembly Requirements

B. Assemblies of materials and components that have an average air leakage not exceeding 0.04 cfm/ft^2, under a pressure differential of 0.3 in. w.g (1.57 psf) (0.2 L/m^2 at 75 pa), when tested in accordance with ASTM E2357, ASTM E1677, ASTM E1680, or ASTM E283; or

- EXCEPTION to Section 140.3(a)9B: The following materials shall be deemed to comply with Section 140.3(a)9B if all joints are sealed and all of the materials are installed as air barriers in accordance with the manufacturer's instructions:

A. **Concrete masonry walls that have at least two coatings of paint or at least two coatings of sealer coating.**
B. **Concrete masonry walls with integral rigid board insulation.**
C. **Structurally Insulated Panels.**
D. **Portland cement or Portland sand parge, or stucco, or a gypsum plaster, each with min. 1/2 inches thickness**

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Air Barrier Whole Building Requirements

C. The entire building has an air leakage rate not exceeding 0.40 cfm/ft^2 at a pressure differential of 0.3 in w.g. (1.57 psf) (2.0 L/ m^2 at 75 pa), when the entire building is tested, after completion of construction, in accordance with ASTM E779 or another test method approved by the Commission.

- **EXCEPTION to Section 140.3(a)9: Relocatable Public School Buildings.**

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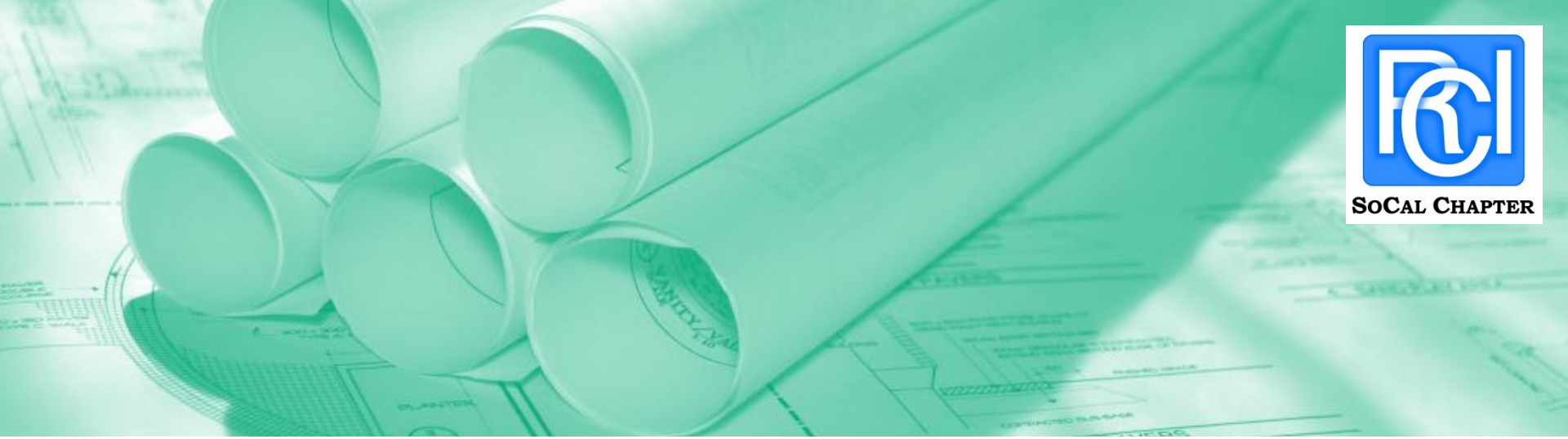

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Air Barrier Benefits

Why Air Barriers?

- Saves Energy = Saves Money
- Noise Reduction
- Pest Reduction
- Moisture Reduction
- Improved Environmental Control = Better Comfort

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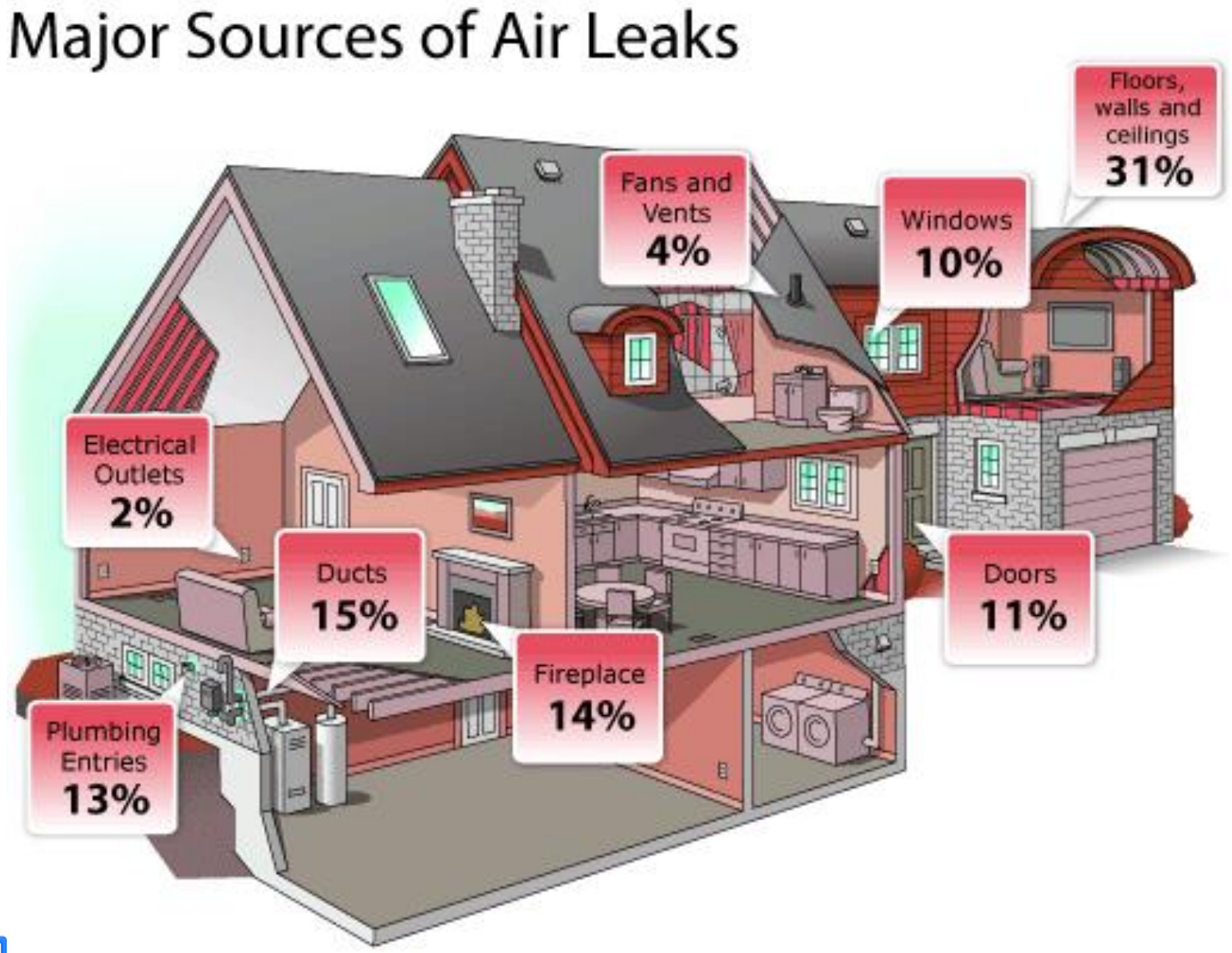
Air Leakage Sources



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Energy Savings

ACH50	Air Leakage Rate	Rating	% of bill	% savings potential
1.5	0.075	Super	2%	none
3.5	0.18	Excellent	6%	1 to 3%
5	0.25	Better	10%	2 to 4%
7	0.35	Good	14%	2 to 5%
10	0.50	Fair	20%	3 to 10%
20	1.0	Bad	40%	5 to 20%

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Annual Energy Savings:

* *Investigation of the Impact of Commercial Building Envelope Airtightness on HVAC Energy Use at 0.4 CFM/SF*^{2}

National Institute of Standards & Technology, 2005

office

City	Gas Savings		Electrical Savings		Total Savings
Bismarck	$1,854	42%	$1,340	26%	$3,195
Minneapolis	$1,872	43%	$1,811	33%	$3,683
St. Louis	$1,460	57%	$1,555	28%	$3,016
Phoenix	$124	77%	$620	9%	$745
Miami	$0	0%	$769	10%	$769

retail

City	Gas Savings		Electrical Savings		Total Savings
Bismarck	$1,835	26%	$33	2%	$1,869
Minneapolis	$1,908	28%	$364	18%	$2,272
St. Louis	$1,450	38%	$298	9%	$1,748
Phoenix	$176	64%	$992	14%	$1,169
Miami	$6	98%	$1,224	14%	$1,231

apartments

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SoCal Chapter

Summary of Calculated Ratios

* *Investigation of the Impact of Commercial Building Envelope Airtightness on HVAC Energy Use* – National Institute of Standards & Technology, 2005

Two Story Office Building	Bismarck	Minneapolis	St. Louis	Phoenix	Miami
Cost of energy saved x Scalar of 8	$25,701	$25,701	$24,122	$5,956	$6,153
Masonry Backup Wall					
First cost of the air barrier	$12,054	$12,054	$12,054	$12,054	$12,054
Calculated Scalar	3.8	3.8	4.0	16.2	15.7
Steel Frame Building - Taped sheathing (Option 1)					
First cost of the air barrier	$4,612	$4,612	$4,612	$4,612	$4,612
Calculated Scalar	1.4	1.4	1.5	6.2	6.0
Steel Frame Building - Commercial Wrap (Option 2)					
First cost of the air barrier	$325	$325	$325	$325	$325
Calculated Scalar	0.1	0.1	0.1	0.4	0.4

One Story Retail Building	Bismarck	Minneapolis	St. Louis	Phoenix	Miami
Cost of energy saved x Scalar of 8	$14,946	$18,174	$13,985	$9,345	$9,840
Masonry Backup Wall					
First cost of the air barrier	$7,287	$7,287	$7,287	$7,287	$7,287
Calculated Scalar	3.9	3.2	4.2	6.2	5.9
Steel Frame Building - Taped sheathing (Option 1)					
First cost of the air barrier	$2,604	$2,604	$2,604	$2,604	$2,604
Calculated Scalar	1.4	1.1	1.5	2.2	2.1
Steel Frame Building - Commercial Wrap (Option 2)					
First cost of the air barrier	$176	$176	$176	$176	$176
Calculated Scalar	0.1	0.1	0.1	0.2	0.1

Four Story Wood Frame Apartment Building (Clapboard Siding)	Bismarck	Minneapolis	St. Louis	Phoenix	Miami
Cost of energy saved x Scalar of 8	$16,567	$18,045	$12,498	$1,067	$3,294
Taped sheathing (Option 1)					
First cost of the air barrier	$5,317	$5,317	$5,317	$5,317	$5,317
Calculated Scalar	2.6	2.4	3.4	39.9	12.9
Commercial Wrap (Option 2)					
First cost of the air barrier	$370	$370	$370	$370	$370
Calculated Scalar	0.2	0.2	0.2	2.8	0.9
Four Story Wood Frame Apartment Building (Masonry Veneer)	Bismarck	Minneapolis	St. Louis	Phoenix	Miami
Cost of energy saved x Scalar of 8	$16,468	$17,067	$12,326	$994	$3,286
Taped sheathing (Option 1)					
First cost of the air barrier	$5,317	$5,317	$5,317	$5,317	$5,317
Calculated Scalar	2.6	2.5	3.5	42.8	12.9
Commercial Wrap (Option 2)					
First cost of the air barrier	$370	$370	$370	$370	$370
Calculated Scalar	0.2	0.2	0.2	3.0	0.9

Color key:

3.8	Scalar = < 8
16.2	Scalar > 8

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Noise and Pest Reduction

Less Holes in the Building =

Less Noise and More Noise Reduction

Less Opportunity for Pests and Rodents

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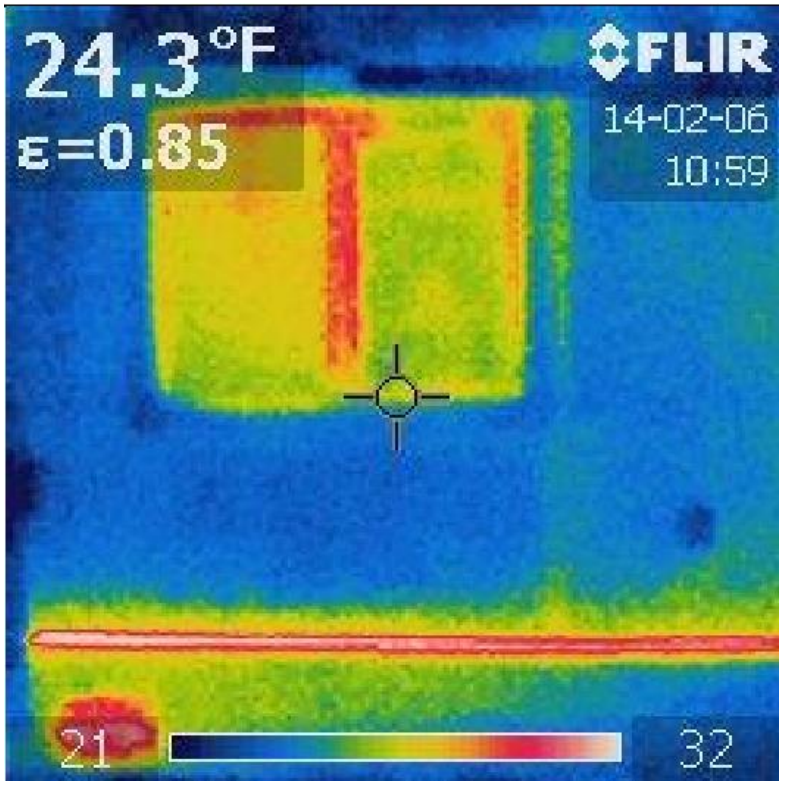
Moisture and Condensation Reduction

Reduced air leakage prevents condensation from occurring in unwanted parts of the building envelope.

Air Leakage at Plate Line

Less uncontrolled air leakage means better air quality, tighter humidity ranges and better control of the interior environment.



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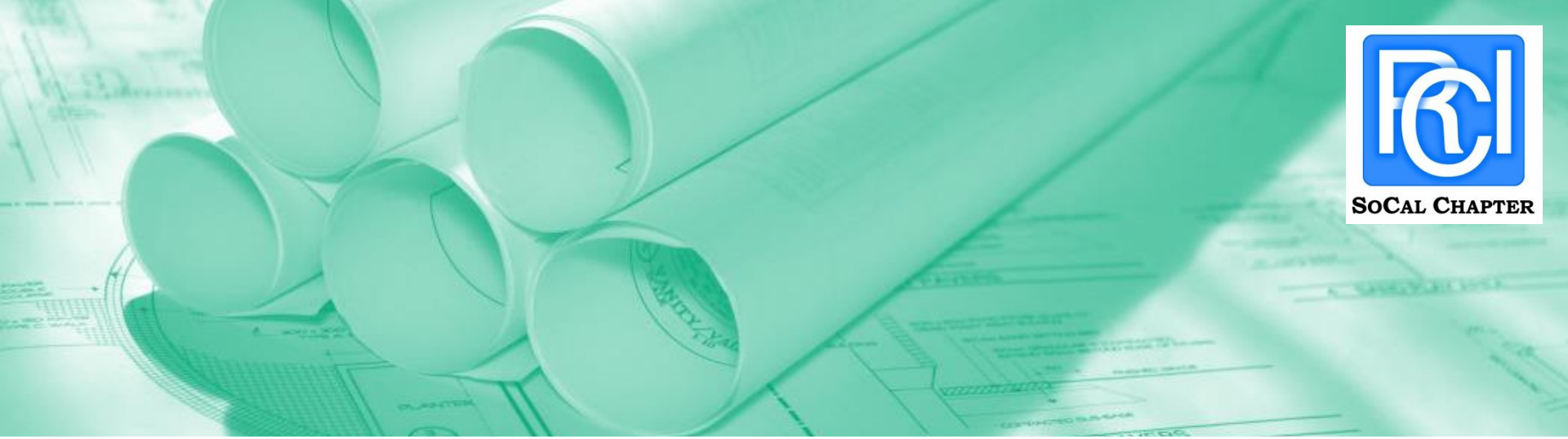

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Air Barrier Design Considerations

4 Typical Air Barrier Approaches

- Air Tight Drywall and Framing
- Interior Vapor Barrier Membrane
- Exterior Sheathing
- Exterior Weather Resistive Barrier

Most successful approach is a combination of approaches

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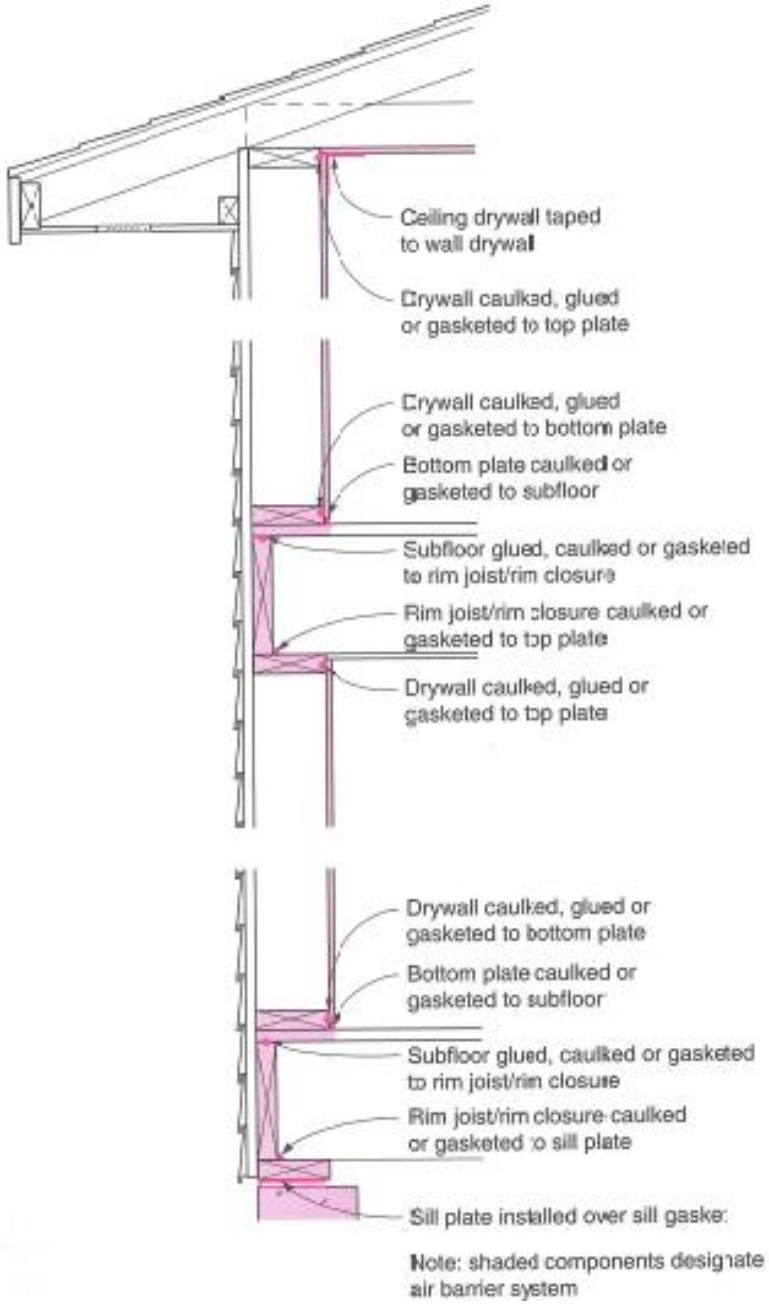
Air Tight Drywall And Framing Approach

Requires tapped seams, spray foam, sealants and other air barrier transition components



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Air Tight Drywall and Framing Approach

Pros

- Controls the entry of interior, moisture laden air from entering into wall cavity
- Can be enhanced with ccSPF
- Repaired easily
- Inspected visually and tested easily
- Lower cost
- Significant history of success in single family residential

Cons

- Interior air barrier does not control wind-washing of insulation
- Easily damaged by occupant usage
- Demising walls require detailing
- Several trades involved in the proper installation of the entire system requires a high level of coordination
- Not suitable for Hawaii

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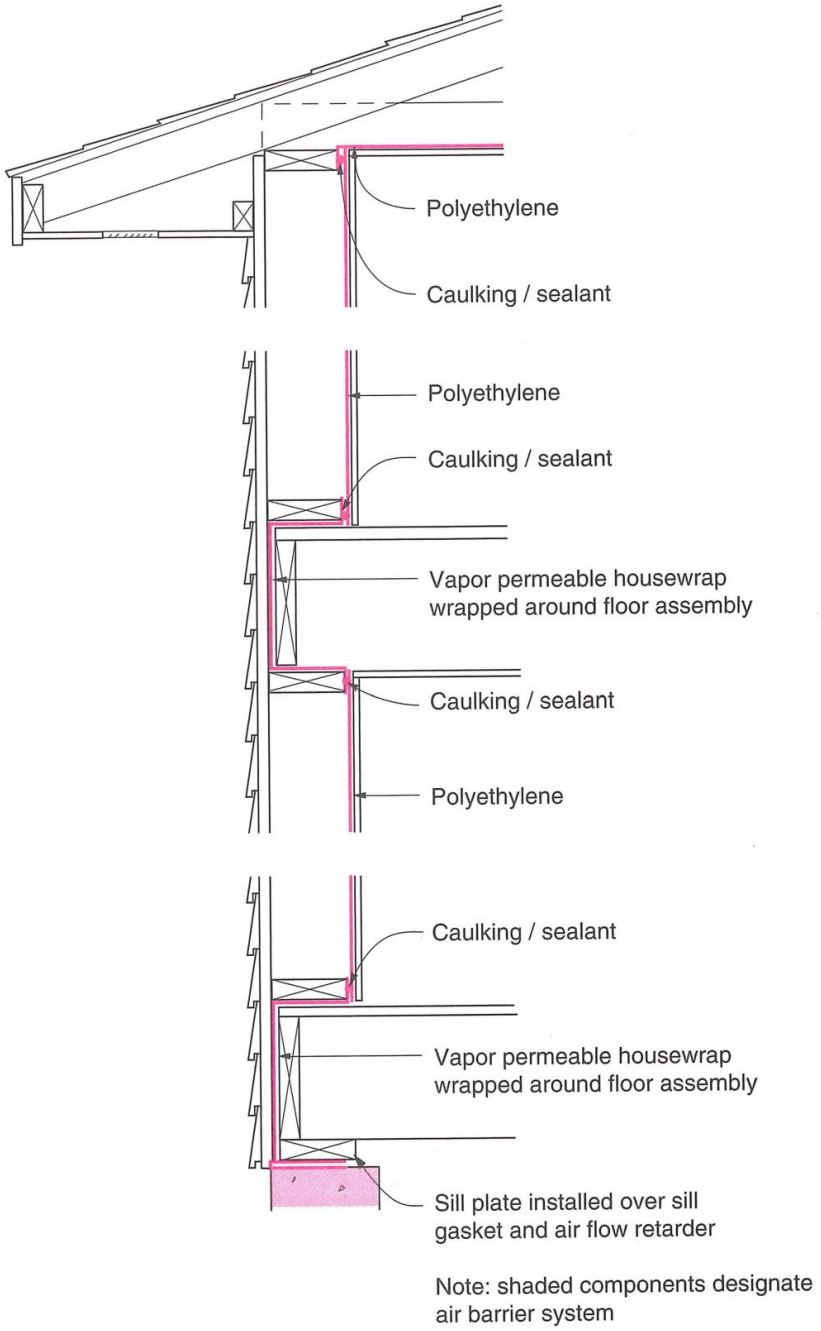
Interior Vapor Barrier Membrane Approach

- **Polyethylene**
- **Semi-Permeable Membranes**



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Interior Vapor Barrier Membrane Approach

Pros

- Controls the entry of interior, moisture laden air from entering into wall cavity
- Can be enhanced with ccSPF
- Controls both air and vapor
- One – two trade installation

Cons

- Does not allow for interior drying of wall cavity. This is necessary in a majority of climates and air conditioned spaces.
- Interior air barrier does not control wind-washing of insulation
- Not accessible for visual review and repair once drywall is installed
- Easily damaged by occupant usage
- Not suitable for Hawaii

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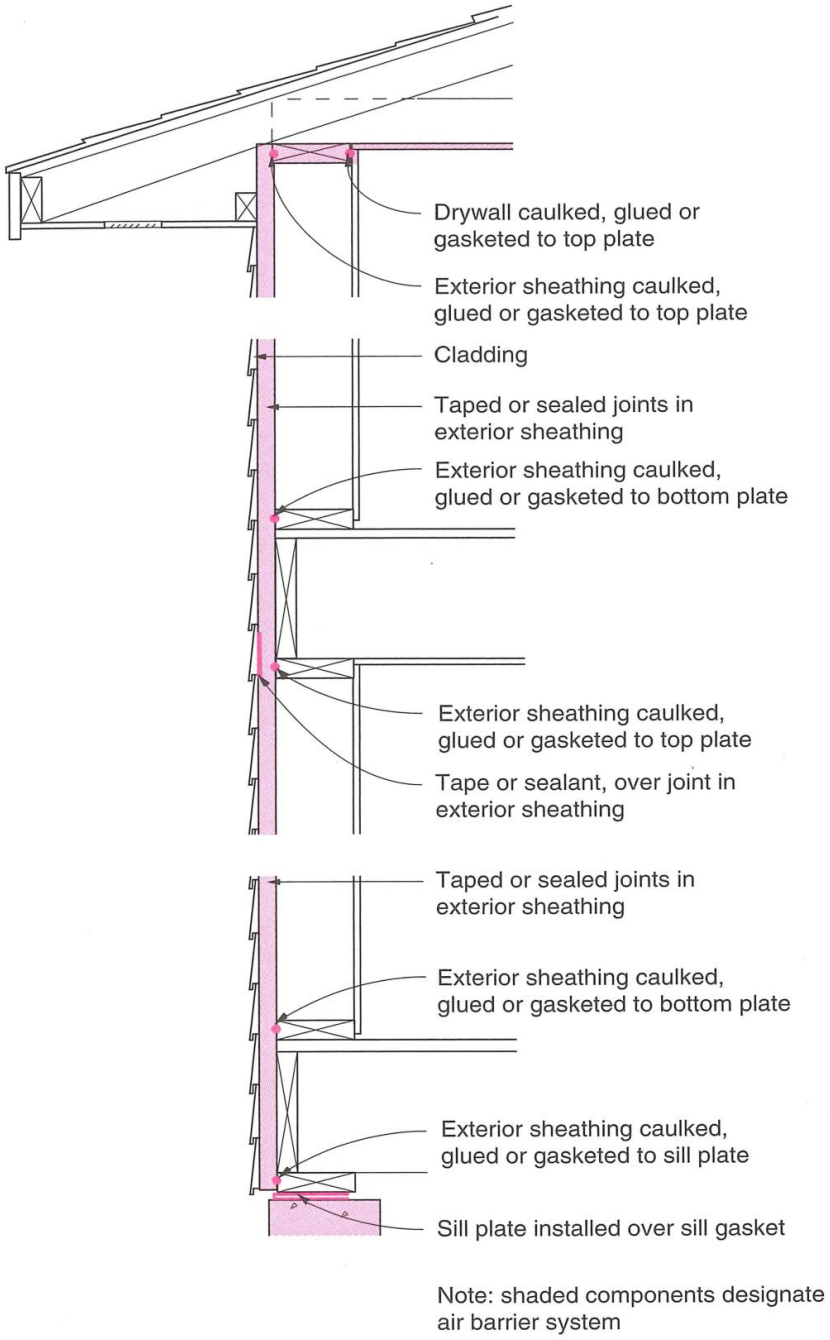
Exterior Sheathing Approach

- **Plywood**
- **OSB**
- **Gypsum Board**

Requires tapped seams, spray foam, sealants and other air barrier transition components



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Seal Joints and Gaps

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Seal Joints and Gaps

The Foam (Miracle in a Can)

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Sealing Gaps in Sheathing

SoCal Chapter

Sealing Sheathing Joints

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Seal Joints and Gaps

Seal Joints and Gaps

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Exterior Sheathing Approach Pros and Cons

Pros

- Cost effective
- Can be enhanced with ccSPF
- Controls both air and vapor
- One – two trade installation
- Inspected visually and tested / repaired easily
- Controls wind-washing of insulation

Cons

- Building movement could create discontinuity
- Joint treatment may be weather sensitive
- Subject to construction damage / penetrations after installation
- Requires weather resistant barrier to control moisture

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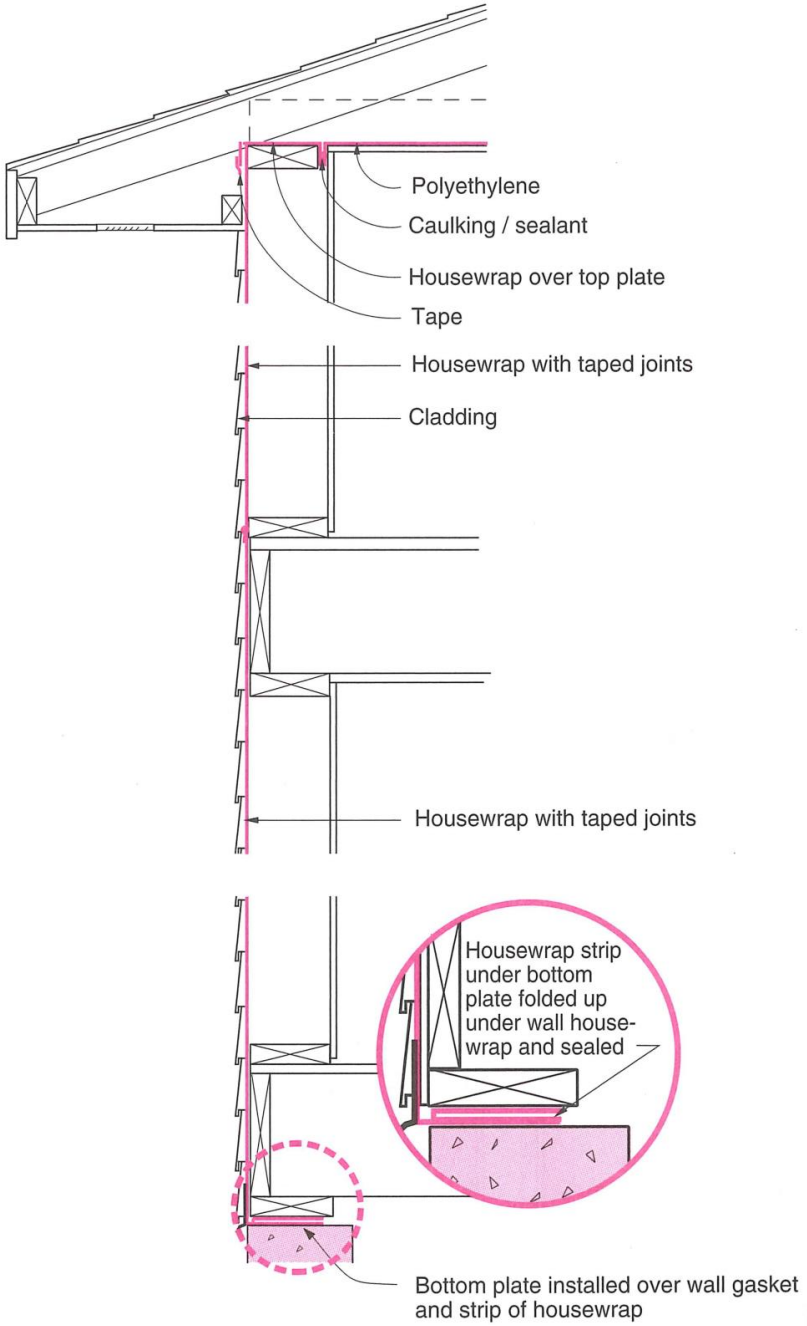
Exterior Weather Resistive Barrier Approach

- **Liquid Applied Coatings**
- **Non-Adhered Membranes**
- **Adhered Membranes**

Requires tapped seams, spray foam, sealants and other air barrier transition components



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Liquid Applied Mock-Up

SoCal Chapter

Liquid Applied

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Liquid Applied Approach Pros and Cons

Pros

- Controls air, vapor and moisture
- One trade installation
- Inspected visually and tested / repaired easily
- Controls wind-washing of insulation
- Nail seal-ability
- Seamless

Cons

- Potential adherence issues with multiple substrates
- Blistering
- Requires substrate board
- May require crack bridging characteristics
- Weather and temp dependent
- Current total system cost higher than other approaches

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Adhesion Issue

Blistering

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Air and Water Barriers Manufacturers

Permeable and Semi Permeable Fluid Applied:

Manufacturer	Product Name	Perms Dry / Wet	Air Leakage
BASF	Various Products	0.08 / 5.85	0.0066
DuPont	Tyvek Fluid Applied WB	11.48/24.23	0.0036
Grace C.P.	Perm-A-Barrier VP Perm-A-Barrier Liquid	 0.09 / 0.03	<0.004 <0.004
Henry Co.	Air Bloc 31 Air Bloc 32	0.57 / 36.12 0.23 / 1.02	0.004 0.0029
Momentive	SilShield AWB	4.27 / 5.49	0.0064
Parex USA	Weatherseal	0.828 / 9.2	0.0548
Prosoco Inc.	R-Guard Spray Wrap	2.52 / 10.5	0.016
Sto Corp.	Gold Coat 265	2.52 / 5.7	0.016
WR Meadows	Air Shield LMP Air Shield LM	na / na na / na	0.0026 0.0035

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Non-Adhered Membrane

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Non-Adhered Membrane Approach

Pros

- Controls air, vapor and moisture
- One trade installation
- Inspected visually and tested / repaired easily
- Controls wind-washing of insulation
- Potential for Nail Seal-ability
- Homogenous materials
- Not Weather or Temp dependent
- Large rolls = Fast installation

Cons

- Potential UV exposure issues if left un-cladded
- Potential blow off issues if left un-cladded
- Seams require taping
- May require substrate board to resistant inward and outward pressures
- Requires different fastenings than WRB installation
- Integration of flexible flashings

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Air and Water Barriers Manufacturers, cont.

Non-Adhered Sheet Assemblies

Manufacturer	Product Name	Perms Dry / Wet	Air Leakage
DuPont	Tyvek Commercial Wrap Tyvek Commervial Wrap D Tyvek HomeWrap	25.31/32.68 42.65/42.48 56 / 54	0.0023 0.00225 Pass
Pactiv	GreenGuard Rain Drop GreenGuard Max GreenGuard Ultra Wrap	12.33 / np 13.52 / np 45.45 / np	<0.001 <0.001 <0.0001
VaproShield	Wallshield Wrapshield Wrapshield SA	np / 212 np / 50 np / 50	Not A.B. <0.0094 <0.0001
Typar	MetroWrap HouseWrap	10 / np 12 / np	Not Test'd Not Test'd

SoCal Chapter

Adhered Membrane

Self Adhered Membrane Approach

Pros

- Controls air, vapor and moisture
- One trade installation
- Inspected visually and tested / repaired easily
- Controls wind-washing of insulation
- Potential for nail seal-ability
- Homogenous materials
- No blow off issues
- Hawaii, can be a vapor barrier

Cons

- Potential UV exposure issues if left un-cladded
- Requires substrate board
- Impermeable (most types)
- May require primer
- Weather and temperature dependent
- Heavier rolls
- Compatibility issues with other air barrier components

SoCal Chapter

Air and Water Barriers Manufacturers

Self Adhered Sheet Assemblies

Manufacturer	Product Name	Perms Dry / Wet	Air Leakage
WR Grace	Perm-A-Barrier WM	np / 0.05	0.0002
Henry	Blueskin SA	0.03 / 0.86	0.006
WR Meadows	Air Shield	np / .047	0.0013
Carlisle	CCW-705	0.05 / np	<0.0009
VaproShield	Wrapshield SA	np / 50	<0.0001

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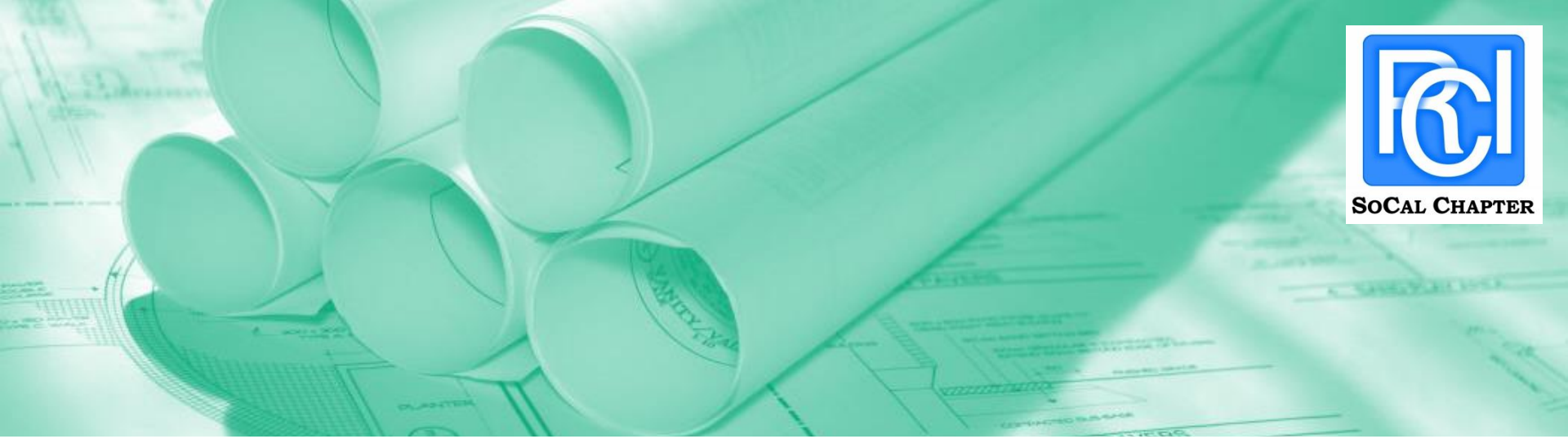

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Combination of Air Barriers and Continuous Insulation

Continuous Insulation Defined

Insulation that is continuous across assemblies that separate conditioned from unconditioned space. It is installed on the exterior or interior or is integral to any opaque surface of the building envelope and has no thermal bridges other than fasteners and necessary service openings.

-2013 Title 24, Part 6

Insulation that is installed in such a that is continuous and is uninterrupted by framing members or other construction elements that would reduce the thermal resistance of the insulation.

-2004 ASHRAE 90.1 User's Manual

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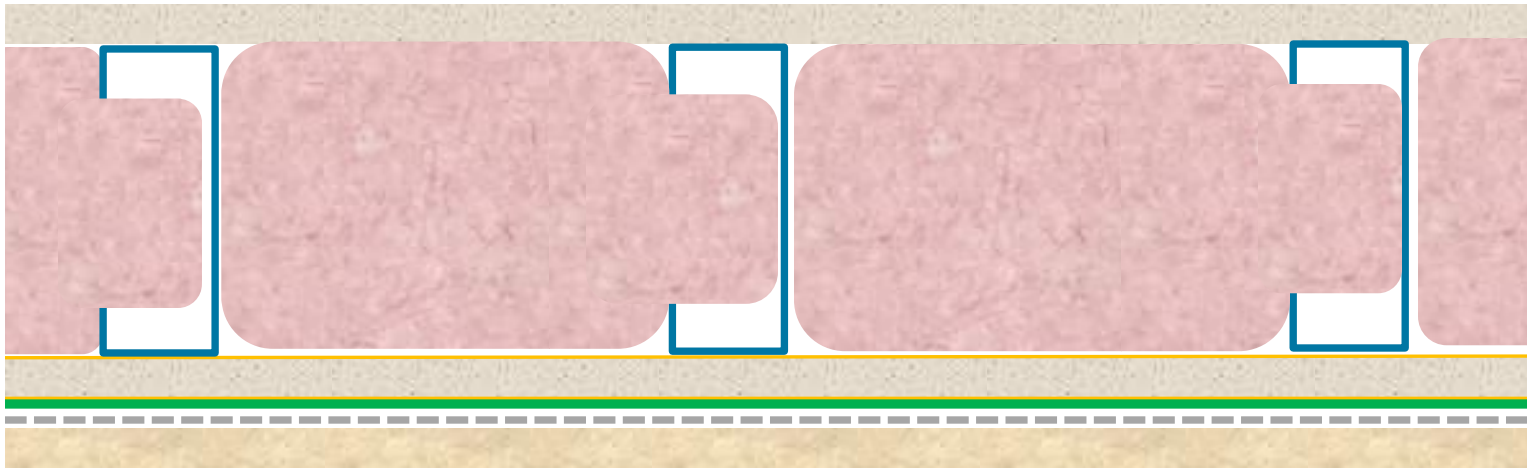
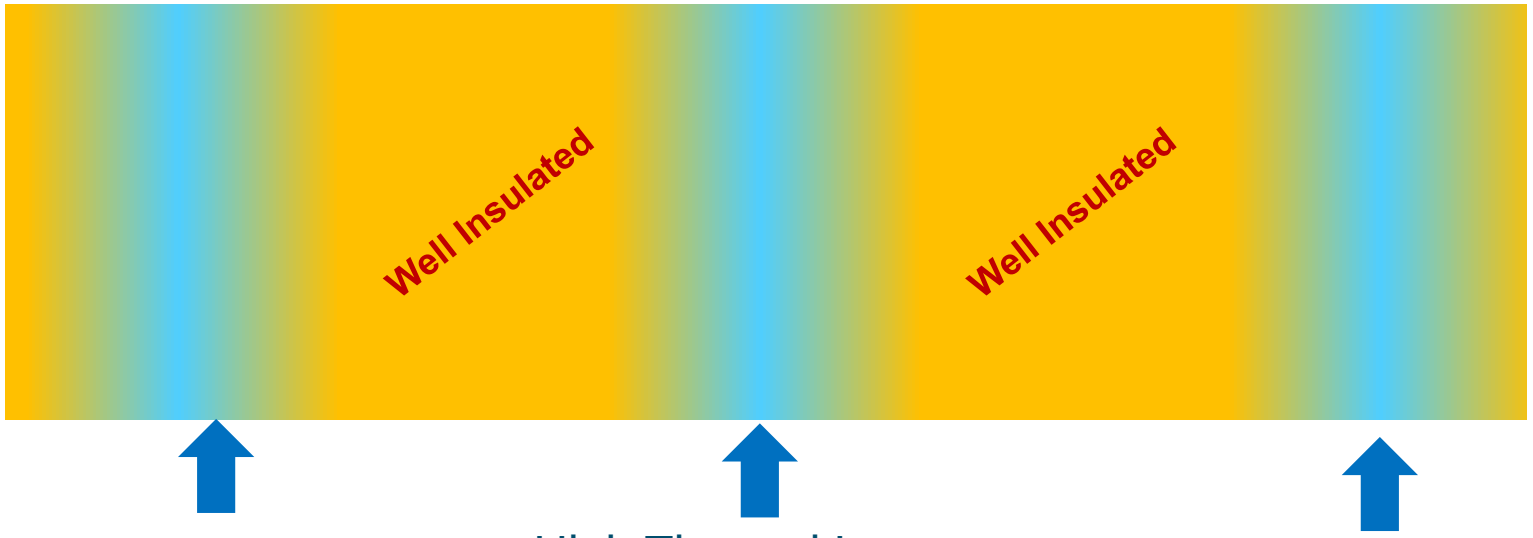
Typical Exterior Insulation



Traditional Insulated Wall Section



High Thermal Losses

R Value Reductions

TABLE A9.2-2 Effective Insulation/Framing Layer R-Values for Wall Insulation Installed Between Steel Framing

Nominal Depth of Cavity, in.	Actual Depth of Cavity, in.	Rated R-Value of Airspace or Insulation	Effective Framing/Cavity R-Value at 16 in. on Center	Effective Framing/Cavity R-Value at 24 in. on Center
Empty Cavity, No Insulation				
4	3.5	R-0.91	0.79	0.91
Insulated Cavity				
4	3.5	R-11	5.5	6.6
4	3.5	R-13	6.0	7.2
4	3.5	R-15	6.4	7.8
6	6.0	R-19	7.1	8.6
6	6.0	R-21	7.4	9.0
8	8.0	R-25	7.8	9.6

Metal framed wall assemblies require a reduction factor.

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Material Selection Considerations

- R-value
- Air and vapor permeability
- Moisture resistance
- Composite qualities (i.e. – integral cladding, weather resistant barrier, air barrier, interior vapor barrier)
- Fire resistance
- UV resistance (for open joint assemblies)
- Furring and effective R reductions

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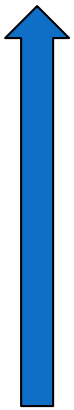
Continuous Insulation Options



R Value

- Insulation Panels and Materials
- ccSPF – Closed Cell Spray Polyurethane
- PolyIso – Polyisocysanurate
- XPS – Extruded Polystyrene
- Mineral Wool Insulation
- EPS – Expanded Polystyrene

- Insulation Panel Enhancements
- Foil Facing
- Plywood Facing
- Reinforced Cementitious Coating Faced

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Design Considerations

- Location of the Air Barrier / WRB
- Thermal Bridging
- Edge Treatments and Terminations
- Sequencing and Testing – Review of WRB

SoCal Chapter

Edge Treatments and Terminations

Insulation requires a designed solution at it's terminations

- ✓ Windows and Doors
- ✓ Floor Line Flashings
- ✓ Z-girts
- ✓ Soffits and Parapets

Let's review Windows and Z-Girts as they are most typical

SoCal Chapter

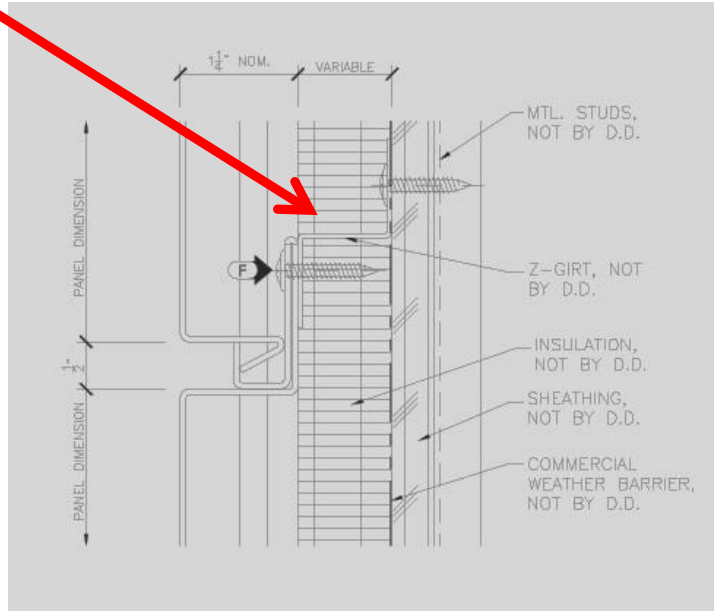
Thermal Bridges and Z-Girts

Because metal is a terrific conductor of heat, thermal bridges increase the U-value of an assembly

In a side by side comparison, metal stud framing is 15 - 50% less efficient than wood framing

Z-girts through continuous insulation assemblies increase the U-values of the assembly by 20-40%

R-21 with Z-girts = R-15eff



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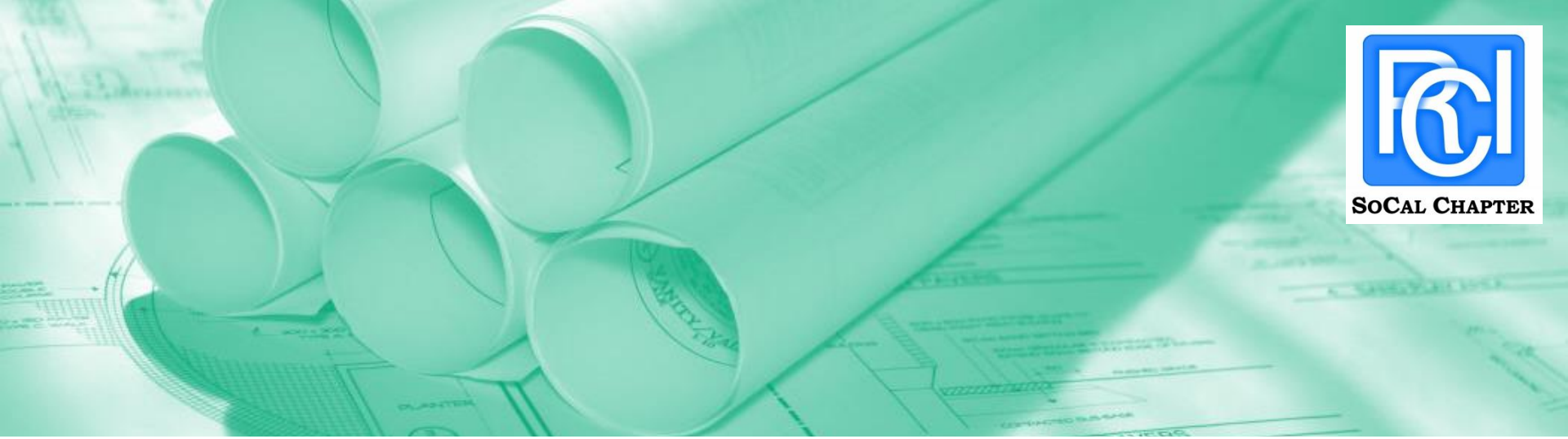

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San Diego International Airport Continuous Insulation Mock-up

Continuous Insulation System for SD Airport

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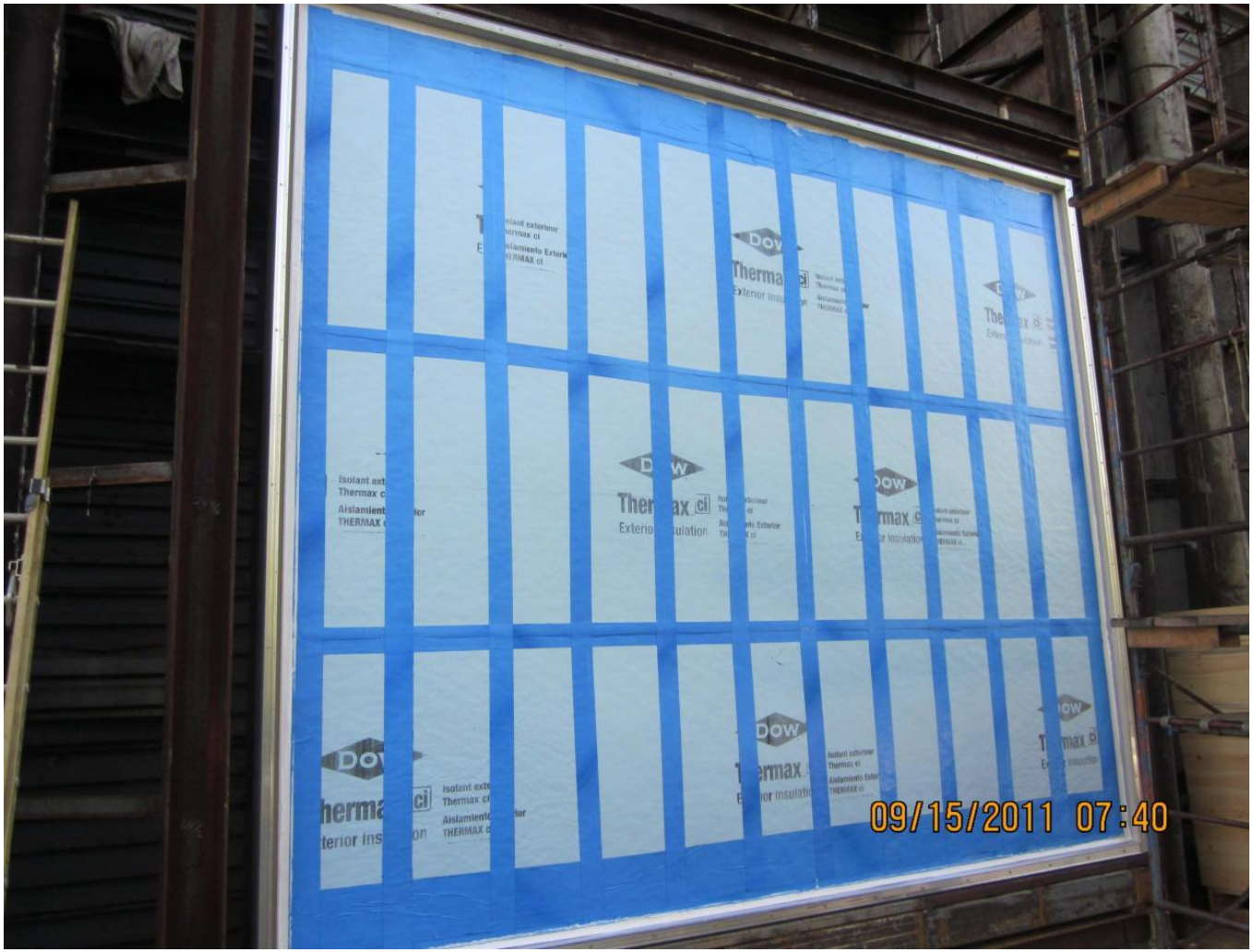
Continuous Insulation System And Air Barrier for SD Airport



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WRB Barrier Over insulation

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Butyl Tape Behind Z Girts

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WRB / Air Barrier Over the Insulation

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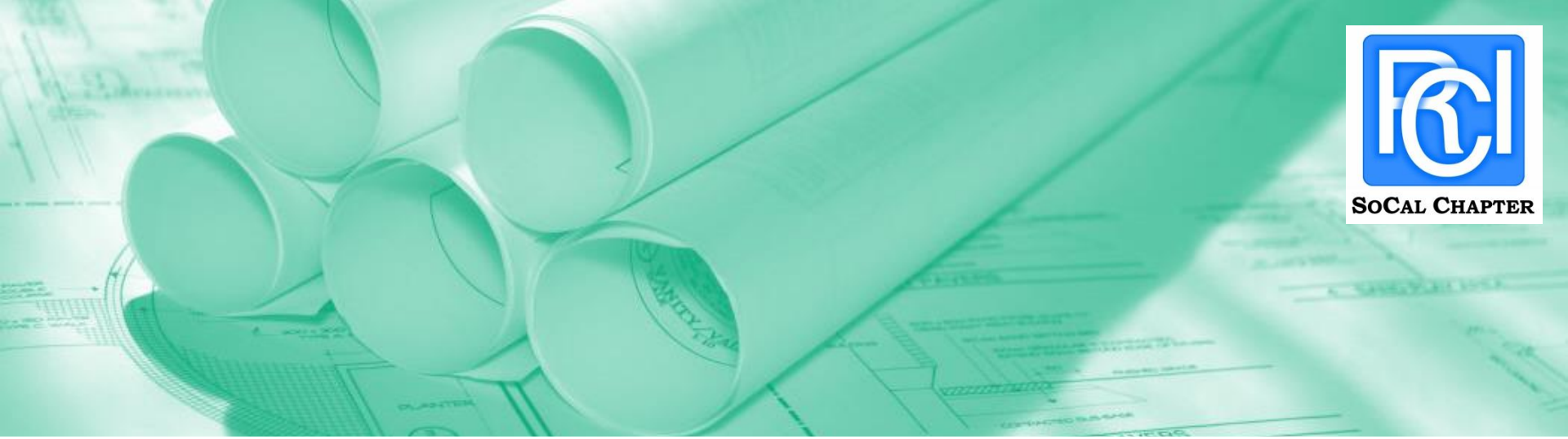

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Snohomish Jr. High School Invited to Review VaproShield

Snohomish Jr. High School – Mineral Wool

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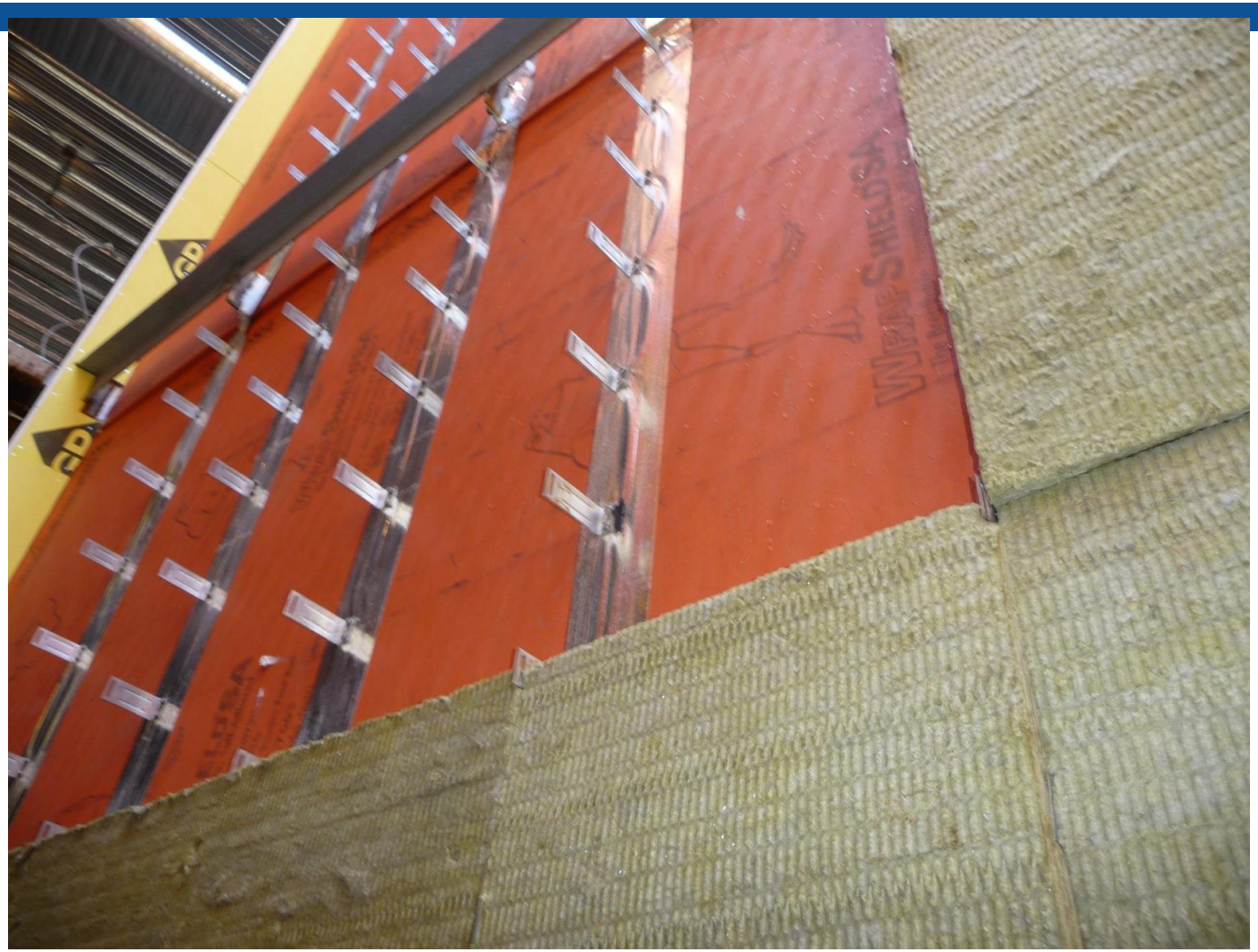
WRB / Air Barrier Under the Insulation



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Snohomish Jr. High School – Hat Channel

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Keys to Success

- Detail the Air Barrier
- Continuity
- Construction Observation
- Testing

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Typical Continuity Challenges

- Changes in Materials at Exterior
- Roof to Wall Connections
- Roof Level Changes
- Separation of Attics to Conditioned Space
- Penetrations
- Window and Door Sills / Thresholds
- Wall to Foundation
- Interior Common Demising Walls

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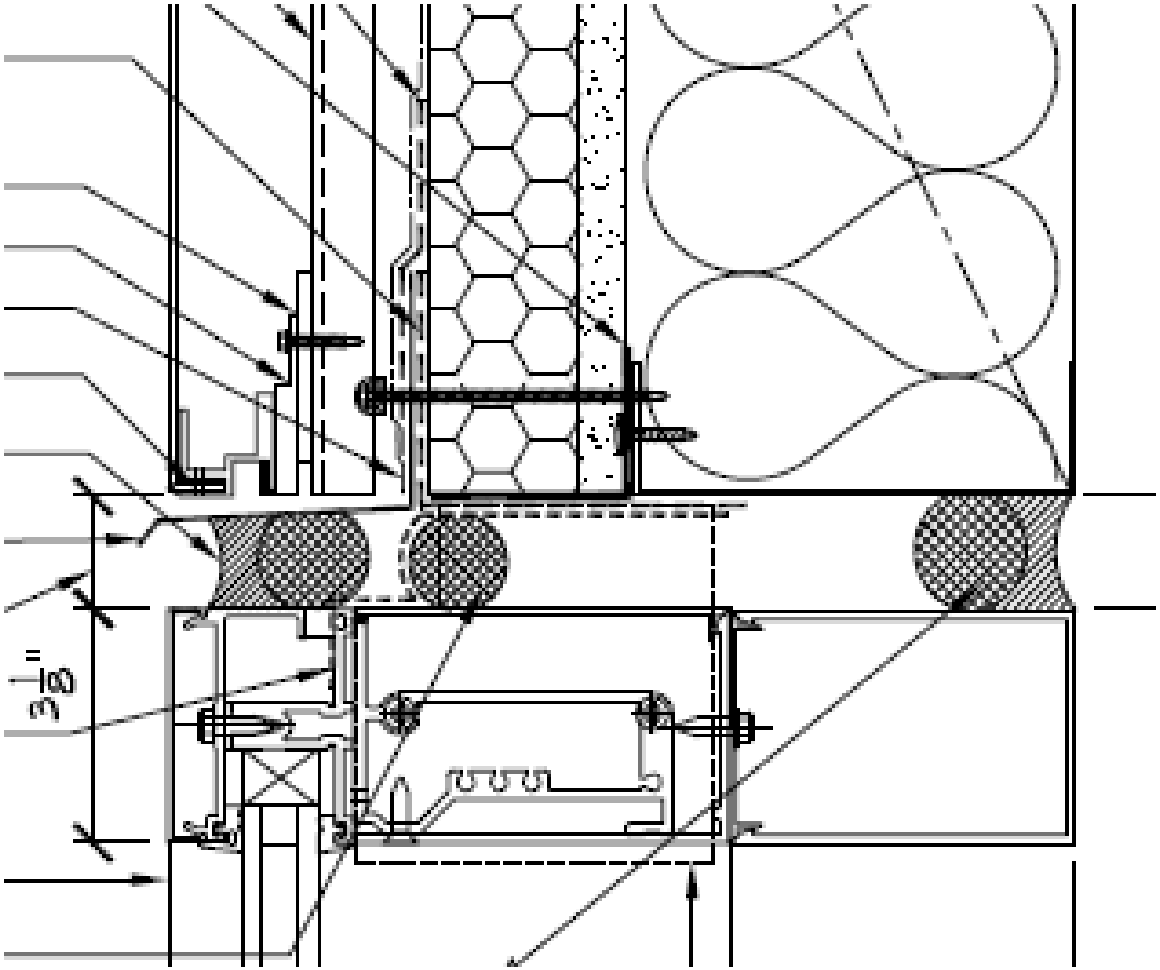
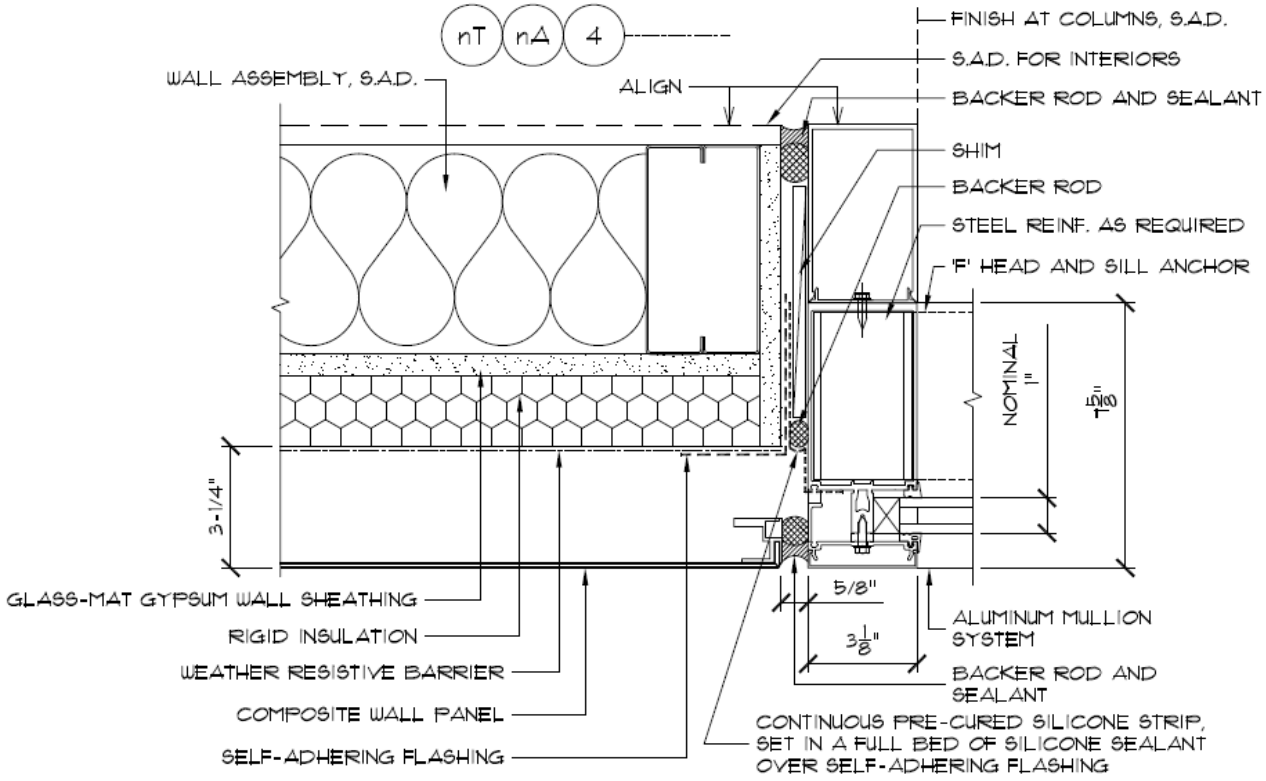
Window Head



Window Jamb



COMPOSITE WALL PANEL TERMINATION AT TYPICAL VERTICAL STOREFRONT JAMB

6
A651

SCALE: N.T.S.

FILE:

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Potential Air Leakage Pathways – Interior

Potential Air Leakage Pathways – Interior Door Thresholds

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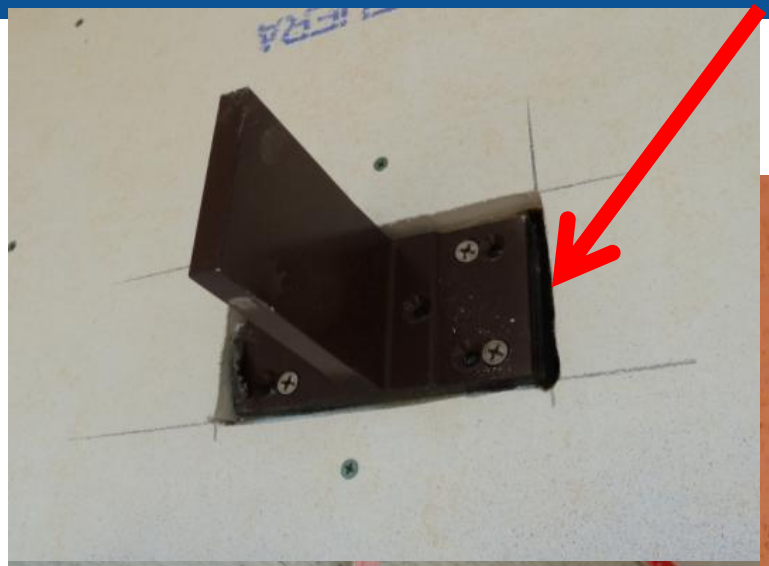
Potential Air Leakage Pathways – Interior Window Perimeters

Potential Air Leakage Pathways – Exterior Penetrations



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Potential Air Leakage Pathways – Drip and Other Flashings

Potential Air Leakage Pathways – Exterior Balloon Framing

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Potential Air Leakage Pathways – Exterior

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Potential Air Leakage Pathways – Exterior Openings

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Potential Air Leakage Pathways – Scupper and Other Penetrations

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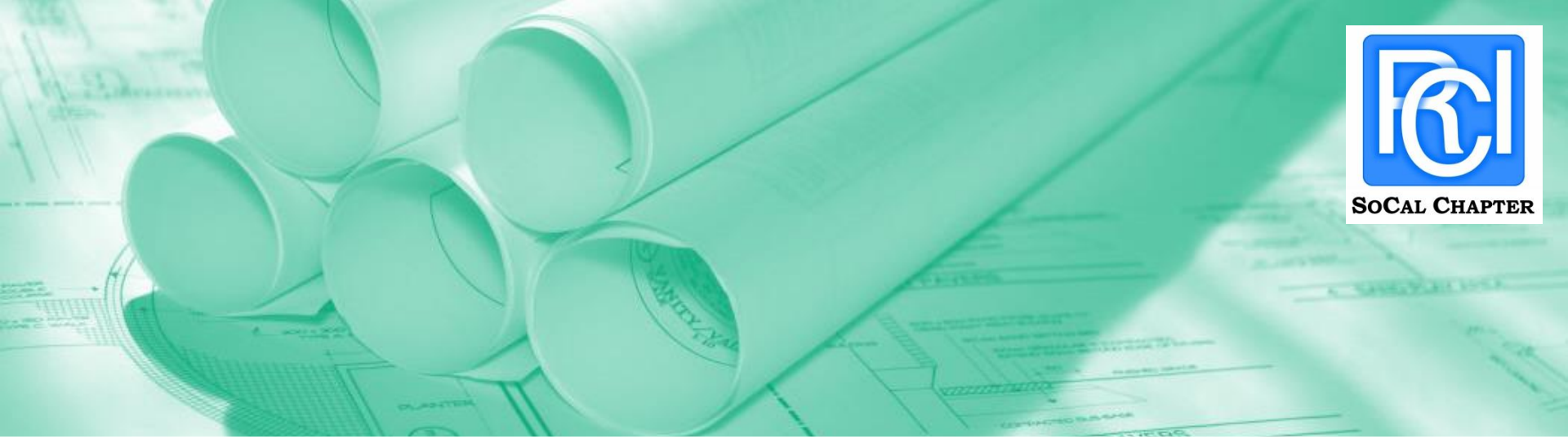

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Available Resources

Available Resources

- Title 24, Part 6 – 2013
- ANSI/ASHRAE/IESNA - 90.1 User's Manual
- Air Barrier Association of America Website
  http://www.airbarrier.org/

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In Closing…

Air Barriers

Code Required*

*in limited applications

Offer Key Benefits

Require Careful Consideration to Detailing

Continuous Insulation

Code Required*

*in limited applications

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Questions?

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