

Christopher Hine, October 8, 2024

Understanding and Addressing Air Leakage in Attached Dwellings

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Description

This session will review areas within attached dwelling units where air sealing can be difficult. These areas include the wall assembly separating two-family dwellings and the rated wall assembly required in townhouses not more than three stories in height. We will assess areas of air leakage in commonly used wall assemblies and review ways to reduce air infiltration. Finally, we will look at additional wall assemblies that may not be commonplace but have the potential to help with reducing high air leakage rates.

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Learning Objectives


1. Identify air leakage trouble spots within the envelope that could lead to a decrease in energy efficiency or introduce contaminants into a conditioned space.
2. Review ways to address those trouble spots with specific products on the market that are designed to help with air infiltration.
3. Understand alternative designs that may differ from typical designs but can help with reducing air leakage in common walls.
4. Identify areas where these designs can also help with the reduction in sound transmittance as well as creating a more energy-efficient assembly.



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Disclaimer

- No individual product or method is being promoted in this webinar. Products and methods should be selected based on the designed assembly.



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Why Do We Seal (2018)?




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N1102.4 Air Leakage

- The building thermal envelope shall be constructed to **limit air leakage** in accordance with the requirements of Sections R1102.4.1 through R1102.4.5.

Source: International Code Council (ICC), 2021, 2018 International Residential Code, County Club Hill, IL.




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N1102.4.1 Building Thermal Envelope

- The building thermal envelope shall comply with Sections N1102.4.1.1 and N1102.4.1.2. The sealing methods between dissimilar materials shall allow for differential expansion and contraction.
 - N1102.4.1.1 - **Installation**
 - N1102.4.1.2 - **Testing**

Source: International Code Council (ICC), 2021, 2018 International Residential Code, County Club Hill, IL.




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N1102.4.1.2 Testing

- The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding five air changes per hour in Climate Zones 1 and 2, and **three air changes per hour in Climate Zones 3 through 8**. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals). Where required by the building official, testing shall be conducted by an approved third party. **A written report of the results of the test shall be signed by the party conducting the test and provided to the building official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope.**

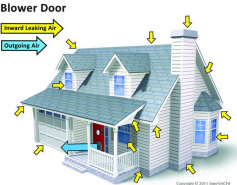
Source: International Code Council (ICC), 2021, 2018 International Residential Code, County Club Hill, IL.



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Blower Door Concept

- Depressurize the home to an exaggerated pressure difference to quantify air infiltration and compare with established benchmarks
- ACH₅₀ = Air Changes per Hour at pressure difference of 50 Pa
 - Current limit in Pennsylvania is 3 ACH₅₀
 - 50 Pa simulates roughly a 20 mph wind on all sides of the home



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Airtightness Requirement: 3 ACH₅₀

- Measured in Air Changes Per Hour at 50 Pascals (ACH₅₀ / ACH₅₀)
- 50 pascals - equivalent to 20 MPH wind on the house

Value we need
(Air Changes Per Hour @ 50 Pascals)

↓

Value from the blower door pressure gauge
(Cubic Feet Per Minute @ 50 Pascals)

↓

Constant
(60 minutes per hour)

↓

$$ACH_{50} = \frac{CFM_{50} \times 60}{V} < 3$$

Volume of the House
(Cubic Feet)

↓

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N1102.4.1.1 Installation

- The components of the building thermal envelope as listed in Table N1102.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria listed in Table N1102.4.1.1, as applicable to the method of construction. Where required by the building official, an approved third party shall inspect all components and verify compliance.

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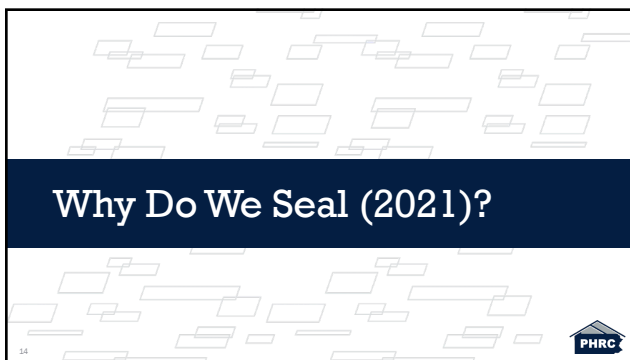
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Table N11.2.4.1.1

TABLE N1102.4.1.1 (R402.4.1.1) AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION*		
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
General requirements	A continuous air barrier shall be installed in the building envelope.	Air-permeable insulation shall not be used as a sealing material.
Ceiling/attic	Breaks or joints in the air barrier shall be sealed. The air barrier in any dropped ceiling or soffit shall be aligned with the insulation and any gaps in the air barrier shall be sealed. Access openings, drop-down stairs or knee wall doors in unconditioned attic spaces shall be sealed.	The insulation in any dropped ceiling/soffit shall be aligned with the air barrier.
Walls	The junction of the foundation and sill plate shall be sealed. The junction of the top plate and the top of exterior walls shall be sealed. Knee walls shall be sealed.	Carries within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance (R-value, of not less than R-3 per inch. Exterior thermal envelope insulation for frame walls shall be installed in substantial contact and continuous alignment with the air barrier.
Windows, skylights and doors	The space between framing and skylights, and the joints of windows and doors, shall be sealed.	-

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N1102.4.1.2 Testing


- The building or dwelling unit shall be tested for air leakage. The maximum air leakage rate for any building or dwelling unit under any compliance path shall not exceed 5.0 air changes per hour or 0.28 cubic feet per minute (CFM) per square foot [0.0079 m³/(s × m²)] of dwelling unit enclosure area. Testing shall be conducted in accordance with ANSI/RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals). Where required by the code official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope have been sealed.

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Dwelling Unit Enclosure Area - Defined

- **DWELLING UNIT ENCLOSURE AREA.** The sum of the area of ceiling, floors and walls separating a dwelling unit's conditioned space from the exterior or from adjacent conditioned or unconditioned spaces. Wall height shall be measured from the finished floor of the dwelling unit to the underside of the floor above.




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N1102.4.1.2 Testing (Exception)

- **Exception:** When testing individual dwelling units, an air leakage rate not exceeding 0.30 cubic feet per minute per square foot [0.008 m³/(s × m²)] of the dwelling unit enclosure area, tested in accordance with ANSI/RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch water gauge (50 Pa), shall be permitted in all climate zones for:
 1. Attached single- and multiple-family building dwelling units.
 2. Buildings or dwelling units that are 1,500 square feet (139.4 m²) or smaller.
- Mechanical ventilation shall be provided in accordance with Section M1505 of this code or Section 403.3.2 of the International Mechanical Code, as applicable, or with other approved means of ventilation.


Source: International Code Council (ICC), (2020), 2021 International Residential Code, County Club #10, Ill.



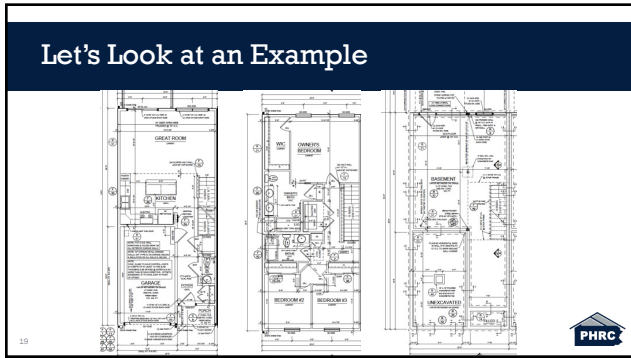
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What Exactly Does That Mean?

<ul style="list-style-type: none"> • 2018 Testing Provisions <ul style="list-style-type: none"> - Volume based test - Air Changes per Hour (ACH) <ul style="list-style-type: none"> • @ 50 Pascals (3ACH50) 	<ul style="list-style-type: none"> • 2021 Testing Provisions <ul style="list-style-type: none"> - Building envelope or dwelling unit enclosure area-based test - Cubic feet per minute per square foot of dwelling unit enclosure area - Tested at 50 Pascals
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Detail of Our Example

- **Square Footage**
 - 1496 Finished
 - 2041 Conditioned
- **Ceiling Height**
 - 9' Basement
 - 8' First Floor
 - 8' Second Floor




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2018 Air Testing Provisions

- **Basement**
 - 5472 cubic feet
- **First floor**
 - 4864 cubic feet
- **Second floor**
 - 7040 cubic feet
- **Total Area**
 - 17,376 total cubic feet

$$4.1ACH_{50} = \frac{1200 \times 60}{17,376 (vol.)}$$

- **Results to pass must be $\leq 3.0 ACH_{50}$**
- **This would not pass**




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2021 Air Testing Provisions

- Basement**
 - 1514 SqFt dwelling unit enclosure area
- First floor**
 - 960 SqFt dwelling unit enclosure area
- Second floor**
 - 1904 SqFt dwelling unit enclosure area
- Total Dwelling Unit Enclosure Area**
 - 4378 SqFt

$$\frac{1200}{4378 \text{ (sq. ft.)}} = .27 \text{ CFM50 per SqFt}$$

- Results to pass must be $\leq .30$ CFM50 per SqFt
- This would pass!



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Typical Air Sealing Areas





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Areas We Already Know: Table N1102.4.1.1 Air Barrier and Insulation Installation

- General requirements
- Ceiling/attic
- Walls
- Windows, skylights and doors
- Rim joists
- Floors
- Crawl space walls
- Shafts, penetrations
- Narrow cavities
- Garage separation
- Recessed lighting
- Plumbing and wiring
- Shower / tub on exterior wall
- Electrical / phone box on exterior walls
- HVAC register boots
- Concealed sprinklers

Source: International Code Council (ICC), (2017), 2018 International Residential Code, Country Club Hill, IL




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Walls


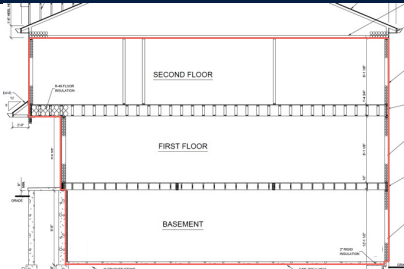
- Air Barrier Criteria**
 - The junction of the foundation and sill plate shall be sealed.
 - The junction of the top plate and the top of exterior walls shall be sealed.
 - Knee walls shall be sealed.
- Insulation Installation Criteria**
 - Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with material having an R-value of R-3 per inch min.
 - Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.

Source: International Code Council (ICC), (2017). 2018 International Residential Code, County Club #14, IL.



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Pen Test



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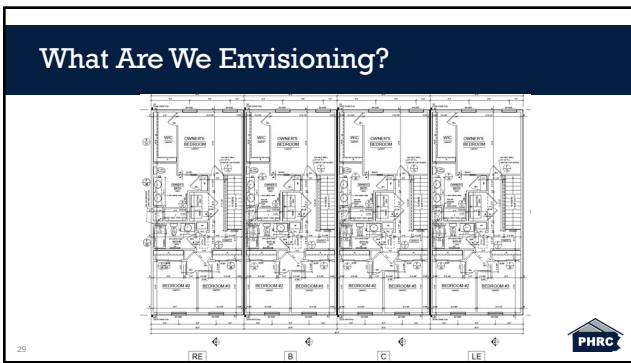
Image Source: https://www.joniblog.com/how-to/exteriors/sealing-the-foundation-to-the-frame/#_g_



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Main Trouble Spots in Townhomes

- Common Wall
- Exterior Wall Intersections & Offsets

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Main Trouble Spots in Townhomes


- Common Wall
- Exterior Wall Intersections & Offsets

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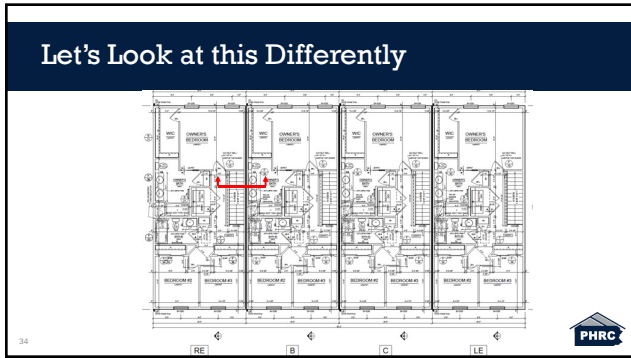
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R302.2.2 - Common Walls

- Common walls separating townhouse units shall be assigned a fire-resistance rating in accordance with Item 1 or 2 and shall be rated for fire exposure from both sides. Common walls shall extend to and be tight against the exterior sheathing of the exterior walls, or the inside face of exterior walls without stud cavities, and the underside of the roof sheathing. The common wall shared by two townhouse units shall be constructed without plumbing or mechanical equipment, ducts or vents, other than water-filled fire sprinkler piping in the cavity of the common wall. Electrical installations shall be in accordance with Chapters 34 through 43. Penetrations of the membrane of common walls for electrical outlet boxes shall be in accordance with Section R302.4.

33 Source: International Code Council (ICC), (2020), 2021 International Residential Code, Country Club Hill, IL. 

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ASW Installation Details (2-Hour Assembly)

- Two layers of 1" Shaftliner
- Minimum 3/4" air space on both sides must be maintained between liner panels and adjacent framing
- Appendix K: Sound Transmission - STC Rating of 45

Source: International Code Council (ICC) (2020), 2022 International Residential Code, County Clark, VA.

2-Hour Fire Rating
Design Reference: UL 263, UL 1013, ULC S101, ULC S102, ULC S103, ULC S104, ULC S105, ULC S106, ULC S107, ULC S108, ULC S109, ULC S110, ULC S111, ULC S112, ULC S113, ULC S114, ULC S115, ULC S116, ULC S117, ULC S118, ULC S119, ULC S120, ULC S121, ULC S122, ULC S123, ULC S124, ULC S125, ULC S126, ULC S127, ULC S128, ULC S129, ULC S130, ULC S131, ULC S132, ULC S133, ULC S134, ULC S135, ULC S136, ULC S137, ULC S138, ULC S139, ULC S140, ULC S141, ULC S142, ULC S143, ULC S144, ULC S145, ULC S146, ULC S147, ULC S148, ULC S149, ULC S150, ULC S151, ULC S152, ULC S153, ULC S154, ULC S155, ULC S156, ULC S157, ULC S158, ULC S159, ULC S160, ULC S161, ULC S162, ULC S163, ULC S164, ULC S165, ULC S166, ULC S167, ULC S168, ULC S169, ULC S170, ULC S171, ULC S172, ULC S173, ULC S174, ULC S175, ULC S176, ULC S177, ULC S178, ULC S179, ULC S180, ULC S181, ULC S182, ULC S183, ULC S184, ULC S185, ULC S186, ULC S187, ULC S188, ULC S189, ULC S190, ULC S191, ULC S192, ULC S193, ULC S194, ULC S195, ULC S196, ULC 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S997, ULC S998, ULC S999, ULC S1000.

90-90 STC Sound Test
See Reference: IAC 11, 10-201
 Test Room: 11' 0" x 11' 0" (Insulated) Shaftliner mounted in 10' Shaft 11' 0" x 11' 0" x 11' 0" x 11' 0" (10' x 11' 0" x 11' 0" x 11' 0")
 Sound Treated with 7" (21 mm) x 4" (102 mm) stud wall with 10" (254 mm) Shaftliner system without stud wall at assembly and 3" (76 mm) fiberglass insulation in stud space both sides.

Image Source: <https://www.bushiga.com/wp-content/uploads/2018/02/11-David-Dewar-Shaftliner-area-walls-technical-guide.pdf>

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Area Separation Walls (ASW) UL Design U373

GYPSUM WALLBOARD, STEEL STUDS

5/8" REGULAR GYPSUM WALLBOARD (SEE MEMO G-6)
 1/4" AIR SPACE (ON BOTH SIDES MUST BE MAINTAINED BETWEEN LINER PANELS AND ADJACENT FRAMING) SOUND TESTED MEMO G-6 (SEE MEMO G-6)
 WITH 1/2" GYPSUM BOARD (SEE MEMO G-6) ON EACH SIDE OF ASSEMBLY AND 1/2" FIBERGLASS INSULATION IN STUD SPACE BOTH SIDES

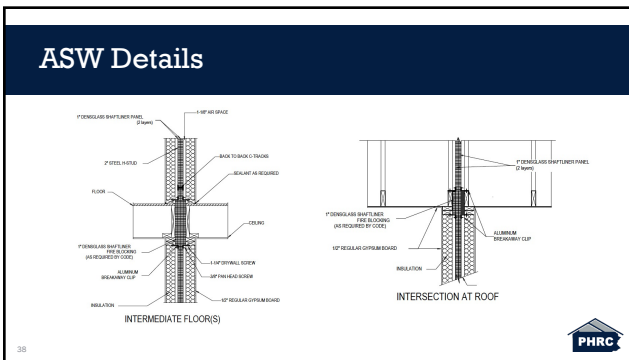
HOURLY RATING: 2-HOUR
 STC RATING: 50 STC
 SOUND TEST REFERENCE: IAC 11, 10-201

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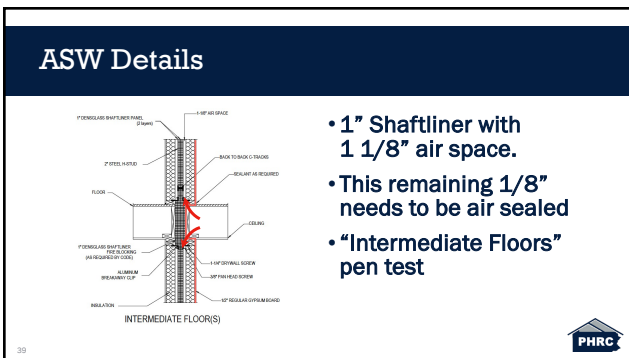




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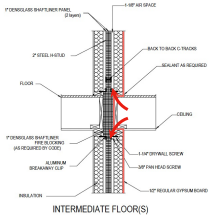


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ASW Details – Between Floors



- Incorporate 1" shaftliner into your air sealing
- Ensure all remaining cracks are filled with sealant



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Seal the Cracks

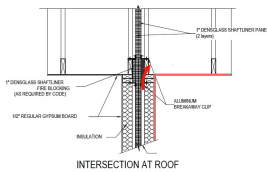


Image Source: PHRC Webinar "Air Sealing Solutions for Attached Homes" delivered on January 10, 2023, by Norm Horn & Jimmy Stock



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ASW Details - Ceiling



- Review the defined air barrier
- Are there penetrations below the fire blocking (electrical boxes)?



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Sealing the Square

- Behind the top plate
- Intersecting walls



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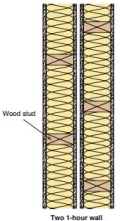
Image Source: PHRC Webinar "Air Sealing Solutions for Attached Homes" delivered on January 10, 2023, by Adam White & Jeremy Smith



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Alternative to the ASW


- **R302.2.1 Double Wall**
 - Each townhouse shall be separated by two 1-hour fire-resistance-rated wall assemblies tested in accordance with ASTM E119, UL 263 or Section 703.3 of the International Building Code.



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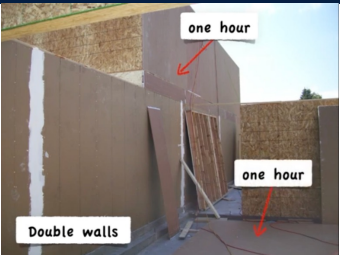
Source: International Code Council (ICC), 2021, 2023 International Residential Code, Country Club Hill, IL

Source: <https://codes.iccsafe.org/content/IRC2018FC/2022-downloads/separation#R302.2.1-2018-2021-2023>




44

Double Wall



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Image Source: <https://www.phrcinc.com/resources/2021/07/28/>



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Key Points for Common Wall

- Be more detailed in your ASW pen test
- Use fire blocking locations as an added air seal location
- Review alternative common wall designs

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Main Trouble Spots in Townhomes


- Common Wall
- Exterior Wall Intersections & Offsets

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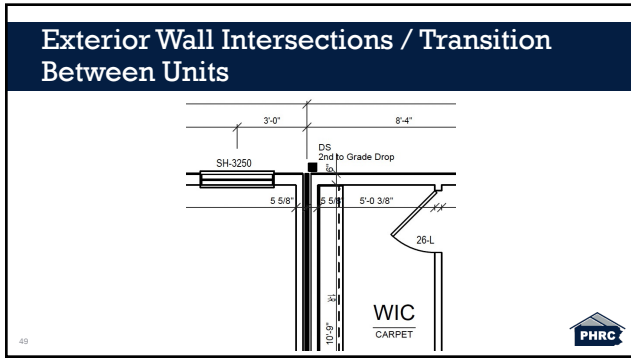
47

R302.2.2 - Common Walls

- Common walls separating townhouse units shall be assigned a fire-resistance rating in accordance with Item 1 or 2 and shall be rated for fire exposure from both sides. Common walls shall extend to and be tight against the exterior sheathing of the exterior walls, or the inside face of exterior walls without stud cavities, and the underside of the roof sheathing. The common wall shared by two townhouse units shall be constructed without plumbing or mechanical equipment, ducts or vents, other than water-filled fire sprinkler piping in the cavity of the common wall. Electrical installations shall be in accordance with Chapters 34 through 43. Penetrations of the membrane of common walls for electrical outlet boxes shall be in accordance with Section R302.4.

48 Source: International Code Council (ICC), (2020), 2021 International Residential Code, Country Club Hill, IL. 

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From the Outside

- Daylight?
- Cantilever
- Air moves based on pressure, not gravity
- What does the sheathing nail to?

Image Source: PHRC Webinar "Air Sealing Solution for Attached Decks", delivered on January 10, 2023, by Adam Mann & Jeremy Dorch

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From the Inside

- Daylight?
- Air moves based on pressure, not gravity

Image Source: PHRC Webinar "Air Sealing Solution for Attached Decks", delivered on January 10, 2023, by Adam Mann & Jeremy Dorch

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R302.2.2 - Common Walls (2021 IRC)

- Common walls separating townhouse units shall be assigned a fire-resistance rating in accordance with Item 1 or 2 and shall be rated for fire exposure from both sides. Common walls shall extend to and be tight against the exterior sheathing of the exterior walls, or the inside face of exterior walls without stud cavities, and the underside of the roof sheathing. The common wall shared by two townhouse units shall be constructed without plumbing or mechanical equipment, ducts or vents, other than water-filled fire sprinkler piping in the cavity of the common wall. Electrical installations shall be in accordance with Chapters 34 through 43. Penetrations of the membrane of common walls for electrical outlet boxes shall be in accordance with Section R302.4.

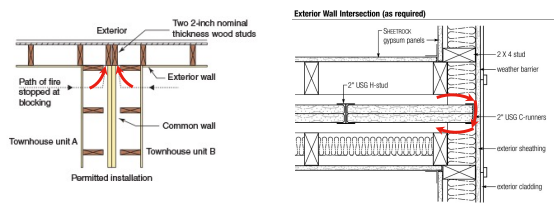
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Source: International Code Council (ICC). (2020). 2021 International Residential Code. Country Club Hill, IL.



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Exterior Wall Intersections



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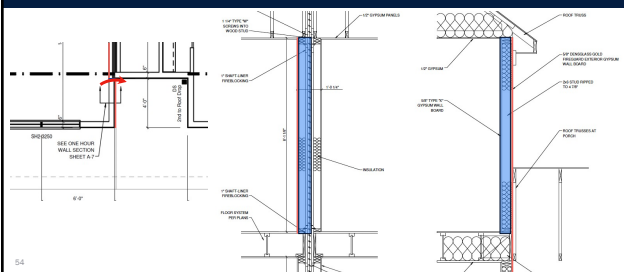
Source: <https://codes.icdweb.org/codes/IRC2021SCP/1/1002-2-townhouses>

Source: https://www.usg.com/content/dam/USG_Marketing_Communications/uniting_images/product_images/interior_interiors/finished_interiors/1/1002-2-townhouses-separation-walls-assembly-en-54-92-2.pdf



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Building Offsets




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Key Points for Exterior Wall Intersections & Offsets

- Be more detailed in your ASW pen test
- Remember, air barriers must be continuous
- Detail air barrier transitions

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Alternative Air Sealing Method

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Case Study

Increasing Innovation and Affordability in Housing: A Case Study on Townhome Area Separation Walls

Christine Barbour
James Lyons
Newport Partners, LLC


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Source: <https://www.phrc.org/resources/whitepapers/whitepaper-2023-01-01>
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Case Study Parameters


<ul style="list-style-type: none"> • "Building one" • 6 units • Installed typical ASW approach only • "Innovated aerosolized sealant" 	<ul style="list-style-type: none"> • "Building two" • 5 units • Installed typical ASW • Incorporated alternative air sealing methods • "Innovated aerosolized sealant"
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"Innovated Aerosolized Sealant" AeroBarrier

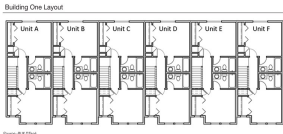

- AeroBarrier is an interior applied air sealing system that seals building envelope leaks up to 1/2".
- The waterborne sealant is aerosolized and injected into a pressurized home.
- The sealant is self-guided to the edges of visible and invisible leaks to create a seal by accumulating across the leak surface.




59 Source: <https://www.aerobarrier.com/press-releases/aerobarrier-launches> 

59

Case Study Parameters

<ul style="list-style-type: none"> • "Building one" 	<ul style="list-style-type: none"> • "Building two" 
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60 Source: <https://www.aerobarrier.com/press-releases/aerobarrier-launches> 

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Preliminary Results

- Typical air leakage prior to the alternative sealing method (AeroBarrier) ranged from 4 to 7 ACH50.
- Temporary coverings were added to horizontal items such as window sashes and these areas were taped.
- Because this temporary condition contributed to the reduction in ACH50, the test was reduced the rate to less than necessary.

61 Source: <https://www.phrc.org/wp-content/uploads/2024/07/2024-07-14-01.pdf>

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Final Results

• Building one

Building One Blower Door Test Results

BUILDING 1 Dwelling Unit	A	B	C	D	E	F
Blower Door Pre-AeroBarrier (same air sealing performed)	4.96 ACH50	5.97 ACH50	6.23 ACH50	4.81 ACH50	6.44 ACH50	3.76 ACH50
Blower Door After AeroBarrier (temporary air sealing)	1.64 ACH50	1.50 ACH50	1.88 ACH50	1.53 ACH50	1.67 ACH50	1.60 ACH50
Final Code Blower Door	2.19 ACH50	2.39 ACH50	2.75 ACH50	2.05 ACH50	2.34 ACH50	2.02 ACH50

• Building two

Building 2 Blower Door Test Results

BUILDING 2 Dwelling Unit	A	B	C	D	E
Blower Door Pre-AeroBarrier (same air sealing performed)	4.63 ACH50	7.24 ACH50	6.43 ACH50	6.62 ACH50	5.10 ACH50
Blower Door After AeroBarrier (temporary air sealing)	1.83 ACH50	1.80 ACH50	1.90 ACH50	1.70 ACH50	1.59 ACH50
Final Code Blower Door	2.88 ACH50	3.00 ACH50	2.54 ACH50	2.64 ACH50	2.31 ACH50

ACH50 - air leakage per hour at 50 pascals pressure. 62 Source: <https://www.phrc.org/wp-content/uploads/2024/07/2024-07-14-01.pdf>

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Conclusions as Stated From This Case Study


- This method minimized worries regarding sealed air gaps
- Reduced the need for incorporating alternative air sealing methods
- Reduced the need to caulk electrical boxes due to the aerosolized sealant filled those small gaps
- “The benefit is that it could give builders a universal solution without code changes or differences across jurisdictions resulting in more consistency with the potential for lower costs.”

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Summary

- Lower air infiltration = lower energy consumption from the occupant
- Air leakage though the ASW is equivalent to air leakage to the outside
- If it's fire blocked, it needs to be air sealed
- Look outside the box

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Questions?



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Understanding and Addressing Air Leakage in Attached Dwellings

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