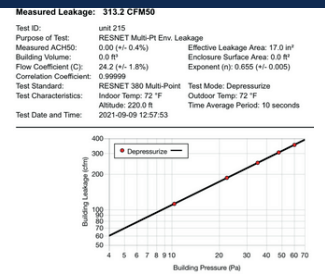
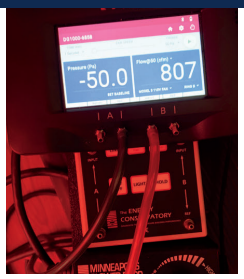
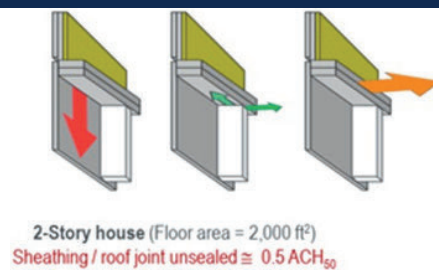
Air Sealing Requirements

2021 VRC/VECC Update Guide







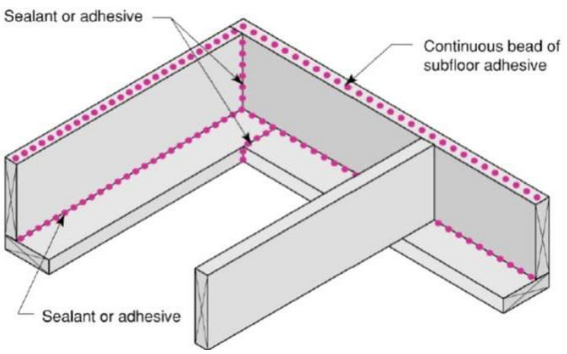
Added Language in Table of Required Air Sealing:

Summary: Conscientious, detail-oriented air sealing is among the most cost-effective tools available to builders seeking to meet code and construct a durable, energy efficient home. The residential energy code has included a list of required air sealing details since the first edition of the International Energy Conservation Code (IECC) in 1998. Each new version has provided more specificity to help ensure key locations of potential drafts are not missed.

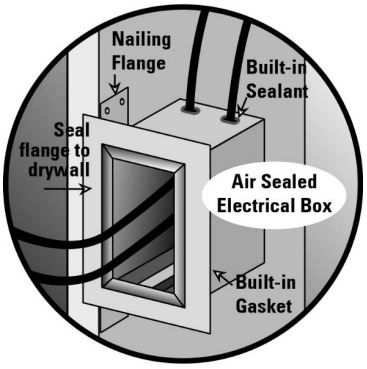
TABLE N1102.4.1.1 (R402.4.1.1) AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION lists locations specifically requiring air sealing. That said, smart construction prioritizes close attention to any and all areas where building materials meet or holes are cut in order to make the home's air barrier complete and continuous – and thereby better manage moisture, pests, air quality, comfort, and heating/cooling costs. Of course, the ultimate test of effective air sealing is the blower door test. Confirming that the locations listed in Table N1102.4.1.1 (R402.4.1.1) are sealed helps ensure the home will pass the blower door test on the first attempt.

Noteworthy new air sealing requirements:
For unvented crawlspaces and conditioned basements, the entire sill plate and rim joist assembly should be made airtight by sealing (with caulk or adhesive) butt joints, corners, and linear joints between boards.

Ideally, a home's primary air barrier occurs at the exterior sheathing layer. Generally, it is much easier to keep it continuous and complete there. The 2021 code stipulates that, if there is not a continuous air barrier installed *behind* the electrical and communication boxes, then those boxes should be made airtight.



Source: https://bsesc.energy.gov/energy-basics/sill-plates-are-installed-sealing-rim-joists



Source: https://basc.pnnl.gov/images/air-tight-electrical-boxes-have-built-gaskets-and-self-sealing-wire-holes

Plan Review Focus: Ideally, plans would note where the continuous air barrier is intended, so that inspectors know whether to look for items such as sealed electrical boxes.

Notes: Air movement through the building envelope can bring moisture-laden air from the exterior during the summertime and lead to potential moisture issues. Air movement through air-permeable insulation such as fiberglass will reduce the R-Value of those materials. Table N1102.4.1.1 (R402.4.1.1) covers major areas of potential air leakage, but there will be other areas of leakage. Being present at a home during the blower door test can be a valuable way to identify additional leakage areas. The house is depressurized during the test and air movement can be felt at leakage spots while the blower fan is running.

Additional Resources:

- https://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Thermal_Enclosure_System_Rater_Checklist_Guidebook_Rev04_v5_FINAL_508.pdf
- https://buildingscience.com/documents/digests/bsd-104-understanding-air-barriers (and related documents)
- https://sws.nrel.gov/spec/3 Detailed guide to air-sealing work

2021 VRC/VECC Code References:

N1102.4.1 (R402.4.1) Building thermal envelope. The building thermal envelope shall comply with Sections N1102.4.1.1 through N1102.4.1.3. The sealing methods between dissimilar materials shall allow for differential expansion and contraction.

N1102.4.1.1 (R402.4.1.1) Installation. The components of the building thermal envelope shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table N1102.4.1.1, as applicable to the method of construction. Where required by the code official, an

TABLE N1102.4.1.1 (R402.4.1.1) AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION[a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA[d]
General requirements	A continuous air barrier shall be installed in the building envelope.	Air-permeable insulation shall not be used as a sealing material.
	Breaks or joints in the air barrier shall be sealed.	
Ceiling/attic	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.	The insulation in any dropped ceiling/soffit shall be aligned with the air barrier.
	Access openings, drop down stairs or knee wall doors to unconditioned attic spaces shall be sealed.	
	Knee walls shall be sealed.	

Walls	The junction of the foundation and sill plate shall be sealed.	Cavities 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 framed walls shall be installed in substantial contact and continuous alignment with the air barrier.
	The junction of the top plate and the top of exterior walls shall be sealed.	
	Knee walls shall be sealed.	
Windows, skylights and doors	The space between framing and skylights, and the jambs of windows and doors, shall be sealed.	—
Rim joists	Rim joists shall include an exterior air barrier.[b]	Rim joists shall be insulated so that the insulation maintains permanent contact with the exterior rim board.[b]
	The junctions of the rim board to the sill plate and the rim board and the subfloor shall be air sealed.	
Floors, including cantilevered floors and floors above garages	The air barrier shall be installed at any exposed edge of insulation.	Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of subfloor decking. Alternatively, floor framing cavity insulation shall be in contact with the top side of sheathing, or continuous insulation installed on the underside of floor framing and extending from the bottom to the top of all perimeter floor framing members.
Basement crawl space and slab foundations	Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder/air barrier in accordance with Section N1102.2.10. (R402.2.10).	Crawl space insulation, where provided instead of floor insulation, shall be installed in accordance with Section N1102.2.10 (R402.2.10).
	Penetrations through concrete foundation walls and slabs shall be air sealed.	Conditioned basement foundation wall insulation shall be installed in accordance with Section N1102.2.8.1 (R402.2.8.1).
	Class 1 vapor retarders shall not be used as an air barrier on below-grade walls and shall be installed in accordance with Section R702.7.	Slab-on-grade floor insulation shall be installed in accordance with Section N1102.2.10 (R402.2.9.1).

HVAC register boots	HVAC supply and return register boots that penetrate building thermal envelope shall be sealed to the subfloor, wall covering or ceiling penetrated by the boot.	—
Concealed sprinklers	Where required to be sealed, concealed fire sprinklers shall only be sealed in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.	—

a. Inspection of log walls shall be in accordance with the provisions of ICC 400.
b. Air barrier and insulation full enclosure is not required in unconditioned/ventilated attic spaces and at rim joists.
c. Air barriers used behind showers and tubs on exterior walls shall be of a permeable material that does not cause the entrapment of moisture in the stud cavity.
d. Structural integrity of headers shall be in accordance with the applicable building code.

N1102.4.1.2 (R402.4.1.2) Testing. The building or dwelling unit shall be tested and verified as having an air leakage rate not exceeding 5 air changes per hour. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779, or ASTM E1827 and reported at a pressure of 0.2 inches w.g. (50 Pa). 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 conducted by a Virginia licensed general contractor, a Virginia licensed HVAC contractor, a Virginia licensed home inspector, a Virginia registered design professional, a certified BPI Envelope Professional, a certified HERS rater, or a certified duct and envelope tightness rater. The party conducting the test shall have been trained on the equipment used to perform the test. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope.

Note: Should additional sealing be required as a result of the test, consideration may be given to the issuance of a temporary certificate of occupancy in accordance with Section 116.1.1.

During testing:

1. Exterior windows and doors and fireplace and stove doors shall be closed, but not sealed beyond the intended weather stripping or other infiltration control measures;
2. Dampers, including exhaust, intake, makeup air, backdraft, and flue dampers shall be closed, but not sealed beyond intended infiltration control measures;
3. Interior doors, if installed at the time of the test, shall be open;
4. Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;
5. Heating and cooling systems, if installed at the time of the test, shall be turned off; and
6. Supply and return registers, if installed at the time of the test, shall be fully open.

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.

N1102.4.1.3 (R402.4.1.3) Leakage rate. When complying with Section N1101.2.1 (R401.2.1), the building or dwelling unit shall have an air leakage rate not exceeding 5 air changes per hour in Climate Zones 3 through 5, when tested in accordance with Section N1102.4.1.2 (R402.4.1.2).

N1102.4.2 (R402.4.2) Fireplaces. New wood-burning fireplaces shall have tight-fitting flue dampers or doors, and outdoor combustion air Where using tight-fitting doors on factory-built fireplaces listed and labeled in accordance with UL 127, the doors shall be tested and listed for the fireplace.

N1102.4.3 (R402.4.3) Fenestration air leakage. Windows, skylights and sliding glass doors shall have an air infiltration rate of not greater than 0.3 cfm per square foot (1.5 L/s/m2), and for swinging doors not greater than 0.5 cfm per square foot (2.6 L/s/m2), when tested in accordance with NFRC 400 or AAMA/WDMA/CSA 101/I.S.2/A440 by an accredited, independent laboratory and listed and labeled by the manufacturer.

Exception: Site-built windows, skylights and doors.

N1102.4.4 (R402.4.4) Rooms containing fuel-burning appliances. In Climate Zones 3 through 8, where open-combustion airducts provide combustion air to open combustion fuel-burning appliances, the appliances and combustion air opening shall be located outside the building thermal envelope or enclosed in a room that is isolated from inside the thermal envelope. Such rooms shall be sealed and insulated in accordance with the envelope requirements of Table N1102.1.3, where the walls, floors and ceilings shall meet a minimum of the basement wall R-value requirement. The door into the room shall be fully gasketed and any water lines and ducts in the room insulated in accordance with Section N1103. The combustion air duct shall be insulated where it passes through conditioned space to an R-value of not less than R-8.

Exceptions:

1. Direct vent appliances with both intake and exhaust pipes installed continuous to the outside.
2. Fireplaces and stoves complying with Sections N1102.4.2 and R1006.

N1102.4.5 (R402.4.5) Recessed lighting. Recessed luminaires installed in the building thermal envelope shall be sealed to limit air leakage between conditioned and unconditioned spaces. Recessed luminaires shall be IC-rated and labeled as having an air leakage rate of not greater than 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E283 at a pressure differential of 1.57 psf (75 Pa). Recessed luminaires shall be sealed with a gasket or caulked between the housing and the interior wall or ceiling covering.

N1102.4.6 (R402.4.6) Electrical and communication outlet boxes (air-sealed boxes). Electrical and communication outlet boxes installed in the building thermal envelope shall be sealed to limit air leakage between conditioned and unconditioned spaces. Electrical and communication outlet boxes shall be tested in accordance with NEMA OS 4, Requirements for Air-Sealed Boxes for Electrical and Communication Applications, and shall have an air leakage rate of not greater than 2.0 cubic feet per minute (0.944 L/s) at a pressure differential of 1.57 psf (75 Pa). Electrical and communication outlet boxes shall be marked "NEMA OS 4" or "OS 4" in accordance with NEMA OS 4. Electrical and communication outlet boxes shall be installed per the manufacturer's instructions and with any supplied components required to achieve compliance with NEMA OS 4.

Definitions:

ABOVE-GRADE WALL. A wall more than 50 percent above grade and enclosing conditioned space. This includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and skylight shafts.

ADDITION. An extension or increase in the conditioned space floor area, number of stories or height of a building or structure.

AIR BARRIER. One or more materials joined together in a continuous manner to restrict or prevent the passage of air through the building thermal envelope and its assemblies.

ALTERATION. Any construction, retrofit or renovation to an existing structure other than repair or addition. Also, a change in a building, electrical, gas, mechanical or plumbing system that involves an extension, addition or change to the arrangement, type or purpose of the original installation.

BASEMENT WALL. A wall 50 percent or more below grade and enclosing conditioned space.

BUILDING THERMAL ENVELOPE. The basement walls, exterior walls, floors, ceiling, roofs and any other building element assemblies that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space.

CAVITY INSULATION. Insulating material located between framing members.

CONDITIONED FLOOR AREA. The horizontal projection of the floors associated with the conditioned space.

CONDITIONED SPACE. An area, room or space that is enclosed within the building thermal envelope and that is directly or indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate through openings with conditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or cooling.

CONTINUOUS AIR BARRIER. A combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.

CONTINUOUS INSULATION (ci). Insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior, or is integral to any opaque surface, of the building envelope.

CRAWL SPACE WALL. The opaque portion of a wall that encloses a crawl space and is partially or totally below grade.

DWELLING UNIT. A single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation.

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.

ENERGY ANALYSIS. A method for estimating the annual energy use of the proposed design and standard reference design based on estimates of energy use.

ENERGY COST. The total estimated annual cost for purchased energy for the building functions regulated by this code, including applicable demand charges.

EXTERIOR WALL. Walls including both above-grade walls and basement walls.

INFILTRATION. The uncontrolled inward air leakage into a building caused by the pressure effects of wind or the effect of differences in the indoor and outdoor air density or both.

INSULATED SIDING. A type of continuous insulation with manufacturer-installed insulating material as an integral part of the cladding product having an R-value of not less than R-2.

LABELED. Equipment, materials or products to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, approved agency or other organization concerned with product evaluation that maintains periodic inspection of the production of such labeled items and whose labeling indicates either that the equipment, material or product meets identified standards or has been tested and found suitable for a specified purpose.

LISTED. Equipment, materials, products or services included in a list published by an organization acceptable to the code official and concerned with evaluation of products or services that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services and whose listing states either that the equipment, material, product or service meets identified standards or has been tested and found suitable for a specified purpose.

ROOF ASSEMBLY. A system designed to provide weather protection and resistance to design loads. The system consists of a roof covering and roof deck or a single component serving as both the roof covering and the roof deck. A roof assembly includes the roof covering, underlayment and roof deck and can also include a thermal barrier, an ignition barrier, insulation or a vapor retarder.

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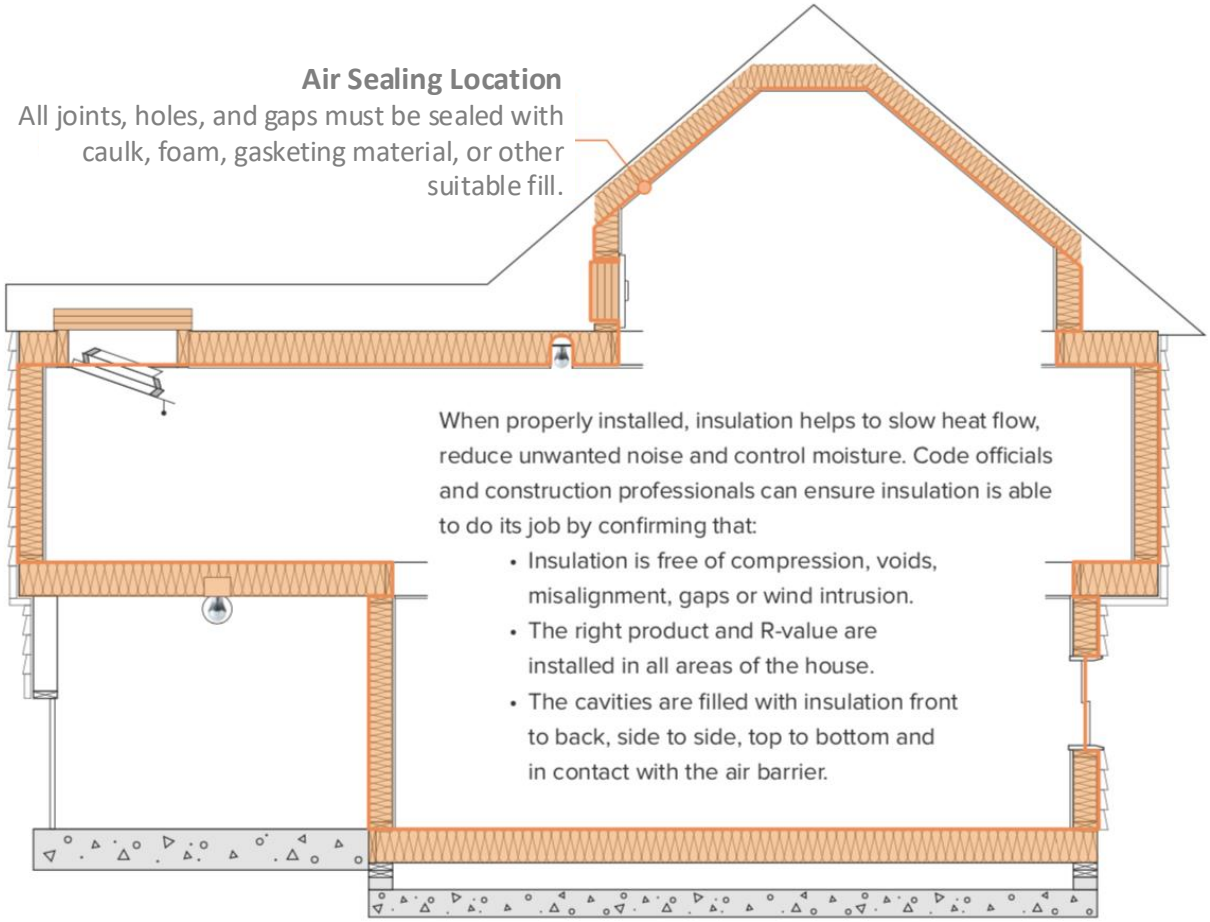
INSULATION INSTALLATION

Tips for Meeting the 2021 VRC/VECC

To obtain the R-values in the 2021 VRC/VECC Table N1102.1.3 (R402.1.1), insulation shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table N1102.4.1.1 (R402.4.1.1), as applicable to the method of construction.



Insulation

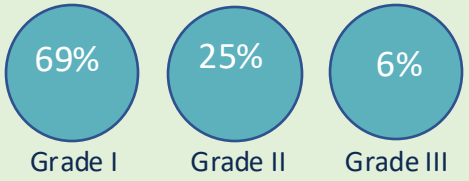
The 2017-2018 Virginia Residential "Field Study" gauged energy code enforcement. www.energycodes.gov/residential-energy-code-field-studies

Ceiling Insulation *R-Value*

- 2015 VA Code: R-38
- Study results: 96% COMPLIANT

Ceiling Insulation *Quality*

- Study results : 69% COMPLIANT



Wall Insulation *R-Value*

- 2015 VA Code required R-15 or R-13 + 1
- Study results : 100% COMPLIANT

Wall Insulation *Quality*

- 2015 VA Code required per manufacturer's instructions
- Study results : 37% COMPLIANT

Grade 1: almost no gaps; Grade II: up to 2% gaps, compression or voids; Grade III: 2-5% gaps, compression or voids

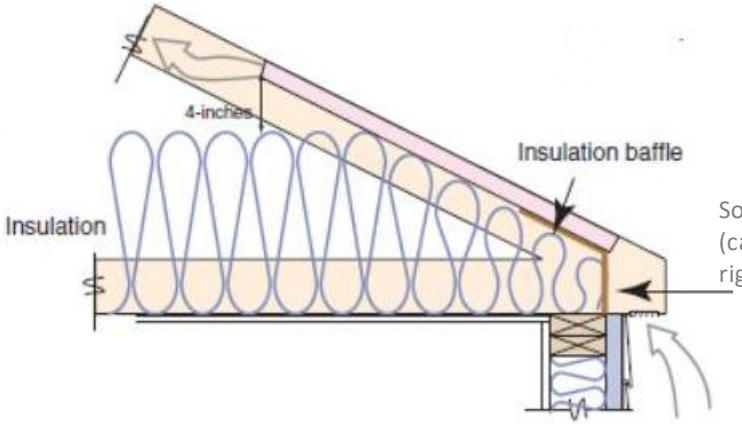
See the Insulation, Air Barrier, and Air Sealing Inspection Checklist to make sure code-compliance is achieved.

Example Details

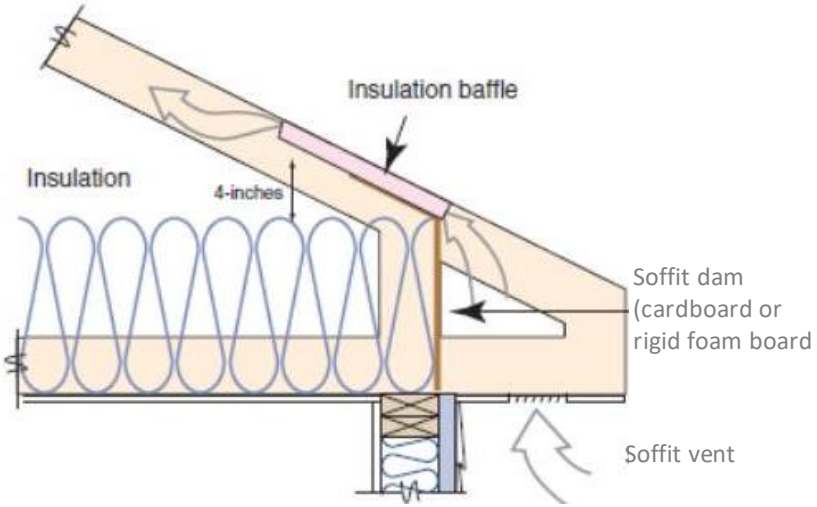
Images: basc.pnnl.gov/resource-guides

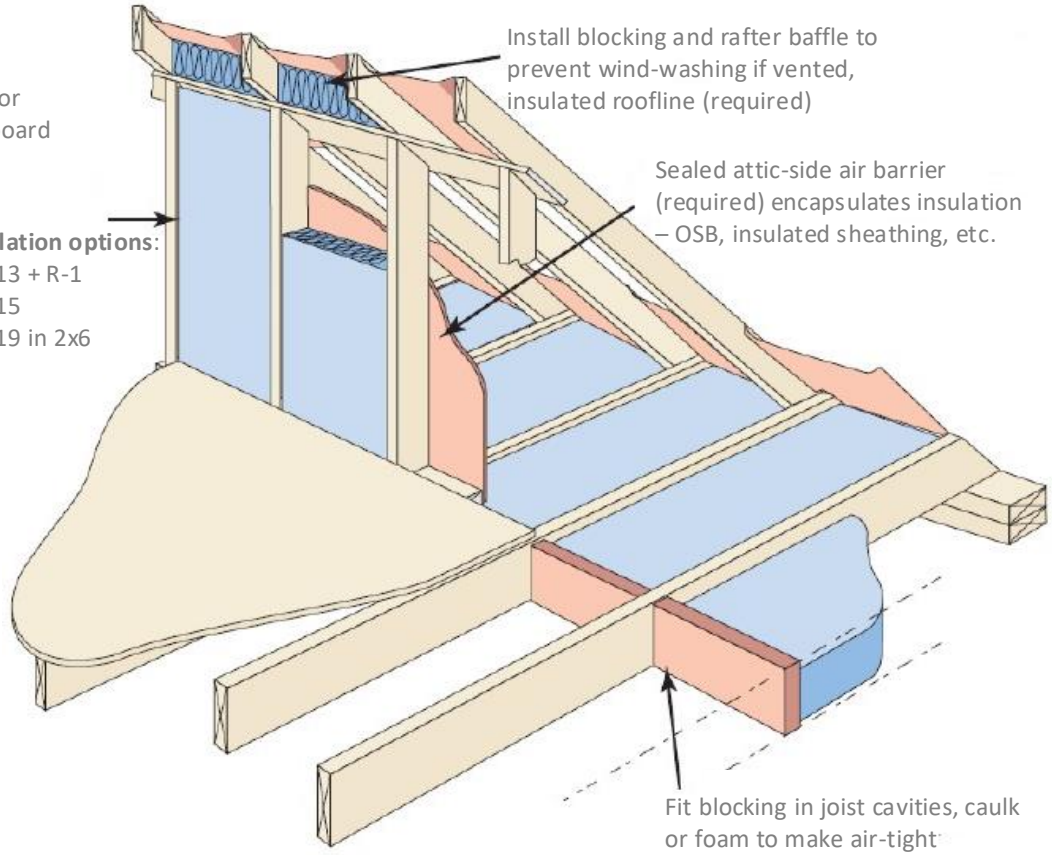
Inspecting Insulation
- Air sealing
- Baffling
- Obstructions
- Odd-sized cavities

Standard Truss with tapered insulation depth



Energy Truss with full height insulation (recommended)





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See the Insulation, Air Barrier, and Air Sealing Inspection Checklist to make sure code-compliance is achieved.

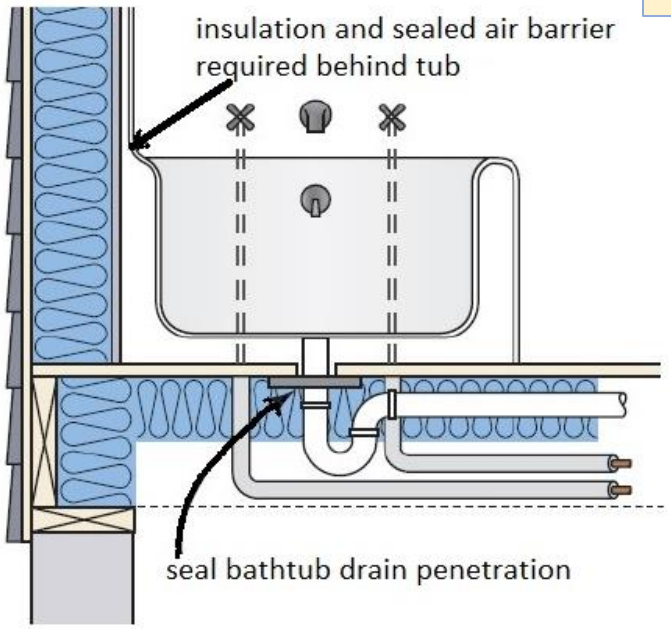
Example Details

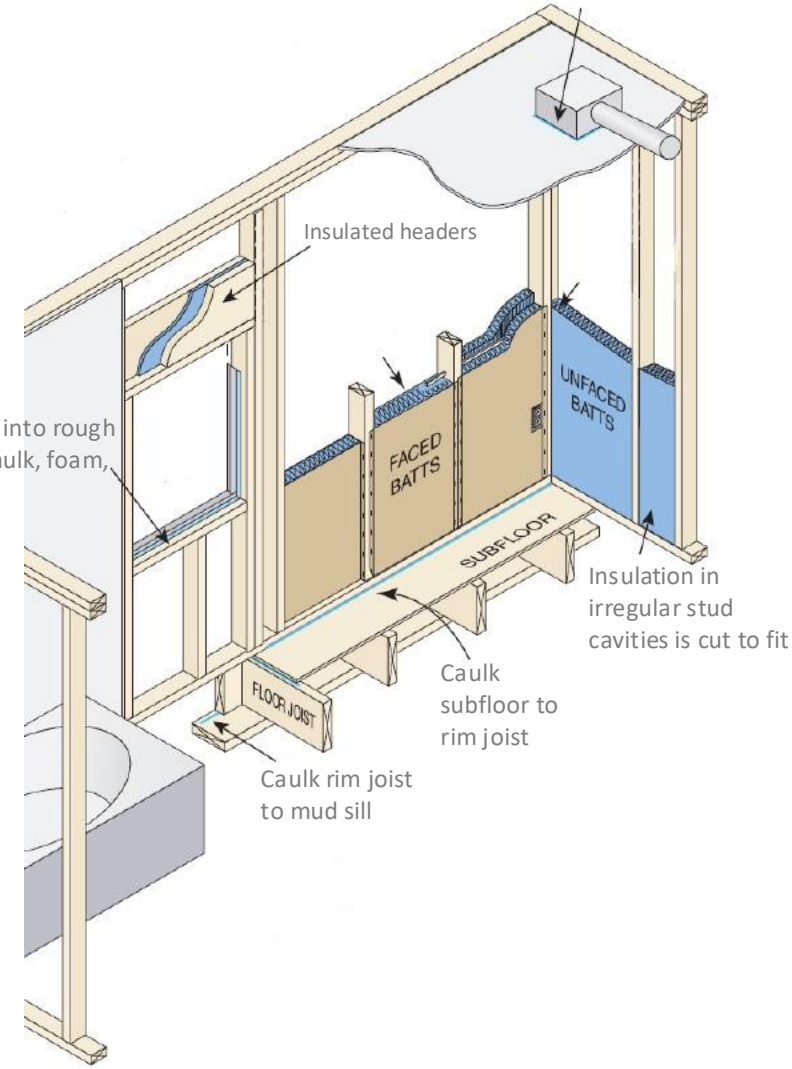
Images: basc.pnnl.gov/resource-guides

Inspecting Insulation

- Tubs
- Showers
- Fireplaces
- Attic knee walls

Tubs on exterior walls: Ensure insulation is fully encapsulated and air barrier is continuous





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Success with the 2021 Virginia Energy Conservation Code:
Tech Tips for Builders

INSULATION

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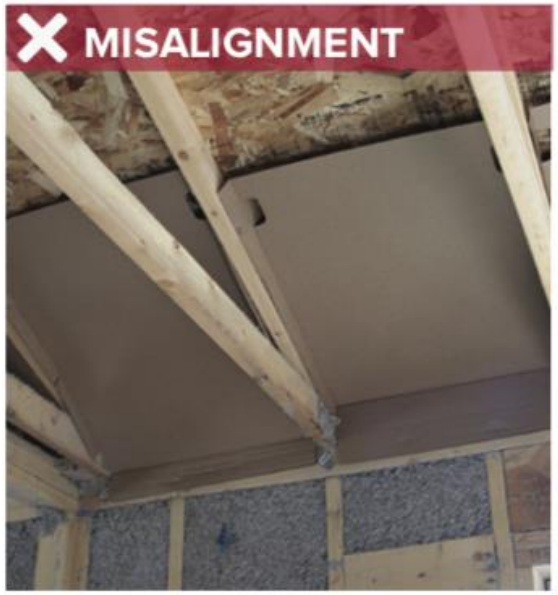
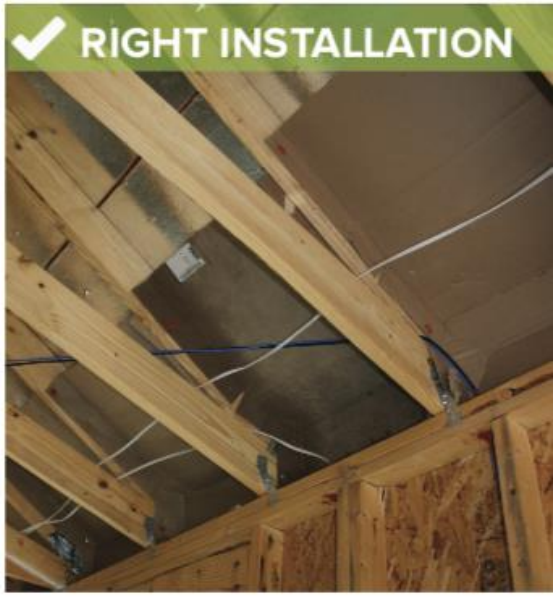
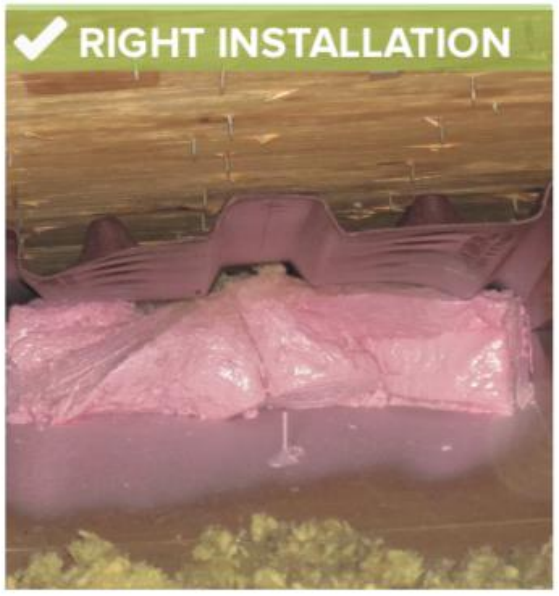
TECH TIPS:
INSULATION

1. For vented attics, install wind baffles on top of all exterior walls, leaving room for at least 4 inches of insulation over top plates and ventilation above.







TECH TIPS:
INSULATION

2. Install insulation to meet Virginia's 2021 R-Value requirements[a]. Insulation shall be installed in accordance with the manufacturer's instructions.

Climate Zone	Ceiling[b]	Wood Frame Wall[g]	Mass Wall[h]	Floor	Basement/ Crawl Wall[c,g]	Slab[d] R-Value & Depth
Zone 3	R-49	R-15 or 13+1	R-8/13	R-19	R-5ci or 13	R-10, 2 ft
Zone 4	R-60	R-15 or 13+1	R-8/13	R-19	R-10ci or 13	R-10, 4 ft
Zone 5	R-60	R-15 or 13+1	R-13/17	R-30	R-15ci or 19 or 13+5	R-10, 4 ft

ci = continuous insulation.

a. R-values are minimums. U-factors and SHGC are maximums. Where insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed R-value of the insulation shall be not less than the R-value specified in the table.

b. 5ci or 13" means R-5 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. "10cior 13" means R-10 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. "15ci or19 or 13&5ci" means R-15 continuous insulation (ci) on the interior or exterior surface of the wall; or R-19 cavity insulation on the interior side of the wall; or R-13 cavity insulation on the interior of the wall in addition to R-5 continuous insulation on the interior or exterior surface of the wall.

c. R-5 insulation shall be provided under the full slab area of a heated slab in addition to the required slab edge insulation R-value for slabs. as indicated in the table. The slab-edge insulation for heated slabs shall not be required to extend below the slab.

d. Basement wall insulation is not required in Warm Humid locations as defined by Figure R301.1 and Table R301.1.

e. The first value is cavity insulation; the second value is continuous insulation. Therefore, as an example, "13&5" means R-13 cavity insulation plus R-5continuous insulation.

f. Mass walls shall be in accordance with Section R402.2.5. The second R-value applies where more than half of the insulation is on the interior of the mass wall.

g. A maximum U-factor of 0.32 shall apply in Climate Zones 3 through 8 to vertical fenestration products installed in buildings located either:
   1. Above 4,000 feet in elevation, or
   2. In windborne debris regions where protection of openings is required by Section R301.2.1.2 of the International Residential Code.

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TECH TIPS:
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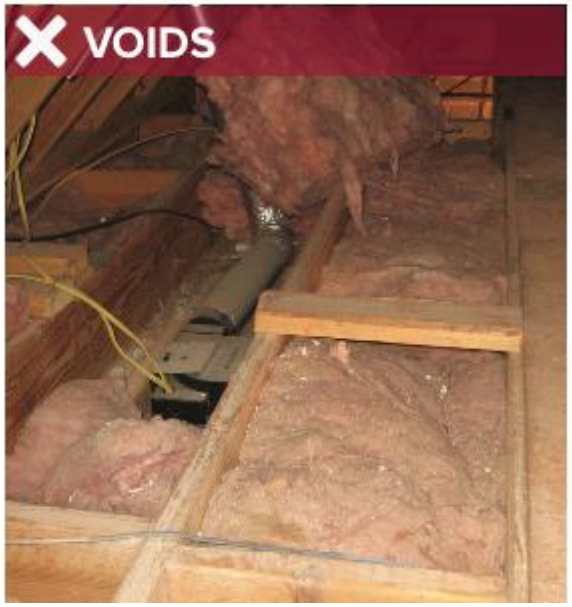
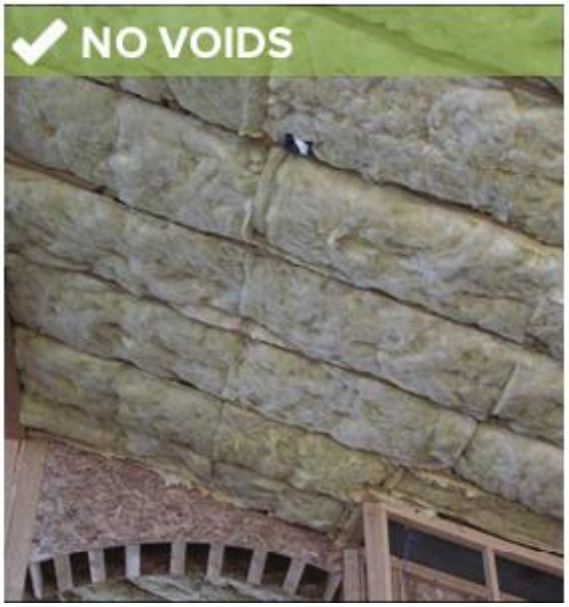
3. Install insulation to fill the cavity between conditioned and unconditioned space without gaps, voids, misalignments or compression.





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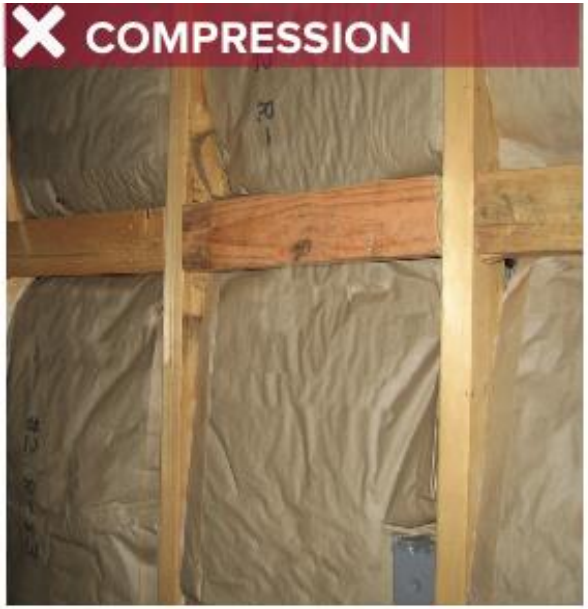
3. (continued) Install insulation to fil the cavity between conditioned and unconditioned space without gaps, voids, misalignments, or compression.



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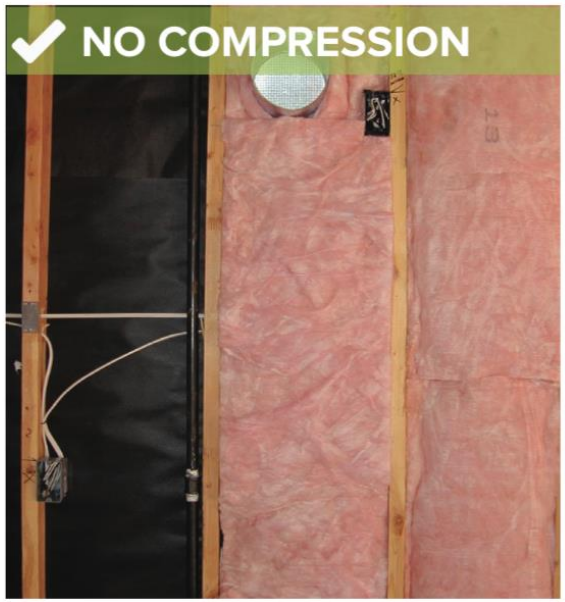
TECH TIPS:
INSULATION

4. Cut and split insulation around all blocking, plumbing, HVAC, and electrical components to obtain a completely full framing cavity.



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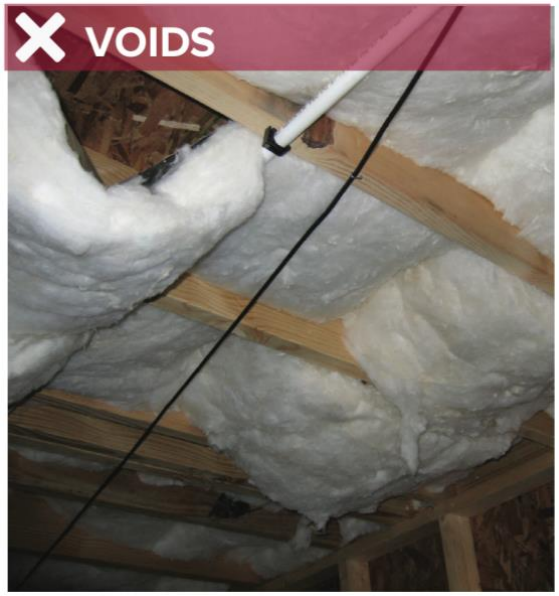
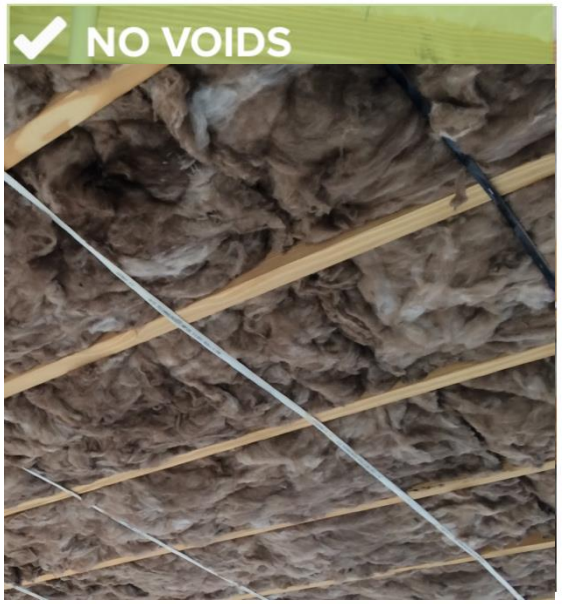
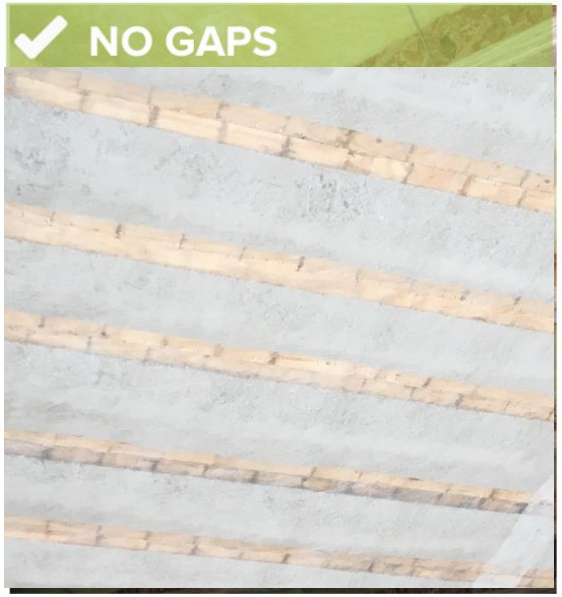
VIRGINIA

TECH TIPS:
INSULATION

5. Install insulation to completely fill floor framing cavity or to maintain permanent contact with the subfloor without voids or compression.







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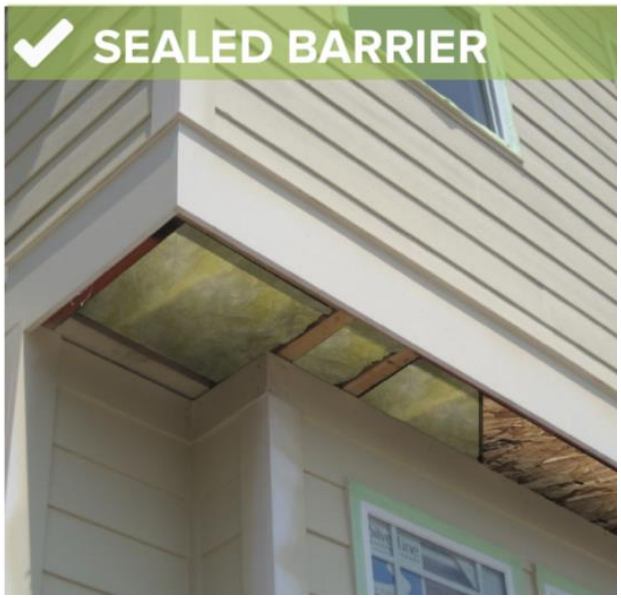
TECH TIPS:
INSULATION

6. For cantilever floors, frame to allow for at least R-19/R-30 depending on local minimums and encapsulate with an exterior rigid air barrier and air sealing.



7. Air seal around windows and doors using backer rod, caulk, or low expansion foam.

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TECH TIPS:
INSULATION

8. Insulate all attic access doors and install weather stripping to make them air-tight.

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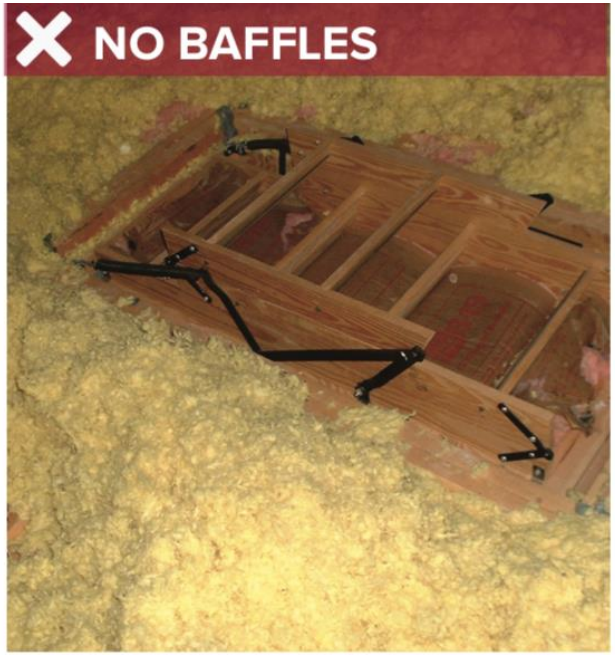
TECH TIPS:
INSULATION

9. For attics with loose fill insula
install baffles/dam around th
attic access opening to hold
insulation in place.



Blower Door Test Report

Home

Home Address	Permit Number	GPIN

Tester

Testing Company	Name of Tester	Signature

Qualification Held:

Virginia licensed general contractor
Virginia licensed HVAC contractor
Virginia licensed home inspector
Virginia registered design professional
Certified BPI Envelope Professional
Certified HERS rater
Certified duct and envelope tightness rater

Test Results

Date:	**Test Procedure:**	RESNET/ICC 380	ASTM E779	ASTM E1827

Volume of House (cubic feet)	Maximum Allowed (ACH50)	Maximum Allowed (CFM50)	Compliance Status
	5		

Test Results (CFM50)	Test Results (ACH50)	*Attach supporting documentation (software generated report, picture, or similar)*

During Testing (from N1102.4.1.2 (R402.4.1.2))

1. *Exterior windows and doors and fireplace and stove doors shall be closed, but not sealed beyond the intended weatherstripping or other infiltration control measures;*
2. *Dampers, including exhaust, intake, makeup air, backdraft, and flue dampers shall be closed, but not sealed beyond intended infiltration control measures;*
3. *Interior doors, if installed at the time of the test, shall be open;*
4. *Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;*
5. *Heating and cooling systems, if installed at the time of the test, shall be turned off; and*
6. *Supply and return registers, if installed at the time of the test, shall be fully open.*

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