

General building envelope component requirements for Residential Buildings under the 2020 VT Residential Building Energy Standard (RBES)

Chapter 4 of the 2020 VT RBES covers the basic building envelope and system components required, the available compliance methods, and performance values that are allowed under the full application of the RBES rule for Residential Construction.

This summary document covers **Section R401**, and **Section R402**, of **Chapter 4**, as applies to the Prescriptive Compliance Path – “Package Plus Points” method for compliance with RBES. *This summary explicitly omits the contents of Section R403 – Systems*, which covers the design and installation requirements for building mechanical systems, as well as Section R404 – Electrical Power and Lighting Systems. The purpose of this summary of Chapter 4 is to guide the Builder or General Contractor through the requirements and process of compliance with the 2020 RBES for the building shell through the Prescriptive Compliance method.

The content provided here in this document does not cover nor does it stand to replace the full content and rule of the complete 2020 VT RBES, but serves as a reference for the Builder/General Contractor of the basic building envelope component requirements and available methods for compliance with the 2020 VT RBES.

For further reference and information, the full content of the 2020 VT RBES should be consulted as well as the 2020 VT RBES Energy Code Handbook.

The full language of the 2020 VT RBES can be found @ https://publicservice.vermont.gov/energy_efficiency/rbes

CHAPTER 4 [RE] RESIDENTIAL ENERGY EFFICIENCY

SECTION R401 | GENERAL

R401.1 Scope. This chapter applies to *residential buildings*.

R401.2 Compliance. Projects shall comply with one of the following:

1. “*Package Plus Points*”: Sections R402 through R404.
2. “*REScheck™ software*”: Section R405 and the provisions of Sections R401 through R404 indicated as “Mandatory.”
3. “*Home Energy Rating System (HERS)*”: An energy rating index (ERI) approach in Section R406.

R401.3 Certificate of Compliance (Mandatory). A certification may be issued and signed by a builder, a licensed professional engineer, a licensed architect or an accredited home energy rating organization. If certification is not issued by a licensed professional engineer, a licensed architect or an accredited home energy rating organization, it shall be issued by the builder. Any certification shall certify that residential construction meets the RBES. The Department of Public Service will develop and make available to the public a certificate that lists key features of the RBES. Any person certifying shall use this certificate or one substantially like it to certify compliance with the RBES. Certification shall be issued by completing and signing a certificate and affixing it to the electrical service panel, without covering or obstructing the visibility of the circuit directory label, service disconnect label or other required labels. The certificate shall certify that the residential building has been constructed in compliance with the requirements of the RBES. The person certifying under this subsection shall provide a copy of the certificate to the Department of Public Service and shall assure that a certificate is recorded and indexed in the town land records. A builder may contract with a licensed professional engineer, a licensed architect or an accredited home energy rating organization to issue certification and to indemnify the builder from any liability to the owner of the residential construction caused by noncompliance with the RBES.

For more information contact the Energy Code Assistance Center @ 885-887-0673

SECTION R402 BUILDING THERMAL ENVELOPE

R402.1 General (Prescriptive). The *building thermal envelope* shall meet the requirements of Sections R402.1.1 through R402.1.6.

Exceptions: The following *buildings*, or portions thereof separated from the remainder of the building by *building thermal envelope* assemblies complying with this section shall be exempt from the *building thermal envelope* provisions of Section R402.

1. **Low Energy Use Buildings.** Those with a peak design rate of energy usage less than 3.4 Btu/h per square foot of floor space for space conditioning purposes (10.7 W/m² or 1.0 watt/ft²).
2. **Unconditioned Buildings.** Those that do not contain conditioned space.
3. **Mobile homes.** Homes subject to Title VI of the National Manufactured Housing Construction and Safety Standards Act of 1974 (42 U.S.C. §§ 5401- 5426).
4. **Hunting camps.** Residential buildings shall not include hunting camps.
5. **Summer camps.** Residential buildings constructed for non-winter occupation with only a biomass (wood) or other on-site renewable heating system.
6. **Yurts** with only a biomass (wood) or other on-site renewable heating and hot water system.
7. **Owner-built homes.** Residential construction by an owner, if all of the following apply:
 - 7.1. The owner of the residential construction is the builder, as defined in 30 V.S.A. § 51, and;
 - 7.2. The residential construction is used as a dwelling by the owner, and;
 - 7.3. The owner in fact directs the details of construction with regard to the installation of materials not in compliance with the RBES, and;
 - 7.4. The owner discloses in writing to a prospective buyer, before entering into a binding purchase and sales agreement, with respect to the nature and extent of any noncompliance with the RBES. Any statement or certificate given to a prospective buyer shall itemize how the home does not comply with RBES, and shall itemize which measures do not meet the RBES in effect at the time construction commenced.

R402.1.1 Vapor retarder. Wall assemblies and roof or ceiling assemblies which are part of the building thermal envelope shall comply with the vapor retarder requirements of Section R702.7 of the International Residential Code or Section 1405.3 of the International Building Code, as applicable, or with R402.2.15 in this document.

R402.1.2 Insulation and fenestration criteria. The building thermal envelope shall comply with one of the following only:

Package Plus Points Approach: tables R402.1.2.1, R402.1.2.2 and R402.1.2.3; or
U-Factor Alternative Approach: R402.1.4; or
Total UA Approach; R402.1.5; or
Log Home Approach: R402.1.6.

Building science principles should be applied in all circumstances. Consult with a building science professional and refer to the Vermont Residential Energy Code Handbook for additional guidance and details.

R402.1.2.1 Package Plus Points Approach – Base. Projects shall comply with items 1 to 3:

1. Select one of the five base packages listed in Table R402.1.2.1; **and**
2. Determine the number of points needed to comply with Table R402.1.2.2 based on building size; **and**
3. Incorporate a sufficient number of points from Table R402.1.2.3 to meet the points requirements from Table R402.1.2.2.

**TABLE R402.1.2.1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT FOR BASE PACKAGES**

Component ^a		Package 1	Package 2	Package 3	Package 4	Package 5
		"Standard"	"SIPS"	"Thick Wall"	"Cavity Only"	"Log Homes"
Envelope	Ceiling R-Value	R-49 ^f	R-28 cont.	R-49 ^f	R-60 ^g attic / R-49 ^f slope	Construct log home to ICC 400-2017 "Standard on the Design and Construction of Log Structures" OR Table R402.1.6
	Wood Frame Wall R-Value	R-20+5 ^e OR 13+10 ^e	R-21 cont.	R-20+12 ^e	R-20 cavity	
	Common Wall Insulation	R-10	R-10	R-10	R-10	
	Floor R-Value	R-30	R-30	R-30	R-38	
	Basement/Crawl Space Wall ^c R-Value	R-15 (continuous) OR 20 (cavity) OR R13+5	R-15 (continuous) OR 20 (cavity) OR R13+5	R-20 (continuous) OR R-13+10 ^e	R-20 (continuous) OR R-13+10 ^e	
	Slab Edge ^d R-Value	R-15, 4ft OR R10 perimeter + R-7.5 under entire rest of slab	R-15, 4 ft OR R10 perimeter + R-7.5 under entire rest of slab	R-10, 4ft	R-15, 4 ft OR R10 perimeter + R-7.5 under entire rest of slab	
	Heated Slab ^d R-Value	R-15 (edge and under)	R-15 (edge and under)	R-15 (edge and under)	R-15 (edge and under)	
	Fenestration ^b (Window and Door) max. U-Value	U-0.30	U-0.30	U-0.30	U-0.28	
	Skylight ^b max. U-Value	U-0.55	U-0.55	U-0.55	U-0.55	
Air Leakage	Air Leakage ⁱ	≤3.0 ACH50 ^h tested	≤3.0 ACH50 ^h tested	≤3.0 ACH50 ^h tested	≤3.0 ACH50 ^h tested	
Mechanicals	Duct Leakage	Inside thermal boundary	Inside thermal boundary	4 CFM25 per 100 sq. ft. of CFA	Inside thermal boundary	
Lighting	Percent High Efficacy Lamps ^j	90%	90%	90%	100%	

For Sl: 1 foot = 304.8 mm.

- a) R-values are minimums. U-factors 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. See R402.1.4 for alternative compliance methods.
- b) The fenestration U-factor row excludes skylights.
- c) The continuous portion of basement and crawlspace insulation can be met through interior, exterior or combination.
- d) "4 ft" can be horizontal or vertical coverage including slab edge. "Edge and under" requires complete coverage. Up to 8 lineal feet of exposed slab edge may be insulated to R-10. "Heated slab" are those with embedded radiation.

- e) The first value is cavity insulation, the second value is continuous insulation, so “13+10” means R-13 cavity insulation plus R-10 continuous insulation. When used, continuous insulation values shall be at least R-5.
- f) Installing R-38 over 100 percent of the ceiling area requiring insulation shall be deemed to satisfy the requirement for R-49 insulation wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves. (See Section R402.2.1). Multifamily buildings using continuous insulation with a maximum U-factor of 0.023 for the ceiling assembly satisfies this requirement.
- g) Installing R-49 over 100 percent of the ceiling area requiring insulation shall be deemed to satisfy the requirement for R-60 insulation wherever the full height of uncompressed R-49 insulation extends over the wall top plate at the eaves. (See Section R402.2.1.)
- h) “ACH50” = air changes per hour at 50 Pascals building pressure as measured with a blower door
- i) “CFA” = conditioned floor area
- j) See Table R402.4.1.1 for further details.

Insulation systems complying with Table R402.1.4 shall be deemed to comply with the R- value requirements of Table 402.1.2.1.

- **R402.1.2.2 Required Points by Building Size.** Determine the number of points required by building size from Table R402.1.2.2. Building size for this table is determined by the finished conditioned floor area per dwelling unit within the building thermal envelope, including unfinished basements and storage/utility spaces. The Multifamily < 2000 square feet point requirement cannot be used for semidetached (semi-attached, side-by-side), row houses, and townhouses, as defined as single-family dwellings in Definitions R202. Multifamily dwelling unit size is based on the average dwelling size for the building.

**TABLE R402.1.2.2
REQUIRED POINTS BY BUILDING SIZE**

Building/Dwelling Size	Required Points
Multifamily < 2000 square feet	4 points
<2000 square feet	5 points
2000 to 4000 square feet	7 points
>4000 square feet	10 points

- **R402.1.2.3 Points by Component.** After determining the number of points required using Table R402.1.2.2, select the components from Table 402.1.2.3 to accumulate the required number of points. The total number of points selected from Table 402.1.2.3 must meet or exceed the required points from Table 402.1.2.2.

**TABLE R402.1.2.3
POINTS BY COMPONENT**

Component		Description	Points
Envelope	Slab	R-10 below entire slab	1
	Walls - Upgraded	Above grade walls R-20+12 (or U-factor maximum 0.033 wall assembly) (Not available for base package 3) OR ^b	2
	Walls - High-R	Above grade walls \geq R-40(cavity and continuous) (or U-factor maximum 0.025 wall assembly)	3
	Ceiling	R-80 attic flat / R-60 sloped, vaulted and cathedral	1
	Windows	Average U-factor \leq 0.27 OR ^b	1
		Average U-factor \leq 0.22	2
Air Leakage and Ventilation	Pre-Drywall	ACH50 is tested with blower door after full insulation/primary air barrier completion but before insulation is fully enclosed/covered OR ^b	1
	Tight	ACH50 \leq 2.0 and balanced ventilation with ECM ^e fans and \geq 70% SRE ^d for HRV ^c , \geq 65% SRE ^d for ERV ^c OR ^b	3
	Very Tight	ACH50 \leq 1.0 and balanced ventilation with ECM ^e fans and \geq 80% SRE ^d for HRV ^c , \geq 75% SRE ^d for ERV ^c	4
Heating and Cooling ^a	Basic	ENERGY STAR basic: (1) Gas/propane furnace \geq 95 AFUE, Oil furnace \geq 85 AFUE, (2) Gas/Propane Boiler \geq 90 AFUE, Oil Boiler \geq 87 AFUE, (3) Heat pump HSPF \geq 9.0; PLUS any AC is SEER \geq 14.5 OR ^b	1
	Advanced	Whole building heat/cool is (1) NEEP-listed air source heat pump combination ⁱ , (2) GSHP ⁱ , closed loop and COP \geq 3.3, (3) ATWHP ^f COP \geq 2.5 and 120F design temp, (4) Advanced wood heating system	3

Water	Basic	ENERGY STAR basic: Fossil fuel [EF 0.67 for \leq 55 gal; EF 0.77 for $>$ 55 gal] OR ^b	1
	Advanced	ENERGY STAR advanced: Electric [EF or UEF \geq 2.00 for \leq 55 gal; EF \geq 2.20 for $>$ 55 gal]	2
	Low Flow	All showerheads \leq 1.75 gpm ^g , all lav. faucets \leq 1.0 gpm ^g , and all toilets \leq 1.28 gpf ^h OR ^b	1
	Certified ^k	Certified water efficient design per WERS, WaterSense, or RESNETH2O	2
	Drain Heat Recovery	Drain water heat recovery system on primary showers and tubs	1
	User-Demand	Controlled hot water recirculation system with user-demand via push-button for furthest fixtures	1
Renewables	Solar Ready	Home is Solar Ready per R407.5, OR ^b	1
	On-Site Generation	Solar Photovoltaic (PV) (or other on-site renewable energy system), 1 point per 1.5 kW per housing unit of renewable generation on site	1 per 1.5 kW, max. 4
	Solar Hot Water	Solar hot water system designed to meet at least 50% of annual hot water load	2
Other Measures	Monitoring	Install whole-building energy monitoring system, min. 5 circuits and homeowner access to data	1
	EV Ready	Level 2 electric vehicle charger-ready per R407.4 ^l	1
	Battery	Min. 6 kWh grid-connected dispatchable demand-response-enabled battery backup	1

For SI: 1 foot = 304.8 mm.

- a) Heating and cooling system points are only available if all components of primary systems comply
- b) "OR" indicates that points are not additive; one component OR the following one can be selected, but not both.
- c) "H/ERV" = Heat or Energy Recovery Ventilation
- d) "SRE" = System Recovery Efficiency
- e) "ECM" = Electronically Commutated Motor
- f) "ATWHP" = Air-to-Water Heat Pump
- g) "gpm" = gallons per minute

- h) "gpf" = gallons per flush. Applies to new construction only.
- i) "GSHP" = ground-source heat pump
- j) <https://neep.org/initiatives/high-efficiency-products/emergingtechnologies/ashp/cold-climate-air-source-heat-pump>
- k) Certification standard as of 1/1/2019 or later. "WERS" = Water Efficiency Rating Score
<http://www.wers.us/>. EPA WaterSense compliance for all water products,
<https://www.epa.gov/watersense>. RESNET Water Energy Rating Index compliant,
http://www.resnet.us/professional/about/resnet_to_develop_water_efficiency_rating_system.
- l) Points are limited to one per dwelling. Additional Level 2 charging equipment receives no more points.

R402.1.3 R-value computation. Insulation material used in layers, such as framing cavity insulation or continuous insulation, shall be summed to compute the corresponding component R-value. The manufacturer's settled R-value shall be used for blown insulation. Computed R-values shall not include an R-value for other building materials or air films. Where insulated siding is used for the purpose of complying with the continuous insulation requirements of Table R402.1.2, the manufacturer's labeled R-value for insulated siding shall be reduced by R-0.6.

Alternative Compliance Method to Prescriptive Packages Plus Points

Total UA alternative

R402.1.4 U-factor alternative. An assembly with a U-factor equal to or less than that specified in Table R402.1.4 shall be permitted as an alternative to the R-values in Table R402.1.2.1. The building must still comply with Table R402.1.2.2 and Table R402.1.2.3.

An assembly with a U-factor equal to or less than that specified in Table R402.1.4 shall be permitted as an alternative compliance method with no Table R402.1.2.3 points required, provided that (a) airtightness is ≤ 2.0 ACH50 tested, and (b) ventilation system is: Balanced; with ECM fan(s) plus $\geq 70\%$ SRE for HRV, or $\geq 65\%$ SRE for ERV.

TABLE R402.1.4
EQUIVALENT U-FACTORS^{a, c}

FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	FRAME WALL U-FACTOR	MASS WALL U-FACTOR ^b	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR	CRAWL SPACE WALL U-FACTOR	SLAB & UNHEATED SLAB U-FACTOR & DEPTH
0.27	0.55	0.022	0.044	0.060	0.030	0.035	0.035	0.066, 4 ft

For SI: 1 foot = 304.8 mm.

- a) Non-fenestration U-factors shall be obtained from measurement, calculation, or an approved source
- b) When more than half the insulation is on the interior, the mass wall U-factors shall be a maximum of 0.057
- c) Airtightness of ≤ 2.0 ACH/50 tested and balanced ventilation system with ECM fan(s) PLUS $\geq 70\%$ SRE for HRV or $\geq 65\%$ SRE for ERV are required, OR the building must comply with Table R402.1.2.2 and Table R402.1.2.3
- d) U-factors are maximums

R402.1.5 Total UA alternative. Where the total *building thermal envelope* UA, the sum of U-factor times assembly area, is less than or equal to the total UA resulting from multiplying the U-factors in Table R402.1.4 by the same assembly area as in the proposed *building*, the *building* shall be considered to be in compliance provided that a) airtightness is ≤ 2.0 ACH50 tested, and (b) the ventilation system is: balanced, with ECM fan(s), plus $\geq 70\%$ SRE for HRV, or $\geq 65\%$ SRE for ERV. The UA calculation shall be performed using a method consistent with the ASHRAE *Handbook of Fundamentals* and shall include the thermal bridging effects of framing materials. In addition to UA compliance, the SHGC requirements shall be met.

Building Envelope Component Installation Requirements

R402.2 Specific insulation requirements (Prescriptive). In addition to the requirements of Section R402.1, insulation shall meet the specific requirements of Sections R402.2.1 through R402.2.15.

- **R402.2.1 Ceilings with attic spaces.** Where Section R402.1.2 would require R-49 insulation in the ceiling, installing R-38 over 100 percent of the ceiling area requiring insulation shall be deemed to satisfy the requirement for R-49 insulation wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves. Where Section R402.1.2 would require R-60 insulation in the ceiling, installing R-49 over 100 percent of the ceiling area requiring insulation shall be deemed to satisfy the requirement for R-60 insulation wherever the full height of uncompressed R-49 insulation extends over the wall top plate at the eaves. This reduction shall not apply to the *U*-factor alternative approach in Section R402.1.4 and the Total UA alternative in Section R402.1.5.
- **R402.2.2 Ceilings without attic spaces.** Where Section R402.1.2 would require insulation levels above R-30 and the design of the roof/ceiling assembly does not allow sufficient space for the required insulation, the minimum required insulation for such roof/ceiling assemblies shall be R-30. Insulation shall extend over the top of the wall plate to the outer edge of such plate and shall not be compressed. This reduction of insulation from the requirements of Section R402.1.2 shall be limited to 500 square feet (46 m²) or 20 percent of the total insulated ceiling area, whichever is less. This reduction shall not apply to the *U*-factor alternative approach in Section R402.1.4 and the Total UA alternative in Section R402.1.5.
 - **R402.2.2.1 Unvented attic assemblies.** Unvented attic assemblies (spaces between the ceiling joists of the top story and the roof rafters) shall be permitted in one- and two-family dwellings and multiple single-family dwellings (townhouses) if all the following conditions are met:
 1. The unvented attic space is completely contained within the building thermal envelope.
 2. No interior vapor retarders (Class I or II) are installed on the ceiling side (attic floor) of the unvented attic assembly.
 3. Where wood shingles or shakes are used, a minimum 1/4 inch (6 mm) vented air space separates the shingles or shakes and the roofing underlayment above the structural sheathing.
 4. Any air-impermeable (e.g., spray foam) insulation shall be a Class II vapor retarder, or shall have a vapor retarder coating, or covering in direct contact with the underside of the insulation.
 5. Either Item 5.1, 5.2 or 5.3 shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.
 - 5.1. Air-impermeable (e.g., spray foam) insulation only. Insulation shall be applied in direct contact with the underside of the structural roof sheathing.
 - 5.2. Air-permeable (e.g., fiberglass or cellulose) insulation only. In addition to the air-permeable insulation installed directly below the structural sheathing, rigid board sheet insulation shall be installed directly above the structural roof sheathing as specified in Table R402.4.1.1 for condensation control
 - 5.3. Air-impermeable and air-permeable insulation. The air-impermeable (e.g., spray foam) insulation shall be applied in direct contact with the underside of the structural roof sheathing as specified in Table R402.4.1.1 for condensation control. The air-permeable (e.g., fiberglass or cellulose) insulation shall be installed directly under the air-impermeable (e.g., spray foam) insulation.

- **R402.2.3 Eave baffle.** For air-permeable insulations in vented attics, a baffle shall be installed adjacent to soffit and eave vents. Baffles shall maintain an opening equal or greater than the net free area of the vent. The baffle shall extend over the top of the attic insulation. The baffle shall be permitted to be any solid material.
- **R402.2.4 Access hatches and doors.** Access doors from conditioned spaces to unconditioned spaces such as attics and crawl spaces shall be weather-stripped and insulated to a level equivalent to the insulation on the surrounding surfaces. Access shall be provided to all equipment that prevents damaging or compressing the insulation. A wood-framed or equivalent baffle or retainer is required to be provided when loose-fill insulation is installed, the purpose of which is to prevent the loose-fill insulation from spilling into the living space when the attic access is opened, and to provide a permanent means of maintaining the installed R-value of the loose-fill insulation.

Exception: Vertical doors that provide access from conditioned spaces to unconditioned spaces shall be permitted to meet the fenestration requirements of Table R402.1.2.

- **R402.2.5 Mass walls.** Mass walls for the purposes of this chapter shall be considered above-grade walls of concrete block, concrete, insulated concrete form (ICF), masonry cavity, brick (other than brick veneer), earth (adobe, compressed earth block, rammed earth) and, solid timberlogs, or any other walls having a heat capacity greater than or equal to 6 Btu/ft² • °F (123 kJ/m² • K).
- **R402.2.6 Steel-frame ceilings, walls and floors.** Steel-frame ceilings, walls, and floors shall meet the insulation requirements of Table R402.2.6 or shall meet the U-factor requirements of Table R402.1.4. The calculation of the U-factor for a steel-frame envelope assembly shall use a series-parallel path calculation method.

TABLE R402.2.6
STEEL-FRAME CEILING, WALL and FLOOR INSULATION R-VALUE

WOOD FRAME R-VALUE REQUIREMENT	COLD-FORMED STEEL^a EQUIVALENT R-VALUE
Steel Truss Ceiling^b	
R-30	R-38 or R-30 + 3 or R-26 + 5
R-38	R-49 or R-38 + 3
R-49	R-38 + 5
Steel Joist Ceilings^b	
R-30	R-38 in 2 × 4 or 2 × 6 or 2 × 8 R-49 in any framing
R-38	R-49 in 2 × 4 or 2 × 6 or 2 × 8 or 2 × 10

Steel-Framed Wall, 16" on center	
R-13	R-13 + 4.2 or R-19 + 2.1 or R-21 + 2.8 or R-0 + 9.3 or R-15 + 3.8 or R-21 + 3.1
R-13 + 3	R-0 + 11.2 or R-13 + 6.1 or R-15 + 5.7 or R-19 + 5.0 or R-21 + 4.7
R-20	R-0 + 14.0 or R-13 + 8.9 or R-15 + 8.5 or R-19 + 7.8 or R-19 + 6.2 or R-21 + 7.5
R-20 + 5 or R-25	R-13 + 12.7 or R-15 + 12.3 or R-19 + 11.6 or R-21 + 11.3 or R-25 + 10.9
R-21	R-0 + 14.6 or R-13 + 9.5 or R-15 + 9.1 or R-19 + 8.4 or R-21 + 8.1 or R-25 + 7.7
Steel Framed Wall, 24" on center	
R-13	R-0 + 9.3 or R-13 + 3.0 or R-15 + 2.4
R-13 + 3	R-0 + 11.2 or R-13 + 4.9 or R-15 + 4.3 or R-19 + 3.5 or R-21 + 3.1
R-20	R-0 + 14.0 or R-13 + 7.7 or R-15 + 7.1 or R-19 + 6.3 or R-21 + 5.9
R-20 + 5	R-13 + 11.5 or R-15 + 10.9 or R-19 + 10.1 or R-21 + 9.7 or R-25 + 9.1
R-21	R-0 + 14.6 or R-13 + 8.3 or R-15 + 7.7 or R-19 + 6.9 or R-21 + 6.5 or R-25 + 5.9
Steel Joist Floor	
R-13	R-19 in 2 x 6, or R-19 + 6 in 2 x 8 or 2 x 10
R-19	R-19 + 6 in 2 x 6, or R-19 + 12 in 2 x 8 or 2 x 10

- a) The first value is cavity insulation R-value, and the second value is continuous insulation R-value. For example, "R-30+3" means R-30 cavity insulation plus R-3 continuous insulation.
- b) Insulation exceeding the height of the framing shall cover the framing.

R402.2.7 Walls with partial structural sheathing. Where Section R402.1.2 would require continuous insulation on exterior walls and structural sheathing covers 40 percent or less of the gross area of all exterior walls, the continuous insulation R-value shall be permitted to be reduced by an amount necessary to result in a consistent total sheathing thickness, but not more than R-3, on areas of the walls covered by structural sheathing. This reduction shall not apply to the U-factor alternative approach in Section R402.1.4 and the Total UA alternative in Section R402.1.5.

R402.2.8 Floors. Floor framing-*cavity insulation* shall be installed to maintain permanent contact with the underside of the subfloor decking.

Exception: The floor framing-*cavity insulation* shall be permitted to be in contact with the topside of sheathing or continuous insulation installed on the bottom side of floor framing where combined with insulation that meets or exceeds the minimum wood frame wall R-value in Table R402.1.2 and that extends from the bottom to the top of all perimeter floor framing members.

R402.2.9 Basement walls. Walls associated with conditioned basements shall be insulated from the top of the *basement wall* down to 10 feet (3048 mm) below grade or to the basement floor, whichever is less. Walls associated with unconditioned basements shall meet this requirement unless the floor overhead is insulated in accordance with Sections R402.1.2 and R402.2.8.

R402.2.10 Slab-on-grade floors. Slab-on-grade floors with a floor surface less than 12 inches (305 mm) below grade shall be insulated in accordance with Table R402.1.2. The insulation shall extend downward from the top of the slab on the outside or inside of the foundation wall. Insulation located below grade shall be extended the distance provided in Table R402.1.2 by any combination of vertical insulation, insulation extending under the slab or insulation extending out from the *building*. Insulation extending away from the *building* shall be protected by pavement or by not less than 10 inches (254 mm) of soil. The top edge of the insulation installed between the *exterior wall* and the edge of the interior slab shall be permitted to be cut at a 45-degree (0.79 rad) angle away from the *exterior wall*. Slab-edge insulation is not required in jurisdictions designated by the *code official or other authority having jurisdiction, where one exists*, as having a very heavy termite infestation.

R402.2.11 Crawl space walls. As an alternative to insulating floors over crawl spaces, crawl space walls shall be permitted to be insulated when the crawl space is not vented to the outside. Crawl space wall insulation shall be permanently fastened to the wall and extend downward from the floor to the finished grade level and then vertically and/or horizontally for at least an additional 24 inches (610 mm). Exposed earth in unvented crawl space foundations shall be covered with a continuous Class I vapor retarder in accordance with the *International Building Code* or *International Residential Code*, as applicable. All joints of the vapor retarder shall overlap by 6 inches (153 mm) and be sealed or taped. The edges of the vapor retarder shall extend not less than 6 inches (153 mm) up the stem wall and shall be attached to the stem wall.

R402.2.12 Masonry veneer. Insulation shall not be required on the horizontal portion of the foundation that supports a masonry veneer.

R402.2.13 Sunroom insulation. Sunrooms enclosing conditioned space shall meet the insulation requirements of this code.

Exception: For *sunrooms* with *thermal isolation*, and enclosing *conditioned space*, the following exceptions to the insulation requirements of this code shall apply:

The minimum ceiling insulation *R*-value shall be R-30.

The minimum wall insulation *R*-value shall be R-13. Walls separating a *sunroom* with a *thermal isolation* from *conditioned space* shall meet the *building thermal envelope* requirements of this code.

R402.2.14 Common, party, and fire walls. Whenever continuity of the building thermal envelope is broken at walls separating dwelling units in Group R-2 building, including common, party, and fire walls, such walls shall be insulated to a minimum of R-10 on each side of the break in insulation continuity, and the walls shall be air sealed in accordance with Section R402.4.

R402.2.15 Frame walls. Efforts must be made to protect insulated cavities from airborne water vapor and condensation. Air sealing the interior face of the assembly, controlled mechanical ventilation (targeting 30% relative humidity during the winter season), exterior continuous insulation and proper consideration of the vapor permeance of materials are all design elements that can contribute to this protection.

R402.2.15.1 Vapor retarders. Class I or II vapor retarders shall be provided on the interior side of frame walls.

Exceptions:

Basement /concrete foundation walls.

Below *grade* portion of any wall.

Construction where moisture or its freezing will not damage the materials.

R402.2.15.2 Low permeability insulating sheathing. Where a Class II vapor retarder is used on the interior side of frame walls, in combination with a low permeability insulating sheathing installed as continuous insulation on the exterior side of frame walls, the Class II vapor retarder shall have a vapor permeance greater than 1 perm when measured by ASTM E96 water method (Procedure B). Use of a Class I interior vapor retarder in frame walls with a Class I vapor retarder on the exterior side shall require an engineered approved design.

R402.2.15.3 Class III vapor retarders. Class III vapor retarders on the interior side of frame walls shall be permitted where any one of the following conditions is met:

Vented cladding over the following sheathing types:

fiberboard;

gypsum;

plywood (CDX or comparable); or

solid wood

Insulated sheathing with *R*-value 7.5 minimum over 2 X 4 wall.

Insulated sheathing with *R*-value 11.25 minimum over 2 X 6 wall.

R402.2.15.4 Material vapor retarder class. The *vapor retarder class* shall be based on the manufacturer's certified testing of a tested assembly. See R202 General Definitions for vapor retarder classes and examples.

R402.3 Fenestration (Prescriptive). In addition to the requirements of Section R402.1, fenestration shall comply with Sections R402.3.1 through R402.3.5.

R402.3.1 U-factor. An area-weighted average of fenestration products shall be permitted to satisfy the *U*-factor requirements.

R402.3.2 Glazed fenestration SHGC. An area-weighted average of fenestration products more than 50-percent glazed shall be permitted to satisfy the SHGC requirements.

Dynamic glazing shall be permitted to satisfy the SHGC requirements of Table R402.1.2 provided that the ratio of the higher to lower labeled SHGC is greater than or equal to 2.4, and the *dynamic glazing* is automatically controlled to modulate the amount of solar gain into the space in multiple steps.

Dynamic glazing shall be considered separately from other fenestration, and area-weighted averaging with other fenestration that is not *dynamic glazing* shall not be permitted.

Exception: *Dynamic glazing* is not required to comply with this section when both the lower and higher labeled SHGC already comply with the requirements of Table R402.1.1.

R402.3.3 Glazed fenestration exemption. Up to 15 square feet (1.4 m²) of glazed fenestration per dwelling unit shall be permitted to be exempt from *U*-factor and SHGC requirements in Section R402.1.2. This exemption shall not apply to the *U*-factor alternative approach in Section R402.1.4 and the Total UA alternative in Section R402.1.5.

R402.3.4 Opaque door exemption. One side-hinged opaque door assembly up to 24 square feet (2.22 m²) in area is exempted from the *U*-factor requirement in Section R402.1.4. This exemption shall not apply to the *U*-factor alternative approach in Section R402.1.4 and the total UA alternative in Section R402.1.5.

R402.4 Air leakage (Mandatory). The building thermal envelope shall be constructed to limit air leakage in accordance with the requirements of Sections R402.4.1 through R402.4.4.5.

R402.4.1 Building thermal envelope. The *building thermal envelope* shall comply with Sections R402.4.1.1 and R402.4.1.2. The sealing methods between dissimilar materials shall allow for differential expansion and contraction.

R402.4.1.1 Installation. The components of the *building thermal envelope* as listed in Table R402.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria listed in Table R402.4.1.1, as applicable to the method of construction.

**TABLE R402.4.1.1
AIR BARRIER and INSULATION INSTALLATION^a**

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
<p>General conditions and appropriate materials for air barriers</p>	<p>A continuous, durable air barrier shall be installed in the building envelope.</p> <p>The exterior thermal envelope contains a continuous, durable air barrier.</p> <p>Breaks or joints in the air barrier shall be sealed.</p> <p>An air barrier is defined as any durable solid (non-porous) material that completely blocks air flow between <i>conditioned space</i> and <i>unconditioned space</i>, including necessary accessories to provide adequate support to resist positive and negative pressures without displacement or damage. The air barrier should be continuous and be durably connected to all penetrations, windows and other (structural) interruptions.</p> <p>Open-cell or closed-cell foam shall have a finished thickness ≥ 5.5 in. or 1.5 in., respectively, to qualify as an air barrier unless the manufacturer indicates otherwise.</p> <p>If flexible air barriers are used, they shall be fully sealed at all seams and edges and supported per manufacturer’s installation instructions. Flexible air barriers shall not be made of kraft paper, or other materials that are easily torn. If polyethylene is used, its thickness shall be ≥ 6 mil. Materials meeting ASTM E2357 Standard Test Method for Determining Air Leakage of Air Barrier Assemblies are acceptable.</p>	<p>Air-permeable insulation shall not be used as a sealing material; when installed in vertical walls, sloped ceilings, and floors within the thermal envelope, it shall be enclosed on all six sides and in contact with a durable, air barrier.</p>
<p>Dropped ceilings/soffits</p>	<p>The air barrier in any dropped ceiling/soffit shall be aligned with (in contact with) the insulation and any gaps in the air barrier shall be sealed.</p> <p>Access openings, drop downstairs or knee wall doors to unconditioned attic spaces shall be sealed, insulated and gasketed.</p>	<p>The insulation in any dropped ceiling/soffit shall be aligned with (in contact with) the air barrier and shall be enclosed on five sides and in contact with a durable, interior air barrier. A top-side air barrier is not required in a flat attic.</p>

<p>Framing junctions and cavities</p>	<p>The junction of the foundation and sill plate shall be sealed. The junction of the top plate and the top of exterior wall sheathing shall be sealed.</p> <p>Knee walls shall be air sealed. When part of the thermal envelope, knee wall insulation shall be enclosed on all six sides and in contact with a durable, interior air barrier.</p>	<p>Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance of R-3 per inch minimum.</p> <p>Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.</p> <p>Exterior thermal envelope insulation for framed walls shall be enclosed on all six sides and in contact with a durable, air barrier.</p>
<p>Windows, skylights and doors</p>	<p>The space between window/door jambs and framing, and skylights and framing shall be sealed with minimally-expanding foam.</p>	<p>—</p>
<p>Rim joists</p>	<p>Rim joists shall include the air barrier. Junctions of the foundation and sill plate, sill plate and rim band, and rim band and subfloor shall be sealed. When air permeable insulation is installed, a durable, interior air barrier shall be installed at the rim joist</p>	<p>Rim joists shall be insulated and air sealed.</p>
<p>Floors (including above garage and cantilevered floors)</p>	<p>The air barrier shall be installed at any exposed edge of insulation.</p>	<p>Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of subfloor decking, or floor framing cavity insulation shall be permitted to be in contact with the top side of sheathing, or with continuous insulation installed on the underside of floor framing and extending from the bottom to the top of all perimeter floor framing members.</p>
<p>Crawl space walls</p>	<p>Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.</p>	<p>Where provided instead of floor insulation, vapor barrier shall be permanently attached to the crawlspace walls.</p>
<p>Shafts, penetrations</p>	<p>Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed. Doors or hatches in knee walls opening to exterior or unconditioned space shall be insulated and gasketed.</p>	<p>—</p>
		<p>Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled by</p>

Narrow cavities		insulation that on installation readily conforms to the available cavity space.
Garage separation	Air sealing shall be provided between the garage and <i>conditioned spaces</i> .	
Recessed lighting and appliances	Recessed light fixtures and other appliances (speakers, exhaust fans, light shafts, etc.) installed in the building thermal envelope shall be ICAT (Insulation Contact and Air Tight) rated, airtight labeled (or "Washington State Approved") and sealed with a gasket or caulk between the housing and the interior wall or ceiling cover. Fixtures and appliances shall maintain required clearances of not less than 1/2" from combustible material and not less than 3" from insulation material, or as required by manufacturer's installation requirements.	Recessed light fixtures installed in the building thermal envelope shall be air tight and ICAT rated (ICAT rated indicates Insulation Contact and Air Tight and meets IC and air tightness requirement).
Plumbing and wiring	All plumbing and wiring penetrations shall be sealed to the air barrier.	Insulation shall be placed between the exterior of the wall assembly and pipes. Insulation should not be installed on the interior of the piping. 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 and shall be in full contact with all air barriers.
Shower/tub on exterior wall	Exterior walls adjacent to showers and tubs shall have insulation filling any gaps or voids between tub or shower walls and unconditioned space.	Exterior walls adjacent to showers and tubs shall have a rigid durable, air barrier separating the exterior wall from the shower and tubs and be insulated.
Electrical/phone box on exterior walls	The air barrier shall be installed behind electrical or communication boxes or air-sealed boxes shall be installed.	Insulation completely fills voids between the box and exterior sheathing.
Common wall	Whenever continuity of the building thermal envelope is broken at walls separating dwelling units in Group R-2 building, including common, party, and fire walls, such walls shall be insulated to a minimum of R-10 on each side of the break in insulation continuity.	Air barrier shall be installed in common wall between dwelling units. Common walls shall be sealed at junctions with outside walls and at the top pressure plane of the house.
HVAC register boots	HVAC register boots that penetrate building thermal envelope shall be sealed to the subfloor or drywall.	

Concealed sprinklers	When 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.	
Fireplace	A durable air barrier shall be installed in contact with insulation. Fireplace shall have compression closure doors and combustion air supplied from the outdoors.	

a) In addition, inspection of log walls shall be in accordance with the provisions of ICC 400-2017.

R402.4.1.2 Air Leakage Testing. The *building* or dwelling unit shall be tested and verified as having an air leakage rate not exceeding three (3) 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 inch w.g.(50 Pascals). Testing and verification shall be conducted by an applicable Building Performance Institutes (BPI) Professional, a Home Energy Rating System (HERS) Energy Rater, HERS Field Inspector, or a Vermont Department of Public Service approved air leakage tester. A written report of the results of the test shall be signed by the party conducting the test. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope.

During Testing

- Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed, beyond the intended weather-stripping or other infiltration control measures.
- Dampers including exhaust, intake, makeup air, backdraft and flue dampers shall be closed, but not sealed beyond intended infiltration control measures.
- Interior doors, where installed at the time of the test, shall be open.
- Exterior or interior terminations for continuous ventilation systems shall be sealed.
 - Heating and cooling systems, where installed at the time of the test, shall be turned off.
 - Supply and return registers, where installed at the time of the test, shall be fully open.
 - Plumbing and drainage traps shall be filled with water as normally found, but not otherwise sealed.

R402.4.1.3 Reporting. Air leakage testing shall be reported on the RBES Certificate in units of air changes per hour at 50 Pascals (ACH50).

Exception: Report cubic feet per minute at 50 Pascals (CFM50) per square foot of building thermal shell area. Building thermal shell area shall include all six (6) sides of the building.

R402.4.2 Fireplaces. New wood-burning fireplaces shall have tight-fitting 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. Where using tight-fitting doors on masonry fireplaces, the doors shall be listed and labeled in accordance with UL 907.

R402.4.3 Fenestration air leakage. Windows, *skylights* and sliding glass doors shall have an air infiltration rate of no more than 0.3 cfm per square foot (1.5 L/s/m²), and swinging doors no more than 0.5 cfm per square foot (2.6 L/s/m²), when tested according to 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

R402.4.4 Rooms containing fuel-burning appliances. Where open combustion air ducts 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, isolated from inside the thermal envelope. Such rooms shall be sealed and insulated in accordance with the envelope requirements of Table R402.1.2, where the walls, floors and ceilings shall meet not less than 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 R403. The combustion air duct shall be insulated where it passes through conditioned space to a minimum of R-8.

Exceptions:

Direct vent appliances with both intake and exhaust pipes installed continuous to the outside.
Fireplaces and stoves complying with Section R402.4.2 and Section R1006 of the International Residential Code.

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. All recessed luminaires shall be ICAT-rated (Insulation Contact and Air Tight) or IC-rated and labeled as having an air leakage rate not more than 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E283 at a 1.57 psf (75 Pa) pressure differential. All recessed luminaires shall be sealed with a gasket or caulk between the housing and the interior wall or ceiling covering.

R402.5 Maximum fenestration U-factor and SHGC (Mandatory). The area-weighted average maximum fenestration U-factor permitted using tradeoffs from Section R402.1.5 or R405 shall be 0.30 for vertical fenestration, and 0.55 for skylights.

R402.6 Vestibules. Multifamily buildings 3-stories or less built above a parking garage require a vestibule in accordance with C402.4.7 from the Vermont Commercial Building Energy Standards (CBES).

Additional Supporting Content from the 2020 VT RBES Handbook on Vapor Retarder Class Definitions and Classifications, and Unvented Roof Assemblies:

Vapor Retarders

There are 3 major classes of vapor retarders.

Vapor Retarder Class ¹	Perm Rating (Dry Cup)	Description	Examples of Materials
Class I	0.1 perm or less	Vapor impermeable or "Vapor Barrier"	Rubber membrane, sheet polyethylene, glass, foils
Class II	0.1 -1.0 perm	Vapor semi-impermeable	Oil-based paint, Kraft-faced batt, vinyl wall coverings, stucco
Class III	1.0 – 10 perm	Vapor semi-permeable	Plywood, OSB, EPS, XPS, most latex paints, heavy asphalt-impregnated building paper, wood board sheathing
Vapor Open	>10 perm	Vapor permeable	Unpainted gypsum board, unfaced fiberglass, cellulose, many "housewraps"

Class I or II vapor retarders are required on the interior side of frame walls. Exceptions:

- Basement/concrete foundation walls.
- Below grade portion of any wall.
- Construction where moisture or its freezing will not damage the materials.

Low permeability exteriors

Where a Class II vapor retarder is used on the interior side of frame walls, in combination with a low permeability insulating sheathing installed as continuous insulation on the exterior side of frame walls, the Class II vapor retarder shall have a vapor permeance greater than 1 perm when measured by ASTM E96 water method (Procedure B). Use of a Class I interior vapor retarder in frame walls with a Class I vapor retarder on the exterior side (e.g. sheet polyethylene on interior and foil-faced foam board on exterior) shall require an engineering approved design. See Section 2.2b below for detail on adaptive vapor barriers.

Class III vapor retarders on the interior side of frame walls shall be permitted where any one of the following three conditions is met:

1. Vented cladding over the following sheathing types:
 - a. Fiberboard;
 - b. Gypsum;
 - c. Plywood (CDX or comparable); or
 - d. Solid wood
2. Insulated sheathing with R-value 7.5 min. over 2x4 wall
3. Insulated sheathing with R-value 11.25 min. over 2x6 wall

Vapor Control Approaches

In Vermont's climate, vapor drive is usually from inside to outside in winter. In summer, it can go either way but in homes using air conditioning vapor will usually move from outside to inside.

Three general vapor control approaches for walls include:

1. Vapor open / flow-through assembly – can dry on both sides of wall;
2. Vapor control layer assembly – slows vapor drive in one direction, typically warm-in-winter side; or
3. Adding enough exterior insulation to keep framing/sheathing above dewpoint.

Code language that restricts a Class I vapor retarder (e.g. poly) on the inside of a frame wall with low permeability insulating sheathing (such as foam) on the outside is meant to avoid building a wall that can trap moisture inside it ("vapor barrier sandwich"). An interior Class II vapor retarder would be allowed in this case, given its greater ability to allow drying to the inside.

Adaptive vapor retarders (also referred to as "smart" vapor retarders) have properties from multiple classes. These materials, which range from the kraft facing on batt insulation to advanced flexible sheeting products, are **generally Class II under dry (typical winter) conditions and open to Class III (vapor open) under humid (typical summer) conditions**. This can slow down the outward vapor drive that may occur in winter, reducing the likelihood of condensation/frost, yet allow the house to dry to the inside under higher humidity conditions.

All moisture vapor control strategies rely on adequate indoor relative humidity control (e.g., mechanical ventilation), careful water-resistive barrier installation, and proper air-barrier installation practices (e.g., air-sealing the interior face of assemblies). A design professional with experience in hygrothermal analysis and design should be consulted for additional advice as needed, especially for abnormal conditions (e.g., high interior moisture generation from indoor pools or hot-tubs) or where alternative materials and solutions are considered.

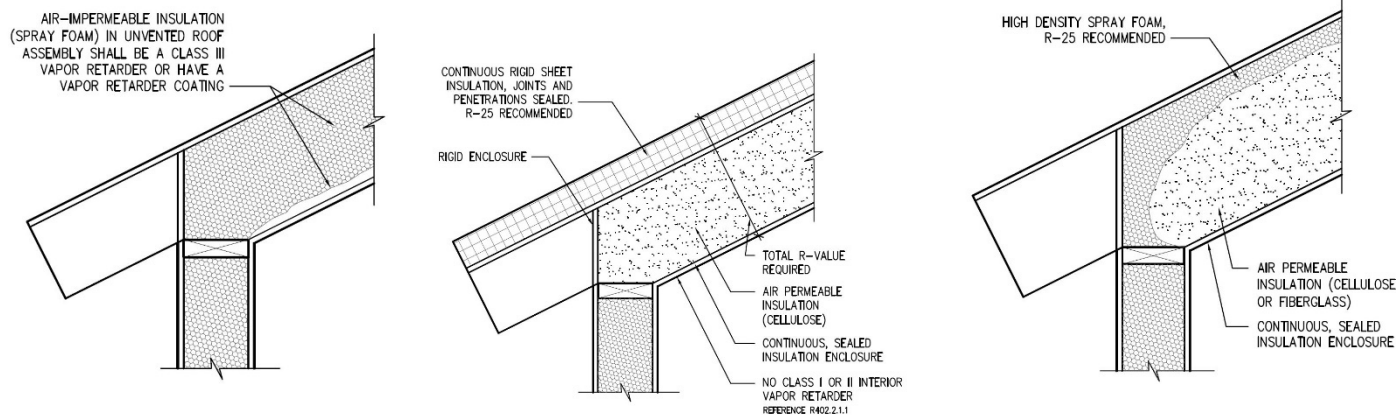
Unvented Attics

Unvented attic assemblies (spaces between the ceiling joists of the top story and the roof rafters) are permitted in one- and two-family homes and multiple single-family dwellings (townhouses) if all the following conditions are met:

1. The unvented attic space is completely contained within the building thermal envelope
2. No interior vapor retarders (Class I or II) are installed on the ceiling side (attic floor) of the unvented attic assembly or on the ceiling side of the unvented enclosed roof framing assembly.
3. Where wood shingles or shakes are used, a minimum 1/4 inch (6 mm) vented air space separates the shingles or shakes and the roofing underlayment above the structural sheathing.
4. Any air-impermeable (e.g., spray foam) insulation must be a Class II vapor retarder or must have a Class II vapor retarder coating or covering in direct contact with the underside of the insulation.

One of the items below must be met, depending on the air permeability of the insulation directly under the structural roof sheathing.

- a. *Air-impermeable (e.g., spray foam) insulation only.* Insulation must be applied in direct contact with the underside of the structural roof sheathing.
- b. *Air-permeable (e.g., fiberglass or cellulose) insulation only.* In addition to the air-permeable insulation installed directly below the structural sheathing, rigid board sheet insulation must be installed directly above the structural roof sheathing for condensation control. For reference, the International Residential Code requires at least R-25 rigid board insulation in Vermont's Climate Zone 6 (Ref. IRC Table R806.5) for unvented roof assemblies in this scenario.
- c. *Air-impermeable and air-permeable insulation.* The air-impermeable (e.g., spray foam) insulation must be applied in direct contact with the underside of the structural roof sheathing for condensation control. For reference, the International Residential Code requires at least R-25 air-impermeable insulation in Vermont's Climate Zone 6 (Ref. IRC Table R806.5) for unvented roof assemblies in this scenario. The air-permeable (e.g., fiberglass or cellulose) insulation must be installed directly under the air-impermeable (e.g., spray foam) insulation.



Spray Foam

Exterior Rigid

Flash and Batt

Figure 0-1. Examples of unvented attic assemblies