

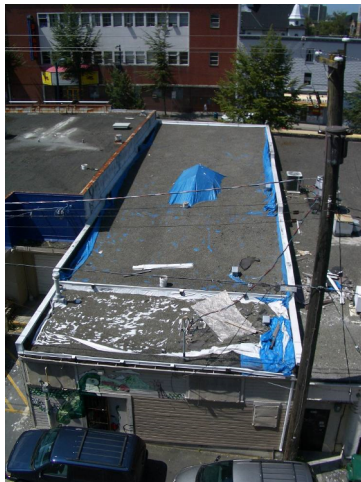
R30+ Effective Roofs in Residential Construction in BC

BUILDING SMART WITH HIGH PERFORMANCE BUILDING DESIGN

February 26, 2019
Lorne Ricketts | MASC, P.Eng. - Principal, Building Science Specialist

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A tarp is not a roof...



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2

Garbage bag + “goop” is not a roof...



3

A roof is not a water feature...



Unless it is a water feature...



4

Building Enclosure Fundamentals

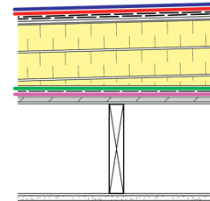
→ Building enclosure separates interior and exterior environments

→ Must control:

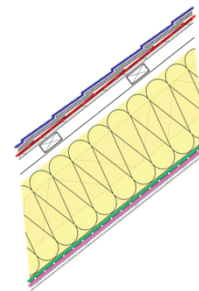
- Water
- Air
- Heat
- Water Vapour

→ We do this with a series of critical barriers

— Waterproof Membrane
 — Drainage Surface
 — Air Barrier
 — Vapour Control
 — Thermal Insulation



— Water-Shedding Surface
 — Water-Resistive Barrier
 — Air Barrier
 — Vapour Control
 — Thermal Insulation



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Outline

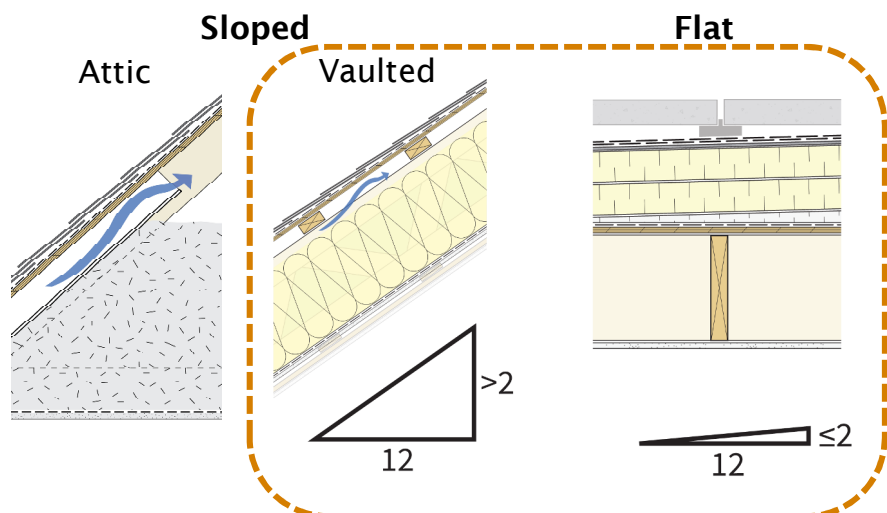
- Roof Thermal Performance
- Wood-frame Roof Assemblies
- Intro to the R30+ Roof Guide



Thermal Requirements

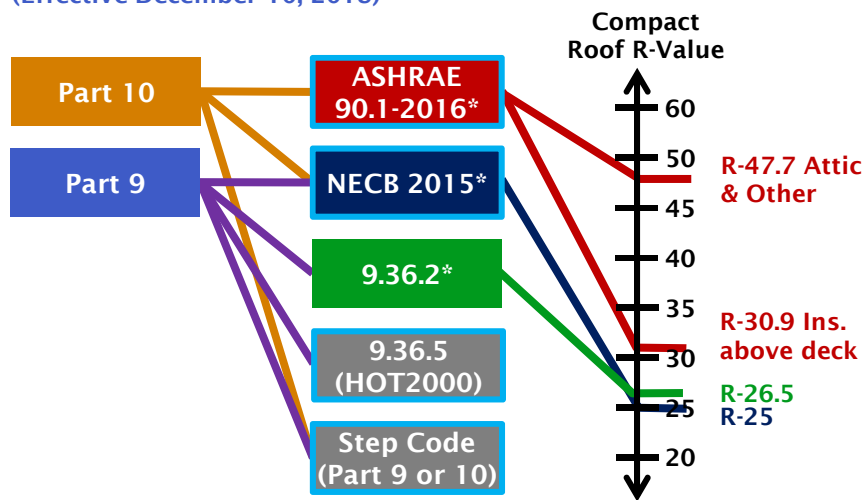


Wood-Frame Residential Roofs



BCBC 2018

(Effective December 10, 2018)



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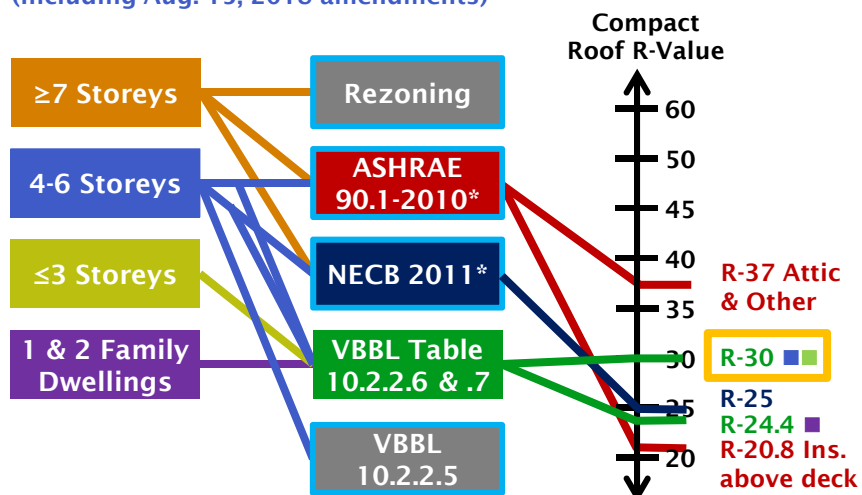
= Performance Path Option

*Climate Zone 4 for all shown. Varies by location.

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VBBL 2014 (Current)

(including Aug. 15, 2018 amendments)



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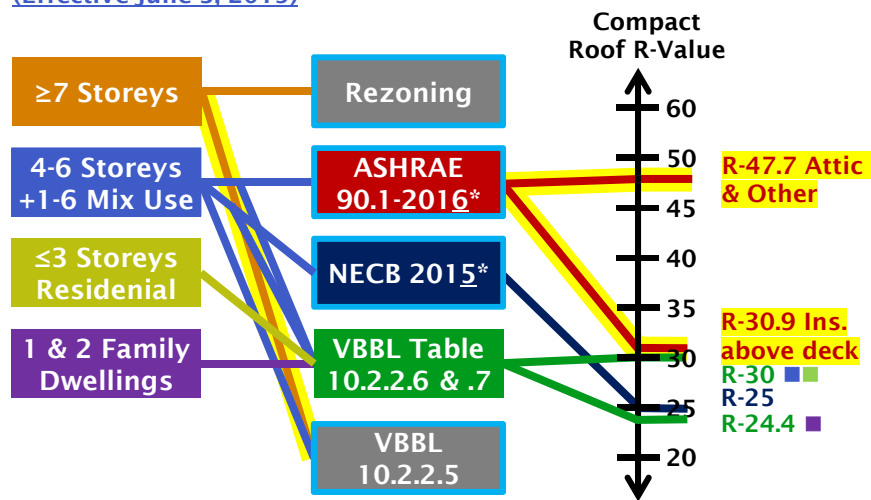
= Performance Path Option

*Climate Zone 5 for ASHRAE & 4 for NECB

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VBBL 2019

(Effective June 3, 2019)



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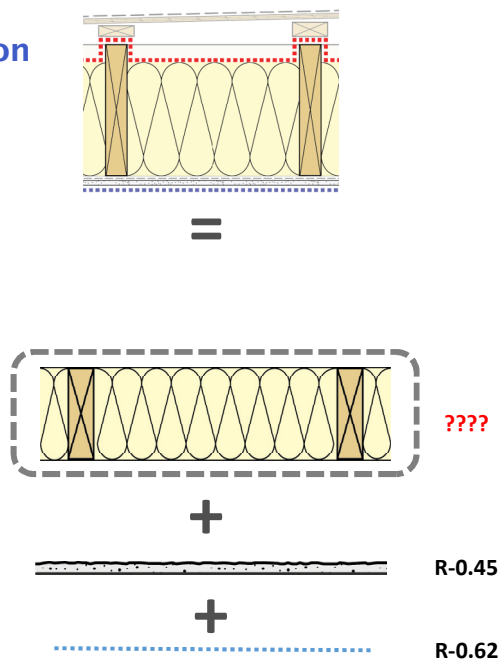
 = Performance Path Option

*Climate Zone 4 for ASHRAE & 4 for NECB

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R-Value Calculation

→ Isothermal Planes

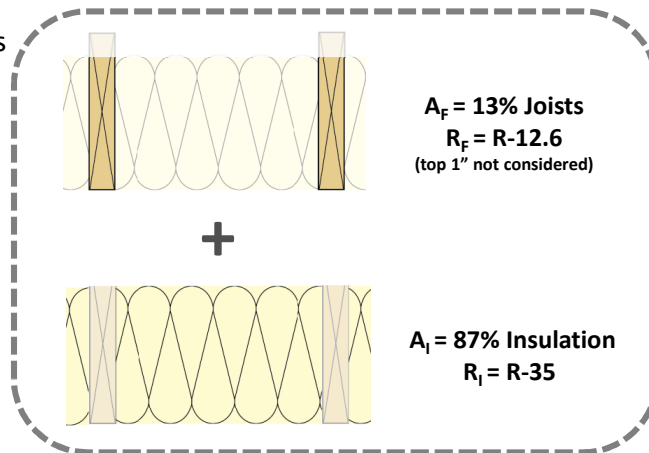


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R-Value Calculation

→ Parallel Paths
(i.e. $U \times A$)

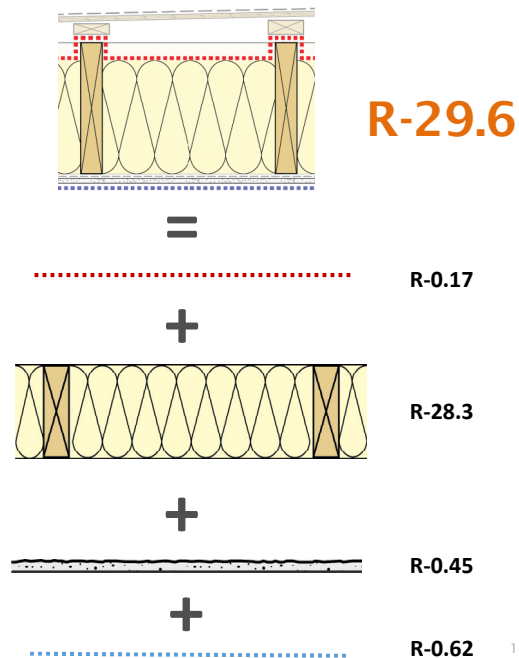


$$R_{\text{eff}} = \left[\frac{100}{\left(\frac{A_F}{R_F}\right) + \left(\frac{A_I}{R_I}\right)} \right] = \left[\frac{100}{\left(\frac{13}{12.6}\right) + \left(\frac{87}{35}\right)} \right] = R-28.3$$

13

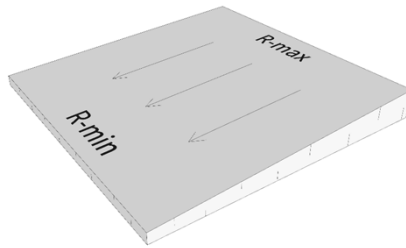
R-Value Calculation

→ Isothermal Planes



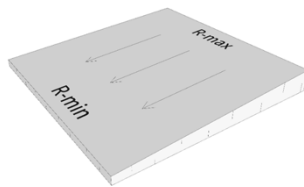
14

Effective R-value of Tapered Insulation

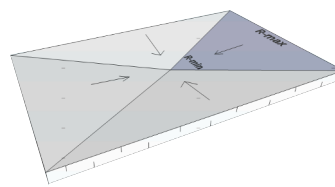


R_{min} (RSI)	R_{max} (RSI)	R-effective (RSI)	R-average (RSI)
5 (0.88)	20 (3.52)	10.8 (1.90)	12.5 (2.20)
20 (3.52)	25 (4.40)	22.4 (3.95)	22.5 (3.96)

Effective R-value of Tapered Insulation



Rectangular



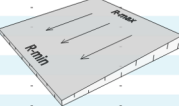
Triangular

$$R_{eff} = \frac{R_{max} - R_{min}}{\ln \left[\frac{R_{max}}{R_{min}} \right]}$$

$$R_{eff} = \left[\frac{2}{R_{max} - R_{min}} \left[1 + \frac{R_{min}}{R_{max} - R_{min}} \ln \left(\frac{R_{max}}{R_{min}} \right) \right] \right]^{-1}$$

Effective R-value of Tapered Insulation

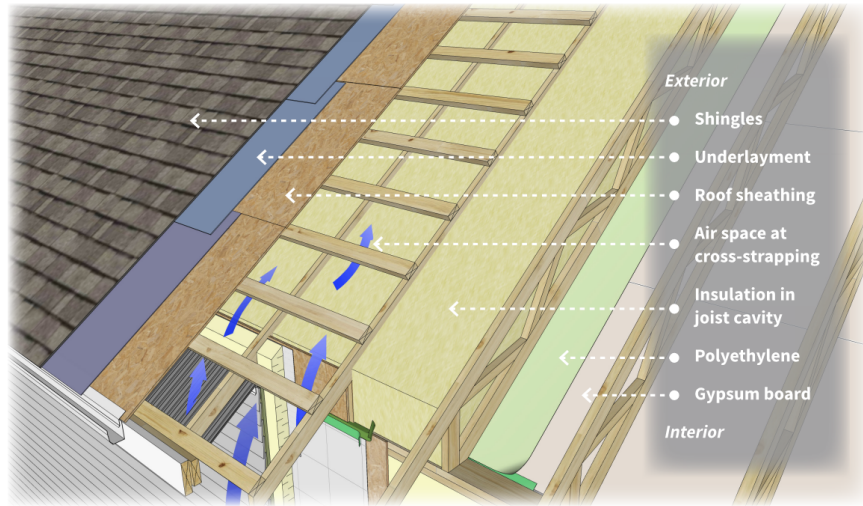
		R_{max} →									
R_{min} ↓		20	25	30	35	40	45	50	55	60	
4		9.9	11.5	12.9	14.3	15.6	16.9	18.2	19.5	20.7	
5		10.8	12.4	14.0	15.4	16.8	18.2	19.5	20.9	22.1	
10		14.4	16.4	18.2	20.0	21.6	23.3	24.9	26.4	27.9	
12		15.7	17.7	19.6	21.5	23.3	25.0	26.6	28.2	29.8	
14		16.8	19.0	21.0	22.9	24.8	26.6	28.3	30.0	31.6	
16		17.9	20.2	22.3	24.3	26.2	28.0	29.8	31.6	33.3	
18		19.0	21.3	23.5	25.6	27.6	29.5	31.3	33.1	34.9	
20		20.0	22.4	24.7	26.8	28.9	30.8	32.7	34.6	36.4	
25		-	25.0	27.4	29.7	31.9	34.0	36.1	38.0	40.0	
30		-	-	30.0	32.4	34.8	37.0	39.2	41.2	43.3	
35		-	-	-	35.0	37.4	39.8	42.1	44.2	46.4	
40		-	-	-	-	40.0	42.5	44.8	47.1	49.3	
45		-	-	-	-	-	45.0	47.5	49.8	52.1	
50		-	-	-	-	-	-	50.0	52.5	54.8	
55		-	-	-	-	-	-	-	55.0	57.5	
60		-	-	-	-	-	-	-	-	60.0	



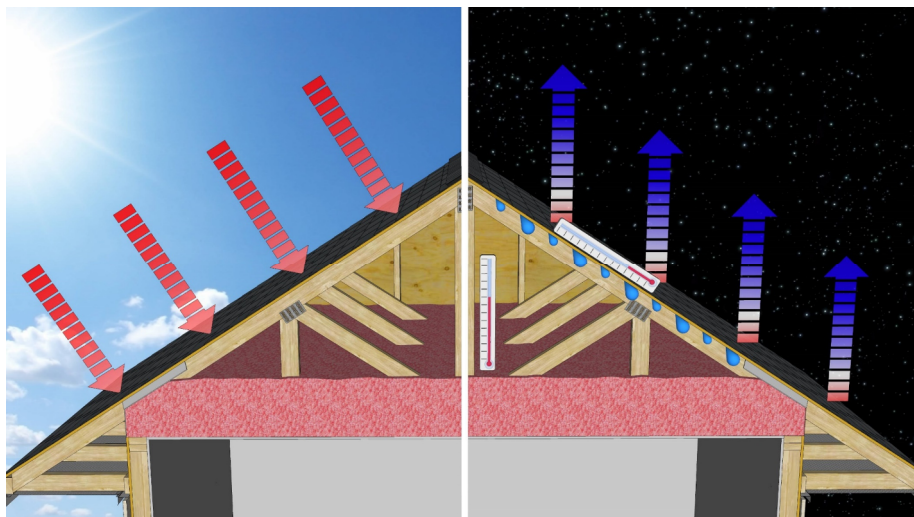
A 3D perspective diagram of a tapered insulation layer. The layer is rectangular with a sloped top surface. Two arrows on the top surface indicate the direction of heat flow, labeled R_{min} at the lower end and R_{max} at the higher end. The layer is shown with a cross-section revealing its internal structure.

Roof Assemblies

Joist-Insulated Vented Vaulted Roof



Influence of Solar Radiation & Night Sky Radiation



Typical Issues – Impact of Orientation

South Facing



North Facing



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A Localized Problem...

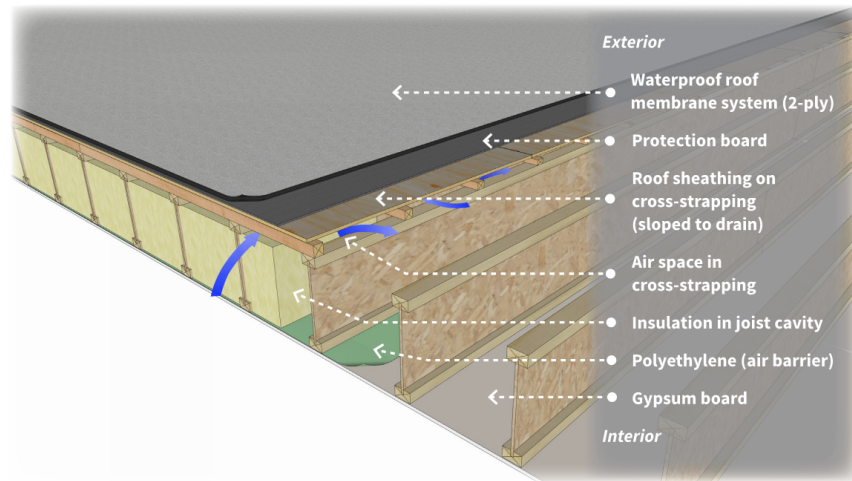
 High Risk Climate for
Night Sky Radiation
Vented Roof Moisture
Issues



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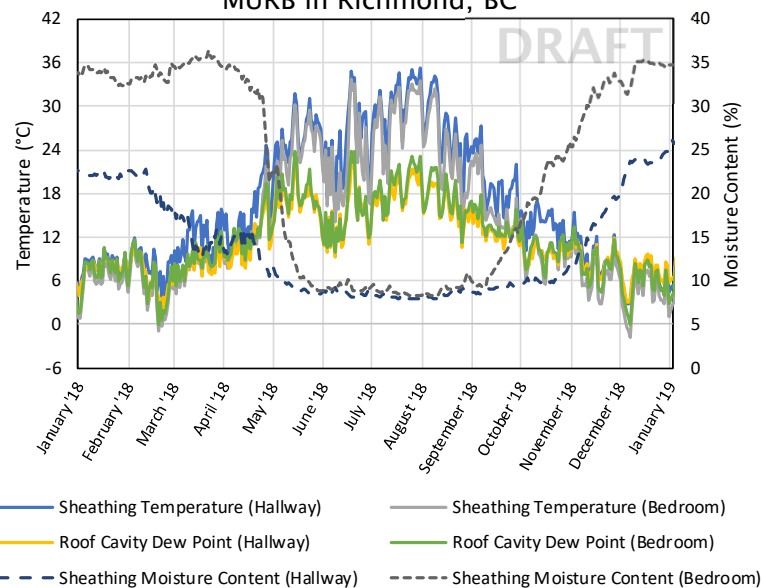
Joist-Insulated Vented Flat Roof



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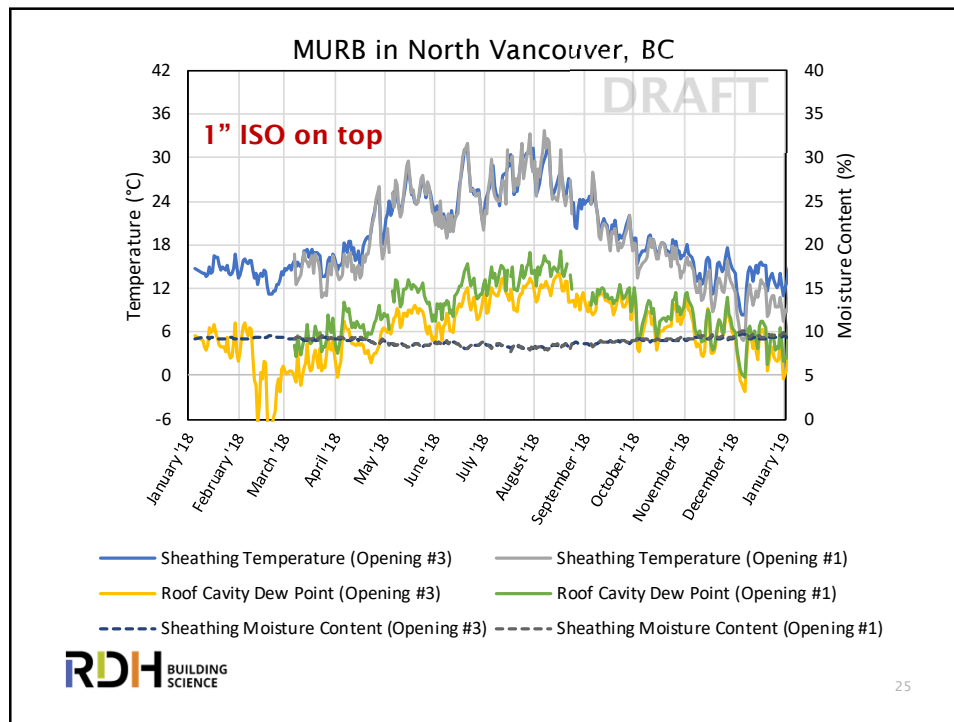
23

MURB in Richmond, BC

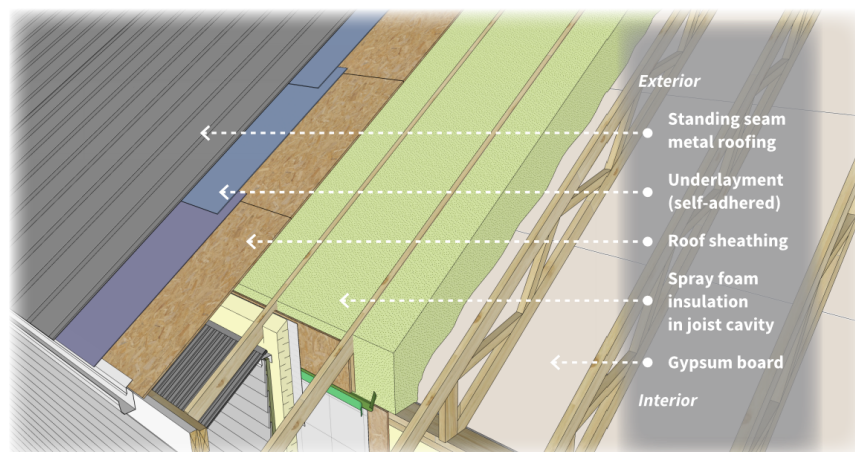


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Joist-Insulated Unvented Spray Foam Vaulted Roof



Are we even allowed to do this?

→ Clause 9.19.1.1

“Except where it can be shown to be unnecessary, where insulation is installed between a ceiling and the underside of the roof sheathing, a space shall be provided between the insulation and the sheathing, and vents shall be installed to permit the transfer of moisture from the space to the exterior”

→ Sensible for roofs without good airtightness, but spray polyurethane foam can provide excellent airtightness and is bonded to the substrate, further reducing risk

Lots of Research to Support

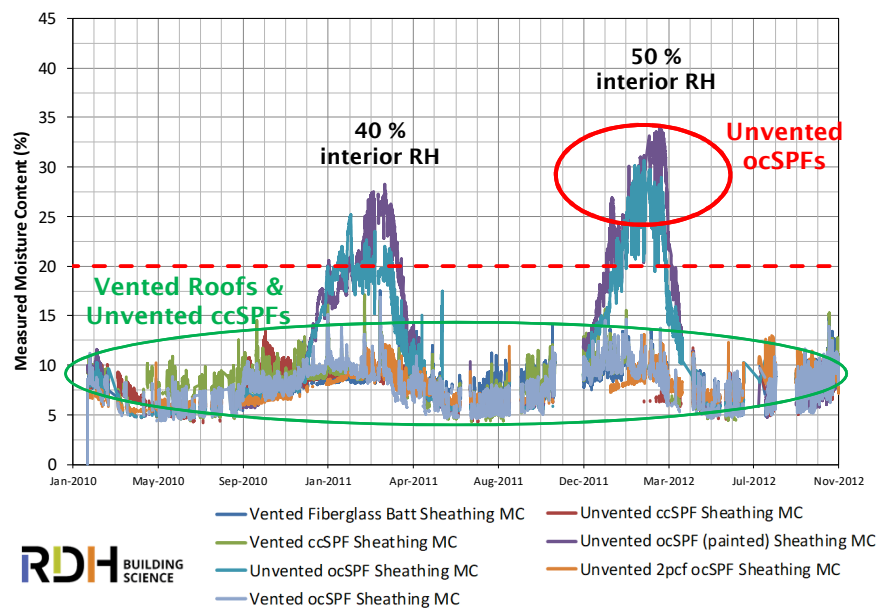
University of Waterloo Building Engineering Group



Test Assemblies

Assembly (all = R-30)	Vented?	Vapour Control	Air Control
Unvented Closed Cell	No	CCSPF	SPF
Vented Closed Cell	Yes	CCSPF	SPF
Vented Fiberglass	Yes	latex paint on drywall	Drywall
Unvented Open Cell w/ Paint	No	paint on foam and drywall	SPF
Unvented Open Cell	No	latex paint on drywall	SPF
Vented Open Cell	Yes	latex paint on drywall	SPF

Measured Sheathing Moisture Content



Hygrothermal Modelling

ASHRAE 90.1

CLIMATE ZONE	THERMAL CRITERIA
4	2000 < HDD18°C ≤ 3000
5	3000 < HDD18°C ≤ 4000
6	4000 < HDD18°C ≤ 5000
7	5000 < HDD18°C ≤ 7000
8	7000 < HDD18°C



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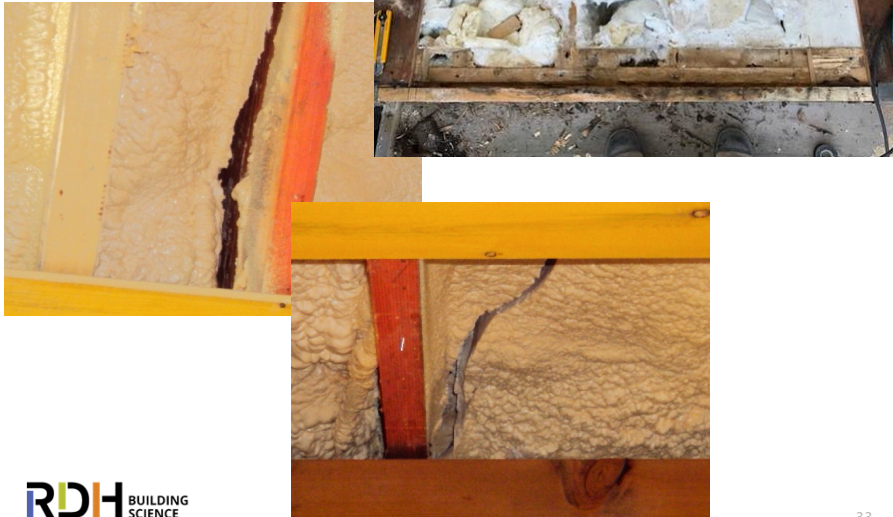
31

Cathedral Roof Construction				Vancouver			Toronto			Ottawa		
				HDD 3000			HDD 4000			HDD 4500		
Contents of Cavity	Depth of Cavity	Ventilation	Type of Vapour Control	Low RH 30/55%	Med. RH 40/60%	High RH 50%	Low RH 30/55%	Med. RH 40/60%	High RH 50%	Low RH 30/55%	Med. RH 40/60%	High RH 50%
Spray Polyurethane Foam (SPF)	2.0 pcf Closed Cell	Ventilated Continuous Baffle	ccSPF	13%	13%	13%	10%	10%	10%	10%	10%	10%
		Non-ventilated	ccSPF	11%	14%	14%	10%	13%	13%	12%	14%	14%
	0.5 pcf Open Cell	Non-ventilated	interior poly	13%	13%	13%	13%	13%	13%	13%	14%	15%
		Ventilated	latex paint	13%	13%	14%	11%	11%	11%	11%	11%	11%
		Non-ventilated	1 US perm paint on foam	12%	17%	18%	13%	24%	28%	15%	30%	32%
		Non-ventilated	latex paint	17%	30%	35%	25%	40%	50%	38%	52%	54%
Fiberglass Batt	9 1/4" R30	Ventilated Continuous Baffle	interior poly									
	9 1/4" R30	Ventilated Continuous Baffle	latex paint	16%	17%	17%	14%	14%	14%	13%	13%	13%
Other Applicable Locations (Heating Degree Days below 18°C)				White Rock (2782) Vancouver (2926) Abbotsford (2981) Victoria (3040)			Windsor (3524) Niagara Falls (3661) Kelowna (3869) Oshawa (3917) Hamilton (4012) Halifax (4030) London (4057) Toronto (4065)			Kitchener-Waterloo (4288) Kingston (4289) Montréal (4518) Moncton (4585) Ottawa (4602) Charlottetown (4715)		

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2

Installation Issues



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But... installation issues..



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Images from Energy Vanguard

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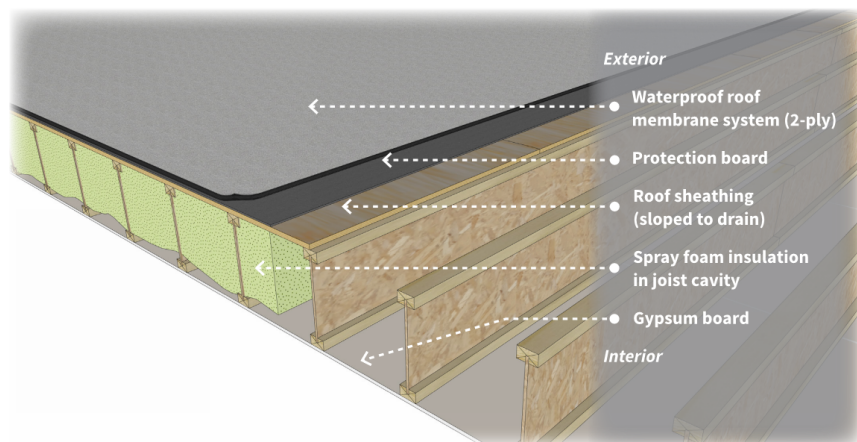
City of Vancouver Bulletin on CCSPUF

→ Bulletin 2017-004-BU “Use of Unvented Roof and Deck Assemblies in the City of Vancouver”

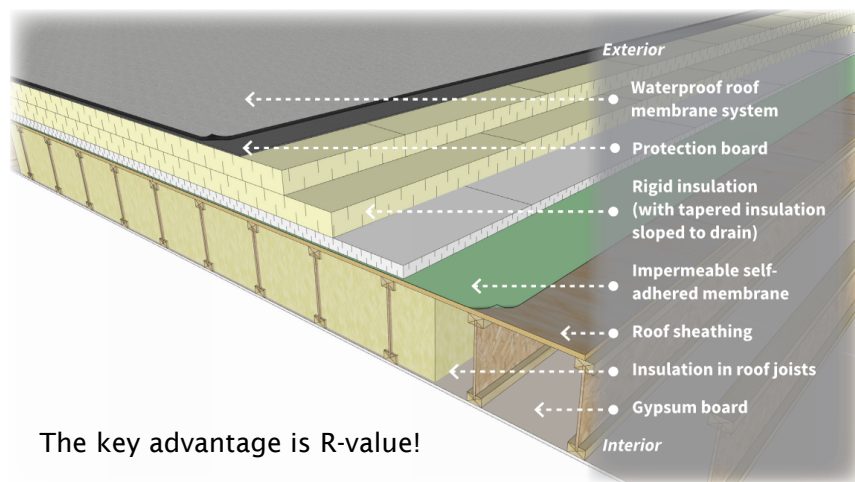
“Effective September 01, 2017, the City of Vancouver will ... no longer accept alternative solutions for unvented roof and deck assemblies.”

Be sure to check with specific AHJ requirements!

Joist-Insulated Unvented Spray Foam Flat Roof



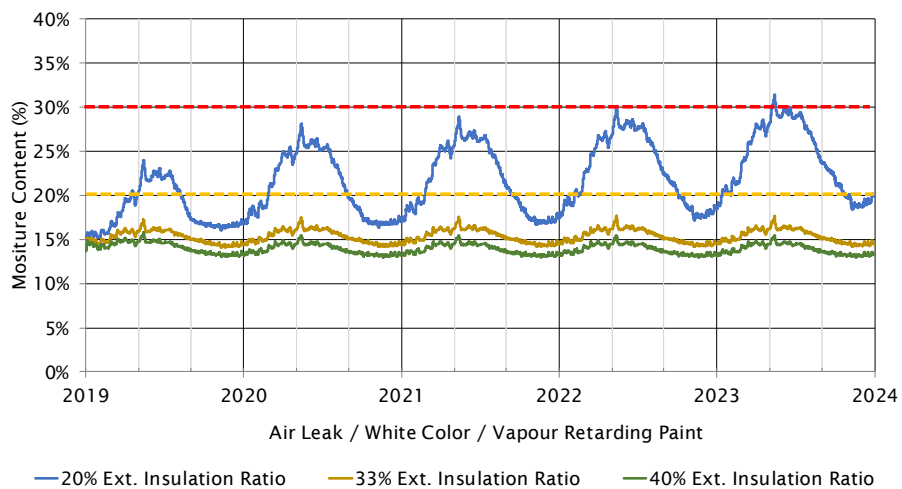
Split-Insulated Exposed Membrane Flat Roof



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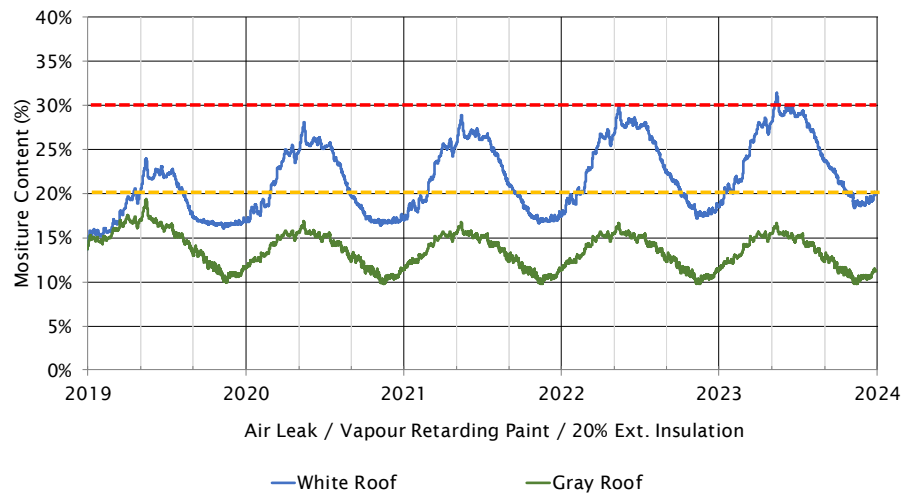
Insulation Ratios



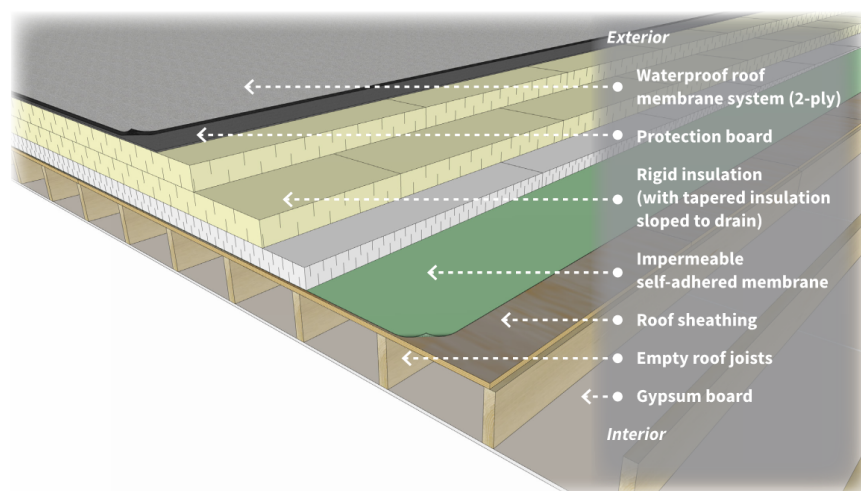
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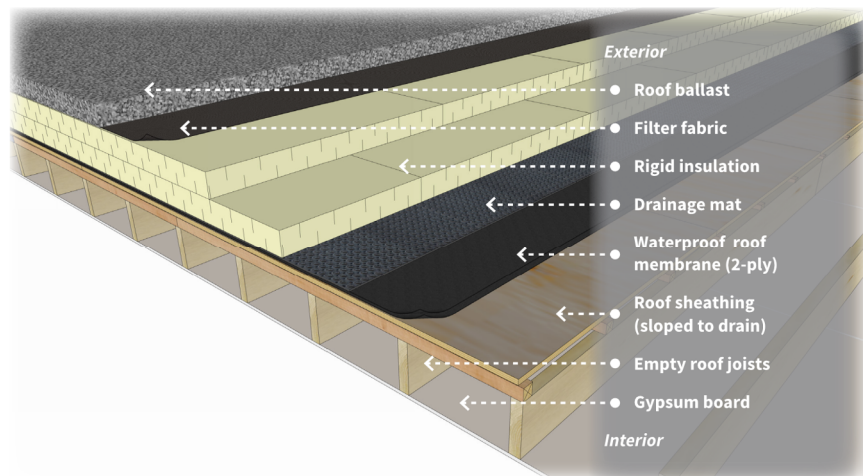
Roof Colour



Exposed Membrane Conventional Flat Roof

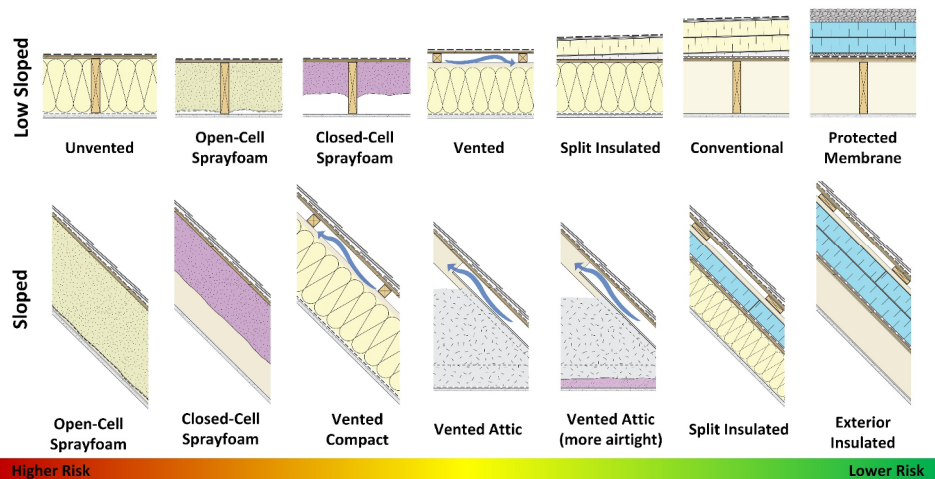


Protected Membrane Flat Roof



Relative Risk of Wood-Frame Roof Assemblies

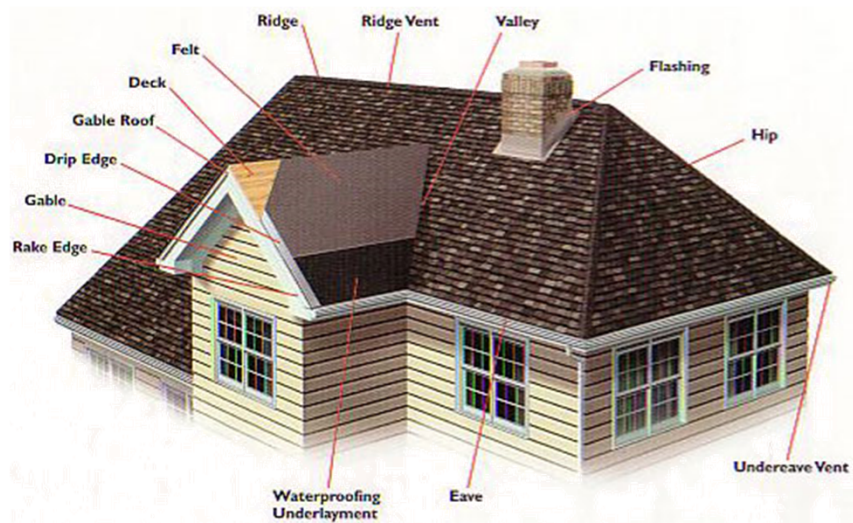
Could debate this for hours... and it depends...

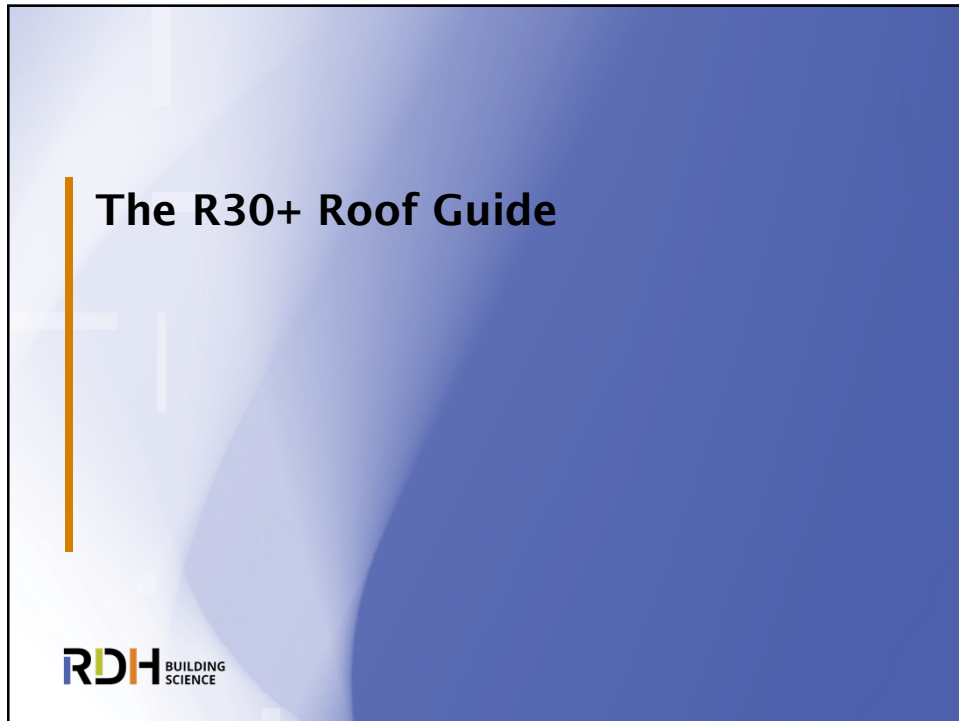


All Roofs Require Maintenance



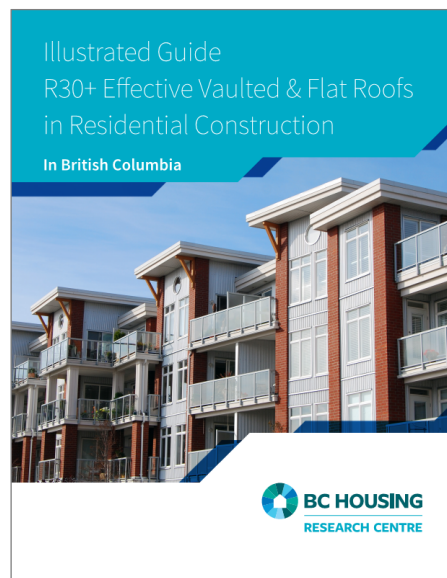
Details Matter Too!





Intro to the Guide

- **Introduction & Background**
 - Building Enclosure Fundamentals
 - R-Value Calculation
 - Effective R-value of Tapered Insulation
 - Vaulted Roofs
 - Low-slope Roofs
- **Spray Foam in Roofs**
- **Roof Decks**
- **Airtightness**
- **Alternative R-30 Roofs**
- **Maintenance & Inspection**
- **Summary**



Intro to the Guide - Assemblies

2 | Vaulted Roofs

Water Penetration Control

This assembly sheds all exterior water by gravity drainage over shingled materials. The sloped nature of the surface means that shedding and drainage capabilities are good and the shingled materials do not need to be resistant to a hydrostatic head of water. The underlayment provides a secondary line of protection. Traditionally, asphalt saturated organic underlayment has been used, but newer synthetic products are becoming more common and may be preferred.

Air Barrier

Both the membrane (i.e., polyethylene) and airtight drywall approaches can be used for the air barrier. Detailing at intersecting wall assemblies and penetrations, such as plumbing stacks, is important for maintaining the air barrier's continuity and effectiveness. An barrier continuity is necessary to resist warm moisture laden air from depositing moisture within the roof assembly, and to meet the airtightness targets for energy efficiency.

Insulation & Ventilation

Stone wool, fiberglass batt, blown in fibrous insulation (i.e., cellulose or Fiberglass), or spray foam can be used to insulate the joint space.

Vapour Control

Polyethylene or vapour retarder paint provides the vapour retarder for control of outward vapour diffusion. A smart vapour retarder, which can allow some vapour diffusion through, can also be considered in this assembly.

Design Considerations

In BC coastal climates, vented vaulted roof assemblies may be at risk of surface mould growth on the sheathing as a result of moisture in ventilation air. Sheathing surface treatment to inhibit mould growth may be prudent for these roof assemblies to reduce this risk.

For assemblies with many ceiling penetrations, such as for electrical service, it will be difficult to achieve a continuous interior air barrier. To avoid these penetrations, an interior service cavity beneath the ceiling air barrier can be used to run services. See 5.1 Airtightness on page 22 for more guidance on achieving good roof assembly airtightness.

Roof colour plays an important role in the durability of the assembly. Dark grey or black roofs will reach higher temperatures when exposed to direct sunlight, compared to lighter coloured roofing materials. This can lead to increased thermal stress on the material. However, higher temperatures provide drying benefits that could make the assembly more durable.

2 | Vaulted Roofs

Thumbnail

This vaulted roof assembly consists of insulated roof joists with ventilation beneath the roof sheathing. The depth of the insulation is limited by the depth of the roof joists, with allowance for ventilation. Engineered trusses can be used to create a deep joint space. The joint space can be insulated using a variety of different insulation types including stone wool or fiberglass batt, and, where dedicated vent spaces are created in the full length of the joint using baffles, blown-in fibrous insulation (i.e., cellulose or fiberglass) or spray foam. Clearance between the insulation and the sheathing is provided by perforin (i.e., cross strapping) at least 15" thick, plus 7" in the joint space, for a total of 22" ventilation clearance. The cross strapping perpendicular to the joists provides ventilation pathways across the top of the insulation in all directions. Continuity of the air barrier at the ceiling is critical to the performance of this assembly. A service cavity can be constructed above the ceiling finish to allow for running of services without penetrating the ceiling air barrier.

Critical Barriers and Other Considerations

Exterior: Shingles, Underlayment, Sheathing, Insulation in joint cavity, Polyethylene, Gypsum board, Interior.

R-Values

Key Performance Items

- Testing must be provided at the eave and the roof ridge, and air must be able to reach all areas beneath the roof sheathing.
- Continuous roof slope is important to allow drainage of water, including melting snow, from all areas. Where possible, long valleys with lower slopes should be avoided.
- Difficulty in achieving adequate venting, sensitivity to interior air leakage, and an assembly configuration where water can be trapped inside undetected puts this roof assembly at a risk of long-term performance issues over the service life of the roof. Therefore, its use must be carefully considered.

Illustrated Guide - R39+ Effective Roof Assemblies in Residential Construction in British Columbia

© BC Housing

Illustrated Guide - R39+ Effective Roof Assemblies in Residential Construction in British Columbia

© BC Housing

Intro to the Guide - Spray Foam

4 | Spray Foam in Roofs

Open-Cell vs. Closed-Cell Spray Foam

- Closed-cell spray foam has a higher R-value per inch compared to open-cell (R-6 vs. vs. ~R-3.7 per inch).
- Open-cell spray foam is vapour permeable, whereas closed-cell is impermeable and can be considered as a vapour control layer.
- Closed-cell spray foam typically must be applied in maximum 2" lifts, though this varies by manufacturer. There is no limit to the amount of open-cell spray foam that can be applied at one time in one lift.
- Open-cell spray foam should be installed to the full depth of the framing and cut flush to avoid creating an air space between the interior vapour control layer and the spray foam.
- Open-cell spray foam is not listed in the WBOL or BCRC as a spray foam insulation type. However it is covered in ULC S712.1 & S712.2. Always check with your local AHJ before using open-cell spray foam.

Code Requirements for Spray Foam Roofs

In addition to the guidance provided in this document, the British Columbia Building Code (BCBC) has specific requirements for unvented roofs and spray foam in Part 9 construction. Different jurisdictions may also have their own codes and requirements; therefore, site specific regulations must be considered when using spray foam in roofs assemblies.

Requirements for Roofing Ventilation Strategies: BCBC - Article 9.19.1.1 & 9.19.1.1 (1)

While the code does not give prescriptive guidance on which roof assemblies require ventilation, this language is intended to allow the designer to consider whether an assembly is sufficiently water, air, and vapour tight to minimize the need for ventilation. As discussed in the previous pages, this includes both interior ceiling airtightness and permeance, as well as exterior watertightness and durability. Important points from this specific BCBC Article and Appendix are as follows:

- Unless proven to be unnecessary, a space must be provided between the insulation and the underside of the sheathing, and vents are to be installed to permit the transfer of interior moisture to the exterior.
- The BCBC recognizes that ventilation may not be required in some roof assemblies have, over time, demonstrated that their construction is sufficiently tight, preventing excessive moisture accumulation.

Requirements for Spray Foam Installation & Materials: BCBC - Article 9.25.2.5 & 5.3.1.3-3

Foam must be installed by a licensed spray foam installer in accordance with applicable ULC standards. These standards include requirements for:

- framing and sheathing humidity levels,
- testing for proper adhesion of foam to substrates,
- quality of installation to ensure airtightness,
- elimination of air pockets within the foam,
- and more.

The code includes prescriptive requirements for the installation and material standards that must be used for closed-cell spray foam. As previously noted, open-cell spray foam is currently not included in the code as "spray-in-place polyurethane insulation" and should be considered as a separate product.

4 | Spray Foam in Roofs

Application of Spray Foam Roofs

Unvented closed-cell spray foam roof assemblies are becoming more common due to the higher R-value per inch found in the spray foam, compared to other standard insulation types. Additionally, by completely filling the joint cavity with closed-cell spray foam and eliminating the vent space, the full depth of the joists can be used to more easily meet code R-value requirements. The foam is also generally used as the primary air barrier and vapour retarder. While this approach has been used successfully in many roof assemblies across British Columbia, there is an increased risk associated with the use of unvented spray foam assemblies that may not be present with vented or exterior-insulated assemblies. The following items outline the most important design and construction considerations for unvented spray foam roofs. Note that many of these concepts may also apply to common vented roofs, though to a lesser extent. Also, see 7 | Additional R39+ roofs on page 26 for more examples of fully insulated roof assemblies with alternative ventilation strategies.

Air Barrier & Vapour Retarder Installation

Limiting interior air and vapour movement into the unvented spray foam roof is important to achieving a safe and durable roof assembly. Warm moist interior air that reaches the exterior roof sheathing can condense and cause moisture accumulation at the underside of the sheathing behind the spray foam. If left unchecked, this can lead to long-term damage of both the sheathing and framing members, because the closed-cell spray foam applied directly to the sheathing will limit drying of the wood materials.

Closed-cell spray foam is usually relied upon to provide the air barrier and vapour control layers. Correctly applied closed-cell spray foam should be continuous across the ceiling planes, with good adhesion to the roof framing members and sheathing, and will be relatively airtight and vapour tight. Open-cell spray foam must be combined with a dedicated vapour retarder such as polyethylene or a smart vapour retarder, since the foam itself is vapour permeable. Always use an accredited spray foam applicator for all spray foam installations. Framing members that do not have spray foam on all sides, like double joists or blocking, must be sealed between all joints in the framing. Penetrations like plumbing stacks and pot lights must be carefully air-sealed. Because spray foam is more susceptible to high temperatures, a 3" clearance from heat emitting devices (i.e., pot lights) is required by both ULC S705 & S712. Airtight boxes or low profile puck lights should be used instead (see above graphic).

Watertightness & Leakage Risks

Unvented roof assemblies risk permanently trapping moisture inside the joint space between the sheathing and the ceiling, since there is no means of drying. Spray foam roofs are especially watertight, so that even large accumulations of water can remain undetected for long periods. Water penetration from the outside at roofing defects presents a large risk for these roof assemblies. As with all roof assemblies, long-term durability requires careful attention to the watertightness of roofing materials. This includes the correct use of flashings, gutters, and drains, as well as regular review and maintenance throughout the service life of the assembly.

Maintenance & Inspections

Early stages of moisture accumulation and damage that may be present in unvented spray foam roofs are likely not detectable visually from the interior, without the use of respiratory openings at the ceiling. Exterior reviews is the only way to detect potential issues, using visual inspection or even thermal imaging, to check if the roof sheathing is wet. Roof replacement should be planned for as soon as the lifespan of the roofing system is reached. Note that maintenance and replacement work on spray foam roofs can be difficult and costly, since the spray foam material is difficult to remove from the sheathing and the framing members.

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Intro to the Guide - Airtightness

Air Barrier Systems

Exterior Sheathing Membrane Approach

This approach uses a self-adhered roof or torch-on sheathing membrane as the primary air barrier element. Self-adhered sheathing membranes rely on adhesion to both the substrate and at membrane laps. The membrane should be installed so that it is fully adhered to the substrate upon initial installation. Penetrations through the sheathing and membrane should be limited by using dedicated service openings that can be appropriately sealed. The air barrier should be reviewed for continuity below the remaining roof assembly components are installed over it.

Sealed Interior Polyethylene Approach

In this approach, polyethylene sheets are installed at the interior framing to form the air barrier. All joints in the polyethylene are sealed and damped between the framing and the interior finish (or service cavity framing). Airtight boxes, made from OSB or plywood with sealant or tape at edges, should be installed at all service openings. Rough-in like cabinets should be installed and sealed at the airtight box. The various interfaces between the roof and interior elements such as partition walls, and the many penetrations at the ceiling, make the sealed polyethylene approach a difficult air barrier system to implement successfully. Therefore, it is not recommended for buildings where high performance airtightness is required, unless a service cavity is also installed.

Sealed Interior Sheathing Approach (with Service Cavity)

This approach uses an interior layer of sheathing as the primary air barrier element at the roof. The sheathing joints are sealed with tape or membrane strips, and the perimeter is set onto gaskets or sealant on the roof framing. Penetrations through the air barrier can be limited by using a service cavity framed inside the sheathing, where services can be run. This approach is a good option for post-roof with insulation in the framing cavity, since the air barrier must be made fully airtight from the interior side of the enclosure, and the self sheathing substrate allows for robust detailing. The service cavity is an important component and should be included wherever possible.

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Ceiling Air Barrier Strategies

Ceiling air barrier systems are usually of two conventional types: exterior air barrier systems, with the primary airtight elements placed at the exterior side of the roof sheathing, and interior air barrier systems, with the primary airtight elements installed at the interior side of the roof structure. Within these systems there are various approaches and components used to achieve the air barrier.

Exterior air barrier approaches use an airtight layer, usually a dedicated membrane, installed over the roof sheathing, and made continuous with tapes, membranes, and sealants over joints, transitions, and penetrations. The interior approaches use an airtight layer applied from the interior of the enclosure, interfacing with the various interior elements, transitions, and penetrations. The exterior approach is often simpler, because it does not interface with numerous interior elements like framing or service penetrations like pot lights. However, the exterior air barrier still must interface with interruptions at the outside of the building like plumbing stacks. The design and detailing must account for these challenges.

Ceiling Penetrations

Common ceiling penetrations such as pot lights and other electrical fixtures present a unique challenge to ceiling airtightness when an interior air barrier is used. There can be dozens of ceiling penetrations in a standard single family home or condominium, and each one is at risk of causing significant air leakage into and through the roof assembly. In many cases, the fixtures are installed after the ceiling drywall is in place, and the ceiling air barrier cannot be accessed from the interior side.

For roof assemblies that use a dedicated interior air barrier material such as polyethylene or sheathing, dedicated airtight boxes should be used to create a continuous air barrier at each electrical penetration, before the ceiling drywall is in place. This is often done with a sealed OSB or plywood box, framed to allow the electrical wiring to be roughed-in and sealed, while still allowing room for the future fixture to be placed without affecting the air barrier. Note that deep pot lights may require additional framing to accommodate the depth inside the joint cavity and reduce the amount of insulation installed in these locations. Where possible, it is better to use shallow depth light fixtures, such as LED puck lights, as getting insulation behind deep boxes can be difficult.

Instead of individual airtight boxes, a dedicated ceiling service cavity can be used at the interior side of the completed air barrier. This allows electrical and other services to run beneath the ceiling air barrier, and limits the penetrations through it. This approach is recommended where high performance airtightness is required, and where many ceiling penetrations will be present. Ceiling service cavities can be framed using standard 2x6 framing, and cross braced if needed to allow uninterrupted access for running services across the ceiling.

Refer to the *Illustrated Guide - Achieving Airtight Buildings and the Energy Step Code Bulletin Guide*, published by BC Housing, for more detailed guidance on designing, constructing, and testing airtight roof assemblies (see Additional Resources on page 26).

Intro to the Guide - Maintenance

Maintenance & Inspections

Regular inspection and maintenance is needed to reduce the likelihood of premature leaks and aging. Roofs are exposed to sunlight, rain, snow, hail, wind, and temperature changes that gradually break down the roofing materials. Eventually, the replacement of the roof will be necessary. However, with proper maintenance and care, the service life of the roof can be maximized.

If possible, roofs should be checked twice a year: in the spring to address any winter damage that may have occurred, and in the fall to prepare for the upcoming winter snow and rain. Gutters, drains and scuppers should be reviewed at least annually, and more detailed roof maintenance should be completed at least every two years. For large or highly sloped roofs, maintenance should be done by a roofing professional or contractor, as it involves specialized knowledge, equipment, training, and safety requirements. A roof inspection and maintenance plan should be developed and should include checklists identifying the important areas to review and the frequency of reviews. As maintenance tasks are undertaken, a record should be kept and updated throughout the service life of the roof.

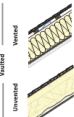
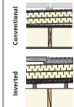
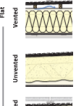
Life expectancies of roofs can range from 10 years to over 30 years, depending on the roof design, exposure, construction and materials used. Roofs should be replaced before the risk of severe failure gets too high, to avoid potentially costly damage from water leakage. The following table lists the common roof maintenance and inspection items that should be reviewed during each roof inspection.

Vaulted Roof Checklist	
Inspection/Maintenance Item	Description
Curled, broken, cracked or missing shingles	Repair the damaged areas immediately.
Missing granules on asphalt shingles	Aging, excessive foot traffic, and wind scouring caused by tree branches located too close to the roof are potential causes.
Excessive moss or algae growth	Moss and algae hold moisture on your roof that can lead to premature failures of shingles and shingles on vaulted roofs.
Foreign objects or build-up of debris/leaves/vegetation (for non-green roofs) on roof	All debris should be removed to avoid damage and clogging of drains.
Overflowing eavestroughs or backed-up downspouts	Gutters and downspouts must be inspected and cleaned regularly. Consider trimming nearby trees back to reduce debris build-up.
Hissing or damaged flashing, eavestroughs, downspouts, valves, and drain bores	These items are all vital to the roof performance and should be repaired or replaced immediately to avoid larger problems. Cackling of flashings must be regularly inspected and maintained.
Staining or damage on the ceiling or walls	Act immediately to locate and repair any potential roof leaks.
Exterior review for signs of moisture penetration/accumulation	For unvented spray foam roofs, exterior review may be the only way to detect potential moisture accumulation issues, using visual inspection, physical force, and even thermal imaging to test if the roof sheathing is wet.

Flat Roof Checklist

Inspection/Maintenance Item	Description
Splitting, ridging, or blistering of the roof membrane	Typically caused by stress and aging, which can occur throughout the roof area. Seek professional roof repair assistance.
Missing gravel (ballast) on low-slope roofs	Ballast is needed in all areas to protect the membrane from damage and retain the insulation. If ballast is sparse or missing in areas it should be replaced as soon as possible.
Standing water (ponding on the roof)	Typically caused by blocked or poorly located drains. This water will accelerate the degradation of roofing membranes if left in place. Using drains to facilitate drainage. If water continues to pond, seek professional roof repair assistance.
Paver pedestals on roof membrane	Paver pedestals may create point-loads on roof membranes and cause localized damage of roof membrane. Therefore, the waterproofing membrane below areas of the roof that may be subject to excessive foot traffic should be reviewed annually. Consider placing paver pedestals on small pads or blocking to limit exposure of the roof membrane surface.
Excessive moss or algae growth	Moss and algae hold moisture on your roof that can lead to premature failures of certain types of membranes on flat roofs.
Foreign objects or build-up of debris/leaves/vegetation (for non-green roofs) on roof	All debris should be removed to avoid damage and clogging of drains.
Overflowing eavestroughs or backed-up downspouts	Gutters and downspouts must be inspected and cleaned regularly. Consider trimming nearby trees back to reduce debris build-up.
Overflowing scuppers or overflow pipe	If the roof overflow drains are active, this is an indication that the primary roof drains are potentially blocked. Seek professional roofing plumbing assistance for clearing drains.
Staining or damage on the ceiling or walls	Act immediately to locate and repair any potential roof leaks.
Exterior review for signs of moisture penetration/accumulation	For unvented spray foam roofs, exterior review may be the only way to detect potential moisture accumulation issues, using visual inspection, physical force, and even thermal imaging to test if the roof sheathing is wet.

Intro to the Guide - Summary

Summary of Roofs		
Detailed discussions of each assembly, including thermal performance values, have been provided throughout the guide. This section provides a summary of the minimum insulation levels required for each assembly to achieve R-30 effective as well as key considerations for ease of reference.		
	Min. Insulation Levels to Achieve R-30 Effective	Key Considerations
 Pitched	2x12 joists with 10" of R-3.4/inch batt insulation 9.5" joists with 8.5" of R-4/inch batt insulation	Besides good roof detailing and watertightness, the performance of the assembly depends on a combination of adequate roof venting and airtightness of the ceiling.
	2x10 joists with R-25" of R-6/inch spray foam 9.5" joists with 9.5" of R-3.7/inch spray foam	Besides good roof detailing and watertightness, the performance of the assembly depends on airtightness of the ceiling.
 Flat	7" of R-4.5/inch rigid insulation 6" of R-5.5/inch rigid insulation 5" of R-6.5/inch rigid insulation	An EPS sloping package installed with the roof insulation is often the simplest way to achieve required sloping. Multiple insulation layers should be offset to provide a continuous thermal insulation layer. The waterproof membrane is protected from loading and therefore can have a longer service life than membranes placed in more exposed environments. The assembly is difficult to maintain and repair because access to the membrane requires removal of the ballast and insulation. Difficulty in achieving adequate venting, sensitivity to interior air leakage, and an assembly configuration where water can be trapped inside undetected puts this roof assembly at a higher risk of long-term performance issues.
	2x12 joists with 10" of R-3.4/inch batt insulation 9.5" joists with 8.5" of R-4/inch batt insulation	Besides good roof detailing and watertightness, the performance of the assembly depends on airtightness of the ceiling.
 Flat	2x10 joists with R-25" of R-6/inch spray foam 9.5" joists with 9.5" of R-3.7/inch spray foam	Besides good roof detailing and watertightness, the performance of the assembly depends on airtightness of the ceiling.
	10" of continuous extruded polystyrene insulation on the exterior + 2x8 joists with 7.25" of R-3.4/inch batt insulation	To reduce the risk of moisture build-up within the roof assembly, the split-rap of insulation should be 2:1 to include two-thirds of the nominal R-value on the exterior side, and the remaining one-third of the insulation between the roof joists. Otherwise, a hygrothermal analysis is required.

Discussion + Questions

FOR FURTHER INFORMATION PLEASE VISIT

→ www.rdh.com

→ www.buildingsciencelabs.com

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