

BUILDER INSIGHT



Builder Insight is a series of bulletins and companion videos designed to provide practical information on new technologies, research results, good building practices and emerging technical issues in residential construction to Licensed Residential Builders and others in the industry. This bulletin was prepared by RDH Building Science with review by Evoke Buildings Engineering Inc.

Retrofit and Renewal of Low-Slope Vented Wood-Frame Roofs

Overview

Low-slope vented wood-frame membrane roof assemblies are widely used in wood-frame construction throughout British Columbia. They can be found on various building types, ranging from single-family homes to larger multi-unit residential buildings (MURBs). In a coastal Pacific Northwest climate, low-slope vented roofs present durability and moisture performance challenges, even in roofs that have been built according to the building code and/or recently renewed. Field investigations frequently identify high roof sheathing moisture contents, fungal growth, and deterioration. There is a need to develop effective renewal and construction strategies for low-sloped roofs to overcome pre-existing performance issues, and to ensure the long-term durability of renewed or newly constructed roof assemblies.

This bulletin provides owners, designers, and contractors with guidance based on the recently completed Low-Slope Vented Wood-Frame Roof Study to indicate best practices, and key considerations for the successful retrofit or renewal of low-slope vented wood-frame roof assemblies in a coastal Pacific Northwest climate. While the bulletin focuses on retrofit and renewal work, by providing solutions to common constraints and challenges, the same design principles also apply to the design of new roof assemblies.

The information included in this bulletin applies to low-slope (i.e., flat, non-attic) wood-frame roofs in coastal areas of British Columbia. A low-slope roof is defined as a roof with a slope equal to, or less than, 1:6. Attic and non-wood-frame roof assemblies are beyond the scope of this bulletin.



Low-Slope Vented Roof Assemblies

Low-slope vented roof assemblies consist of insulated roof joists with ventilation beneath the roof sheathing. In this assembly, the depth of the roof insulation is limited by the depth of the roof joists, with allowance for ventilation at the underside of the roof sheathing. The joist space can be insulated using a variety of different insulation types, such as mineral wool, fibreglass batt, blown-in fibrous insulation (e.g., cellulose or fibreglass), or spray foam.

This assembly controls all liquid water at the waterproof membrane above the sheathing. The waterproof membrane and drainage surface are coincident. Water must drain over the membrane to centrally located drains or perimeter scuppers. Older low-slope vented roofs were typically waterproofed with built-up roof (BUR) waterproofing systems consisting of multiple layers of felt saturated in bitumen; while newer roof systems are often waterproofed with styrene butadiene styrene (SBS) modified bitumen membrane systems that generally consist of two plies of SBS modified bitumen waterproofing membrane. Other waterproofing materials include polyvinyl chloride (PVC), ethylene propylene diene monomer rubber (EPDM), thermoplastic polyolefin (TPO), and other proprietary membranes.

The air barrier is typically located at the ceiling plane using sealed-polyethylene, airtight drywall, or other sealed

interior ceiling method. Besides the use of polyethylene, vapour retarder paint on the drywall can also be used to control outward vapour diffusion to the roof cavity.

Vented roofs are popular for low-slope roof assemblies because the placement of insulation is between the joists rather than above the roof sheathing, which allows effective use of the joist space (i.e., reducing the overall thickness of the roof), and it often eliminates or reduces the need for cavity barriers for fire compartmentalization. Batt insulation is also typically more economical than rigid foam boards required for unvented (exterior insulated) assemblies, making vented roofs a cost-effective assembly.

As shown in Figure 1, vented roof assemblies are one of the low-slope roof assembly design approaches recognized by the BC Building Code (BCBC). Section 9.19 of the BCBC states that where insulation is installed between the ceiling and the roof sheathing, a space must be provided between the insulation and the underside of the sheathing, and vents must be installed, unless it can be shown to be unnecessary. Ostensibly, the purpose of ventilation in these assemblies is to allow transfer of moisture from the vent space to the exterior to dry incidental wetting from air leakage and water ingress, as well as to dilute humidity from air leakage. This is thought to be necessary because the roof membrane creates an impermeable layer on the exterior of the assembly, which limits drying.

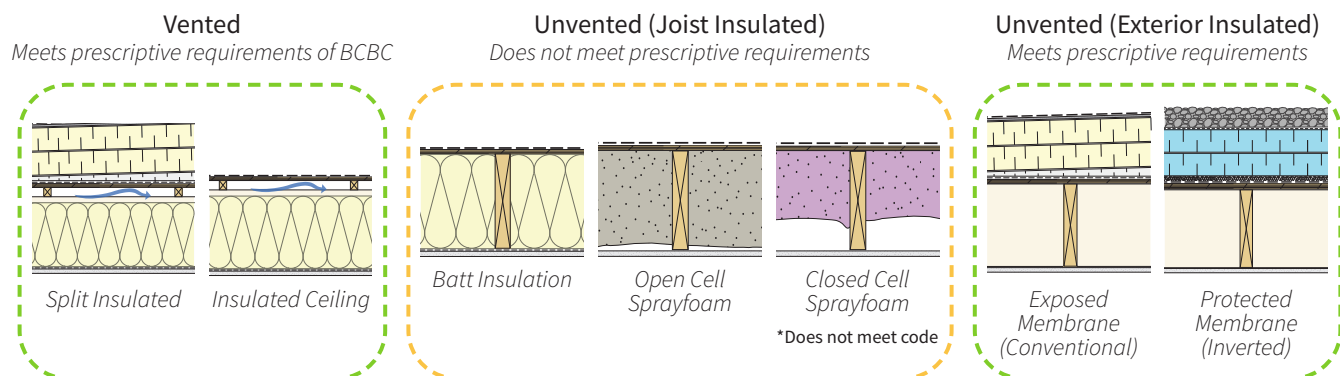


Figure 1: Roof Assemblies with Different Insulation and Venting Strategies

See the Insulated Wood-Frame Vaulted and Flat Roofs for Residential Construction in British Columbia for more roof designs and details at <https://www.bchousing.org/sites/default/files/media/documents/Illustrated-Guide-Insulated-Wood-Frame-Vaulted-and-Flat-Roofs.pdf>

For low-slope roofs with less than 1:6 slope, the BCBC requires minimum 1/150 of the insulated ceiling area to be unobstructed vent area. The required venting can be a combination of various types (e.g., above the roof, at the eaves, or at the gable ends), but should be distributed on opposite sides of the building and have minimum 25% of the openings each at the top and at the bottom of the vented joist space. In low-slope vented roofs, common methods of achieving venting include soffit vents, doghouse vents, and parapet vents. Within the roof assembly, BCBC requires a total minimum ventilation clearance of 63 mm

(2.5") between the top of the insulation and the underside of the roof sheathing. Unless each joist space is separately vented, the total ventilation clearance is typically provided by use of purlins at least 38 mm (1.5") thick between the joist and the sheathing, with additional 25 mm (1") clearance above the insulation in the joist space.

A cut-away graphic of a typical low-slope vented roof assembly is provided in Figure 2, and examples of commonly used venting strategies and venting products (that BCBC requires to comply with CAN3-A93-M "Natural Airflow Ventilators for Buildings") are provided in Figure 3.

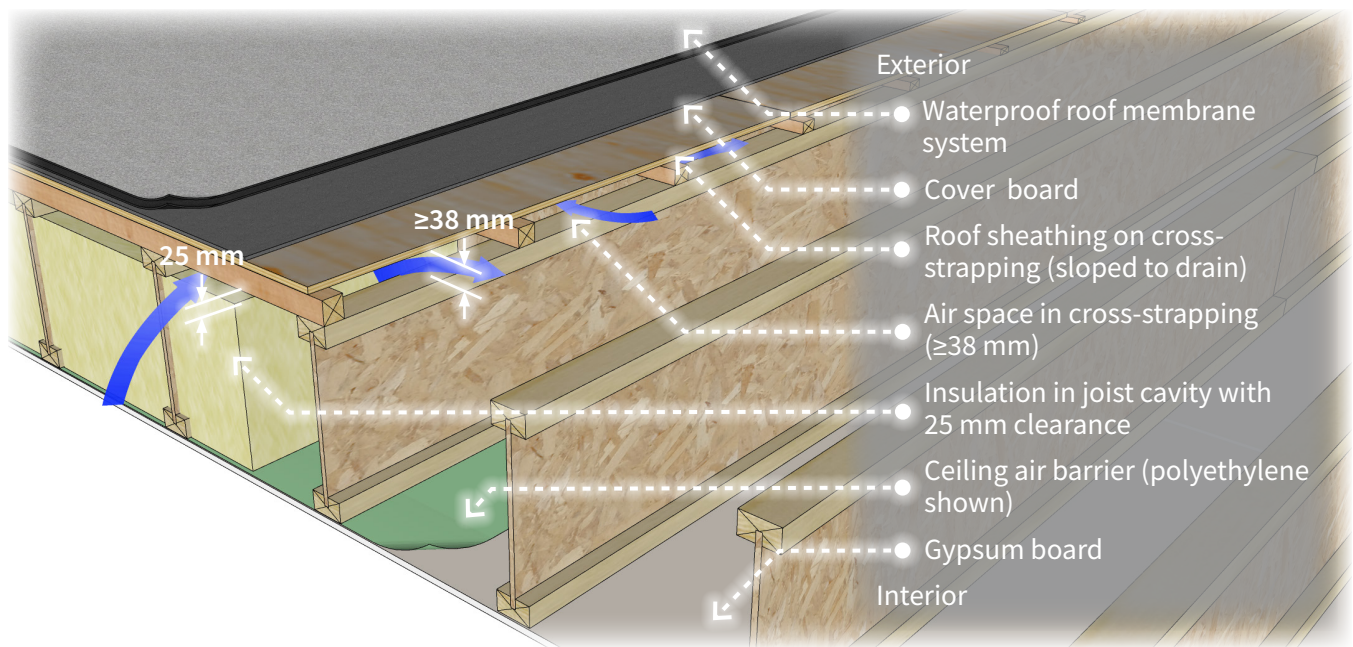


Figure 2: Low-slope vented wood-frame roof assembly

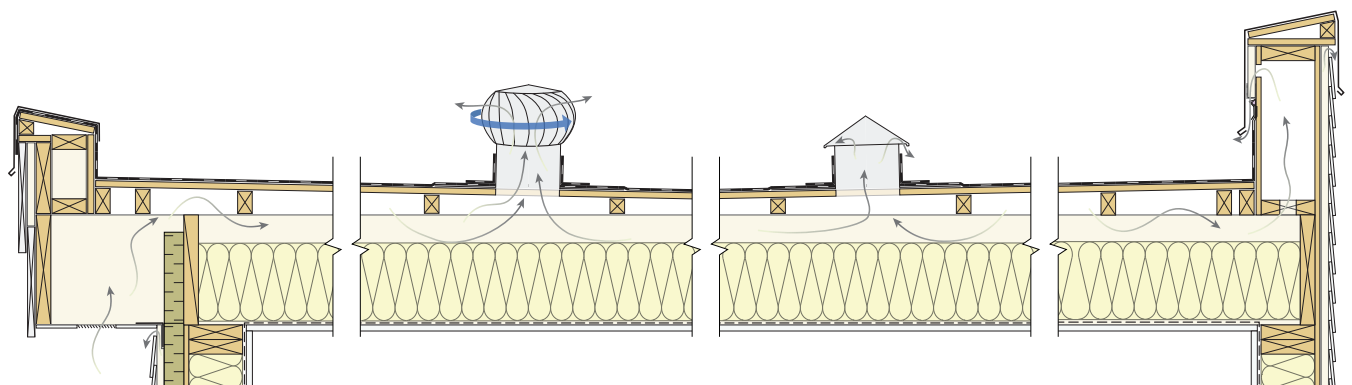


Figure 3: Example of Venting Options from left to right: Soffit Vent, Turbine Roof Vent, Doghouse Roof Vent, Parapet Vent

Issues

Issues in low-slope vented roof assemblies are common in the Pacific Northwest (area of concern highlighted in Figure 4), largely due to a damp and cool marine climate, where there is significant opportunity for wetting, but limited opportunity for drying due to its moderate winter coinciding with overcast and rainy wetting season. Compared to sloped attic roofs, low-slope vented roofs are less reliably ventilated, and the vented space is inaccessible for periodic inspection.

Studies done in the Pacific Northwest have shown that low-slope vented wood-frame roofs, even when built in conformance with the building code, have experienced high occurrences of mould growth, staining, and in some cases, decay. Investigations of low-slope vented wood-framed roof assemblies are sometimes prompted by water dripping down onto finished ceilings (i.e., staining on the ceiling), or due to deterioration of the roof sheathing that can be detected when walking on the roof; however, often, the issues are hidden from view.

Figure 5 shows the range of conditions that have been observed for low-slope vented wood-framed roofs in BC during recent roof renewals. Sources of moisture are often attributed to rainwater ingress; unintentional exfiltration of conditioned air from the interior spaces; or air leakage from ductwork that condenses on the underside of the roof sheathing. However, another source of moisture within the



Figure 4: Map of Pacific Northwest with high mold risk area highlighted

vented cavity can be the venting itself. In the winter, moist ventilation air from the exterior can also be a source of moisture absorbed by the otherwise dry sheathing.

Night Sky Cooling

High humidity wintertime exterior air, especially in combination with limited solar heating of the ventilation space, is particularly challenging for two reasons: the unheated exterior air has limited drying capacity to remove moisture from the roof assembly when venting

Like New

*Roof deck in pristine condition
(insulation above roof sheathing)*



Stained

Significant staining of the sheathing and purlins



Deteriorated

Structural damage of the sheathing



Figure 5: Range of observed low-slope vented wood-framed roof sheathing conditions in the Lower Mainland of BC at time of roof membrane renewal

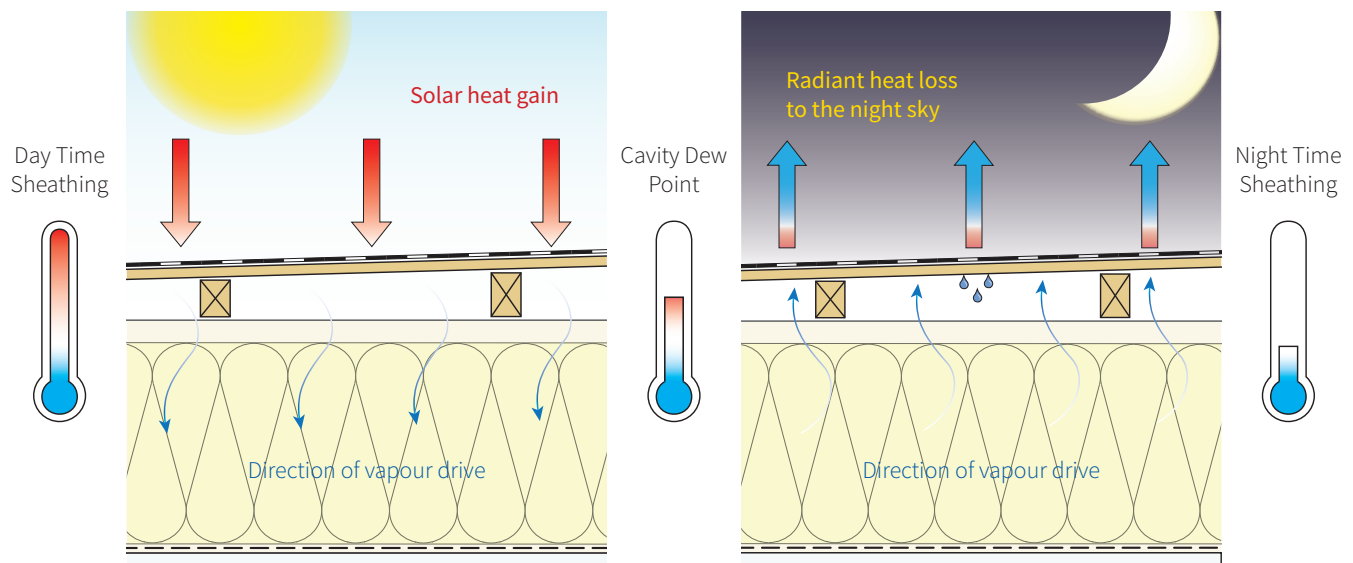


Figure 6: Illustration of solar warming (left) and night sky cooling (right) mechanisms

occurs; and the high humidity of the exterior air means that it is already close to vapour saturation (i.e., dewpoint). When the exterior air is near saturation, condensation or frost can form on the sheathing even without significant moisture contribution from the conditioned space. Studies have found that condensation or frost on the sheathing is linked to night sky cooling where the roof radiates heat to the clear night sky, thus, reducing its temperature. As a result of night sky cooling, the surface temperature of the underside of roof sheathing can fall below the dewpoint temperature of the exterior air used to ventilate the roof cavity, causing condensation or frost to form (see Figure 6). Condensation (or melted frost) on the underside of the roof sheathing can be absorbed to increase the moisture content of the sheathing. Additionally, as illustrated in Figure 6, the outward direction of vapour diffusion through low-slope vented roof assemblies at nighttime drives moisture from the roof cavity to the underside of the roof membrane. Without the ability for the air in the roof cavity to provide drying, these moisture sources maintain high equilibrium moisture content of the wood over prolonged periods.

Condensation wetting through night sky cooling is often overlooked, and issues can be incorrectly attributed to other causes, such as vapour diffusion, air leakage, or water

ingress. Given the prevalence of this wetting mechanism in the Pacific Northwest climate, it is possible for assemblies with no ceiling air leakage or bulk water ingress to still experience damage, and adding more ventilation may actually exacerbate the problem.

Roof Ventilation

Unlike in an attic where there is significant height difference between the eave and the ridge vents, allowing for air buoyancy to drive ventilation, low-sloped roofs rely to a larger extent on wind pressures to drive ventilation. The relatively small and circuitous ventilation spaces in low-slope vented roofs also restrict ventilation more so than the relatively open spaces provided in attics. The result is low-slope roofs typically have lower airflow rates when compared to attics, which makes it difficult to ensure adequate ventilation is achieved throughout the entire roof area to effectively dry the assembly.

Insulation Arrangement

One of the key challenges with low-slope roof assemblies is that they experience significant wetting and generally necessitate a perfect barrier approach to water management (i.e., a roofing membrane). However, appropriate roofing membranes are also typically impermeable to water

vapour, which when combined with the vapour control layer positioned on the interior side of the insulation in colder climates, create a double vapour barrier situation. This double vapour situation is particularly problematic for vented wood-frame roof assemblies because moisture-sensitive materials, such as wood framing, are located between these vapour impermeable layers, increasing the risk of damage. A vented roof attempts to solve this problem by venting underneath the impermeable roofing membrane in an attempt to remove incidental moisture.

Other Factors

Anecdotal evidence from the roofing industry has suggested that there is a correlation between BUR systems being converted to direct applied, SBS modified bitumen membranes and an increase in occurrence of moisture issues with low-slope vented roofs becoming more common on low-sloped roofs. In a roof renewal survey conducted by BC Housing as part of the recent study, the older BUR roofs did not show as much condensation damage even when air leakage was confirmed. The greater overall thickness of older BURs, typically topped with gravel, compared to SBS, has greater thermal mass, which likely helps reduce frequency and magnitude of condensation events by moderating sheathing temperature and keeping the sheathing drier (see bottom of p. 7). All the surveyed BUR roofs generally performed well regardless of whether they were renewed or original roofs. However, the survey data showed that many of the SBS roofs that had condensation issues were renewed roofs. While it is difficult to determine if this was due to changes in the roof system as the data lacks accurate history of these roofs and what the previous assemblies were, it is likely they were BUR roofs due to their prevalence in older buildings. Another takeaway from the survey was that renewal with a like-for-like system generally continued to perform similarly.

Retrofit and Renewal

As discussed above, difficulty with the limited effectiveness of venting to remove moisture in low-sloped roofs, sensitivity to interior air leakage, and an assembly configuration where moisture can accumulate puts a low-slope vented roof assembly at a higher risk of long-term performance issues. This section of the bulletin addresses topics and strategies to consider when retrofitting or renewing existing low-slope vented roof assemblies. These considerations are provided in approximate order of importance and effectiveness with respect to reducing the moisture-related risk associated with low-slope vented roof assemblies.

This section is followed by a risk assessment tool, which illustrates how the retrofit/renewal considerations and strategies affect overall relative moisture-related risk.

While several considerations and risk mitigation strategies are discussed, as every retrofit and/or renewal is unique, there may be alternate solutions not discussed here, as well as other factors which may impact the relative risk associated with different approaches. The specific conditions and performance issues, constraints, and the scope/budget of each project should be considered.

Insulation Arrangement

Why Does It Matter?

The benefits of exterior insulation are well-understood in the industry. In roof assemblies, exterior insulation keeps the sheathing warmer, which can reduce or eliminate condensation wetting due to night sky cooling. While insulation outboard of a vented air space is generally considered less effective, in most common low-slope venting arrangements, the amount of heat transferred by venting does not significantly bypass the insulation because the airflow rates are low; and therefore, the insulation generally maintains its effectiveness.

As part of renewals, insulation is often added to increase thermal performance and/or to meet the code-required thermal resistance value for the assembly. Increasing the thermal resistance can also help moderate the sheathing temperature to achieve lower daily maximum and higher daily minimum temperatures. Controlled monitoring data, as shown in Figure 7, demonstrates this moderation effect on sheathing temperatures of roof assembly samples with varying insulation thicknesses in the winter. In studies of conventional roofs, roof assemblies using insulation with higher heat capacity has been shown to experience decreased daily peak temperatures on the interior side, while experiencing warmer daily minimum temperatures, with thermal fluctuation lag of a few hours compared to roofs with lightweight foam insulation.

Studies have shown that adding insulation outboard of sheathing is an effective solution to improve the moisture durability of these roof assemblies. In addition to its thermal benefits, exterior insulation can also serve as a taper package to improve drainage on the roof surface.

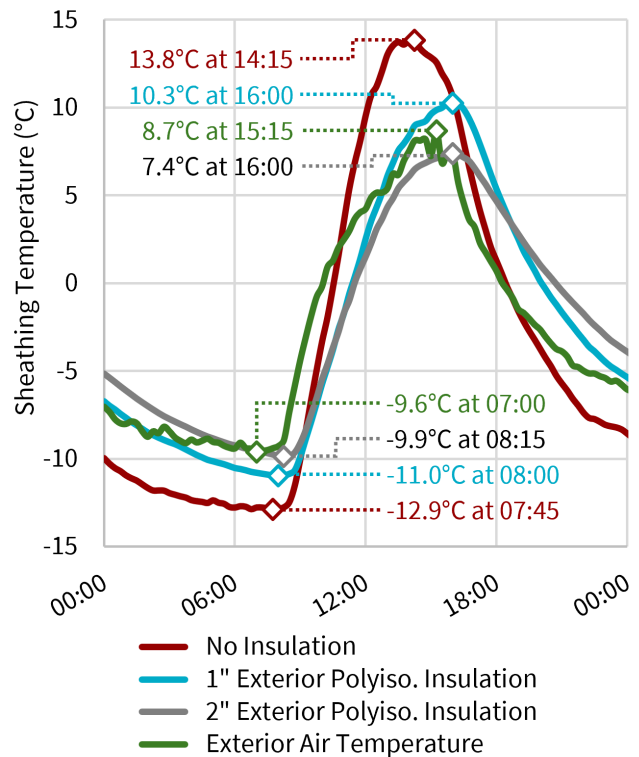
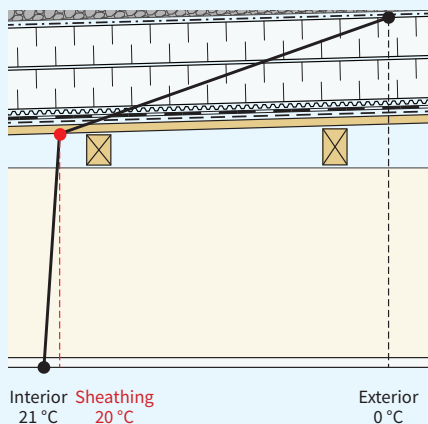


Figure 7: Sheathing temperatures in controlled roof assemblies with varying exterior insulation thicknesses for Feb. 6, 2019

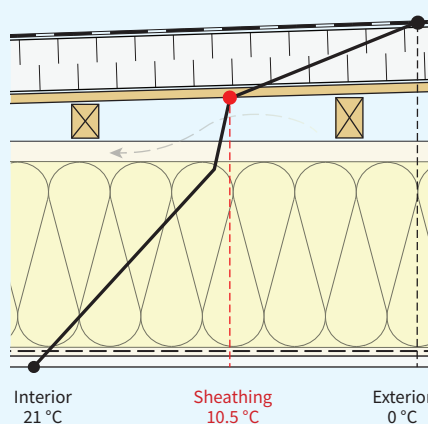
Exterior Only (Unvented)

Exterior insulated roof assemblies have all of the insulation on the exterior side of the roof sheathing. This insulation arrangement offers the greatest buffer for the sheathing from night sky cooling, eliminating the risk of condensation. Common exterior insulated roof assemblies include exposed membrane conventional roof assemblies and protected membrane roof assemblies (i.e. inverted roof assembly, shown below).



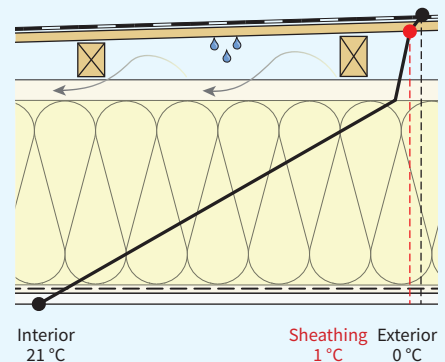
Split

Split insulated roof assemblies have some insulation on the exterior side of the roof sheathing and also have insulation in the joist space. The insulation on the exterior provides some buffer for the sheathing from night sky cooling, typically keeping the sheathing temperature above the dew point of the vented cavity air. The BCBC requires that split insulated assemblies be vented.



Interior Only

Interior insulated roof assemblies have all of the insulation on the interior side of the roof sheathing. This insulation arrangement offers minimal buffer for the sheathing from night sky cooling and condensation is much more likely to occur. The BCBC requires that interior insulated assemblies be vented. This insulation arrangement is the most susceptible to air leakage and the effectiveness of venting. Additionally, other considerations (i.e. membrane type, colour) have much greater influence on this insulation arrangement.



Considerations

Given the typical low-slope roof renewal period of more than 20 years, additional insulation may be desired in retrofit or renewal projects looking to improve the thermal performance of roof assemblies for improved energy efficiency. The addition of insulation is also often a practical approach to increasing roof sloping for drainage. Adding exterior insulation to a roof likely requires adjusting the height of various elements, including parapets, curbs, and penetrations. Raising the height of door thresholds is often particularly challenging.

If existing conditions allow the full depth of the roof insulation to be installed above the roof sheathing, a fully exterior insulated roof assembly, such as exposed membrane conventional assembly or protected membrane (inverted roof) assembly, is the most durable option. See the following sections for implication on airtightness and roof ventilation.

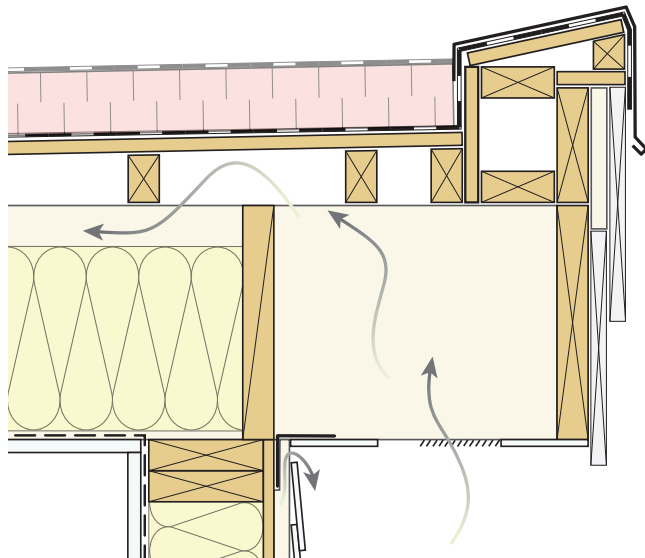


Figure 8: Insufficient parapet height to accommodate additional exterior insulation

If there is insufficient clearance above the sheathing to accommodate the desired thickness of insulation, a split insulation arrangement is the next best option to increase the durability of the roof assemblies (Figure 8). A split insulation arrangement is also appropriate when there is the desire to use the existing assembly and avoid

removal of insulation and other materials from the joist space. Generally, when adding exterior insulation, venting should be maintained unless insulation accounting for at least 50% of the nominal R-value is located above the roof sheathing. It is potentially possible to reduce this ratio, but the condensation risk, depending on project-specific factors (e.g., climate, roof membrane solar properties, indoor use of space) should be assessed.

When the overburden (i.e., gravel layer) is being removed from the roofing system as part of a renewal, exterior insulation should be added to provide the roof sheathing with a similar buffer to night sky cooling (see **Roof Membrane Type** section below).

Airtightness

Why Does It Matter?

Air leakage from the interior of the building is a primary cause of condensation-related moisture accumulation, which can lead to fungal growth, and in the case of excessive air leakage, deterioration of moisture-sensitive materials. The amount of air leakage which occurs depends on the airtightness of the air barrier system, which is typically located at the ceiling level in these assemblies. Sealing of the air barrier at penetrations through the ceiling plane, such as pot lights and plumbing for fire suppression systems (i.e., sprinklers), can be difficult and often leads to air leakage paths into the roof assembly.

Considerations

Regardless of the failure mechanism of the existing roof assembly, air sealing of penetrations is recommended. In MURBs, connection details at the top of interior demising walls and fire-rated suite partition walls are also common air leakage locations that should be air sealed. If the scope of the retrofit or renewal involves new roof sheathing, the roof should be assessed for accessibility to the existing ceiling air control layer and existing ductwork. Efforts should be made to improve airtightness where possible, following current best practices (see Figure 9).

If the roof is being fully converted to an unvented, exterior

insulated assembly, the existing air control layer at the ceiling plane, along with any existing interior cavity insulation, should be removed and replaced with an air control layer on the exterior side of the roof sheathing to avoid having a double vapour barrier. This new air control layer must tie-in to the existing one in the adjacent assemblies and be properly detailed to provide a continuous air barrier system (see Figure 10). Any existing vents of the cavity space should also be sealed off. In some cases, it may be necessary or beneficial to maintain the batt insulation for acoustic or fire related reasons. Also, maintaining the polyethylene sheet can assist in providing

some level of protection to interior finishes during roof renewals. In these situations, the ratio of interior to exterior insulation should be carefully considered to reduce risk of condensation within the roof assembly.

Whenever the roof sheathing is removed for air sealing improvements or for conversion to an exterior insulated assembly, the air control plane at the interior ceiling is exposed and is more prone to puncture and damage from workers, tools, and material on the roof. The exposure also makes the interior ceiling more prone to water intrusion during construction.

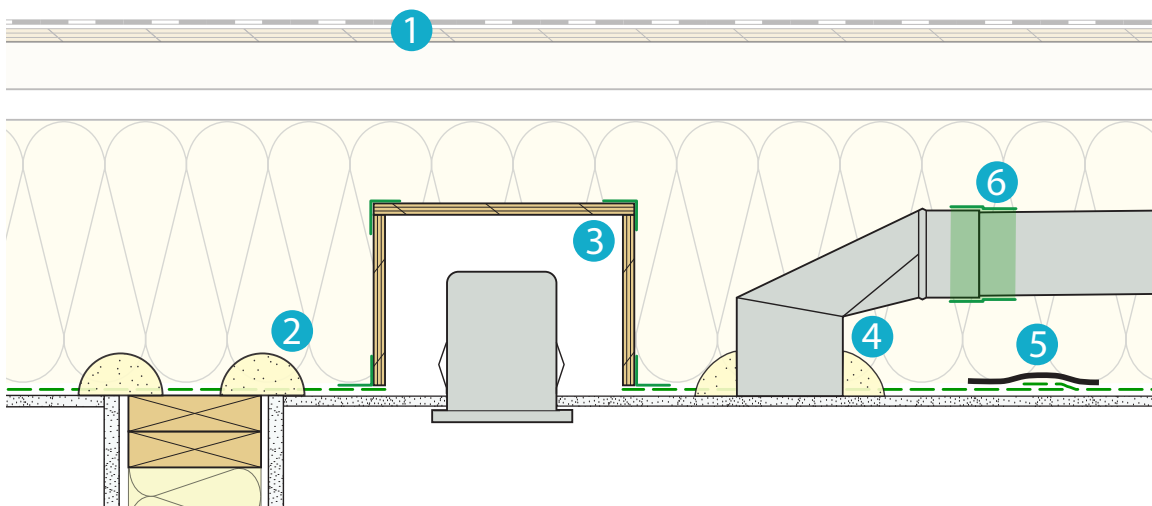


Figure 9: Example Interior Air Barrier Improvement Procedures

1. Remove existing roof membrane, sheathing and batt insulation to access existing polyethylene sheathing.
2. Spray foam, tape, or seal around interior demising walls and fire-rate suite partition walls
3. Box around penetrations in the ceiling, and tie into the air barrier
4. Spray foam, tape, or seal around duct penetrations through the air barrier
5. Tape laps, joints or cracks in the existing air barrier
6. Seal joints in ducts

Tight

A tight air barrier is continuous and minimal air leakage is expected, which significantly reduces risk of condensation. Exterior air barrier systems typically more easily achieve “tight” levels of performance. Where the air barrier is located below the roof joists, “tight” levels of performance are often difficult to achieve due to various penetrations and limited access during retrofit/renewal work.

Medium

This refers to an air barrier with airtightness somewhere between tight and leaky that has some discontinuities and allows some air leakage but continues to perform at an acceptable level. While airtightness improvement is always recommended, it may be economical to leave it as is, and focus on adding exterior insulation.

Leaky

A leaky air barrier is discontinuous and poses significant risk of condensation in a vented roof assembly. As airtightness improvement at the ceiling level is challenging, consider an exterior insulated assembly where no venting is required, and a new exterior air barrier can be installed and made airtight. If the roof cannot be fully exterior insulated, the air barrier must be made reasonably airtight.



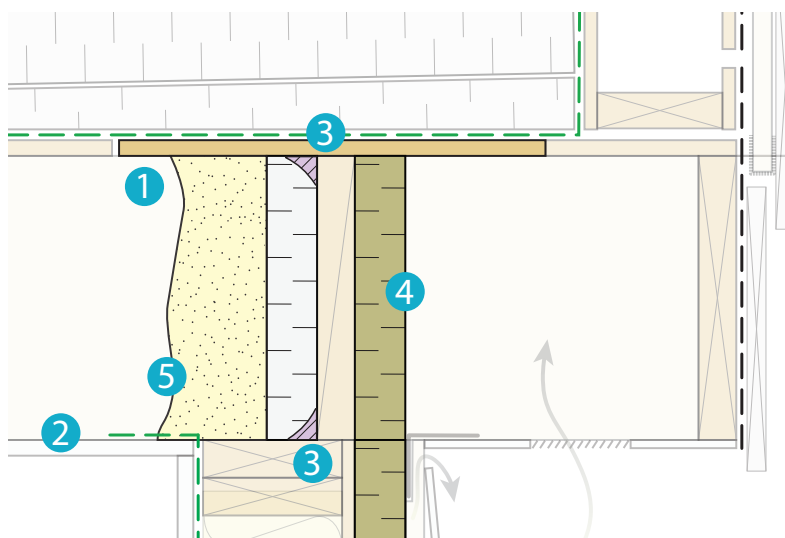


Figure 10: Example Retrofit Strategy for the Roof Exterior to Wall Interior Air Barrier Transition

1. Perimeter pre-stripping of roof sheathing, extending 50 mm (2") past interior of wall assembly
2. Leave sufficient existing polyethylene sheeting for air barrier tie-in
3. Caulk all four sides at blocking at every joist space to accommodate transition to exterior air barrier system on the wall in the future
4. Add exterior insulation
5. Provide continuous air barrier from existing polyethylene to underside of perimeter roof sheathing using spray foam insulation (provided joist and other wood frame member has undergone drying and shrinkage)

If the existing air barrier system is intact and an acceptable level of airtightness is verified, a split insulation system may be an appropriate cost-effective option. Split-insulated assemblies are less reliant on the air barrier performance compared to interior insulated assemblies, and it is likely that the existing air barrier may be used. Provided that the roof has not experienced moisture-related issues and adequate insulation is installed above the roof sheathing, the removal of the roof sheathing may not be required in this case.

Roof Ventilation

Why Does It Matter?

Unless pursuing an engineered design through an alternative solution, in a low-slope roof assembly where insulation is provided on the interior of the roof sheathing, ventilation must be provided to meet the BCBC prescriptive requirements. In low-slope vented roofs, there is limited vertical distance between the vents. Consequently, ventilation of the roof depends primarily on

wind-induced pressure differences, which are less reliable than pressures created by stack effect, such as in attics for a pitched (sloped) roof. Additionally, the ventilation paths and vent space in low-slope vented roof assemblies are relatively complex due to the small and restricted ventilation spaces created by purlins, and the difficulty in locating vents (e.g., parapets, soffits, doghouses) such that ventilation is reliably provided to all areas of the roof. Where the assembly cannot facilitate effective ventilation to provide drying, eventual moisture accumulation from air leakage and other interior sources is detrimental to the durability of these types of roof assemblies.

As mentioned previously, high humidity in exterior air that is close to the dewpoint temperature can be another source of moisture. Radiation heat loss to the night sky can cool the roof sheathing to below the dewpoint of the exterior air, causing condensation on the underside of the roof sheathing. This issue cannot be solved by increasing ventilation.

Considerations

When retrofitting or renewing a vented roof assembly, the existing venting area should be confirmed, and additional vents should be provided if building code minimum requirements are not met. The distribution of vent locations should also be considered to ensure adequate ventilation is reliably provided to all areas of the roof. Adding extra ventilation beyond code requirements won't necessarily improve durability and may cause moisture problems due to increased moisture accumulation from sources like interior air leakage. Venting methods that create additional pressure difference, such as turbine vents or fans, should generally be avoided where the ceiling plane airtightness cannot be confirmed, as depressurization can increase air leakage.

While vented low-slope roofs are typically installed with no insulation outboard of the exterior sheathing, in some cases, including retrofits or renewals of existing roofs, additional insulation is installed above the sheathing of

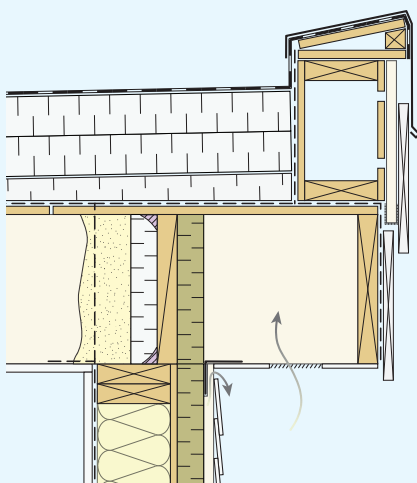
vented low-slope roofs to provide slope to poorly sloped roof decks, or to increase the roof thermal performance. The additional insulation often raises questions regarding whether the roof vents should be sealed so that the roof can act as an unvented roof, or whether they should be maintained to allow ventilation and potentially drying. As mentioned previously, venting should be maintained unless insulation accounting for at least 50% of the nominal R-value is located above the roof sheathing, and project-specific conditions should always be considered before closing off roof vents.

Other Considerations

The design considerations discussed in this section are typically less impactful than the insulation arrangement, airtightness, and ventilation of the roof assembly. However, in certain situations can be significant, especially when using vented arrangements where the wetting and drying balance for the sheathing can be impacted by subtle, yet consequential, changes.

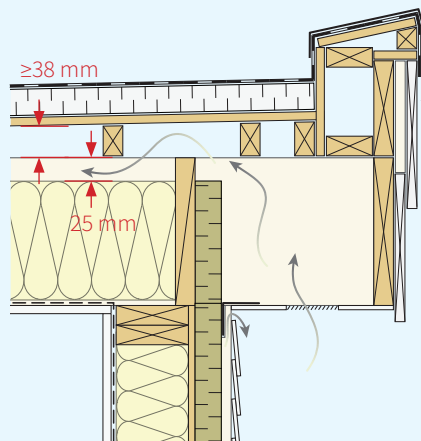
Unvented

Unvented assemblies are only permitted for exterior insulated assemblies. Venting is rendered unnecessary since the sheathing temperature is moderated by interior conditions to eliminate condensation risk, and the air barrier is continuous below the exterior insulation.



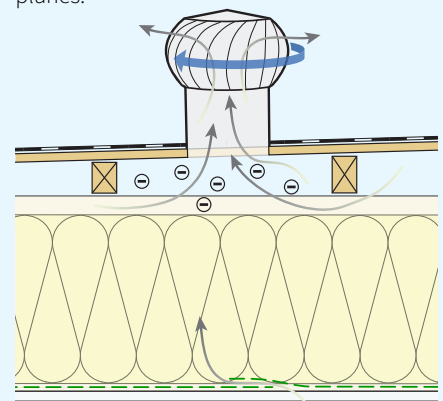
= Code Minimum

The provided ventilation meets the code minimum prescriptive requirement (area ratio of unobstructed vent area to insulated ceiling area of 1:150). Unless it can be shown to be unnecessary, venting must be provided when some or all insulation is installed between the joists. Soffit and dog-house style vents which rely on natural air movement are preferred.



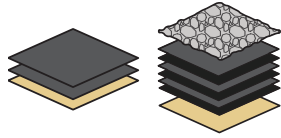
> Code Minimum

The provided ventilation exceeds the code minimum prescriptive requirement. Excess ventilation has not shown to provide increased durability. For example, wind-assisted turbine vents pull air out of the cavity, which creates negative pressure zones within the roof assembly and can exacerbate air leakage issues at the ceiling plane. Above code-minimum ventilation is unlikely an effective solution to addressing moisture-related performance issues, especially for assemblies with leaky ceiling planes.



Roof Membrane Type

Why Does It Matter?



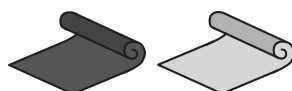
Older low-slope vented roofs were typically waterproofed with BUR waterproofing systems consisting of multiple layers of felt saturated in bitumen and topped with gravel acting as UV and wear protection. Newer roof systems are often waterproofed with a two-ply SBS modified bitumen system, or with a single-ply membrane system (e.g., PVC, TPO, EPDM). A survey conducted as part of the recent study has shown that something as simple as changing the roof waterproofing system during re-roofing can negatively affect the performance of the roof and increase potential for moisture-related risks. This trend was more commonly observed when BUR roofs were renewed with a new membrane type. While the thermal mass of the overburden (e.g., gravel, ballast) in BUR assemblies was just enough to moderate roof sheathing temperatures, with the new lower thermal mass roof system (e.g., two-ply SBS modified bitumen membrane), the roof sheathing has less buffer and is at increased risk of wetting from condensation, either by air leakage from the interior or night sky condensation of the ventilation air within this space.

Considerations

When retrofitting or renewing, compare the thermal mass of the old and new roof waterproofing systems and consider how changes might affect condensation risk. If the new system has less thermal mass, consider adding exterior insulation with at least R-5 thermal resistance.

Roof Membrane Colour

Why Does It Matter?



Low-slope roof membranes are available in a wide range of colours and associated solar thermal properties (i.e., solar absorption and emissivity). While dark membranes absorb a large amount of solar radiation and create roof temperatures significantly above ambient air temperatures, light-coloured roof membranes absorb relatively less radiation and consequently experience

lower temperatures (see Figure 11). Therefore, changing the roof colour as part of a retrofit or renewal can impact the roof temperature, which in turn affects drying of the roof sheathing. Hygrothermal analysis and in-situ roof monitoring have shown that in vented wood-frame roofs, light-coloured roofs have the highest moisture levels while BURs and dark-coloured SBS roofs have lower moisture levels. The impact of roof colour is of significantly less importance for the moisture durability of conventional and protected membrane roof assemblies where the exterior surface of the roof is separated from the roof sheathing by insulation.

Considerations

Roof sheathing moisture content in vented wood-frame roofs is sensitive to the drying capacity provided from solar absorption when no exterior insulation is provided. In cases where more reflective membranes are used, there is an increased risk of high sheathing moisture contents conducive to damage, such as fungal growth. Therefore, for vented wood-frame roof assemblies with no exterior insulation, it is recommended that darker (more solar absorptive) membrane be used to increase drying capacity, and light-coloured reflective membranes should only be used for exterior insulated assemblies.

Wood Treatment

Why Does It Matter?



There are always moisture-related risks in low-slope vented roof assemblies; therefore, redundancy in the strategy for mitigating moisture-related issues should be considered.

Considerations

One option to provide redundancy is to make the wood material in the roof assembly more resilient to moisture-related damage by using surface mould treatments (e.g., moldicide), treatment to mitigate decay, and water-repellent products. While this does not replace more important and effective risk mitigation efforts that improve durability and prevent moisture accumulation that may

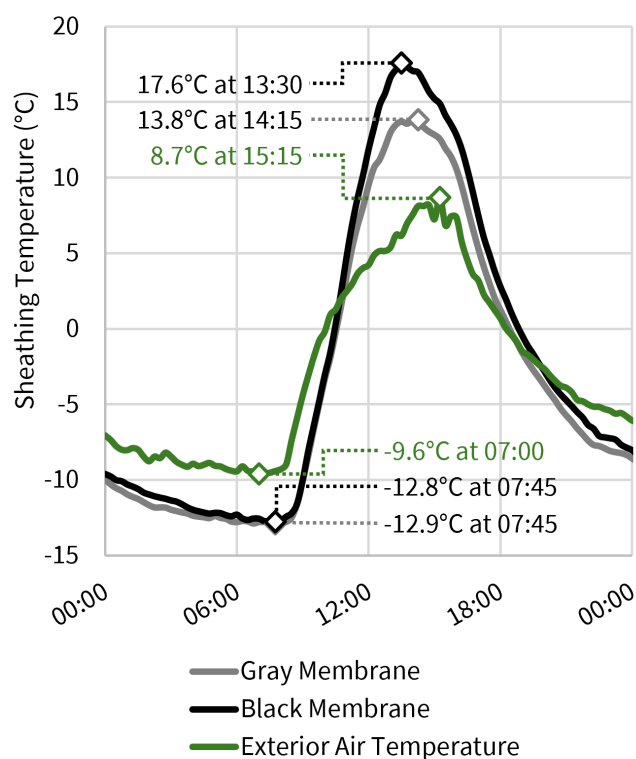


Figure 11: Graph of sheathing temperatures in controlled roof assemblies with varying membrane colours for Feb. 6, 2019

lead to damage to the interior finishes, wood treatment is a relatively practical measure that can be easily performed to supplement other measures to improve performance.

Key Considerations

1. Use exterior insulated roof assemblies where possible. Provide exterior insulation (min. R-5 thermal resistance) to mitigate moisture accumulation on the roof sheathing of vented roofs. The insulation on the exterior can also provide roof slope.
2. Provide an effective air barrier at the ceiling plane, which is especially important where insulation is split, or on the interior of the sheathing. Alternatively, provide sufficient exterior insulation to limit condensation risks.

3. Assess the airtightness of the ceiling plane (e.g., via smoke testing). Above code minimum ventilation may not be an effective solution to addressing moisture-related performance issues in the presence of air leakage paths. Airtightness verification is recommended.
4. Changing roof membrane type may introduce unforeseen moisture-related risk. Consider darker roof membrane colours for assemblies with insulation on the interior of the sheathing. Use wood treatment to provide resiliency against moisture-related damage.

Additional Resources

Available at BC Housing (www.bchousing.org)

- › Illustrated Guide: Achieving Airtight Buildings
- › Illustrated Guide: Insulated Wood-Frame Vaulted & Flat Roofs
- › Building Enclosure Design Guide - Wood-Frame Multi-Unit Residential Buildings
- › Asphalt Shingle Sloped Roofing Research Study
- › Attic Ventilation and Moisture Research Study
- › Field Evaluation of Roof Sheathing Surface Treatments Report
- › Mouldy Sheathing Treatments | FPInnovations

Available at British Columbia Codes (www.bccodes.ca)

- › Vancouver Building By-law (VBBL) 2019
- › British Columbia Building Code (BCBC) 2024

Available at RDH Building Science (www.rdh.com)

- › Re-Thinking Ventilated Attics: How to Stop Mold Growth in Coastal Climates
- › Six-Year Conventional Roof Monitoring Report
- › Renewal Strategies for Low-Slope Ventilated Wood-Framed Roofs (ICBEST 2020)

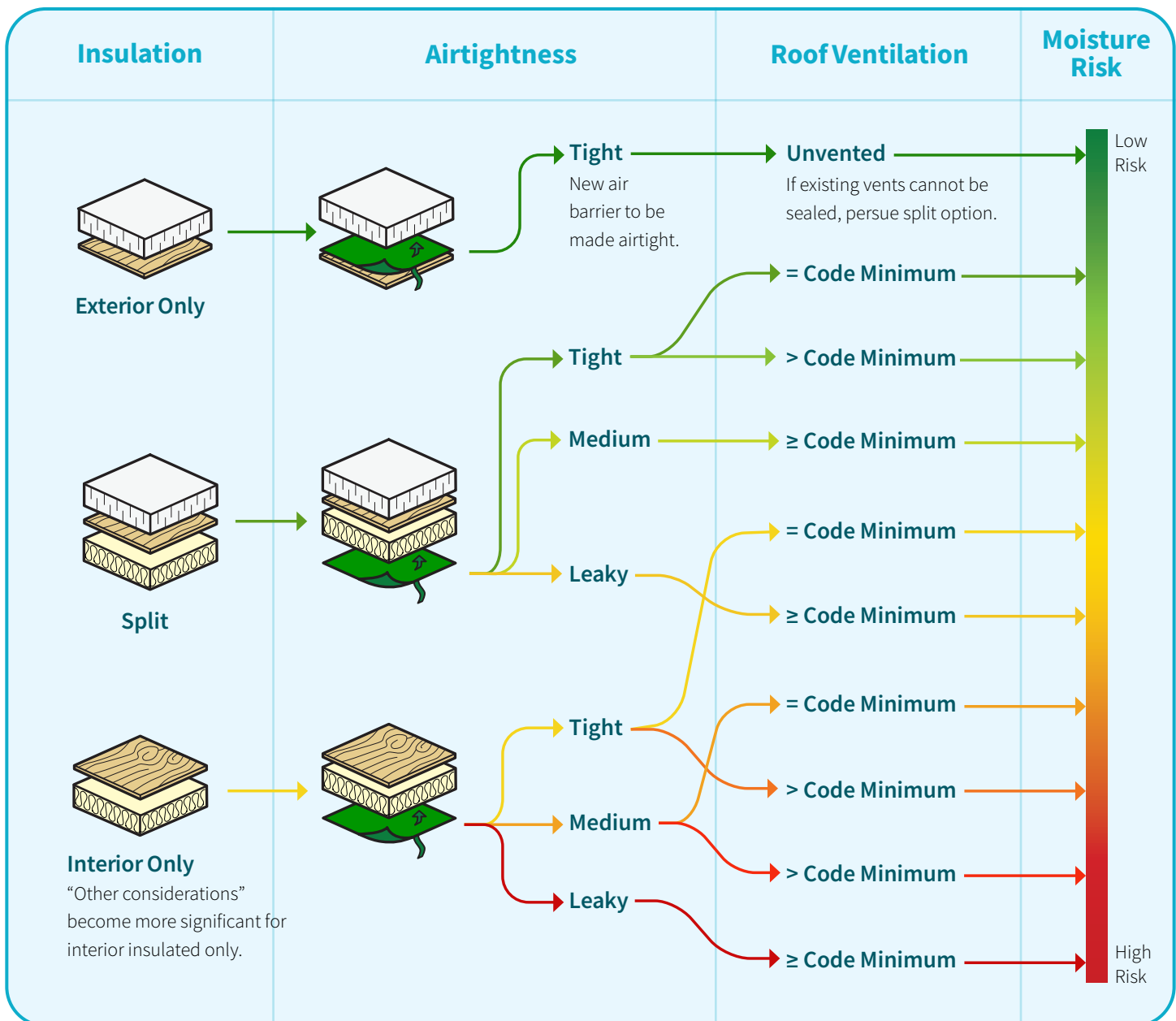
Available at Evoke Buildings Engineering (www.evokebuildings.com)

- › Renewal Strategies for Low-Slope Ventilated Wood-Framed Roofs (ICBEST 2020)



Boxes in this document with this icon in the top right corner define the terms used in the flow chart below.

Moisture Risk for Low-Slope Wood-framed Roofs



Legend

- Exterior Insulation (e.g., rigid foam (polyiso, EPS), rigid mineral wool)
- Wood Sheathing (i.e. plywood)
- Interior Insulation (e.g., fiberglass batt)
- Air barrier (e.g., polyethylene sheet, vapour impermeable self-adhered membrane)

How do I use this risk assessment tool?

Start on the far left column. Consider which insulation arrangement will be feasible. Next consider how your existing air barrier is performing and whether a replacement/renewal is in order based on your target risk level. Finally, consider the effect of excess venting on your roof assembly. The less exterior insulation in your assembly, the more influence venting has on moisture risk. The color on the arrows indicate the lowest level of moisture risk that can be achieved by following that path.

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It is acknowledged that many product options exist. Materials and products depicted in figures are shown as examples and do not represent an endorsement of any specific brands or products.

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