Canadian SPRAY FOAM GUIDE

Recommended enclosure details using light-density (0.5 pcf) and medium-density (2.0 pcf) polyurethane spray foam

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CUFCA
CANADIAN URETHANE FOAM CONTRACTORS ASSOCIATION INC.
ASSOCIATION CANADIENNE DES ENTREPRENEURS EN MOUSSE DE POLYURÉTHANE INC.

Spray Foam Installation Notes

- With the emergence of spray foams that have different densities and vapour permeances, it should be noted that this guide refers to only two types of spray foam:
  1. Light-density open-cell spray foam 0.5 pcf (ocSPF)
  2. Medium-density closed-cell spray foam 2.0 pcf (ccSPF)
- The spray foam details in this guide assume that all other aspects of the building enclosure are constructed adequately and comply with the building code. It is assumed that there is no water intrusion into the enclosure due to poorly constructed water management details.
- Always follow the spray foam manufacturer's guidelines for spraying foam. Adhere to required temperatures (air and substrate), substrate moisture content, thickness and fire protection.
- If it is unclear which construction strategy to use, further guidance should be sought from CUFCA or building enclosure experts.
- The NBC and local building codes should be followed at all times unless permission is given otherwise based on sound engineering and physics.
- The TDS and MSDS should be reviewed and adhered to for the spray foam product(s) being installed.

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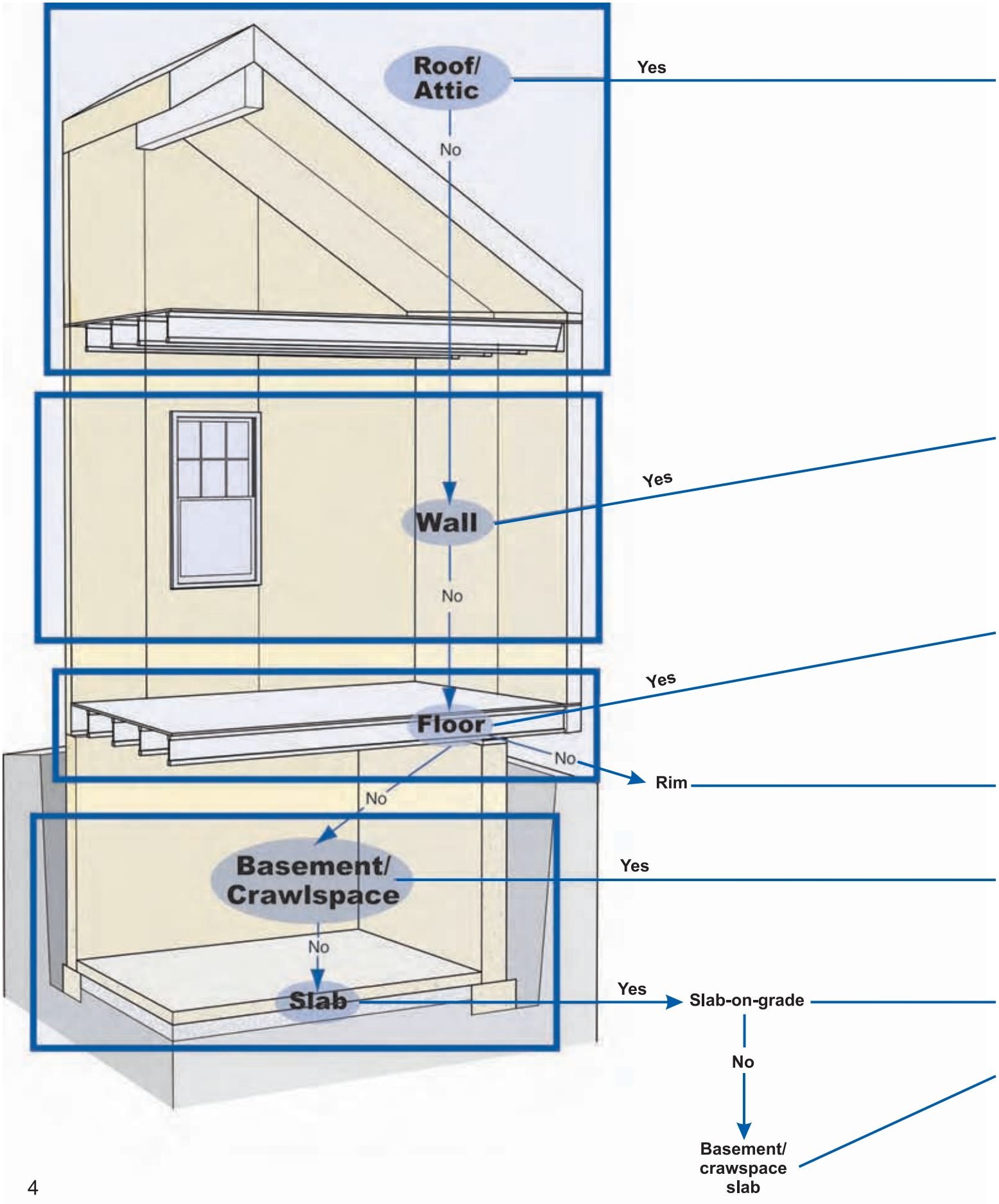
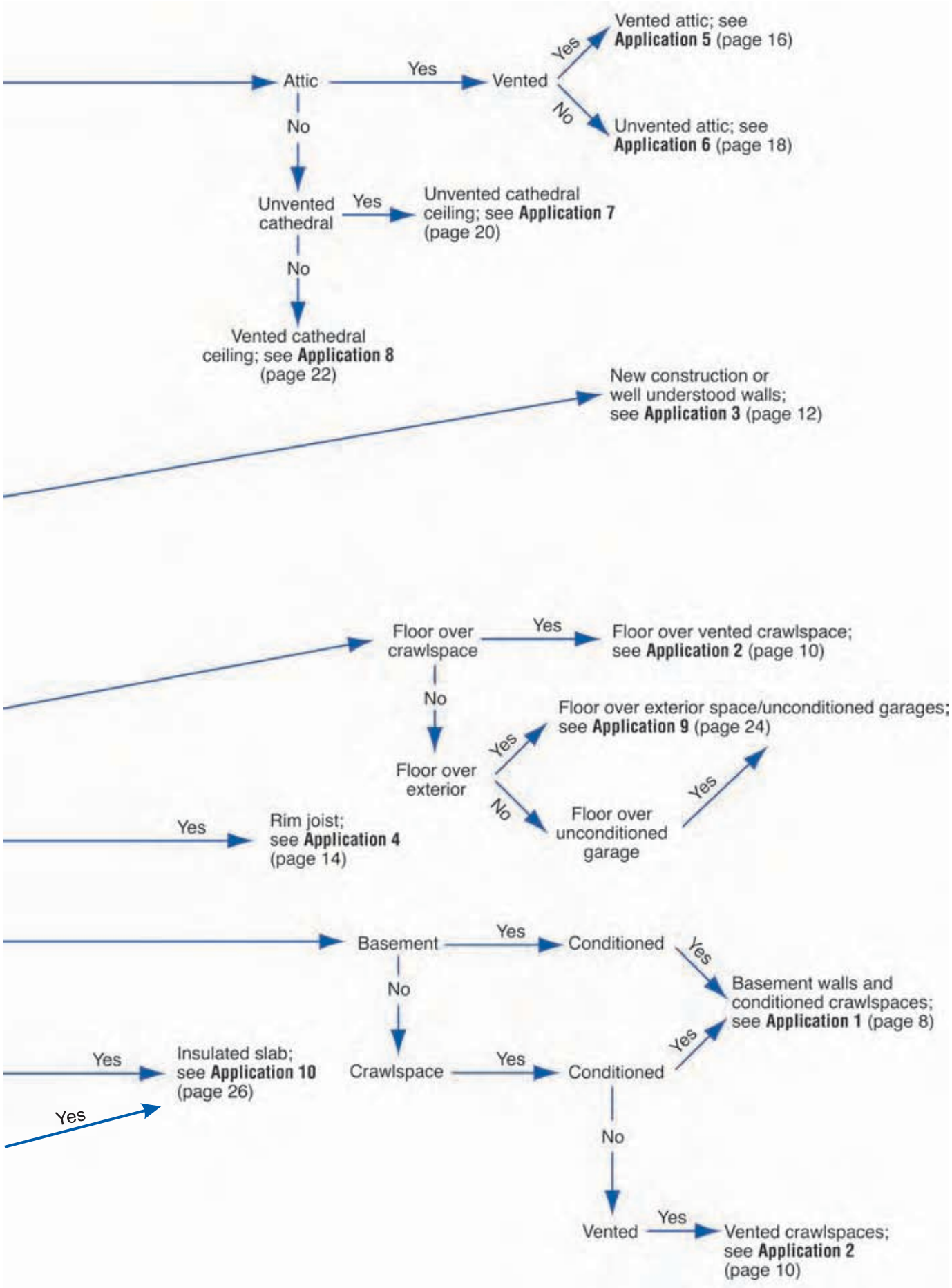
Flow Chart

Choose the part of the building being insulated and follow the arrows to recommended SPF installation practice.




Attic
Yes
Vented
Yes
Vented attic; see Application 5 (page 16)
No
Unvented attic; see Application 6 (page 18)
No
Unvented cathedral
Yes
Unvented cathedral ceiling; see Application 7 (page 20)
No
Vented cathedral ceiling; see Application 8 (page 22)
New construction or well understood walls; see Application 3 (page 12)
Floor over crawlspace
Yes
Floor over vented crawlspace; see Application 2 (page 10)
No
Floor over exterior
Yes
Floor over exterior space/unconditioned garages; see Application 9 (page 24)
No
Floor over unconditioned garage
Yes
Yes
Rim joist; see Application 4 (page 14)
Basement
Yes
Conditioned
Yes
Basement walls and conditioned crawlspaces; see Application 1 (page 8)
No
Yes
Insulated slab; see Application 10 (page 26)
Crawlspace
Yes
Conditioned
Yes
Yes
No
Vented
Yes
Vented crawlspaces; see Application 2 (page 10)

Heating Degree Days

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

Heating Degree Days

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

Application 1

Interior of Foundation Walls in Basements and Conditioned Crawlspaces

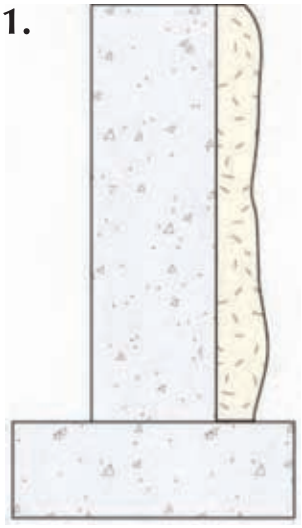
Not applicable to vented crawlspaces or foundations; see Application 2.

Discussion

Medium-density ccSPF installed against the foundation wall is the most moisture durable option for interior insulation. Light-density ocSPF is also a good option when installed directly against the foundation wall. Hybrid applications are also possible: ccSPF or ocSPF may be installed against the foundation wall, with air and vapour permeable insulation (e.g., batt) installed inboard of that. For a finished basement (i.e, with a wood or metal frame wall), keep the wall framing away from the foundation wall (minimum 1½″), and fill behind the framing with spray foam. For additional information about framed walls, see page 12.

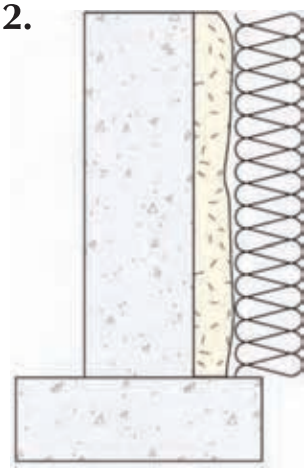
The rim joist performs much differently than the foundation wall (see p.14), and caution must be used with vapour permeable insulation.

1.



Spray foam installed directly on foundation wall

2.



Hybrid foundation insulation system

General Cautions

1. Insulation R-value should meet the required minimum for the area of construction based on the provincial or regional code requirements.
2. Thermal or ignition barriers should also meet the provincial or regional code requirements.
3. It is important to control interior RH to reasonable levels based on climate zone and season. In very cold climates this may be less than 30%. A functional ventilation system may be required.
4. Reference: “Info-512: Crawlspace Insulation” at www.buildingscience.com.
5. Reference: “Info-511: Basement Insulation” at www.buildingscience.com.

Climate Zone Matrix

Insulation Type	4	5	6	7 - 8
ocSPF	Recommended	Caution (Note 1, 2)	Caution (Note 1, 2)	Not Recommended
ccSPF	Recommended	Recommended	Recommended	Recommended
Hybrid (SPF and fibrous)	Caution (Note 1, 2)	Caution (Note 1, 2)	Caution (Note 1, 2)	Caution (Note 1, 2)

Note 1

Install minimum thickness of ccSPF, PIR or XPS in contact with above grade portion of exterior wall before application of ocSPF. In cold climates, using vapour permeable insulation (ocSPF) in the rim joist and in above grade portions of basement walls, may lead to moisture accumulation at the rim joist framing or the interior surface of the exterior sheathing. A vapour retarding insulation (ccSPF, PIR, XPS) should be used adjacent to the above grade basement wall/rim joist in these conditions (either on the interior or exterior) of such a thickness that the condensation plane is kept warm to minimize condensation potential from interior relative humidity.

Note 2

Do not install a low permeance vapour barrier on interior of foundation wall. Because the moisture drive in below-grade walls is almost always from the exterior to the interior, it is never recommended to install a low-permeance layer on the interior side of below grade insulation. A vapour barrier on the interior surface of a below grade wall will cause moisture related durability issues by trapping moisture in the enclosure and not allowing drying to the interior. A vapour barrier is less than 60 ng/Pa·s·m^2 (e.g. polyethylene sheet, vinyl wallpaper, epoxy paint).

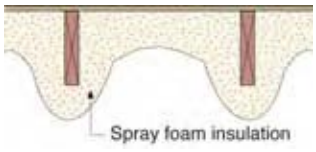
Application 2

Underside of the Floor Joists in Vented Crawlspaces

Discussion

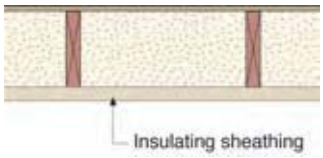
Vented crawlspaces are not recommended due to the common occurrence of serious moisture related issues and building enclosure failures. However, in some cases vented crawlspaces are mandated by code in certain areas (flood-prone or permafrost areas). The floor joists must be kept warm to avoid condensation, mold and rot, so completely encapsulating the floor joists is the safest and most recommended method of insulating in a vented crawlspace. Hybrid applications are also possible: ccSPF or ocSPF may be installed against the underside of the floor, with insulating sheathing installed on the underside of the joists. The joints in the insulating sheathing should be sealed with tape or mastic.

1.



Spray foam encapsulating floor joist

2.



Hybrid insulation system

General Cautions

1. Insulation R-value should meet the required minimum for the area of construction based on the provincial or regional code requirements.
2. Thermal or ignition barriers should also meet the provincial or regional code requirements.
3. Reference: "BSI-009: New Light in Crawlspaces" at www.buildingscience.com.

Climate Zone Matrix

Insulation Type	4	5	6	7 - 8
ocSPF (fully encapsulated joists)	Caution (Note 1)	Caution (Note 1)	Caution (Note 1)	Recommended
ccSPF (fully encapsulated joists)	Recommended	Recommended	Recommended	Recommended
Hybrid (spray foam & insulating sheathing)	Caution (Note 2)	Caution (Note 2)	Caution (Note 2)	Caution (Note 2)

Note 1

Vapour Impermeable floor covering prohibited with ocSPF. The worst moisture-related issues for floors occur when moisture moves through the floor assembly towards the interior and is stopped by a vapour impermeable floor covering such as vinyl flooring. In contrast, floor coverings with a higher vapour permeance than the assembly (such as carpet) allow the moisture to safely pass to the interior, where it is removed via air conditioning or a dehumidifier. This process minimizes moisture-related risk. Similarly, plywood floor sheathing is preferred to OSB floor sheathing because of the increased vapour permeance and moisture distribution properties of plywood.

Note 2

Taping joints in insulating sheathing. Sealing the joints with tape or mastic is more critical if ocSPF is used in the joist space, and slightly less critical if ccSPF is used in the joist space. Often the tape on the joints will fail quickly, especially when installed on the downward-facing surface. Air leakage and vapour diffusion condensation could be problematic if this system is not maintained or installed correctly. Vapour permeable floor coverings are still recommended to decrease the risk of moisture accumulation.

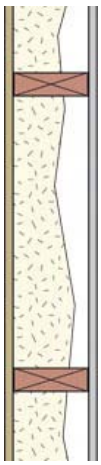
Note 3

Choose a flood-resistant insulation material when applicable. Vented crawlspaces are often used to deal with buildings in flood-prone or permafrost areas; therefore, the assembly should be designed with this problem in mind. It is generally considered that closed-cell spray foams have greater recoverability from flooding.

Application 3

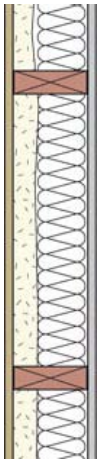
Above Grade Walls

1.



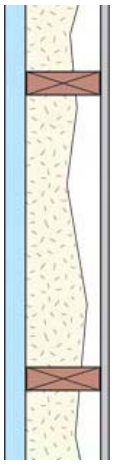
Spray foam filled wall cavity

2.



Hybrid insulation system

3.



Insulating sheathing and spray foam

Discussion

Both open-cell and closed-cell spray foam are air impermeable and can help to reduce energy losses by increasing the airtight-ness of the enclosure when the enclosure is properly designed and the spray foam is properly installed. Open-cell foam is vapour permeable (>60 ng/Pa·s·m^2) and as such, care must be taken in colder climates to minimize the risk of vapour diffusion wetting of the exterior sheathing. Hybrid applications, known as "flash-and-batt", "flash-and-fill", or "combo systems", consist of spray foam against the exterior sheathing covered with a layer of fibrous insulation. Spraying foam directly against insulating sheathing is also possible as a hybrid approach but care must be taken during the foam application process (see general cautions below). Note that SPF application against exterior wood sheathing may require additional considerations (see Note 3).

General Cautions

1. As per CUFCA standards, pass thickness must be >12mm and <50 mm to both ensure and mitigate the exothermic reaction.
2. Insulation R-value should meet the required minimum for the area of construction based on the provincial or regional code requirements.
3. It is important to control interior RH to reasonable levels based on climate zone and season. In very cold climates this may be less than 30%. A functional ventilation system may be required.
4. Reference: "BSI-038: Mind the Gap, Eh!" at www.buildingscience.com.
5. Reference: "Info-310: Vapor Control Layer Recommendations" at www.buildingscience.com.
6. Reference: "BSD-163: Controlling Cold-Weather Condensation Using Insulation" at www.buildingscience.com.
7. Relevant Code Sections: National Building Code Chapter 9, section A.25.4 and A.25.5.

Climate Zone Matrix

Insulation Type	4	5	6	7 - 8
Full ocSPF	Recommended (Note 3)	Recommended (Note 3)	Caution (Note 3, 4)	Caution (Note 3, 4)
Full ccSPF	Recommended (Note 1)	Recommended (Note 1)	Recommended (Note 1)	Recommended (Note 1)
Hybrid (ocSPF and fibrous)	Recommended	Caution (Note 2)	Caution (Note 2, 4)	Caution (Note 2, 4)
Hybrid (ccSPF and fibrous)	Recommended (Note 3)	Caution (Note 1, 2, 3)	Caution (Note 1, 2, 3)	Caution (Note 1, 2, 3)
Hybrid (insulated sheathing and spray foam)	Recommended	Caution (Note 1, 2)	Caution (Note 1, 2)	Caution (Note 1, 2)

Note 1

Double sided vapour barrier eliminates redistribution and drying to interior. It is not recommended to use a polyethylene vapour barrier on the interior of assemblies where the spray foam/board foam combination meets the minimum level of vapour control as calculated by Figure A-9.25.5.2 and according to Table A-9.25.5.2 in the National Building Code. Removing the polyethylene in these assemblies eliminates the "double vapour barrier" and allows redistribution and drying of any incidental water in the enclosure. See "BSD-106: Understanding Vapour Barriers" at www.buildingscience.com.

Note 2

Ratios of air impermeable and air permeable insulation must be maintained. As the climate gets colder, the ratio of air impermeable insulation (SPF, PIR, XPS, EPS) to air permeable insulation (fiberglass, cellulose) should be increased to avoid an elevated risk of condensation on the interior surface of the foam if there is air leakage. Designing for the condensation point to occur in the middle of the closed-cell spray foam or insulating sheathing is ideal so that condensation will not occur on the interior surface.

Note 3

Add a drainage gap when ocSPF or ccSPF is applied to OSB sheathing. OSB has limited moisture tolerance, and SPF significantly reduces or eliminates redistribution and drying to the interior. To make up for these issues, it is recommended to install exterior cladding with a drainage/ventilation gap ($^3/_8$" minimum) between the cladding and water resistive barrier.

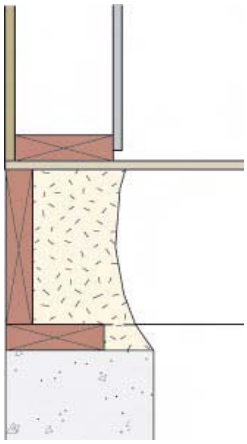
Note 4

Interior vapour control. An interior vapour control should be installed that is less than 60 ng/Pa·s·m^2 (e.g. polyethylene sheet).

Application 4

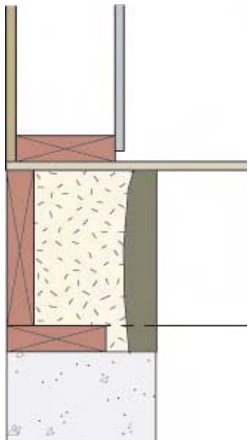
Rim Joists

1.



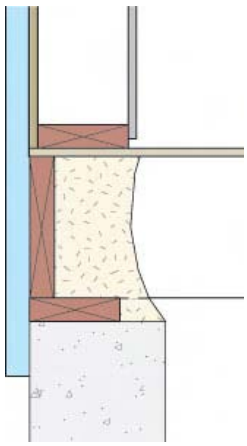
Spray foam filled rim joist

2.



Spray foam with rock-wool batt hybrid

3.



Board foam against rim joist exterior with spray foam interior of that

Discussion

The rim joist (or band joist) is a particularly troublesome detail in typical construction. This area is often a source of significant air leakage. Typically, the vapour barrier is also the air barrier, and the interior is not well air sealed as it is cumbersome to attach the poly between every floor joist. When housewrap is used around the rim joist as an air barrier it is typically penetrated with mechanical and electrical connections and not always repaired. The interior side of the rim joist is a cold surface in the winter months and has risks of condensation and moisture-related durability issues. Closed-cell spray foam is an ideal material to spray on the interior of the rim joist, ensuring continuity between the top of the foundation wall and the underside of the floor sheathing above. This strategy minimizes the air leakage at the rim joist, and the risk of air leakage condensation. Open-cell foam is vapour permeable, so care must be taken in colder climates to minimize the risk of vapour diffusion wetting of the rim joist. Hybrid applications, known as "flash-and-batt", "flash-and-fill", or "combo systems", consist of spray foam against the rim joist covered with a layer of fibrous insulation. As with above-grade walls, SPF application against the rim joist may require additional considerations (see Note 3). If the spray foam at the rim joist is left exposed, as in an unfinished basement, it will require fire protection as per the provincial or regional code requirements.

General Cautions

1. Insulation R-value should meet the required minimum for the area of construction based on the provincial or regional code requirements.
2. Thermal or ignition barriers should also meet the provincial or regional code requirements.
3. It is important to control interior RH to reasonable levels based on climate zone and season. In very cold climates this may be less than 30%. A functional ventilation system may be required.
4. Reference: "Info-408: Critical Seal (Spray Foam at Rim Joist)" at www.buildingscience.com.
5. Reference: "Info-511: Basement Insulation" at www.buildingscience.com.
6. Reference: "BSD-163: Controlling Cold-Weather Condensation Using Insulation" at www.buildingscience.com.

Climate Zone Matrix

Insulation Type	4	5	6	7 - 8
Full ocSPF	Recommended	Caution (Note 1)	Caution (Note 1)	Caution (Note 1)
Full ccSPF	Recommended (Note 3)	Recommended (Note 3)	Recommended (Note 3)	Recommended (Note 3)
Hybrid (ocSPF and fibrous)	Recommended	Caution (Note 1, 2)	Caution (Note 1, 2)	Caution (Note 1, 2)
Hybrid (ccSPF and fibrous)	Recommended	Caution (Note 2, 3)	Caution (Note 2, 3)	Caution (Note 2, 3)
Hybrid (insulating sheathing and ccSPF)	Recommended (Note 4)	Recommended (Note 4)	Recommended (Note 4)	Caution (Note 1, 4)
Hybrid (insulating sheathing and ocSPF)	Recommended (Note 4)	Caution (Note 1)	Caution (Note 1)	Caution (Note 1)

** All exposed spray foam will need fire protection as per provincial and regional code requirements.*

Note 1

Vapour control may be required. In cold climates, the interior surface of the rim joist may be cold and wintertime vapour condensation wetting of the exterior sheathing is possible with a vapour permeable insulation, so a vapour control layer is likely required to minimize moisture-related durability risk. Polyethylene is not typically recommended as it eliminates all redistribution and drying of any moisture to the interior. Adding exterior insulation significantly minimizes this risk.

Note 2

Ratios of air impermeable and air permeable insulation must be maintained. As the climate gets colder, the ratio of air impermeable insulation (SPF, PIR, XPS, EPS) to air permeable insulation (fiberglass, cellulose) should be increased to avoid an elevated risk of condensation on the interior surface of the foam if there is air leakage.

Note 3

Add a drainage/ventilation gap when SPF is applied to interior of rim joist. Wood has limited moisture tolerance, and SPF eliminates redistribution and drying to the interior. To make up for these issues, install exterior cladding with a drainage gap ($^3/_8$" minimum) between the cladding and water resistive barrier. If low permeance exterior insulation is used, open-cell spray foam could be a less risky option on the interior of the rim joist as it allows more drying and redistribution to the interior.

Note 4

Moisture redistribution with low permeance exterior insulation. If PIR, XPS, or another insulation that has very low vapour permeance is used on the exterior of the rim joist, open-cell spray foam is recommended on the interior to allow redistribution of any moisture in the rim joist and to avoid the "double vapour barrier" provided that the R-value ratio of the insulation types does not result in vapour accumulation at the rim joist from the interior. A smart vapour retarder may be desirable on the interior of this assembly.

Application 5

Vented Attics

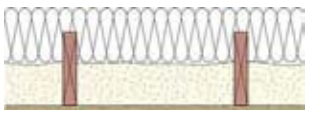
Discussion

Attic moisture and energy problems are typically the result of air leakage from the interior space into the attic. This can result in condensation in cold climates, and significant energy losses in all climates. By using spray foam or a hybrid approach of spray foam and fibrous insulation (cellulose, fiberglass) the air leakage into the attic can be significantly reduced or eliminated, resulting in decreased energy losses and fewer moisture problems. It is always recommended to only install mechanical space conditioning equipment and duct work in conditioned space. The Critical Seal Hybrid solution (see Detail 3 at left) consists of installing spray foam only at locations in the attic where air leakage is expected, such as above exterior walls, above partition walls, and above ceiling fixtures. This strategy could eliminate nearly all of the air leakage between the interior and the attic.

1.

Attic insulated entirely with spray foam

2.



Hybrid insulation system

3.

Critical seal hybrid example

General Cautions

1. Insulation R-value should meet the required minimum for the area of construction based on the provincial or regional code requirements.
2. Thermal or ignition barriers should also meet the provincial or regional code requirements.
3. It is important to control interior RH to reasonable levels based on climate zone and season. In very cold climates this may be less than 30%. A functional ventilation system may be required.

Climate Zone Matrix

Insulation Type	4	5	6	7 - 8
Full ocSPF	Recommended	Recommended	Recommended	Recommended
Full ccSPF	Recommended	Recommended	Recommended	Recommended
Hybrid	Recommended	Recommended	Recommended	Recommended
Critical Seal Hybrid	Recommended	Recommended	Recommended	Recommended

Note 1

Ensure adequate attic ventilation. It is likely that some moisture will still reach the attic either by air leakage or vapour diffusion. In a properly vented attic, this moisture will be carried away without causing problems. Ice dam control may also require ventilation in some demanding climates.

Note 2

A polyethylene vapour barrier is not required but an air barrier is required. Research, simulations and field observations show that a low permeance vapour barrier is not required to control vapour diffusion into the attic since vapour diffusion moves so slowly and attic ventilation will easily remove this small amount of moisture. Condensation could occur if air leakage occurs from the interior into the attic in cold climates, but this issue can be reduced or eliminated by incorporating a functional air barrier.

Application 6

Unvented Attics

Discussion

When properly installed, both open-cell and closed-cell spray foam are air impermeable and may help to reduce energy losses and avoid air leakage condensation by increasing the airtightness of the enclosure. Because open-cell foam is quite vapour permeable, care must be taken in colder climates to minimize the risk of vapour diffusion wetting of the roof sheathing. Hybrid applications, known as "flash-and-batt", "flash-and-fill", or "combo systems", consist of air impermeable spray foam against the roof sheathing with an inboard layer of fibrous insulation (e.g., fibreglass or netted cellulose) and may be safely used provided that vapour diffusion is controlled. Board insulation (PIR, XPS, EPS, stone wool) can be installed on the exterior of the roof deck to decrease thermal bridging, increase the R-value and reduce the risk of condensation wetting of the roof sheathing.

Although now accepted in the US Building Codes, Part 9 of the National Building Code of Canada (NBCC) does not allow unvented sloped roofs unless the Authority Having Jurisdiction (AHJ) or design professional approves it. An engineer or architect can use unvented attics in Part 5 buildings.

1.

Spray foam filled rafter cavity

2.

Hybrid insulation system

3.

Exterior insulating sheathing and spray foam

General Cautions

1. Insulation R-value should meet the required minimum for the area of construction based on the provincial or regional code requirements.
2. Thermal or ignition barriers should also meet the provincial or regional code requirements.
3. It is important to control interior RH to reasonable levels based on climate zone and season. In very cold climates this may be less than 30%. A functional ventilation system may be required.
4. Reference: "BSD-102: Understanding Attic Ventilation" at www.buildingscience.com.
5. Reference: "IRC FAQ: Conditioned Attics" at www.buildingscience.com.
6. Reference: "BSD-149: Unvented Roof Assemblies for all Climates" at www.buildingscience.com.
7. Reference: "BSD-163: Controlling Cold-Weather Condensation Using Insulation" at www.buildingscience.com.

Climate Zone Matrix

Insulation Type	4	5	6	7 - 8
Full ocSPF	Recommended (Note 1)	Caution (Note 1)	Caution (Note 1)	Not Recommended
Full ccSPF	Recommended	Recommended	Recommended	Recommended
Hybrid (ocSPF and fibrous)	Recommended (Note 1)	Caution (Note 1, 2)	Not Recommended	Not Recommended
Hybrid (ccSPF and fibrous)	Recommended (Note 2)	Caution (Note 2)	Caution (Note 2)	Caution (Note 2)
Insulating sheathing and spray foam	Recommended	Caution (Note 2)	Caution (Note 2)	Caution (Note 2)

Note 1

Vapour control may be required. In cold climates, the interior surface of the roof sheathing will be cold and wintertime vapour condensation wetting of the exterior sheathing is possible with a vapour permeable insulation, so a vapour control layer is likely required to minimize the moisture related durability risks. Polyethylene is not typically recommended as it eliminates all redistribution and drying of any moisture to the interior. Adding exterior insulation significantly minimizes this risk of sheathing wetting. Night sky cooling may increase the risk of condensation on the roof sheathing more than in walls of the same enclosure.

Note 2

Ratios of air impermeable and air permeable insulation must be maintained. As the climate zone gets colder, the ratio of air impermeable insulation (SPF, PIR, XPS, EPS) to air permeable insulation (fiberglass, cellulose) must increase to avoid condensation on the interior surface of the air impermeable foam if there is air leakage. Designing for the condensation point to occur in the middle of the closed-cell spray foam or insulating sheathing is ideal so that condensation will not occur on the interior surface.

Application 7

Unvented Cathedral Ceilings

1.

Spray foam filled cavity

2.

Hybrid insulation system

3.

Insulating sheathing and spray foam

Discussion

When properly installed, both open-cell and closed-cell spray foam are air impermeable and may help to reduce energy losses and avoid air leakage condensation by increasing the airtight-ness of the enclosure. Because open-cell foam is quite vapour permeable, care must be taken in colder climates to minimize the risk of vapour diffusion wetting of the roof sheathing. Hybrid applications, known as "flash-and-batt", "flash-and-fill", or "combo systems", consist of air impermeable spray foam against the roof sheathing with an inboard layer of fibrous insulation (e.g., fibreglass or netted cellulose) and may be safely used provided that vapour diffusion is controlled. Board insulation (PIR, XPS, EPS, stone wool) can be installed on the exterior of the roof deck to decrease thermal bridging, increase the R-value and reduce the risk of condensation wetting of the roof sheathing.

Although now accepted in the US Building Codes, Part 9 of the National Building Code of Canada (NBCC) does not allow unvented sloped roofs unless the Authority Having Jurisdiction) (AHJ) or design professional approves it. An engineer or architect can use unvented attics in Part 5 buildings.

General Cautions

1. Insulation R-value should meet the required minimum for the area of construction based on the provincial or regional code requirements.
2. It is important to control interior RH to reasonable levels based on climate zone and season. In very cold climates this may be less than 30%. A functional ventilation system may be required.
3. Reference: "BSD-163: Controlling Cold-Weather Condensation Using Insulation" at www.buildingscience.com.
4. Reference: "BSD-149: Unvented Roof Assemblies for all Climates" at www.buildingscience.com.
5. Reference: "IRC FAQ: Conditioned Attics" at www.buildingscience.com.

Climate Zone Matrix

Insulation Type	4	5	6	7 - 8
Full ocSPF	Caution (Note 1)	Caution (Note 1)	Caution (Note 1)	Not Recommended
Full ccSPF	Recommended	Recommended	Recommended	Recommended
Hybrid (ocSPF and fibrous)	Caution (Note 1,2)	Caution (Note 1, 2)	Not Recommended	Not Recommended
Hybrid (ccSPF and fibrous)	Recommended	Caution (Note 2)	Caution (Note 2)	Caution (Note 2)
Insulating sheathing and spray foam	Recommended	Caution (Note 2)	Caution (Note 2)	Caution (Note 2)

Note 1

Vapour control may be required. In cold climates, the interior surface of the roof sheathing will be cold and wintertime vapour condensation wetting of the exterior sheathing is possible with a vapour permeable insulation, so a vapour control layer is likely required to minimize the moisture related durability risks. Polyethylene is not typically recommended as it eliminates all redistribution and drying of any moisture to the interior. Adding exterior insulation significantly minimizes this risk of sheathing wetting. Night sky cooling may increase the risk of condensation on the roof sheathing more than in walls of the same enclosure.

Note 2

Ratios of air impermeable and air permeable insulation must be maintained. As the climate zone gets colder, the ratio of air impermeable insulation (spray foam, PIR, XPS, EPS) to air permeable insulation (fiberglass, cellulose) should be increased to avoid an elevated risk of condensation on the interior surface of the foam if there is air leakage. Designing for the condensation point to occur in the middle of the closed-cell spray foam or insulating sheathing is ideal so that condensation will not occur on the interior surface of the impermeable insulation.

Application 8

Vented Cathedral Ceilings
Vented Cathedralized Attic

Discussion

Vented cathedral ceilings require backer board to act as a substrate for the spray foam while still maintaining an air gap against the roof sheathing. Spray foam can provide the required airtightness in these systems. In a ceiling that uses sawn timber, blocking can be used next to the joists, either running along the entire joist or only at discrete connection points. In a ceiling with engineered I-joists, the backer board can be attached directly to the top flange of the joist. To increase the R-value and vapour control of an open-cell spray foam system, the backer board can be replaced by a rigid board insulation product such as XPS, PIR or high-density EPS, assuming the foam board insulation is compatible with the spray foam.

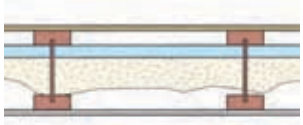
1.

Vented cathedral ceiling with framing lumber rafters

2.

Vented cathedral ceiling with I-joists

3.



Vented cathedral ceiling using board foam

4.

Hybrid vented cathedral ceiling

General Cautions

1. Insulation R-value should meet the required minimum for the area of construction based on the provincial or regional code requirements.
2. It is important to control interior RH to reasonable levels based on climate zone and season. In very cold climates this may be less than 30%. A functional ventilation system may be required.
3. Reference: "BSI-046: Dam Ice Dam" at www.buildingscience.com.
4. Reference: "RR-1006: Building America Special Research Project—High-R Roofs Case Study Analysis" at www.buildingscience.com.

Climate Zone Matrix

Insulation Type	4	5	6	7 - 8
Full ocSPF	Caution (Note 1, 2)	Caution (Note 1, 2)	Caution (Note 1, 2)	Not Recommended
Full ccSPF	Recommended	Recommended	Recommended	Recommended
Hybrid (ocSPF and fibrous)	Recommended	Caution (Note 1, 2)	Not Recommended	Not Recommended
Hybrid (ccSPF and fibrous)	Recommended	Caution (Note 2)	Caution (Note 2)	Caution (Note 1, 2)

Note 1

Vapour control may be required. In cold climates, water vapour may move from the interior to the roof sheathing as a result of vapour diffusion through vapour permeable insulations. A vapour control layer on the interior may be required to minimize the moisture related durability risks, although in this assembly, if the vented cavity is well vented, the risk of moisture accumulation decreases significantly. Polyethylene is not typically recommended as it eliminates all redistribution and drying of any moisture to the interior. Adding exterior insulation with vapour resistance (as in a board foam insulation of sufficient thickness as per Note 2) will minimize or eliminate this risk. Note that night sky cooling may increase the risk of condensation on the roof sheathing more than in walls of the same insulation.

Note 2

Ratios of air impermeable and air permeable insulation must be maintained. As the climate zone gets colder, the ratio of air impermeable insulation (spray foam, PIR, XPS, EPS) to air permeable insulation (fiberglass, cellulose) must increase to avoid condensation on the interior surface of the foam if there is air leakage. Designing for the condensation point to occur in the middle of the closed-cell spray foam or insulating sheathing is ideal so that condensation will not occur on the interior surface.

Application 9

Floors Over Exterior Space/Unconditioned Garages

Discussion

Spray foam can be used in unconditioned garage ceilings, and floors over exterior spaces (such as houses on piles), and cantilevered floors on any level. Because of its ability to act as an air barrier, spray foam performs very well in garage ceilings and cantilevered floors, where air movement can result in energy losses, comfort issues, and potential indoor air quality issues (often there are unintentional air flow pathways between the garage and the interior space). Spray foam beneath houses that are open to the outdoors should be well protected against insects and small animals. Ducts should be avoided in the enclosure that is adjacent to unconditioned space but ducts are often put in garage ceilings to condition the space above the garage. Detail 3 (at left) shows a recommended detail for running ducts. Because the duct is considered interior space, the code required amount of insulation needs to be installed to the exterior of the duct.

Complaints about the floor feeling cold are typical in floors over exterior space or unconditioned garages even with sufficient insulation, as a result of thermal bridging through the framing components. Adding a layer of continuous board insulation (PIR, XPS, EPS, stone wool) as shown in Detail 4 will significantly decrease the thermal bridging and increase the surface temperature of the floor.

1.

Spray foam between floor joists

2.

Hybrid insulation system

3.

Detail showing ductwork

4.

Board foam insulation thermal break

General Cautions

1. Insulation R-value should meet the required minimum for the area of construction based on the provincial or regional code requirements.
2. Thermal or ignition barriers should also meet the provincial or regional code requirements.
3. It is important to control interior RH to reasonable levels based on climate zone and season. In very cold climates this may be less than 30%. A functional ventilation system may be required.

Climate Zone Matrix

Insulation Type	4	5	6	7 - 8
ocSPF	Caution (Note 1)	Caution (Note 1, 2)	Caution (Note 2)	Caution (Note 2)
ccSPF	Recommended (Note 1)	Recommended (Note 1)	Recommended (Note 1)	Recommended (Note 1)
Hybrid (ocSPF and fibrous)	Caution (Note 1)	Caution (Note 1, 2)	Caution (Note 2)	Caution (Note 2)
Hybrid (ccSPF and fibrous)	Recommended	Recommended	Recommended	Recommended

Note 1

Vapour impermeable floor covering. Using a vapour impermeable floor covering with vapour permeable insulation could increase the risk of moisture accumulation in the subfloor from inward moving vapour.

Note 2

Exterior vapour impermeable cladding. Vapour impermeable claddings should be avoided on the exterior underside of exposed floor assemblies, especially with vapour permeable insulations.

Application 10

Beneath Slabs

Discussion

Medium-density closed-cell spray foam can be used underneath basement slabs and slabs on grade for residential and light commercial. The 2.0 pcf closed-cell spray foam has the advantage of accommodating variations in the ground surface, and will perform well as a continous air, vapour and insulation layer. To avoid thermal bridging through the footing, a thinner (1″- 2″) layer should cover the top of the footing and extend up the foundation wall between the slab and the footing. No additional vapour control such as polyethylene sheeting is required below the slab, provided there is a minimum of 2″ of 2.0 pcf closed-cell spray foam. These assemblies assume that there is no liquid water in continuous contact with the spray foam. Spray foam installed on the exterior surface must be protected from UV radiation, physical damage, and insects.

1.

Basement slab

2.

Slab-on-grade interior insulation

3.

Slab-on-grade exterior insulation

General Cautions

1. Insulation R-value should meet the required minimum for the area of construction based on applicable provincial or regional code requirements.
2. Reference: “Info-513: Slab Edge Insulation” at www.buildingscience.com.
3. Reference: “BSI-059: Slab Happy” at www.buildingscience.com.

Climate Zone Matrix

Insulation Type	4	5	6	7 - 8
ccSPF	Recommended	Recommended	Recommended	Recommended

Note 1

Permafrost. Special considerations may be required when installing spray foam around foundations and slabs in climate zones 7-8 to account for varying permafrost conditions.

Glossary of Terms

Air Barrier System

Air barriers are three-dimensional systems of materials designed, constructed, and/or acting to control air flow across a building enclosure, or between a conditioned space and an unconditioned space. In multi-unit/townhouse/apartment construction an air barrier system should also separate the conditioned air from any given unit and adjacent units. The pressure boundary of the enclosure should, by definition, be coincident with the plane of a functional air barrier system. In multi-unit/townhouse/apartment construction the air barrier system may also be the fire barrier and smoke barrier between units. In such assemblies the air barrier system must also meet the specific fire resistance rating requirement for the given separation.

Air barrier systems are assembled from "materials" incorporated in "assemblies" (or "components" such as windows) that are interconnected to create "enclosures." Each of these three elements has measurable resistance to air flow. The minimum recommended resistance or air permeance for the three components are:

Material 0.02 l/(s-m^2)@ 75 Pa (0.004 cfm/ft^2 @ 0.3" WC)

Assembly 0.20 l/(s-m^2)@ 75 Pa (0.04 cfm/ft^2 @ 0.3" WC)

Enclosure 2.00 l/(s-m^2)@ 75 Pa (0.4 cfm/ft^2 @ 0.3" WC)

Materials and assemblies that meet these performance requirements are said to be air barrier materials and air barrier assemblies. Air barrier materials incorporated in air barrier assemblies that in turn are interconnected to create enclosures are called air barrier systems.

Air-impermeable Insulation

An insulation having an air permeance equal to or less than 0.02 L/s·m^2 at 75 Pa pressure differential tested according to ASTM E 2178 or E 283.

Expanded Polystyrene Insulation (EPS)

A rigid cellular foamed plastic insulation material manufactured by expansion of polystyrene beads within a mold. This mold creates an open cell structure filled with air.

Extruded Polystyrene Insulation (XPS)

A rigid cellular foamed-plastic insulation material manufactured by extrusion of polystyrene in the presence of a blowing agent. The blowing agent creates a porous structure that resists liquid water penetration and vapour diffusion. The manufacturing process for XPS insulation results in a smooth surface skin. Typical density of 2 lb/ft^3 and R-value of 5 per inch (0.029 W/mK).

Ignition Barrier

The following materials conform to NBC as ignition barriers (combustible construction):

3.1. Lath and plaster conforming to CSA A82.30-M, mechanically fastened;
3.2. 12.7 mm gypsum board;
3.3. Sheet metal mechanically fastened and having a thickness of 0.38 mm;
3.4. Masonry;
3.5. Concrete; or
3.6. Any thermal barrier tested in accordance with CAN/ULC S124 (cementitious and fibre)

Reflective (foil-faced) Polyisocyanurate (PIR)

A closed-cell foam insulation material typically sold in rigid boards. R-value can range from R-5.6 to R-9, depending on the manufacturer, the age of the foam, and the presence or absence of foil facings. Foil-faced PIR has a greater R-value and is also vapour impermeable (less than 0.1 perm).

R-value; Thermal Resistance

Quantitative measure of resistance to heat flow or conductivity, the reciprocal of U-factor. The units for R-value are ft^2 °F hr/Btu (English) or m^2 °K hr/W (SI or metric). While many in the building community consider R-value to be the primary or paramount indicator of energy efficiency, it only deals with conduction, one of three modes of heat flow, (the other two being convection and radiation). As an example of the context in to which R-value should be placed, 25% to 40% of a typical home's energy use can be attributed to air infiltration.

Thermal Barrier

A thermal or fire barrier is a material or coating, applied over polyurethane foam, designed to slow the temperature increase of the foam during a fire, and to delay the foam's involvement in a fire. Such thermal barriers limit the temperature rise of the underlying polyurethane foam to not more than 250°F after 10 minutes of fire exposure complying with the standard time temperature curve of CAN/ULC S124B. The thermal barrier shall be installed in such a manner that it will remain in place for 10 minutes.

Vapour Retarder Class

A measure of the ability of a material or assembly to limit the amount of moisture vapour that passes through that material or assembly. Vapour retarder class shall be defined using the desiccant method with Procedure A of ASTM E 96 as follows:

Class I: 0.1 perm or less ($\leq$ 5.72 ng/Pa•s•m^2)

Class II: 0.1 perm < 1.0 perm (> 5.72 ng/Pa•s•m^2; $\leq$ 57.2 ng/Pa•s•m^2)

Class Ill: 1.0 perm < 10 perm (> 57.2 ng/Pa•s•m^2; $\leq$ 572.0 ng/Pa•s•m^2)

The NBC states that a material is considered a "vapour barrier" when permeance is not greater than 60 ng/(Pa•s•m^2); NBC reference 9.25.4.2.

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