SPFA-112

Spray Polyurethane Foam for Residential Building Envelope Insulation and Air Seal

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ABOUT SPRAY POLYURETHANE FOAM ALLIANCE (SPFA)

Founded in 1987, the Spray Polyurethane Foam Alliance (SPFA) is the voice, and educational and technical resource, for the spray polyurethane foam industry. A 501(c)6 trade association, the alliance is composed of contractors, manufacturers, and distributors of polyurethane foam, related equipment, and protective coatings; and who provide inspections, surface preparations, and other services. The organization supports the best practices and the growth of the industry through a number of core initiatives, which include educational programs and events, the SPFA Professional Installer Certification Program, technical literature and guidelines, legislative advocacy, research, and networking opportunities. For more information, please use the contact information and links provided in this document.

DISCLAIMER

This document was developed to aid building construction and design professionals in choosing spray-applied polyurethane foam systems. The information provided herein, based on current customs and practices of the trade, is offered in good faith and believed to be true to the best of SPFA's knowledge and belief.

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DOCUMENT HISTORY

Date	Sections Modified	Description of Changes
1994		
August 2015	All	Administrative changes to format only
January 2021	All	Major revisions including guide specification references and architectural details

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BUILDING ENVELOPE COMMITTEE

MISSION STATEMENT

The mission of the Building Envelope Committee is to:

1. To identify, explore, develop, and communicate an understanding of technical issues, including building codes and other standards, for the SPF industry.
2. Provide a wide range of technical information for members and building design professionals to properly specify and install spray foam insulation.
3. Maintain current and develop new SPFA TechDocs and TechTips applicable to application of spray foam insulation.

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DESIGN CONSIDERATIONS

GENERAL

The performance of a spray-applied polyurethane foam (SPF) insulation system can be affected by all the component parts of a structure, as well as the atmospheric conditions inside and outside the structure.

Structural design, specification review, and contractor and material selection, coupled with the compatibility and positioning of the various structural components, are necessary to produce a successful building envelope insulation system.

The specifier should consult with the respective material suppliers and the contractor to receive written confirmation of their agreement to all facets of the insulation system. This should include, but not be limited to, material selection, expansion joints, load design, vapor retarders, and flashing details.

SPF can be applied to most surfaces successfully. However, the following general practices must be observed.

DETERMINING REQUIRED INSULATION THICKNESS

There are five considerations for determining minimum insulation thickness which often produce different values. The installed insulation R-value or thickness should be the greatest of the following:

(1) Building and Energy Codes: Most jurisdictions require certain buildings to meet the prescriptive or performance requirements of the code or standard enforced within the jurisdiction.

(2) Condensation Control: Condensation can occur inside a building assembly when the surface temperature is lower than the dew point of the surrounding air. The minimum insulation thickness to control condensation should be based on interior and exterior air conditions, including temperature and relative humidity.

(3) Economic Thickness: Greater insulation thickness (R-value) decreases recurring heating and cooling costs and the initial cost of HVAC equipment. However, there is a diminishing return on investment by increasing R-value, where the time-weighted costs of additional insulation exceed the expected energy cost savings.

(4) Minimum Practical Thickness: The minimum insulation thickness that can be applied per manufacturer's installation instruction.

(5) Insulation thickness requested by the building owner or architect/designer.

NOTE: Maximum SPF insulation thickness is limited by fire testing. Ensure the thickness determined above does not exceed the maximum thickness qualified by applicable fire testing.

ADHESION

When a primer or coating is specified, there must be adequate adhesion between the substrate/primer, primer/SPF and SPF/coating. Coatings may include:

- primers applied to a substrate to improve adhesion
- a protective coating for fire, UV or mechanical damage, or
- a vapor retarder for moisture control

Prior to application of a coating or SPF the surface must be cured, dry, and free of loose dirt or any contaminants that may interfere with adhesion of any of the respective components. For wood substrates, typically the moisture content must be below 18% or per manufacturers installation instructions.

Contaminants may be removed by use of air pressure, vacuum equipment, a hand power broom, chemical solvents, sandblasting, manual scraping, etc.

SELECTION OF PRIMER

Depending on substrate materials, a primer may be needed to improve SPF adhesion. Consult SPFA-143 “Primers for Spray Polyurethane Foam Insulation and Roofing Systems” or manufacturer’s installation instructions for selecting appropriate primer.

SELECTION OF A VAPOR RETARDER

If a vapor retarder is required, its selection should be based on the following criteria:

(1) Permeance required to control vapor transmission and condensation within the assembly. The permeance of the vapor retarder may depend upon permeance of other components and is often determined by code requirements or specific design requirements.

(2) Compatibility with adjoining materials

(3) Manufacturer’s recommendation

SELECTION OF THE SPRAY POLYURETHANE FOAM SYSTEM

The contractor, in the case of SPF applications, fabricates the product on-site in accordance with manufacturer instructions.

Many different SPF systems are available in various densities, each exhibiting different temperature limitations, combustibility characteristics, etc. The use of these systems, in combination with each other or with other insulation products, offers a wide range of economical installations. See SPFA-146 “Spray Polyurethane Foam Insulation for Hybrid

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Insulation Systems – Part 1: Warm Climates" and SPFA-147 "Spray Polyurethane Foam Insulation for Hybrid Insulation Systems – Part 2: Cold Climates" for use of SPF in combination with other insulation products.

Most published data are based on laboratory produced samples. The thickness of the polyurethane foam sprayed, the number of passes, the temperature of the substrate, ambient temperatures, etc., have a pronounced effect on all physical properties.

From a fire safety standpoint, SPF should be used in accordance with building code requirements. Additional fire-protective coatings or coverings may be needed when SPF and other foam plastics are installed in building assemblies. Certain building assemblies containing spray foam may require specific test data or third-party certification.

Polyurethane foam insulation is combustible and should be treated as such. Flame spread ratings provided for polyurethane products using small scale tests are not intended to reflect the hazards presented by this or any other materials under actual fire conditions. Care must be taken to ensure that the foam is not exposed to service temperatures more than 180°F (82°C). Contact the SPF manufacturer for specific information regarding service temperature limits.

SELECTION OF A THERMAL BARRIER/IGNITION BARRIER

Most model building codes and jurisdictions require, with some exceptions, that SPF and other foam plastics be separated from the interior of the building by a thermal barrier. Therefore, unless an exception applies, all SPF applications are required to be covered with an approved thermal barrier or be part of an approved alternative thermal barrier assembly.

As an exception to the thermal barrier requirement, it is permitted to install an ignition barrier between the SPF and the interior of certain attics and crawlspaces. For more information on thermal barriers, ignition barriers and alternative assemblies required for SPF, see SPFA-126 "Thermal and Ignition Barriers for Spray Polyurethane Foam Insulation".

GUIDE SPECIFICATION FOR SPF INSULATION

Some projects will require an architectural specification for insulation materials and accessories. SPFA has prepared a CSI-compliant model specification, SPFA-149 "Architectural Specification for Spray Polyurethane Foam Insulation" which may be used. This model specification includes general information, products, and execution.

For residential insulation applications, typical material property requirements are summarized in the tables below. It should be noted that certain applications of SPF may require different material properties. For example, structural loads in some assemblies may require increased density, water resistance, as well as tensile or compressive strength to provide structural enhancement for wind uplift resistance or supporting surface loads from foot traffic or support of concrete slabs and backfill for below-grade applications. Consult the product technical data sheets and/or code compliance reports to evaluate suitability for a specific application.

NOTE: The project or code enforced may specify project requirements or compliance with a standard specification (such as ASTM C1029 [Type I, II, III or IV], ASTM D7425 or ICC-1100). The values presented in Tables 1 and 2 are for guidance purposes only.

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TABLE 1 - SPRAY POLYURETHANE FOAM INSULATION: OPEN CELL (LOW DENSITY)

PROPERTIES	ASTM TEST	SI UNITS	U.S. UNITS
Thermal Resistance (R-Value/inch at 75°F (24°C) mean temperature after aging for 30 days at a temperature of at 75°F (24°C) @ ambient RH	C518, C177 or C1363	0.06 K•m²/W average aged value (min.)	3.4 °F•ft²•hr/Btu average aged value (min.)
Nominal Core Density	D1622	6.4-24 kg/m³	0.4 – 1.5 lbs/ft³
Open Cell Content	D2856	80% (min.)	
Surface Burning Characteristics: Flame Spread Index (FSI)	E84*	75 (max.) [25 (max.) for certain applications]	
Surface Burning Characteristics: Smoke Developed Index (SDI)	E84*	450 (max.)	
Dimension Stability under Thermal and Humid Aging (158°F, 97% RH for 7 days)	D2126	15% (max.)	
Air Permeance less than 0.004 cfm/ft² @ 1.57 psf, (0.020 L/(s·m²) @ 75 Pa)	E283 or E2178	Report thickness at which air permeance is below 0.020 L/(s·m²) @ 75 Pa pressure	Report thickness at which air permeance is below 0.004 cfm/ft² @ 1.57 psf pressure
Water Vapor Permeability	E96 desiccant/dry cup method	Report ng/(Pa-s-m)	Report perm-inches

TABLE 2 - SPRAY POLYURETHANE FOAM INSULATION: CLOSED CELL (MEDIUM DENSITY)

PROPERTIES	ASTM TEST	SI UNITS	U.S. UNITS
Thermal Resistance (R-Value/inch at 75°F (24°C) mean temperature after aging for 180 days at a temperature of at 75°F (24°C) @ 50% RH or after aging for 90 days at 140°F (60°C) temperature @ ambient RH	C518, C177 or C1363	As reported	
Nominal Core Density	D1622	24-56 kg/m³	1.5-3.5 lb/ft³
Tensile Strength	D1623	138 kPa (min.)	20 lb/in² (min.)
Compressive Strength	D1621	100 kPa (min.)	15 lb/in² (min.)
Closed Cell Content	D2856	90% (min.)	
Surface Burning Characteristics: Flame Spread Index (FSI)	E84*	75 (max.) [25 (max.) for certain applications]	
Surface Burning Characteristics: Smoke Developed Index (SDI)	E84*	450 (max.)	
Dimension Stability under Thermal and Humid Aging (158°F, 97% RH for 7 days)	D2126	15% (max.)	
Air Permeance less than 0.004 cfm/ft² @ 1.57 psf, (0.020 L/(s·m²) @ 75 Pa)	E283 or E2178	Report thickness at which air permeance is below 0.020 L/(s·m²) @ 75 Pa pressure	Report thickness at which air permeance is below 0.004 cfm/ft² @ 1.57 psf pressure
Water Vapor Permeability	E96 desiccant/dry cup method	4.4 ng/(Pa-s-m) (max.)	3.0 perm-inches (max.)

* This standard test method is used solely to measure and describe the properties of products in response to heat and flame under controlled laboratory conditions. This numerical flame spread rating is not intended to reflect hazards presented by this or any other material under actual fire conditions

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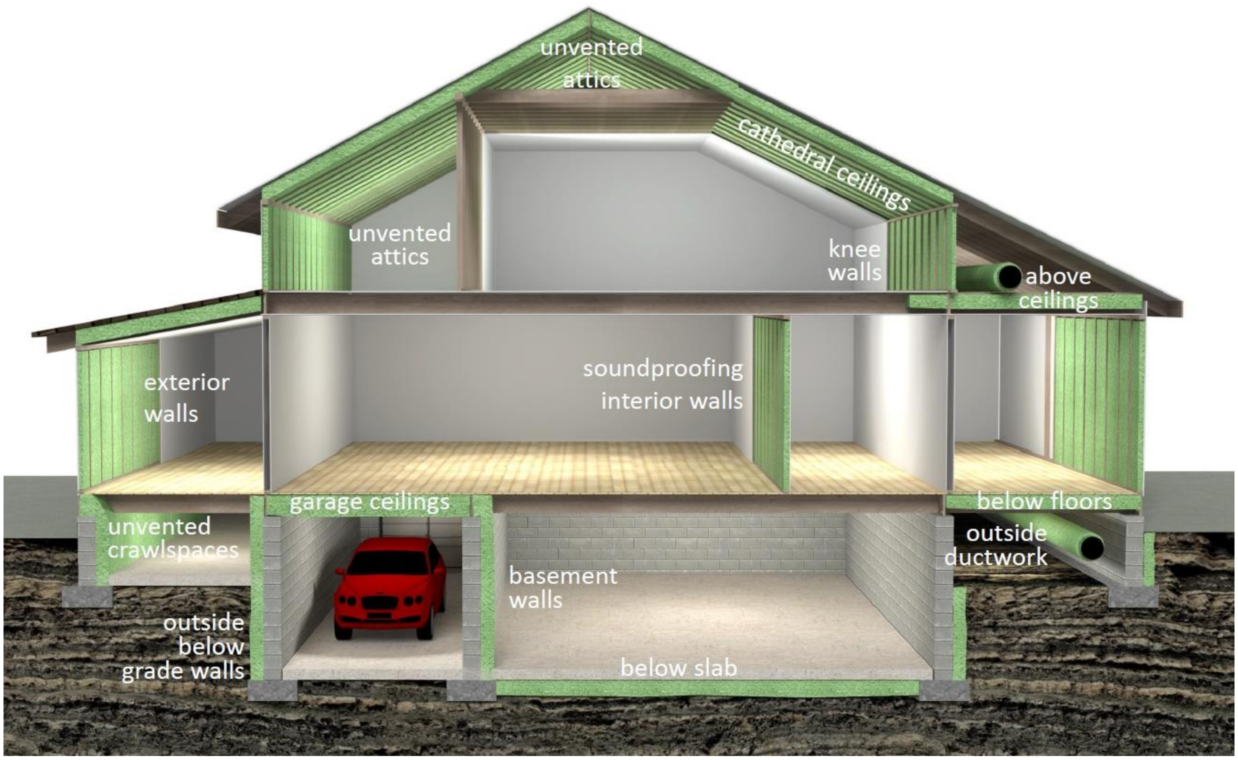
RESIDENTIAL APPLICATIONS FOR SPF INSULATION

SPF insulation can be used virtually any location within the residential building enclosure. The illustration below shows typical locations where SPF insulation may be used.



SPF Insulation has many applications in the residential building envelope. Table 3 below shows locations were SPF can be applied. Several of these applications are described in detail in other SPFA TechDocs. This section also includes example details for these different SPF applications.

TABLE 3 – APPLICATION OF SPF IN RESIDENTIAL BUILDINGS

Assembly	Figure	Closed-Cell (medium density)	Open-Cell (low density)	Applicable SPFA TechDoc(1)	Reference Sections 2018 Edition	
					IRC	IECC
Building Envelope Air Leakage	N/A	☑	☑		N1102.4, N1102.4.1, Table N1102.4.1.1	R402.4; R402.4.1, Table R402.4.1.1
Exterior Walls (framed cavity)(3)	1	☑	☑		N1102.1.1, Table N1102.1.2	R402.1.1, Table R402.1.2
Exterior Walls (hybrid cavity with SPF and fibrous insulation)	2	☑	☒	SPFA-146, SPFA-147	R702.7.1, Table R702.7.1, N1102.1.1, N1102.1.2, N1102.1.3,	R402.1.1, R402.1.2, R402.1.3
Exterior Walls (exterior continuous)	3	☑	☒		N1102.1.1, N1102.1.2, Table N1102.1.2, N1102.1.3	R402.1.1, Table R402.1.2, R402.1.3
Interior Wall Soundproofing	N/A	☑	☑		N/A	N/A
Above Ceilings (floors of ventilated attics)	4	☑	☑	See (2)	N1102.2.1	R402.2.1
Below Floors (framed floors)	5	☑	☑	See (2)	N1102.2.8	R402.2.8
Cathedralized Ceilings (3)	6	☑	☑	SPFA-141 (2)	N1102.2.2	R402.2.2
Unvented Attics (3)	7	☑	☑	SPFA-141 (2)	R316.5.3, R806.5	N/A
Outside Ductwork	8	☑	☒	See (2)	M1603.1.3, M1601.4.6	N/A
Unvented Crawlspaces	9	☑	☒	SPFA-152 (2)	R408.3; R316.5.4, N1102.2.11	R402.2.11
Conditioned Basements	10	☑	☒	SPFA-152 (2)	N1102.2.9	R402.2.9
Foundation Walls (exterior side of below-grade walls)	11	☑	☒	SPFA-140 (4)	N1102.2.9, R316.7, R318.4	R402.2.9
Below Concrete Slab-on-grade	12	☑	☒	SPFA-153	N1102.2.10, R316.7, R318.4	R402.2.10

(1) It is recommended to consult the applicable SPFA Technical Documents for more information on these

applications.

- SPFA-126 "Thermal and Ignition Barriers for Spray Polyurethane Foam Insulation".
- SPFA-140 "Spray Polyurethane Foam Insulation for the Exterior of Foundation Walls"
- SPFA-141 "Spray Polyurethane Foam Insulation for Unvented (Conditioned) Attics and Cathedralized Ceilings"
- SPFA-146 "Spray Polyurethane Foam Insulation for Hybrid Insulation Systems – Part 1: Warm Climates"
- SPFA-147 "Spray Polyurethane Foam Insulation for Hybrid Insulation Systems – Part 2: Cold Climates"
- SPFA-152 "Spray Polyurethane Foam Insulation for the Interior of Basement and Crawlspace Walls"
- SPFA-153 "Spray Polyurethane Foam Insulation Below Concrete Slabs"

(2) When SPF is left exposed without a thermal barrier prescribed by the model building codes (e.g., ½: gypsum board), additional fire protective coverings or coatings may be needed. Consult SPFA-126 for more information on thermal and ignition barriers for SPF insulation.

(3) Assemblies using open-cell SPF in colder climates may require a Class II or Class III vapor on the interior side of the SPF. Consult with building code requirements, product technical data sheets and code compliance reports.

(4) Below-grade exterior applications may require protective elastomeric coatings

DETAILS AND ILLUSTRATIONS

The following diagrams, photos and architectural details illustrate the application of SPF insulation in a variety of different residential applications.

FIGURE 1: EXTERIOR WALLS (CAVITY)

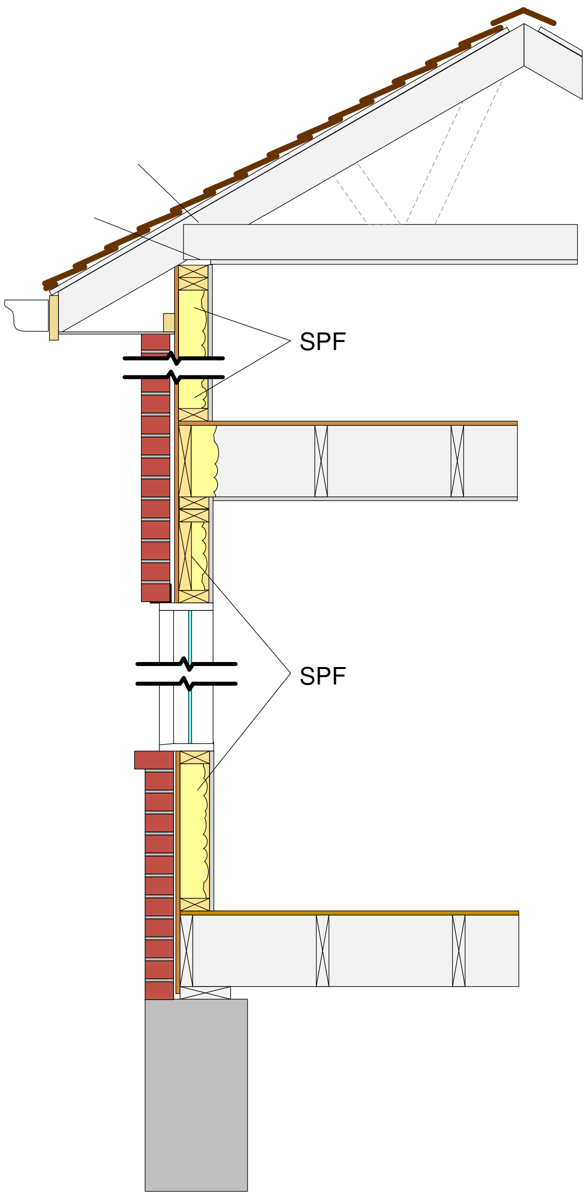
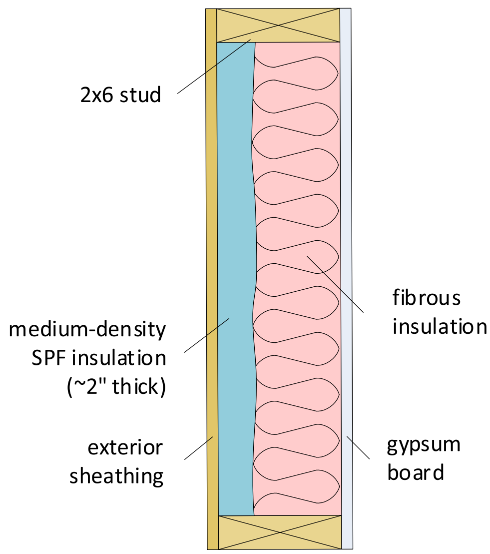


FIGURE 2: EXTERIOR WALLS (HYBRID)



(plan view)

FIGURE 3: EXTERIOR INSULATION (CONTINUOUS)

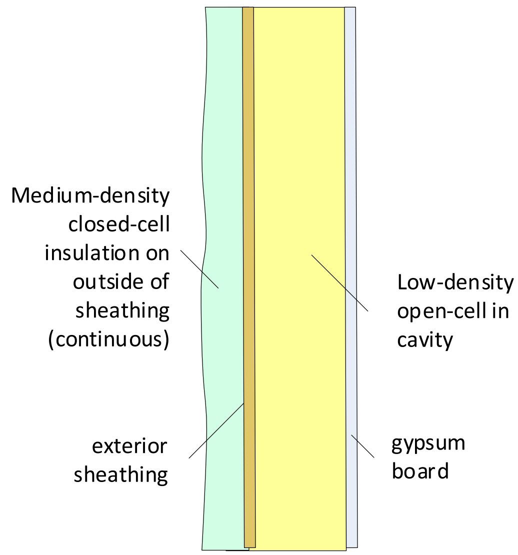
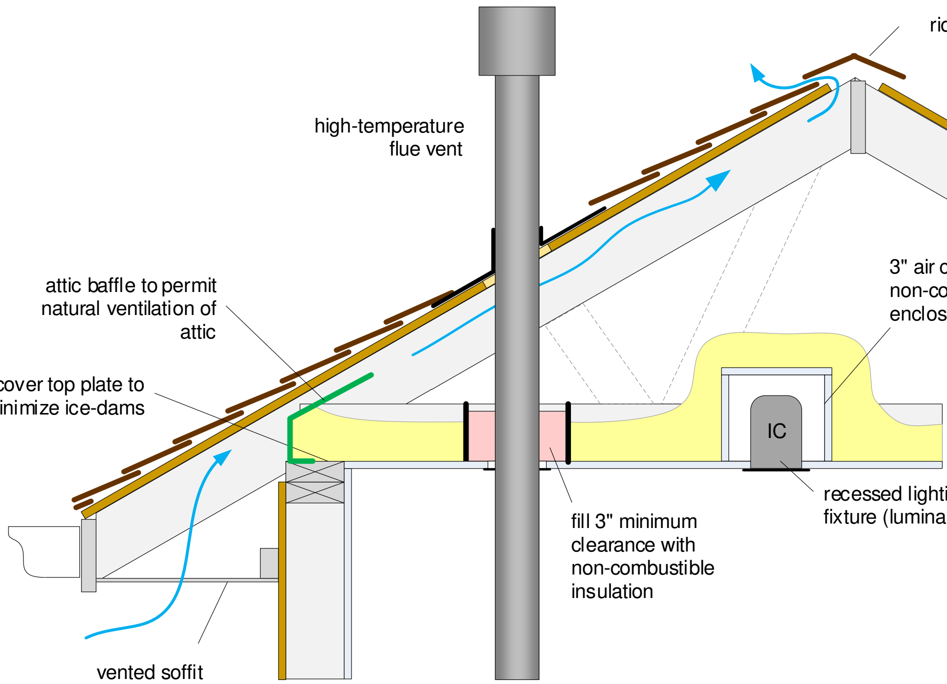


FIGURE 4: ATTIC FLOORS



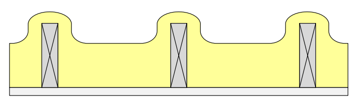


FIGURE 5: BELOW FLOORS

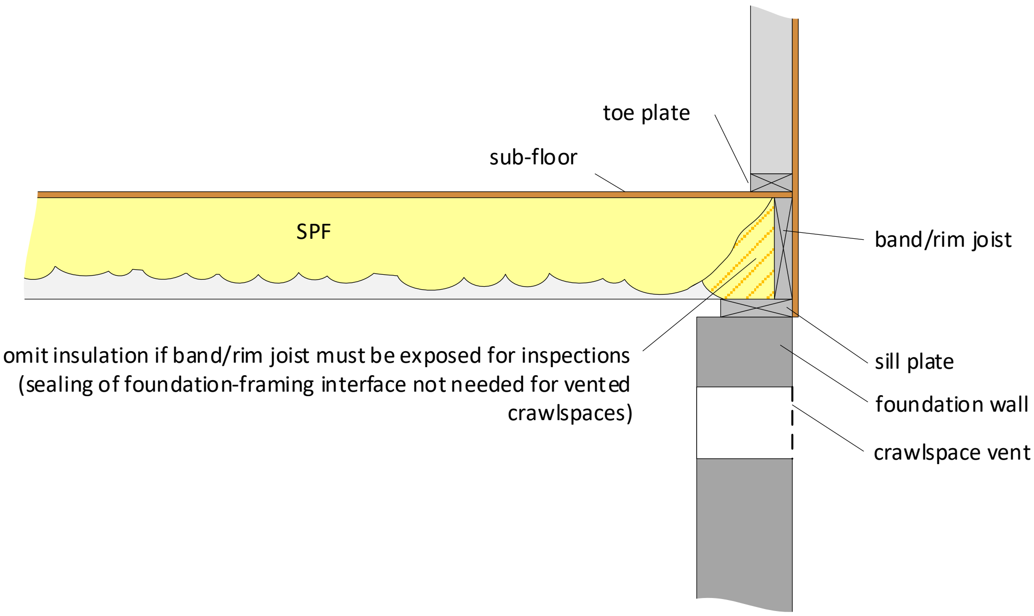
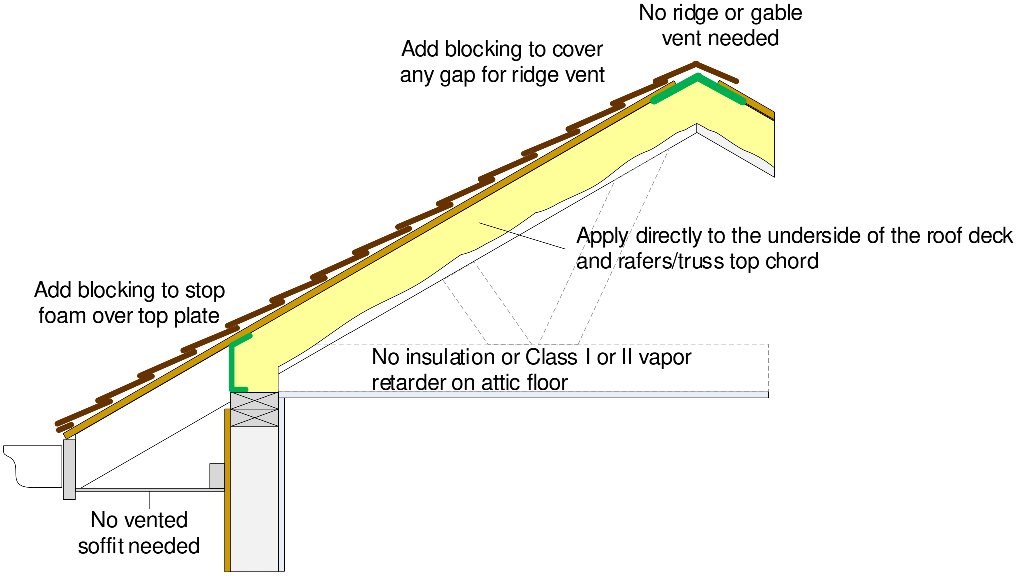
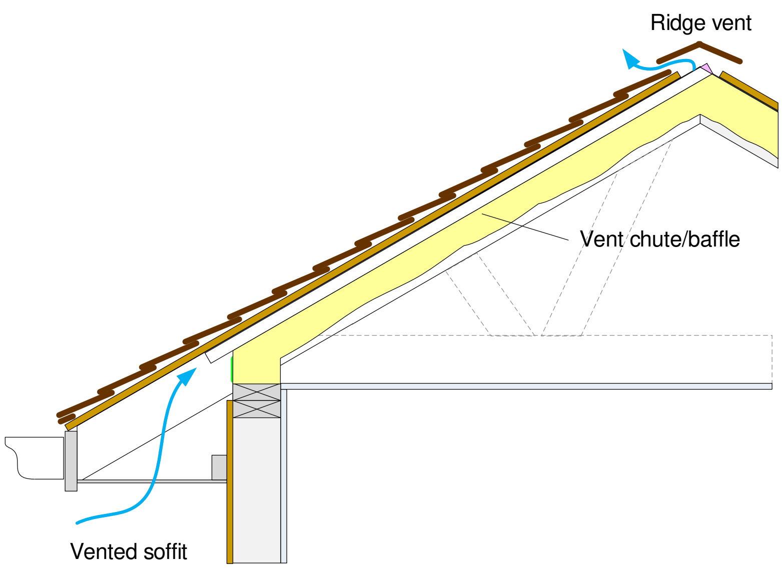


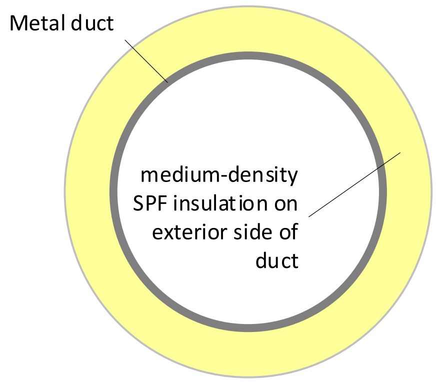
FIGURE 6: CATHEDRALIZED CEILINGS/CEILINGS WITHOUT ATTIC SPACES

FIGURE 7: UNVENTED ATTICS

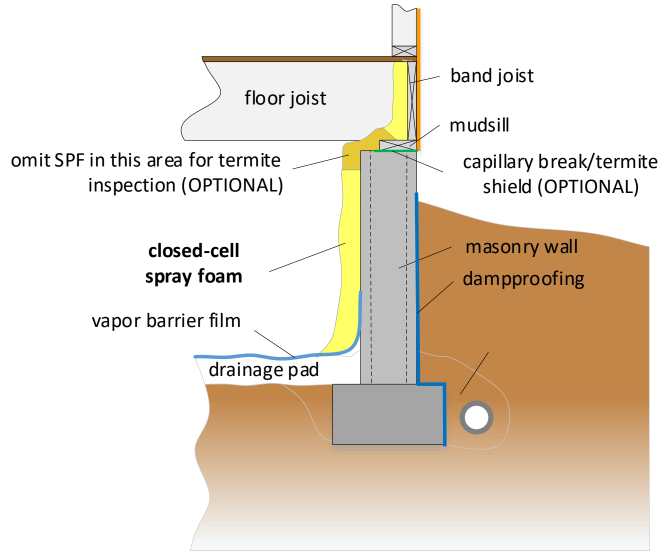




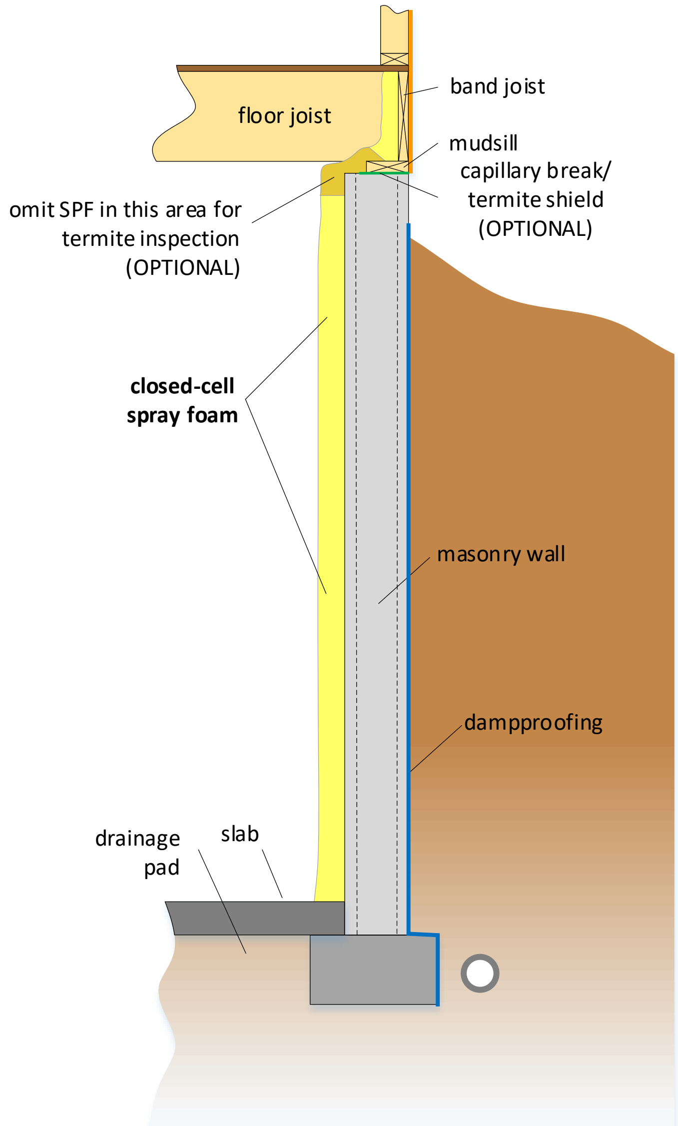
8. EXTERIOR SIDE DUCTWORK

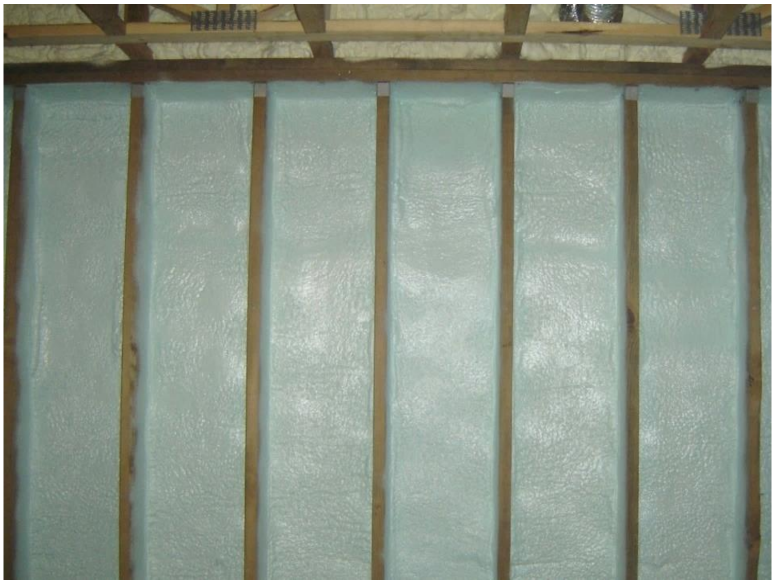


9. UNVENTED (CONDITIONED) CRAWLSPACES

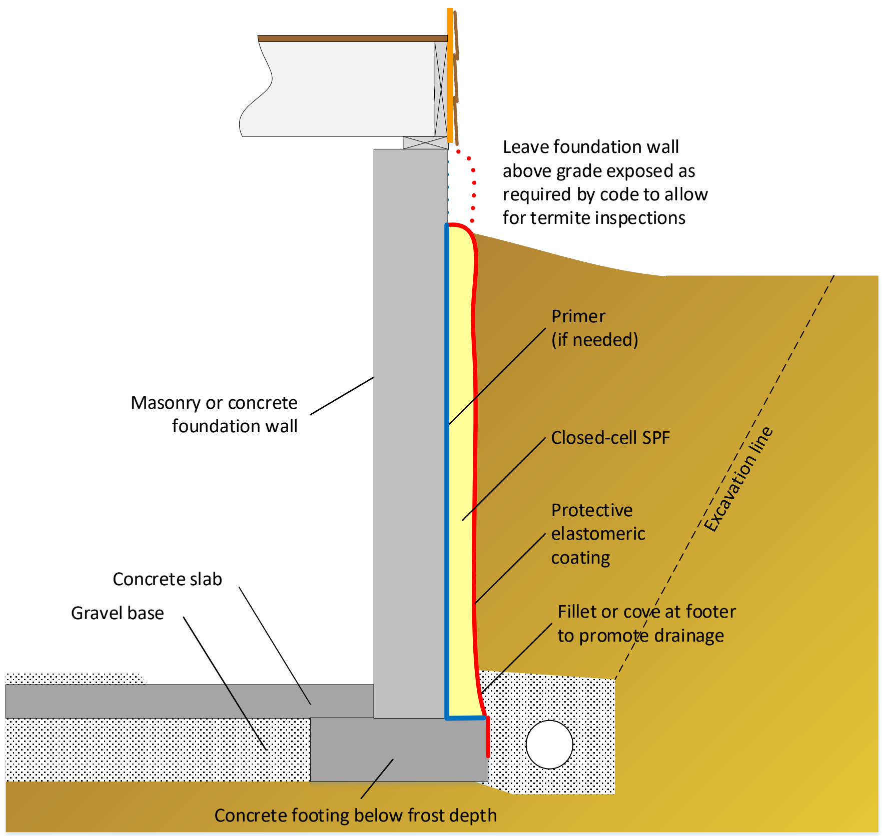


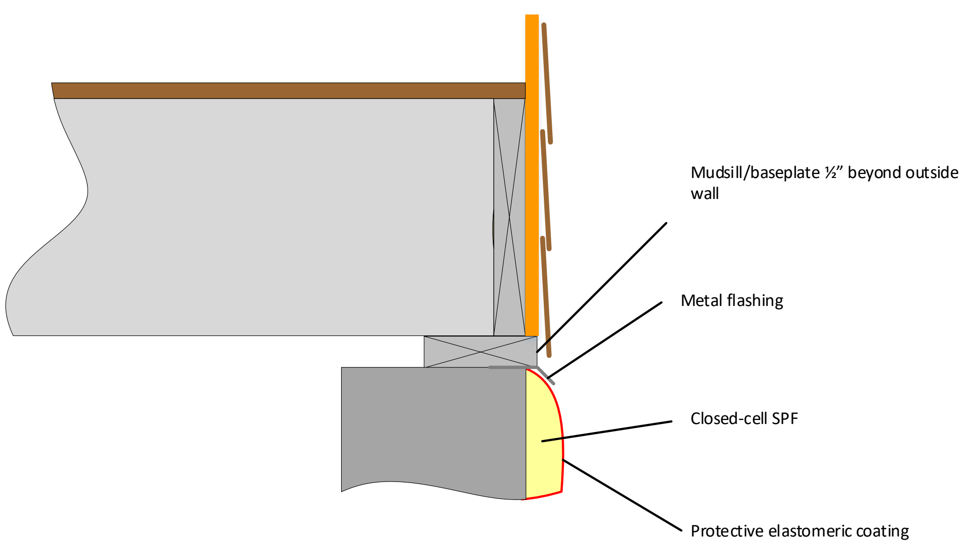
10. CONDITIONED BASEMENT WALLS (INTERIOR)



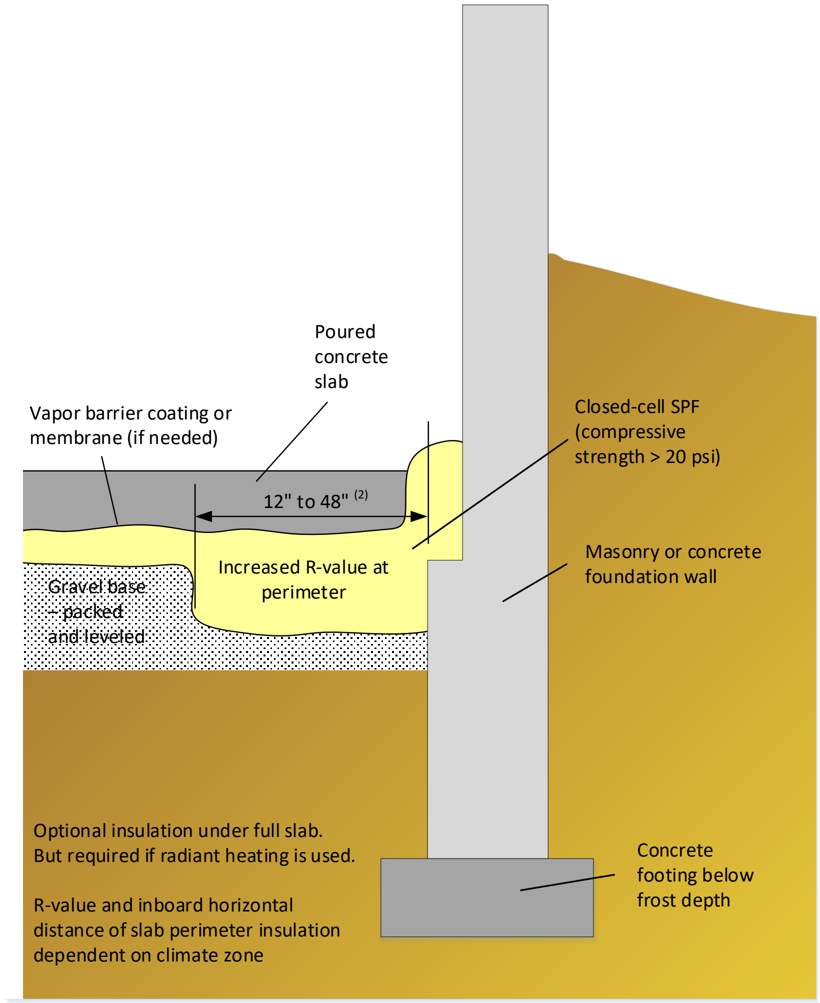


11. BELOW-GRADE WALLS – EXTERIOR





12. BELOW SLAB




After SPF installed,
before concrete is