SPFA-153

Spray Polyurethane Foam Insulation Below Concrete Slabs

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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
October 2019	All	New document
January 2021	Cover and Header	New SPFA Logo

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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DOCUMENT SCOPE

This document focuses on the application of closed-cell spray polyurethane foam (ccSPF) insulation installed below a new concrete slab floor (below or at grade). It does not address the use of injected spray foam below existing concrete slabs used for jacking or leveling. It also does not address the use of ccSPF insulation below or around load-bearing concrete footings.

It is not the purpose of this guidance document to provide building science decisions or recommendations for specific project needs, but to provide guidance on the means and methods for the installation of the ccSPF prior to the installation of a concrete slab floor.

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BUILDING SCIENCE AND APPLICABLE RESEARCH

The building science industry has researched and written a large body of information on heat, air, and moisture control in below-grade applications. Information relevant to the use of SPF in these applications includes literature on these and other topics including the following:

1. When installation of insulation beneath a below or on grade concrete slab floor is required
2. Bulk water management
3. Vapor control
4. Air leakage control
5. Insulation performance and minimum requirements (including ROI for insulation on crawl space floors)
6. Frost action in wet soils
7. Embedded wood members in insulated masonry walls in cold climates
8. Radon gas control
9. Pest control

USING ccSPF vs OTHER INSULATION SYSTEMS

Closed-cell rigid foam board and SPF products are generally recommended for all below-grade installations where bulk water may contact the installation. Closed-cell SPF can generally be used in any location indicated as appropriate for rigid foam board, even if ccSPF is not specifically included as an option. Insulation materials that either easily absorb water or are air-permeable are typically not recommended for below-slab installation.

There are several advantages for using ccSPF in lieu of foam board insulation in below-slab applications. ccSPF provides a continuous layer of insulation without any cracks and gaps found at the edges of rigid foam boards. This helps to provide a better seal to prevent the infiltration of soil gases, as well as water vapor and liquid water. Secondly, ccSPF can help level the gravel base, minimizing concrete use and reducing uneven edges of the foam board. This prevents breakage of the foam and trip hazards after installation of the foam boards prior to installation of the concrete floor. The monolithic SPF layer stays in place without the need for pins to prevent the rigid foam insulation boards from becoming displaced.

FUNCTIONS OF ccSPF IN BELOW-SLAB APPLICATIONS

ccSPF provides several functions which are important for below-grade applications. These include:

- Insulation
- Air Sealing
- Moisture Control
- Water Resistance
- Compressive Strength

1. **Insulation:** The rate of heat loss through the floor decreases with the depth of the floor below grade. The most critical area of the floor to insulate is around the perimeter of the floor near the walls. Appendix B shows the 2018 IECC requirements for slab insulation which have not changed since 2012.

2. **Air Sealing:** A measurable source of air leakage can exist at the perimeter of a concrete slab floor where it contacts the footer and wall. Concrete floors shrink and pull away from footers and walls. Additionally, other cracks, gaps and penetrations in the slab can allow for air leakage, which may result in the infiltration of unwanted soil gases, including radon, methane and other gases that may be present in the ground below[i]. A substantial amount of air infiltration through the slab can occur when driven by negative air pressures from the stack effect, wind load and unbalanced ventilation.

3. **Moisture Control:** The use of closed-cell SPF insulation can serve as a code-compliant vapor retarder to help moderate moisture drive through the slab.

4. **Water Resistance:** Below-grade slabs are often subject to flooding from heavy rains because of poor exterior grading and drainage. Closed-cell foam insulation such as ccSPF is identified by FEMA is a flood-resistant insulation[ii]. It should be noted that proper drainage of the gravel base below the sub-slab insulation is important, as closed-cell SPF, like other closed-cell foam plastic insulations, may absorb water with extended exposure to liquid water.

5. **Compressive Strength:** Below-grade slabs will impart uniform, distributed 'dead' load onto the spray foam insulation below. Closed-cell foam insulation products have been used in this application and structural engineers have routinely specified a minimum compressive strength of foam below load-bearing concrete footers to be 20 psi.

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OTHER DESIGN CONSIDERATIONS

FOUNDATION DRAINAGE SYSTEMS

Construction of new buildings should include proper foundation drainage systems. Gravel backfill, and water-resistant coatings should be used below the concrete slab. Additionally, proper grading and water runoff is necessary to prevent the long-term retention of water below the concrete slab during heavy rains.

However, dry foundation walls are not always achievable, especially in existing buildings. In these cases, a perimeter drainage system may be needed. For economic reasons, an exterior foundation drainage system may not be feasible. Instead, a perimeter drainage system along the interior side of the foundation walls may need to be installed. An example of an interior perimeter foundation drainage system with a sump pump is shown in Figure 1.

Figure 1 – Interior Foundation Drainage System with Sump Pump

http://aviationpictures.info/residential-foundation-drainage-systems/interior-drain-tile-vs-exterior-drain-tile-which-system-is-better-in-residential-foundation-drainage-systems/

RADON AND SOIL GAS CONTROL SYSTEMS

Buildings located in some parts of the US may be subject to infiltration of radon, methane or other unwanted soil gases. These gases enter the building through cracks, gaps and penetrations in the masonry walls and/or concrete slab in the basement or crawlspace. ccSPF,

alone or in combination with air-impermeable vapor barriers covering the crawlspace floors, can dramatically reduce infiltration of these gases. In some cases, a passive or active radon mitigation system may need to be installed behind or below the air impermeable barrier created by ccSPF.

The air sealing from the monolithic layer of ccSPF can reduce the amount of conditioned air removed by active radon removal systems. In regions susceptible to radon or other soil gases, it is recommended that ccSPF contractors consult with companies that provide radon testing and mitigation services prior to installation of ccSPF.

ccSPF APPLICATION EXAMPLES

SURFACE PREPARATION

ccSPF can successfully be applied to most surfaces. The gravel base should be installed and properly compacted and leveled as it would be if the concrete slab is to be poured directly over the gravel base. ccSPF should not be installed over a sand base. Although adhesion is not a significant concern, gravel base should be relatively dry and should be free of any standing water. The gravel should not contain excessive amounts of dust or fines, as these may become airborne during the application of ccSPF. Compressed air may be used remove excessive surface dust, or the gravel base may be watered and dried before ccSPF application to remove excessive dust and fines from the surface.

SELECTION OF A VAPOR RETARDER/BARRIER

Although 2" of closed-cell SPF qualifies as Class II (0.1 to 1.0 perm) vapor retarder, an additional Class I vapor retarder (vapor barrier) may be needed based on hygrothermal analysis or soil conditions. Wet soils or the potential for liquid water in the gravel base may suggest using a vapor barrier layer between the ccSPF and gravel base. If a vapor retarder/barrier is required, its selection should be based on the following criteria:

(1) Permeance required (based on moisture vapor drive and perm ratings of other components)
(2) Water resistance
(3) Compatibility with adjoining materials
(4) Mechanical stability
(5) Compatibility with and adhesion to ccSPF.

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SELECTION OF THE SPRAY POLYURETHANE FOAM SYSTEM

Many different ccSPF systems are available in various compressive strengths, each exhibiting different temperature limitations and physical properties. For sub-slab applications, the ccSPF must be capable of supporting the dead load of the slab, plus some margin of safety. Live loads from foot traffic during slab installation should also be considered. Based on experience with other closed-cell foam insulations, a ccSPF with a 20 psi or greater compressive strength should be specified.

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

Where the SPF is separated from the interior of the building by a minimum 1" thick concrete slab, the IBC/IRC building codes recognize the concrete as the necessary "Fire Protective Covering" in lieu of the 15 minute Thermal Barrier; no other covering is required. It is important, however, that all persons associated with the design, fabrication, storage, and installation understand the materials and environments involved.

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 temperatures in excess of 180°F (82°C) .

SELECTION OF WATERPROOFING

ccSPF is resistant to water intrusion; however, under circumstances such as high water tables, which result in long-term water exposure, water can be absorbed by and accumulate in closed-cell foams below the slab. If these circumstances are anticipated, waterproofing is recommended. Waterproofing must form a water-resistant protective membrane below the ccSPF.

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BETWEEN GRAVEL BASE AND SLAB

Recent editions of the building and energy codes may require insulation of below-grade walls[1] or below the slab. It is suggested that you determine the insulation requirements and confirm insulation options with a local code official, as different editions of the code and different climate zones have different insulation requirements.

In the most recent (2018) edition of the IECC, a minimum of R5 is required in all climate zones under the entire slab if a radiant floor heating system is used. Additionally, increase levels of insulation may be required at a specific vertical depth along the inside or outside of the foundation wall or at a specific horizontal distance inside the footer below the slab, depending on the depth of the slab below grade. These options are shown in Figure 2. Note that when no insulation is below the slab or on the perimeter (Figure 2d), insulation may still be used on the side of the slab to prevent capillary water absorption from the foundation and provide an air seal for the slap.

[1] A below-grade wall that has a portion below the finished ground level adjoining the building.

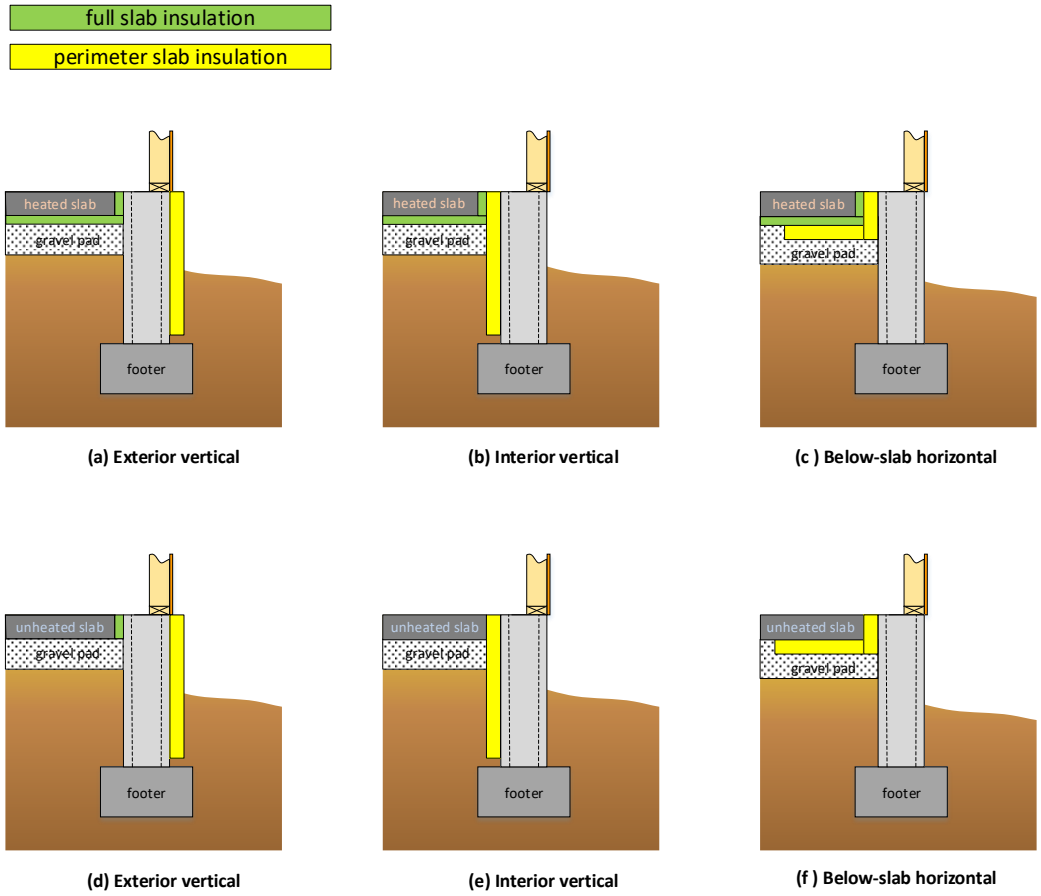

Figure 2 – Slab and Slab Perimeter Insulation Options

For ccSPF, the most feasible slab perimeter option is to extend the insulation horizontally inboard of the foundation under the slab as shown in Figures 2c (heated slab) and 2f (unheated slab).

Below are several suggestions that should be followed during the installation of ccSPF below concrete slabs:

a. Surface Preparation: The gravel base should be installed and properly compacted and leveled as it would be if the concrete slab is to be poured directly over the gravel base. SPF should not be installed over a sand base. Although adhesion is not a significant concern, the gravel base should be relatively dry and should be free of any standing water. The gravel should not contain excessive amounts of dust or fines, as these may become airborne during the application of ccSPF. Compressed air may be used remove excessive surface dust, or the gravel base may be watered and dried before ccSPF application to remove excessive dust and fines from the

surface. Large gravel (#1 stone is preferred over small gravel or sand (pea gravel, crusher run, screenings, fines and stone dust) to promote adhesion, reduce foam lift and voids and promote drainage and soil gas removal.

b. Leveling Guides: Poured concrete slabs should have a uniform, minimum thickness. For this reason the ccSPF layer should have a level top surface. Some contractors use a grid of guide strings at or near the desired foam thickness. Others may use a rotary laser level to assure a level surface of the installed foam. The American Society of Concrete Contractors suggests that concrete slab thickness varies no more than +/- ½" [iii].

c. Coverage Area: In moderate climates, sub-slab insulation may only be required by code at a certain distance inboard of the perimeter wall footers. This boundary can be marked by spray painting a line on the gravel base the specified distance inboard of perimeter walls

d. Before ccSPF installation, an optional vapor barrier membrane may be placed over the top of the gravel base prior to SPF installation.

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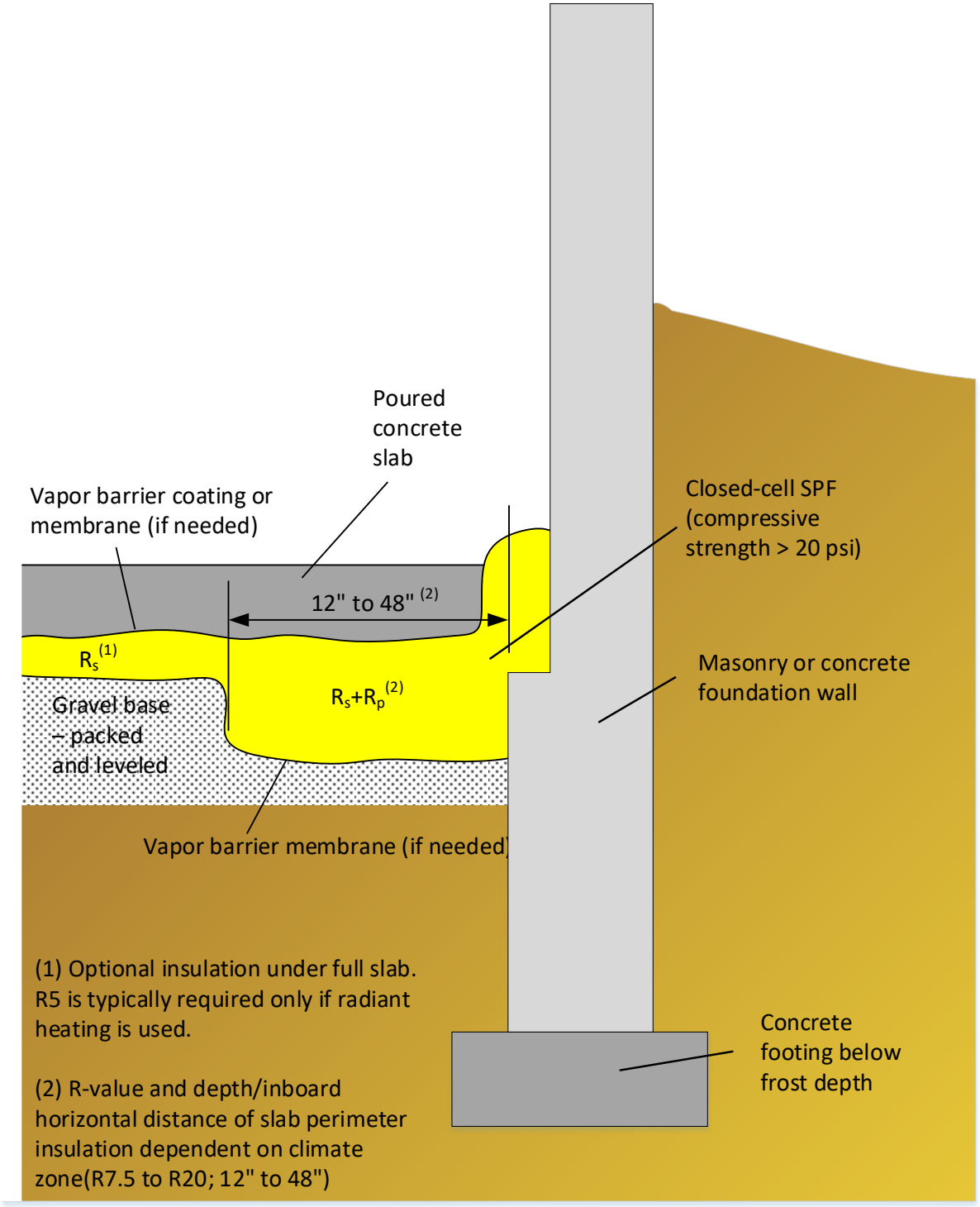

Figure 3 – Sub-Slab Insulation Application (diagram)

Note: Foam above top surface of slab may be removed and/or coated after slab installation.

Figure 4 - Sub-Slab Insulation Application (photo)

POST-INSTALLATION SAFETY PROTOCOLS

Recommend that the owner have radon and other IAQ testing performed (insert EPA citation on radon here)

APPENDIX A – CSI SPECIFICATION

PART 1—GENERAL

1.01 SCOPE OF WORK

Furnish all labor, materials, tools, and equipment necessary for the application of an SPF subgrade thermal and moisture protection system, including accessory items, subject to the general provisions of the contract.

1.02 RELATED WORK SPECIFIED ELSEWHERE

Cast-in-place concrete	Section 03300
Masonry construction	Section 04200
Rough carpentry	Section 06100
Foundation drainage	Section 02710
Waterproofing	Section 07700
Insulation	Section 07200

1.03 QUALITY ASSURANCE

Contractor Qualifications: The contractor should provide information concerning projects similar in nature to the one proposed, including location and person to be contacted. Some manufacturers of SPF systems have approval programs and/or licensing methods that could be applicable.

1.04 SUBMITTALS

(1) Manufacturer's published data sheets or letters of certification that products comply with the materials specified, including primers (if required), SPF, and waterproofing
(2) Shop drawings on specific foundation and footer terminations
(3) Manufacturer's application or installation instructions
(4) Contractor and applicator certification from SPF manufacturer or other evidence of contractor qualification and experience. (See Section 1.03)
(5) Safety and handling instructions for storage, handling, and use of the materials to include SDS (Safety Data Sheets)
(6) Field Quality Control Procedures to be utilized by the contractor and applicator to ensure proper preparation and installation of SPF and protective coating, detail work and follow-up inspection

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1.05 MATERIALS, DELIVERY, AND STORAGE

(1) Materials shall be delivered in the manufacturer's original, tightly sealed containers or unopened packages, all clearly labeled with the manufacturer's name, product identification, safety information, and batch or lot numbers where appropriate.
(2) Containers shall be stored out of the weather and direct sun, where the temperatures are within the limits specified by the manufacturer.
(3) All materials shall be stored in compliance with local fire and safety requirements.

1.06 ENVIRONMENTAL CONDITIONS

Do not apply the SPF below the temperature or above the humidity specified by the manufacturer.

1.07 SEQUENCE AND SCHEDULING

The SPF is installed when the floor penetrations have been completed. Subsequent penetrations must be resealed. There should not be any other trades in the immediate area when the SPF is being installed.

1.08 SAFETY REQUIREMENTS

(1) See CPI Bulletin, "*MDI-Based Polyurethane Foam Systems: Guidelines for Safe Handling and Disposal*."
(2) Refer to appropriate MSDS for additional safety information.
(3) Proper disposal of waste materials and containers must be done in compliance with the manufacturer's guidelines and federal, state, and local regulatory agencies.
(4) See OSHA 29 CFR 1926 "Safety and Health Regulations for Construction."

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PART 2—PRODUCTS

2.01 SPF

The polyurethane foam to be applied shall be a two-component system made by combining an isocyanate (A-component) with a polyol (B-component) and shall possess the following physical characteristics:

PROPERTIES (Sprayed in Place)	ASTM TEST	US UNITS	SI UNITS
Density	D-1622	1.5—3.0 lbs/ft^3	48 kg/m^3
Compressive Strength	D-1621	20 lb/in^2 (minimum)	134 kPa (minimum)
Closed Cell Content	D-2856	90% (minimum)	90% (minimum)
R-Value	C-177, C-236, or C-518	6.0°F•hr•ft^2/Btu	1.1 K•m^2/W (minimum)
Flame Spread	E-84	<75	<75
Smoke*	E-84	<450	<450

*This standard is used solely to measure and describe 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.

2.02 RELATED PRODUCTS

(1) A moisture barrier membrane (<0.1 perm) or acceptable coating may be placed over the foam if determined to be necessary.

PART 3—EXECUTION

3.01 APPLICATION OF PRODUCTS

The products intended for use in the building envelope insulation system must be applied within the manufacturer's guidelines for temperature, humidity, and other atmospheric conditions. They must be sequenced so as to take into consideration substrate preparation, proper cure times, and inter-coat adhesion.

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1.02 SUBSTRATE CONSIDERATION AND PREPARATION

(1) The gravel base should be installed and properly compacted and leveled as it would be if the concrete slab is to be poured directly over the gravel base. SPF should not be installed over a sand base.

(2) Although adhesion is not a significant concern, gravel base should be relatively dry and should be free of any standing water. The gravel should not contain excessive amounts of dust or fines, as these may become airborne during the application of SPF. Compressed air may be used remove excessive surface dust, or the gravel base may be watered and dried before SPF application to remove excessive dust and fines from the surface.

3.03 SPF APPLICATION

(1) Inspection
   a. Prior to the application of the SPF, the substrate surface shall be inspected to ensure that conditions required by Section 3.02 have been satisfied.
   b. Verify that temperature, humidity, and other atmospheric conditions are within the SPF manufacturer's guidelines for the application of SPF.

(2) Application
   a. The SPF A- and B-components shall be processed in accordance with the manufacturer's instructions.
   b. The SPF shall be sprayed in minimum 1/2 inch (13 mm) thick passes with the overall thickness to be a minimum of ___ inches (__ mm). The full thickness of SPF to be applied within any given area should be completed in one day.
   c. The SPF total thickness will be a minimum of 1 inch (25 mm) or more if specified. The SPF shall be applied uniformly over the entire surface with a thickness tolerance to yield a level slab of plus ±1/2 inch thickness (±12 mm).
   d. SPF shall be terminated in a clean, neat line. Foam extending above the top surface of the slab may be removed after slab installation.

(3) Surface Finish
   a. The final SPF surface shall be smooth and level.
   b. Damage or defects to the SPF surface shall be repaired prior to the application of the concrete slab.

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APPENDIX B – BUILDING CODE INSULATION REQUIREMENTS

2018 IECC INSULATION REQUIREMENTS FOR CONCRETE SLABS

The insulation requirements from the 2018 IECC[iv] are provided in the table below for both residential and commercial buildings. These prescriptive insulation requirements have remained unchanged since the 2012 IECC. The requirements are different depending on climate zone and if the slab is heated or unheated. Group R occupancies for commercial buildings include multi-family structures and hotels, motels and boarding houses.

Insulation is always required below the entire slab if the slab is heated in Climate Zones 4-8. Perimeter insulation may be installed as (1) measured from the top of the slab along the vertical foundation wall (Figure B.1)or (2) on the vertical side of the slab and horizontally below the slab around the perimeter in addition to any required insulation below the slab (Figure B.2). The total length of the perimeter insulation must be equal to or greater than the prescribed depth of the perimeter insulation prescribed by the IECC.

Another option for perimeter insulation (not shown) is to apply the insulation on the exterior surface of the foundation wall.

		IECC Climate Zone							
		1	2	3	4 except Marine	5 and 4 Marine	6	7	8
RESIDENTIAL (Table R402.1.2)									
Unheated Slab	Full-Slab R-value (R_s)	NR	NR	NR	NR	NR	NR	NR	NR
	Perimeter Insulation R-value (R_p)	NR	NR	NR	10	10	10	10	10
	Depth of Perimeter Insulation (in)	NR	NR	NR	2	2	4	4	4
Heated Slab	Full-Slab R-value (R_s)	5	5	5	5	5	5	5	5
	Perimeter Insulation R-value (R_p)	NR	NR	NR	10	10	10	10	10
	Depth of Perimeter Insulation (in)	NR	NR	NR	24	24	48	48	48
COMMERCIAL ex Group R (Table C402.1.3)									
Unheated Slab	Full-Slab R-value (R_s)	NR	NR	NR	NR	NR	NR	NR	NR
	Perimeter Insulation R-value (R_p)	NR	NR	NR	10	10	10	15	15
	Depth of Perimeter Insulation (in)	NR	NR	NR	24	24	24	24	24
Heated Slab	Full-Slab R-value (R_s)	5	5	5	5	5	5	5	5
	Perimeter Insulation R-value (R_p)	7.5	7.5	10	15	15	15	20	20
	Depth of Perimeter Insulation (in)	12	12	24	24	36	36	48	48
COMMERCIAL Group R (Table C402.1.3)									
Unheated Slab	Full-Slab R-value (R_s)	NR	NR	NR	NR	NR	NR	NR	NR
	Perimeter Insulation R-value (R_p)	NR	NR	NR	10	10	15	15	20
	Depth of Perimeter Insulation (in)	NR	NR	NR	24	24	24	24	24
Heated Slab	Full-Slab R-value (R_s)	5	5	5	5	5	5	5	5
	Perimeter Insulation R-value (R_p)	7.5	7.5	10	15	15	20	20	20
	Depth of Perimeter Insulation (in)	12	12	24	24	36	48	48	48

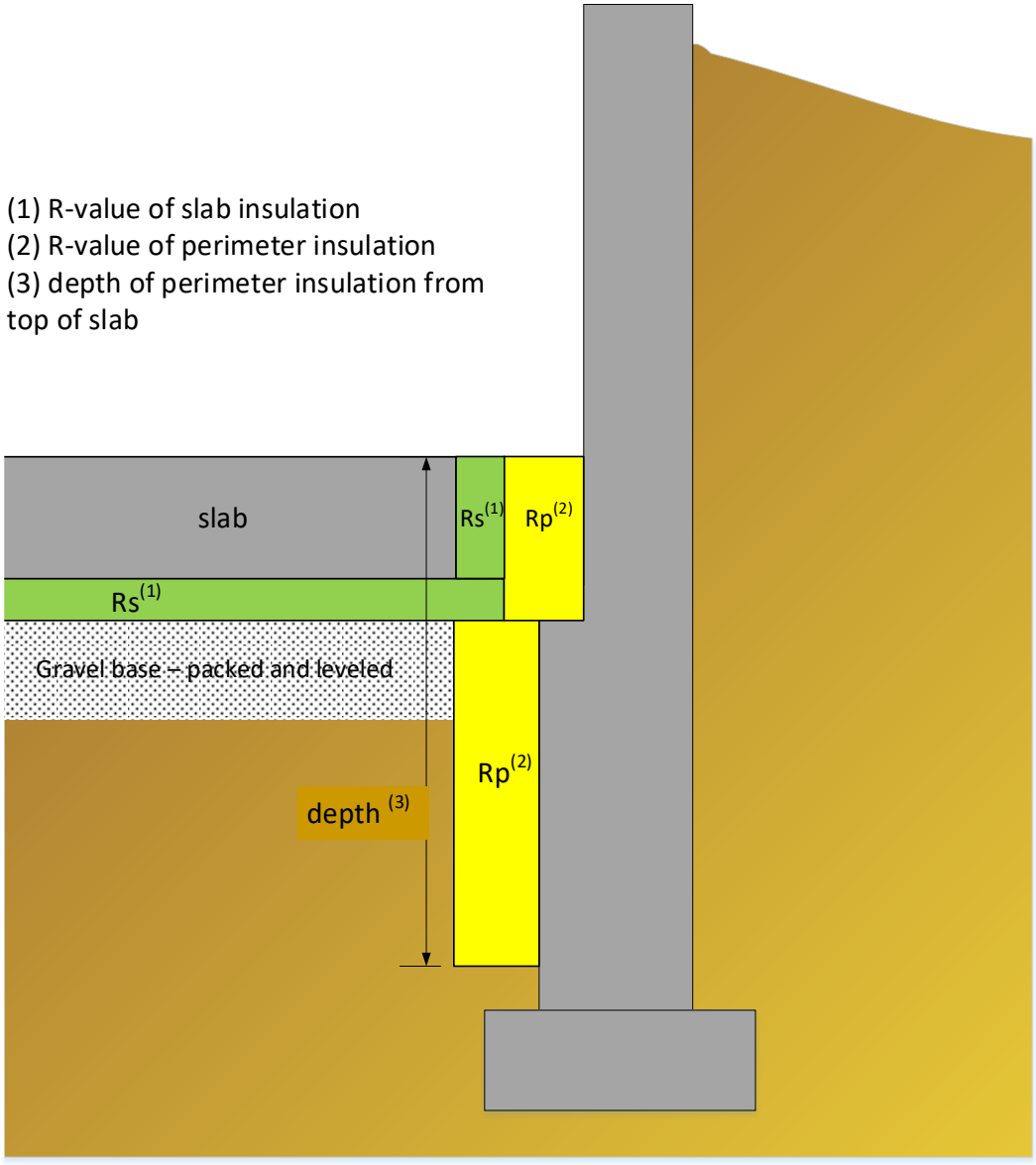

FIGURE B.1 – Perimeter Insulation on Foundation Wall

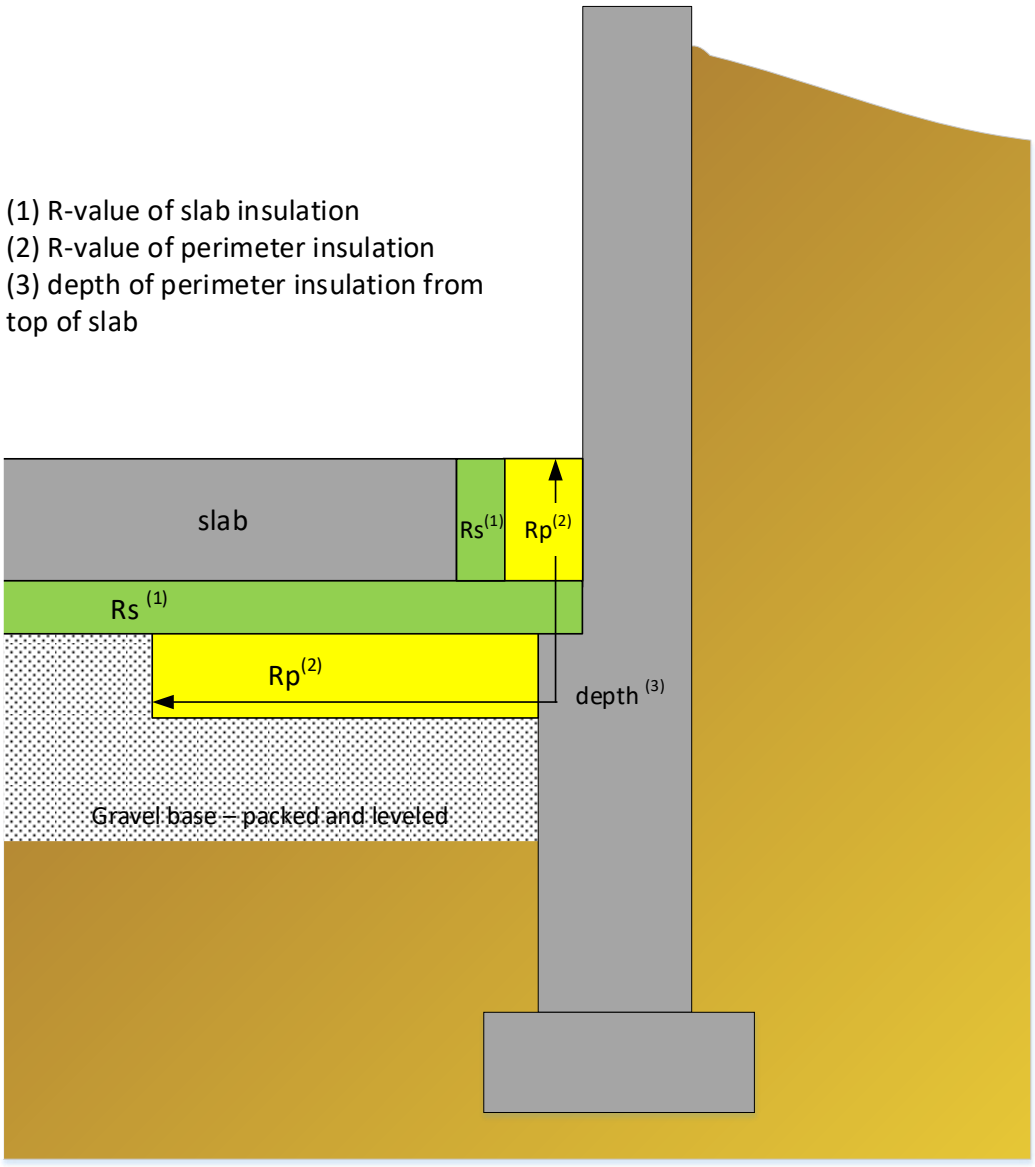

FIGURE B.2 – Perimeter Insulation Below Slab Inboard of Foundation Wall

APPENDIX C - REFERENCES

[i] https://www.buildinggreen.com/feature/radon-and-other-soil-gases-dealing-hazards-below

[ii] "Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program Technical Bulletin 2 / August 2008 FEMA.

[iii] https://www.ascconline.org/Portals/0/docs/POSITION-STATEMENTS/PS-9-concrete-slab-thickness-tolerances.pdf

[iv] 2019 International Energy Conservation Code (IECC), published by the International Code Council, www.iccsafe.org