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Which Spray Foam Is Right For You?

Appropriate applications for open-cell and closed-cell foam insulation

Thermal insulation for low-rise residential construction has historically been dominated by loose-fill and pre-formed blanket cavity-fill materials, primarily fiberglass and cellulose. With a new generation of building insulation materials and systems on the market, a careful assessment of their physical properties needs to be made in the context of potential applications to assure that performance matches expectations and that unintended consequences, in this case moisture related building-envelope failure, are avoided. This guideline focuses on performance benefits and the potential performance limitations of open-cell and closed-cell spray polyurethane foam.

SPRAY POLYURETHANE FOAM INSULATION

Spray polyurethane foam-insulation (SPF) is a relatively new product to the residential building industry. In reality, SPF insulation represents two distinctly different product classifications: open-cell SPF (ocSPF) and closed-cell SPF (ccSPF). Both categories of SPF are chemically similar and are applied in a two-part liquid spray consisting of polymeric MDI (methylene diphenyl diisocyanate) on one side, and a cocktail of polyol resins, surfactants, fire-retardants, and catalysts on the other. Compositionally, the most significant difference is in the blowing agents. Closed-cell foam primarily uses non-ozone depleting hydroflurocarbons (HFC's), while open-cell primarily uses water. The formulations result in differing expansion reactions with closed-cell expanding about 35 to 50 times its original volume compared to open-cell which expands triple that to 150 times is original volume. In applying the foams, closed-cell is typically limited to 2"-3" thick layers per pass, with greater thicknesses made up of multiple layers. Open-cell foam may be applied to full thickness in a single pass, generally up to 10".

Both types of SPF are excellent at air-sealing, a once overlooked, but critical aspect of insulated assemblies. The liquid-to-expanding foam process tends to fill gaps, cracks and voids responsible for uncontrolled air leakage. It is this attribute that makes SPF insulation performance superior to other typical insulations such as fiberglass or cellulose which are far less able to block air flow.

Both ocSPF and ccSPF are combustible, and as such are formulated with fire-retardants and other additives to decrease flame spread and smoke generation as measured by ASTM Standard E 84, *Test for Surface Burning Characteristics for Building Materials.* Each foam type generally falls into the area of less then 25 flame-spread index, and less then 450 on the smoke-developed index, dependant on thickness, manufacturer, and formulation.

Because of its categorization as combustible, SPF used in building assemblies is typically required to be fire-protected by a "thermal barrier" or an "ignition barrier". The most relevant definition for that thermal barrier for our purposes is contained within the International Residential Code (IRC), which for most applications is a 15-minute thermal-barrier (the equivalent of ½" gypsum board) as tested under ASTM E 119. For some applications not within habitable space, such as attics and crawlspaces, an ignition barrier may suffice.

Although similar in chemical composition, the differences represented by their respective physical properties and performance attributes are so significant, that potential applications need to be gauged separately: the two products *are not* interchangeable in all applications.

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Open-Cell SPF

Once installed, open-cell SPF consists of a three-dimensional matrix of interconnected open cells, hence the name. Alternately called half-pound foam, the finished material weighs approximately 0.5 PCF, and is soft and easily compressed. The material remains somewhat flexible, but once compressed will not fully expand back to its original shape as the open-cell voids are reduced through compaction. The resistance to thermal heat flow is obtained through the interconnected cell matrix which acts to inhibit air movement and conductive heat flow. Typical R-values for open-cell SPF is approximately 3.6 per inch.

Open-cell SPF is excellent at blocking air-flow and is considered air-impermeable at typical application thicknesses. Although it is defined as air-impermeable, open-cell SPF is *not* vapor impermeable. At a typical thickness of 5", open-cell foam is rated from 5 to 10 Perms (dependant on specific product). By definition, a vapor retarder has a Perm rating of 1.0 or less.

Open-cell SPF will also absorb and hold liquid water. The water source can be from pressure-driven vapor diffusion, moisture from air leakage through finished wall and ceiling coverings, or bulk water through leaks. The amount of water capable of being held varies by specific product, but it can be significant; up to one-third by volume.

Open-cell SPF has a lower installed cost than ccSPF as its expansion ratio is higher given the same volume of liquid base ingredients. Retail installed cost of ocSPF varies but is generally in the $0.35-$0.40 per board-foot range or roughly $0.12 per R-1 per square-foot.

TYPICAL MATERIAL PROPERTIES for OPEN-CELL SPF

PROPERTY	VALUE
Density (ASTM D 1622)	**0.5 lb/cf (nominal)**
Thermal Performance (ASTM C 518)	**R-3.6 per inch (Aged, variable within range)**
Air Permeance (ASTM E 283)	**0.0049 L/s-m^2 @75 Pa for 5.25"**
Vapor Permeance (ASTM E 96)	**10 perms @ 5" thick**
Closed Cell Content	**< 10%**
Flame Spread (ASTM E 84)	**< 25**
Smoke Development (ASTM E 84)	**< 450**
Fuel Contribution (ASTM E 84)	**Zero**
Oxygen Index (ASTM D 2863)	**23**
STC (ASTM E 90)	**37 (2 x 4 wood stud wall assembly)**
NRC (ASTM C 423)	**70 (2 x 4 wood stud wall assembly)**
Compressive Strength	**< 2.0 psi**
Tensile Strength	**< 4.0 psi**

Closed-Cell SPF

At 2-lbs per cubic foot closed-cell SPF, alternately called 2-lb foam, is approximately four times denser than open-cell foam. Once set, the material remains rigid and more difficult to compress by hand-applied pressure. In compression closed-cell is ten times stronger than open-cell and seven times stronger in tension. Closed-cell SPF is in fact utilized as structural adhesive at many modular-housing factories to glue gypsum board to wall studs and ceiling joists. Studies at the University of Florida and elsewhere have documented the structural advantage of using ccSPF to glue roof decking to trusses in hurricane-prone areas. Similarly studies have found that the racking strength of frame walls is substantially increased when ccSPF is used in the frame cavities: an advantage for seismic and hurricane zone construction.

The largest difference however, is in the cell structure: Closed-cell foam maintains over 90% of its cells as closed, with the insulative gases contained within them trapped. Air or other gases do not communicate from one cell to the next. This property results in the key differences between open and closed-cell SPF's: the R-value for typical closed-cell foam is R-6 per inch; the material is rigid and far more difficult to compress; and at typically applied thickness ccSPF is defined as a vapor-retarder, essentially moisture-vapor impermeable.

Closed-cell SPF is hydrophobic and will not absorb water. Dependant on formulation, ccSPF can be appropriate for extreme cold-temperature applications such as liquefied-gas storage vessels, and rigorous-service building envelope uses such as low-slope (flat) roofs.

Closed-cell SPF has a higher installed cost than ocSPF mainly because there is more material per volume due to the lower expansion ratio. Retail installed cost of ccSPF varies but is generally in the $1.10-$1.25 per board-foot range or about $0.20 per R-1 per square-foot (about 60 percent higher than open-cell for R-value achieved).

TYPICAL MATERIAL PROPERTIES for CLOSED-CELL SPF

PROPERTY	VALUE
Density (ASTM D 1622)	**2.0 lb/cf (nominal)**
Thermal Performance (ASTM C 518)	**R-6.1 per inch (Aged, variable within range)**
Air Permeance (ASTM E 283)	**0.000025 L/s-m^2 @75 Pa for 5.25"**
Vapor Permeance (ASTM E 96)	**< 1 perms @ 2" thick**
Closed Cell Content	**>90%**
Flame Spread (ASTM E 84)	**< 25**
Smoke Development (ASTM E 84)	**< 450**
Fuel Contribution (ASTM E 84)	**Zero**
Oxygen Index (ASTM D 2863)	**23**
STC (ASTM E 90)	**No Data**
NRC (ASTM C 423)	**No Data**
Compressive Strength	**22 psi**
Tensile Strength	**28 psi**

CODE APPROVAL and FIRE-SAFETY

Open-cell and closed-cell SPF are both organically based materials and are considered combustible. Its use is specifically regulated in model building codes including the IRC under Section R314 FOAM PLASTIC, (under which a maximum flame spread index of 75, and a maximum smoke generation index of 450 is allowed). As noted above, the IRC requires that for all applications in habitable space and in most applications in non-habitable accessible building cavities, SPF must be protected by a 15 minute thermal barrier, as determined by ASTM E 119.

Exceptions allowing exposed SPF without a thermal barrier are delineated in IRC Section R314.5.3 Attics, and Section R314.5.4 Crawl spaces. In these exceptions where "the space is entered only for the service of utilities" (no storage or other ancillary uses permitted), the SPF must be protected by an "ignition barrier", or if the *specific* foam and *specific* assembly has been tested and approved under “NFPA 286 with the acceptance criteria of Section R315.4, FM4880, UL 1040 or UL 1715, or fire tests related to actual end-use configurations.”

What this means is the product manufacturer or representative must have the *specific-assembly* tested and approved for a *specific-application* if the ignition barrier is to be avoided for attics and crawl-spaces, and for what thickness the material may be applied. Because all manufactures have not done the same testing, acceptable applications will vary from product to product, therefore neither ocSPF, nor ccSPF can be treated generically. Individual product Evaluation Service Reports (http://www.icc-es.org/Evaluation_Reports/index.shtml) must be obtained from the product manufacturer to determine if a particular unprotected application of its product is acceptable.

POTENTIAL APPLICATIONS of SPF IN RESIDENTIAL CONSTRUCTION

Once the physical attributes of the two SPF’s are understood, we can start to look at specific applications to assess the potential risks and what other building-envelope assembly factors need to be accounted for to obtain the desired result: a safe, durable, high-performance thermal envelope. Potential applications for SPF insulation include all aspects of the residential thermal envelope where more convention types of insulation are currently used. Among these are:

- Frame wall cavities
- Sloped roof rafters above living space or unvented attics
- Ceilings below vented attics
- Foundations and below-grade spaces
- Band joists and mudsills
- Cantilevered framing and living spaces over unconditioned space

In addition, non-traditional applications of SPF may be appropriate where conventional types of cavity fill insulation are not. These applications include:

- Auxiliary HVAC duct insulation
- Behind brick veneer
- Hybrid applications in combination with traditional insulation fill methods such as “Flash-and- Batt”

REGIONAL CONSIDERATIONS

In combination with where in the thermal envelope the particular insulation is to be placed, the climate-zone where the subject building is to be constructed must be considered. For the purposes of this analysis, the main issues are wet versus dry, and hot versus cold. Dry climates, causing relatively less moisture loading on building envelope components than wet climates, are the less rigorous of insulation applications. Conversely, thermal assemblies in wet climates will be subjected to higher moisture loading and more rigorous moisture scenarios. Very cold climates, having the greater temperature gradient from inside to out (and therefore the greatest potential change in relative humidity for a given volume of air), present more challenging conditions than do warm climates.

We must also consider that the thermal and moisture driving forces are significantly different in cold climates versus warm climates. Assembly wetting and drying mechanisms will be different under peak load conditions, with warm climate moisture (generally) emanating from the exterior of the building and cold climate moisture emanating from the conditioned interior spaces.

SPECIFIC APPLICATIONS of SPF IN RESIDENTIAL CONSTRUCTION

The intent of this guideline is to provide usable, implementable information on acceptable uses of ocSPF and ccSPF in specific applications in residential construction. For that purpose, each of the above potential applications will be considered within a climate-zone context, and opined to be “preferred”, “acceptable”, or “not acceptable”. Each specific application and opinion of appropriateness will be followed by a brief commentary.

Applications	ocSPF	ccSPF
frame-wall cavities: cold climates	[green]	[light green]
frame-wall cavities: hot-humid climates	[yellow]	[green]
frame-wall cavities: hot-dry climates	[green]	[light green]
sloped roof rafters: cold climates	[yellow]	[green]
sloped roof rafters: hot-humid climates	[yellow]	[green]
ceiling below vented attic space	[yellow]	[green]
foundations and below-grade spaces	[red]	[green]
band joists and mudsills	[yellow]	[green]
cantilevered framing	[yellow]	[green]
living space over unconditioned space	[yellow]	[green]
auxiliary HVAC duct insulation	[red]	[green]
behind brick veneer	[red]	[green]

preferred [green]	acceptable [yellow]
preferred, but more expensive [light green]	not acceptable [red]

SPF in Frame-Wall Cavities, Cold-Climates

Open-Cell SPF: Preferred

Cold-climate use of ocSPF in frame wall cavities is an effective application of this insulation material with excellent air-sealing characteristics and reasonable R-value per inch. OcSPF is nearly always applied to full cavity depth: a 5-1/2” cavity providing approximately R-20.

Critical Factors: Three critical factors need to be accounted for: interior vapor retarders; interior air sealing; and exterior vapor permeance. Contrary to some ocSPF manufacturers recommendations, interior finish-surface air-sealing and vapor retarders are critical to long-term durability and moisture control. High interior relative-humidity combined with pressure-drive and air-flow can cause ocSPF to become wet, even to the point of saturation. A vapor-retardant at the interior finish surface, such as vapor-retarder primer or multiple coats of latex paint will suffice. An exterior enclosure surface which is not vapor permeable will not allow drying to the exterior, potentially holding moisture gained from the interior. At least one reported moisture related catastrophic failure has been reported (in Northern Vermont) due to the combination of no interior air/vapor retarder and a moisture impermeable exterior.

Closed-Cell SPF: Preferred

Cold-climate application of ccSPF in frame wall cavities is an effective application of this insulation material with excellent air-sealing characteristics and high R-value per inch. Installed to full depth (5” in a 5-1/2” cavity) R-values would exceed R-30. More typical applications would leave a 1”-2” air space in the stud cavity depending on the R-value target for the assembly. These wall systems would be neither air nor vapor permeable and would perform much like a polyurethane structural-insulated-panel (SIP). Due to its high cost per volume, most uses will likely continue to be a hybrid application such as “flash-and-batt” with a coating of ccSPF on the interior surface of the exterior sheathing, and the remaining cavity filled with fiberglass batt insulation. Other insulation fill materials are also appropriate including blown-in-fiberglass or cellulose.

Critical Factors: Closed-cell SPF at typical thicknesses is a vapor retarder: Frame walls will not be able to dry effectively to the exterior. Because of this, a minimum thickness of 1-1/2" of ccSPF should be used in hybrid system applications. This will keep the interior surface of the SPF above the dew point in most climates, preventing condensation. In climates above 6,000 heating degree days, a minimum of 2" should be used. Additional SPF thickness may sometimes be required. A simplified hygrothermal calculation or equivalent should be performed during the design process to ensure the durability of the wall assembly. Like ocSPF, air-sealing and interior vapor control is essential with hybrid systems, however the thicker the foam, the less critical this becomes. Interior visqueen (polyethylene) vapor retarders should be avoided. Air-sealed and latex painted drywall is preferred. If required by code officials, variable permeance Class II vapor-retarders such as kraft-faced batts, smart membranes, or vapor-retarder primers may be used.

SPF in Frame-Wall Cavities, Hot-Humid Climates

Open-Cell SPF: Acceptable
The insulation levels provided by ocSPF are typically adequate to provide a high-level of thermal performance given the relatively low delta-T between inside and outside. Excellent air-sealing capabilities can control air-leakage assuring that the insulation performs up to its potential.

Critical Factors: Open-cell SPF is moisture permeable, and in this potentially rigorous application, moisture flow must be controlled. Conditioned buildings in hot-humid climates require that the excessive interior moisture be removed by the mechanical air-conditioning system. This means the interior space will be dryer than the exterior and that the vapor drive through the thermal envelope is exterior to interior. If that flow is impeded by an interior-side vapor retarder higher relative humidity, potential condensation, and mold may develop. Exterior wall surface bulk-water and water-vapor control is also critical. It is possible that leaks and vapor pressure drive can wet the ocSPF assembly beyond the point the HVAC system can effectively dry it. In this climate, HVAC systems may not run enough to provide adequate dehumidification during shoulder months and may be turned off completely when "snow-bird" occupants head north for the summer. Brick-veneer siding installed over housewrap should also be avoided with ocSPF in hot-humid climates. Solar driven moisture (from wet brick) can be pushed into the frame cavity and overwhelm the drying capacity of the wall. Exterior drainage planes and bulk water management need to be well planned and executed.

Closed-Cell SPF: Preferred
In hot-humid climates, the ideal scenario is effective air-sealing and moisture-vapor control at the exterior of the wall assembly. This is provided by ccSPF in both full R-value thickness or hybrid system installations. For flash-and batt, the thickness of the ccSPF application on the interior side of the exterior sheathing is not critical as in cold climates, but a minimum of 1" is preferred to achieve at least semi-vapor permeable status. The air-sealing, vapor control, and the high R-value of the "flash", in combination with fiberglass fill provides a thermally efficient, forgiving wall system. Exterior drainage planes and bulk water management need to be well planned and executed. Unlike ocSPF, the ccSPF can provide a redundant moisture control layer keeping water out of the cavity in the event of a leak or drainage plane failure.

Critical Factors: Closed-cell SPF is vapor-impermeable at typical thicknesses. In hot-humid climates, interior vapor-retarders must be avoided. Otherwise a double vapor-retarder condition would result with the potential to trap moisture within the cavity. Because the impermeable ccSPF will be directly behind the exterior sheathing, if the sheathing gets wet from bulk water leaks, drying must be accommodated to the exterior. The drainage plane and siding assemblies must account for this.

SPF in Frame-Wall Cavities, Hot-Dry Climates

Open-Cell SPF: Preferred

The insulation levels provided by ocSPF are typically adequate to provide a high-level of thermal performance given the relatively low delta-T between inside and outside. Excellent air-sealing capabilities can control air-leakage assuring that the insulation performs up to its potential.

Critical factors: Hot-dry is generally a forgiving climate in terms of moisture loading. Interior vapor retarders must be avoided none-the-less. Some hot-dry regions are subjected to periodic substantial rain events, such as El Nino, so exterior drainage planes remain critical.

Closed-Cell SPF: Preferred

Closed-cell SPF in either full R-value thickness or hybrid system scenarios is highly effective in hot-dry climates. By providing air-sealing and redundant moisture control at the exterior and vapor permeance at the interior excellent air and moisture control may be provided.

Critical factors: With the exterior vapor-retarder inherent to the ccSPF, an additional interior vapor retarder must be avoided. If the exterior sheathing does get wet though bulk water leaks or other mechanisms, drying must be allowed to occur to the exterior. The drainage plane and siding must provide for this.

SPF in Sloped Roof Rafters

Open-Cell SPF, Cold Climate: Acceptable

Open-cell SPF has a growing market presence in sloped roof applications in both sealed (unvented) attics, and with finished interior spaces defined by the roof slope (cathedral ceilings). Applying ocSPF directly to the sloped roof deck achieves the basic goal of both these approaches: providing full insulation at the roof deck, and blocking air-infiltration.

Critical factors: The thickness of ocSPF allowed is dependant on individual manufacturer Evaluation Service Reports and varies between 5-1/2" and 10". Even though the ocSPF is considered air-impermeable, it is not moisture-vapor impermeable. On the exterior roof deck, a vapor-retarder covering (such as Grace Tri-Flex 30) should be used, unless the roof surface is not moisture permeable, such as with standing seam metal. In cold-climates, interior relatively-humid control is essential, or an interior-side vapor-retarder becomes critical in this application. If left exposed (unvented attic) a latex based vapor-retarder paint may be used. If covered by a ceiling finish, the vapor-retarder may be the ceiling paint finish. Dependant on manufacturer, a thermal or ignition barrier may be required to cover the SPF. Roofs are rigorous-service assemblies and as such are more prone to failure than are walls. When leaks occur in ocSPF the material will become wetted, but will dry given time and dry conditions.

Open-Cell SPF, Hot-Humid Climate: Acceptable

Same as above, except that a vapor retarder *should not* be added to the interior surface of the ocSPF. The exposed foam or its finish surface should remain moisture permeable to allowing drying to the interior.

Closed-Cell SPF, All Climates: Preferred
Both unvented attics and cathedral ceilings can be accomplished with ccSPF. The high R-value per inch means required assembly R-values are achievable even given the limits to allowable thicknesses. As noted earlier in this paper, roof structure and wind-storm resistance are enhanced with roof deck applied ccSPF. Like ccSPF in walls, applications may be full depth, or a hybrid system augmented by a fiberglass blow-in blanket (BIB) system or Johns Manville Spider (self-adhered) spray fiberglass. Closed-cell SPF of at least 2" is not vapor permeable so in cold-climates a separate vapor retarder is not needed. As discussed in cold-climate frame-wall cavities, the ccSPF must be thick enough to prevent dewpoint condensation on its interior surface.

Critical factors: Dependant on manufacturer, a thermal or ignition barrier may be required to cover the SPF. Roofs are rigorous service assemblies and as such are more prone to failure than are walls. When leaks occur in ccSPF they may not be immediately apparent as the water will not penetrate the insulation. In the case of a catastrophic roofing failure, such as may occur in a hurricane, this can be a benefit. In the case of a worn roof, it will make the leak more difficult to locate.

<u>Ceiling below Vented Attic Space</u>

Open-Cell SPF: Acceptable
Although not a common application for ocSPF, insulating at the ceiling plane of a vented attic does provide a number of potential benefits. Air-leakage between the living space and vented attic is a commonly overlooked, and easy to rectify problem in typical building envelope. OcSPF can be very effective at providing the excellent air-sealing at this location. The R-value per inch is, however not much higher than far less expensive choices such as cellulose and fiberglass.

Critical factors: To be truly effective the ocSPF must seal at all ceiling penetrations like recessed electric boxes, fan covers, etc. Most ocSPF is not rated for such applications. Individual products will differ in their code-compliance. From a moisture and thermal viewpoint this is not a rigorous application, but in cold climates a vapor retarder should be included at the ceiling plane.

Closed-Cell SPF: Preferred
Like ocSPF, placing full depth ccSPF at the ceiling plane of a vented attic is not a common practice. The use of ccSPF in a similar fashion to wall hybrid system applications does have major advantages. A thin coating of ccSPF will provide excellent air sealing between the vented attic and the conditioned living space. In combination with the latex painted ceiling, an effective vapor retarder assembly will be established, critical for cold climates.

Critical factors: For some ceiling penetrations a fire-stop rated ccSPF may be required. The two formulations are compatible so the critical spots may be coated first with the fire-stop, followed by the standard SPF for the rest. Blown in fiberglass insulation to a minimum 1.5" depth is considered an adequate ignition barrier by the IRC, so no other ignition barrier is required.

Foundations and Below Grade Spaces

Open-Cell SPF: Not acceptable

The moisture permeable nature of ocSPF renders it incompatible with the requirements of below-grade thermal insulation in many cases. Basement and crawlspace foundations are, essentially, holes in the ground with fail-proof moisture control measures very difficult if not impossible to implement. The presence of unintended bulk water may cause significant water absorption by the ocSPF. As a finished surface would need to be present covering the insulation, short-term drying would be impeded, leading to water-damaged finishes and other moisture related problems.

Closed-Cell SPF: Preferred

Research on basement insulation systems by Steven Winter Associates and other organizations has concluded that the most consistently effective system places a water-tolerant insulation directly against the interior surface of the foundation walls. This accomplishes two major benefits: the insulation is air-sealed against the foundation wall so moist, interior air cannot come in contact with it, and condense out moisture; and the moisture resistant insulation is protected in case of unanticipated water entry. CcSPF can also be used effectively on the exterior of the foundation, but above grade covering remains a challenge.

Critical factors: In basements, the ccSPF must be covered by an acceptable thermal barrier. In crawl spaces not used for storage, an ignition barrier may suffice, including an approved intumescent paint. For basement spaces intended to be finished, a 2" layer of ccSPF applied against the foundation may be followed by framing, additional batt insulation and gypsum drywall.

Band Joists and Mudsills

Open-Cell SPF: Acceptable

Perimeter band-joist locations where floor joists intersect the exterior perimeter are notoriously difficult to insulate. Typically, batt insulation is stuffed into the voids with no regard for air-sealing or gaps. OcSPF provides a good alternative at this critical area. Being a relatively small area, this is also an excellent place to use ocSPF where the budget is limited and less expensive insulations are called for elsewhere.

Critical factors: Band joists between floors are most often concealed, so no other thermal barrier is required. For hot-humid, or extreme cold climates ccSPF is preferred to ocSPF in this application.

Closed-Cell SPF: Preferred

Perimeter band-joist locations where floor joists intersect the exterior perimeter are notoriously difficult to insulate. Typically batt insulation is stuffed into the voids with no regard for air-sealing or gaps. CcSPF provides an excellent alternative at this critical area. Being a relatively small area this is also an excellent place to use ccSPF where the budget is limited and less expensive insulations are called for elsewhere.

Critical factors: Band joists between floors are most often concealed, so no other thermal barrier is required. The IRC also allows for ccSPF to be left exposed in basement and crawlspace band-joist applications in thicknesses less than 3-1/4".

Cantilevered Framing and Living Spaces Over Unconditioned Space

Open-Cell SPF: Acceptable

This application is similar to a typical frame-wall application, though in a less rigorous configuration. Since there is no additional drainage plane to be concerned with, just a soffit or a ceiling below, the ocSPF can adequately meet thermal and moisture requirements under most conditions. Depending on the R-value needed the framing void can be completely filled or left with a void at the bottom.

Critical factors: If a void is left in the assembly it must be at the bottom and not at the top against the conditioned space. In hot-humid climates a vapor-retarder should be employed below the insulation. Latex vapor-retarder paint will suffice.

Closed-Cell SPF: Preferred

Closed-cell SPF may be applied in this location as either full depth, partial depth, or as a hybrid flash-and-batt type application. The ccSPF is applied against the bottom of the floor decking to a minimum thickness (see cold climate walls), or the cavity receives enough depth of material to equal the wall insulation R-value.

Critical factors: With a partial-fill application, the SPF must be placed against the bottom of the floor decking leaving a void at the bottom of the assembly. The hybrid application requires that the remainder of the cavity should be completely filled with insulation leaving no voids (similar to walls).

Auxiliary HVAC Duct Insulation

Open-Cell SPF: Not acceptable

Providing HVAC ducts with additional levels of thermal insulation and air-sealing using SPF insulation is a relatively new technique in residential construction. The technique can provide substantial benefits when ducts are placed outside-of-condition-space, such as in attics, (a common installation). Attics can be harsh environments with large temperature swings and very high humidity, so additional thermal protection and decreased leakage can drastically improve HVAC efficiency.

Critical factors: When placing HVAC ducts on the attic floor, placing SPF over them, and then burying them in loose fill insulation a set of very specific dynamics come in to play. Cooled air form the air-conditioning air-handler will be in the range of 50-55 degrees F. Attic air, during the cooling season will be very warm and potentially very humid. If the outside surface of the (cooling) ducts is below the dew-point, condensation will occur causing a moisture problem. If the SPF on the ducts is moisture permeable (ocSPF) the material would become wetted from the condensate, adding to the problem.

Closed-Cell SPF: Preferred

The additional air-sealing and thermal protection provided by ccSPF to HVAC ducts placed on the attic floor and buried in loose fill insulation is substantial. The 2007 Supplement to the IRC (Section M1601.3) contains specific language pertaining to this application including limitations and required minimum ccSPF characteristics.

Critical factors: There are two key factors which need to be accounted for in order to safely gain the additional thermal and air-leak prevention benefits: dew-point on the exterior duct surface, and vapor retarder placement. Under design conditions in hot-humid attics during peak cooling loads, the exterior surface of the insulation-buried ducts must be kept above the dew-point. This means that the amount of insulation placed on them is critical. SWA has determined that when using R-6 flex ducts, an additional R-9 (1-1/2” of ccSPF) for a total of R-15 will prevent the dew-point from being reached in nearly all typical conditions. The 1-1/2” of ccSPF is also an effective vapor retarder inhibiting moist attic air from penetrating into the insulation where the dew-point might be met.

<u>Behind Brick Veneer in Wood Frame, light-Gauge Steel, or CMU Construction</u>
Placing one-inch or more of SPF over the structural sheathing or CMU surface within a brick veneer cavity can provide multiple benefits: Air-sealing, thermal break (especially over CMU or steel-studs), and drainage plane.

Open-Cell SPF: Not acceptable
Open-cell SPF is not able to function as a drainage plane, but rather must be fully protected from bulk water and water-vapor loading.

Closed-Cell SPF: Preferred
Several formulations of ccSPF are specifically designed for use as combination air-barrier/drainage planes in brick veneer applications. The closed-cell and continuous nature of the product is ideally suited for this use. Other similar systems rely on two-part applications such as a spray on drainage plane/air-sealant followed by rigid board insulation.

Critical factors: Not all ccSPF will be appropriate for this application; confirm specific product availability with individual manufacturers. For thermal performance and condensation control in cold-climates, a minimum 1-1/2” thickness should be applied. In regions over 6,000 heating degrees days, 2” minimum thickness is recommended.

For more information or comments, contact William Zoeller at wzoeller@swinter.com