UNIVERSAL POLYMERS CORPORATION

A Division of General Manufacturing Coatings Corp.

APPLICATION GUIDE

Residential Walls

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025

www.upcfoam.com

Overview

The purpose of UPC's Application Guide for Residential Walls is to provide the installer and specifier with the knowledge necessary to install UPC spray foam products safely and effectively in residentials walls. While we make every effort to include the technical information most needed for typical residential wall installations, we cannot account for every type of wall assembly and situation. We also cannot detail every type of application scenario and condition. We encourage applicators and specifiers to contact our technical and building science support at: 203-760-0025. While this guide can provide in depth design and application instruction, it cannot replace the practical need for hand-on installation experience. UPC has technicians available for application training and support.

TABLE OF CONTENTS

Disclaimer

Published Technical data and instructions are subject to change without notice. Contact your local UPC representative or visit our website at www.upcfoam.com for current technical data and instructions. All guidelines, recommendations, statements, and technical data contained herein are based on information and tests we believe to be reliable and correct, but accuracy and completeness of said tests are not guaranteed and are not to be construed as a warranty, either expressed or implied. It is the user's responsibility to satisfy himself, by his own information and tests, to determine suitability of the product for his own intended use, application, and job situation. User assumes all risk and liability resulting from his own use of the product. Neither seller nor manufacturer shall be liable to the buyer or any third party for any injury, loss or damage directly or indirectly resulting from use of, or inability to use, the product.

DESCRIPTION

Spray Applied Polyurethane Foam (SPF) is commonly used in residential walls as an insulation and sealant around penetrations. Not only is SPF an excellent insulation, but it's also an air barrier at specific thicknesses. According to the U.S. Department of Energy (DOE), 40-60% of the homes HVAC energy cost is due to uncontrolled air leakage. Applying Closed Cell SPF (ccSPF) or Open Cell SPF (ocSPF) can prevent air infiltration, exfiltration, and moisture movement within the wall cavity.

In some cases, a combination of non-permeable (ccSPF) insulation and permeable insulation (ocSPF or fibrous) is used within the stud cavity. This "hybrid" approach uses ccSPF to provide a minimum or R-15 and air barrier in the exterior (back) of the cavity and the remainder of the cavity is filled with permeable insulation to a depth, or total R-value, to meet local building codes.

In all cases, SPF insulation must be protected from the conditioned living space by an approved thermal barrier.

DEFINITIONS

Attic	A space immediately below the roof of the building
AHJ - Authority Having Jurisdiction	An organization, office, or individual responsible for enforcing the requirements of a code or standard.
Air Barrier Material	A material which exceeds the performance of ASTM E 2178 when tested for air leakage through the material at 75 Pa pressure difference.
Air Barrier Assembly	A combination of materials and accessories which exceeds the performance of ASTM E 2357 when tested for air leakage through the assembly, including substrate, at 75 Pa pressure difference.
Approved Thermal Barrier	A material, product or assembly which exceeds the requirements of ASTM E 119-20 "Standard Test Methods for Fire Tests of Building Construction and Materials" or UL 263 and stay in place for a minimum of 15 minutes under large scale fire testing such as NFPA 286, UL 1715, UL 1040 or FM 4880 or exceed NFPA 275.
Approved Ignition Barrier	Alternative test used in applications with limited-access spaces such as attics and crawlspaces and ONLY when access is for repair or service of utilities or equipment.
Building Code	A collection of regulations adopted by a city to govern the construction of buildings.
Control Layer	A material or assembly within the building envelope which performs a specific function and addresses a specific issue. ie. Moisture Control Layer.
Dew Point	The atmospheric temperature (varying according to pressure and humidity) below which water droplets begin to condense and dew can form.
Exotherm	Heat generated by a compound when undergoing change or formation.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

DEFINITIONS (CONT)

Exothermic Reaction	A reaction creation or destruction which gives off heat.
Hybrid Wall Assembly	In the case of insulations, the combination of two different types of material within the same assembly, usually within the same stud cavity and in full contact with each other. i.e., Non-air permeable closed cell SPF and air permeable fiber glass insulation.
Ignition Barrier	A material which is applied directly to a combustible material to eliminate the potential for ignition from minor heat sources and incidental spark, flame, or heat source – meeting the specific criteria as tested.
Staggered Stud Assembly	A framing option to eliminate thermal bridging through framing members by which vertical studs are placed flush with alternating front and back side of a single base plate and header.
Thermal Barrier	An element of low thermal conductivity placed in an assembly to reduce or prevent the flow of thermal energy between conductive materials.
Thermal Envelope	The exterior or shell of a building that repels the elements.
Thermal Resistance	The ability of a material to resist the flow of heat energy across a stated thickness and temperature.
Primer	A substance used as a preparatory coat on previously unpainted substrate, especially to prevent the absorption of subsequent layers of paint or the development of rust.
R-Value	The capacity of an insulating material to resist heat flow.
Vapor Semi-Permeable	A material with a perm rating between 1 and 10 which allows a small amount of moisture infiltration.
Vapor Permeable	A material with a perm rating over 10 which allows moisture to pass relatively easily.
Class I Vapor Barrier/Retarder	A material with a perm rating less than 0.1.
Class II Vapor Retarder	A material with a perm rating between 0.1 and 1.0.
Class III vapor Retarder	A material with a perm rating between 1.0 and 10.0.
Vapor Barrier	A material with a perm rating less than 0.1.
WRB (Weather Resistant Barrier)	A material that shields the walls of a structure from water and air infiltration, along with moisture accumulation within the wall systems.

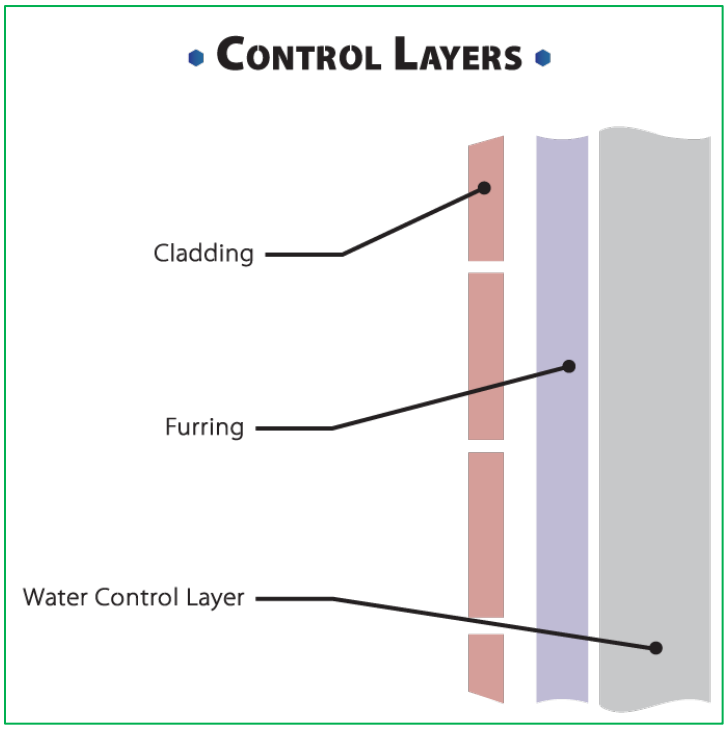
3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

BASIC BUILDING SCIENCE - WALLS

Walls hold up roofs, they protect the contents from the elements while they define our space. We put holes in them to walk through, look through and transfer things through. In design, we need to consider the interior and exterior environmental loads and the materials that comprise the wall.

To address all the things a wall must do, we think of 4 basic control layers;

1. A water control layer for rainwater
2. An air control layer for air transported moisture
3. A vapor control layer for vapor transported moisture
4. A thermal control layer for heat transfer



When you look at wall materials and assemblies, you can assign each material one or more of the control layers above. Cladding like brick veneer or siding is the water control layer, air barriers are the air control layer, polyethylene sheet is our vapor control layer and insulation plays the role of thermal control layer. In a "perfect wall" the cladding is on the outermost position and is allowed to wet and dry from both directions. The control layers are behind the cladding and in front of the structural components, in order to protect the structural members from the exterior environment.

Walls, and wall design, is never this simple, but if we understand the capability and limitations of our spray foam product and the role it plays in the performance of the building envelope, we can assure ourselves and our customers of a successful installation.

Let's look at the control layers and how SPF can play a role.

As a cladding or water control layer, closed cell foam must be protected from the elements including sunlight and ponding or standing water – it's not intended to be used on its own as a finish. On commercial or industrial roofs, ccSPF is a great choice of insulation and holds many advantages over alternative roofing systems, but it must be protected from the elements with a fluid applied coating. In residential construction, ccSPF is used in combination with stucco finishing systems to produce an Adobe look home in the Southwestern region of the U.S. Stucco over closed cell spray foam is also popular in Europe.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

As an Air Control Layer or Air Barrier in wall construction, 1 inch of UPC closed cell SPF and 3.5 inches of UPC open cell foam exceed the requirements of ASTM E 2178-01 "Standard Test Method for Air Permeance of Building Materials".

The type of building will dictate which code is enforced. In Residential Construction it is the International Residential Code (IRC) and in Commercial Construction it is the International Energy Conservation Code which dictates. Each treat the issue of air infiltration differently. The IECC provides performance criteria and test procedures for individual products, materials, and assemblies, while the IRC identifies overall building envelope performance requirements for the entire envelope, not the specific material.

2012 IRC

In 2012 the IRC adopted language to address the need for an air control layer to be included in the building envelope. The requirements are identified in the table below and the testing requirements below that. Full-scale material testing, ASTM E2178 is not required for residential construction under the jurisdiction of the IRC, but remains a part of commercial construction under the IECC.

N1102.4.1.2 (402.4.1.2) Testing

The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding 5 air changes per hour in zones 1 and 2, and 3 air changes per hour in zones 3 through 8. Testing shall be conducted with a blower door at a pressure of 0.2 inches w.g. (50 Pascals). Where required by the *building official*, testing shall be conducted by an *approved* third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the *building official*. Testing shall be performed at any time after creation of all penetrations of the *building thermal envelope*.

TABLE N1102.4.1.1 (R402.4.1.1)
AIR BARRIER AND INSULATION INSTALLATION

COMPONENT	CRITERIA
Air Barrier & Thermal Barrier	• A continuous air barrier shall be installed in the building envelope. • The exterior thermal envelope contains a continuous air barrier. • Breaks or joints in the air barrier shall be sealed. • Air-permeable insulation shall not be used as a sealing material
Ceiling / Attic	• The air barrier in any dropped ceilings/soffit shall be aligned with the insulation and any gaps in the air barrier sealed. • Access openings, drop down stair or knee wall doors to unconditioned attic spaces shall be sealed.
Walls	• Corners and headers shall be insulated and the junction of the foundation and sill plate shall be sealed. • The junction of the top plate and top of exterior walls shall be sealed. • Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuos alignment with the air barrier. • Knee walls shall be sealed.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

2018 IRC

In 2018 the IRC continued the requirement for whole house testing for air infiltration rates "as built". The use of UPC SPF (open or closed) within stud cavities at a minimum of 1 or 3.5 inches for closed cell or open cell respectively eliminates the need for sheathing caulking and air-tight drywall related products and approaches. The need for continuous insulation outboard of the wall sheathing remains in climate zones 6, 7 and 8

TABLE N1102.4.1.1 (R402.4.1.1)
AIR BARRIER AND INSULATION INSTALLATION

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
General Requirements	• A continuous air barrier shall be installed in the building envelope. • The exterior thermal envelope contains a continuous air barrier. • Breaks or joints in the air barrier shall be sealed.	• Air permeable insulation shall not be used as a sealing material.
Walls	• The junction of the foundation and sill plate shall be sealed. • The junction of the top plate and the top of exterior walls shall be sealed • Knee walls shall be sealed.	• Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance of not less than R-3 per inch. • Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and in continuous alignment with the air barrier.

VAPOR CONTROL LAYER

As a vapor control layer, all UPC closed cell foams achieve a perm rating of less than 1 perm (<1 perm) when applied at a minimum thickness of 1.5 inches. This means moisture vapor continues to pass through the insulation, but at a very low rate. The foam may also dry in both directions depending on the assembly and the location of the foam within the assembly. Open cell foams are never considered vapor retarders and need additional vapor protection when installed in climate zones 4a-marine and above.

UPC recommends conducting a hygrothermal analysis (Condensation Analysis) on the wall assembly using ASHRAE local climate data if there is a question regarding the ability of any wall design to perform.

UPC recommends a final inspection of all UPC spray foam products be conducted following installation to confirm a continuous seal between the sides of the framing member (stud) and SPF insulation. Repair any areas that may have delaminated from the substrate to eliminate the possibility of moisture laden air moving around the insulation and condensing.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

THERMAL CONTROL LAYER

As a *thermal control layer*, no other form of insulation compares to UPC closed cell SPF for value and sustainability. With "aged" R-values over 6 per inch, UPC 2.0 HFO provides very high R-value in very little space. These products can be used within the stud space (inboard) or applied directly to the exterior of the wall sheathing to provide continuous insulation. Open cell foams can also be used within the stud space but are not recommended for use outboard of the sheathing. When used in the stud space, open cell foam provides an R-value of 3.5 per inch and eliminates air movement between stud spaces, through exterior sheathing seams and at the header and base plate. Additional vapor protection is required in some climate zones. Always confirm the required R-value (insulation thickness) and need for additional vapor protection with the local AHJ.

SOUND CONTROL LAYER

As a *thermal control layer*, UPC open cell foams are an excellent choice for use as sound dampening around theater rooms, bedrooms, floor-to-floor, music rooms, living spaces adjacent to offices and areas that need to be isolated from other living spaces.

ENHANCED STRUCTURAL STRENGTH

UPC closed cell SPF enhances the structural strength of wall assemblies through the principle of "stressed-skin". Loads for above ground walls are under two types of loads – live and dead loads. Examples of dead loads are the second floor and roof assembly, and snow loads which get carried by the wall and its framing components, while examples of live loads include wind, gravity and occupancy loads.

ccSPF, when installed at greater than 2.5 inches in the stud cavity, doubled the maximum racking load carrying potential of a plywood clad wood framed wall with stud spacing of 16 inch OC and more than doubled the racking load bearing capacity of the same wall with 24 inch stud spacing. In order to enhance the structural integrity of a framed wall assembly, the foam must be in full, continuous contact with the exterior cladding (back of the stud bay) and the framing members (side of the stud bay) at an installed depth of at least 2.5 inches.

FLOOD RESISTANT

Closed cell foam is the only insulation material accepted by the Federal Emergency Management Agency (FEMA) for use as wall insulation in flood zones. As an insulation, UPC ccSPF resists water absorption, and any moisture that makes its way into the foam can be dried out and the foam returns to its original characteristics. Several wall designs have been developed using ccSPF to be used specifically in flood prone areas of the US south. There are no special installation requirements associated with the application, however, the cavity must have an airspace between the interior face of the installed foam and the back of the gypsum board. A coat of latex paint onto the surface of the ccSPF adds an extra layer of water resistance to the assembly and will extend the time the foam insulation remains dry. In most cases of flood repair the gypsum is removed and discarded, however, if the exposure to blown and grey water is minimal, the drywall can be dried using fans. This design calls for a 1.5-inch gap to be left at the top and bottom of the gypsum board and top and bottom decorative molding to be installed to cover the gap. In order to dry the cavity, the top (crown molding) and base boards are removed, and fans used to blow air into the cavity to promote complete drying.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

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

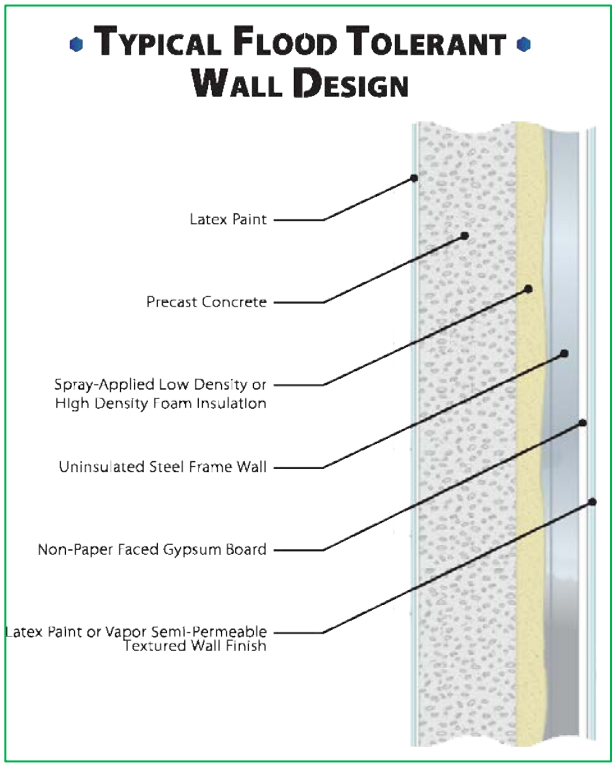
FEMA

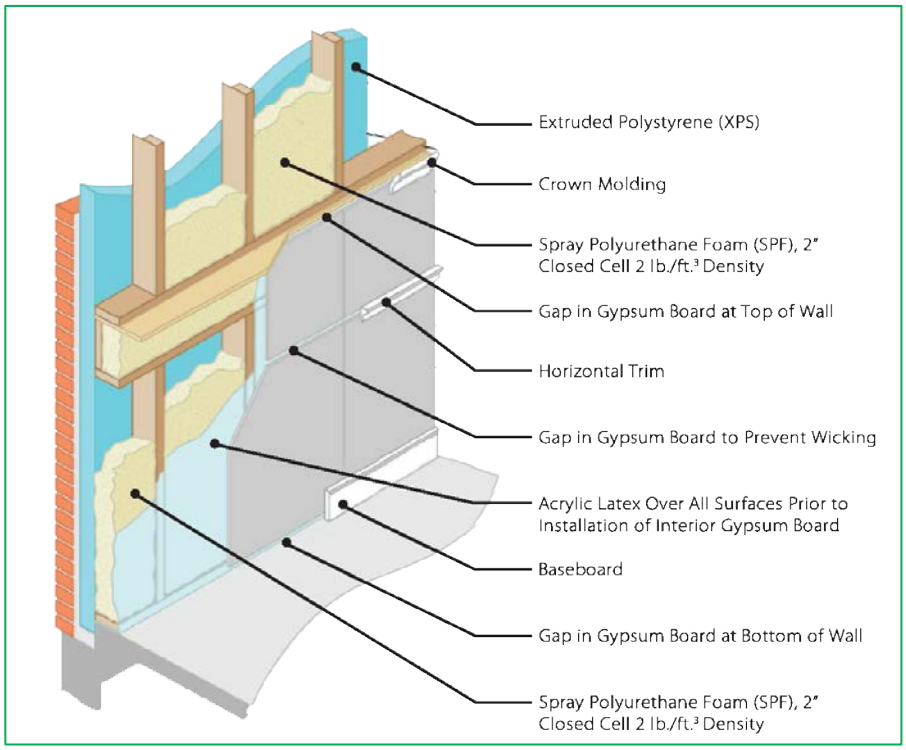
TABLE 2
Types, Uses and Classifications of Materials

TYPES OF BUILDING MATERIALS Finish Materials (floor coverings, wall and ceiling finishes, insulation, cabinets, partitions, and windows	USES OF BUILDING MATERIALS		CLASSES OF BUILDING MATERIALS				
			Acceptable		Unacceptable		
	FLOORS	WALLS / CEILINGS	5	4	3	2	1
Glass (sheets, colored tiles, panels)		✓		✓			
Glass Blocks		✓	✓				
Insulation Sprayed poyurethane foam (SPUF) or closed-cell plastic foams	✓	✓	✓				

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

Typical Flood Tolerant Wall Design



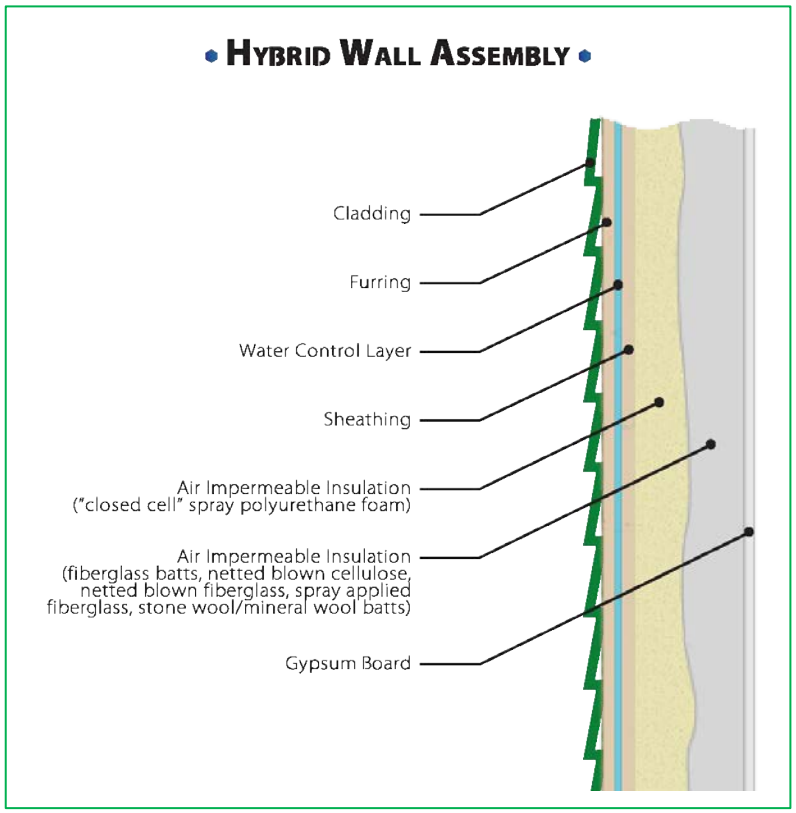


3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

HYBRID WALL ASSEMBLIES

Hybrid wall assemblies are very common practice when continuous insulation outboard of the sheathing is required. In many cases, a more robust insulation such as extruded polystyrene or polyisocyanurate (PolyIso or Iso) board is used on the exterior of the sheathing and an air permeable insulation is used with the framing cavity inboard of the sheathing. This can be considered a "hybrid" wall assembly. Within the SPF market sector, we see the use of air permeable materials in combination with closed cell SPF (ccSPF) in the same stud cavity creating a "hybrid" assembly. See design below.

These combinations of air impermeable and air permeable materials is an effort to reduce the installed cost of insulation systems while maintaining the required thermal performance of the assembly. Air impermeable ccSPF is applied to the inside surface of the exterior sheathing to eliminate lateral cavity-to-cavity air movement and eliminate the gaps and seams of the panelized exterior sheathing material.



Caution must be exercised when installing any hybrid assembly to make sure (confirm with a Heat / Air / Moisture analysis utilizing hydrothermal modeling software such as WUFI – consult building envelope specialist) there is sufficient ccSPF installed at the back of the cavity to drive the inside surface (interior face) of the ccSPF well below the potential dew point of the warm interior air. If the thickness of ccSPF is too thin, condensation will form on the surface of the SPF and potentially saturate the ccSPF and exterior sheathing. Premature wood rot and mold may result. UPC recommends conducting a Heat / Air / Moisture Analysis to determine the thickness of ccSPF required to eliminate the potential for condensation prior to bidding and installing a hybrid assembly.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

High Performance Wall Assemblies

The International Building Codes, IRC, IBC establish a performance minimum. Keeping in mind, the version of the code being used by the state may vary from state to state, the thermal performance of the residential building envelope (walls specifically) is very low. Wall assemblies used by the design community and construction practices used by local builders is often more advanced and produces a structure which outperforms the prescriptive codes. In general, any wall assembly which outperforms the local code requirements is considered a "high performance wall assembly".

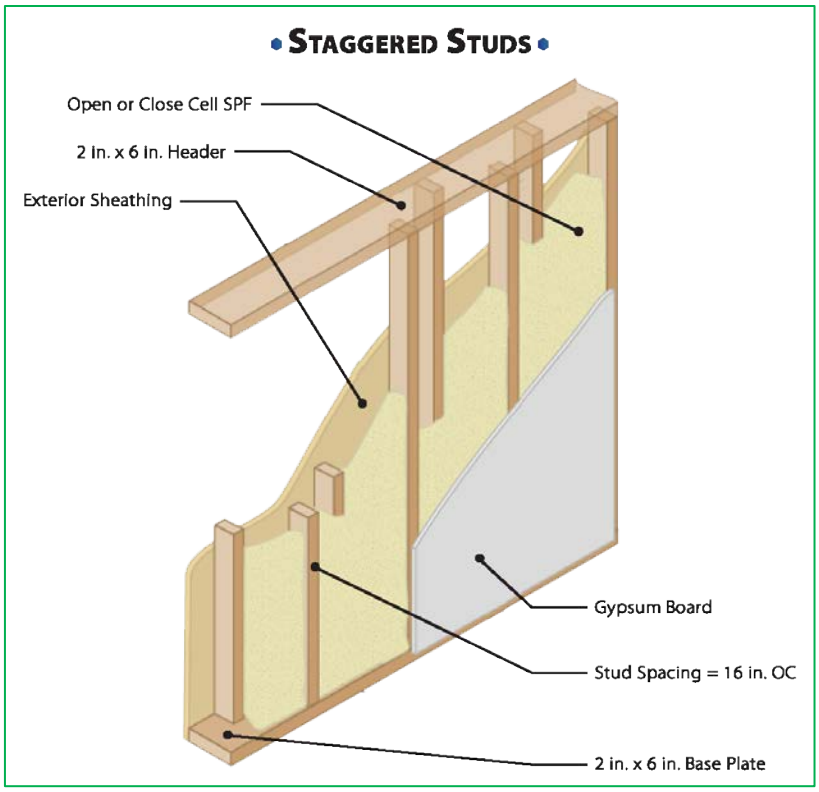
There are a number of ways to achieve a high-performance wall assembly, and some are even trademarked and patented. Simply installing SPF in the stud bay does not constitute a high-performance wall assembly. There are a number of issues which need to be addressed and optimized. Thermal bridging must be eliminated. Air barriers must be included, and the assembly tested as an assembly, not just the products themselves. Sound transmission may be a key consideration and therefore must be optimized. The definition of *high-performance* is not limited to the wall's thermal performance.

Let's look at some typical wall assemblies which achieve "high-performance".

Staggered Studs

2X4 studs with a 6 inch or 8 inch base and header provide 2 or 4 inches respectively of thermal break. When using spray foam, the studs are wrapped on three sides providing a minimum or R-14 between the framing member and the exterior/interior of the structure.

When applying SPF, be sure the foam is continuous behind the stud and fully adhered. Do not full-fill the stud bay with ccSPF in a single pass as this technique may result in "bowing" of the studs. When filling behind the "front-flush" stud, install enough foam to completely fill behind the stud in a single pass.



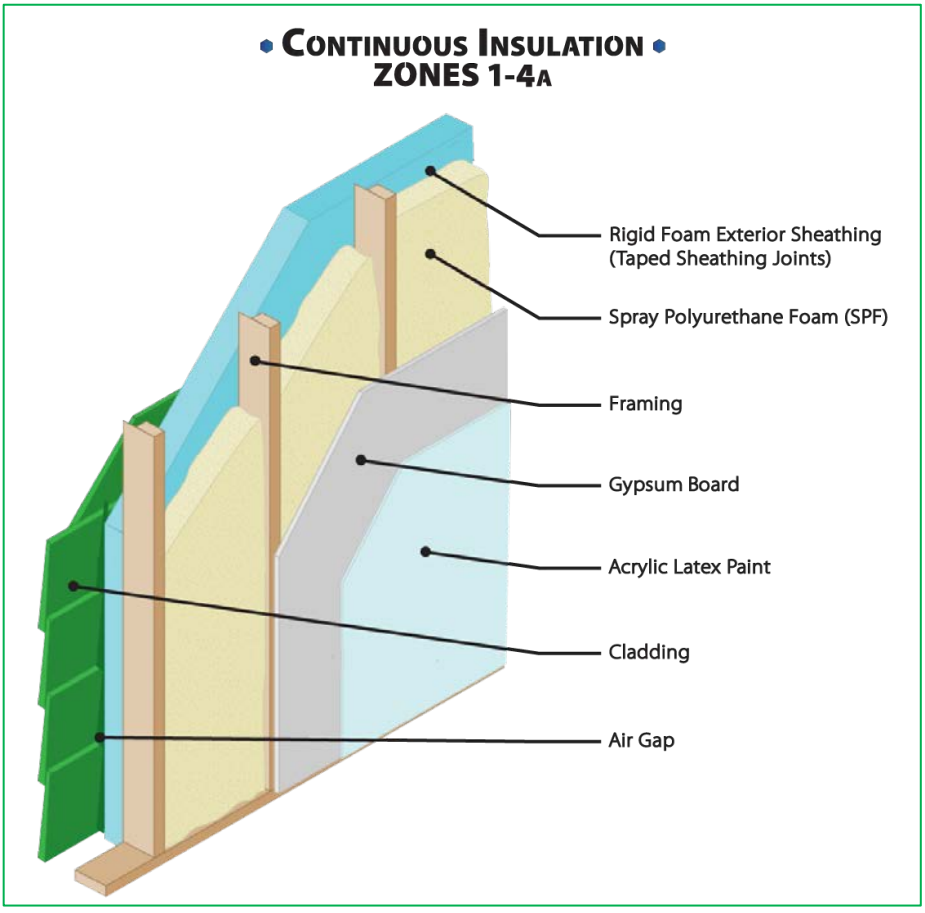
3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

CONTINUOUS OUTBOARD INSULATION

High performance wall designs now incorporate, and so does the building code in some climate zones and states, continuous insulation installed outboard of the exterior sheathing on top of the WRB. SPF is then installed on the inside of the exterior sheathing to provide approx. 65% of the required R-value.

To keep costs down and still meet the code requirement to eliminate thermal bridging through the framing member, some states and/or climate zones, use insulated sheathing boards to provide a thermal break for framing members and a non-structural separation between the stud bay and exterior. Insulated sheathing is also a suitable substrate for the application of SPF.

Expanded polystyrene sheets may be incorporated as the insulated sheathing material. Use caution when installing SPF onto polystyrene as the exotherm (heat) may distort the polystyrene. UPC recommends the first pass of ccSPF be restricted to 1 inch thick and 10-minute wait time between before applying an additional pass.



3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

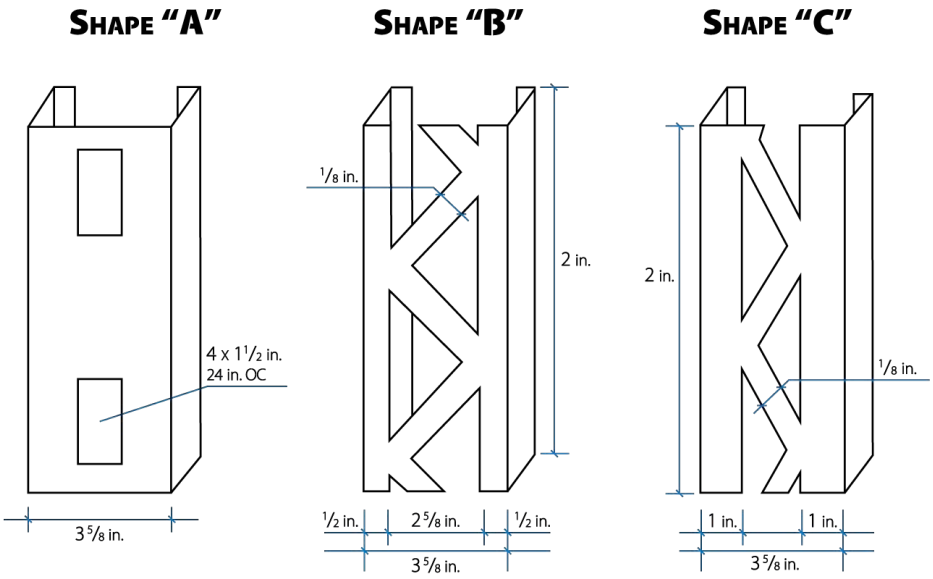
THERMAL BROKEN FRAMING

Thermal bridging through framing members has long been an hinderance to the total wall thermal performance. The impact of framing member thermal bridging has been understood for many years and the industries best address has been to add cost and another layer of insulation outboard of the exterior sheathing. A small number of framing members have been developed which incorporate open webs into which insulation can be installed to all-but eliminate thermal bridging. One of the latest is the T-Stud by U.S. Engineered Wood Inc. The design allows for spray foam, open or closed cell to pass through the framing member to form a continuous insulation layer. Think of a 2X6 with the middle 2 inches removed and SPF installed in the airspace between the inner and outer flange.

Treat the thermally broken framing member like a double wall or staggered stud wall. SPF must be in full contact with the exterior sheathing and framing member and the SPF must be continuous through the airspace of the stud.

This same concept has been applied to metal studs. Channels and punch-outs are now found in the web sections of some metal stud assemblies which allow the spray foam to "pass through" the framing unit forming a continuous layer.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com



Openings on the stud web area reduce the heat conducting area of the stud web. reducing the thermal bridge effect.

METAL STUDS

When applying SPF to metal stud framed walls, attention must be paid to the adhesion between the SPF and the metal framing unit. Often, metal framing members arrive to a jobsite with finishing oils and mill oils on the surface of the metal. Any and all oils, release agents or protective materials must be removed before SPF is applied. UPC recommends testing the adhesion of SPF insulation to any substrate when in doubt. Galvanized metals must be primed before applying SPF. UPC also recommends reading and understanding Industry Best Practice documents supplied by the American Chemistry Council, SPFA and the National Association of Corrosion Engineers (NACE) before applying any UPC spray foam to metal substrates.

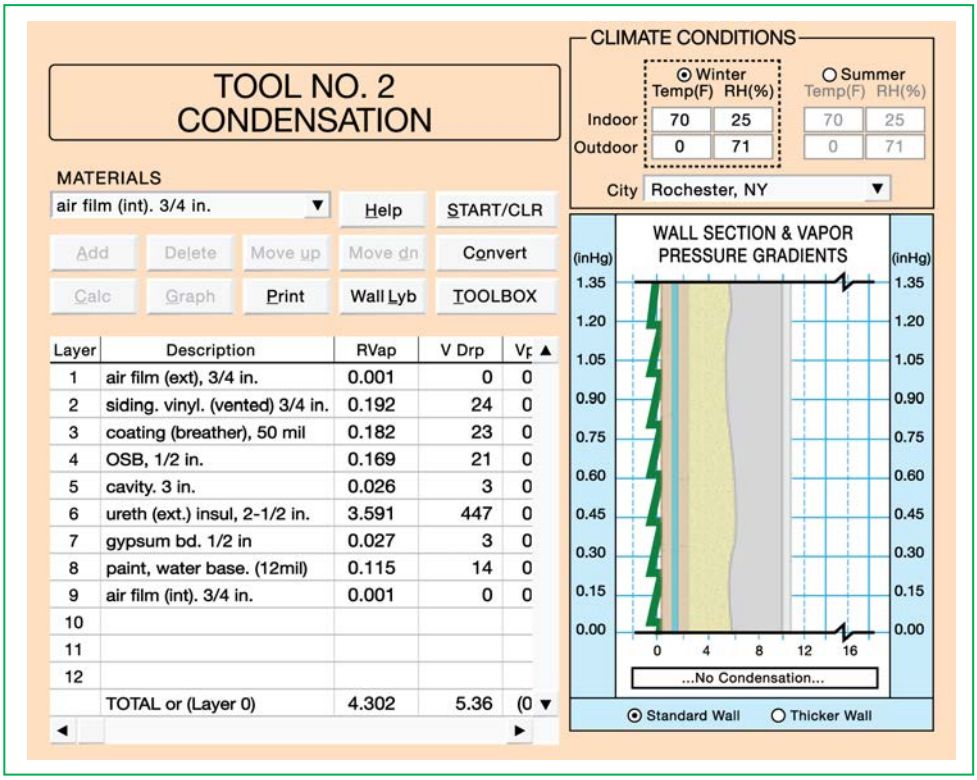
It is good practice to temporarily "strap" metal studs with horizontal bracing prior to installing ccSPF, whereas ccSPF may warp or bend the metal studs during expansion, particularly light gauge metal studs.

VAPOR RETARDER

In climate zones 4a marine and above, any open cell SPF must be protected with an additional vapor retarder installed on the inside (warm side) of the insulation to eliminate the potential for moist air to travel through the permeable insulation and condense on the inside face of the exterior sheathing. If in doubt, UPC recommends conducting a hygrothermal analysis of the assembly (Condensation Potential Model) in order to confirm the intended assembly does not contribute to the potential to form condensation within the wall assembly. The analysis can then be presented to the local AHJ for review and approval. Failure to confirm the acceptability of the proposed assembly (contradicting the local code) with the AHJ places the installer/contractor at risk for replacement.

The drawing below shows the output from a condensation analysis for a typical residential wall assembly.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com



Closed cell foam may be installed within the wall/stud cavity or outboard of the exterior sheathing without the need for additional vapor retarders in any climate zone.

Always confirm the R-value requirements (thickness of foam) with local Building Codes and the local AHJ.

Benefits of Using SPF in Residential Walls

SPF is an excellent sealant and is the most effective common insulation available:

- When applied within a wall assembly, SPF seals all penetrations, gaps in the exterior sheathing and forms a continuous, fully adhered, durable, insulated wall assembly.
- Unlike loose-fill, batt or blown products, SPF is sprayed directly onto the surface and sticks wherever it's applied.
- SPF doesn't sag or settle over time and can't be blown around by wind passing through penetrations.
- Either variety of SPF, open cell or closed cell, can be installed directly onto the inside face of exterior sheathing. Consideration must be given to local building and energy codes when determining how much (how thick) and which type (open or closed cell) SPF is best suited for the specific building location. Always refer to the local building code. ccSPF adds a substantial amount of rigidity and strength to the structure to resist wind loads. Fibrous insulations can't do that. ccSPF is an environmentally sound choice. ccSPF formulations utilize recycled PET plastic (pop bottles) and many are based on renewable plant material such as soy and cashew oils. Open cell SPF is a tremendous sound insulator and when installed in interior walls and around theater rooms eliminates almost all sound transmission. Unlike board or batt insulations, SPF can be applied directly onto difficult shapes and hard to reach void spaces and remain in place for the lifetime of the building.

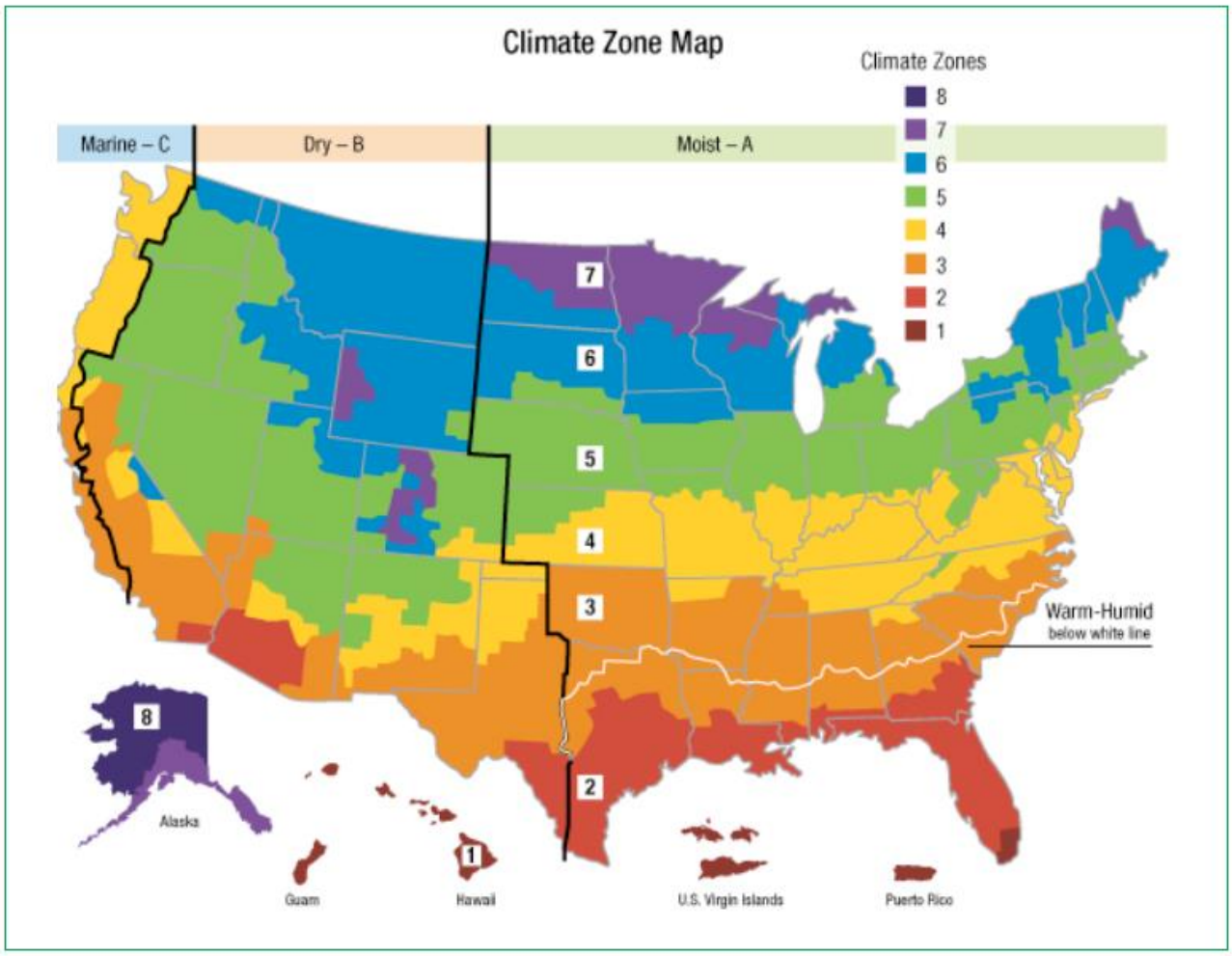
3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

Code Compliance and Requirements

Local Building (IBC) and Energy Codes (IECC) will provide the minimum requirements for insulation thickness expressed as R or U value, the level of fire protection (thermal protection) required for the application and the need for additional vapor retarders based on the geographic location of the building and the type of SPF used. Closed Cell SPF (ccSPF) is considered a type II vapor retarder – semi permeable, while Open Cell SPF (ocSPF) is *always* vapor permeable.

The chart below shows the American Society of Heating, Refrigerating and Air- Conditioning Engineers (ASHRAE) Climate Zones in the U.S. These zones are used to determine the level of insulation required to eliminate the potential to form condensation within the assembly under "normal" conditions. The Building Code (IECC and IBC) use this chart to establish the minimum insulation requirements for various assemblies including attics and ceilings. Local Building and Fire Officials (AHJ – Authority Having Jurisdiction) should always be consulted to confirm the requirements before installing any insulation.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com



Chapter 4 of the International Energy Conservation Code (IECC) entitled "Residential Energy Efficiency" specifically identifies the level (R-value) and type (cavity or continuous) of insulation required to meet the minimum requirements of the Building Code. The chart below is taken from the 2018 IECC. Always understand and confirm the specific requirements of the Building Code and Energy Code in effect in the project area.

The version (year) of various codes vary dramatically from state to state. Local Building and Fire Officials (AHJ – Authority Having Jurisdiction) should always be consulted to confirm the requirements before installing any insulation.

IMPORTANT NOTICE: Before beginning any operation, which may expose you to any chemical, wear appropriate PPE, including but not limited to face shield, splash googles, gloves, skin protection, Tyvek suite, cartridge respirator. Conduct operation near eye wash and emergency body shower location. Read and understand all material SDS. Material may be under pressure, use caution.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

TABLE R402.1.2 INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT

CLIMATE ZONE	FENESTRATION U-FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b,e]	CEILING R-VALUE	WOOD FRAME WALL R-FACTOR	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c] WALL R-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.32	0.55	0.25	38	20 or 13+5[h]	8/13	19	5/13[f]	0	5/13
4 Except Marine	0.32	0.55	0.40	49	20 or 13+5[h]	8/13	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.30	0.55	NR	49	20 or 13+5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.30	0.55	NR	49	20+5[h] or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.30	0.55	NR	49	20+5[h] or 13+10[h]	19/21	30[g]	15/19	10, 4 ft	15/19

NR= Not Required • For SI:1 ft=304.8 mm

a. R-Values are minimums. U-Factors and SHGC are maximums. Where insulation in a cavity that is less than the label or design thickness of the insulation, the installed R-Value of the insulation shall not be less than the R-Value specified in the table.
b. The fenestration U-Factor column excludes highlights. The SHGC column applies to all glazed fenestration.
Exception: In climate zones 1 through 3, skylights shall be permitted to be excluded from glazed fenestration SHGC requirements proved the SHGC for such skylights does not exceed 0.30.
c. "10/13" means R-10 continuous insulation on the interior or exterior of the home or R-13 cavity insulation of the basement wall. "15/19" means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. Alternatively, compliance with "15/19" shall be R-13 cavity insulation on the interior of the basement wall plus continuous insulation on the interior or exterior of the home.
d. R-5 insulation shall be provided under the full slab area of the heated slab in addition to the required slab edge insulation R-Value for slabs, as indicated in the table. The slab edge insulation for heated slabs shall not be required to extend below the slab
e. There are no SHGC requirements in the Marine Zone
f. Basement wall insulation is not required in warm-humid locations
g. Alternatively, insulation sufficient to fill the framing cavity and providing not less than and R-Value of R-19.
h. The first value is cavity insulation, the second value is continuous insulation. Therefor, as an example, "13+5" means R-13 cavity insulation plus R-5 continuous insulation.
i. Mass walls shall be in accordance with section R402.2.5. The second R-Value applies where more than half the insulation is on the interior of the mass wall.

LET'S LOOK AT THE 2018 INTERNATIONAL RESIDENTIAL CODE (IRC) REQUIREMENTS FOR WALLS SPECIFICALLY

UPC PRODUCT THICKNESS REQUIRED (INCHES)

CLIMATE ZONE	R-VALUE	2.0 R & HL	1.7 R	2.0 HL HFO	500 R	500 MAX/PRO	500 OCX
1	13	2	2	2	3.5	3.5	3.5
2	13	2	2	2	3.5	3.5	3.5
3	20/13+5	3/2+1	3/2+1	3/2+1	5/NA	5/NA	5/NA
4 Except Marine	20/13+5	3/2+1	3/2+1	3/2+1	5/NA	5/NA	5/NA
5 & Marine 4	20/13+5	3/2+1	3/2+1	3/2+1	5/NA	5/NA	5/NA
6	20+5/13+10	3+1/12+1.5	3+1/12+1.5	3+1/12+1.5	5/NA	5/NA	5/NA
7 & 8	20+5/13+10	3+1/12+1.5	3+1/12+1.5	3+1/12+1.5	5/NA	5/NA	5/NA

NOTE: Only closed cell SPF may be used outboard of the sheathing to provide continuous insulation. UPC ocSPF may then be installed within the stud cavity to meet inboard insulation requirements with the appropriate additional vapor retarder when required by code

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

Approvals & Certifications

All UPC products have been independently tested by a Nationally Accredited laboratory to meet or exceed the requirements of Intertek's Clean Air Gold standard. When properly mixed and installed by approved contractors and installers in accordance with all prevailing building codes, our installation and processing guidelines, as well as industry best practices, the foam produced is inert and will continue to meet the requirements of the Clean Air Gold standard and our product technical data sheet.

All UPC products have been independently tested by a Nationally Accredited third-party laboratory to exceed the requirements of the International Building Code (IBC), International Residential Code (IRC) and the International Energy Conservation Code (IECC) as stated on the product Code Compliance Research Report (CCRR) specific to the product under consideration. Refer to our website, www.UPCFoam.com, for the latest version of the CCRR.

All physical properties of UPC products have been determined by an independent, Nationally Accredited third-party laboratory as provided on our Product Technical Data Sheet.

UPC stands behind its products with a Limited Lifetime Residential Insulation Warranty available to the original homeowner under the terms and conditions stated on the warranty document.

Thermal Barrier (fire) Protection Requirements

In all cases, the foam must be protected by an approved 15-minute thermal barrier or ignition barrier depending on attic accessibility, end-use and code interpretation. Local Building and Fire Officials (AHJ – Authority Having Jurisdiction) should always be consulted to confirm the requirements before installing any insulation.

The intended use of the attic will determine the level of thermal protection required. UPC provides Code Compliance Research Reports (CCRR) for all SPF products. The CCRR identifies the conditions of use and appropriate thermal protection, describes the maximum allowable thickness for the insulation and thickness of the thermal protection as well as the specific Building Code (IBC, IRC, IECC) reference for attics.

Section 5.3 - Thermal Barrier. This section, and subsections, describe the fire protection requirements for SPF when installed in living spaces in two ways – with or without a prescriptive thermal barrier.

Section 5.3.1- Application with a Prescriptive Thermal Barrier describes the allowable thermal barrier materials (1/2 -inch-thick gypsum board and 25/32-inch-thick wood structural panel) and the maximum thickness of product behind it. This section also identifies the specific IRC/IBC references, Section R316.4 and 2603.4 respectively.

Section 5.3.2- Application without a Prescriptive Thermal Barrier describes alternative Thermal Barrier materials which can be applied over the specific UPC SPF insulation while meeting the requirements of the code. These are usually fluid applied (spray) options. UPC has tested and exceeded the requirements of the IRC/IBC regarding alternative Thermal Barriers with the following materials: DC315 and No Burn Plus ThB. The individual insulation product's CCRR identifies the required thickness (WFT – wet film thickness) of each spray applied Thermal Barrier.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

JOBSITE SETUP BEST PRACTICES

Upon arrival at the jobsite, the application team must ensure the jobsite is suitable, secure, and safe to conduct spray operations. A partial list of considerations is listed below and are not exhaustive; members of the installation team must maintain a safe work environment during and after spray operations:

- Park vehicles on level, non-permeable ground (concrete, asphalt) and provide spill containment absorbent "Pigs" around the perimeter of the vehicle.
- If located on level, permeable ground (gravel, earth, sand), place a non-permeable ground sheet on the ground first and locate the vehicle on the ground sheet. Provide spill containment pigs around the perimeter of the ground sheet.
- Provide sufficient spill containment material to contain a spill 2X the liquid volume transported to the jobsite.
- Locate the vehicle on stable, firm ground or hard surface. Do not position the vehicle on wet, soft earth.
- Locate the vehicle in a manner which will not block other traffic or access to or from the workplace.
- Position the vehicle within a reasonable distance from the access point to the jobsite to minimize the length of dispense hose exposed to the elements.
- Position wheel chocks on all wheels to prevent vehicle movement.
- Designate a single, highly visible, accessible location as a "Communication Post" to provide easy access to all product technical information, SDS sheets, permits and general information concerning materials being used by the SPF installation team. Include the location (address) and contact information of the nearest hospital, and emergency response teams.
- Erect hazard, warning signs and physical barricades at all worksite entry points to eliminate or manage access to the SPF application work area.
- Position ABC fire extinguishers inside the work truck, outside the work truck and in the designated spray foam work area.
- Position emergency eyewash stations inside the work truck and in the designated spray foam work area.
- Locate and store all PPE equipment and material in a single location in accordance with the manufacturer's instructions.
- Confirm all surfaces within the isolated work area NOT intended to receive SPF insulation are fully protected from direct contact with SPF chemical or overspray.
- Determine the need for and provide any necessary fall protection equipment in accordance with OSHA Title 29 (CFR) Subpart M – *Fall Protection* and all appropriate subsections.
- Ensure potable water is available to the jobsite.
- Ensure suitable latrine facilities are available to the jobsite.
- If equipment is left on the jobsite overnight, provide suitable locked storage facilities.
- Confirm and/or establish appropriate jobsite security to prevent unrelated entry during or after normal working hours.
- Collect and remove all waste from jobsite at the end of each day.
- Provide "job card", typically adhered to convenient framing member in attic or attached to attic hatch identifying material manufacturer, Installer/Contractor, contact information, Total R-value of installation and date of installation.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

Chemical Storage Requirements

- Confirm all SPF chemical arriving at jobsite is provided in suitable containers provided by UPC, all labels are legible and not hidden and there are no leaking containers.
- Confirm chemical temperature is within UPC recommended storage temperature and the chemical temperature is consistent within the drum. Drums must be stored between 50°F and 75°F.
- Material should be stored off the floor to eliminate cold chemical on the bottom of drums – specifically in cold climates. Storing material on pallets or skids also allows air to circulate under the drum to help warm or cool the drum.
- Materials not immediately needed must be securely stored in accordance with UPC storage and handling recommendations.
- Do not store material in direct sunlight.
- Do not circulate or agitate SPF resin containing a blowing agent. All closed cell SPF resin contains a blowing agent.
- Band style drum heaters are not recommended to be used for closed cell resin drums. These devices produce hot spots and can result in excess pressure and drum rupture.
- Drum blankets and indirect heating is recommended for use with closed cell resin material.
- Store all flammables in designated containers in accordance with OSHA 1926.152 and local fire regulations.

Isolation & Ventilation Best Practices

- For retrofit applications, ensure the attic is isolated from the living space to prevent overspray and airborne SPF particles from entering the occupied space. Confirm the HVAC system is turned "OFF".
- All home occupants and animals must be out of the home while spraying is conducted. Occupants must remain out of the home for a full 24 hrs. following the completion of SPF installation. The isolated work area is to remain under full ventilation for 24 hrs. following SPF installation.
- Erect continuous, non-permeable material to establish, Isolate and identify SPF work area.
- Locate isolated work area air intake fan in accordance with Industry best practice as provided by the Spray Polyurethane Foam Alliance and American Chemistry Council – Center for the Polyurethane Industry.
- Locate isolated work area exhaust fan in a manner to draw air across the face of the work area in accordance with Industry best practice as provided by the Spray Polyurethane Foam Alliance and American Chemistry Council (Center for the Polyurethane Industry.)
- Provide ventilation intake air at a minimum rate of 10 ACH within the isolated SPF work area.
- Provide ventilation exhaust air at a minimum rate of 11 ACH (10% greater than intake rate) to create a slight negative pressure within the isolated SPF work area.
- Continue ventilating the isolated work area for a period of 24 hrs. following the installation of any/all UPC polyurethane foam products when products are installed in a residential structure.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

PPE Requirements

Before working with any UPC product, you must read and understand the available information (e.g. Safety Data Sheets, Technical Data Sheets, and Industry best practices) on its risks, proper use and safe handling. All applicators and their support teams must use appropriate respiratory, skin and eye Personal Protective Equipment (PPE) in addition to construction task related protective safety gear when handling and processing spray foam systems.

Refer to the Center for the Polyurethane Industries (CPI): "Health and Safety Product Stewardship Workbook for High Pressure Application of Spray Polyurethane Foam (SPF)", "Guidance for Working with MDI: Things You Should Know", NIOSH Poster: "Got Everything Covered?", "High Pressure SPF Insulation in New Home Construction and Retrofit Application: Worker and Homeowner Health and Safety Information", which can be found on the ACC/CPI website at www.americanchemistry.com

The Spray Foam Industry trade association Spray Polyurethane Foam Alliance (SPFA) also provides Health and Safety related resources as well as SPF Professional Certification Training Programs. UPC is a contributing member to the SPFA and active participant in the development of industry standards and guides. The SPFA website is located at www.sprayfoam.org

Safety Considerations for Walls

Residential walls are a unique application area for SPF. A safety inspection of the entire work area must be conducted before spray foam applications begin to determine and address any safety issues present. UPC provides several technical tips related to the application of SPF on its website.

In new construction, walls often extend uninterrupted to the roofline and may require fall protection measures be employed to meet OSHA requirements. Use scaffolding in accordance with industry best practice and OSHA requirements for fall protection and scaffolds.

All SPF is considered combustible by the code and must be protected with a minimum approved 15-minute thermal barrier.

Special Considerations for Residential Walls

UPC provides the following list of items to consider when insulating residential walls. The list is not exhaustive but is provided as a reminder.

- Homes under construction are generally not conditioned spaces and can be hot environments to work in. Be aware of the temperature and environmental conditions – stay hydrated.
- Walls often include overhead work which strains the neck, shoulders, and arms. Be aware of light-headedness and rest often.
- Walls often present angles, corners and areas which are difficult to insulate. Do not "over-pack" or "fill" hard to reach areas such as corners as this may exceed the maximum recommended pass thickness for the specific system and result in hazardous thermal decomposition of the insulation.
- Ductwork not intended to be insulated and mechanicals must be properly protected from overspray.
- PVC/cPVC and electrical wires are often encountered in walls. Follow the UPC recommendations when installing SPF around or onto these plastic substrates.
- Fireplaces and other sources of heat are often built into walls. The maximum continuous service temperature of UPC SPF is 180^{0}F. Confirm the application of any UPC SPF insulation will not result in exposure to heat sources above 180^{0}F.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

- UPC SPF insulation must never be installed within 3 inches of recessed lighting fixtures.
- Protect the inside of all electrical boxes, terminal boxes, switches, and electrical outlets from SPF. Do not allow SPF to enter electrical devices.
- Never install UPC SPF insulation products around window or door jams. Plural component SPF is not intended to be used as a sealant and if used, may void the warranty of the window or door manufacturer, cause damage to the door frame or window frame and potentially crack the glazing unit. UPC recommends the use of single component polyurethane foam for the purpose of sealing doors and windows.
- Protect all surfaces not intended to be insulated from overspray.
- Protect all surfaces from contact with dispense hose when access to the work area is restricted
- Wear a hard hat or bump cap to protect your head from accidental contact with low hanging framing members, bump outs, framing members and construction equipment.
- In cool temperatures, start the work on the "sun side" of the structure and move in a direction to "follow the sun". The sun's radiation will heat the substrate and help burn-off any surface moisture which may be present.

Substrate Preparation

Framing members, and sheathing materials (OSB, plywood, insulated sheathing board – zip panels) are common substrates for wall insulation applications. Generally, wood, or wood-based products are the most common framing and sheathing materials.

In all cases, the substrate must be free of oil, grease, process films and release agents, waxes, rust scale, frost, mold, loose dirt or dust. The moisture content of substrates must be below 19% before applying any UPC SPF product. Substrate temperature should always be a minimum of 5^0F above the ambient air dew point. UPC recommends the use of a test area to evaluate the adhesion of SPF to the substrate.

The suitability of the substrate for the application of UPC SPF is at the discretion of the applicator.

Metal substrates may require a primer coating be applied before the application of SPF. Galvanized metals are particularly troublesome and must always be primed before the application of SPF.

PVC and cPVC piping may be present in the wall. UPC provides specific documentation for the application of SPF to plastic piping. Please read and understand the requirements for the application of SPF to PVC and cPVC piping.

Before applying any SPF insulation around plastic piping, request a pressure test be conducted or a pressure test has been completed and the system is leak-free. Request a pressure test be conducted immediately following the SPF installation to confirm there are no leaks as a result of installing SPF around plastic piping. Obtain a signature or sign-off from the inspector or technician confirming the piping system is undamaged.

Always protect surfaces not intended to be insulated from overspray before beginning the application of SPF or Primers.
In wall applications, there are many substrates which may be encountered. The use of primers in specific conditions may be warranted. If adhesion of SPF to typical wall substrates is in question, prepare a test area and conduct an adhesion test using ABAA T0002-2019 Pull Adhesion Test Method. The adhesion of the closed cell SPF to the substrate must be greater than 15 lb./in^2.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

To increase the adhesion of all SPF products to the substrate, a suitable primer may be used. Application area ventilation and proper PPE must be used when applying primers to avoid inhalation. UPC recommends the use of water-based primer materials – avoid combustible primer application in the work area. Follow manufacturers application guidelines when applying any primer. Avoid excessive application thickness.

Most substrates are wood based. Confirm the moisture content of the substrate is below 19% before applying any SPF material. Excessive moisture in/on the substrate will result in reduced adhesion.

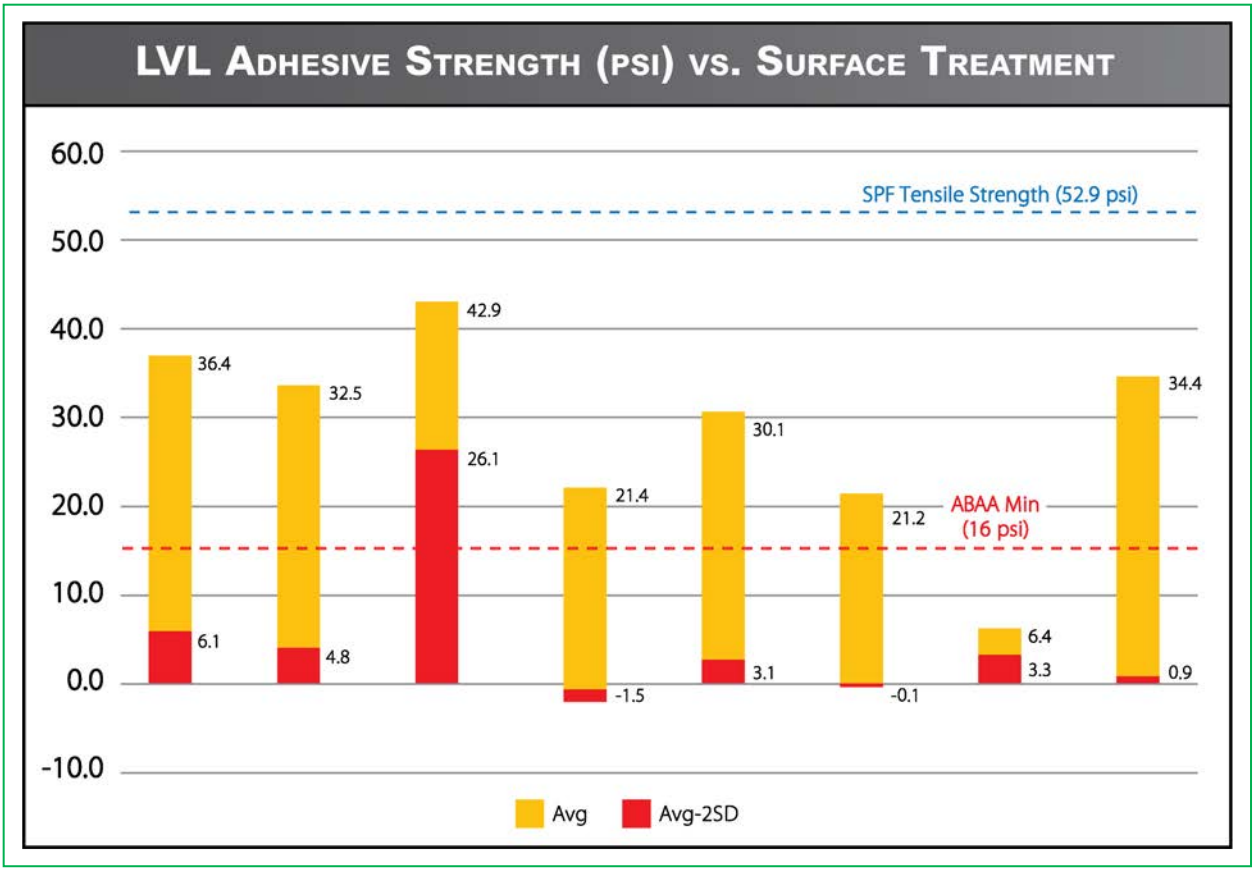
UPC supports the development of industry standard documents and industry best practices found on the SPF trade association website at sprayfoam.org.

When applying closed cell foam to engineered wood products, there may be a waxy surface on the substrate. These materials include but are not limited to; Laminated veneer lumber (LVL) beams, oriented strand board (OSB) sheathing and wood I-Joists.

On behalf of the SPF industry, the SPFA conducted extensive testing evaluating several options thought to improve adhesion of SPF to LVL beams. The results are provided below. Your results may vary. The use of primers or other means of apparent adhesion promoters and the final condition and suitability of the substrate is at the discretion of the installer/applicator.

ID	NAME	SUBSTRATE CONDITION
A	Control #1	Smooth (waxy) LVL Surface
B	Control #2	Rough OSB Surface
C	Primer #1	Modified Acrylic Adhesion Primer (off-the-shelf e.g., Kilz® Adhesion)
D	Mech #1	80 Grit Sandpaper on Belt Sander
E	Mech #2	Curry Comb Scuff
F	Fabric #1	BIBS Fabric (non-woven PE), T-50 x ½" Staples on 2" Grid
G	Fabric #2	Weather Resistant Barrier (Tyvek), T-50 x ½" Staples on 2" Grid
H	Flash Coat	Apply ½" SPF Sacrificial Pass and Remove; Apply Final Pass of SPF

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com



Environmental Limitations

Each UPC SPF chemical system has been specifically formulated for application within an ambient temperature range, humidity range and substrate temperature range. Please refer to the product Technical Data Sheet for information regarding Processing Instructions for the specific foam system.

The following chart is provided for your guidance.

REACTION SPEED	AMBIENT TEMPERATURE	SUBSTRATE TEMPERATURE
Regular		
Summer		
Winter		

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

In all cases, when substrate temperatures are below 45°F, pre-heat the building to a temperature above 45°F (in the case of metal substrates, limit pre-heating to no more than 55°F to prevent condensation from forming).

Do not heat enclosures with propane fueled heaters. This type of fuel adds substantial moisture to the air and may result in condensation forming on the substrate.

Protect installed foam from UV (sunlight) exposure with a suitable, approved coating.

Not intended for use where direct contact for extended periods of time with liquid water is expected.

LIMITATION OF USE SUMMARY

UPC produces polyurethane foam resin formulations in several ISO 9001:2015 certified facilities. With any polyurethane foam material there are limitations of use for both the chemical (resin and Isocyanate) and finished foam insulation. The following list does not include all limitations. Please read and understand all UPC technical and safety information provided on the UPC website and packaging labels. In addition, please read and understand the information provided by Industry Trade Association websites.

- Do not allow foam insulation to enter or be installed in electrical boxes, electrical junction boxes or connection boxes.
- Do not exceed the "continuous service temperature" of the specific foam formulation you are installing.
- Maintain minimum clearance of 3 inches between recessed lighting and other heat sources (chimney, flue, steam pipe, etc.).
- Maintain correct chemical storage conditions as stated on the chemical container and current Technical Data Sheet for the foam system.
- Do not process chemical system outside recommended ambient conditions specific to the chemical system being installed.
- Do not install SPF in an area which may experience extended periods of liquid water contact.
- Do not exceed "single pass thickness" requirements for the specific chemical system as stated on the current Technical Data Sheet.
- Protect the installed foam insulation from sunlight.
- SPF must always be protected from fire with an approved, 15-minute minimum thermal barrier unless specifically allowed by local building code and AHJ.
- Do not install UPC SPF materials over flexible ductwork.
- Do not install UPC SPF materials in passes less than 1 inch thick.
- UPC open cell SPF insulation is not a vapor retarder and must be protected with a minimum type II vapor retarder when used in attic applications in climate zone 4a marine and above.
- UPC closed cell SPF insulation is not intended for use as a caulk or sealant around window units. Excessive pressure may restrict window operation or result in damage to the window glazing.
- Do not use without proper PPE.
- Do not use without properly isolated and ventilated workspace.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

Start Up & Shut Down Procedure

Equipment manufacturers provide detailed instructions regarding the use and maintenance of the equipment. UPC recommends attending the appropriate training course for the specific equipment intended for use.

Yield Calculation

The yield of SPF insulation may be defined as "the area covered by a known quantity of chemical material at a defined thickness". In mathematical terms it is Area divided by Consumption at a defined thickness.

Yield = Area / Consumption

Consumption: The amount of chemical used must be accurately determined. The preferred method is by "cycles" as the pump volume is fixed, known and consistent. Each proportioner is equipped with fixed volume pumps and the volume is prescribed in the owner's manual. The table below with common equipment types is provided for your convenience.

	E-20	E-30	H-30	H-40
Output Per Cycle	0.0104 gal.	0.0272 gal.	0.074 gal.	0.063 gal.

A "set" of chemical (A and B drums) is often used as the "unit" of consumption. This will lead to inaccurate yield calculations as a "set" volume varies from formulation to formulation and manufacturer to manufacturer. Each drum fill weight also varies from formulation to formulation and manufacturer to manufacturer. Measuring the height of the chemical in the drum is also not accurate as the height of the chemical will vary with temperature and the diameter of the drum is not consistent. Measuring the change in liquid height with a measuring tape and then converting the linear measurement to lbs. is complicated and doesn't consider the materials specific gravity (ratio of the density of the liquid compared to the density of water).

Each cycle of the pump is registered on the cycle counter. When determining yield, set the cycle counter to zero and begin spraying. Once the known area is insulated, record the number of cycles indicated on the cycle counter.

Area: The length and height of the test area must be accurately measured. Do not include framing members, windows, doors or penetrations in the calculation. Measure ONLY the area to be insulated. To eliminate variables, use an area without studs, or framing and few/no penetrations as your test area.

Thickness: The average thickness of the insulation in the test area must be accurately determined. Take several measurements to determine average thickness over the entire installed area of insulation. Measure and record the thickness to the nearest 1/8th inch. Here is an example:

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

Convert the number of cycles to lbs. of chemical system.

We know the number of strokes and the volume of the cylinder. Multiply these two numbers together to get the volume of chemical consumed for our known area.

- (# of strokes) x (Volume of Cylinder) = Total Volume of Chemical Consumed

For Example, if our equipment is a Graco Reactor E-30 with standard pumps:

Here is the information we noted from our test.

- Graco Reactor 2 E-30
- 854 Cycles
- UPC 2.0 HL HFO chemical system
  - Average Specific Gravity = 1.23

    *1.23 is the average specific gravity between the A-side and B-side specific gravity provided on the system Technical Data Sheet
- Area = (60 ft. long X 12 ft. high) X 1.5 inches thick = 1,080 board ft.

1) Calculate the lbs. of chemical consumed:
   - 854 cycles X 0.0272 gal/cycle = 23.23 gallons of system (A & B combined)

     *0.0272 gal/cycle is provided by the Graco Reactor 2 E-30 manual
2) Convert the gallons of system to lbs. of system
   (Use the specific gravity number to do this)
   - 23.23 X ((8.34 lbs. ÷ gal) X 1.23) = 238.3 lb.'s of chemical system

     *8.34 is the number of lb.'s / gal of water
3) Divide the Total Area (board feet) by Total Chemical Consumption (lbs.)
   - 1,080 Brd ft. ÷ 238.3 lb.'s = 4.53 Brd. ft/lb.

     Use the "net weight" of the material in the A + B drum to give you "set weight" (see drum label)
4) Multiply the set weight by the yield/lb. value

   Total Net Weight of set X 4.53 = Yield per set

   In this example, the set of 2.0 HFO is yielding: 1,000lbs x 4.53 = 4,530 Brd Ft.

IMPORTANT NOTICE: Before beginning any operation, which may expose you to any chemical, wear appropriate PPE, including but not limited to face shield, splash googles, gloves, skin protection, Tyvek suite, cartridge respirator. Conduct operation near eye wash and emergency body shower location. Read and understand all material SDS. Material may be under pressure, use caution.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025

www.upcfoam.com

Factors Effecting Yield

There are many factors which impact yield. Here is a short list or the major factors and their influence, positive or negative, on the yield of SPF chemicals. See UPC's *"Maximizing Yield"* flyer for more information select Tech Tips at UPCFoam.com.

Density: In general, the lower the density, the higher the yield. Remember the skins (top surface of a pass and the foam contact surface) are higher density material and will negatively impact yield.

Environmental Temperature: The lower the temperature, the lower the yield. This is due to heat energy needed for the reaction of SPF being drawn away from the foam chemical and into the surrounding environment.

Substrate Temperature: Most applications in the attic are onto exterior sheathing, either roof sheathing or wall sheathing. Exterior sheathing is exposed to the environmental elements and may be at a different temperature than the interior space of the attic. If the substrate temperature is below the recommended lower limit specified by UPC for the specific chemical system, the chemical reaction will be slowed, and the yield of the system negatively impacted.

Processing Temperatures: UPC provides recommended processing temperatures for each SPF system. Processing UPC material outside those recommendations may negatively impact system yield.

Number of Passes: Minimize the number of passes. Maximum allowable pass thickness is identified on the system Technical Data Sheet.

Application Technique: It's recommended to spray into the rising foam front, to overlap the previous pass by approx. 70% while the foam is still rising. In open stud bays or roof truss assemblies, if long passes are used, at least 50% of the liquid foam is applied to foam which has past the tack free stage. This results in a pass-line and thin pass thickness which adds overall density and negatively affects yield.

Application Technique (Industry Best Practice: High Lift vs. Regular)

Whenever possible, the application of SPF chemical should be "into the rising foam" in order to eliminate the potential for pass-lines within the foam and maximize yield. In attic applications, much of the foam insulation is installed overhead or from scaffolding. Attention to general overhead safety and the use of scaffolds is highly recommended.

When spraying UPC foam insulation from scaffolding, it is recommended to install the maximum recommended pass thickness stated on the material Technical Data Sheet onto the entire reachable surface area before adding the next pass. This technique provides time to allow the first pass to cool before applying subsequent passes and minimizes the number of times the scaffolding needs to be moved.

When spraying UPC high lift formulations, it is recommended to adjust the application technique from 70% overlap to 50% overlap in order to move the liquid in front of the rising foam rather than applying high volumes of liquid onto the rising foam in order to avoid disrupting cell formation. As always, install the required thickness or maximum allowable thickness as stated on the material Technical Data Sheet in a single pass.

Refrain from flash-coating the top surface to even out the surface profile.

Refrain from filling in the top surface edges of stud and truss bays.

Always confirm applied foam thickness with a depth gage before relocating scaffolding.

Flash the small hole left by the depth gage before relocating scaffolding.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

Thickness of Pass Limitations

Heat is generated during the chemical reaction during the development of the final foam insulation. As SPF is such a good insulation, this heat dissipates slowly. The internal foam temperature of each recommended pass thickness has been measured and the maximum allowable recommended pass thickness determined. UPC provides the maximum allowable pass thickness for each foam system on the appropriate Technical Data Sheet.

The table below summarizes the current SPF systems recommended maximum pass thickness.

	2.0 HL HFO	2.0 Regular	2.0 HL HFC	1.7 Regular	500 Classic	500 Max	500 Max Pro	500 OCX
Maximun Pass Thickness	5.0 in.	2.0 in.	4.5 in.	2.0 in.	6-8 in.	6.0 in.	10 in.	6.0 in.

Once the installed foam has become hard to the touch (surface cure) a second pass may be applied.

Care must be taken with the application of "High-Lift" closed cell foam formulations to control the foam thickness and assure the finished thickness is at or below the maximum recommended pass thickness. UPC recommends the use of multiple 3-inch passes be installed onto each other until the final foam thickness is achieved. This technique will improve cell structure, reduce the potential for shrinkage and substrate delamination, improve thickness control, and improve system yield while providing the productivity advantages associated with High-Lift formulations.

Quality Assurance Testing Procedures

UPC delivers a fully tested and approved chemical blend from its ISO 9001:2015 series production facilities. We provide installer training and fully support the development of industry best practices. To assure a high-quality installation, UPC provides a "Quality Assurance" form for use by our contractor/installers to gather critical information concerning the installed product. UPC recommends the completion of the Quality Assurance form for each site, each day, and each time a new lot number of chemical material is installed.

Installed product testing includes the following:

Installed Foam Thickness

- Confirm installed thickness with physical probe inserted through SPF to substrate
- Conduct thickness checks frequently
- Report installed thickness, maximum pass thickness, and number of passes on daily work report
- Report Installed R-Value on Installation Report Card to be conveniently located at jobsite

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

Density Determination

- Before beginning to install UPC closed cell SPF each day, each change of material lot number and at new sites, perform a foam density test in accordance with ASTM D 1622 – water displacement method
- Record density on Daily Work Report

Adhesion Determination

- Confirm the adhesion of UPC closed cell SPF to any substrate, each day, change of material lot number and at new sites or when the adhesion of foam to the substrate is questionable

Void Detection

- Used predominantly for open cell foam installations, use a coring tool to remove a core sample through the foam to the substrate
- Inspect the sample for interlaminar voids (pass-to-pass) and loss of adhesion to the substrate
- Repair sample void with like material

Cell Structure (Visual)

- Confirm consistent and regular cell structure throughout the application thickness with visual inspection
- Use a coring tool to remove a core sample through the foam to the substrate

Sample Collection

- UPC recommends installers collect, tag and store core samples in a sealed plastic bag, in a dark, cool location for a minimum of 1 year
- Samples must be labeled with the installation date, jobsite location, area the sample was taken, manufacturer and material lot number
- Repair all sample voids with like material
- The Quality Assurance form can be found at upcfoam.com in the Technical Resources Section under Forms. Look for the *"UPC Quality Assurance Program"*.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

TROUBLESHOOTING

Residential wall applications are subject to additional considerations regarding safety, ventilation, and application thickness control. Beyond those, the application of UPC SPF may encounter.

- Delamination from the substrate which may be a result of excess contamination on the substrate. In attic applications contaminants may include, dust, frost, substrate moisture content greater than 19% and loose substrate material. The acceptability of any substrate as suitable for the application of UPC SPF is at the discretion of the applicator.

- Delamination between foam passes is not common and typically a result of applying the foam at too great an angle to the substrate causing the foam to "creep" along the surface of the substrate. Best practice calls for the dispense head to be held at 90 degrees to the substrate while applying foam. The foam then rises perpendicular to the target and not at an angle.

- Interlaminar (between passes) blisters are not common in attic applications and may be a result of slow reacting foam on the edge of a pass where the foam thickness is less than ½ inch thick – specifically in cool/cold ambient conditions. The foam chemical does not have enough mass (amount of chemical) to "drive" the reaction in cold conditions and the reaction is slowed. When more chemical is sprayed over the top, the reaction is suddenly energized, and gas is released. This excess gas results in a blister. Changing the reactivity grade of the chemical system to a faster speed will eliminate the issue. (Regular Grade to Winter Grade)

- Elongated cells in the center of the closed cell foam pass may result in shrinkage (delamination) or cracking in the middle of the pass between framing members. This is an indication of excessive single pass thickness. Reduce the pass thickness.

- Poor cell structure throughout the foam is an indication of resin contamination as a result of improper change-over practice. Chasing one resin with another is not recommended. Attempting to process resin material which is past the stated shelf-life of the material will also result in poor quality foam insulation. Always install UPC SPF material within the recommended shelf-life as stated on the drum label and system Technical Data Sheet.

- Friable surface foam (powder, chalk, crispy) is an indication of an incomplete reaction typically caused by applying the foam system outside the recommended environmental window for the specific system (usually in too cold conditions). Friable surface foam will have reduced adhesion to the substrate resulting in separation from the framing members. Change the closed cell resin to a colder temperature grade.

- Excessive dispense head clogging is a result of high temperature processing. Reduce the chemical heaters and hose heater until processing improves. UPC SPF systems are designed to be installed with a minimum of down-time.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

- Spurts of "A" or "B" side chemical at the dispense head are a result of pump cavitation and will result in poor quality foam product, areas of off-ratio foam and must be corrected immediately. *Resin pump* cavitation may be caused by cold resin material – improper chemical temperature which causes the resin to thicken and not flow easily through the transfer pump or supply lines. Confirm the resin drum and chemical temperatures are within the proper temperature range (55°F-75°F) stated on the drum label or the specific chemical system Technical Data Sheet. Isocyanate pump cavitation may be caused by dirty chemical filters on the supply side of the isocyanate delivery assembly. Filters must be maintained regularly to assure proper equipment function.

Material Change Over Procedure

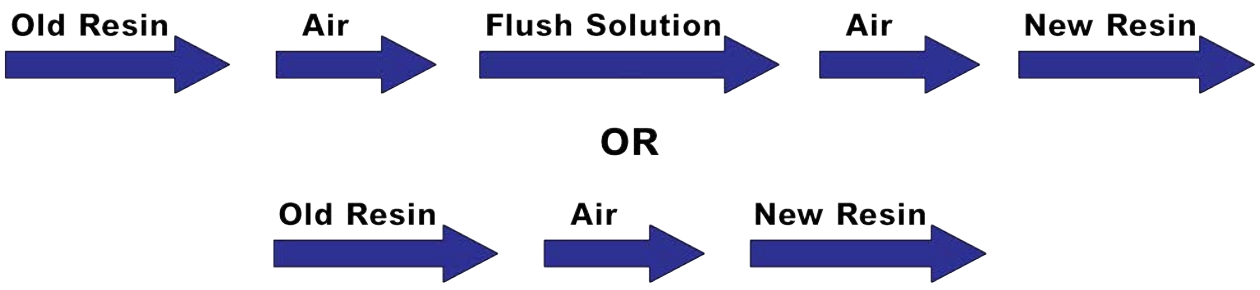
Isocyanate from one manufacturer may be different than the isocyanate from another manufacturer. The correct isocyanate must be paired with the identified resin from a single manufacturer. Each chemical system has been extensively tested as a matched pair of A-side and B-side. Mixing one supplier's resin with a different supplier's isocyanate is never permitted.

When handling polyurethane foam chemicals and axillary chemicals (solvents, primers, etc.), always read and understand the material Safety Data Sheet (SDS), wear all required PPE and conduct material change-over operations in a well-ventilated area.

UPC does not recommend "chasing" one resin after another without using a flushing solution and/or air. Today's equipment is a complex network of small openings and chambers which hold residual chemical. Delivery hoses often have a convoluted core to help the hose bend. These convolutions trap chemical. Open cell resin is simply not compatible with closed cell resin and any amount of closed cell resin will contaminate open cell resin and open cell resin will contaminate closed cell resin. The resulting foam is not suitable for application under any circumstance. Every effort must be made to keep the two resins apart from each other and make sure the dispensing equipment is completely clean before charging the system with the different resin. The following procedure is recommended under the following circumstances.

- Changing from Open Cell to Closed Cell Resin
- Changing from Closed Cell to Open Cell Resin
- Changing from one resin manufacturer to another

In general terms, this is the concept behind our changeover procedure.



CHANGEOVER WITH AIR ONLY

Step 1 Purging B-side Supply Lines

- Disconnect the air supply to the pump
- Open the Recirculation valve
- Drain transfer pump fluid section by fully depressing the ball valve at the bottom of the pump
- Drain the material wetting cup section of the pump by inverting the pump over a collection bucket
- Once fully drained, close pump air valve and reconnect supply air
- Place pump in clean, open top, empty pail and secure pump
- Open B-side relief valve and slowly open transfer pump air valve
- Slowly cycle transfer pump to draw air into the pump and push resin chemical through return line into old resin drum
- Once air is heard exiting the return line, close B-side relief valve

Step 2 Switching Chemical

The procedure will be different whether you have a recirculating block or not.

Without Recirculating Block

- Clean and dry wet section of transfer pump
- Slowly insert transfer pump into new B-side material. Be gentle as agitation may cause closed cell resin to froth
- Secure gun manifold over open large bung of old resin drum and slowly open manifold resin valve
- Drain hose chemical into old B-side drum until air escapes from manifold (15-20 minutes)
- Close manifold B-side valve
- Into properly labeled "waste container" open manifold B-side valve and allow the remaining air in the hose assembly to escape
- When new chemical is draining from hose assembly, continue until liquid is clean and free of entrapped air
- Close B-side manifold valve
- Dispose of "waste" material in accordance with UPC resin material SDS

With Recirculating Block

- Clean and dry wet section of transfer pump
- Slowly insert transfer pump into new B-side material. Be gentle as agitation may cause closed cell resin to froth
- Connect gun manifold to recirculating block and open manifold and recirculating block B-side valves
- Drain hose chemical into old B-side drum until air escapes from manifold (15-20 minutes)
- Into properly labeled "waste container" open manifold B-side valve and allow the remaining air in the hose assembly to escape

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

- When new chemical is draining from hose assembly, continue until liquid is clean and free of entrapped air
- Close B-side manifold valve
- Dispose of "waste" material in accordance with UPC resin material SDS

CHANGEOVER WITH AIR + FLUSHING SOLUTION

Step 1 Purging B-side Supply Lines

- Disconnect the air supply to the pump
- Open the Recirculation valve
- Drain transfer pump fluid section by fully depressing the ball valve at the bottom of the pump
- Drain the material wetting cup section of the pump by inverting the pump over a collection bucket
- Once fully drained, close pump air valve and reconnect supply air
- Place pump in clean, open top, empty pail and secure pump
- Open B-side relief valve and slowly open transfer pump air valve
- Slowly cycle transfer pump to draw air into the pump and push resin chemical through return line into old resin drum
- Once air is heard exiting the return line, close B-side relief valve

Step 2 Adding Flushing Solution

The procedure will be different whether you have a recirculating block or not.

Without Recirculating Block

- Clean and dry wet section of transfer pump
- Slowly insert transfer pump into flushing solution
- Secure gun manifold over open large bung of waste resin drum and slowly open manifold resin valve
- Drain hose chemical into waste resin drum until flushing solution escapes from manifold (15-20 minutes)
- Close manifold B-side valve
- Into properly labeled "waste container" open manifold B-side valve and allow the remaining air in the hose assembly to escape
- When flushing solution is draining from hose assembly, continue until liquid is clean and free of entrapped air
- Close B-side manifold valve
- Dispose of "waste" material in accordance with UPC resin material SDS

With Recirculating Block

- Clean and dry wet section of transfer pump
- Slowly insert transfer pump into flushing solution.
- Connect gun manifold to recirculating block and open manifold and recirculating block B-side valves

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

- Drain hose chemical into waste resin drum (15-20 minutes)
- Into properly labeled "waste container" open manifold B-side valve and allow the remaining air in the hose assembly to escape
- When flushing solution is draining from hose assembly, continue until liquid is clean and free of entrapped air
- Close B-side manifold valve
- Dispose of "waste" material in accordance with UPC resin material SDS

Step 3 Flush with Air

- Disconnect the air supply to the pump
- Open the Recirculation valve
- Drain transfer pump fluid section by fully depressing the ball valve at the bottom of the pump
- Drain the material wetting cup section of the pump by inverting the pump over a collection bucket
- Once fully drained, close pump air valve and reconnect supply air
- Place pump in clean, open top, empty pail and secure pump
- Open B-side relief valve and slowly open transfer pump air valve
- Slowly cycle transfer pump to draw air into the pump and push resin chemical through return line into old resin drum
- Once air is heard exiting the return line, close B-side relief valve

Step 4 Switching Chemical

The procedure will be different whether you have a recirculating block or not.

Without Recirculating Block

- Clean and dry wet section of transfer pump
- Slowly insert transfer pump into new B-side material. Be gentle as agitation may cause closed cell resin to froth
- Secure gun manifold over open large bung of old resin drum and slowly open manifold resin valve
- Drain hose chemical into old B-side drum until air escapes from manifold (15-20 minutes)
- Close manifold B-side valve
- Into properly labeled "waste container" open manifold B-side valve and allow the remaining air in the hose assembly to escape
- When new chemical is draining from hose assembly, continue until liquid is clean and free of entrapped air
- Close B-side manifold valve
- Dispose of "waste" material in accordance with UPC resin material SDS

With Recirculating Block

- Clean and dry wet section of transfer pump
- Slowly insert transfer pump into new B-side material. Be gentle as agitation may cause closed cell resin to froth
- Connect gun manifold to recirculating block and open manifold and recirculating block B-side valves
- Drain hose chemical into old B-side drum until air escapes from manifold (15-20 minutes)

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

- Into properly labeled "waste container" open manifold B-side valve and allow the remaining air in the hose assembly to escape
- When new chemical is draining from hose assembly, continue until liquid is clean and free of entrapped air
- Close B-side manifold valve
- Dispose of "waste" material in accordance with UPC resin material SDS

Drum Disposal

- Do not remove empty drums from the worksite for personal use.
- Do not remove tops or bottoms or use a torch (open flame) in contact with either resin or isocyanate drum.
- Remove all material labels.
- Puncture all empty drums to eliminate possible reuse *(never use the drum for a fire barrel).*
- Always wear appropriate PPE when handling SPF chemicals.
- Read and understand material Safety Data Sheet available on UPC website.
- "A"-side drums must be neutralized before disposal. A neutralizer solution consists of 2% liquid detergent, 5-10% sodium carbonate or 3-8% concentrated aqueous ammonia and 80% water. Take care to avoid exposure to high concentrations of ammonia vapor. Neutralizer solution can be stirred rapidly into the waste isocyanate in a well-ventilated area. Keep the drum open – remove all closure bungs. Allow mixture to stand 48 hrs. Separate solid waste from liquid. The collected neutralizer solution may be stored and reused. The solid waste may be considered hazardous waste. Confirm material status with your local landfill authority.
- "B"-side Resin an "A"-side Isocyanate drums can be recycled at a DOT certified recycling center. There are three options for empty drums which contained "A"-side, Isocyanate or MDI:
  - Offer the drums to a Department of Transportation (DOT) certified reconditioner for recycling
  - Dispose of the drums in a municipal solid waste landfill, unless MDI is considered a hazardous waste in the state
  - Dispose of drums through an RCRA-permitted Hazardous Waste Incinerator if MDI is considered a hazardous waste in the state

Chemical Waste Disposal

- Always wear appropriate PPE when handling SPF chemicals
- Small quantities of resin (B-side) and isocyanate (A-side) can be mixed together in an open top container such as a bucket or large plastic bag. The chemicals will react with each other very quickly and produce heat. Keep quantities small to avoid excessive heat build-up. Avoid inhaling any vapors produced. Mix chemicals in a well-ventilated area. Once cool, cut the resulting foam mass in quarters to confirm complete reaction (no liquid material remains) and the material has cooled.
- Once the reaction product has completely cooled, it can be disposed of in a landfill.

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com

Spill Containment and Clean-Up

- Wear appropriate PPE during all spill containment and material cleanup operations.
- For small spills, soak up with noncombustible absorbent material (sand, earth, vermiculite) and transfer to a container for disposal according to local/national regulations. Clean contaminated area thoroughly.
- For large spills, contain spill with absorbent pigs or dyke constructed from noncombustible absorbent material.
- Treat spill area with decontaminant solution using 10 parts of decontaminant solution to 1 part spill and allow to react for a minimum of 30 minutes.
- Soak up all material with noncombustible absorbent material. Let stand for 30 minutes.
- Shovel into open-top container and add decontaminant solution, mix, and let stand for 24 hrs.
- Cover and dispose as solid waste at approved waste disposal center.
- Refer to product Safety Data Sheet section 6 for more information.

Contact and Links

UPC Technical Service www.upcfoam.com	203.760.0025
UPC Customer Service www.upcfoam.com	682-503-8069
Chemtrec Emergency Response www.chemtrec.com	800-424-9300
Spray Polyurethane Foam Alliance (SPFA) www.sprayfoam.org	800-523-6154
Occupational Safety and Health Association (OSHA) www.osha.gov	800-321-6742
Center for the Polyurethane Industry (CPI) www.americanchemistry.com/industry-groups/center-for-the-polyurethanes-industry-cpi	800-321-6742

3001 E. Pioneer Pkwy | Arlington, TX 76010 | Office: 682.503.8069 | Tech Support: 203.760.0025
www.upcfoam.com