SPFA-102

A Guide for Selection of Elastomeric Protective Coatings Over Exterior Spray Foam Applications

Spray Polyurethane Foam Alliance
O: (800) 523-6154 | F: (703) 563-7425
www.sprayfoam.org | info@sprayfoam.org

ABOUT SPRAY POLYURETHANE FOAM ALLIANCE (SPFA)

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

DISCLAIMER

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

THIS DOCUMENT IS MADE AVAILABLE "AS IS" AND WITHOUT WARRANTIES OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, SATISFACTORY QUALITY, AND NON-INFRINGEMENT. TO THE FULLEST EXTENT PERMITTED BY APPLICABLE LAW, SPFA, ITS OFFICERS, DIRECTORS, EMPLOYEES, AUTHORIZED AGENTS AND VOLUNTEERS DISCLAIM ANY AND ALL LIABILITY OR RESPONSIBILITY FOR ANY LOSSES, DAMAGES, COSTS AND/OR INJURIES OF ANY KIND OR NATURE ARISING OUT OF OR RESULTING FROM THE USE AND/OR RELIANCE UPON THE CONTENTS OF THIS DOCUMENT.

Individual manufacturers and contractors should be consulted for specific information. Nominal values which may be provided herein are believed to be representative but are not to be used as specifications nor assumed to be identical to finished products. SPFA does not endorse the proprietary products or processes of any individual manufacturer, or the services of any individual contractor.

DOCUMENT HISTORY

Date	Sections Modified	Description of Changes
1994		
August 2015	All	Administrative changes

ROOFING COMMITTEE

Mission Statement

The mission of the Roofing Committee is to provide a wide range of technical service to the SPF (spray polyurethane foam) industry such as, but not limited to:

(1) Review existing documents and serve as a clearing house to ensure the "Continuity of Value" of technical information published by SPFA and others concerning roofing system products and services to the SPF industry;
(2) Review, research, develop, and issue documents concerning new products, systems and services for SPF roofing applications; and
(3) To identify, explore, develop, and communicate an understanding of roofing technical issues facing to the SPF industry.

Participating Members	
Roger Morrison, Chairman North Carolina Foam Industries	John Courier Equipment & Coating Technology
Jim Calkins Dow Chemical	John Ewell Dallas/Ft. Worth Urethane, Inc.
John Hatfield Penta Engineering Group, Inc.	Jack Moore West Roofing Systems, Inc.
Tim Leonard ERSystems	Bruce Schenke BASF
Mary Bogdan Honeywell	Robert Smith KoSa
Larry Smiley Poly-Tek	John Stahl Preferred Solutions, Inc.
Dennis Vandewater Sadler Coatings Systems	**AD HOC MEMBER**
Brad Beauchamp Stepan Co.	Laverne Dalgleish CUFCA

TABLE OF CONTENTS

SECTION I—WHY PROTECTIVE COATINGS ARE REQUIRED

Spray polyurethane foam (SPF) is used to insulate vessels, as a roofing system, and in other exterior applications. SPF also has a closed cell structure and is water resistant. However, SPF must be protected with a covering to prevent surface degradation caused by UV exposure and other weathering processes. Correctly specified and applied elastomeric coatings will protect SPF from surface degradation. Elastomeric coatings can also be used for other purposes:

- To inhibit moisture vapor transmission
- To enhance the aesthetics of the system
- To increase the impact, chemical, and abrasion resistance of the system
- To help achieve fire resistance criteria and code requirements
- To renew the weathering surface of existing roof systems

SECTION II—COATING CLASSIFICATIONS AND DEFINITIONS

Elastomeric Coating: A coating system, which when fully cured, is capable of being stretched at least twice its original length (100% elongation) and recovering to its original dimensions.

Water Vapor Transmission: Water vapor tends to migrate or diffuse from regions of high absolute humidity to regions of low absolute humidity. Protective coatings form films or membranes, which to varying degrees retard the transmission of water vapor. The rate of water vapor transmission across or through a protective coating is dependent upon: (1) the chemical makeup of the coating, (2) the thickness of the coating, and (3) the absolute humidity difference on either side of the coating.

ASTM E-96 (Standard Test Method for Water Vapor Transmission of Materials) is used to determine the water vapor transmission rates of protective coatings. The resulting value may be expressed in either of two ways:

Value	Coating Thickness	Units
1. Permeability	Common Thickness	Perm-inch [ng/(Pa•s•m2)]
2. Permeance	Specific Thickness such as 0.5 mm (20 mils)	Perm [ng/(Pa•s•m)]

Coatings that have higher permeability or permeance are more "breathable" than coatings with low values. Coatings may be relative "breathers" or "vapor retarders." Thickness is as important as coating chemistry; for example, a thickly applied breathable coating could perform as a relative vapor retarder and a thinly applied normally retardant coating could be a "breather."

For design calculations, the in-place water vapor transmission must be determined by converting the reported permeability or permeance values to the application thickness of the specific coating. The permeance of the protective coating at its application thickness is termed the "perm rating."

Water vapor transmission, per se, is harmless. However, when the diffusing water vapor chills to its dew point, it condenses to liquid water resulting in potential loss of insulation value or deterioration of building components. Selection of protective coatings, thickness, and placement will influence the likelihood of condensation.

Packaging of Elastomeric Coatings: Coatings are packaged as single-component or plural-component materials. Single-component coatings are packaged in one container. Plural-component coatings may be packaged in two or more containers. Some plural-component coatings must be sprayed through plural-component equipment.

SECTION III—GENERIC TYPES OF ELASTOMERIC COATINGS

This section contains a review of the elastomeric coating materials most frequently used over SPF. As generic types—rather than specific coatings—are discussed, the information presented is very general. Manufacturer's data should be used for comparing particular coatings and for specifying dry-film thickness, application procedures, etc.

ELASTOMERIC COATINGS

(1) Acrylic Coatings
(2) Butyl Rubber Coatings
(3) Silicone Coatings
(4) Polyurethane Coatings
(5) Polyurea Coatings

(1) ACRYLIC COATINGS:

a. **General Description**: Acrylic coatings are single-component coatings based on acrylic polymers. They are water based, which allows for easy clean up. Acrylic coatings have good resistance to weathering and have a high moisture vapor transmission rate or permeability. There are "quick-setting" versions that tend to skin faster than standard versions of acrylic coatings. There are also "high-tensile" versions that tend to perform better under physical duress. Reference ASTM D6083 (Standard Specification for Liquid Applied Acrylic Coating Used in Roofing).
b. **Color Availability**: Acrylics are generally available in white, tan, or gray, and almost any color can be provided through custom tinting.
c. **Compatibility with other Elastomeric Coatings**: Acrylics have been used with other elastomeric coatings; however, manufacturers should be consulted to ensure compatibility. Acrylics are not recommended to be used over existing silicone coating.
d. **Minimum Dry-film thickness**: A dry-film thickness (DFT) of 0.6–0.8 mm (25–30 mils) applied in a minimum of two coats is generally recommended. The specified thickness depends on existing project conditions and manufacturer recommendations.
e. **Application Recommendations:** It is important that the application of the acrylic coatings be done in strict accordance with the manufacturer's recommendations.

A few of the more common requirements are:

i. SURFACE PREPARATION: The SPF substrate should have positive slope to drains and be clean, dry, and free of UV degradation.
ii. MINIMUM NUMBER OF COATS: The coating should be applied in two separate contrasting color coats. After the first coat is cured, the second coat should be applied at right angles to the first. Heavy coats may cause the coating to blister or mudcrack as it dries.
iii. AMBIENT TEMPERATURE CONDITIONS: Acrylic coatings should not be applied below 10°C (50°F) or above 49°C (120°F). Do not allow material to freeze in containers or on roof surface before fully cured.
iv. CURE TIME: Standard acrylic coatings require 4–12 hours at 75°F for curing or 2–4 hours for faster curing versions. Cure times may vary depending on temperature, humidity, and coating thickness.
v. EQUIPMENT REQUIREMENTS: Airless spray equipment is recommended. Acrylic coatings may also be brush- or roller-applied. (See SPFA-144 Coating Equipment Guidelines.)

f. **Limitations**

i. Do not apply when inclement weather is imminent. Curing is necessary prior to precipitation or dew to avoid the coating being washed off or an adverse effect on adhesion or physical properties.
ii. Do not apply if the temperature will drop below 10°C (50°F) within 4–6 hours. Acrylic coatings will not cure at temperatures below 50°F.
iii. Keep stored material from freezing. Do not apply when freezing temperatures are anticipated within 12 hours after application. If the acrylic coating freezes (at 32°F), it will not be useable even as it warms up.
iv. Do not apply when the relative humidity is in excess of 85%. Avoid applying late in the day when conditions for dew and condensation are imminent.
v. Acrylic coatings have a high permeability and should not be used when a vapor retarder is required.
vi. When applying coating at temperatures above 85°F, it is recommended not to apply more than 0.75 gal/sq. per pass. This is particularly critical with high-tensile coatings and non-white coatings.
vii. Granules are often imbedded into the wet topcoat to enhance mechanical resistance and traction.

(2) BUTYL COATINGS

a. **General Description**: Butyl coatings are elastomers, which have extremely low water vapor permeability. Having the lowest permeability in comparison to other coatings makes these coatings especially recommended in situations that have relatively high vapor drive, such as low temperature applications (coolers, freezers, and cryogenic storage) or water immersion (water storage and ponding water). When exposed to exterior weathering or in areas where mechanical damage may occur, butyl coating should be top-coated with tougher or more weather resistant coatings. (Consult with the coating manufacturer for specific recommendations.) While most butyl coatings are two-component materials, some single-component versions are available.

b. **Color Availability**: Black and gray.

c. **Compatibility with Other Coatings**: Other elastomeric coatings can be used as a topcoat over butyl coatings. Consult the coating manufacturer for specific recommendations.

d. **Minimum Dry-film thickness (DFT)**: A dry-film thickness (DFT) of 0.5–1.0 mm (20–40 mils) is generally recommended. When butyl coatings are used as vapor retarders in cooler and freezer construction or low temperature vessels, additional DFT is recommended for optimum performance. The type of top-coating used and the manufacturer's recommendation will determine total system DFT.

e. **Application Recommendations**:

   i. SURFACE PREPARATION: The SPF substrate should be clean, dry, and free of UV degradation.

   ii. MINIMUM NUMBER OF COATS: The coating should be applied in two separate contrasting color coats. After the first coat is cured, the second coat should be applied at right angles to the first.

   iii. CURE TIME: Standard butyl coatings require 8–12 hours at 24°C (75°F) for curing. Cure times may vary depending on temperature, humidity, and coating thickness.

   iv. AMBIENT TEMPERATURE REQUIREMENTS: The coating should be applied between 7–38°C (45–100°F).

   v. EQUIPMENT REQUIREMENTS: Consult with the coating manufacturer for equipment requirements. (See SPFA-144 Coating Equipment Guidelines.)

IMPORTANT: When butyl coatings are to be used as vapor retarders, particular care must be taken in applying the butyl to produce a pinhole-free membrane. Furthermore, butyl coatings should always be applied to the correct side of the insulation in applications involving vapor drives. (See SPFA-118 Moisture Vapor Transmission.)

f. **Limitations**:

   i. Plural component butyl coatings have a limited working life due to a material pot life of 1.5 hours (or less) depending on ambient temperature conditions.

   ii. Butyl coatings have limited impact resistance (hail or mechanical) and limited traffic resistance.

   iii. Butyl coatings are subject to more rapid weathering and chalking than some coatings and should be top-coated with other compatible coatings for optimum performance.

(3) SILICONE COATINGS

a. **General Description:** Silicone coatings are silicone polymer elastomeric coatings. They are available as single-component materials. They are characterized by their exceptional weather resistance and their ability to withstand temperature extremes and retain physical properties. Silicone coatings have high moisture vapor permeability and are classified as breathable coatings. Silicone coatings are available in standard and "high-solids" versions. (Reference ASTM 6694 [Standard Specification for Liquid-Applied Silicone Coatings used in Spray Polyurethane Foam Roofing Systems].)

b. **Color Availability:** Single-component silicone coatings are available in white, gray, tan, and dark gray. Other earth tone colors may be available.

c. **Compatibility with Other Coatings:** Other coatings will generally not adhere to silicone. Silicone may be used as a topcoat over other elastomeric coatings. The manufacturer should be consulted to ensure compatibility.

d. **Minimum Dry-film Thickness:** A dry-film thickness (DFT) of 0.51–0.76 mm (20–30 mils) applied in two coats is generally required. The specified thickness is dependent on the existing project conditions and the manufacturer's recommendations.

e. **Application Recommendations**:

   i. SURFACE PREPARATION: The SPF substrate should have a positive slope to the drain and be clean, dry, and free of UV degradation.

   ii. MINIMUM NUMBER OF COATS: The coating should be applied in two separate contrasting color coats. After the first coat has cured, the second coat should be applied at right angles to the first.

   iii. CURE TIME: Standard silicone coatings require 2–8 hours at 24°C (75°F). Cure times may vary depending on temperature, humidity, and coating thickness.

   iv. TEMPERATURE REQUIREMENTS: Silicone coatings can be applied between 2–49°C (35–120°F)

   v. EQUIPMENT REQUIREMENTS: Consult with the coating manufacturer for equipment requirements. (See SPFA-144 Coating Equipment Guidelines.)

f. **Limitations**:

   i. Silicone coatings are breathable-type coatings and should not be used alone when a vapor retarder is required.

   ii. Other materials, such as SPF and other types of coatings, do not adhere well to silicone coatings.

   iii. Granules are often embedded into the wet topcoat to enhance mechanical resistance and traction.

(4) POLYURETHANE COATINGS:

a. **General Description**: Polyurethane is a general term describing a polymer based on an isocyanate and polyol reaction. There are a number of different types of polyurethane coatings and they typically are classified as follows:

   i. **Aromatic or Aliphatic Polyurethane Coatings**: Aromatic polyurethanes are polymers based on unsaturated aromatic backbones. This unsaturation accounts for the slight-to-moderate darkening and chalking characteristics in exterior exposure. The degree to which the discoloration and chalking occur depends on the particular formulation. Aromatic polyurethane coatings are mostly used as a base coat for the aliphatic polyurethane coatings; however, some may be used as a finish coat with only mild chalking and discoloration. Aliphatic polyurethanes have similar physical properties to aromatics, but in contrast aliphatic polyurethanes have no unsaturation and are characterized by their exceptional color and gloss retention. They are recommended in applications where a highly aesthetic finish coat is required.

ii. **Modified Polyurethane Coatings:** These polyurethanes have been modified with non-reactive resins including phosphate or phthalate plasticizers, synthetic hydrocarbons, refined oils, tar, or asphalt. Due to the wide variety of modifying resins, there is a great variance in physical properties.

iii. **Single-component or Plural-component:** Aromatic, aliphatic, and modified polyurethane coatings are available as single-component and plural-component materials. A wide range of properties is found in this broad family of coatings.

Moisture-cure polyurethane coatings are single-component and cure from reaction with moisture in the air, which allows the polyurethane to polymerize. (Reference ASTM D6947 [Standard Specification for Liquid Applied Moisture Cured Polyurethane Coating Used in Spray Polyurethane Foam Roofing Systems].)

Plural-component polyurethane coatings polymerize by the reaction of the isocyanate (A-component) with polyols (B-component). These polyurethanes are normally available in two versions: standard cure and fast set.

b. **Color Availability**: Aliphatics are generally available in white. Other colors are available. Aromatics are generally available in aluminum, gray, and tan. Other colors are available.

c. **Compatibility with Other Coatings**: Aliphatic and aromatic polyurethane coatings may be used as a base or as topcoats for other coatings. Consult the manufacturer for specific recommendations. They are not recommended for use over an existing silicone coating.

d. **Minimum Dry-film thickness**: Dry-film thickness (DFT) will range from 0.5–1.0 mm (20–40 mils) depending on the system used. The specified thickness depends on the existing project conditions and the manufacturer's recommendations.

e. **Application Recommendations**:

i. SURFACE PREPARATION: The SPF substrate should be clean, dry, and free of UV degradation.

ii. NUMBER OF COATS: The coating should be applied in a minimum of two separate contrasting color coats. After the coating is cured, each coat should be applied at right angles to the previous coat.

CURE TIME*

Type	Dry To Touch	Cure
Aliphatic	4–6 hours	10–24 hours
Aromatic Standard Fast Set	 4–6 hours 3 sec.–20 min.	 10–24 hours 10–24 hours
Moisture Cure	6–8 hours	10–24 hours

*Cure times may vary depending on temperature, humidity, and coating thickness.

iii. AMBIENT TEMPERATURE REQUIREMENTS: Polyurethane coatings can be applied between 2–43°C (35–110°F).
iv. EQUIPMENT REQUIREMENTS: Vary with specific system. Spray fast-set polyurethane coatings with plural-component equipment as recommended by the coating manufacturer. (See SPFA-144 Coating Equipment Guidelines.)

f. **Limitations**: Plural-component coatings have a limited working pot life. Some may only be sprayed through plural-component equipment.

Granules are often embedded into the wet topcoat to enhance mechanical resistance and traction.

(5) POLYUREA COATINGS

a. **General Description**: Polyurea coatings are characterized as plural-component, fast-curing elastomeric coatings.
   i. Polyurea coating chemistry varies widely between formulations; some are classified as hybrid polyureas and/or hybrid polyurethanes. Most polyurea coatings are aromatic, but some aliphatic versions are available. Polyurea coatings provide a very tough coating that can be applied in a wide range of weather conditions.

b. **Color Availability**: Aromatic polyurea coatings are available in aluminum, gray, and tan. Aliphatic polyurea coatings are available in white and a wide range of colors. Aromatic polyurea coating colors can change or fade with weathering.

c. **Compatibility with Other Coatings**: Polyurea coatings can be top-coated with other polyurethane coatings or other polyurea coatings, although the top-coating time frame is short, and a primer may be required for good intercoat adhesion.

d. **Minimum Dry-film thickness**: Dry-film thickness (DFT) will range from 0.5–1.0 mm (20–40 mils) depending on the system used. The specified thickness is dependent on existing project conditions and the manufacturer's recommendations.

e. **Application Recommendations**:
   i. SURFACE PREPARATION: The SPF substrate should be clean, dry, and free of UV degradation.
   ii. NUMBER OF COATS: The coating should be applied in a minimum of two separate coats. Each coat should be applied at right angles to the previous coat (cross-hatching), and it is common practice to install subsequent coats immediately using the cross-hatch method.
   iii. CURE TIME: Aromatic and aliphatic polyurea coatings cure and dry to the touch in 3 sec.–20 min. and are usually completely cured in 10–24 hours at 75°F. Cure times may vary depending on temperature, humidity, and coating thickness.
   iv. AMBIENT TEMPERATURE REQUIREMENTS: Apply between 2–43°C (35–110°F).
   v. EQUIPMENT REQUIREMENTS: Vary with specific system. Spray polyurea coatings with plural-component equipment as recommended by the coating manufacturer. (See SPFA-144 Coating Equipment Guidelines.)

f. **Limitations**:
   i. Polyurea coatings cure very quickly and are sprayed with plural-component spray guns which can limit touch-up and detail work.
   ii. Polyurea coatings have a very short time frame for over-coating or tying into coatings that have already been applied.

SECTION IV—THEORETICAL FILM COVERAGE VS. ACTUAL FILM COVERAGE

(1) **Theoretical Coverage**:

a. **Traditional U.S. Units:** The theoretical coverage rate of a coating is the number of roofing squares covered by one gallon of a coating material spread over a flat smooth surface area at a thickness of 1/1000 of an inch (0.001" or 1 mil). One gallon of a coating material that has 100% solids content by volume will cover an area of 16 roofing squares (R2), 1 dry mil thick (16 R2•mil/gal). This definition is used to calculate theoretical coverage rates for coatings containing less than 100% solids. For example, a coating with a 60% (0.60) solid content by volume (SCV) to be applied at 30 mils dry-film thickness (DFT) will be used in the formulas listed to arrive at various theoretical coverages. (NOTE: These calculations use solids content by volume, NOT solids content by weight.)

TO FIND THE THEORETICAL THICKNESS FOR ONE (1) GALLON OF COATING:

Theoretical Thickness per Gallon	= 16 R2•mil/gal•SCV
	= 16 x 0.6
	= 9.6 R2•mil/gal

TO FIND THE THEORETICAL NUMBER OF GALLONS REQUIRED AT
A SPECIFIED THICKNESS:

Theoretical Thickness per Gallon	= DFT / Theoretical Thickness per Gallon
	= 30 mil /9.6 R2•mil/gal
	= 3.1 gal/R2
	(R2 = Roofing Square = 100 square feet)

NOTE: For conversion between traditional U.S. units and metric (SI) units, see SPFA-121 Spray Polyurethane Foam Estimating Reference Guide.

b. **Metric (SI) Units**: The theoretical coverage rate of a coating is the number of square meters covered by one liter of a coating material spread over a flat smooth surface area at a thickness of 1 millimeter. One liter of a coating material that has 100% solid content by volume will cover 1 square meter, 1 dry millimeter thick (1 mm•m2/L). This definition is used to calculate theoretical coverage rates for coatings that contain less than 100% solids. For example, a coating with a 60% (0.60) solids content by volume (SCV) to be applied at 0.8 millimeter dry-film thickness (DFT) will be used in the formulas listed to arrive at various theoretical coverages. (NOTE: These calculations use solids content by volume, NOT solids content by weight.)

TO FIND THE THEORETICAL THICKNESS FOR ONE (1) LITER OF COATING:

Theoretical Thickness per Liter	= % Solids × 1 mm2/L
	= 1 × 0.60
	= 0.60 mm•m2/L

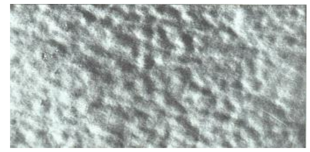
TO FIND THE THEORETICAL NUMBER OF LITERS REQUIRED AT
A SPECIFIED THICKNESS:

Theoretical Thickness per Liter	= DFT / Theoretical Thickness per Liter
	= 0.8 mm•m2/L
	= 1.3 L/m2

(2) **Actual Coverage Requirements**: When coatings are applied over SPF, many factors, such as the polyurethane surface texture, overspray loss, container residue, equipment characteristics, applicator technique, etc., will directly affect the amount of coating material required to meet the designed in-place minimum dry-film thickness (DFT). Therefore, it is very important that additional material be added to the theoretical quantities to ensure that the proper minimum coating thickness is applied. Consideration must be given to the following factors:

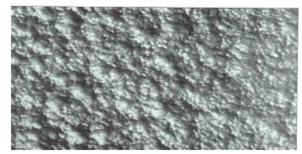
a. **Minimum Dry Film Thickness (DFT):** In order to perform the functions required of the elastomeric coating, the coating material should form a cured film of a prescribed thickness. The surface of SPF is somewhat uneven—SPF is never completely smooth like a piece of glass. Therefore, peaks and valleys exist and the film thickness over the peaks can be considerably less than in the valleys. In order to overcome this potential problem, the minimum DFT of any given coating is defined as the in-place dry-film thickness DFT at its thinnest point on the coated surface.

b. **Polyurethane Foam Surface Textures**: The surface texture of sprayed polyurethane foam influences the extra material needed to achieve the minimum in-place dry-film thickness (DFT). Smoother surfaces require less coating material than rougher surfaces. It is also important to note that excessively rough surface textures must not be coated due to the inability of the coating material to provide complete coverage without voids, pinholes, etc. The following photographs show various polyurethane foam textures that have been established as industry reference standards. An elastomeric coating should not be applied over a surface texture rougher than verge of popcorn.

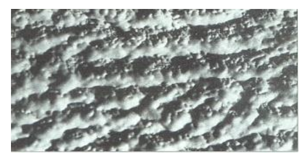


Smooth Surface Texture
Description: The surface exhibits spray undulation and is ideal for receiving a protective coating. Even though the surface texture is classified as smooth, this surface requires at least 5% additional material than the theoretical amount.

Orange Peel Surface Texture
Description: The surface exhibits a fine texture and is compared to the exterior skin of an orange. This surface is considered acceptable for receiving a protective coating. This surface requires at least 10% additional material to the theoretical amount.



Coarse Orange Peel Surface Texture
Description: The surface exhibits a texture where nodules and valleys are approximately the same size and shape. This surface is acceptable for receiving a protective coating because of the roundness of the nodules and valleys. This surface requires at least 25% additional material to the theoretical amount.



Verge of Popcorn Texture
Description: The verge of popcorn surface is the roughest texture suitable for receiving a protective coating. The surface shows a texture where nodules are larger than valleys and the valleys are relatively curved. This surface is considered undesirable because of the additional amount of coating required to protect the surface. This surface requires at least 50% additional material to the theoretical amount.

Popcorn Surface Texture or Tree bark
Description: The surface exhibits texture where valleys form sharp angles. This surface is unacceptable for coating applications.

Over-sprayed Surface Texture
Description: The surface exhibits a coarse textured pattern and/or a pebbled surface. This surface is typically found downwind from the SPF path and can vary from mild to severe. This surface requires 25%–50% additional material to the theoretical amount. Severe over-sprayed surfaces are not acceptable for coating applications.

c. **Wind Loss:** In spray applications, up to 30% of the coating may be lost due to wind. Consider using wind screens and add wind loss to your coating calculations.

d. **Miscellaneous Loss**: A miscellaneous factor must be added to the theoretical coverage rate to cover losses because of material left in containers, equipment problems, etc. Use a percentage factor of 3%–10%, depending on the contractor's experience and efficiency.

(3) **Summary**: After taking into consideration minimum dry-film thickness DFT, polyurethane foam surface textures, wind loss, and miscellaneous loss, you can arrive at a total percentage to add to the theoretical coverage formulas found in Section 111, Paragraphs (1) Metric SI or (2) Traditional U.S. To compare theoretical overages with actual coverage requirements, the formula to find the theoretical amount of liters (gallons) needed to cover one square meter (one roofing square) at a specified dry-film thickness DFT is used.

The example coating is 60% SCV to be applied at 0.8 millimeters (30 mils) dry-film thickness DFT. The additional material percentages (AMP) are as follows:

Orange Peel Texture	—	10%
Wind Loss	—	12%
Miscellaneous	—	5%
Total (AMP)		27%

TO FIND THE ACTUAL THICKNESS FOR ONE (1) GALLON OF COATING:

Actual Coverage = Theoretical Coverage•AMP
= 3.1 gal/R^2 •1.27
= 3.9 actual gallons/roofing square

TO FIND THE ACTUAL THICKNESS FOR ONE (1) LITER OF COATING:

Actual Coverage = Theoretical Coverage•AMP
= 1.3 L/m^2 •1.27
= 1.7 actual liters/square meter

Due to the foregoing variables detailed, specifiers are encouraged to address coating application rates as “dry-film thickness” or “DFT” versus “gallons per square.” This method will provide for simple field quality control by all parties.

SECTION V—FIRE RESISTANCE AND CODE REQUIREMENTS

Coatings based on organic compounds are subject to combustion and exhibit characteristics similar to all other combustibles under fire conditions, such as emitting heat, smoke, and toxic gases. Additives are formulated into coating compositions, inhibiting ignition and/or reducing fuel contribution to a fire.

Users of SPF insulation materials should be familiar with the various applicable test procedures, and codes and laws—national, state, and local. In addition, insurance companies may have specific requirements of fire performance.

NOTE: Polyurethane foam used in interior spaces must be protected by an ignition or thermal barrier and/or smoke detectors or sprinkler systems as required by local building code or insurance requirements (see SPFA-126 Thermal Barriers and Ignition Barriers for the Spray Polyurethane Foam Industry).

The risks involved with combustible roof coverings include exterior flame spread across the surface of the roof and interior flame spread resulting from combustible vapors and liquids entering the building through seams, joints, and openings in the roof's substrate. The following tests and standards have been developed over the years and are designed to evaluate fire propagation for both exterior and interior areas.

(1) **Underwriters Laboratory (UL)**

To be Underwriters Laboratory (UL) Classified, both the coating and SPF must meet UL standards; and material manufacturing facilities are subject to inspections by UL. The system classification denotes specific SPF with specific coatings at a specified maximum slope. For re-cover over an existing roof with a non-combustible deck, SPF roof systems with minimum 3.8 cm (1.5 inch) thick SPF will assume the foam system's fire classification. For combustible decks, the lesser of the existing roof or the SPF roof rating, will prevail.

a. **UL-790 (ASTM E-108):** UL-790 is the UL test for resistance to fire originating from sources outside a building. The tests include the intermittent-flame test, the spread-of-flame test, and the burning-brand test. Systems are rated Class A (best), Class B, and Class C.
b. **UL-723 (ASTM E-84) "Steiner Tunnel Test":** This test is required by building codes for determining the flame spread and smoke development indexes of SPFs. It uses a 25-foot tunnel and compares the performance of polyurethane foam with that of red oak planking. This test can also be used to determine/compare the flame spread and smoke developed indexes of coating systems, per se.
c. **UL-1256:** This tests roof deck constructions and membranes for their resistance to interior fires. Construction Numbers 74, 136,181, 206, and others in the UL Roofing Materials and Systems Directory are spray-applied polyurethane foam systems.

d. **UL-263 Fire Resistance (P Rating):** Measures the ability of the roof, ceiling, and structural members to withstand interior fires for specified time periods, i.e., 1 hour, 2 hours, and 3 hours. New construction designs for SPF are provided in the UL Fire Resistance Directory, under Design No. P733, P826, P830, and others.

(2) **FM Global (Factory Mutual)**
FM Global Approvals test the flame spread potential of building materials and assemblies related to their end-use application. FM Global uses standard FM 4470 to approve systems (Class 1), which are listed in FM's Approval Guide and the RoofNav online database. Approved assemblies are designated with a RoofNav number. In addition, FM publishes Loss Prevention Data sheets, such as the 1-57 Rigid Plastic Building Materials data sheet, which discusses the acceptable uses of various materials and components.

(3) **Summary of Code Approvals**
Although the following model building codes do not have the force of law, they are good references because most state and local codes, which do have the force of law, are based on their provisions:

- International Building Code (IBC): Chapter 15 Roof Assemblies and Rooftop Structures
- International Residential Code (IRC): Chapter 9 Roof Assemblies

SECTION VI—DESIGN CONSIDERATIONS FOR SELECTION OF A PROTECTIVE COATING

The specifier should consider a number of factors on each specific project when making the selection of a suitable protective coating.

(1) **Environmental Conditions**: An elastomeric coating system must be able to cure under the expected climatic conditions in the area of application. Freezing temperatures and/or high relative humidity combined with low temperatures (<60°F) and shaded areas will affect cure times.

The following conditions will also affect cure times:

- Temperatures: Low temperatures generally increase cure times; freezing temperatures may damage the coating film and/or prevent curing. High temperatures can decrease cure times, but may cause problems, such as mudcracking or blistering.
- Humidity: Low humidity generally decreases cure times; however, moisture-cured coatings require moderate-to-high humidity. High humidity may inhibit the cure of acrylic coatings and may negatively impact physical properties of polyurethane coatings.
- Shaded areas: Shading may affect the cure time and the physical properties of various coatings.
- Other conditions: Expected nighttime conditions, probable precipitation, dew, etc.

High tensile strength or abrasion resistance will be required in areas where hail or blowing abrasives are expected. If unusual conditions are present, such as chemical attacks or pollutants, the coating's resistance to these contaminants must be assessed prior to use.

(2) **Code and Flammability Requirements**: Any system specified should meet all local code and insurance requirements.

(3) **Mechanical Damage and Foot Traffic**: A coating must be able to resist anticipated mechanical damage and foot traffic. Key physical properties for a coating system to inhibit mechanical damage are tensile strength, elongation, Shore A Hardness, and dry-film thickness (DFT). Damage resulting from punctures and other surface stresses can be reduced by the use of high tensile strength and high elongation coatings. Increasing DFT in potential damage areas will also reduce the possibility for mechanical damage. Granules and reinforcements in walkway areas are also helpful.

(4) **Moisture Vapor Transmission**: Protective coatings in conjunction with spray-applied polyurethane foam (SPF) can reduce the likelihood of condensation within the SPF or other building components. Install building materials, including SPF and coatings, such that relative vapor impermeability increases toward the side with the higher absolute humidity (usually the warm side). When this practice cannot be followed, install a vapor retarder such that:

   a. The vapor retarder is positioned as close as possible to the side with the higher absolute humidity (usually the warm side).
   b. The vapor retarder has an installed perm rating substantially less than that of the next lowest component.

(5) **Ponding Water**: While all roofs should slope to provide positive drainage, at times this may be difficult to accomplish. In these circumstances, select a coating system that is resistant to the anticipated water accumulation and that will meet with the warrantor's requirements.

(6) **Maintenance**: Recommendations for temporary repair and preventive maintenance procedures for use with coating system should be provided by the manufacturer.

(7) **Aesthetics**: Many coatings used over SPF can be colored or tinted various shades to comply with job requirements. The use of colored granules may create a more uniform appearance on the coated surface. Various colored granules are also available to meet job requirements.

(8) **Other Factors**: Once the selection process has narrowed to a particular type of coating or the systems of a particular manufacturer, the specifier should weigh these factors:

   a. Historical performance
   b. Manufacturer quality control
   c. Warranty
   d. Applicator experience with the coating system

Careful consideration of these factors in the selection process should help ensure a successful, long-lasting application.

SECTION VII—QUALITY CONTROL AND PHYSICAL TESTING

(1) **Manufacturer's Responsibility**: It is the manufacturer's responsibility to provide a product that conforms to its claims relative to the basic product description and uses, physical properties, and in-place performance. In order to ensure that the end-user actually receives a product comparable to the manufacturer's claims, the manufacturer should provide the following:

a. **Literature**: Literature published to provide information about a particular product should include the following: product description, basic uses, wet physical properties, cured physical properties, performance characteristics, fire rating and approvals, building code and insurance acceptance, application instructions, coating DFT requirements and techniques, limitations, and precautions.

b. **Plant Quality Control**: Coating manufacturers should provide strict quality assurance to produce a product that will comply with their advertising and literature claims. All products manufactured should be tested to ensure batch-to-batch uniformity and to determine that product quality is indeed within the established parameters. Manufacturers should also retain liquid samples for a specified time. These samples should be taken from each batch produced.

c. **Shipping and Handling**: Coatings should be properly and expediently shipped to the contractor job site or distributor. The product should be packaged in clean, properly sealed, and labeled containers according to ICC regulations and other pertinent laws. Coatings beyond their shelf life should not be used.

d. **Applicator Training and Approval**: Most manufacturers will help the contractor train personnel to handle and apply their products. This training can be undertaken in formal seminar-type programs or as an in-field exercise, depending on the complexity of the product and/or the equipment necessary for its application.

e. **Job Inspection**: For warranted applications, many manufacturers require various inspections:

i. **Techniques and Procedures**: The job should be inspected to determine that the following areas are in compliance with the manufacturers printed instructions: surface texture, uniformity of coating coverage, minimum coating thickness, existence of pinholes, evidence of uncoated SPF, and overall appearance. Where deficiencies exist, these should be brought to the attention of the contractor for correction. Coating dry-film thickness (DFT) is usually measured from a slit sample using an optical comparator.

ii. **Inspection Tool**s**:** The following is a list of devices used during the application of SPF and coating installation:

- **Moisture Meter**: Measures the degree of moisture within or on the surface of a particular substrate.
- **Psychrometer**: Measures the ambient temperature and humidity.
- **Surface Thermometer**: Reads the temperature of a particular surface.
- **Optical Comparator**: Provides scale, in millimeters, inches, or mils to read the dry-film thickness (DFT) of a coating.

- **Utility Knife**: Cuts slit samples from the installed roof system.
- **Wet Film Thickness Gauge**: Reads wet coating thickness. Spray polyurethane foam surfaces are too irregular for the accurate use of a wet film thickness gauge; these gauges work well over smooth substrates.
- **Caulking Gun with Compatible Caulking Material**: Repairs areas where samples were removed for inspection or where other coating deficiencies exist. Only use silicone sealant on a silicone roof.
- **Coating**: Coats touch-up or test areas with a small amount of coating after installation of caulking.

(2) **Contractor's Responsibility**: The contractor should assume responsibility for product use, handling, and proper application.

a. **Knowledge of Product**:

i. Contractors and their crews should be aware of all the parameters regarding the proper application of a particular product, including uses, packaging, mixing, storage, and all application requirements.

ii. Field personnel should be provided with the proper training and knowledge by both the contractor and the manufacturer to successfully apply the particular system.

iii. Safety Manager should be aware of considerations including personal protective equipment (PPE), first aid, spill cleanup, etc. Refer to SDSs (formerly known as MSDSs) for specific coating product instructions.

b. **Equipment**:

i. Applicators must have a complete understanding of their equipment and its use with the particular material being applied. Of particular importance are mix ratios, solvents, pressures, output, filters, spray tip size, wind screens, and operating temperatures. Personal protective equipment may also be required for some coatings per the product's safety data sheet.

ii. Proper maintenance, repair, and clean-up of equipment will also provide for minimum downtime, increased production, and better crew and product performance.

c. **Job Inspection**:

i. Spot checking product ratios, output coating thickness, and cured film properties are good measures for quality control.

ii. Monitoring specific output measured in gallons (liters), film thickness, and areas covered will provide material yields and more uniform coverage.

The quality control of a coated polyurethane foam system is the responsibility of everyone involved—from the selection and testing of raw materials to the inspections of project slit samples. It is incumbent on all those involved to have the knowledge, equipment, and personnel to provide the most successful application possible in this most important aspect of our industry.

SECTION VIII—PHYSICAL PROPERTY TESTS

(1) **Tensile Strength (ASTM D2370 or ASTM D412)**: This method tests the maximum tensile stress applied during the stretching of a specimen to its rupture point. The type of die used, and the temperature and speed at which the sample is tested should be reported.
   - Tensile strength relates to the membrane's resistance to rupturing when subjected to forces such as the thermal movement or impact by hail or falling objects.

(2) **Elongation, Ultimate (ASTM D412)**: This method tests the maximum extension or stretching of the membrane at the time of rupture. The type of die used, and the temperature and speed at which the sample is tested should be reported.
   - The elongation relates to the membrane's ability to stretch with thermal movement or with various indentations and compressions to the foam.

(3) **Solids by Weight (ASTM D1644)**: These test methods are applicable to coatings and are useful to producers and users in determining nonvolatile content. These tests are sometimes an appropriate measure of the film-forming matter in coating.

(4) **Solids by Volume (ASTM D2697)**: This test method is intended to provide a measure of the volume of dry coating obtainable from a given volume of liquid coating. This value is useful for comparing the coverage (square feet of surface covered at a specified dry-film thickness per unit volume) obtainable with different coating products.

(5) **Weight per Gallon (ASTM D1475)**: Density is weight per unit volume, and is a key property in the identification, characterization, and quality control of a wide range of materials. Density measurements in terms of weight per gallon are commonly used to check coating quality. This is also useful in the shipping and handling of the coating materials.

(6) **Tear Strength (ASTM D624)**: This method tests the measurement of the force required to propagate a tear in the membrane. A die produces a 90° angle cut. The tear strength relates to the resistance of a membrane to tearing or to the migration of a tear.

(7) **Hardness (ASTM D2240 or ASTM D626)**: Hardness is a measurement of a membrane's inherent resistance to compression and indentation. In many instances, a coating with a greater degree of hardness (Shore A range of 40–90) will have better abrasion resistance, as well as resistance to cutting and tearing. Also, some harder coatings have better dirt release properties than softer coatings.

(8) **Abrasion Resistance (ASTM D4060)**: This method tests the measurement of the amount (by weight) of coating lost when subjected to the abrasive wheel of a Taber Abraser. The test is normally performed with a 1,000-gram weight and the weight lost is reported after 1,000 revolutions. The abrasive wheels used for elastomers' membranes are either the CS 17 or CS 10. (The CS 17 wheel is more abrasive than the CS 10 and will produce higher weight-lost figures.) The type of wheel used should be reported.
   - The abrasion resistance is related to the wear resistance of a membrane when subjected to repeated traffic or abrasive materials.

(9) **Impact Resistance (ASTM D2794)**: This test involves a procedure for rapidly deforming by impact a coating film and its substrate (usually a metal panel) and for evaluating the effect of such deformation. The apparatus for this test is a cylindrical weight, which is raised and dropped within a guide onto the coating film from various heights. Failure is indicated by cracks in the film.

(10) **Bond Strength (ASTM D903)**: The measurement of the force required to separate the coating from the substrate (reported in kPa [PSI]).

- The adhesion of the coating may vary, depending on the particular formulation of polyurethane foam used, so the substrate should be reported.

(11) **Moisture Vapor Transmission (ASTM E 96 or ASTM D1653)**: The measurement of the amount of moisture vapor transferred through a membrane.

ASTM E 96 uses perm cups, which are either filled with water or a desiccant, depending on the test method. The amount of moisture that passes through the membrane is measured by weighing the cups at periodic intervals. Two methods are normally used:

a. Procedure B: Water is placed inside the cup, and the cup is placed in an environment of 50% humidity at 23°C (73°F).
b. Procedure E: A desiccant is placed inside the cups, and the cups are placed in an environment of 90% humidity at 38°C (100°F). (Procedure E produces a greater vapor drive and will produce a higher value.)

ASTM D1653 is much the same as ASTM E E96, Procedure B, but uses smaller cups to determine the rate at which water vapor passes through films of paint, varnish, lacquer, and other organic coatings. The films may be free films or they may be applied to porous substrates.
This is related to the coating being a “breather” or “non-breather” and is important where ponding water or high vapor drives are present in the application.

(12) **Water Absorption (ASTM D471)**: The amount of water absorbed by a membrane when totally immersed in water at a given temperature.
This is related to a membrane’s resistance to swelling and temporary or permanent degradation of physical properties because of the influence of retained water.

(13) **Low Temperature Flexibility**: The following four methods can be used:

a. **ASTM D2137**: This method determines the lowest temperature at which flexible elastomeric materials will not exhibit fractures or cracks when subjected to impact.
b. **ASTM D2136**: This method determines the ability of rubber like materials to resist the effects of low temperature when subjected to bending at specified temperatures.
c. **ASTM D522**: These test methods cover the determination of the resistance to cracking (flexibility) of the attached organic coatings on substrates of sheet metal or rubber-type materials.
d. **ASTM C734**: This test method covers a laboratory procedure for the determination of the low-temperature flexibility of latex sealants after 500 hours of artificial weathering.

This factor is particularly relevant to coating performance during the winter season. It is an indication of the coating’s ability to flex and elongate with stress, impact, or building movement at lower temperatures.

(14) **Heat Aging (ASTM D 573)**: The resistance of a membrane to degradation when subjected to various specified elevated temperatures. A typical temperature for an elastomer designed for roofing is 70°C (160°F) for a minimum of 30 days.

This property is pertinent to the membrane's retention of physical properties over an extended period of time and therefore may be related to expected life. It is also correlated to sun loads across various parts of the country.

(15) **Chemical Resistance (ASTM D 471 or ASTM D1308)**: This method tests the ability of a membrane to retain physical properties when subjected to incidental contact, spill, splash, or immersion conditions in various chemical solutions.

(16) **Accelerated Weathering**: Accelerated weathering can be simulated when membranes are subjected to an intense concentrated ultraviolet light, high humidity, or condensation; and elevated temperatures.

Two methods are commonly used:

a. **ASTM G155**: This method uses a Weather-Ometer, which normally cycles between a special light source and a water spray. The light source, which correlates to the spectrum of natural sunlight, is xenon.
b. **ASTM G154**: A UV Fluorescent Accelerated Weathering Tester differs from an Weather-Ometer in that the light source is special UV fluorescent bulbs, and the tester is constructed so that there is warm moisture condensation (up to 80°C [180°F]) on the panel rather than water spray.

Signs of film deterioration and retention of physical properties are recorded at various intervals. These tests are generally used to screen coatings for comparison purposes.

(17) **Mold and Mildew Resistance (ASTM D 3273):** This method tests the resistance of a membrane to mold and mildew growth and the resulting deterioration of film integrity. In addition, the growth also causes an unsightly appearance of the finish.

(18) **Fungi Resistance (ASTM G21)**: This method tests the determination of the effect of fungi on the properties of synthetic polymeric materials in the form of coating materials.

(19) **Solar Reflectance (ASTM C1549)**: This test method covers a technique for determining the solar reflectance of flat opaque materials in a laboratory or in the field using a commercial portable solar Reflectometer. The purpose of the test method is to provide solar reflectance data required to evaluate temperatures and heat flows across surfaces exposed to solar radiation.

(20) **Emissivity (ASTM C1371)**: This test method covers a technique for determination of the emittance of typical materials using a portable differential thermopile Emissometers. The purpose of the test method is to provide a comparative means of quantifying the emittance of opaque, highly thermally conductive materials near room temperature as a parameter in evaluating roof coatings and other materials.

(21) **Solar Reflectance Index (SRI) (ASTM E1980)**: This method determines the calculation of the Solar Reflectance Index (SRI) of horizontal and low-sloped opaque surfaces at standard conditions. The method is intended to calculate SRI for surfaces with emissivity greater than 0.1.

For physical property test procedures related to flammability and building code requirements, see Section V.