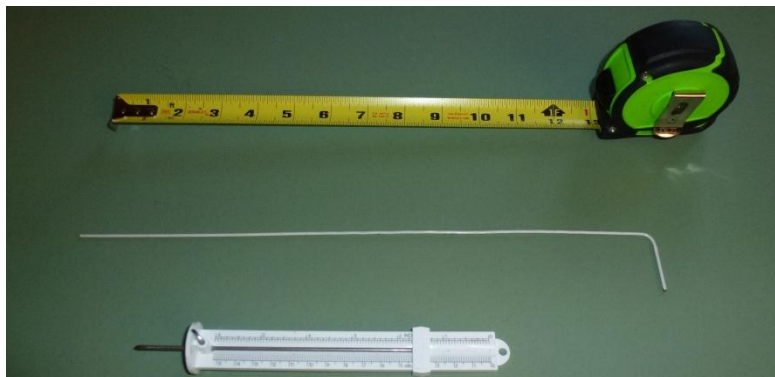


Spray Polyurethane Foam: Guidance on Sampling Techniques for the Inspection of Installed SPF



Spray Foam Coalition
Center for the Polyurethanes Industry



Spray Foam
Coalition

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Section 1: Introduction

1.1: Scope

This document is intended for inspectors that are familiar with Spray Polyurethane Foam (SPF) to provide general guidance and present techniques that can be used for the inspection and sampling of SPF insulation projects, with an emphasis on observation and physical sampling. Air sampling and emissions testing are beyond the scope of this general guidance document. Please keep in mind that the physical sampling and in-situ testing procedures described herein may affect air samples and, subsequently, emissions testing so air sampling and physical sampling are not conducted at the same time. Please remember that this is general information and you should always refer to specific information provided by the product manufacturer on the specific product, code compliance information, ASTM standards, and the client requesting the inspection. This is not an exhaustive list of resources and your inspection will often be based on the specific situation.

1.2: Overview

Generally, SPF insulation inspections follow a multi-step process with each step documented through observation, photography and commentary:

- General observations and visual surface inspection
- Thickness testing
- Physical sampling
 - Qualitative analyses
 - On-site quantitative tests
 - Off-site quantitative tests

Please remember that your specific project may have circumstances that will determine the steps and the sequence of steps necessary.

The purpose and scope of SPF insulation inspections can vary depending on the needs of the inspector's client and is usually stated in writing prior to conducting the inspection. The purpose and scope can include, but is not limited to, the following items:

- Project attributes to be tested or examined;
- The number and locations of sites to be thickness tested and/or sampled; and
- What on-site and off-site (laboratory) tests are to be conducted.

Depending on the inspection scope inspectors can typically familiarize themselves with the SPF project specifications; the manufacturer's installation instructions, code compliance evaluation report(s), Safety Data Sheets (SDS); project specific recommendations; and ASTM standards. This list is not meant to be exhaustive.

A Glossary is included in this document. Most glossary items used in the text of this document are indicated by italicized font.

1.3: Health and Safety

While conducting inspections, inspectors follow job-specific safety requirements and general safe practices, like on any construction site. Occasionally, inspectors may be inspecting an SPF project during active spray application or while using low-pressure SPF kits to repair sample cuts. In such situations, take the appropriate precautions to minimize potential health

and safety exposures. Depending on the nature of the inspection, inspectors may need to consider doing the following and take other actions as appropriate:

- Avoid areas in the immediate vicinity of spraying;
- Wear SPF project specific personal protective equipment (PPE) such as a respirator, coveralls, eye protection and gloves; and
- Avoid areas where liquid components of SPF are being handled.

When an inspector or other professional is repairing sample cuts using low-pressure SPF kits, wear appropriate PPE and review and follow any manufacturer's installation instructions. Specific requirements are beyond the scope of this document. Online chemical health and safety training, as well as best practices for PPE by activity, are available for both low-pressure and high-pressure SPF installation at www.spraypolyurethane.org and EPA's website http://www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html.

Section 2: General Observations and Visual Surface Inspection

Sampling and laboratory testing can benefit from an understanding of the context of the project and the purpose and nature of the inspection. Therefore, prior to probing, sampling, or laboratory testing, inspectors typically conduct a qualitative visual, *tactile* and *olfactory* inspection of the overall project. Documentation of these qualitative observations can include photos (visual items) and notes. When conducting an inspection, include all information that could be useful. For example, include comments and observations of the building occupants and document the specific circumstances of any complaints, such as when, where, and under what conditions.

An example of an inspection sheet is included in Appendix A. This is only an example and may not fit every situation and an inspector may have different components to an inspection. Examples of items and issues to look for can include, but are not limited to, the following:

2.1: Project Characteristics

- Manufacturer
- Contractor
- Installation date(s)
- Building location
- Daily job QC sheets
- Type of SPF (open- or closed-cell, reported density, sealant, etc.)
- Installation locations (walls, ceilings, attics, crawlspaces, under slab, rim joists, etc.)

2.2: Substrate Characteristics

Generally describe to what materials the SPF has been applied. Examples would be: plywood, oriented strand board (OSB), gypsum wallboard, masonry units, brick, among others. Since substrates vary considerably within a given project, note as many as can be identified and which substrates cover large areas versus those that cover small or minor areas. Also, note any substrates where defects, if any, are observed. Use professional judgment to determine what other characteristics may need to be noted.

2.3: Primers

If a primer was used on the project (and discovered by inspection or reported by client/installer), note which types were used (generic type and manufacturer designation) and in what locations, including defects, if any, related to primer use.

2.4: Fire Protection (*Thermal and Ignition Barriers*)

Building codes require that SPF be separated from interior spaces with a *thermal barrier* (for fire protection). Additionally, building codes permit the use of an *ignition barrier* (or specifically tested exposed SPF) in some attics and crawlspaces. Because inspections may take place prior to the building's completion, *thermal* and *ignition barriers* may or may not be in place at the time of inspection. Note in the inspection documentation (with photos as appropriate) where and what types of *thermal* and *ignition barriers* are in place.

The presence of *thermal* and *ignition barriers* may impact qualitative observations and sampling. An inspector may determine that an inspection cannot be completed without the removal or partial removal of the barriers, and may need to request permission to remove and provide a plan for the repair of damaged barriers.

Refer to Spray Polyurethane Foam Alliance (SPFA) Document [AY-126](http://www.sprayfoam.org/uploads/pages/4544/AY-126%20Thermal%20Barriers%20for%20SPF%20Dec%202011.pdf), "Thermal Barriers and Ignition Barriers for the Spray Polyurethane Foam Industry," for additional information on *thermal* and *ignition barriers* (<http://www.sprayfoam.org/uploads/pages/4544/AY-126%20Thermal%20Barriers%20for%20SPF%20Dec%202011.pdf>).

2.5: Visual Observations

Visual observations are those that can be seen with the naked eye. Visual observations can reveal overall characteristics of the project and some defects. Please note this is an example of what to look for during an inspection and some defects can only be identified from a core sample. Examples of detectable defects by visual observations may include the following examples:

2.5.1: Cracks

Cracks are characterized by a foam-to-foam *cohesive* failure. Their appearance may be random or patterned. Note location(s), characteristics (i.e. random, patterned), approximate size and numbers. An example of a crack is in Figure 1.



Figure 1: Crack in foam. (Photo courtesy of Henri Fennell Consulting)

2.5.2: Surface Appearance

SPF typically appears relatively uniform in color and surface profile. These topics are discussed in more detail in later sections. The SPF surface may be shaved or sanded (wherein the surface will be relatively flat) or the surface may have its top skin in place (resulting in an undulating surface appearance). Figures 2, 3, 4 and 5 are examples of various surface appearances.



Figure 2: Typical appearance of closed-cell SPF.



Figure 3: Typical appearance of open-cell SPF.



Figure 4: Typical appearance of shaved SPF (be aware that shadows in photographs can make uniform foam appear multiple colors in photographs).



2.5.3: Shrinkage

Shrinkage manifests itself as cracks or crevasses as a result of either *cohesive* (e.g., cracks within the mass of SPF) or *adhesive* (e.g., cracks between the SPF and a stud or substrate) failure. Shrinkage resulting in cracks is considered a defect and is often documented in inspections (see previous section).



Figure 5: Foam shrinkage.

2.5.4: Gaps and Voids

Gaps are unintentional openings in the thermal envelope which may permit excessive heat transfer. Examples include areas mistakenly not sprayed or sprayed too thin or areas where shrinkage has left gaps between the SPF and a stud or substrate. Gaps are considered defects and are documented in inspections.

Voids are uninsulated air spaces within building assemblies caused by the installation of interior (or exterior) finishing material over an otherwise satisfactory SPF surface. An example of a void is the air space resulting when a building assembly's R-value may be met without completely filling the cavity with SPF. Voids, per se, are not defects, provided a sufficient thickness of SPF has been applied to meet the intended function (such as insulation or air barrier). Voids are a normal consequence of partially filled cavity walls (See Figure 7).

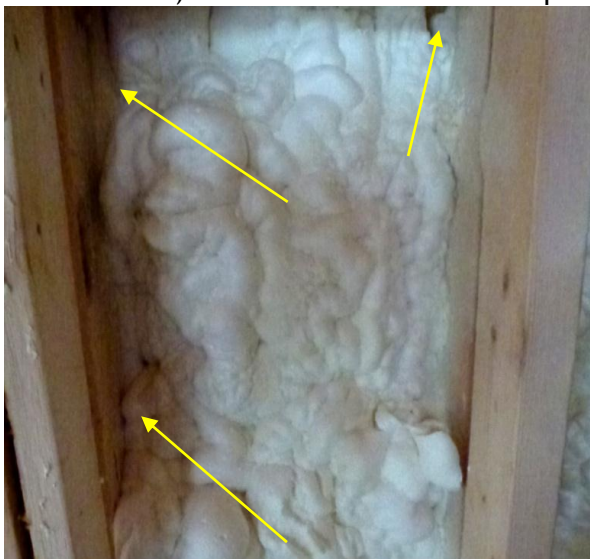


Figure 6: Example of Gaps.



Figure 7: Space between interior finish and SPF due to partially filled wall cavity.

2.5.5: Mechanical Damage

The SPF surface may become damaged as the result of mechanical damage (e.g., it was inadvertently struck by a tool or fork lift). Such damage would be considered a defect and documented accordingly in an inspection.

2.6: Color

Document the overall surface color and note differences where observed in the color of the SPF. There is a further discussion of core sample color under the On-Site Qualitative Examination section.

2.6.1: Overall

SPF color is variable for a number of reasons, including the following:

- Some manufacturers add colorants to their formulations for identification or marketing purposes. Unless pigmented or dyed, SPF color can be described as tan, beige, or buff in most but not all situations.
- SPF's raw materials (e.g., A- and B-side components) can vary in color and affect foam color.
- UV radiation (sunlight) exposure tends to darken the color of SPF to an orange or rusty coloration, which is discussed further under On-Site Qualitative Examination.

Describing color is dependent on each inspector's interpretation as well.

2.6.2: Uniformity

While SPF color varies, unless different SPF products have been applied, the color is likely to be relatively uniform throughout the project. This is not always the case. UV degradation can be an exception to this.

2.6.3: Blotchiness

An Inspector may observe blotchiness on the surface of SPF as either an irregular dark or a light patch. This can be due to a number of factors, which could include: off-ratio foam, dark foam lacking B-component, light foam lacking A-component. See the discussion on Off-Ratio Foam below.

2.7: Blisters and Delaminations

Delamination occurs when the bond between the SPF and the substrate or a prior foam pass is broken. A blister occurs when the effect of the delamination is an uplifting or bulging of the foam surface. Frequently, the cause of either one can be a weak adhesive bond between the foam and the substrate or between the foam and the prior foam pass.

Small, isolated delaminations or blisters may not present a defect sufficient to impact the SPF's performance. Widespread, large delaminations and blisters could affect performance and may be symptomatic of application or material defects.

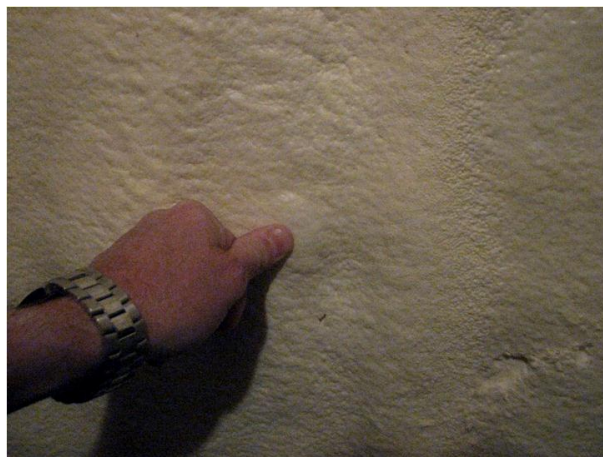


Figure 8: Verifying a possible blister. (Photo courtesy of the Spray Polyurethane Foam Alliance)

Blisters typically can be seen and verified by touch: they may have a slight give to them whereas a bulge created by solid SPF will be firm. Delaminations typically can be identified by lightly tapping the SPF surface with an open palm; a hollow feel or sound is indicative of a delamination.

Locations and extent of blisters and delaminations are documented by Inspectors.

2.8: Odor

During SPF applications, odors are common and normal. During retrofit applications, existing problems prior to the installation of SPF, such as moldy or mildewed carpets, wet ducts, or existing insulation, may be accentuated by the tighter building envelope that results from the application of SPF. Once the project is completed and the spray area ventilated, odors generally dissipate. Lingering odors may be the result of several factors and can be a combination of numerous sources, making it difficult to identify them. Sources of odors in new construction and retrofit applications can include: SPF; other construction materials, such as paints, cleansers, lumber, finishing treatments; occupant life style; nearby industrial or other emissions; pre-existing (“old house”) odors; construction defects, such as misrouted plumbing vents; or high individual sensitivity.

Odors may be noticed within areas of the building, for example, specific rooms, or when taking or examining a core sample. Document the presence of odor, describe its characteristics with specific adjectives such as “fishy,” or “rotten egg,” and where and under what conditions it was noticed.

2.9: Surface Profile

As SPF is field applied, the foam surface will tend to be undulating. SPF surfaces are not flat unless they have been mechanically sanded or shaved. An undulating surface is not considered a defect unless its effect is extreme to the point that the irregularity adversely affects the SPF’s intended function. Lower-density, open-cell SPFs tend to have greater surface profile variation than medium-density, closed-cell SPFs.

Closed-cell SPF, at thicknesses of approximately 2 - 3 inches, typically exhibit profile variations of $\frac{1}{4}$ to $\frac{3}{4}$ inch. Open-cell SPF, at thicknesses of approximately 3.5 - 5.5 inches, typically exhibit profile variations of $\frac{1}{2}$ to 1 inch. Review the Manufacturer’s information for the specific SPF’s typical profile variation.

Surface profile affects the way thickness measurements are taken. If the inspection includes thickness measurements, then document the foam’s surface profile and whether or not the thickness was measured at a high point or a low point in the foam.

Section 3: Thickness Testing (Probes)

SPF thickness is generally determined by probing with a wire probe and measuring the depth penetrated. Some probing devices have built in measuring scales which may limit the maximum depth which can be measured. Often inspectors use improvised probes consisting of a stiff wire, such as a coat hanger wire, and measure depth penetrated with a ruler or scale.

The surface profile will affect the depth measurement. A highly undulating foam surface may make representative measurements difficult (particularly if the probe device has a disk-

shaped base). If using an improvised wire probe, take thickness measurements at a variety of high and low locations. Note in the inspection report the surface profile characteristics.

The frequency of thickness testing can be mutually agreed upon by the inspector and client prior to conducting any inspection. Certain building code jurisdictions may have specific requirements. As a general idea for inspections addressing the overall quality of an SPF project, see Table 1 below. These are not job specific so adjust as needed to suit the size of the project and needs and requirements of the building owner.

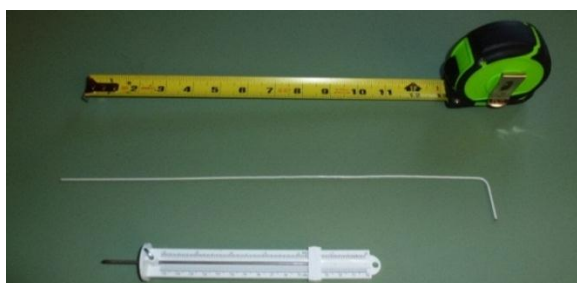


Figure 10: Thickness testing tools

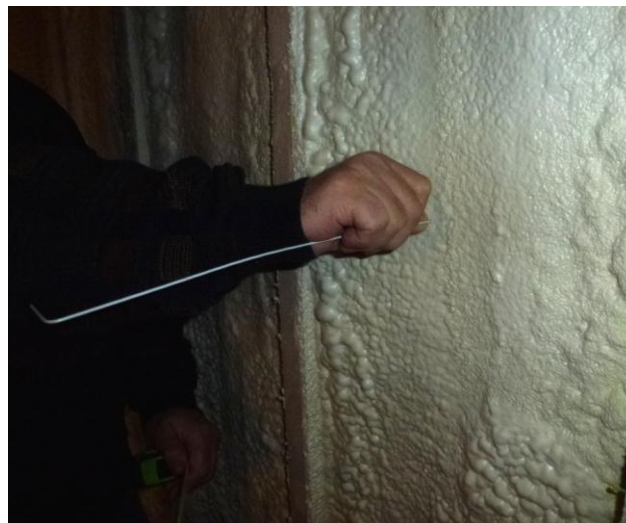


Figure 9: Using a wire probe to test thickness.

Table 1: Examples of Thickness Probe Frequency

| Project Size | Area Assemblies (walls, floors, ceilings, roof decks, etc.) | Lineal Assemblies (rim joists, etc.) | Minimum No. per Assembly Type | Minimum No. per Project |
|----------------------------------|--|---|-------------------------------------|----------------------------|
| Small (<10,000 ft ²) | 1 per 100 ft ² | 1 per 10 linear ft | 6 | 25 |
| Large (>10,000 ft ²) | 1 per 500 ft ² | N/A | 6 | 25 |

Section 4: Sampling

Sampling the SPF provides access below the skin to assess overall SPF quality, to diagnose specific problems and to permit measurements of physical properties. Sample type and size are determined by the sampling objective (i.e., qualitative examination, on-site or off-site quantitative analyses, ASTM test standard). Sample types, from lesser to more intrusive, are as follows:

4.1: Slits

Slit samples are surface cuts in the SPF mass intended to examine surface characteristics rather than the full SPF profile or physical properties. Slits are normally prismatic in shape, although they do not have to be. Slits have approximate dimensions of ½ inch wide by ½ inch deep by 3 inches long. Slit samples are primarily taken to measure the dry film thickness of coatings used over SPF, such as intumescent thermal or ignition barriers.

4.2: Cores

Core samples are frequently cylindrical in shape (2 - 3 inches diameter) showing the full profile of the SPF from substrate to final skin. Cores are typically cut using a core cutter designed for this purpose. Core cutters may be purchased or fabricated at a local machine shop.



Figure 11: Coring tool with handle/pusher and plugs.



Figure 12: Using the coring tool to extract a core sample.

The cutting edge of the coring tool will influence the quality of the core sample. A smooth, knife-edge cutting blade results in a smooth core surface that can be readily examined. A rough-surfaced cutting edge, such as a deeply toothed roof coring tool or a saw blade, will tear into the foam as opposed to cutting into the foam. This could result in a rough surface that could hide the visual characteristics of the foam's cross-sectional profile. Under these conditions, consider if the core sample may be cut longitudinally with a sharp knife to expose a smooth surface for examination.

Core samples assist in the following analyses:

- Determining number and thickness of passes and overall thickness;
- Determining characteristics such as off-ratio foam; scorching; *knit line* adhesion and UV degradation; color inconsistencies; odor; and cell structure; and
- On-site density and compression testing

Depending on how well the SPF is adhered to its substrate, it may not be easy to remove the core. In these cases, use a long knife to cut a wedge from the adjoining SPF. This can provide access to the base of the core where a pry bar may be inserted to free the core.



Figure 13: This specimen was cleanly sliced from a cylindrical core sample.

Note: Cores do not have to be cylindrical in shape. Other options include a triangular or square shaped core because the primary reason to extract a core sample is to examine the full profile of the SPF mass, making the base shape of the core unimportant.

Core sample locations and frequency are determined by the nature, purpose and scope of the inspection as well as the size of the project. For example, for an Inspector whose purpose is to troubleshoot or diagnose a problem, probing or sampling may be limited to specific areas.

Typically, the frequency of core sampling is mutually agreed upon by the Inspector and client prior to conducting any inspection. As guidance on inspections addressing the overall quality of an SPF project, see Table 2 below for general information to consider.

Table 2: Examples of Core Sample Frequency

| Project Size | Area Assemblies (walls, floors, ceilings, roof decks, etc.) | Lineal Assemblies (rim joists, etc.) | Maximum No. per Project |
|----------------------------------|--|---|----------------------------|
| Small (<10,000 ft ²) | 1 per assembly | 1 per 50 linear ft | 10 |
| Large (>10,000 ft ²) | 1 per 3000 ft ² | NA | 10 |

4.3: Rectangular Sections/Slabs

For most samples acquired for laboratory testing, a rectangular section or slab is removed from the field assembly. Some may be cut from core samples. Size will be dependent on the specific test (see Table 4 for ASTM test sample requirements). Consult with the test laboratory ahead of time to determine what size sample the lab requires, keeping in mind that the laboratory will likely need to trim the edges and surfaces prior to testing.

Rectangular samples may be cut with a knife or reciprocating power saw. Depending on how well the SPF is adhered to the substrate, removing the sample may present some difficulty and a pry bar may be required to loosen the sample. Sample cutting and removal will likely damage the sample's surface and require trimming at the laboratory. To allow for some trimming, extract larger samples than needed for testing.

Slab samples are not normally required for routine quality control inspections. Sample locations and frequency will be determined by the nature, purpose and scope of the inspection as well as the size of the project and what the Inspector and client mutually agree to prior to conducting the inspection.

4.4: Documentation

Document samples by assigning them a unique number or letter, or a combination of numbers and letters. Indicate location, total thickness, individual pass thicknesses and unusual characteristics identified by sight, touch or smell. Photograph the sample and its location. Identify and store samples in plastic bags or other appropriate containers (see section on Packaging Samples and Preparing for Shipment for additional information).

Section 5: On-Site Qualitative Examination

Consider examining core samples and rectangular sections on-site for the following characteristics:

5.1: Color

5.1.1: Streakiness

Document the presence and extent of visually detected streakiness, such as darker then lighter SPF within the same sample area.

5.1.2: Scorching

Scorching may occur when the SPF becomes excessively hot during its application and cure phase. When SPF's *exothermic* reaction results in the foam getting too hot for too long a period of time, the foam may degrade, resulting in scorching indicated by a brownish discoloration. The affected area is usually within the foam mass and not observable without cutting a core sample.



Figure 14: Scorching from applying too thick causing excessive heat.

If observed, document the presence and extent.

5.1.3: UV Degradation

Ultra-violet radiation (such as from sunlight) can degrade and darken the exposed surface of SPF. The degradation occurs on the surface, whereas the interior of the SPF mass is not affected. The SPF surface tends to turn an orange or rusty color. After prolonged exposure, the degraded foam surface typically becomes dusty and friable.

UV degradation primarily affects the *adhesion* of materials subsequently applied to the SPF, such as additional SPF or a coating. If the UV exposure and degradation continues for an extended period of time, the degraded foam may gradually erode, resulting in a loss of foam thickness.



Figure 15: Effects of UV radiation.

Interior applications typically do not have UV degradation since the foam surface is protected by the building. However, exterior applications, such as masonry cavity walls, may be subjected to UV degradation if left uncovered for a period of time. UV degradation is typically considered a defect only if it impacts the performance of the foam or adhesion of material (i.e. SPF or coatings) applied over the foam.

If a core sample exhibits a darker, rusty *knit line* between passes of SPF, this may signify UV degradation at that knit line. This may be an indication that fresh foam has been applied to older, UV degraded foam. The adhesion at such a *knit line* can be weak. A tensile adhesion test could be used to determine if the knit line bond is satisfactory.

Document the presence and extent of UV degradation. For UV degraded exposed foam surfaces, document whether or not the UV degraded surface is to receive additional foam or a coating.

5.2: Foam Profile (Cross-Sectional)

Core samples are normally extracted to provide a full-depth sample of the SPF, from its substrate to its top skin surface. Within this cross section, *knit lines* may be evident indicating the number of passes or lifts, and the thickness of those passes.

When taking core samples, document the number and thickness of passes and the total thickness for each core.

5.3: Cell Structure Consistency

When visually examining an SPF core sample, the foam profile (substrate to surface) is typically uniform and the cells are small and consistent. The cell structure is tight, small and consistent at the substrate interface and on either side of *knit lines*.

Potential cell structure defects could include the following:

- Internal voids: A large cell forming within the SPF mass, which may be due to air entrapment. These may constitute a defect if the internal voids are large or frequent enough to significantly affect the SPF's performance (Figures 16 and 17).
- Open, irregular cells: A layer of open, irregular cells may be an indication that moisture was introduced or present on the substrate. If extensive, this can lead to structural failure of the cell layer, *blistering* and/or *delamination* (Figure 18).
- Elongated cells: Isolated, occasional elongated cells that are visually detectable do not normally constitute a defect. If extensive, then consider documenting (Figure 19).



Figure 16: Example of internal void (open-cell SPF).



Figure 17: Example of internal void (closed-cell SPF).



Figure 18: Example of open, irregular cells. (Photo courtesy of the Spray Polyurethane Foam Alliance)

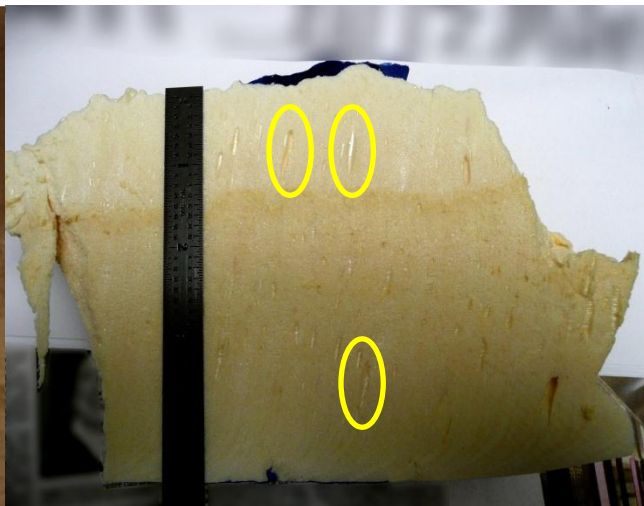


Figure 19: Example of elongated cells.

5.4: *Knit-line* Adhesion

When SPF is applied, it forms a surface skin which is typically denser than the core of the foam mass. When SPF is applied to an existing SPF surface, the adhesion of the subsequent foam pass forms a *knit line* with the first pass. Normal *knit lines* are strong, exhibiting excellent adhesion.

If an older foam has surface defects, such as extensive UV degradation or moisture present, the resulting *knit line* may be weak. *Knit line* adhesion can be qualitatively tested by attempting to break apart a core sample or a segment, also known as a slice, of a core sample.

Note: Quantitative knit line adhesion may be tested using a tensile adhesion tester. See further discussion in the On-Site Quantitative Tests section.

UV degradation may be identifiable by a rusty-colored *knit line*. Moisture may be identifiable by a layer of enlarged, irregular cells at the *knit line*. Document the evidence and the extent of weak *knit lines*.

5.5: Off-Ratio Foam: Stickiness or Brittleness

Typically, commercial SPF insulation systems are designed to be applied in a one-to-one ratio (by volume) of the A- and B-components. Malfunctions can occur that could upset the SPF ratio, such as line or strainer blockages, running out of one material and pump cavitation.

Off-ratio foam is normally classified by the lacking material, thus off-ratio foam may be said to be “B-side lacking” or “A-side lacking.” Opposite jargon is also used: “B-rich” or “A-rich.” Off-ratio SPF may not provide the same physical properties of on-ratio SPF. In the field, off-ratio foam at times can be identified by its color and feel, but there are exceptions. Table 3 below provides some general characteristics of off-ratio SPF. The SPF manufacturer can also provide additional guidance for the specific SPF being used.

Table 3: General Characteristics of Some Off-Ratio Foams

| Off-Ratio Condition | | Color | Feel |
|---------------------|----------|--------------------------|---|
| A-side lacking | (B-rich) | Lighter than normal SPF. | Sticky, spongy, soft. |
| B-side lacking | (A-rich) | Darker than normal SPF. | Brittle, hard, glassy, <i>friable</i> . |

Characteristics of off-ratio SPF may be observable on the surface or within core samples. Off-ratio SPF is considered a defect. Document its presence, location and extent.

5.6: Odor

Odors may be noticed while extracting samples or within the sample. Document the presence of odor and describe its characteristics with descriptive words such as “fishy” or “rotten egg,” along with other sample documentation.

5.7: Photographic Documentation

Take photographs of the SPF. When appropriate, include a scale or a common object in the photograph to provide scale. Include the following, which is not an exhaustive list:

- Samples themselves
- Sample locations
- Information or notes for the inspector
- Information or notes to communicate to the report reader

Section 6: On-Site Quantitative Tests

Quantitative testing may include the use of on-site test equipment. The objective is to quantify certain physical properties of the SPF that can readily be determined in the field. Inspectors and clients typically agree in advance of the inspection process as to the applicability and interpretation of on-site tests.

Common on-site quantitative tests include density, adhesion, and compressive strength. There are specialized test kits and equipment for measuring these physical properties. These tests may or may not have an ASTM or other consensus standard associated with them. Follow the directions of the test equipment suppliers when conducting on-site quantitative tests.

6.1: Density

Density is the ratio of weight to volume. To determine the density of an SPF sample, both weight and volume need to be determined. Weight determination can be obtained by weighing the sample using a calibrated balance. Typical density units of SPF are lb/ft³ and kg/m³.

Examples of volume measurement include water displacement or measurement and calculation. **Water Displacement (for closed-cell foams only):** An SPF sample is cut to a size that fits inside a graduated cylinder. The SPF sample is weighed. The cylinder is partially filled with water and the water volume noted. The sample is then fully submerged into the water and the combined water plus sample volume noted. The sample volume is equal to the water volume subtracted from the water plus sample volume. The density is then calculated by dividing the sample weight by the sample volume. The water displacement method is not suitable for open-cell SPF. **Measurement and Calculation:** An SPF sample is cut to form a regular shape such as a cylinder, cube or rectangular solid. The sample is weighed. The sample dimensions are measured using a micrometer, caliper or steel rule. These dimensions are then used to calculate the sample volume. The density is calculated by dividing the sample weight by the sample volume.

6.2: Adhesion

Adhesion of SPF to its substrate, including knit line adhesion, may be determined on-site using a pull tester. Follow the manufacturer's instructions on how to complete such a test. ASTM D 4541 (Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers) may be followed.



Figure 20: Pull tester for adhesion testing. (Photo courtesy of Com-Ten)

6.3: Compressive Strength

Field compression testers are available. Some are adaptations of the pull tester. Follow the manufacturer's instructions for determining compressive strength. See Figure 20.

Section 7: Off-Site (Laboratory) Quantitative Tests

Quantitative analyses may include the use of off-site, laboratory-based test equipment. The objective is to quantify certain physical properties of the SPF that cannot readily be determined in the field. Inspectors and clients typically agree in advance of the inspection process as to which laboratory quantitative analyses are to be performed.

There are additional SPF properties that may be of interest to the Inspector or client but cannot be tested using field-acquired samples. Such tests include fire tests, thermal resistance tests, foam ratio tests, and air permeance tests.

7.1: Laboratory Tests

Table 4 lists common physical property tests that could be conducted on SPF samples removed from projects at laboratories. Most of the test methods in Table 4 require that test specimens be specifically prepared under controlled conditions. For example, substrates, spraying conditions and the presence of skins or *knit lines* may affect the test result. Samples taken from the field may not meet the requirements of the test standard. The number and size of samples taken from a field inspection may be modified with agreement between the Inspector, client and laboratory.

Table 4: Common Physical Property Tests for SPF

| Test | Purpose | No. of Samples (min) | Sample Description |
|--|--|-----------------------|---|
| ASTM C 1621 Standard Test Method for Compressive Properties Of Rigid Cellular Plastics | Compressive Strength | 5 | 4 to 36 in ² by 1 in (min) thick. |
| ASTM D 1622 Standard Test Method for Apparent Density of Rigid Cellular Plastics | Core Density | 3 | Size and shape whose volume can be readily measured and calculated, min 1 in ³ . |
| ASTM D 1623 Standard Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics | Tensile Strength | 3 | Sample size dependent on test equipment. Consult with laboratory for specifics. |
| ASTM D 2126 Standard Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging | Dimensional Stability | 2 | 4" x 4" x 1" Consult with laboratory for specifics. |
| ASTM D 4541 Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers | Adhesion | Not specified | Consult with client and/or laboratory for specifics. |
| ASTM D 6226 Standard Test Method for Open Cell Content of Rigid Cellular Plastics | Closed/Open Cell Content | 3 sets of 2 (6 total) | 3 sets of 2 cubes @ 1" x 1" x 1" |
| ASTM E 96 Standard Test Methods for Water Vapor Transmission of Materials | Water Vapor Transmission, Desiccant Method | 3 | Consult with laboratory for specifics. |

Section 8: Repair of Sampled SPF Assemblies

Probing and the removal of samples may violate the integrity of the SPF assembly as a continuous thermal envelope or air barrier. Therefore, Inspectors typically repair holes and gaps left by inspection activities. Common repair methods for consideration are included below.

Use the appropriate personal protective equipment when applying materials to reseal probe and sample holes. Follow the manufacturer's instructions when handling all materials.

8.1: Using Spray-Applied Polyurethane Foam

Sample holes like core holes may be filled with additional SPF of various varieties by a professional applicator.

High-Pressure SPF

When inspecting a project where the SPF applicator is still working, sample holes may be filled with the same high-pressure SPF that was removed during the sampling process. Negotiate this with the SPF applicator as appropriate.

Low-Pressure SPF

Low-pressure SPF is available as single- or two-component systems in containers easily transported and utilized. Consider a trained professional to apply two-component low-pressure SPF. These systems usually come with their own spray hoses and nozzles. They are typically packaged in sizes to meet specific physical properties and volume requirements (in board feet). Many low-pressure SPF systems are closed-cell foams which can be used to repair either open- or closed-cell assemblies.



Figure 21: Low-Pressure System

8.2: Plugs

For core holes, foam plugs may be used as fillers. Foam plugs may be cut from insulation boards, or SPF sprayed onto cardboard panels, using the same coring tool utilized to cut the core (thus provides plugs of the correct diameter). Plug material should have the same or greater thermal resistance (R-value per inch) and air resistance of the SPF being sampled. Coat plugs with caulk or sealant to reestablish the original SPF's air barrier integrity.

For larger, rectangular sample holes, plugs or inserts may not be appropriate because of the difficulty in reestablishing the air seal of the original application. Project specific conditions may permit the use of foam inserts. Refer to manufacturer's recommendations on how to use plugs.



Figure 22: Repairing a core hole with plug and sealant.

8.3: Sealants

Sealants and caulks, while capable of providing an air seal, typically do not have the same R-value as the original SPF because they are not an insulation material. In some circumstances, sealants and caulks may be used to repair shallow slit samples and probe holes without detrimentally affecting the overall thermal envelope. Refer to manufacturer’s instructions on how to repair.

Table 5: General Guidance on Repair Techniques

| Type of Penetration | Examples of Repair Material |
|---------------------|---|
| Thickness probe | Sealant or caulk |
| Slit Sample | Sealant or caulk |
| Core hole | High- or low-pressure SPF; plugs with sealant/caulk |
| Rectangular holes | High- or low-pressure SPF |

Section 9: Packaging Samples and Preparing for Shipment

Samples generally can be packaged and shipped in plastic bags suitable for freezing food items (see exception below). Clearly identify each sample so that it can be cross referenced to inspection documentation. Avoid writing sample ID information on the sample itself as this may affect test results.

When shipping samples, package in sturdy, corrugated boxes with a generous amount of packing materials cushioning all sides of the sample(s). Ship samples to the laboratory via a carrier suitable to the destination laboratory.

Exception: For samples destined for environmental emissions testing, follow the requirements in ASTM D 7859 “Standard Practice for Spraying, Sampling, Packaging, and Test Specimen Preparation of Spray Polyurethane Foam (SPF) Insulation for Testing of Emissions Using Environmental Chambers,” which sets forth requirements, including that SPF samples be wrapped in aluminum foil, secured in a layered PET bag and shipped in an insulated cooler. Refer to the actual standard for specific guidance.

Section 10: Tools and Supplies

The following tools and equipment are frequently used for conducting SPF insulation inspections:

- Camera
- Core hole repair materials
- Coring tool(s)
- Knife
- Notebook
- Sample bags
- Tape measure
- Thickness probe(s)
- Magnifying glass and/or optical comparator (optional)
- Onsite testing equipment for density and adhesion (optional)
- Appropriate Personal Protective Equipment

Section 11: Glossary

| | |
|---------------------|---|
| A-side, A-component | Polymeric methyl diisocyanate (pMDI). One component of a two-component SPF system. |
| Adhesive, Adhesion | The bonding of one substance to another or the bonding between applications of the same substance. |
| B-side, B-component | Blend of polyols and other ingredients composing one component of a two-component SPF. |
| Blister | An uplifting of coating or polyurethane foam caused by an enclosed pocket of gas or liquid entrapped between coating passes, foam and coating, foam and substrate, or within the foam itself. |
| Cohesive, Cohesion | The bonding of one substance to itself. |
| Delamination | The separation of layers within a material or materials. May result in blister formation. |
| Exothermic | Characterized by heat generated by a chemical reaction. |
| Friable | The tendency of a material or product to crumble or break into small pieces easily. |
| Gap | An unintended, uninsulated or underinsulated area at the edge of an insulated area or penetration of the insulation. |
| Ignition Barrier | A protective covering used in attics and/or crawlspaces over SPF to decrease the SPF's chance of igniting when exposed to heat or flame. Building codes provide a list of prescriptive ignition barriers, but others may be permitted provided appropriate testing has been conducted. Review buildings code for more information. Prescriptive ignition barriers are listed in the International Residential Code (IRC) and the International Building Code (IBC). |
| Knit line | The adhesion plane between spray polyurethane foam passes. |
| Olfactory | Relating to the sense of smell. |
| Optical Comparator | An eyepiece with magnification ranging from 4-12 power, with a scale used for measuring thickness. |
| Qualitative | Properties which can be described generally but not numerically (e.g., "rusty in color"). |
| Quantitative | Properties which can be described numerically (e.g., "density is 2.1 lb/ft ³ "). |

| | |
|-----------------|---|
| Tactile | Perceptible by touch; relating to the sense of touch. |
| Thermal Barrier | A material applied over polyurethane foam designed to slow the temperature rise of the foam during a fire situation and delay its involvement in the fire. Thermal barriers for use with polyurethane foam are required by building codes to have a time rating of not less than 15 minutes. Building codes prescribe ½-inch gypsum wall board one option for a thermal barrier. Others are permitted once appropriately tested for equivalent performance as defined in the building code. Review building codes for more information. |
| Void | An uninsulated space within an enclosed building assembly created when the assembly has been insulated by partial filling of the framed cavity. The partial fill results in an air space (void) between the insulation surface and the assembly's exterior or interior layers. |

Section 12: Acronyms

| | |
|------|--|
| ASTM | ASTM International (formerly American Society for Testing and Materials) |
| CPI | Center for the Polyurethanes Industry |
| MSDS | Material Safety Data Sheet |
| PET | Polyethylene terephthalate |
| SFC | Spray Foam Coalition |
| SPF | Spray polyurethane foam |
| SPFA | Spray Polyurethane Foam Alliance |
| UV | Ultra-violet |

Appendix A: Example of an Inspection Form

An inspection form may include a number of components. The following is only an example and you may have different components in your form due to your inspection.

1. Inspection Date

2. Inspector Information

Inspection Company Name

Street (PO) Address

City

_____ State, Zip _____

Telephone No.

_____ Fax _____ Email _____

Inspector's Name

3. SPF Applicator Information

Contracting Company Name

Street (PO) Address

City

_____ State, Zip _____

Telephone No.

_____ Email _____

Name(s) of Contractor's Representative(s)

Accompanying Inspection (if any)

4. Project Information

Project Name or ID

Street Address

City

_____ State, Zip _____

Date of SPF Completion

New Construction Renovation Other _____

Type: Residential Commercial Other: _____

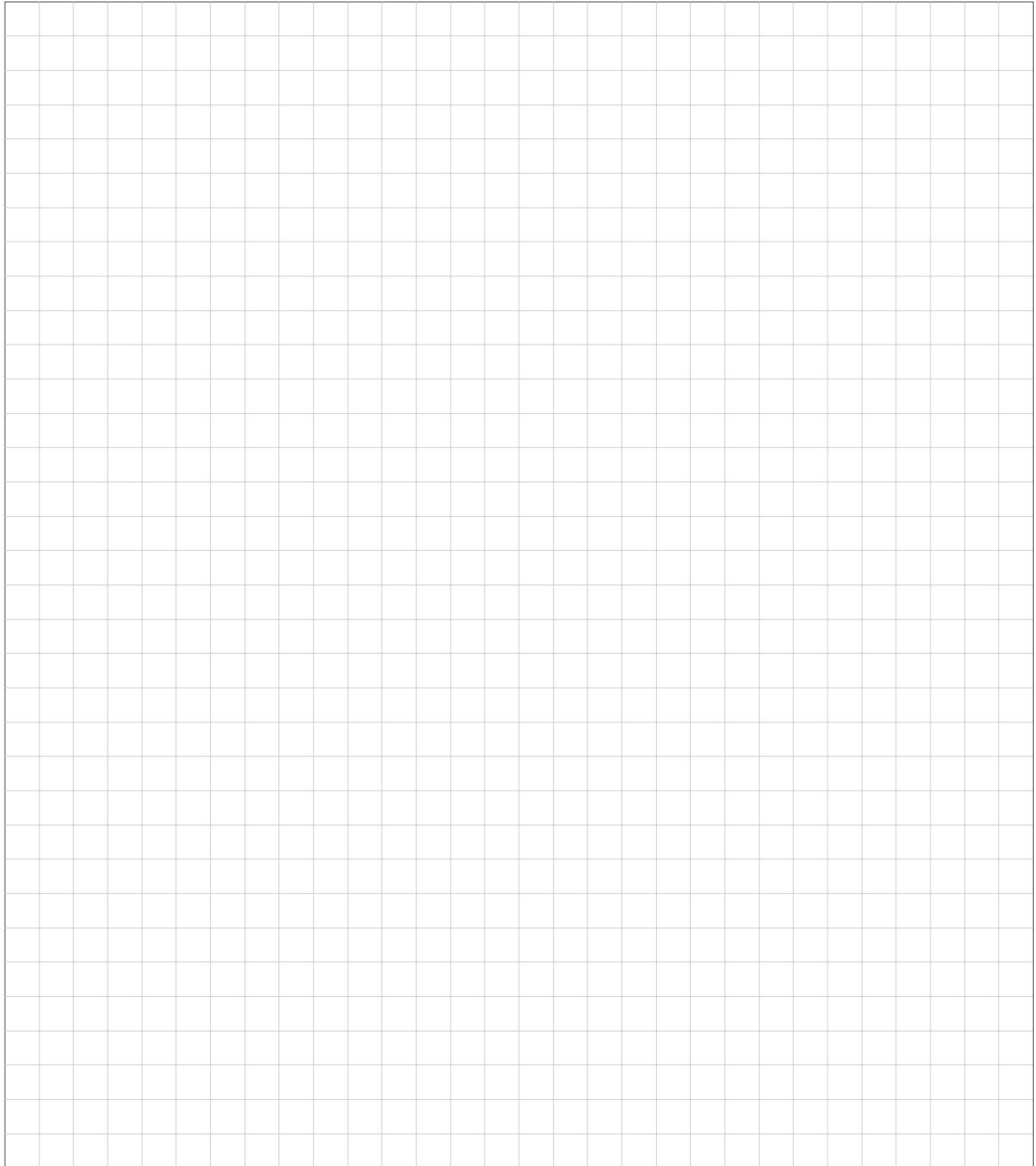
Type SPF used: Closed-cell Open-cell Multiple types Other _____

Description of Project Scope (include a list of the insulated building assembly types and approximate areas):

Purpose of Inspection:

5. Project Sketch

Note: Sketch is intended to show overall layout of Project to be able to identify where samples and/or photographs are taken. The nature of the sketch will be dependent upon the project type and scope and the detail will be at the discretion of the Inspector. Use additional pages as needed. Where appropriate, indicate which direction is north.

A large, empty grid area for drawing a project sketch. The grid consists of 20 columns and 30 rows of small squares, providing a structured space for the inspector to sketch the overall layout of the project.

6. Visual Inspection Observations

Provide additional comments on last page of this report or attached additional pages as needed. A “Yes” indicates installation is acceptable; a “No” indicates deficiencies; an “NA” indicates not applicable on this Project.

| Yes | No | NA | Crawlspace/Floor Insulation (NA if floors slab on grade) |
|-----|----|----|---|
| | | | All floor joist cavity insulation installed to uniformly fit the cavity side-to-side and end-to-end (vented crawlspaces). |
| | | | All wall surfaces insulated uniformly as required (unvented crawlspaces). |
| | | | Insulation in full contact with the subfloor. |
| | | | Insulation adhered to substrates and other building components to provide an air seal where required. |
| | | | Insulation surface profile satisfactory. |
| | | | Insulation of uniform color and consistency. |

Comments:

| Yes | No | NA | Wall Insulation |
|-----|----|----|--|
| | | | All stud wall cavity insulation installed to uniformly fit the cavity side-to-side and end-to-end. |
| | | | Insulation adhered to substrates and building components to provide an air seal where required. |
| | | | Rim joists insulated as required. |
| | | | Corner channels, wall intersections and behind tubs/showers insulated and air sealed as required. |
| | | | Skylight shafts and attic kneewalls insulated and air sealed as required. |
| | | | Insulation surface profile satisfactory. |
| | | | Insulation of uniform color and consistency. |

Comments:

| Yes | No | NA | Roof/Ceiling Insulation |
|-----|----|----|--|
| | | | All joist and/or rafter cavity insulation installed to uniformly fit the cavity side-to-side and end-to-end. |
| | | | Insulation adhered to substrates and other building components to provide an air seal where required. |
| | | | SPF insulation separated from recessed luminaries and other heat sources. |
| | | | Insulation surface profile satisfactory. |
| | | | Insulation of uniform color and consistency. |
| | | | Unvented attics air sealed to the outside as required. |

Comments:

Fire Protection (Thermal Barriers and Ignition Barriers)

Ignition Barriers (applicable to attics and crawlspaces only) check all that apply:

- In place: Type(s): _____
- SPF approved to be left exposed
- Contractor provide assurances of installation of ignition barriers as required to be installed

Comments: _____

Thermal Barriers (applicable for surfaces between SPF and building interiors) check all that apply:

- In place: Type(s): _____
- Approved exception(s)
- Contractor provided assurances of installation of thermal barriers as required to be installed

Comments: _____

