Spray Foam Event 2014 Presentations Contents List

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4. **Foam Plastic Insulation and the Codes (Click to go to PDF Page 17)**
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Henri Fennell, CSI/CDT

Henri is an architect and building envelope specialist with over forty years of experience in the construction industry. He was a pioneer in the solar industry, introduced the installation technique for field-applied closed-cell cavity-fill polyurethane foam, developed a pressurized theatrical fog quality assurance technique and protocol, and has designed and constructed a net-zero energy research structure in Antarctica. He has four energy-Related U.S. patents.

THE GREEN CENTER

Bristol Community College, 777 Elsbree Street, Fall River, MA 02720, 1:30 – 4:00

INSULATE RIGHT: Workshop on Safe Insulation for Homes and Buildings

Quality Assurance and Safety in Spray Foam

By: Henri Fennell, CSI/CDT
HC Fennell Consulting, LLC

The MA Office of Technical Assistance and Technology
The Executive Office of Energy and Environmental Affairs

Quality Assurance and Safety in Spray Foam

Copyright Materials

Introductions

1. Introductions all around
2. Don't forget:
   - Sign-up sheet
   - Resources on the web site
   - HCF Business cards in back

Building Science and Polyurethane Foam Bibliographies
http://polyurethanefoamconsulting.com/education-training/

Also see the March 2012 JLC article "Avoiding Problems with Spray Foam"

Net-zero energy in Antarctica in 2007

Resources & information

Web site - *www.hcfennellconsulting.com*

- Resources (20+ pages of bibliography)
- Planning foam projects
  - How to select foam products
  - How to select foam contractors
  - Special foam applications
- Diagnostics and quality assurance techniques
- Technical resources by category - Building science, foam, safety, quality control, products, etc.
- Sample completed projects with details
- Foam industry commissioning services available

Program choices:

- Foam review
  - General intro to foam
  - Foam Installation methods
- Codes and Foam
  - Codes overview
  - Test methods used for compliance
  - Gray areas in the codes
  - Fire protection requirements
  - Specific building locations
- Hazards/Safety
  - Protect the site
- Foam Problems
  - Why are there so many foam problems?
  - What are the causes of foam problems/failures?
  - How do we prevent foam-related problems?
  - Diagnosing foam problems
- Remediation options and protocols
  - Repair and stabilize
  - Remove and replace

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Review Polyurethane Foam

4 types of polyurethane foam

1. Polyurethane foam caulking (tube)
2. Single-component foam sealant (cans)
3. Two-component foam insulation/sealant kits
4. Spray-applied/injected foam insulation (SPF/IPF)
   - Open-cell vs. closed-cell foam
   - Spray vs. injection
   - Molded

The History of Polyurethane foam

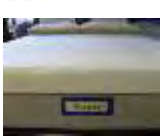
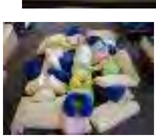
History

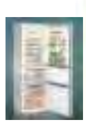
- Polyurethanes were originally developed in the late 1930s in Leverkusen, Germany (Otto Bayer).
- The technology arrived in the US after World War II (Mobay Chemical Company).
- Flexible foams (furniture) were prevalent before their use as acoustic and thermal insulations.
- Rigid Foam, medium density
  - Spray applications first began in 1950 in North America
  - 1970 - beginning of current significant level of use in construction
  - Daily field-installed cavity-fill applications began in 1982

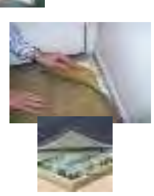
The History of Polyurethane foam

The size of the industry

Common uses



Common Uses of Polyurethanes	
Type	Product
Rigid and semi-rigid foam	Refrigerators, freezers, hot water storage tanks, process equipment
	Building insulation Conventional and cold-storage building insulation, SIPs Marine flotation
Flexible foam	Furniture cushions, car seats
	Packaging materials, foam-in-place packaging
Urethane coatings	Marine & wood finishes
High-density molded polyurethanes	Wood-look TV & appliance cabinets Automobile bumpers

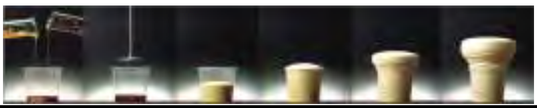
SPF Chemistry Fundamentals

Two component liquid systems manufactured in plant

- A-Side: MDI – Isocyanate
- B-Side: Proprietary Resin (polyols , catalysts, fire retardants, blowing agents, etc.,…)
- A+B = spray polyurethane foam

Sold to insulation contractors – Processed and installed on site

- A+B components are heated, pressurized and pumped through hoses and mixed at spray gun just before contacting the surface



Polyurethane foam

A-Side

The A-side is typically a mixture of approximately 50% methylene diphenyl diisocyanate (MDI) and 50% polymeric methylene diphenyl diisocyanate (pMDI). A-side chemicals are very reactive and reactions can result from improper mixing with water; acids; inorganic bases (such as sodium hydroxide), ammonia, and amines; magnesium, aluminum and their alloys; other metal salts, especially halides (such as tin, iron, aluminum and zinc chlorides); oxidizing agents (such as bleach or chlorine); or polyols.

A-side chemicals have a musty odor, but because of the relatively high odor threshold, most people cannot smell A-side chemicals when present in concentrations equal to applicable occupational exposure limits. As a practical matter, this means that if you smell MDI (musty odor), you have probably exceeded the exposure limits.

Courtesy: Center for the Polyurethanes Industry (CPI) of the American Chemistry Council

Polyurethane foam

B-Side

Figure 1: Typical Composition of Polyol Resin Systems

Component	[illegible]	[illegible]
Polyols	[illegible]	[illegible]
Blowing Agents	[illegible]	[illegible]
Catalysts	[illegible]	[illegible]
Flame Retardants	[illegible]	[illegible]
Surfactants and Glycerin	[illegible]	[illegible]

Additives determine:

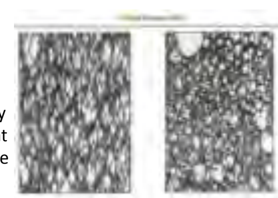
1. Cell size and R-value
2. Speed of the chemical reaction
3. Fire resistance
4. Flexibility and dimensional stability

Courtesy: Center for the Polyurethanes Industry (CPI) of the American Chemistry Council

Polyurethane foam

The Material

- The bubbles or hollow cells are created by introducing "blowing agents" into the plastic resin.
- Blowing agents are primarily low-conductivity gases or water. These boil at atmospheric pressures from the heat of the exothermic reaction to form the bubbles.
- Without blowing agents, urethanes are hard plastics (urethane varnish, molded furniture parts)
- Blown foams vary in density in proportion to the amount of blowing agent used in the formulation



Polyurethane foam

Cell types

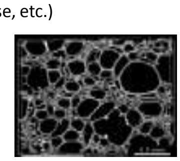
- <u>Closed-cell foams</u> with low-conductivity gasses in the bubbles have higher R-values, high resistance to air and vapor flow, and are very strong. Closed-cell foams will be at least 1.85#/cu. ft. There are closed-cell foam products that are not filled with low-conductivity gasses.
- <u>Low density</u> foams with open cells, usually water-blown, have R-values typical of other insulation materials with air in the interstitial spaces. They are permeable to vapor transmission, and are non-structural. They can, however, have a high resistance to air flow. Open-cell foams are usually less than 1#/cu. ft.

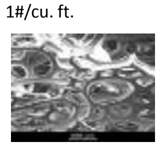
**Handout – FAQ response from BES Website –"What is the difference between open-cell and closed-cell urethane foams?"*

Polyurethane foam

Cell types

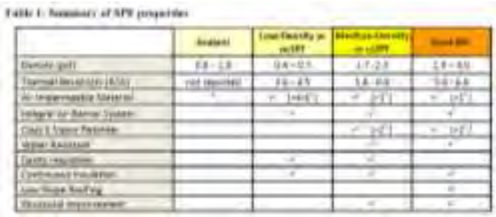
- <u>Low-density open-cell foams</u>
  - are usually water-blown,
  - have R-values typical of other insulation materials with air in the interstitial spaces (fiberglass, cellulose, etc.)
  - are permeable to vapor transmission
  - are non-structural
  - have a high resistance to air flow
  - are <u>not</u> water tolerant
  - are usually less than 1#/cu. ft.





Open-cell PUF at different magnifications

SPF properties



I would add closed-cavity low slope insulation to this with a check in the center two boxes. These are the only code compliant materials for this application.

Courtesy of The Center for the Polyurethanes Industry and the Spray Foam Coalition - American Chemistry Council (ACC)

Polyurethane foam - Physical Properties

In-place physical properties are not the same as in the lab

- Density
- Physical strength (compression, tension, shear)
- R-value
- Water permeability
- Air permeability
- Vapor permeability

- Bond Strength

Foam blowing agents

GWP ratings

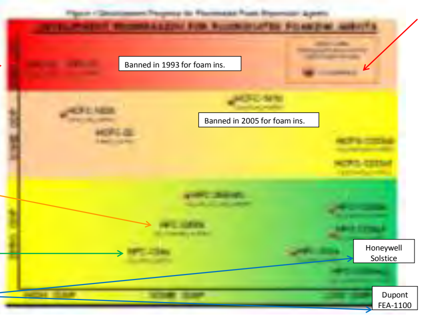
ODP ratings: All current products are zero ODP

My first foam job (1971) Who knew?

The current technology (2003)

F-T SUPERGREEN FOAM (1993)

The next generation (2013)



Source: Dupont Formacel 1100 paper

Processing and installing polyurethane foam

Delivery systems for field-processed materials

- Low-output (3 to 10 #/minute) pressurized portable units (Kits and Cans)

Kits and Cans

Two-component kit foam (Kits and cans)

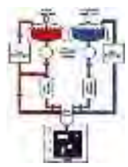
Processing and installing polyurethane foam

Delivery systems for field-processed materials

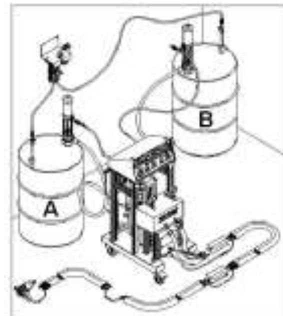
- High-output (6 to 100 #/minute) pressurized or pumped bulk equipment (Low-tech and high-tech machine processing equipment)

Bulk foam – Pump systems

Mobile Spray Rig (Bulk foam)



Bulk foam



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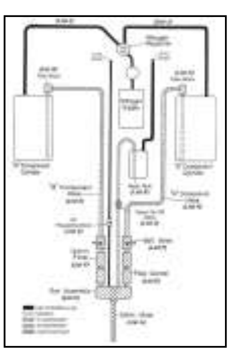
Field Processed & Field Applied

Pressure vessel system



Pressure vessel system

No pumps or open drums

Static mix method

Spray guns

Advantages

Open-cell foam

1. Lower cost even though it usually requires trimming and waste disposal
2. Dimensional stability is not an issue
3. One-step convection, diffusion, and conduction control

Advantages

Lower cost even though it usually requires trimming and waste disposal

Advantages

Closed-cell foam

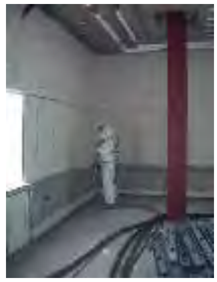
1. Higher R-values are possible in smaller existing framing cavities
2. Will not be damaged by roof leaks, foundation leaks, or condensation
3. Can function as a drainage plane
4. Not prone to weather damage
5. Has structural capabilities
6. One-step convection, diffusion, and conduction control
7. Self supporting

Advantages

Not prone to weather damage

Advantages

Self supporting



Better depth control

Advantages

Below grade application

Advantages

Unvented roof application

Advantages

Drainage planes

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Field application methods

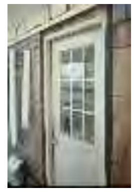
Foam Sealant (SPF and FS)

- Kits and cans (FS) – portable and low tech
- Higher cost than bulk foam
- Cost effective in small areas that are difficult to access with high-pressure hoses.

FS - Foam sealants

FS - Foam sealant

a. Open crack/penetration sealing
b. Limited cavity fill



Foam Sealant (FS)

U5

Field application methods

Spray-applied (SPF)

- Requires open cavities.
- Requires OSHA-approved supplied air equipment and isolation of the work area. Depressurization can be used to protect occupied spaces.
- Allows application of desired R-value thickness.
- Allows visual inspection and infrared, R-value, and air leakage testing before the installation of interior finishes.

SPF – Bulk foam

Gutt rehabs – Walls – inside

SPF – Bulk foam

Closed-cell in a double 2x4 Wall - R-21 with no trimming

Closed-cell foam is a rigid product designed for interior and exterior applications. It expands at a ratio of ~30:1.

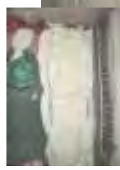
Half-Pound Density Foams

It is an expanding soft foam product designed for interior applications. It insulates and air-seals at the same time. Expanding at a ratio of 100:1, it fills every crevice, virtually eliminating air leakage, convection, and airborne moisture movement.

SPF – Bulk foam

Open-cell SPF

Trimming is required



SPF – Bulk foam

Gutt rehabs – Walls – outside

New construction – outside

SPF – Bulk foam

Exterior cavity-wall installation = air barrier continuity

O'Connor Residence – St. Simons Island, GA

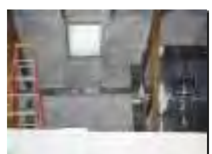
SPF – Bulk foam

Attics – Open slopes – from inside

Vented and unvented

SPF – Bulk foam

b. Attics – Open slopes - inside



SPF – Bulk foam

SPF for air sealing in attics before installing fiber insulation

SPF – Bulk foam

b. Basement/Crawl - inside

Crawl space – before and after mitigation work

SPF – Bulk foam

Advantages

Below grade application

SPF – Bulk foam

Slab Insulation

Exterior wall and roof retrofits

Not prone to weather damage

Exterior wall and roof installations

Exterior wall and roof retrofits

Inject closed roof slopes

Spray open roof slopes

SPF – Bulk foam

Exterior wall and roof retrofits

Continuous insulation –
minimal thermal bridging

SPF – Bulk foam

SPF provides continuity even on complex substrates

SPF – Bulk foam

Exterior cavity-wall installation

SPF – Bulk foam

Exterior cavity-wall installation = air barrier continuity

SPF – Bulk foam

SPF – Bulk foam

Drainage plane

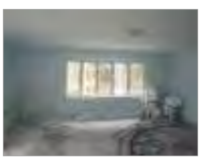
Field application methods

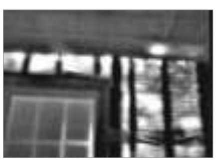
Injected (cavity fill) on site

- Allows insulation, vapor control, and air sealing in closed building cavities.
- Requires ventilation of the work area. Depressurization can be used to protect adjoining occupied spaces.
- Requires filling closed cavities - R-value can be varied only by foam selection to match cavity thickness (if vapor issues allow).
- Requires care to avoid distorting the sheathing.
- Requires infrared R-value and air leakage quality assurance (voids).

IPF – Bulk foam

Injected on site

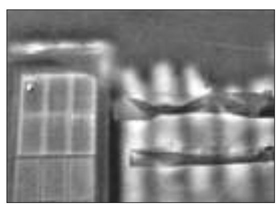




IPF – Bulk foam

How do you know you got it all?

IR quality assurance testing during construction



Cavity-fill applications

IPF – Bulk foam

1. Single-family (owner-occupied or rental units)
2. Multi-family (owner-occupied or rental units)
   - Apartments
   - Condominiums




1

Slots and holes outside

Cavity-fill – Wood framed


Franklin Square (1988) - Low-cost housing

1

Slots and holes outside

Wood-framed cavity-fill application – Energy upgrade from R=11 batts to closed-cell urethane (R=24)

Carrus Residence (2007)

Lath & Plaster Thermal Barrier

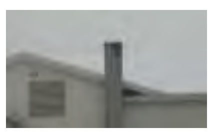


IPF – Bulk foam

Sequenced finishes and foaming

Ice Dam Remediation – IPF in vent spaces






Portable equipment IPF

Using kit foam to seal small bays

Forms – outside

1

Etnier Residence – Installation (1992

IPF – Bulk foam

Limitations: access – 1 holes possible only at apex of each vault

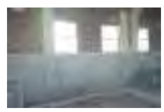
Cavity fill – Masonry/Plaster
Conditioned space above covered outside walkway

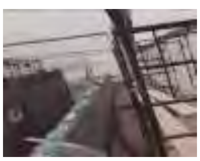
Brady Residence (1995)

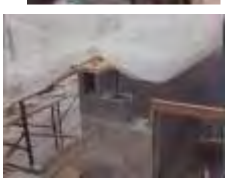
IPF – Bulk foam

What ifs:

a. A location has batts in the cavity
b. Historic finishes
c. Lath is good, but plaster is not





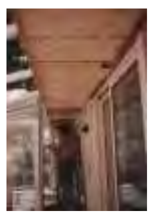


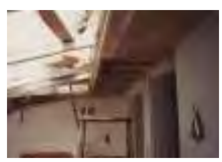
Integra Wall System

IPF – Bulk foam

Special conditions

- Soffits





IPF – Bulk foam

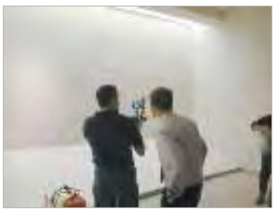
Special conditions

- Structural tubes

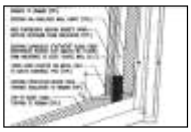
IPF – Bulk foam

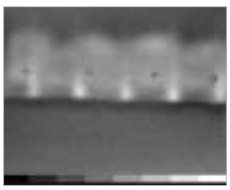
Infrared QA of foamed-in-place insulation – effective year-round (240F)

IPF – Bulk foam



Infrared QA of foamed-in-place insulation behind 1” plaster – effective year-round (240F)





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Foam Plastic Insulation and the Codes

Status of the foam industry

The positives!

- Polyurethane foam is becoming much more commonplace in the Home Performance industry and in commercial buildings.
- The number of polyurethane foam contractors has increased dramatically.

The negatives!

- There are no ANSI or other uniform industry installation standards to define what is required.
- There is no uniform installer certification process.
- Training is not typically required or comprehensive.
- Anyone can buy foam.

Status of the foam industry

The most common code violations encountered in foam projects:

- Missing thermal barriers
- Missing PFI barriers
- Lack of required fire protection inspections in commercial projects
- Failure to meet ventilation requirements in attics and crawl spaces

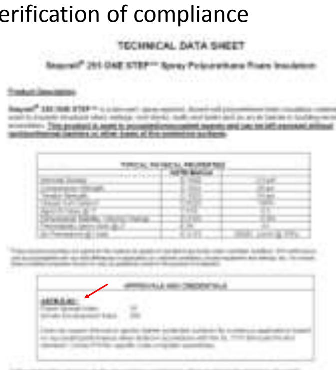
OSHA safety, site protection, and CAZ safety are separate issues.

Verification of compliance

1. Manufacturer's data
2. Labeling
3. Third-party evaluations

Verification of compliance

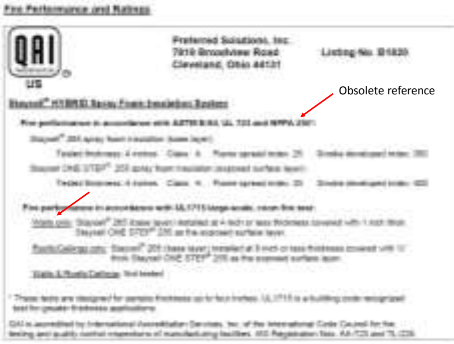
Manufacturer's data


TECHNICAL DATA SHEET

Verification of compliance

- Labeling
  1. All Foam Plastic must meet general, labeling, and surface burning characteristics to qualify for use in occupied buildings (Sections 3.16.1 through 3.16.3 per E84 tunnel test <u>or</u> UL 723)
  2. All foam plastic requires labeling and identification
  3. Approved agencies provide compliance certification

Labeling requirements



Verification of compliance

- Third-party evaluations
  - ICC
  - Other approved agency

Why third-party evaluations?
It's complicated, who knew, why, and, …….
you've got to be kidding!

ICC-ES Reports

1. An Evaluation Service Report (ESR) is a third-party report verifying that a product meets the code requirements for a given use.
2. The ICC Acceptance Criteria are a standardized set of compliance "guidelines" for evaluating product compliance.
3. The ICC Acceptance Criteria are not part of the codes.
4. Manufacturers are not required by the codes to have a third-party evaluation for their products.
5. AHJs, architects, owners, etc. may require them as submittals.
6. AHJs may still disapprove a product that has an ESR, or approve a product based on Acceptance Criteria that are not in the codes.

ICC Acceptance Criteria – SPF

ICC developed the Acceptance Criteria for any evaluation service.
Includes guidelines for:

- products
- Installations
- applications

ICC-ES Reports

See Appendix X
in AC-377

Why are barriers required?

Why are ignition & thermal barriers required?

Foamed plastics, like most organic materials, are combustible (spray, rigid foam board, sealants)
- Unprotected foam can ignite when exposed to fire sources
- Flashover and smoke can develop in interior spaces in certain conditions
- Flame retardants are added to slow flame spread
- Flame spread measured under controlled conditions, (ASTM E84), may not be representative of actual fire conditions

Why do Codes Require Ignition & Thermal Barriers?

Barriers are required in the ICC Model Building Codes (I-codes)
- Delays combustion and ignition of SPF
- Provides extra time needed for worker and occupant egress
- Requirements for Foam Plastics
  - IBC Chapter 26, Section 2603
  - IRC Chapter 3, Section R316

INTERNATIONAL CODE COUNCIL

Foam and the codes FAQs

- Do the protection requirements for bulk foam apply to foam sealants?
- Question posed to the ICC: Foam sealants are typically used to fill cracks and seal penetrations; but, when they are used to seal top plates or rim joists, the application may be wider and thicker than the term "sealant" would seem to imply. Where is the line between foam sealants and foam plastic insulation?
- ICC - No response to where they would draw the line in real-world situations, but generally said if it is foam plastic, it must be protected as such (Dow Froth-Paks NFPA 286 tested).

The code definition for "foam plastic"

Definition: Foam Plastic Insulation - IRC (2012) SECTION R202 Definitions

"A plastic that is intentionally expanded by the use of a foaming agent to produce a reduced-density plastic containing voids consisting of open or closed cells distributed throughout the plastic for thermal insulating or acoustic purposes and that has a density less than 20 pounds per cubic foot (320 kg/m3) unless it is used as interior trim."

Ref: Section R316 Foam Plastic

15-minute thermal barriers

Where <u>aren't</u> 15-minute thermal barriers required?

- Some assemblies that <u>meet specific requirements</u> do not require 15-minute thermal barriers
  - 1"Masonry or concrete construction (R316.5.1)
  - Roof decks (R316.5.2 per R803)
    - 15/32" T&G wood planks
  - Exterior re-siding (R316.5.8 per NFPA 259, , 2603.4.1.10)
  - Interior trim (R316.5.9 , 2603.4.1.11)
  - Sheathing (R316.5.12 per R316.5.3 – attics only)
  - Floors with ½" wood structural panel deck (316.5.13)

Where aren't 15-minute thermal barriers required?

- Unoccupied spaces - Ignition barriers or products with specific approvals are required in:
  - Attic walls, floors, slopes (R3.16.5.3 per R807.1, R3.16.6, 2603.4.1.6)
  - Crawl spaces (R3.16.5.4 per R408.4, R3.16.6 , 2603.4.1.6)
- Sill plates and headers (R316.5.11 per ASTM E84 or UL 723 , 2603.4.1.13)

What is a 15-minute thermal barrier?

- Thermal barrier – an insulating material that prevents foam from reaching 250F *above the ambient* (E119 or UL263).
- 15-minutes
  - How long it has to keep the foam cooler than the ignition temperature (E119 or UL263).
  - How long it has to stay in place during specified large-scale fire tests (NFPA 286, etc.).

Where are 15-minute thermal barriers required?

- In all occupied spaces - All building types
- In unoccupied spaces "with reasonable access"
- IBC - 2603.4.1.6
- IRC – R316.4

Types of 15-minute thermal barriers

- Prescriptive
- Non-prescriptive, but listed as acceptable
- Equivalent/alternate non-prescriptive
  - Not assembly specific
  - Assembly specific
- Typically approved, but not listed or equivalent
- Foam products that do not need a barrier

SPFA/ACC

- Thermal Barriers and Ignition Barriers for the Spray Polyurethane Foam Industry – SPFA/ACC AY-126 Search AY-126 at http://www.sprayfoam.org
- AY-126 is approved by the ICC and on the ICC web site - http://www.icc-es.org/News/Articles/AY126Thermal BarriersSPF2011-51811.pdf

What is a 15-minute thermal barrier?

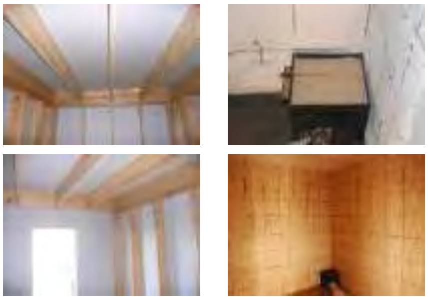
Prescriptive - 1/2" gypsum board (C-C IPF)

What is a 15-minute thermal barrier?

Non-prescriptive or equivalent/alternative coatings or coverings (not assembly specific)

- Must be tested in accordance with, and meet the acceptance criteria of both the following:
  - Temperature Transmission Fire Test (ASTM E119)
  - Integrity Fire Test (NFPA 286, UL 1715, UL 1040 or FM 4880)
- Or: NFPA 275 (combines both tests above)
- Examples:
  - Cement-based coatings of an adequate thickness
  - Fire retarded cellulose of an adequate thickness
  - Some liquid-applied coatings of an adequate thickness

Fire Testing: Room-Corner



Fire Testing: Room-Corner

The large-scale testing process


Safety First

Building Code Requirements for SPF Fire Safety: Interior Applications in Occupied Spaces

What is a 15-minute thermal barrier?

Examples of trade-name, spray-applied thermal barrier products

1. CAFCO 560 (3/4)
2. CAFCO Ceramospray IV (1")
3. Contego TB (30 mil)
4. Fire Free 88 (.02")
5. Fire shell
6. Fire Stop
7. Flame Seal (400 sf/gal)
8. Foam Safe (50 sf/ 40 lb. bag)
9. IFT, DC315 (22 mil)
10. MCT 15
11. Monokote Z-3306 (7/8")
12. NTEC Supertherm (40 mil)
13. Pyrocrete 239 (1")
14. Pyroshield (40 mil)
15. SAFECOAT (5 mil dry)
16. ThermoCon (1")
17. Ure-K (3/4")
18. Zonolite (3/4")

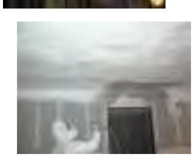
Do-it-yourself barriers

Follow the manufacturer's Instructions

(excerpt from 7-page product application procedures for "qualified" installers using "specified" airless spray equipment)

Coatings – Spray-applied

Cast-in-place concrete



NTEC Supertherm
Use colorant to QA thickness

What is a 15-minute thermal barrier?

Non-prescriptive or equivalent/alternative coatings or coverings

Product-Specific Assemblies must be tested:
- Coating/Covering Brand A onto Foam Brand B

What is a 15-minute thermal barrier?

IFT DC 315

What is a 15-minute thermal barrier?

Non-prescriptive or equivalent/alternative coatings or coverings

Product-Specific Assemblies must be tested:
- Tested cladding materials

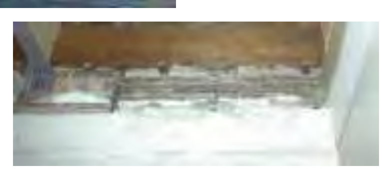
Tested products

Rigid foam board

What is a 15-minute thermal barrier?

Examples of materials that are not prescriptive, exempt, or tested; but, are generally accepted as a thermal barrier by AHJs:
- ¾ ” SE wood boards - Not prescriptive but generally accepted for floors or roof sheathing
- Metal or wood lath and plaster
- Sheet metal siding or decking
- Attics or basements with sprinklers (varies with AHJs – only mentioned in coolers)

Lath & Plaster Thermal Barrier



Plaster Thermal Barrier

Injection, Poured, FIP

When aren't thermal barriers required?

Specific approved products or systems that don't require a thermal barrier:

- Great Stuff Fireblock
- Dow Froth Pak
- PSI One Step
- EcoGuard 500 (pending)

Exceptions – Specialty Approved Foams

Attic application

Protect from ignition barriers?

Frequently Asked Questions

1. What is the difference between a thermal barrier and an ignition barrier?
   – TBs provide time to escape a fire, IBs prevent a fire from igniting. The test methods for products are also different.
2. Can I spray on intumescent coatings myself?
   – Yes, but the manufacturer may have requirements.
3. What constitutes an acceptable ignition barrier? Coatings? Hard Barriers? Answer to follow.
4. There's also been mention of the use of fiberglass batts as an ignition barrier...... True?
   – True, 1 ½" mineral fiber is a prescriptive ignition barrier. 2" cellulose is also an IB in JHAs that have adopted the 2012 IRC. Mass. is using the ___?____ version.

What is an ignition barrier?

Ignition barriers are intended to prevent foam from reaching flash-over for the minimum time provided by prescriptive ignition barriers. When designing the test, the time chosen was 4:18, which is equivalent to when wood paneling (the worst prescriptive ignition barrier) reached flash over.

- Ignition barriers protect against auto-ignition (650-800°F).
- Ignition barriers (Pass/Fail criteria = 4 minutes 18 seconds) - Modified NFPA 286.

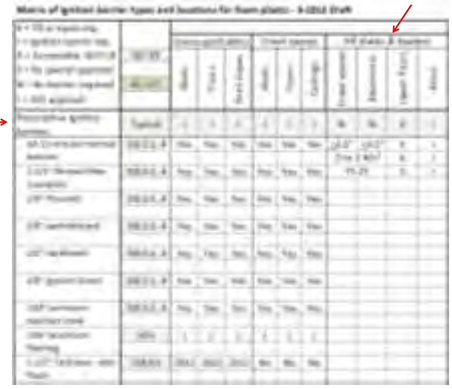
What are protect from ignition barriers?

Prescriptive ignition barriers for attics and crawl spaces (R316.5.3, R316.5.4)

- All 15-minute thermal barriers
- 1-1/2" Mineral fiber insulation
- 1/4" Plywood
- 3/8" particleboard
- 1/4" hardboard
- 3/8" gypsum board
- .016" corrosion-resistant steel
- 1-1/2" Cellulose - attic floors (Attics only – new in 2012)

Others by special approval:

Ignition barrier matrix



Ignition barriers

Why are there so few IB tests?

- Most foam manufacturers make foam that is approved to be left exposed in attics, so why use ignition barriers?
- Some manufacturers are uncomfortable with what may happen with intumescent barriers that have only been tested for 4:18.
- Why 4:18?

Building locations

- Typical locations
  - Occupied spaces
  - Attics
  - Crawl spaces
  - Rim joists
- Exceptions

Locations – typical unoccupied spaces

Unfinished and/or unoccupied spaces where entry is made only for the service of utilities.

- Attics
- Crawl spaces

The means and purpose of access to an attic primarily determines if it is unoccupied space. *Some AHJs consider all attics with walk-up or pull-down stairs as occupied space*.

Locations - Attics

R316.5.3 Attics. The thermal barrier specified in Section R316.4 is not required where all of the following apply:

1. Attic access is required by Section R807.1.
2. The space is entered only for purposes of repairs or maintenance.
3. The foam plastic insulation is protected against ignition using one of the prescriptive ignition barrier materials.

The above ignition barrier is not required where the foam plastic insulation has been tested in accordance with Section R316.6.

From IRC (2012)

Locations – Attics

AC-377
As an alternative, the prescriptive ignition barrier shall not be required when satisfactory testing is conducted with exposed foam plastic insulation or with a foam plastic insulation system, such as foam plastic insulation covered by a coating, in accordance with either Appendix A1.0 or Appendix X of this criteria.

Locations – Attics

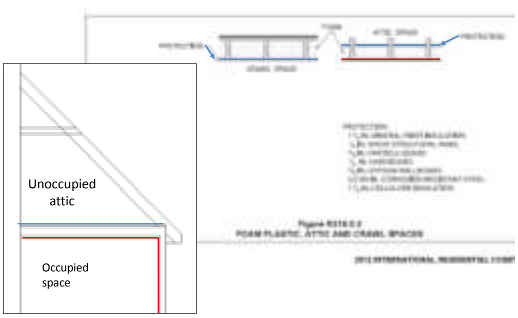
An attic qualifies for the ignition barrier exception if:

- IRC R316.5.3 Attics: If the attic area exceeds 30 square feet and has a vertical height of 30 inches or more.
- The “purposes of repairs and maintenance” are for attics that contain only mechanical equipment, electrical wiring, fans, plumbing, gas or electric hot water heaters, gas or electric furnaces, etc.
- The attic space cannot be used for storage.

- AC-377 definition: Same as R316.53

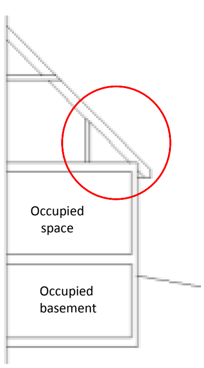
Is this code language?

Locations - Attics

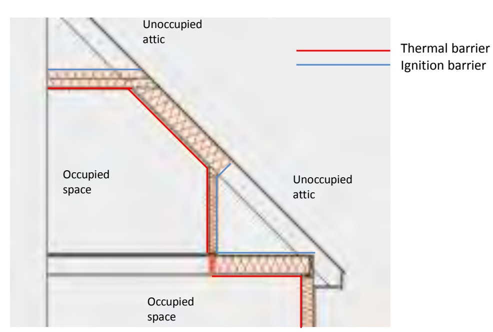


Locations - Attics

Locations - attics



Locations - attics



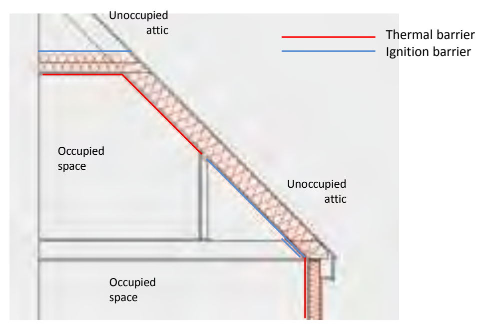
No PFI barrier

No code approval for AC-377 exception

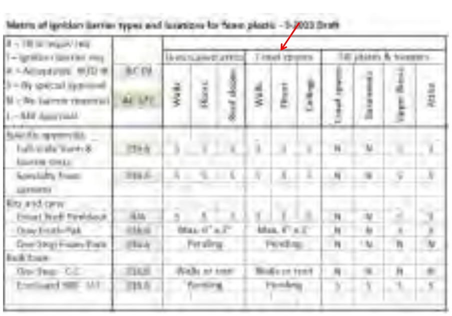
Locations - Attics

Locations - attics

Locations - attics



Ignition barrier matrix



Locations – Crawl spaces

- R316.5.4 Crawl spaces. The thermal barrier specified in Section R316.4 is not required where all of the following apply:
  - Crawlspace access is required by Section R408.4.
  - Entry is made only for purposes of repairs or maintenance.
  - The foam plastic insulation is protected against ignition using one of the prescriptive ignition barrier materials.
- An ignition barrier is not required where the foam plastic insulation has been tested in accordance with Section R316.6.

Locations – Crawl spaces

AC 377

A2.0 Use in Crawl Spaces:

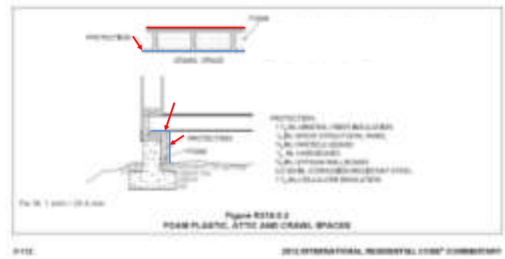
- A2.1 Spray-applied polyurethane foam plastic insulation installed in a crawl space where entry is made only for service of utilities shall be protected by an ignition barrier as set forth in IBC Section 2603.4.1.6, IRC Section R314.5.4 or Exception 4 of UBC Section 2602.4, except as noted in Section A2.2.
- A2.2 As an alternative, the ignition barrier shall not be required when satisfactory tests are conducted with exposed foam plastic.

X2.1 Test Method: The test procedure to be used is NFPA 286, "Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth."

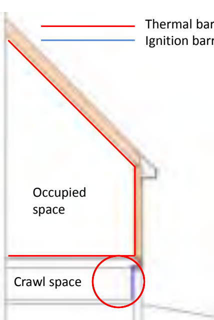
X2.2.1 No interconnected spaces, not circulated to another space.

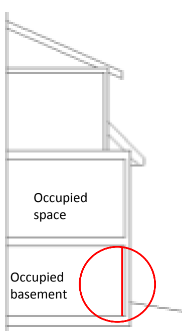
Locations – Crawl spaces

Thermal barrier
Ignition barrier

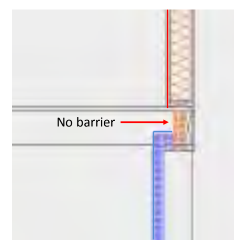


Locations – Crawl spaces



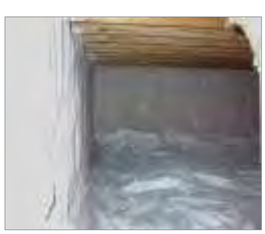


Locations – Crawl spaces



Thermal barrier
Ignition barrier

Locations – Crawl spaces



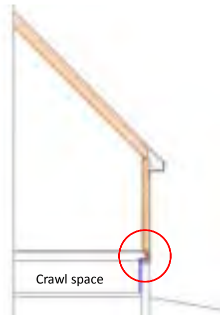
Ignition barrier matrix

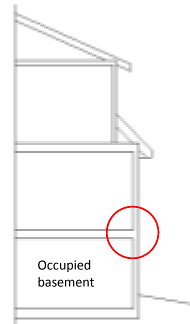
Locations - Sill plates and headers

R316.5.11 Sill plates and headers. Foam plastic shall be permitted to be spray applied to a sill plate and header without the thermal barrier specified in Section R316.4 subject to all of the following:

1. The maximum thickness of the foam plastic shall be 3-1/4 inches (83 mm).
2. The density of the foam plastic shall be in the range of 0.5 to 2.0 pounds per cubic foot (8 to 32 kg/m3).
3. The foam plastic shall have a flame spread index of 25 or less and an accompanying smoke-developed index of 450 or less when tested in accordance with ASTM E 84 or UL 723.

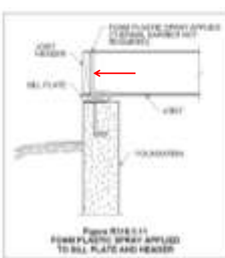
Locations - Sill plates and headers





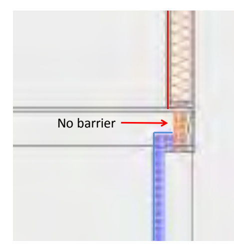
Locations - Sill plates and headers

Commentary Figure R316.5.11



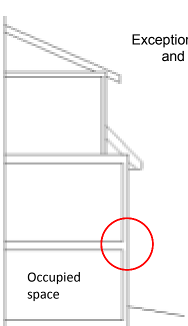
Typical rim joist configuration

Locations - Sill plates and headers



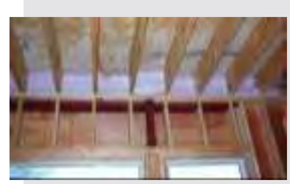
Thermal barrier
Ignition barrier

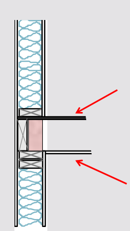
Locations - Sill plates and headers?



Exception – Plenums and chases

Locations - Sill plates and headers?

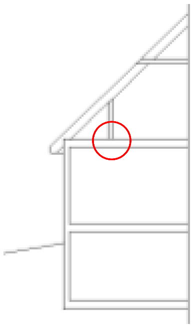




Floor = thermal barrier

Gypsum ceiling = thermal barrier

Locations - Sill plates and headers?



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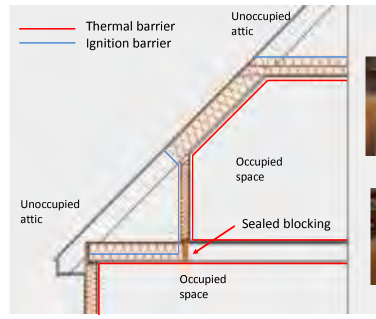
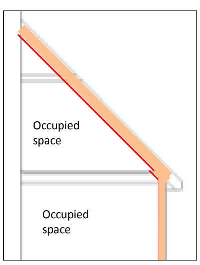
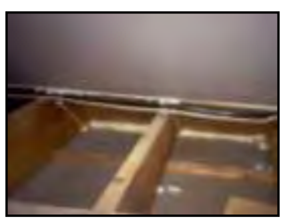
Locations - Sill plates and headers?



Locations - Sill plates and headers?

Thermal barrier
Ignition barrier





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Cover insulation with IB or attic insulation

Locations - Sill plates and headers?

Return to
Contents List

Foam Safety

Foam installer protection vs……….

Site and occupant protection
- air quality management
- re-occupancy timing
- combustion appliance safety

Hazards and Safety – Site protection

Site protection - before the work begins

- Notification: Inform building users of air quality issues related to your work
- Provide product safety documentation
- Provide and review your air quality management plan (part of the written safety plan – required by law)
- Review the safety and emergency protocols for the specific site with the applicators and building operators
- Inform building users of the implications of a tight building
- Applicators must be trained in safety and emergency protocols related to foam installations

Hazards and Safety – Site Protection

Protect the site - before the work begins

- Isolate the work area
  - Install fans, signage and barriers
  - Locate the HVAC controls and have them set to isolate the work area from the occupied spaces
- Verify there are no occupants with respiratory problems – vacate when necessary
- Take necessary fire-protection measures
  - Follow CAZ (Combustion Appliance Zone) safety protocols
  - Remove ignition sources (Auto-Ignition Temperature = 650-800°F)

Hazards and Safety – Site protection

Protect the site - During the work
- Work area ventilation vs. evacuation
- When to keep people out and how long before re-entry
- Know what to do in the case of a chemical spill or if there is an off-ratio spray event
  - Most MSDS documents reference other documents
  - Most MSDS don't identify what the hazards are
    - Chemicals components are proprietary
    - Personal protection requirements and exposure limits are not provided
  - Some MSDS don't identify cleanup methods
  - Some MSDS don't explain disposal requirements

Hazards and Safety – Site protection

Protect the site - During the work
- Know what to do in the case of a chemical spill or if there is an off-ratio spray event

Section 2: Composition and Ingredient Information

Alkanolamine	hazardous
Alkylamine	hazardous
Additional non hazardous ingredients are trade secrets belonging to the general chemical families of polyether/ester polyols, silicone surfactants and halogenated phosphates	

3. Composition/Information on Ingredients

Hazardous components

Weight percent	Components	CAS-No.
20 - 30%	Polymer	CAS# is a trade secret
7 - 13%	Hydrofluorocarbon	460-73-1
3 - 7%	Tris-(2-chloroisopropyl)-phosphate	13674-84-5
1 - 5%	2-Butoxyethanol	111-76-2
1 - 5%	Tertiary Amine	CAS# is a trade secret
1 - 5%	Ester derivative	CAS# is a trade secret
0.1 - 1%	Tertiary Amine	CAS# is a trade secret

Hazards and Safety – Site protection

Protect the site - During the work
- Know what to do in the case of a chemical spill or if there is an off-ratio spray event

13. Disposal considerations

Waste Disposal Method
Waste disposal should be in accordance with existing federal, state and local environmental control laws.

Empty Container Precautions
Recondition or dispose of empty container in accordance with governmental regulations.

Hazards and Safety – Site protection

Section 6:	Accidental Release Measures
SEE MATERIAL SAFETY DATA SHEET Section 8. Exposure controls, personal protection	
Small Spill and Leak:	Clean-up should only be performed by trained personnel. People dealing with major spillages should wear full protective clothing including appropriate respiratory protection. Evacuate the area. Prevent further leakage, spillage or entry into drains.
Large Spill and Leak:	Contain and absorb large spillages onto an inert, non-flammable adsorbent carrier (such as earth or sand). Shovel into open-top drums or plastic bags for further decontamination, if necessary. Wash the spillage area clean with liquid decontaminant. Test atmosphere for MDI. Neutralize small spillages with decontaminant. Remove and properly dispose of residues. (See Section 13 for disposal considerations). Notify applicable government authorities if release is reportable. The CERCLA RQ for 4,4-MDI is 5,000 lbs. (see CERCLA in Section 15)
Decontaminant:	Preparation of Decontamination Solution: Prepare a decontamination solution of 0.2 – 0.5% liquid detergent and 3-8% concentrated ammonium hydroxide in water (5-10% sodium bicarbonate may be substituted for the ammonium hydroxide). Follow the precautions on the supplier's material safety data sheets when preparing and using solution. Use of Decontamination Solution: Allow deactivated material to stand for at least 30 minutes before shoveling into drums. Do not tighten the bungs. Mixing with wet earth is also effective, but slower.

Hazards and Safety – Site protection

3. COMPOSITION / INFORMATION ON INGREDIENTS

CAS #	Component	Percent
Not Available	Polyester Polyol	30-60
Not Available	Polyether Polyol	10-30
460-73-1	1,1,1,3,3-Pentafluoropropane	5-10
78-40-0	Triethyl phosphate	1-5
13674-84-5	Tris(1-chloro-2-propyl) phosphate (TCPP)	1-5
34354-45-5	Diethanolomine	1-5
108-01-0	Dimethylaminoethanol	0.5-1.5
3855-32-1	Pentamethyldipropylenetriamine	0.5-1.5
107-21-1	Ethylene glycol	0.1-1

B: Component Analysis - Inventory

Component	CAS #	TSCA	DSL
1,1,1,3,3-Pentafluoropropane	460-73-1	Yes	No
1,2-Benzenedicarboxylic acid, 3,4,5,6-tetrabromo-, 2-(2-hydroxyethoxy)ethyl 2-hydroxypropyl ester	20566-35-2	Yes	Yes
Triethyl phosphate	78-40-0	Yes	Yes
Tris(1-chloro-2-propyl) phosphate (TCPP)	13674-84-5	Yes	Yes
Diethanolomine	34354-45-5	Yes	No
Dimethylaminoethanol	108-01-0	Yes	Yes
Pentamethyldipropylenetriamine	3855-32-1	Yes	Yes
Ethylene glycol	107-21-1	Yes	Yes

Vacate the premises

Vacating areas adjacent to the work zone that will be influenced by the foam installation is the most reliable approach

How long before re-entry?

1. "Re-entry time is dependent on product formulation and other factors that affect the foam curing rates."*
2. <u>Require a re-occupancy schedule in the product documentation</u>

*Spray Foam Safety - SPF Contractor and Consumer Guide http://www.sprayfoamsafety.com/reentry-time-spray-polyurethane-foam-applications.html#determining

Hazards and Safety – Site protection

Isolate the work zone

- Install signage - required by OSHA
- Close openings between the work zone(s) and adjacent spaces
- Configure the mechanical systems to prevent cross-circulation between the work zone and the adjacent spaces
- Depressurize the work zone
  – Verify that a constant negative pressure in the work zone with respect to the adjacent spaces is being maintained
  – Verify that the depressurization exhaust is not going to occupied outdoor areas or mechanical system inlets

Hazards and Safety – Site protection

Ventilation

- Depressurization can be used to isolate work areas from other trades or occupants.
- Two air changes recommended to carry out the contaminants after installation – test to verify.
- See new SPC Ventilation Guideline document

Industry information

<u>New draft SPC document</u>: "Residential Ventilation Guide for High-Pressure Spray Polyurethane Foam (SPF) Applications" in structures covered in the International Residential Code (IRC)

– Isolation/containment protocols
– Ventilation
– How long should ventilation continue?

- Refer to information posted on CPI's SPF chemical health and safety website at www.spraypolyurethane.com
- Consult the National Institute for Occupational Safety and Health (NIOSH) by either calling 1-800-CDC-INFO or by visiting the NIOSH website .
- Refer to EPA's Ventilation Guidance for Spray Polyurethane Foam Application

Protect adjoining spaces

Winter attic project

Fan location - depressurization

Open pressure boundary

Protect adjoining spaces

Isolate the mechanical systems

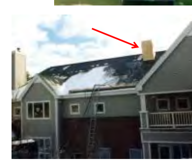
Close openings

Protect adjoining spaces

Pressurization and depressurization

Protect adjoining spaces

Pressurization and depressurization



Work zone ventilation

Use air movers to change the air in the work zone.

1. Provide ventilation to reduce airborne chemical concentrations.
2. Supply air (active or passive) at one end of spray zone.
3. Direct airflow through spray zone from clean to contaminated.
4. Filter and exhaust air at opposite end of spray zone to unoccupied location (ideally outside).

Enclose the work zone as much as possible.

- Create negative pressure within the enclosure (remember CAZ safety) – must be with respect to occupied spaces, not just with respect to the outdoors.
- Maintain depressurization throughout the installation to avoid contamination of the adjacent areas.

Work zone ventilation

Use air movers to reduce airborne chemical concentrations

Work zone ventilation

Remote ventilation – inflated ducting

Hazards and Safety – Site protection

Protect the site - After the foam work

Install thermal or ignition barriers
- Why/when 15-minute thermal and ignition barriers
- Auto-Ignition Temperature (650-800°F)

Hazards and Safety – Site protection

Protect the site - After the fire protection work

- Continue to ventilate the work area and maintain isolation of the occupied areas
- Clean surfaces in the work zone if they were not protected
- Test to verify that safe levels have been achieved in the work zone (and adjacent occupied spaces)
- Provide continued ventilation and air quality monitoring if necessary
- Remove signage and isolation barriers
- Return HVAC settings to normal
- Authorize re-entry

When to re-occupy the building

EPA - Determining safe re-entry times

"To determine a safe re-entry time for unprotected applicators, helpers, other workers, and building occupants, such as homeowners and school children, decision-makers should exercise caution and consult their SPF contractor for specific guidance in advance of SPF installation."*

"Re-entry should be restricted until:
1. the product has finished curing
2. the building has been adequately ventilated and cleaned."

*Spray Foam Safety - SPF Contractor and Consumer Guide
http://www.epa.gov/dfe/pubs/projects/spf/when_is_it_safe_to_re-enter_after_spf_installation.html

When to re-occupy the building

From: spraypolyurethane.org

"Ask your SPF contractor about re-occupancy guidance appropriate for your specific SPF installation and follow that guidance."*

Therefore:
Require verification and certification of when it is safe to re-occupy the space as a part of the installer's work scope. Select a product whose manufacturer provides guidance for the installer about re-occupancy for their "secret formula" product.

*http://www.spraypolyurethane.org/what-to-expect

Re-entry time - EPA

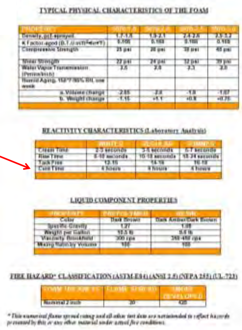
"Some manufacturers estimate that it can take approximately 23-72 hours after application for the foam to fully cure for the two-component high pressure "professional" SPF system, and approximately 8 to 24 hours to cure for one component foam, typically available in 12 oz. to 24 oz. cans."*

*Spray Foam Safety - SPF Contractor and Consumer Guide

EPA "SPF Research Priorities" includes:

"Evaluating SPF curing times and determining safe re-entry as related to:
- Effects of SPF composition, temperature, applicator technique, and proportioning and mixing on curing.
- Presence of un-reacted isocyanate on dust particles after cutting.
- Replicating real-life conditions to explore ventilation and containment strategies.

Cure time



TYPICAL PHYSICAL CHARACTERISTICS OF THE FOAM

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Density, pcf sprayed	1.7-1.8	1.9-2.1	2.4-2.6	2.9-3.2
K Factor aged [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Compressive Strength	25 psi	[illegible]	[illegible]	40 psi
Shear Strength	22 psi	24 psi	32 psi	[illegible]
Water Vapor Transmission (Perms/inch)	2.5	2.8	2.1	2.0
Humid Aging, [illegible] RH, one week				
a. Volume change	-2.85	-2.8	-1.8	-1.87
b. Weight change	-1.15	+1.1	+0.8	+0.75

REACTIVITY CHARACTERISTICS (Laboratory Analysis)

	[illegible]	[illegible]	[illegible]
Cream Time	2-3 seconds	3-5 seconds	5-7 seconds
Rise Time	8-10 seconds	10-13 seconds	18-24 seconds
Tack Free	12-15	14-18	16-18
Cure Time	4 hours	4 hours	4 hours

LIQUID COMPONENT PROPERTIES

PROPERTY	[illegible]	RESIN
Color	Dark Brown	Dark Amber/Dark Brown
Specific Gravity	1.27	1.08
Weight per Gallon	10.5 lb	9.0 lb
Viscosity Brookfield	300 cps	350-450 cps
Mixing Ratio by Volume	100	100

FIRE HAZARD* CLASSIFICATION (ASTM-E84) (ANSI 2.5) (NFPA 255) (UL-723)

[illegible]	FLAME SPREAD	SMOKE DEVELOPED
Nominal 2 inch	20	425

*This numerical flame spread rating and all other test data are not intended to reflect hazards presented by this or any other material under actual fire conditions.

When to re-occupy the building

Are odors useful as air quality indicators?

1. Odors may indicate benign or toxic outgassing
2. Odor detection is subjective, not quantitative
3. Odors may require concentration to be detected
4. Reductions in odor release rates are hard to verify

When to re-occupy the building

So, how do you verify that the space is safe for re-entry?

Test the air quality to be sure concentrations from both processing and cure off-gassing have been reduced to below the PEL:

- Laboratory testing – long response time, cost
- On-site metering – short response time, cost
- Disposable badges – real-time monitoring, inexpensive, but there are limitations

When to re-occupy the building

Alternative #1: Laboratory testing

“Air sampling and testing the indoor air following SPF installation is one way to assure the foam is completely cured.

Testing should be conducted by a certified laboratory using a validated method such as the Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers, Version 1.1 (2010) (PDF) (52pp, 429KB, About PDF) under California Section 01350.”*

*http://sprayfoamsafety.com/spray-foam-exposure-off-gassing.html#curingrates

Monitoring and testing air quality

Alternative #2: Personal or zone monitoring devices

- IsoSense kit (DOD ~ $1,500)
- Cost each test (<$1.00)
- 1.0 ppb (TL), TWA = 5.0 ppb
- +/- 25% accuracy

DOD Technologies, Inc
740 McArdle Drive, Unit C
Crystal Lake, IL 60014
815-788-5200

Monitoring IAQ

Monitoring and testing air quality

Alternative #3: Vapor test badges

- Morphix ($3.50/badge)
- 3.5 ppb (TL), TWA = 5.0 ppb
- +/- 25% accuracy with 95% confidence

Prices Effective January 1, 2011

SafeAir® System

Badges (50/box)	Part No.	Price
Ammonia	382010-50	$142.95
Aniline	382021-50	$174.95
Aromatic Isocyanates (TDI and MDI)	382001-50	$174.95
Carbon Dioxide	382017-50	$142.95
Carbon Monoxide	382012-50	$142.95
Chlorine	382009-50	$142.95
Chlorine/Chlorine Dioxide	382003-50	$174.95
Dimethyl Amine	382019-50	$222.95
Formaldehyde	382011-50	$142.95
Hydrazine	382002-50	$174.95
Hydrides	382037-50	$174.95

Monitoring and testing air quality

1. Note that the published levels for occupants is different than for construction workers.
2. Foam manufacturers provide information about cure time or re-occupancy time for their products.
3. Specify/select a product that includes adequate safety information in the product literature. If this is not published by the manufacturer or readily available upon request, choose one of the other quality foam products that has full documentation.

Summary – General air quality safety requirements

- Personal protection for the installers is mandatory (OSHA), straight-forward, generally well understood by installers, and manageable at reasonable costs – verification is not costly.
- Mandatory Air quality levels (PELs) are included in the OSHA-required product documentation (make this a requirement).
- Site protection requires prior notification, signage, work zone isolation, ventilation, and CAZ management protocols (specify/require an air quality management plan be part of the OSHA-mandated written safety plan).
- Re-occupancy can be estimated in terms of time or ventilation, but verification of safe air quality levels requires effective testing (always require re-occupancy certification and an AQ report as part of the final documentation).

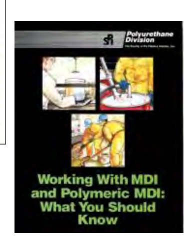
Summary – Re-occupancy

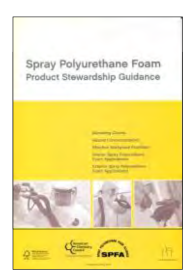
- The contractor is responsible for determining when re-entry to the work zone by the building occupants is allowed, unless it is specified otherwise in the contract.
- For unoccupied spaces adjacent to occupied spaces, isolating and maintaining depressurization is the first/best strategy for protecting the occupants, and is manageable at normal costs.
- Standards for re-entry to all occupied areas are still being researched by the EPA – OSHA does not cover building occupants.
- Verifying when air quality is at acceptable levels for occupants is required and can be determined by monitoring. Verification is difficult and much more costly if the EPA mandates levels that are below the OSHA threshold.

Summary – Re-occupancy

- Cure time is one industry benchmark for when the out-gassing has ended and resident MDI vapors will have dissipated with ventilation. Cure time varies, but is typically reported by the manufacturer (specify/require that this is included in the product documentation).
- Verifying when air quality is at acceptable levels for occupants can be accomplished reasonably if the OSHA threshold is observed for building occupants.
- Air quality in spaces adjacent to the work zone should be verified before re-occupancy even if the depressurization strategy is used. Ideally, PEL verification should be carried out for at least 24 hours after the work is completed.

Industry resources





Return to Contents List

Foam problems

Are you still awake?

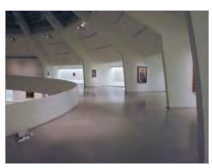
- Why do we have foam problems?
- What are the most common causes?
- How do we prevent foam-related problems?

My foam-related experience

1. First spray foam project was in 1971
2. Foam SIP manufacturing from 1973 to 1979
3. Foam contracting from 1979 to 2009
   - Developed the method for injecting closed-cell foam on site
   - Installed ~ 3 million pounds of foam
4. Noteworthy foam projects include:
   - Bruce Museum, The Big Dig, 4 American Ski Grande Hotels in the Northeast, Net-zero energy weather station in Antarctica, The Guggenheim Museum
5. Two US patents and two published technical papers related to foam products and quality assurance

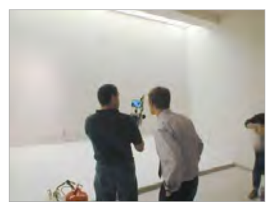
Out of the thousands of projects we completed in the 30 years I was a foam contractor, I can only remember four projects where we had material quality call-backs.

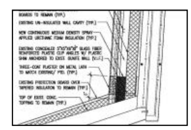
IPF – Bulk foam

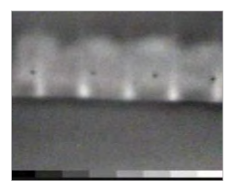


Infrared QA of foamed-in-place insulation – effective year-round (240F)

IPF – Bulk foam







Infrared QA of foamed-in-place insulation behind 1" plaster – effective year-round (240F)

My message

- Most foam applications result in very high-performing building enclosures.
- Once in a while, things can go wrong.
- How can we as owners, designers, inspectors, contractors, installers, and administrators be sure that we get the best possible results?
  - Specify or require quality assurance in your projects
  - Perform quality assurance protocols during the work
  - Verify quality assurance after the work

QA = Product Quality <u>and</u> IAQ Safety

Background

Why do I call them foam problems, not foam failures?
Not all problems are defects in the foam materials!

1. Perception problems (Owners – bad press)
2. Chemical problems (Manufacturer and/or Installer)
3. Design problems (Design professional, GC if no designer, Owner if neither)
4. Preparation & installation problems (Installer)
5. Inadequate follow-up (any or all of the four)

Comment: In the old days, the contractor was responsible for all of the technical and design issues, plus training and education. Now, it is only #2 and #4.

Not all problems in projects with foam are related to the foam product or the foam installation.
SPF can't seal the wood-to-wood AB connections

Brief outline

- Why are problems occurring on projects that include foam?
- What are the causes of foam problems/ failures? (some are both)
- How can we avoid foam problems?
- And, who am I talking to? Owner/Designer, General Contractor/Foam Installer?

Why are problems occurring on projects that include foam?

Why are problems occurring on projects that include foam?

1. Lack of standards and training
2. There is a lot for a new Foam Installer to learn
3. There are Design issues
4. It's not my problem syndrome
5. I have been doing it that way forever!

Why are problems occurring on projects that include foam?

There are no installation standards and not enough training

- There are no national ANSI standards and certifications
  - Industry guidance documents are "inadequate," but getting better – new 2013 certification program launched
- Inadequate installer training and/or experience
  - Where have all the old sprayers gone…? story
  - The "Cleveland Museum experience" story
  - The "Is Installer A certified to install your product?" story
- Foam problems are not usually advertised by the Installer, manufacturer, or the referral source
  - There are often legal issues associated with settlements
  - It is bad for the industry, so the manufacturers don't…
  - The Katz experience

Why are problems occurring on projects that include foam?

2. There is a lot to learn for a new Foam Installer
   - ASTM, NFPA, State and local zoning and fire regulations
   - OSHA, NIOSH, Industrial Hygiene Assoc., etc.
   - Foam and Chemical trade association guidance documents for "best practice"
   - Building science, materials science, chemistry
   - Codes (International, State, Local, and then there are standards)
   - How to use the equipment properly

Guidance Documents

AY-141 Spray Polyurethane Foam and Cathedral Roofs and Cathedralized Attics

- To vent or not to vent...for typical applications for SPF.

AY-147 Spray Polyurethane Foam for Hybrid Insulation Systems - Part 2: Climate Zones 4-7

- Provides a set of best practices for installing SPF in a hybrid insulation applications. Hybrid insulation systems covered in this document include the use of low-density and medium-density spray foam for insulation and air sealing in combination with air and moisture permeable insulations.

AY-148 SPF Insulation Installation Certificate

- This form must be completed and posted to comply with building code requirements for insulation levels and fire safety. This form is intended to be a guide or template only.

Make sure to follow:

Guidance on Best Practices for the Installation of Spray Polyurethane Foam (ACC Center for the Polyurethanes Industry and the Spray Foam Coalition)

A significant amount about worker safety and…

4) SPF Application Best Practices on the Jobsite 27
Introduction SPF Application Best Practices 27
4.1) Applying and Processing Spray Foam on the Jobsite 27
5) Post-Application Best Practices 31
Introduction to Post-Application Best Practices 31
5.1) Frequency of Post-Application Inspection 31
5.2) Visual Inspection 31
5.3) Thickness Measurement 32
5.4) Physical Sampling and Testing Best Practices 32
5.5) Performance Testing Best Practices 33
5.6) Posting of Code Compliance Material Documentation 34
5.7) Posting of Use/Occupancy Statements 34

One sentence – "…spray out a small amount of material to verify the quality of the SPF produced"

2013

Material selection

For the Installer

- Processing data is different for each product – does it work with his equipment?
- Equipment requirements may change from lot to lot – does he have to recirculate the material?
- Installation instruction data – different ambient temperatures, pass thicknesses, approved locations
- Shipping and handling data – temperatures, shelf life, etc.
- Manufacturer technical support capabilities – where and when?

Pop quiz: Can all spray foams be used on walls and roofs?

Product Data Sheet

PROCESSING CHARACTERISTICS AND RECOMMENDATIONS

RECOMMENDED PROCESSING TEMPERATURES	Preheater	Hose
Component A	100-130°F	100-130°F
Component B	110-130°F	100-130°F

These temperatures are typical of those required to produce acceptable product using conventional Gusmer or Grace equipment. Environmental conditions may dictate the use of other temperature ranges. However, under no circumstances should a temperature of 140°F be exceeded. It is the responsibility of the applicator to determine the specific temperature settings to match the environmental conditions and his own equipment.

PROCESSING CHARACTERISTICS

Machine Mix at recommended temperatures*	Winter	Regular
Cream Time	1 second	2 seconds
Tack Free Time	On Rise	On Rise
Cure Time	4 Hours	4 Hours

Building movement

Will the foam crack or delaminate if the building moves?

Does foam crack because a building moves?

How to avoid this potential problem

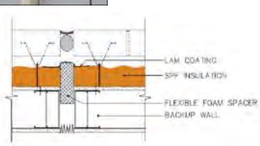
- Anticipate building movement in the design
- Be sure of substrate compatibility
- Prepare substrates properly
- Test the material <u>and</u> the application

Building movement

Anticipate building movement in the design

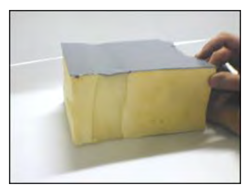
- Provide control joints
- Relieve stresses with surface cuts or bond breakers where necessary – also a QA method
- Use flexible membranes on substrates that move, and at transitions between materials that move at different rates

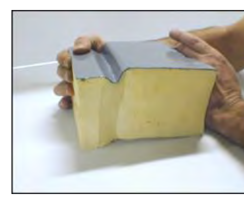
Control Joints



Control Joints

Allow movement to relieve stress, maintain air barrier continuity





Building movement

Will the foam crack or delaminate if the building moves?

Answer: Significant building failure will occur long before the foam will crack or "fall off" if the building is designed properly.

What are the causes of foam material problems?

What are the causes of foam problems?

- Chemical problems
- Site processing problems
- Installation problems
- Post-installation problems

Chemical problems

Before the installation

- QA problems at the factory – record the lot numbers used for each project
- Too hot or too cold during shipping
- Too hot or too cold during storage. Do not store above 86F or below freezing

During the installation

- The rig is too hot or too cold during the installation
- The ambient and/or substrate are too hot or too cold
- Process-equipment heaters are not working properly
- Kit or can materials are too hot or too cold

Delivered too cold

Cold weather issues

A-side: There are only three manufacturers of isocyanate, so temperature requirements should be the same for all foam products. Can cool down to -0F before being damaged

B-side: This brand can go down to -10F before it is damaged. Do not mix when it is warm. 245fa will boil out at 59F, 79F when in solution. So only mix the B-side up to 55F.

Chemical problems

1. The chemicals are prone to stratification when stored (mechanical mixing or recirculation may be required, but this can release the blowing agent)
2. Work-arounds for each
   a. Specify processing to the manufacturer's specs.
   b. Require process monitoring records as a submittal (temperature/ratio monitor output).

Note: Pressure monitoring is not a true indication of ratio – pressure changes with temperature and up and down-stream restrictions, while flow is specific to the ratio of the chemicals to each other.

The top 3 causes

Let's assume that we only buy top-quality chemicals and they are delivered to the foam installer in good shape. So what are the top 3 issues that cause almost all of the foam material problems/failures (my estimates)?

1. Site Processing problems
   - Off-ratio and off-temperature processing (50%)
2. Installation technique
   - Pass thickness (35%)
3. Surface preparation (15%)
   - Wet surface or high moisture content
   - Too hot or cold
   - Release agent on the surface - waxy beams, vent chutes form bond break

Site Processing problems

What are the causes of foam problems?

Field processing problems

1. The pump/proportioner goes off ratio
2. The mix is not adequate
3. The drum pumps, proportioner, and hose heat are not properly set or maintained
4. Inadequate QA control systems in place to avoid problems when changes occur after the initial equipment start-up (Ideally use temperature and ratio monitors with shut-down capability)

Hint: Require processing QA reports in your submittals to assure product quality

Installation problems - processing

1. Off-ratio and off-temperature processing (50%)

- Poorly processed material, even if it reacts to a large extent will not be:
  - Dimensionally stable (cracking, shrinkage)
  - Well bonded to otherwise compatible substrates (delamination)
  - A reliable air barrier material
- Poorly processed material, even if it reacts to a large extent may:
  - Release gasses from un-reacted raw material
  - Give off odors
  - Have a lower R-value
  - Have a higher perm rating

What are the causes of foam problems?

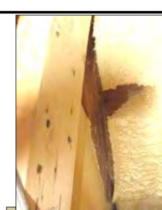
Things change!

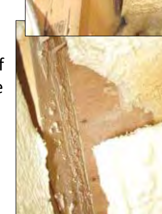
Photo DSCN1993.jpeg

Photo DSCN2003.jpeg

Pictures of cracks along rafters in the House attics. The one on the right has been temporarily stuffed with batt insulation until the remediation work begins.

Wet and cold substrates





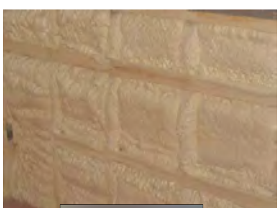
Note the lack of adhesion at the roof sheathing and rafter

Off ratio – B-rich

Low-tech froth equipment with no monitoring capabilities

Off ratio – B-rich

After replacement



How to stop processing problems

Four types of QA for foam plastic = causes

1. Design
   - Verify that the right type of foam is being used for the application
   - Verify that the design reflects good building science for the specific application
   - Verify the intent (product quality <u>and</u> application performance) of the design
2. Chemicals
3. Installation
   - *Processing*
   - Technique
4. Installation follow-up
   - Maintain minimum cure requirements

Comment: In the old days, the contractor was responsible for all of these, plus training and education. Now, it is only #2 and #3.

Installation problems - processing

Industry processing & installation troubleshooting guide

SPRAY FOAM TROUBLE SHOOTING HINTS

Poor Yield	Too cold for system. Doesn't get full rise. It is substrate that counts. Order faster system or winter system. Too hot for system-cures too fast to allow full rise. - Hose or unit heat too high - Blowing agent boiled off in opened containers - Order slower reactivity system or seal containers or order summer system. Off Ratio Foam - Check Equipment - Surface contamination: water, solvent Poor Mix – Use correct impingers and or mixing chambers Wind conditions – Wind taking heat from substrate and foam before cure. - Use a windscreen, tighter pattern, less heat to reduce overspray, or stop work.
Crawling/ Creep	Substrate temperature too cold for the system. Wind conditions too high for system. Off ratio foam, check equipment and check for surface contamination. Check for adhesion to substrate or primer.
Reversion or Disappearing Foam	Substrate too cold for system. Off ratio resin rich foam. Check equipment. Poor mix - use correct impingers or chambers.
Spongy Foam	Off ratio resin rich foam. Also can exhibit large cells. Check equipment. May later revert to some extent. Next pass may blow off or "disappear". Poor adhesion of next pass. Tear off and refoam. Check for moisture, humidity and surface contamination.
Dark Yellow Glassy Foam	Off ratio isocyanate rich foam. Poor yield, poor adhesion, glass eyes. Next pass may "blow off" and have poor adhesion.

Product Data Sheet

RECOMMENDED SUBSTRATE TEMPERATURES

At time of application	RT2045 Winter	RT2045 Regular
Minimum	40°F	60°F
Maximum	80°F	120°F

For applications below 40°F, FOAM-TECH personnel should be consulted. At the lower end of the indicated temperature ranges, flash passes should be avoided.

Extreme pass thickness on a hot roof

Thermal shock plus deep pass thickness

Installation problems - processing

How can we prevent these problems?

"Quality Assurance/control = IAQ Safety"

Off-ratio and off-temperature processing (50%)

- This is the big one, it can be handled with **built-in quality control equipment**
- This equipment is about a $5,000 to $10,000 upgrade
- Avoiding one drum run-out event can save hundreds of dollars, and a typical bulk foam installer uses at least one set of drums per day
- Removal, cleanup, replacement, and disposal for one off-ratio installation can cost tens of thousands or even millions of dollars to remediate.

Installation problems - processing

Can you do it?

Processing Equipment

2:1 transfer pumps are recommended for material transfer from container to the proportioner. The plural component proportioner must be capable of supplying each component within ± 2% of the desired 1:1 mixing ratio by volume. Hose heaters should be set to deliver 120°F to 135°F materials to the spray gun. These settings will ensure thorough mixing in the spray gun mix chamber in typical applications. Optimum hose pressure and temperature will vary with equipment type and condition, ambient and substrate conditions, and the specific application. It is the responsibility of the applicator to properly interpret equipment technical literature, particularly information that relates to the acceptable combinations of gun chamber size, proportioner output, and material pressures. The relationship between proper chamber size and the capacity of the proportioner's pre-heater is critical. Mechanical purge spray guns (specifically

Processing quality control

What QA methods that can meet and verify this tolerance?

- Option 1 – use a ratio and temperature monitor with output to provide documentation of compliance.
- Option 2 – use processing equipment that has automatic shutdown if the processing is off ratio or temperature requirements are not met.
- Option 3 – use scales with real-time weights to monitor material use, A:B. If automatic shut-down at preset weight differential is not part of the system, provide full-time manual oversight of this system.

Processing quality control

What QA methods that can meet and verify this tolerance?

Option 4 – provide the following documentation

- Provide written information from Bayer that stipulates what the installer has to do as an alternative to ratio monitoring to achieve this maximum deviation requirement.
- Provide a written copy of the "Tune-up" report from a qualified equipment service.
- Certify in writing that the equipment met the manufacturer's processing requirements during the entire installation.
- Provide a test report from the manufacturer verifying that physical samples taken at intervals during the installation were processed properly (mix, ratio, physical properties, etc.).

Test sample A-to-B ratio analysis – Lab only

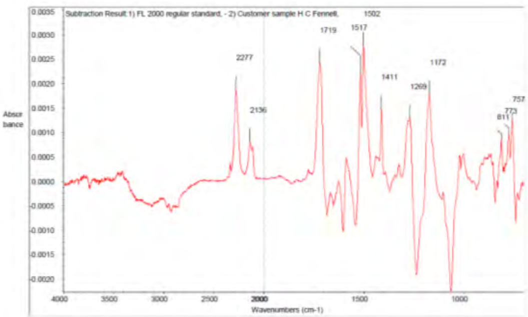


Figure 3. Spectral subtraction result (Sample #1 – Sample #2)

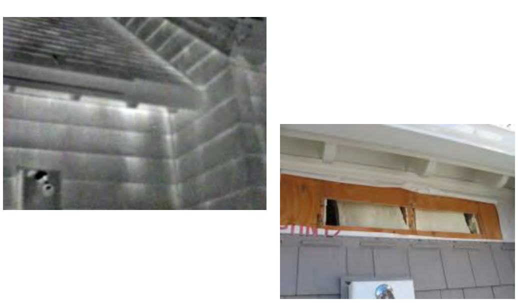
Short-term off-ratio event

Short-term off-ratio event

The following are RATED AC, AL

Remember, these are rare situations, but they demonstrate the implications of inadequate quality control

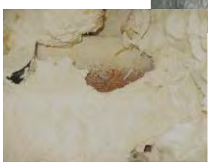
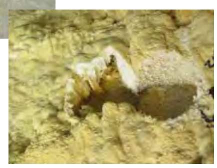
Infrared locates off-ratio material



Pattern analysis discovers off-ratio material

Foundation walls that required remediation



Full-time off-ratio event






The remediation process - removal

Removal was required as this was a Type II problem





Product Data Sheet

PROCESSING CHARACTERISTICS AND RECOMMENDATIONS

RECOMMENDED PROCESSING TEMPERATURES	Preheater	Hose
Component A	100-130°F	100-130°F
Component B	110-130°F	100-130°F

These temperatures are typical of those required to produce acceptable product using conventional Gusmer or Grace equipment. Environmental conditions may dictate the use of other temperature ranges. However, under no circumstances should a temperature of 140°F be exceeded. It is the responsibility of the applicator to determine the specific temperature settings to match the environmental conditions and his own equipment.

PROCESSING CHARACTERISTICS

Machine Mix at recommended temperatures*	Winter	Regular
Cream Time	1 second	2 seconds
Tack Free Time	On Rise	On Rise
Cure Time	4 Hours	4 Hours

Product Data Sheet

RECOMMENDED SUBSTRATE TEMPERATURES

At time of application	RT2045 Winter	RT2045 Regular
Minimum	40°F	60°F
Maximum	80°F	120°F

For applications below 40°F, FOAM-TECH personnel should be consulted. At the lower end of the indicated temperature ranges, flash passes should be avoided.

Product Data Sheet

FLAMMABILITY CHARACTERISTICS*
SURFACE BURNING CHARACTERISTICS*

ASTM E-84*	3"	4"
Flame Spread*	25	25
Smoke	400	400

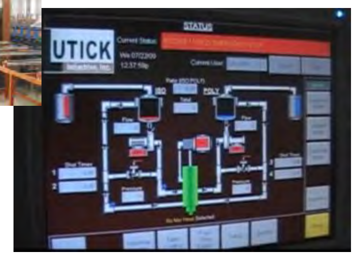
Sample spray applied at 1/4" Cement Asbestos Board.

*Note: This numerical flame spread and all other data presented is not intended to reflect the hazards presented by this or any other material under actual fire conditions.

CAUTION: Polyurethane foam produced from these materials may present a fire hazard if exposed to fire or excessive heat (i.e. cutting torches). The use of polyurethane foam in interior applications on walls and ceilings presents an unreasonable fire risk unless protected by an approved fire resistant barrier with a finish rating of not less that 15 minutes. A code definition of an approved "thermal barrier" is a material equal in fire resistance to ½' gypsum board. Each firm, person, or corporation engaged in the use, manufacture, production or application of polyurethane foams products from these resins should carefully examine his end use to determine potential fire hazard associated with such product in a specific use and to utilize appropriate precautionary and safety measures. Consultation with building code officials and insurance agency personnel before application is recommended.

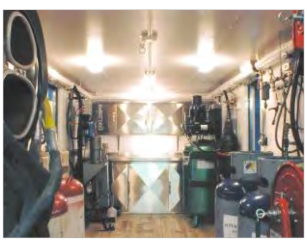
OEM PU Foam processing

QA meters since 1954



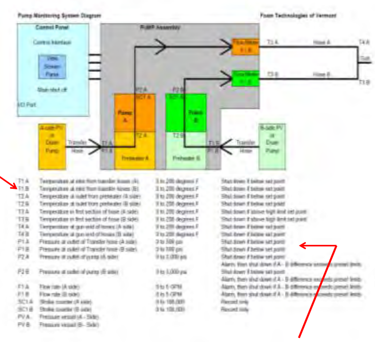
Processing quality control

This is industry-standard off-the-shelf quality control equipment that can eliminate most foam processing failures – specify this type of processing QA for your projects!



Ratio, usage, and temperature monitor with auto shut-off

Note the number of processing parameters that need to be on spec. for good quality control



Note that these parameters shut down the pump if the pre-set quality assurance limits are exceeded

These are the two main components of a temperature and ratio monitoring system.

Miscellaneous accessories needed for a complete monitoring system include the following:
1. Thermistors and wire to locate at the gun, in the hoses, and right after the primary heaters.
2. In line air valve to shut off pump if electrical lock-out is not easily available
3. Electrical outlet with surge/overload protector at monitor plug in
4. Remote alarm or warning light if used in addition to built-in alarm

Graco

Graco

Installation problems

Installation problems

Technique

1. Passes/lifts are too thick/high
2. Not enough time between passes
3. Installing SPF when the relative humidity is 80% or above
4. Improper spray pattern sequencing (picture framing, fillet pattern, etc.)
5. Improper response to substrate and environmental conditions
6. Proper work-around protocols not used for extreme environmental conditions when “the work must go on”
7. More about IPF protocols in the applications section
8. Improper product and performance quality assurance protocols

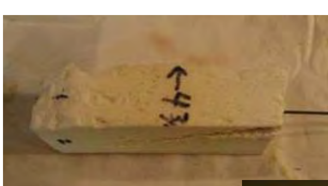
See SPFA: AY-145 Surface Texture of Spray Polyurethane Foam

Installation problems – pass thickness

2. Pass thickness above the maximum recommendation (35%)

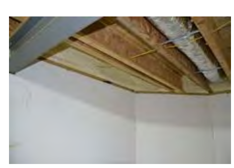
- Foam installed with too-thick passes will not be:
  - Dimensionally stable (cracking, shrinkage)
  - Well bonded to otherwise compatible substrates (delamination)
  - A reliable air-barrier material
- Foam installed with too-thick passes could:
  - Have a lower R-value
  - Have a higher perm rating
  - Have a lower compressive strength
  - Be prone to scorching and burnout
  - Give off odors
  - Produce voids in the insulation

Pass thickness field test

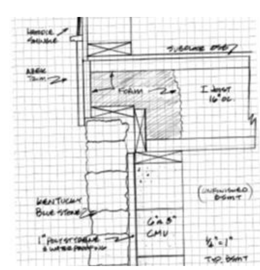


Require Work Report and QA Submittals to assure product quality & encourage patience

Design for a pass thickness failure



Deep rim joist design with a spray foam spec.



Design for a pass thickness failure

One 11” pass with an 1-1/2” lift spray foam product

Removing an SPF sample for density testing

Low-tech Schedule 40 PVC cutter for deep sections

Too hot - burnout

2012 Cape Cod attic fire

Installation problems

Now we have to worry about thickness <u>and</u> how long to wait between passes?

Per Lift Application
Applicators should apply a maximum pass thickness of 2 inches, with a minimum of 30 minutes between passes.

Health and Safety Information
Appropriate literature has been assembled which provides information concerning the health and safety precautions that must be observed when han-

Installation problems – Pass thickness

How can we prevent these problems?

2. Pass thickness above the maximum recommendation or inadequate wait time between passes (35%)

- Unfortunately, this is a behavior issue. Training is important, but when the installer is in an awkward, hard to reach, or confined space, he just wants to get the work done. Quality control, including core and total insulation thickness sampling, by another member of the installation team or a third party, is probably the best way to encourage the type of patience this requires. Good personal protection equipment and safe work cycle limits can also make difficult (hot, etc.) conditions more tolerable.

Installation problems – wait time

How can we prevent these problems?

2. Pass thickness above the maximum recommendation or inadequate wait time between passes (35%)

- The Owner/Designer should specify random <u>core sampling</u> and <u>slit tests</u> to further encourage proper technique in order to protect the Owner from problems. Require sampling reports and certifications in the project submittals.
- Sometimes this occurs when difficult access or enclosed cavities are specified for insulation with a spray foam product rather than <u>cavity-fill slow-rise formulations</u>. Foam installers should use froth or pour formulations for large closed-cavity installations, and use slow-rise kits for incidental accessory work. (stud corners, closed rim joists, boxed headers, etc.)

Diagnosing foam problems

Stress testing - Dimensional stability

Diagnosing foam problems

Slit test that opened up – sounded like a gun shot! Excessive pass thickness was the cause.

Installation problems - preparation

3. Surface preparation/verification (15%)

- Substrate compatibility – foam doesn't adhere to all substrate materials
  - Foam will not adhere to Teflon, water, ice, or snow
  - The substrate isn't fully adhered to the structure, or de-bonds when exposed to exothermic heat
  - Foam does not stick to polyethylene (Ice and Water Shield, some air and vapor barrier materials)

Installation problems - preparation

3. Surface preparation/verification (15%)

- Surface conditions
  - The substrate is wet or has a high moisture content
  - The substrate is too hot or too cold
  - There is a release agent on the surface (waxy LVL beams, oily galvanized steel, oily mill finish aluminum, some transition membranes and roofing fabrics)
  - The substrate is not attached to the structure

Compatibility

Substrate material compatibility for foamed-in-place polyurethanes

Substrate Materials - General Description	Product/Brand name	Adhesion rating	Preparation	Maximum moisture content allowed
Plastics / membranes				
Polyethylene films and membranes		Poor	N/A	N/A
Polytetrafluoroethylene (PTFE) products		Poor	N/A	N/A
Polypropelyne products	Tyvek, Typar, etc.	Moderate	N/A	N/A
Glass fiber reinforced products				
Reinforced plastic membranes (Poly, TPO, PVC, etc.)	Reinforced polyethylene (many brands)	Varies with plastics (see this list for the plastic film to assess compatibility)		N/A
Reinforced bituminous membranes	Many	Varies with membrane - note that most bituminous-based product can soften or melt from the heat of reaction - this can temporarilly compromise bond strength of the substrate		N/A
Reinforced in paper membranes (Scrim)	Many	Good	Verify paper is not coated with a plastic or wax that may reduce bond strength	Value unknown, but integrity of the paper is important
Polyester resin sheet goods with integral glass fibers (Corvettes, tub-showers units, translucent roofing, etc.)	Fiberglas	Moderate	Clean and dry*	N/A
Peel-and-stick membranes				
Products with polyethylene film finish	Ice and Water Shield	Poor	Torch	N/A
Products modified to accept foam	Blueskin, Perm-A-Barrier	Moderate	Clean and dry*	N/A
Polyurethane and Isocyanurate board stock	Tuff-R, Thermax	Good	Clean and dry*	N/A
Polystyrene foam				
Expanded	Styrofoam EPS	Good	Clean and dry*	N/A
Extruded	Styrofoam XPS	Good	Clean and dry*	N/A

Compatibility

Substrate material compatibility for foamed-in-place polyurethanes

Substrate Materials - General Description	Product/Brand name	Adhesion rating	Preparation	Maximum moisture content allowed
Wood products				
Construction grade spruce	Many	Good	Clean and dry*	< 11%
Pressure treated lumber	Many	Varies	Clean and dry*, free of preservative buildup	< 11%
Wood boards	Rough-sawn and planed			
Glue-laminated beams & joists				< 11%
Natural wood face layer	Many	Good	Clean and dry*	< 11%
Waxed finish	Many	Poor	Apply bonding material	< 11%
Plywood				< 11%
Standard wood	Many	Good	Clean and dry*	< 11%
Pressure treated	Many	Varies	Clean and dry*, free of preservative buildup	< 11%
OSB				< 11%
Smooth side	Many	Moderate	Sand and/or prime	< 11%
Rough side	Many	Good	Clean and dry*	< 11%
High and medium-density composite wood panels				< 11%
MDO	Many	Moderate	Sand and/or prime	< 11%
Particle board	Many			< 11%

Compatibility

Substrate material compatibility for foamed-in-place polyurethanes

Substrate Materials - General Description			Product/Brand name	Adhesion rating	Preparation	Maximum moisture content allowed
Metals						
	Steel					
		Mill-finish cold rolled sections	Many	Moderate	Clean and apply etching agent/primer	
		Mill-finish coil stock	Many	Poor	Clean and apply etching agent/primer	
		Primed and/or painted	Many	Good	Clean and dry	
		Galvanized steel - Spangled	Many	Poor	Apply etching agent	
		Galvanized steel - Hot dipped	Many	Moderate	Prime	
		Galvanized steel - Cold coated	Many	Moderate	Prime	
		Galvanized steel - with paint-prep. galvanization process	Galvalume	Good	Clean, dry, free of oil and grease, or uncured solvent-based materials	
	Aluminum					
		Mill-finish		Poor	Etching & prime	
		Primed and/or painted		Good	Clean and dry*	
		Galvanized - Galvalume		Moderate	Clean and dry*	
		Aluminum foil facers on RFB		Moderate	Clean and dry*	
Coatings						
		Bituminous coatings	Tar, foundation coatings, vapor barrier coatings	Poor	May delaminate from heat of reaction	
		Water-based coatings	Foundation coatings, vapor barrier coatings	Varies by product - verify with manufacturer	As directed by manufacturer	
		Polyurea	Many	Good	Clean and dry	
		Oil and water-based paints	Many	Good	Clean and dry	

Compatibility

Substrate material compatibility for foamed-in-place polyurethanes

Substrate Materials - General Description		Product/Brand name	Adhesion rating	Preparation	Maximum moisture content allowed
Masonry/glass					
	Aged poured-in-place or pre-cast concrete	Many	Good	Clean and dry*	
	Fresh poured-in-place or pre-cast concrete	Many	Varies	Clean and dry*	
	Concrete block	Many	Good	Clean and dry*	
	Brick	Many	Good	Clean and dry*	
	Stone		Good	Clean and dry*	
	Ceramic clay block	Many	Good	Clean and dry*	
	Ceramic tile - natural	Many	Good	Clean and dry*	
	Ceramic tile - glazed	Many	Moderate	Clean and dry*	
	Glass fiber products	Open mesh	Good	Clean and dry*	N/A
		Woven roving	Good	Clean and dry*	N/A
	Paper faced gypsum board	Standard gypsum wall board	Good		
		Exterior gypsum board (Densglas)	Moderate		
	Plaster		Good		
	Window glass	Many	Moderate	Clean and dry*	
	Foam glass board stock	Many	Moderate	Clean and dry*	

Installation problems - preparation

How can we prevent these problems?

3. Surface preparation/verification (15%)
   - The Owner/Designer should specify compatible substrates where foam is to be applied, or specify pull-testing prior to the installation when substrate compatibility is unknown (mockups, etc.).
   - The Installer should verify that his products will adhere adequately to any material that is not a standard substrate by doing pull testing and that the substrate itself is fully adhered or mechanically fastened.

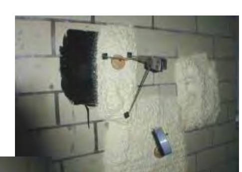
Material compatibility

You can test materials at home instead of in the field – before you have a problem on a building

1. Natural cure shrinkage – as the gas in closed-cell foam cools, it contracts
2. Heat of reaction reduces substrate bond strength

Material compatibility

Field adhesion/pull test



CMU with VB coating

Field adhesion/pull test

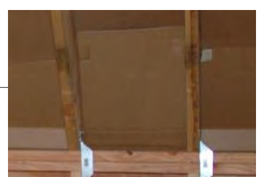
Glazed terra-cotta tile

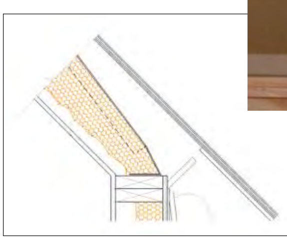
Heat-of-reaction

Bituminous VB coating loses bond due to heat-of-reaction

Preparation problem

No bonding surface due to incorrect location of the cardboard vent chute





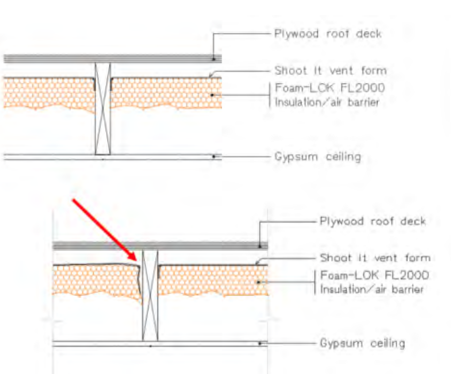
Not enough room for specified R-value ~3” for R-38 min.

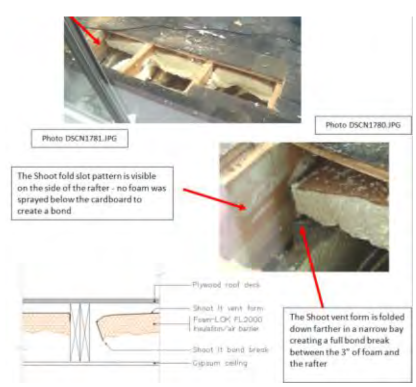
Preparation problem

Daylight is visible under the cardboard vent chute form

Photo DSC_4966.JPG

Air bypass under the cardboard vent form





Installation problems - preparation

Installation problems - preparation

How can we prevent these problems?

Substrate compatibility

- Eliminate or plan for known material incompatibilities
- Verify unknown material bond strength with a pull test
- Verify unknown material bond strength with heat stress tests
- Consider heat of reaction bond release
- Consider cure pull of adhered substrate layers

Installation problems

Technique

1. Passes/lifts are too thick/high
2. Not enough time between passes
3. Installing SPF when the relative humidity is 80% or above
4. Improper spray pattern sequencing (picture framing, fillet pattern, etc.)
5. Improper response to substrate and environmental conditions
6. Proper work-around protocols not used for extreme environmental conditions when “the work must go on”
7. More about IPF protocols in the applications section
8. Improper product and performance quality assurance protocols

See SPFA: AY-145 Surface Texture of Spray Polyurethane Foam

Good technique

Good technique also saves material ($)

Good technique

Better depth control

Self-supporting

Good technique

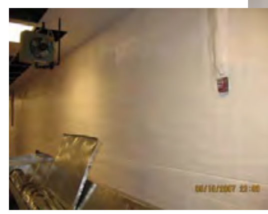
Below-grade application

Good technique

Note the "fillet edges" detail along the rafters

Unvented roof application

Good technique



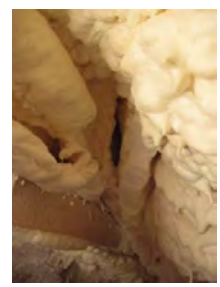
Food processing facility

Poor technique

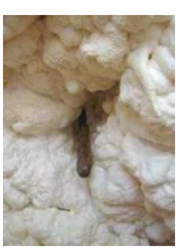
Lack of over-spray protection, multiple foam products, uneven texture, voids

Poor technique

Uneven texture, voids



Poor technique

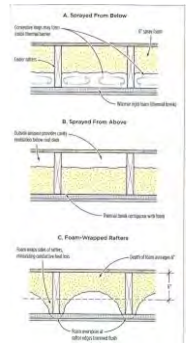


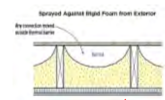
Technique – Specialty Approved Foam

Good technique

The picture framing technique will ensure that insulation seals cracks and crevices without resulting in fold-over along the stud face or air-pockets or voids which will affect the insulation's performance.

Good technique





Good technique also saves material ($)

Average foam thickness with fillet edges is more effective per unit of foam

JLC article, 2005

Poor technique

Photos # DSCN1996.jpeg, IMG_2160.jpg, and DSCN2004.jpg

Post-installation problems

Typical post-installation problems

1. Inadequate quality assurance protocols
2. Failure to maintain minimum cure requirements – thermal shock
3. Lack of protection against damage by related trades (open flames, air-barrier penetrations for mechanical systems, etc.)

Product Data sheets and ESRs report cure requirements – specify and verify compliance with the manufacturer's requirements. Temporary insulation can extend the installation window.

Quiz questions:

- Foam products can be damaged prior to the installation?
- Problems in field-applied polyurethane foam plastic installations are always the fault of the foam installer?
- All foam products are generally equal in terms of their physical properties and performance?
- All foam installations need the same quality assurance tests?
- All foam products meet the code requirements without additional accessory materials?
- The most common cause of foam problems is bad spray technique by the installer?
- The ICC codes require all foam installers to have to have the same minimum qualifications?

Foam remediation

- Diagnosing foam problems
- Selecting the right approach
- The remediation process

Return to Contents List

Diagnosing foam problems

IHAA IAQ lab testing – at the site

- Test the site, not the material. Sample lab tests don’t tell you the concentrations at the site or what other vapors may be causing health issues associated with the foam.
- Most labs can only test for MDI; you have to know what the proprietary formulations contain to test for more.
- This type of testing would probably cost around $3,000 (residential).

Diagnosing foam problems

Odor and harmful out-gassing notes

- We can smell things that most field monitoring systems can't detect (except dogs)
- Testing is expensive, but smelling is cheap
- Heat accelerates outgassing
- Bag/smell tests can verify if an isolation strategy could be effective

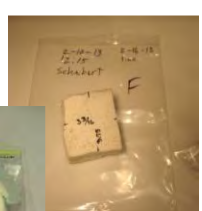
Diagnosing foam problems

Odor and harmful out-gassing

- Is the problem going away on its own as the foam cures and ventilation changes the air?
  - Bag and heat samples, do smell tests
- Can the problem be solved if the foam is isolated?
  - Isolate test area, bag the area, do smell tests
- Can the problem be solved if the area is ventilated?
  - Bag a test area, ventilate it, do smell tests
  - Identify rate of ventilation that handles rate of odor release

Diagnosing foam problems

Sample bags – for hot box odor tests



160F Test is designed to match hot roofs

Diagnosing foam problems

Odor and harmful out-gassing - Does removal solve the problem? Sequence of tests…

1. Remove the foam in a test area, bag the area, do smell tests
2. Remove the foam in a test area, clean and neutralize the surfaces, bag the area, do smell tests
3. Remove the foam in a test area, isolate the test area, bag the area, do smell tests
4. Remove the foam in a test area, clean and neutralize the surfaces, isolate the area, bag the area, do smell tests

Diagnosing foam problems

Odor and harmful out-gassing - Does removal solve the problem? Sequence of tests…from low-cost to most costly.

5. What happens if you ventilate the test area?
6. What happens if you add ventilation to each of the first four tests?

Diagnosing foam problems

Odor test bag areas

1. Just remove the foam
2. Remove and clean
3. Remove and encapsulate
4. Remove, clean, encapsulate

5. Just remove and add local ventilation to the test area
6. Remove and add local ventilation to the other three test areas (numbers 2 – 4)

Diagnosing foam problems

Diagnostic conclusions – foam quality

- Classify the foam
  - Class I: Is the foam completely reacted and cured?
  - Class II: Has it been determined that the foam is not completely reacted and cured?
  - Class III: Has the foam been damaged by an external factor such as a fire, flood, or growth of mold or mildew

Diagnosing foam problems

Industry terms for foam qualities with respect to removal requirements

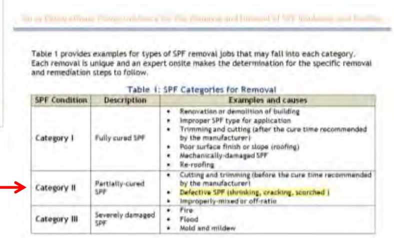


Table 1 provides examples for types of SPF removal jobs that may fall into each category. Each removal is unique and an expert onsite makes the determination for the specific removal and remediation steps to follow.

Table 1: SPF Categories for Removal

SPF Condition	Description	Examples and causes
Category I	Fully cured SPF	• Renovation or demolition of building • Improper SPF type for application • Trimming and cutting (after the cure time recommended by the manufacturer) • Poor surface finish or slope (roofing) • Mechanically-damaged SPF • Re-roofing
Category II	Partially-cured SPF	• Cutting and trimming (before the cure time recommended by the manufacturer) • Defective SPF (shrinking, cracking, scorched) • Improperly-mixed or off-ratio
Category III	Severely damaged SPF	• Fire • Flood • Mold and mildew

See ACC/SFC: Spray Polyurethane Foam: Guidance for the Removal and Disposal of SPF Insulation and Roofing, 2014

Diagnosing foam problems

Industry terms for foam qualities with respect to removal requirements

Category I SPFs are completely reacted and cured. As stated by the EPA, after SPF is applied and cured, it is considered to be relatively inert.[1] Although Category I SPFs may present a respirable dust hazard during removal, these SPFs are considered to be chemically inert and present no chemical hazard for those removing and handling the material. Many SPF manufacturers provide Safety Data Sheets for reacted SPF products.

[1]http://www.epa.gov/dfe/pubs/projects/spf/exposure_potential.html

Diagnosing foam problems

Industry terms for foam qualities with respect to removal requirements

Category II SPFs are those that have been determined not to have completely reacted and cured. Incompletely reacted SPF could be due to factors such as improperly mixed and off-ratio application. SPF that has not been allowed to cure for the amount of time recommended by the manufacturer would generally be included in Category II SPFs. Category II SPFs may not be chemically inert and could present a chemical hazard for those removing and handling the material.

See ACC/SFC: Spray Polyurethane Foam: Guidance for the Removal and Disposal of SPF Insulation and Roofing, 2014

Diagnosing foam problems

Industry terms for foam qualities with respect to removal requirements

Category III SPFs are Category I SPFs (fully reacted SPF) that have been damaged by an external factor such as a fire, flood, or growth of mold or mildew.

NOTE 1: It is beyond the scope of this document to determine the condition and the category of the SPF. Determining the precise condition of a SPF is often product-dependent and may require examination or testing by a representative from the SPF manufacturer or expert consultants.

See ACC/SFC: Spray Polyurethane Foam: Guidance for the Removal and Disposal of SPF Insulation and Roofing, 2014

Diagnosing foam problems

Diagnostic conclusions – foam quality

- Identify the foam remediation needs
  - Class I: The foam does not require remediation, however, the installation may need repairs to achieve the intended performance
  - Class II: Requires remediation – type/method to be determined
  - Class III: Requires remediation – remove and replace

Diagnosing foam problems

Can the foam application be repaired (Class I or Class II)?

- Good quality (Class I) or foam of marginal or mixed quality (Class II) – depends how fully the chemicals are reacted and cured?
  - Examples: Good foam delaminated from the substrate, substrate was wet, all but the first layer is good foam.
- Can non-quality functional defects (Class I) be repaired with other materials
  - Example: Thermal shock material can be salvaged if on ratio, over-thick pass material can be salvaged if not scorched or out-gassing.

Diagnosing foam problems

Can the application be repaired?

- If yes, how do you know if a problem will re-occur?
  - Treat it as if it will
  - This usually applies to dimensional stability foam problems
  - Relieve stresses before remediating
  - Remove damaged or contaminated bonding surfaces before making repairs
- If no, are there alternative solutions that cost less than removal?

Diagnosing foam problems

Should the application be isolated instead of repaired?

- Due to impossible or extremely difficult access
- Because the cost of repairs is too high
- If so, which methods are effective?
  - Coatings and barriers
  - Local ventilation
  - General ventilation

Diagnosing foam problems

- Does the foam need to be removed?
  - Are there un-reacted (Class II) chemicals?
  - Is the material still out-gassing?
- If there are no un-reacted chemicals:
  - Is the foam dimensionally stable and/or can it be stabilized?
  - Is the bond likely to break over time?
  - Can the defects be repaired?

Some foam installations are of good quality, but Owners decide to remove it anyway

Diagnosing foam problems

Has the foam really failed?

- If no, … move on to other solutions
- If yes, … proceed to remediation

The remediation process

Selecting the right remediation approach based on:

- Risk assessments
  - Health problems trump all
  - Sometimes health risks dictate removal
- If health is not at risk, a cost-benefit analysis of the remediation options available
  - Function and performance follow health risks

The remediation process

There are three basic remediation approaches

- Repair and stabilize
- Isolate
- Remove and replace
- Combinations of these (is this a fourth type?)

The remediation process

Repair and stabilize

The remediation process

Repair and stabilize

The remediation process

Repair and stabilize

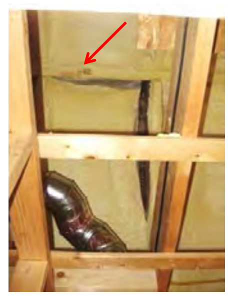
The remediation process

Repair and stabilize

- Repairs can include isolation or remove and replace strategies in limited areas.
  - Closed-cell foam shrinkage in limited areas due to slightly off-ratio events
    - Drum run-out events
    - Heating system events
    - Mixer restriction
    - Brain failure
  - Localized delamination due to substrate compatibility

Short-term off-ratio event = limited remediation

Short-term off-ratio event



Drum run-out event

What are the causes of foam problems?

A roof "repair and stabilize" project

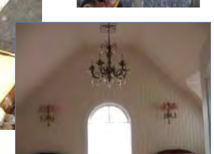
Photo DSCN1993.jpeg

Photo DSCN2003.jpeg

Pictures of cracks along rafters in the House attics. The one on the right has been temporarily stuffed with batt insulation until the remediation work begins.

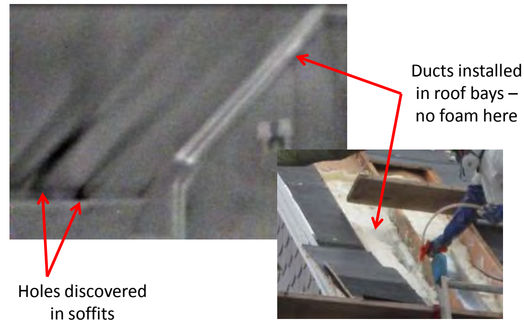
The remediation process

A roof "repair and stabilize" project



The remediation process

The remediation process



North side soffit areas

Holes in framing and missing foam sealant discovered in soffits

0.54 CFM50 / sf before air sealing
0.19 CFM50 / sf after air sealing

The remediation process

Isolation alone

- Clean/prepare the foam as required for the encapsulation product/method
- Encapsulate the foam and/or residue
- Ventilation (short and long term) can be a means of isolating vapors from the occupied space. It may dilute the vapors to a safe level, but this is not an isolation strategy – either strategy requires equipment and uses energy

The remediation process

Isolation alone

- Encapsulate the foam and/or residue with barriers or coatings that will limit vapor release to the degree that it can be removed by the normal ventilation
  - When buying vapor barrier coatings (paints), most distributors, and some manufacturers, don't know if the material is a vapor barrier or what its perm rating is. Target >1.0 as a maximum perm rate. You will have to monitor outgassing to verify that this is enough.
  - Must be compatible with the foam and the substrate
  - BIN and other shellac-based products are not vapor barriers – they all withdrew this claim

The remediation process

Remove and replace (Category I SPFs - if no un-reacted chemicals are present)

- Mechanically remove the material - avoid damage to mechanical systems (there are chemical removers)
- Disposal
- Perform adhesion tests on the substrate before installing new foam of good quality to verify that the substrate does not have any residue that will affect bonding

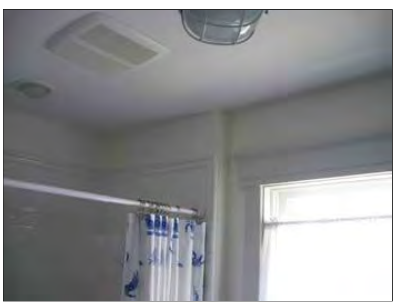
See ACC/SFC: Spray Polyurethane Foam: Guidance for the Removal and Disposal of SPF Insulation and Roofing

Mixing and matching products

Changing over on the fly can involve at least 40#, or 20 cu. Ft., of finished product. Both products are contaminated during the change over.

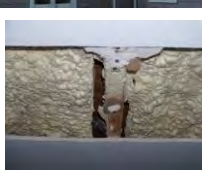
Infrared locates off-ratio material

Shower inside of the wall



Adhesion test required?

Pattern analysis discovers off-ratio material



The remediation process

Remove and replace (Category II SPFs - if un-reacted chemicals are present)

- Mechanically remove the material - avoid damage to mechanical systems (there are chemical removers)
- Clean the surfaces?
- Neutralize the substrate material?
- Isolate the substrate (coatings, barriers, short-term or permanent ventilation)?
- Disposal

See ACC/SFC: Spray Polyurethane Foam: Guidance for the Removal and Disposal of SPF Insulation and Roofing

The remediation process - removal

Mechanically remove the material - avoid damage to mechanical systems

Tools of the removal trade


knife or sidewalk ice scraper may be used to remove the SPF from the sheathing, subfloor or roof deck. Use these tools carefully, especially around embedded obstacles. Remaining chunks of SPF may be removed by a hand scraper or powered wire brush.

Closed-Cell, Medium Density SPF Removal
The rigid closed-cell structure of medium density SPF creates a material with higher strength and stiffness, which makes cutting and removal more difficult than that required for low density SPF. Power hand tools are necessary except for very small removals. Like low-density SPF, begin by separating the SPF from the sides of the studs, joists or rafters. A reciprocating saw or circular saw can be used. Then separate the SPF from the sheathing, subfloor or roof deck with a sidewalk ice-scraper or spud bar. A hand-held electric power scraper, like those used for tile removal, may be needed.

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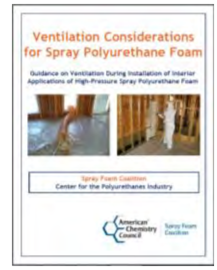
See ACC/SFC: Spray Polyurethane Foam: Guidance for the Removal and Disposal of SPF Insulation and Roofing

The most important tools are:

If there are Class II materials, use the SFC protocols for isolating and ventilating during a spray foam installation

- Signage
- Enclosure systems
- Blowers and fans
- AQ monitoring system



Ventilation Considerations for Spray Polyurethane Foam, 2013, ACC/Center for the Polyurethanes Industry

Cause – Off-ratio foam

A floor "remove and replace" project

Data collection

The first attempt

Off ratio - fluctuations

- Layers of A-rich, good quality, and B-rich foam

Off ratio - fluctuations

The second attempt

Layers of A-rich, good quality, and B-rich foam

Off ratio - fluctuations





The remediation process - removal


Removal was required as this was a Type II problem


Off ratio - fluctuations

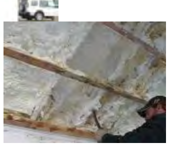
Layers of A-rich, good quality, and B-rich foam



The remediation process - removal


Class II materials, but outside

Flat bar and a hammer worked the best



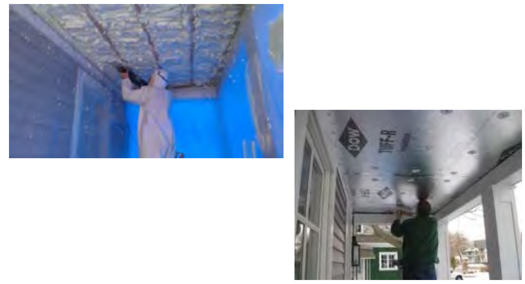
The remediation process - removal

Three days for two men – approx. 120 sq. ft. No wires cut, one water leak found



After removal

After replacement



Cause – Off-ratio foam

Basement and attic “removal” project

The remediation process - removal

Removal was required as this was a Type II problem

The remediation process - removal

Site protection

The remediation process - removal

Air quality management

The remediation process - removal

Personal protection

The remediation process - removal

Difficult access

The remediation process - removal

In progress

The remediation process - removal

The results

The remediation process - removal

The results

The remediation process - removal

Disposal

Remediation testimony

"Yes it was incredibly difficult to get the foam out (and the *unreacted* foam chemicals that have leached into the wood is impossible to remove). The remediation crew was here for more than six weeks on and off. A huge time commitment. When they were done, Annie and I put in at least one hundred additional man hours continuing and finishing off the removal, just brutal.

After we do the repainting, we still have the heat exchange ventilator to install and finally, we need to insulate, once again."

The remediation process – removal

- Clearly, mechanical removal methods are difficult for large volumes of foam, but necessary to preserve mechanical systems.

The remediation process – removal next steps

- Cleaning works for residue in some cases, but coatings, barriers, and short-term ventilation may be required to restore safe air quality given the complexity of the substrates involved.
- Neutralizing agents can work for some chemicals - See the product's MSDS/GHS for cleanup of chemical spills.

The remediation process

Two ventilation strategies

- General ventilation – whole house exhaust vent, centralized HRV system, etc.
- Local ventilation – depressurize attics, crawlspaces, structural cavities to the outdoors. Similar to a radon remediation system.

Diagnosing foam problems

How can you add local ventilation to this project? Think radon remediation.

1. Make sure the bays are all connected
2. Sheath the underside of the floor joists
3. Depressurize the floor cavity with a small-flow Fantec fan through the rim joist to the outside

The remediation process

What are the replacement options?

- New, good quality foam
- Alternative comparable performance systems (is this always possible, reasonably?)
  1. Stone foundations?
  2. Attic slopes with small framing?
  3. Is rigid foam board cut-and-fit an alternative?
  4. Are higher cost alternatives the responsibility of the party who is at fault?

Recommendations

General guidelines for making remediation decisions

- Determine the cause of the problem before implementing a remediation strategy
- If this is not a health issue, only target the original function and performance goals in the remediation unless upgrades are authorized
- Plan the remediation work so it will be a durable (life of the building) solution

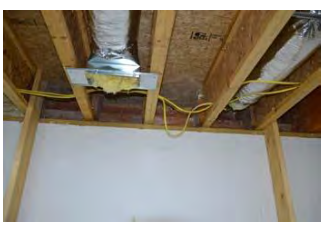
Recommendations

General guidelines for the remediation work

- Perform the appropriate IAQ management and personal protection during remediation, including CAZ management
- Require a rigorous quality assurance program for all three types of remediation
- Require full documentation of the conditions & processing (repairs, removal/replacement)

Recommendations

If there are Class II materials, use LEED protocols for ductwork and protection of adjoining spaces



What's wrong with this picture?

Recommendations

Guidelines for after the remediation work

- Follow and verify CAZ safety requirements
- Implement full-time, low-level exhaust and/or HRV ventilation as appropriate to meet minimum ventilation standards
- When possible, require long-term monitoring (IAQ, Blower door performance, fuel use, comfort)

Quiz questions:

- Do all projects with foam problems require the foam to be removed and replaced?
- Do all symptoms of foam problems indicate processing and installation defects?
- Does all problem foam have to be replaced with the same type/brand of foam?
- Is it possible to ensure that foam that is cracking will not shrink again after the work is remediated?
- Can the substrate be a source of air quality concerns even after problem foam has been removed?
- Do all foam problems require the same level of personal and site protection?
- Does air quality testing work for foam installations?