Introduction to Spray Polyurethane Foam (SPF)

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Pennsylvania Housing Research Center

Rick Duncan
Technical Director
Spray Polyurethane Foam Alliance v2.5

Today's Presenter

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Technical Director, Spray Polyurethane Foam Alliance

Rick is currently Technical Director for the Spray Polyurethane Foam Alliance. Prior to joining SPFA, he was the Senior Marketing Manager for Honeywell's Spray Foam Insulation business from 2006 to 2008. From 1997 to 2006, he was the Global Program Director for CertainTeed/Saint-Gobain Insulation's New Materials and Applications Portfolio. From 1989 to 1997 he was a Visiting Assistant Professor of Mechanical Engineering at Bucknell University. He holds a Ph.D. in Engineering Science and Mechanics from The Pennsylvania State University, MSME from Bucknell and a BSME from the University of Maryland. Rick is a Registered Professional Engineer in three states and is a certified BPI Building Analyst.

SPFA History

- Spray Polyurethane Foam Alliance
  - Originally founded as the Urethane Foam Contractors Association (UFCA) in 1975
  - In 1987 it became the Polyurethane Foam Contractors Division of the Society of the Plastics Industry (SPI)
  - Since 2003, it has been an independent trade association for contractors, manufacturers and distributors of polyurethane foam, equipment, protective coatings, inspections, surface preparations and other services.
  - Maintains strong relationship with the American Chemistry Council (ACC) and their Center for Polyurethanes Industry (CPI)

SPFA Programs and Activities

- Education and Research
  - Accreditation/Certification and Education programs
  - Technical Literature and Guidelines
  - "Hotline" for Technical questions (1-800-523-6154)
  - Industry Research Programs
- Promotion and Awareness
  - Regulatory and Legislative Activities
  - Promotional and Marketing Tools
  - Website www.sprayfoam.org
  - Annual Spray Foam Conference and Exposition
  - *Spray Foam Professional magazine*
  - Directory and Buyers' Guide

SPFA Website

- www.sprayfoam.org
  - Key features of home page
    - Health and Safety
    - Technical
    - Membership

SPFA Publications

- Spray Foam Professional Magazine
  - Quarterly magazine through NACE Publishing
  - SPFA works with SFP editors at Naylor to develop and review content

www.naylornetwork.com/spfa/

Poll: Who's Who?

Content

- History and products
- SPF chemistry and delivery methods
- Safety requirements
- Environmental impact
- Performance
- Applications
- Building codes

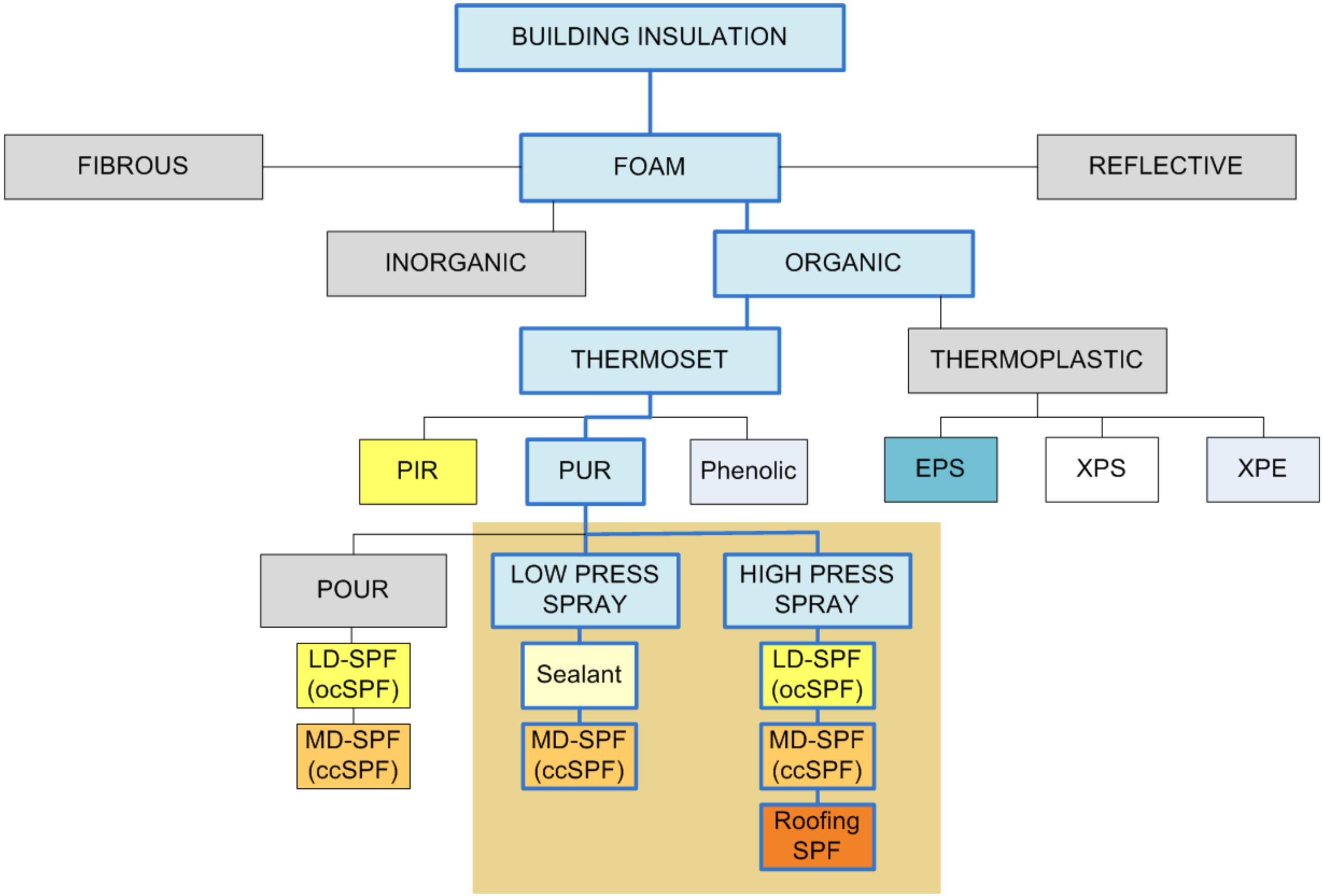
History of SPF in Buildings

SPF in construction for 50 years

- Late 60's - Medium Density (agricultural and industrial)
- Mid 70's - Roofing
  - Medium Density (general const.)
  - Sealants
- Mid 90's - Low Density (residential)

Product Category

SPF: field-applied thermoplastic foam



Product Category

Four types of SPF in Construction

	Spray Foam			
	Sealant	LD	MD	Roof
Density (lb/ft^3)	0.6 – 1.8	0.5 - 1.4	1.5 -2.3	2.5 - 3.5
Thermal Resistivity (R/in)	NR	3.6 - 4.5	6.2 - 6.8	6.2 - 6.8
Air Impermeable Material	*	✓	✓	✓
Integral Air Barrier System		✓	✓	✓
Integral Vapor Retarder			✓	✓
Water Resistant			✓	✓
Cavity Insulation		✓	✓	
Continuous Insulation		✓	✓	✓
Low-Slope Roofing				✓
Structural Improvement			✓	✓

Basic Chemistry

Reaction of 1:1 mixing of two liquids

- A-Side: Blend of monomeric and polymeric MDI

  (MDI=Methylene diphenyl diisocyanate)

- B-Side or Polyol
  - polyols
  - blowing agents
  - flame retardants
  - surfactants
  - catalysts

Proprietary blend of additives affect cell formation and foam performance

Basic Chemistry

Two Competing Chemical Reactions

BLOW: Expansion of liquid into a cellular structure

a. MDI + chemical blowing agent (H_2O) → CO_2 gas
b. Exothermic heating of polymerization transforms liquid physical blowing agent (HFC) into vapor

SET: Polymerization of liquid into solid polyurethane

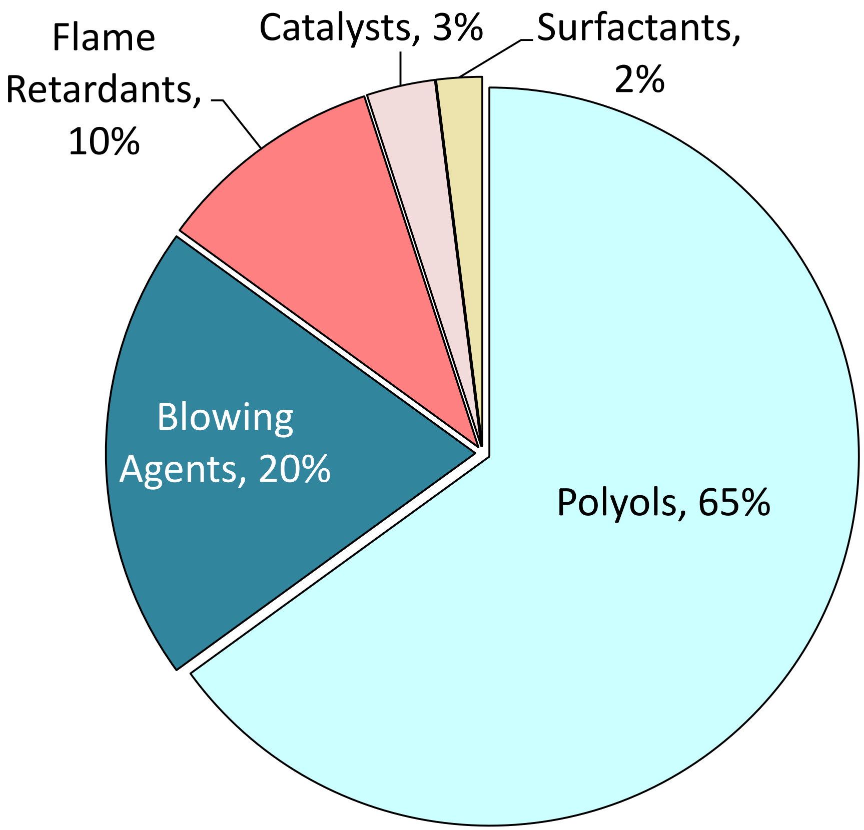
a. MDI + polyols → polyurethane

Other additives are important:

- Catalysts control polymerization reaction time and temperature (speed)
- Surfactants control cell formation and structure
- Flame retardants embedded in PU provide built-in fire resistance

Basic Chemistry

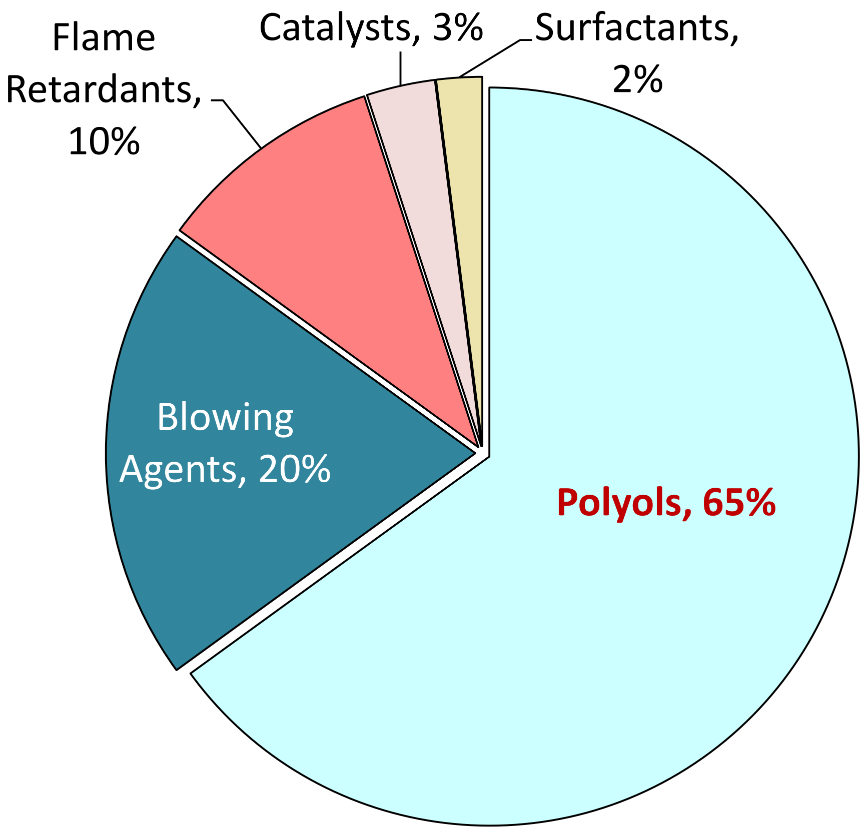
B-Side Formulation:



- These are the five basic categories of B-side chemicals.
- Percentages will vary based on foam type (oc vs cc) and manufacturer.
- Some foam formulations contain small amounts of additional additives for appearance and added function, such as colorants and anti-microbial chemicals.

Basic Chemistry

B-Side Formulation: Polyols

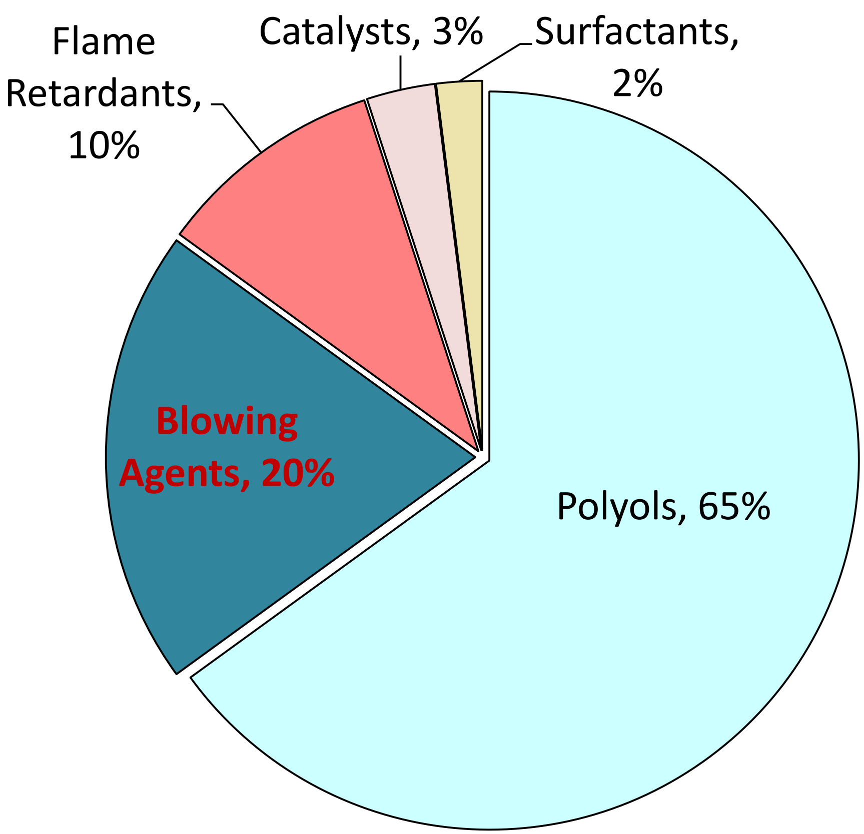


Polyols plus MDI are basic building blocks needed to make polyurethane

- Provide the hydroxyls (OH) that combine with MDI (NCO) to form polyurethane
- Petroleum polyols are polyester and/or polyether blends
- Some natural oil polyols, like soybean oils or sucrose-based polyols can be blended with petroleum polyols (20+45)
- Some products add brominated diols (polyols) to improve flame retardancy

Basic Chemistry

B-Side Formulation: Blowing Agents

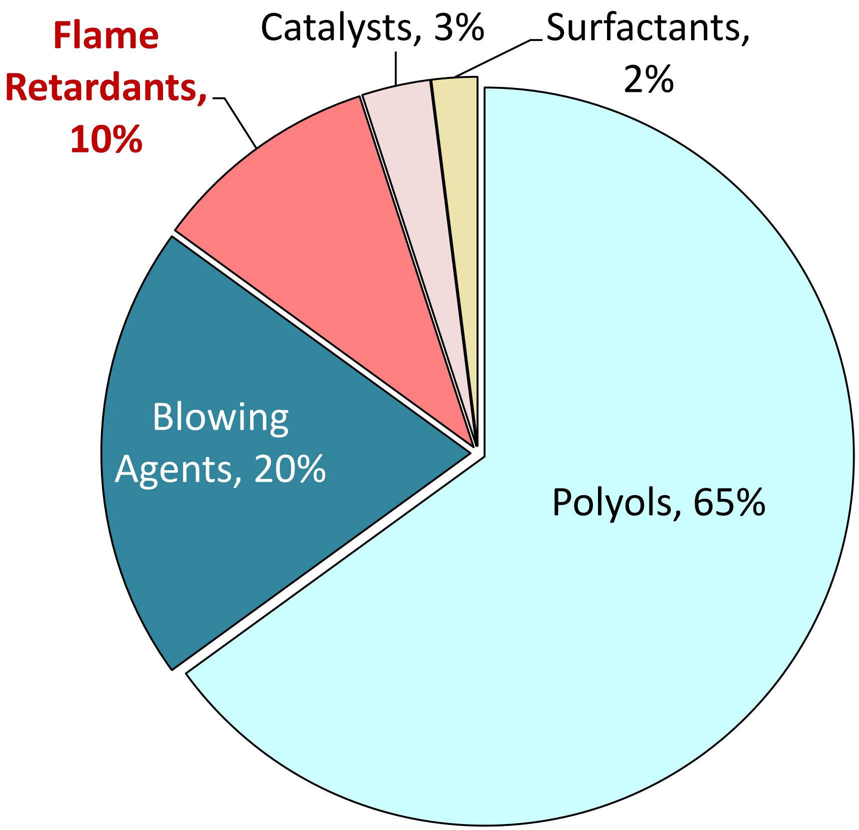


Without blowing agents to expand foam, solid polyurethane would result

- Create the gas needed to expand the liquid polyurethane mixture
- Physical blowing agents convert from liquid to a gas from the heat of the reaction (HFC-245fa)
- Chemical blowing agents are gases created from chemical reactions. Water + MDI = CO_2
- Some SPF uses blend of water and HFC-245fa
- Non-flammable when used in SPF, No VOC

Basic Chemistry

B-Side Formulation: Flame Retardants

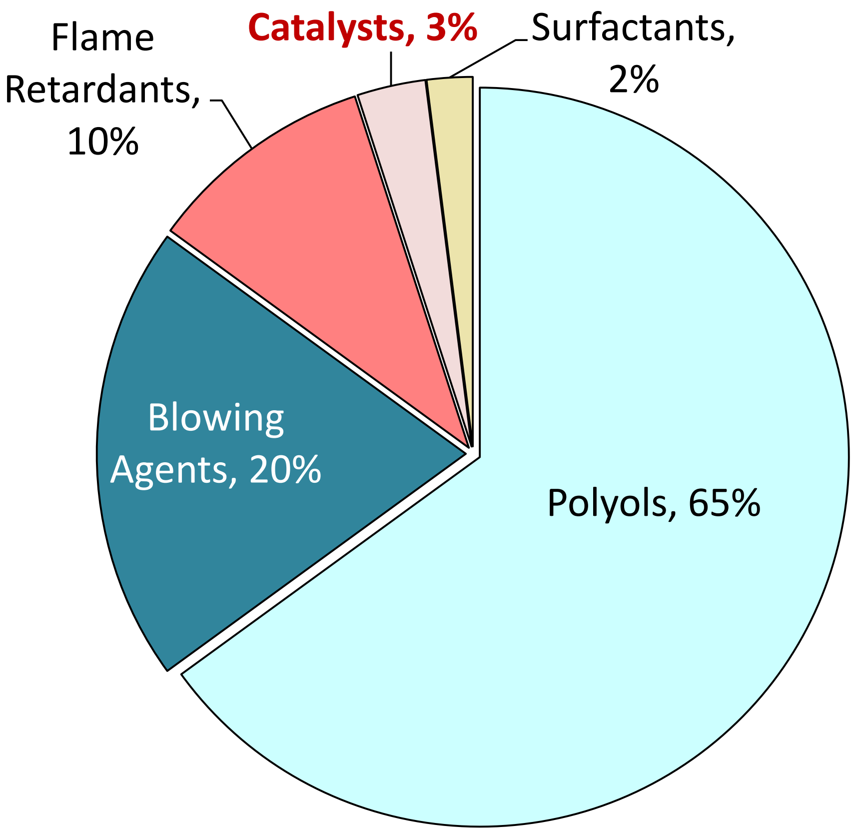


Flame retardants necessary for building fire safety

- Polyurethane foam is an organic material and is combustible.
- Without fire retardants, foam plastics would not meet building code flame spread requirements.
- No brominated FRs – (PBDE)
  - Some use Br-diols in polyol blend
- Uses halogen-phosphorous FRs such as
  - TCPP – most common
  - TDCP – phasing out
  - TEP – increased interest

Basic Chemistry

B-Side Formulation: Catalysts

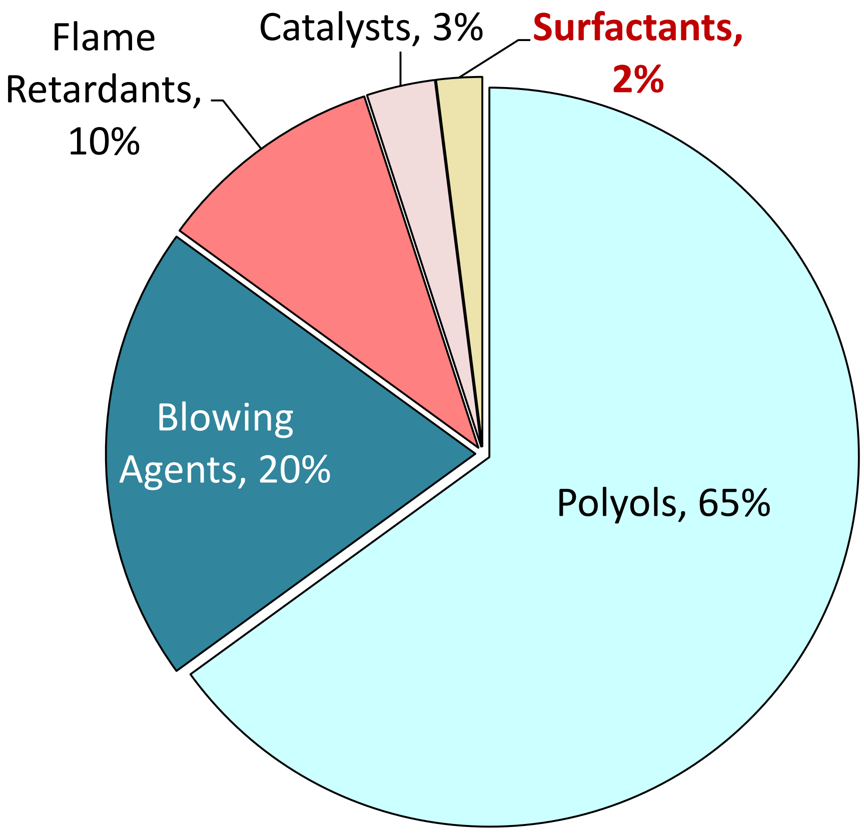


Catalysts control rise and cure of SPF

- Amine catalysts are used to control the polyurethane reaction.
  - Reactive
  - Non-Reactive (odor-prone)
- Metal catalysts may also be used.
- To achieve proper desired foam properties, competing balance between BA expansion and polyurethane curing – stabilizing the foam.

Basic Chemistry

B-Side Formulation: Surfactants



Surfactants control cell structure

- Surfactants control cell formation rheology (flow properties) and degree of opening of panes inside each cell

Basic Chemistry

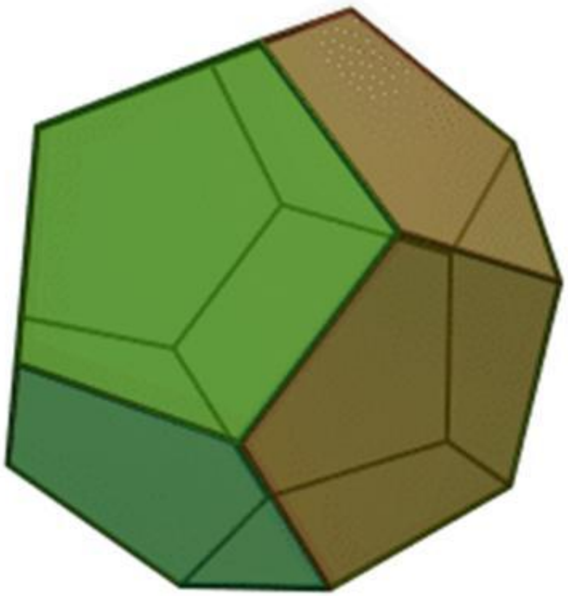
Typical (generic) B-Side Formulations

B-SIDE	RAW MATERIAL	B-Side WGT % (Generic)		
		0.5 pcf	2.0 pcf	3.0 pcf
Polyols	Polyester		45.0%	35.0%
	Mannich		30.0%	45.0%
	Natural Oil (Soy)			
	Compatibilizer	10.0%		
	Polyether	35.0%		
Blowing Agents	Reactive (H_2O)	23.5%	2.0%	1.6%
	Physical (HFC)		8.5%	7.0%
Flame Retardants	TCPP	25.0%	4.0%	8.0%
	TDCP		6.0%	
Catalysts	Amine	6.0%	3.0%	2.0%
	Metal		0.5%	0.4%
Surfactants	Silicone	0.5%	1.0%	1.0%

Generic formulations used for SPFA's Life-Cycle Assessment (LCA)

Basic Chemistry

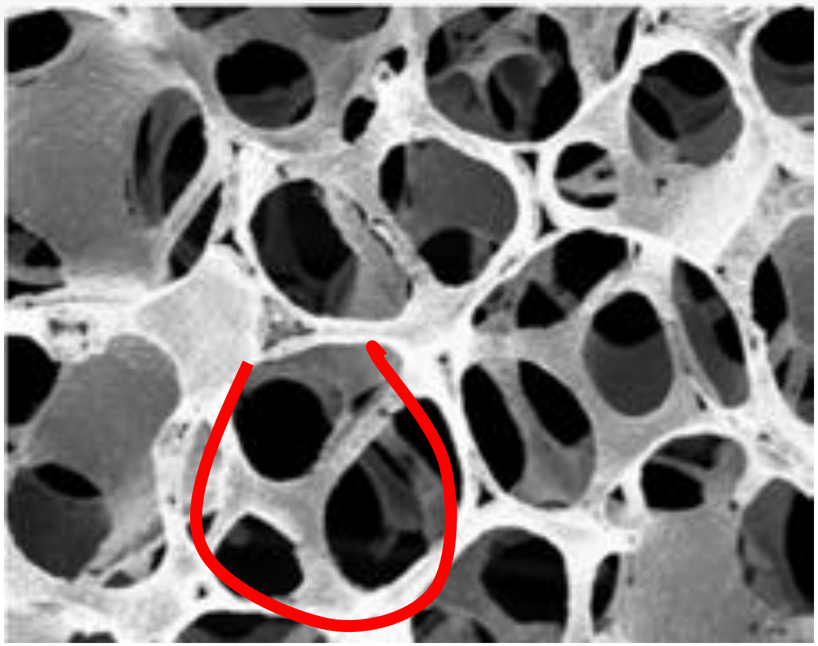
Fundamental Cell Model



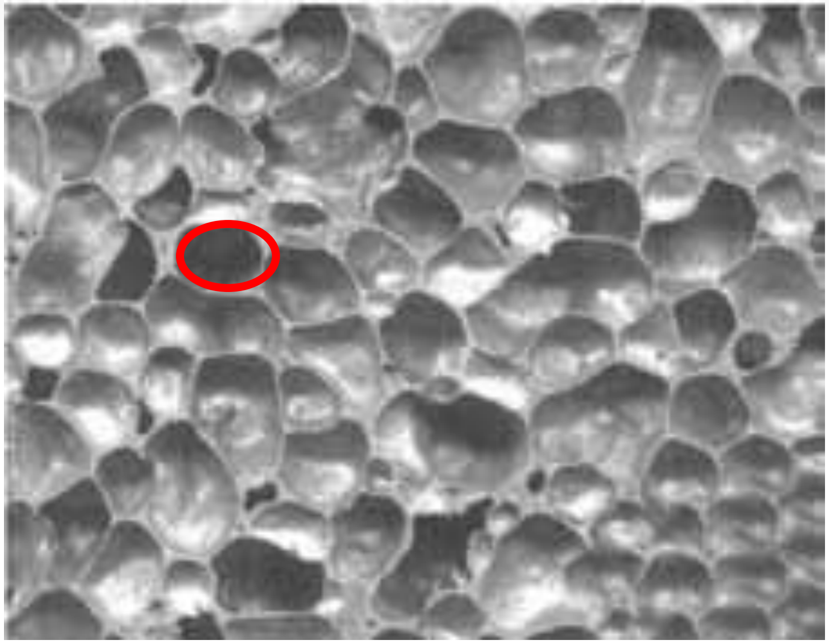
- **Closed-Cell Foam:** Essentially all panes are intact (>90% cc)
- **Open-Cell Foam:** One or more panes open (mostly oc)
- **Reticulated Foam:** All panes open, thick struts

Cell structure and size affects density, flexibility, recovery as well as all other physical properties

3. Basic Chemistry



OPEN CELL
~100x expansion
0.5 to 0.8 pcf
R-3.6 to R-4.5 per inch (air)



CLOSED CELL
~30x expansion
1.7-3.5 pcf
R-5.8 to R-6.8 per inch
(trapped low-k gas)

Delivery Methods

One-Component Low-Pressure Sealants

- 6-15 BF/min froth
- A and B pre-mixed; cured by contact with ambient moisture
- Low/high expansion
- Air-sealing of small cracks, gaps and holes
- Non-insulating

Retail DIY product for air sealing only

Delivery Methods

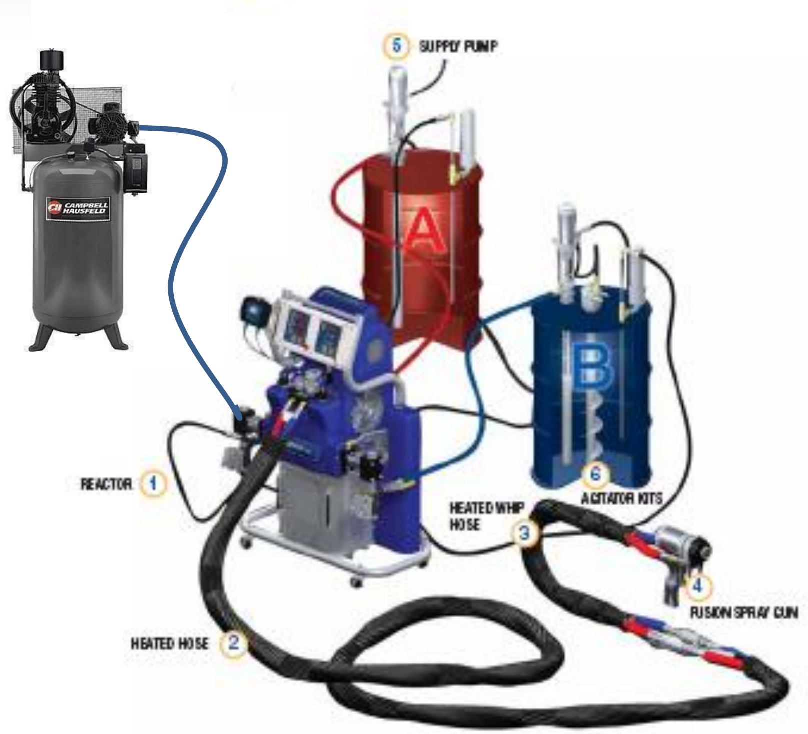
Two-Component Low-Pressure Foam

- 30-40 BF/minute froth
- A and B in separate pressurized cylinders
- Mechanical mixing
- Insulation and air sealing - small jobs

Professionally applied product used by weatherization contractors and by SPF contractors for small jobs or repair work

Delivery Methods

Two-Component High-Pressure SPF



Professionally applied insulation and roofing SPF installed by trained contractors large jobs

- 100-500 BF/minute spray
- A and B in unpressurized drums or totes
- Chemicals heated and pressurized by proportioner
- Larger insulation jobs and all roofing applications
- Special training and capital investment

Chemical Safety During Application

- Hazardous chemicals are used for SPF
  - A-side (Isocyanate) is reactive and can cause respiratory or dermal sensitization
  - B-side components (catalysts) can cause irritation
  - Delivery methods affect exposure
    - Low-pressure: gloves, eyes, APR
    - High-pressure: full-skin, eyes, APR or SAR

©2012 SPFA - Spray Polyurethane Foam Overview

Chemical Safety <u>During</u> Application

- Chemical Safety Measures
  - PPE required during and just after installation
  - Isolate, contain and vent work zone
  - SPF contractor safety plan
  - www.spraypolyurethane.com

Chemical Safety After Application

- No known chemical hazards for occupants
  - Safe MDI levels in 1-6 hours
  - 24 hour re-occupancy typical
  - Installed SPF is low-VOC (SPF is solvent-free)
    - GreenGuard Environmental Institute
    - CAN/ULC-S774 Saskatchewan Research Council

Environmental Impact

Raw Materials

- Petroleum vs. natural oil polyols

Environmental Impact

Raw Materials

- Fluorocarbon blowing agent evolution

Years	Generation	SPF Blowing Agent	ODP	GWP
1960s -1993	1	CFC-11	1.0	4750
1993 - 2003	2	HCFC-141b	0.12	760
2003 - pres	3	HFC-245fa	0	1020
2012?	4	HFO/HFE	0	6 - 15

Environmental Impact

Raw Materials

- Phosphate flame retardants (no brominated)
  - No brominated FRs used
  - TEP, TCPP, TDCP are typical
  - Evaluated as potential carcinogen, mutagen, reproductive system, bio-toxicity, bio-accumulative
  - Low risk per EU EEC No. 793/93 Risk Assessment

EU EEC No. 793/93 Risk Assessment

Environmental Impact

Disposal and Recycling

- Landfill safe
- Mechanical grinding for fillers and packaging
- Chemical recycling

Environmental Impact

Life-Cycle Assessment

- Industry-wide LCA recently completed by SPFA
  - ISO-compliant to ISO 14040/14044
  - Third-party analysis and review
  - Transparent, credible review
  - Cradle-to-End-of-Life
  - SPF insulation and roofing

Environmental Impact

Life-Cycle Assessment

Impact Category Characterization Factor	Description	Unit
Global Warming Potential (GWP)	A measure of greenhouse gas emissions, such as CO_2 and methane.	kg CO_2 equivalent
Eutrophication Potential (EP)	Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which nitrogen (N) and phosphorus (P)..	kg Nitrogen equivalent
Acidification Potential (AP)	The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H^+) concentration in the presence of water, thus decreasing the pH value.	mol H^+ equivalent
Photochemical Ozone Creation Potential (POCP)	A measure of emissions of precursors that contribute to ground level smog formation (mainly ozone O_3),	kg O_3 equivalent
Ozone Depletion Potential (ODP)	A measure of air emissions that contribute to the depletion of the stratospheric ozone layer.	kg CFC-11 equivalent
Additional Inventory/Impact Category		
Primary Energy Demand (PED) [1]	A measure of the total amount of primary energy extracted from the earth, expressed in energy demand from non-renewable or renewable resources	MJ

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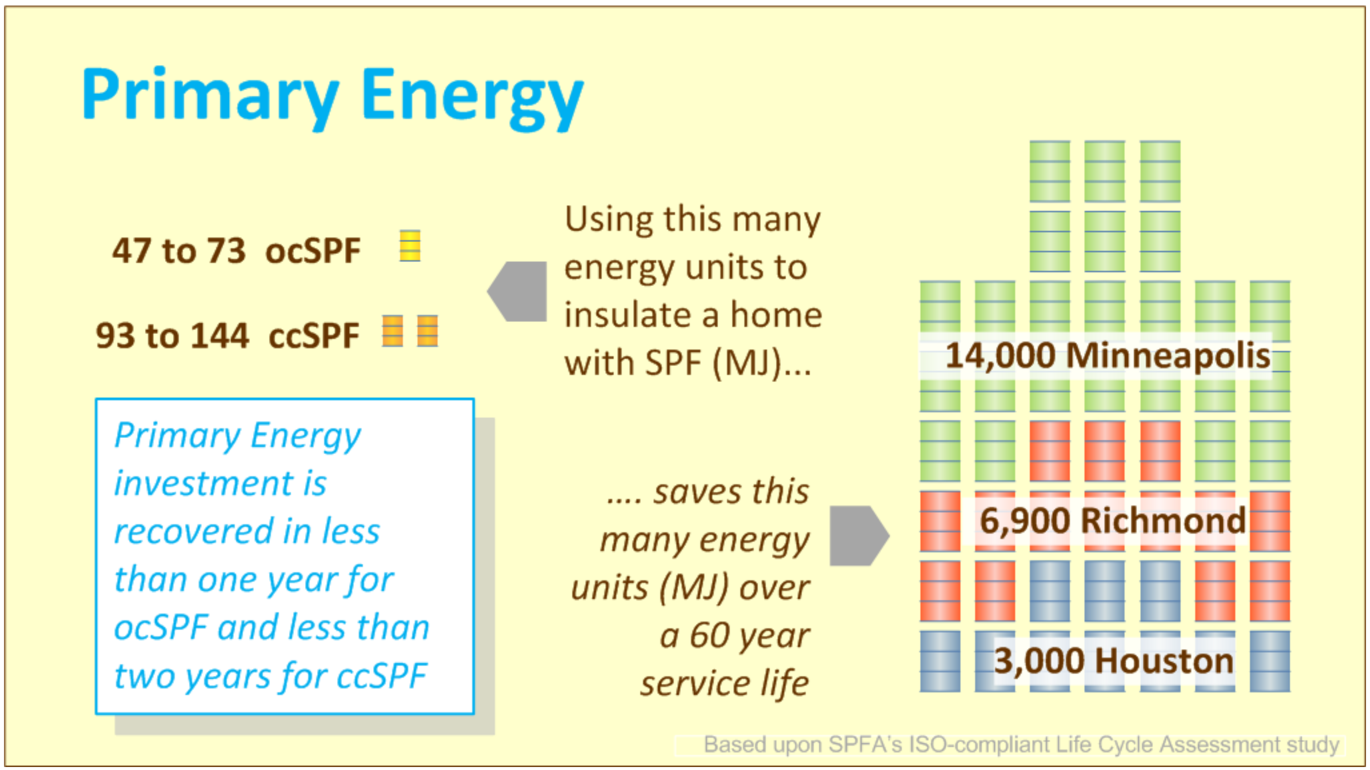
Environmental Impact

Life-Cycle Assessment

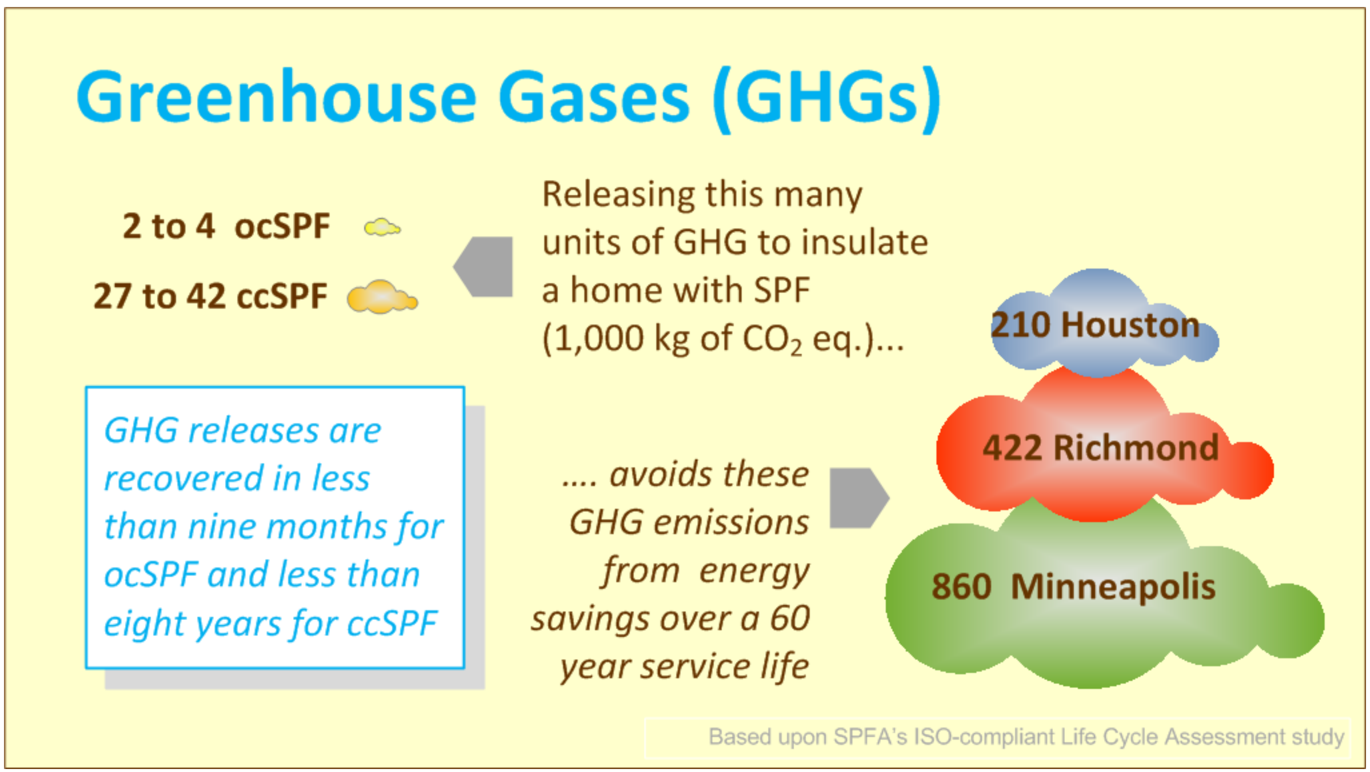
$$\frac{\text{environmental impacts prevented during use}}{\text{environmental impacts from production}} \gg 1$$



Environmental Impact

Life-Cycle Assessment

$$\frac{\text{environmental impacts prevented during use}}{\text{environmental impacts from production}} \gg 1$$



Environmental Impact

Life-Cycle Assessment

Application	SPF Type	Ratio & Payback	Houston		Richmond		Minneapolis	
			Energy	GHG	Energy	GHG	Energy	GHG
Residential Insulation	Low Density Open-Cell	Avoided/Embodied	64	92	128	164	194	248
		Payback (Yr)	0.9	0.7	0.5	0.4	0.3	0.2
	Medium Density Closed-Cell	Avoided/Embodied	32	7.6	64	13.6	98	21
		Payback (Yr)	1.9	7.9	0.9	4.4	0.6	2.9
Commercial Roofing	Roofing R4 --> R20	Avoided/Embodied	55	15	56	15	66	17
		Payback (Yr)	1.1	4	1.1	4.1	0.9	3.6
	Roofing R12 --> R20	Avoided/Embodied	30	8.2	28	7.5	29	7.3
		Payback (Yr)	2	7.3	2.1	8.0	2.1	8.3

SPF Performance

- Consistent Thermal Performance
- Air Impermeable
- Moisture Control
- Structural Enhancement

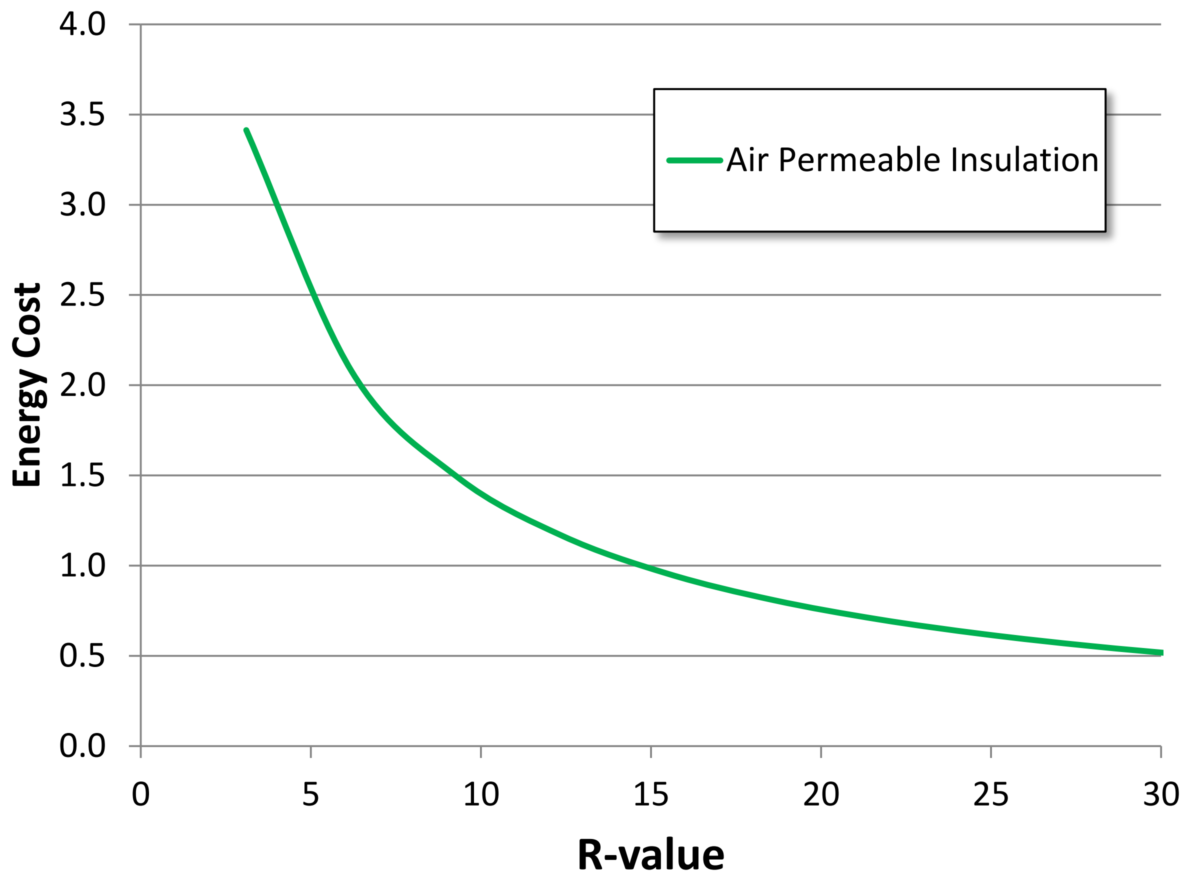
SPF Thermal Performance

Guarded Hot Box Studies

- Several GHB studies show 15-30% better performance
- Why?
  - Reduced internal convection
  - Reduced air infiltration
  - Consistent performance over range of operating temperatures

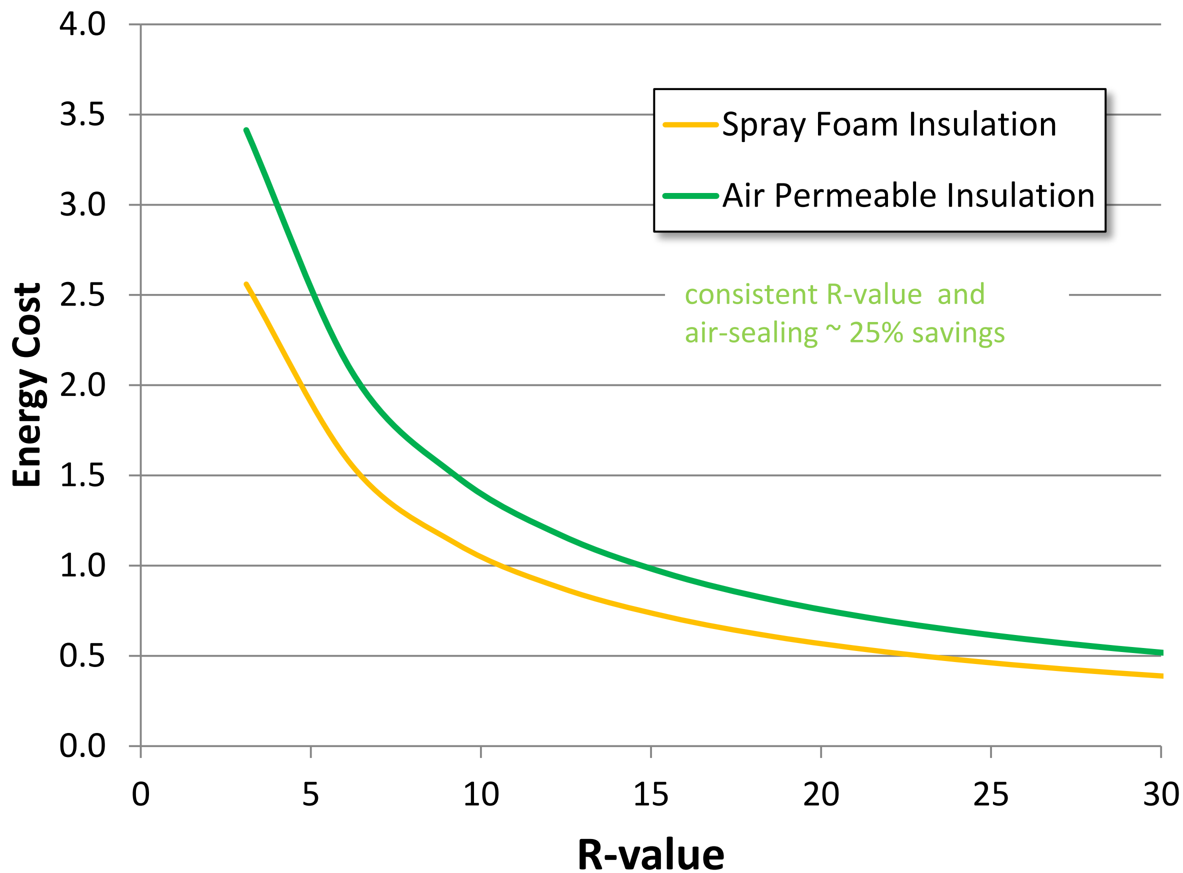
SPF Thermal Performance

Thermal Envelope Design



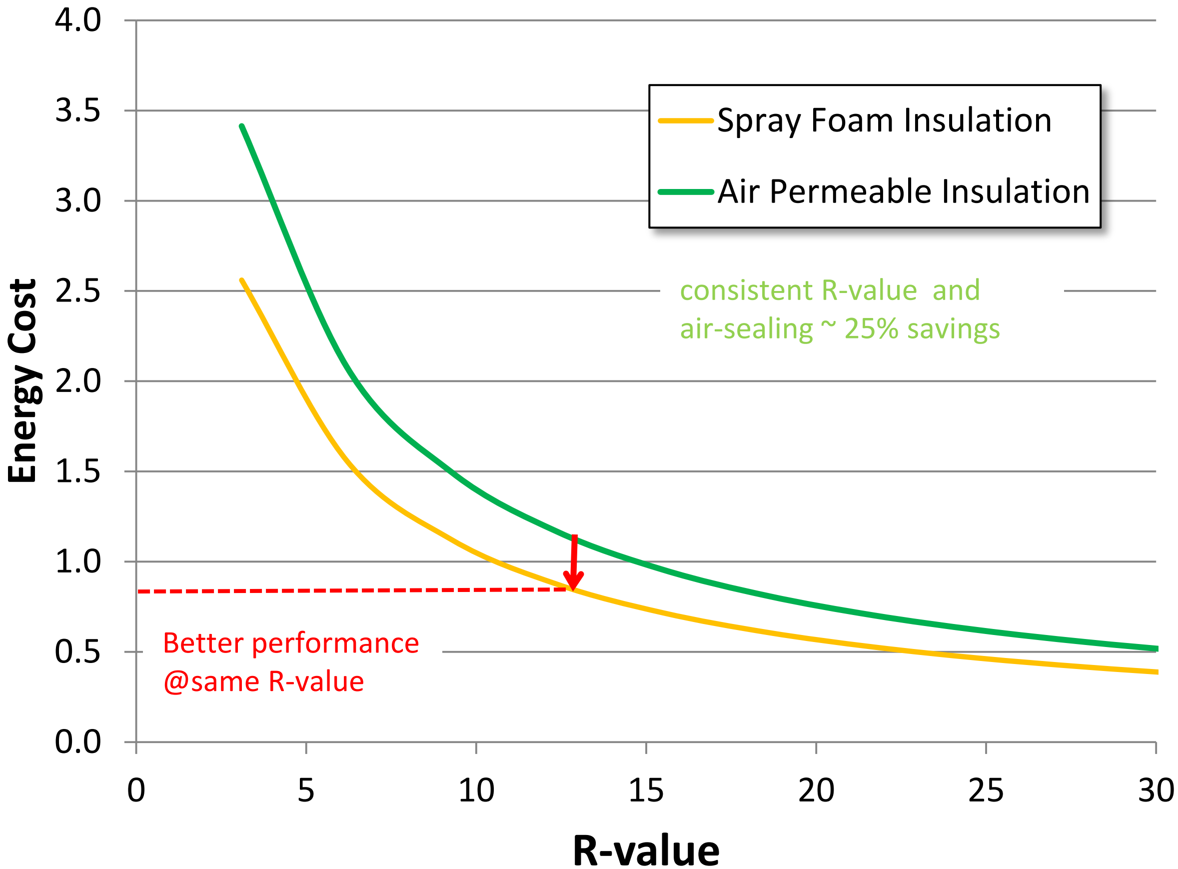
SPF Thermal Performance

Thermal Envelope Design



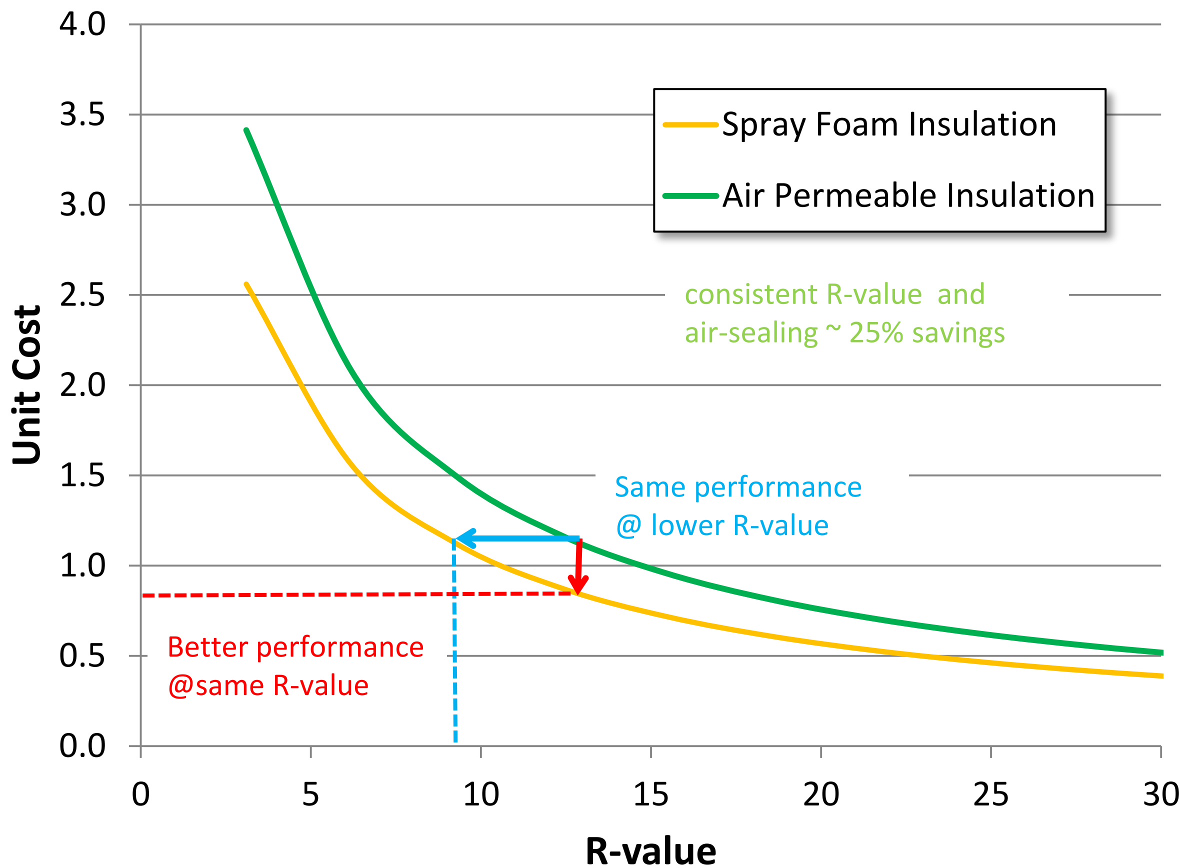
SPF Thermal Performance

Thermal Envelope Design



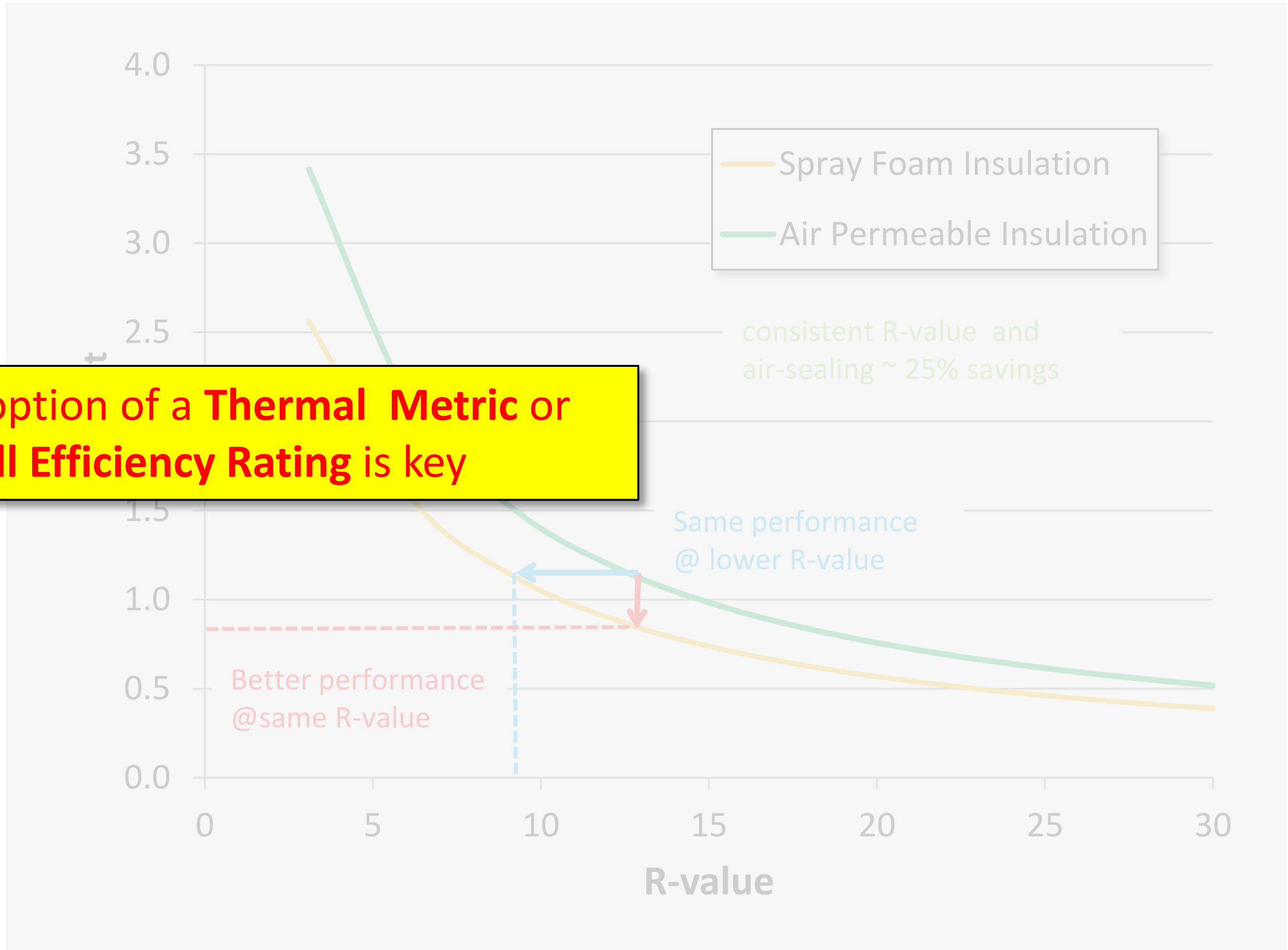
SPF Thermal Performance

Thermal Envelope Design



SPF Thermal Performance

Thermal Envelope Design



Adoption of a **Thermal Metric** or **Wall Efficiency Rating** is key

SPF Air Barrier Performance

Air Barrier System

- Materials
  - Air-impermeable per ASTM E283 or E2178
  - air barrier material
- Assemblies/Systems
  - Low air leakage per ASTM E2357
  - SPF on opaque walls + sealant foams around fenestration creates air barrier system
- ABAA Spec for MD SPF
- Integral air-barrier

Poll: Head Count

Password for certificate of attendance: spfoam

SPF Air Barrier Performance

Weatherization Case Studies

Home Size (SF)	Minimum Ventilation (ACH_{50})	Initial Air-Leakage (ACH_{50})	Foam Treatment	Final Air-Leakage (ACH_{50})	% Change
2300	5.4	9.3	1” Attic floor	7.0	-25%
			Rim joist	6.3	-32%
2500	5.4	10.4	Rim joist	8.8	-15%
			100SF cantilevered floor	6.6	-37%

SPF Moisture Barrier Performance

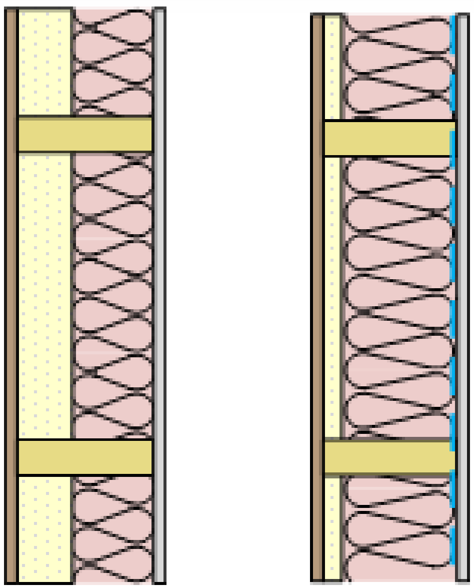
Vapor Retarder – Moisture Control

- Open-cell SPF
  - Permeability 15-40 perm-inch
  - Class III: semi-permeable at 6” or more
- Closed-cell SPF
  - Permeability 2 perm-inch
  - Class II: semi-impermeable at 2” or more
  - Special considerations for extreme cold climates, high interior humidity loads, or low interior-temperatures

SPF Moisture Barrier Performance

Hybrid Insulation Systems

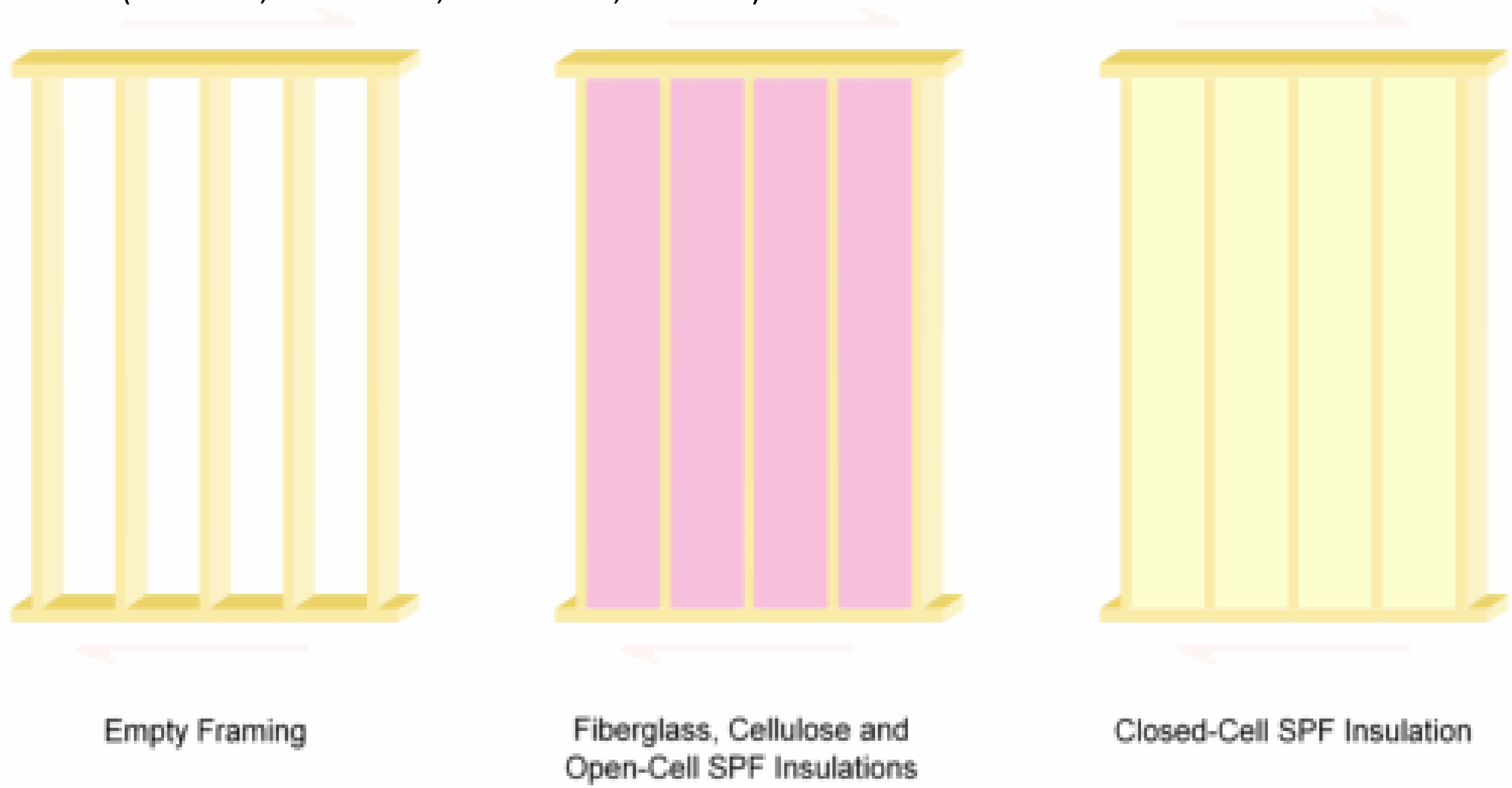
- MD SPF + vapor/air-permeable insulations to lower cost
- Air barrier performance?
- Vapor retarder plane
- SPFA Guideline under development
  - IECC Zones 1-3 guideline complete
  - IECC Zone 4 and above addressed in 2009 IRC Section 601.



SPF Structural Performance

Racking Strength Doubled by SPF

- Supported by numerous studies
  - (1991 CFI, 1992 NAHB, 1996 NAHB, 2007 ATI)



SPF Structural Performance

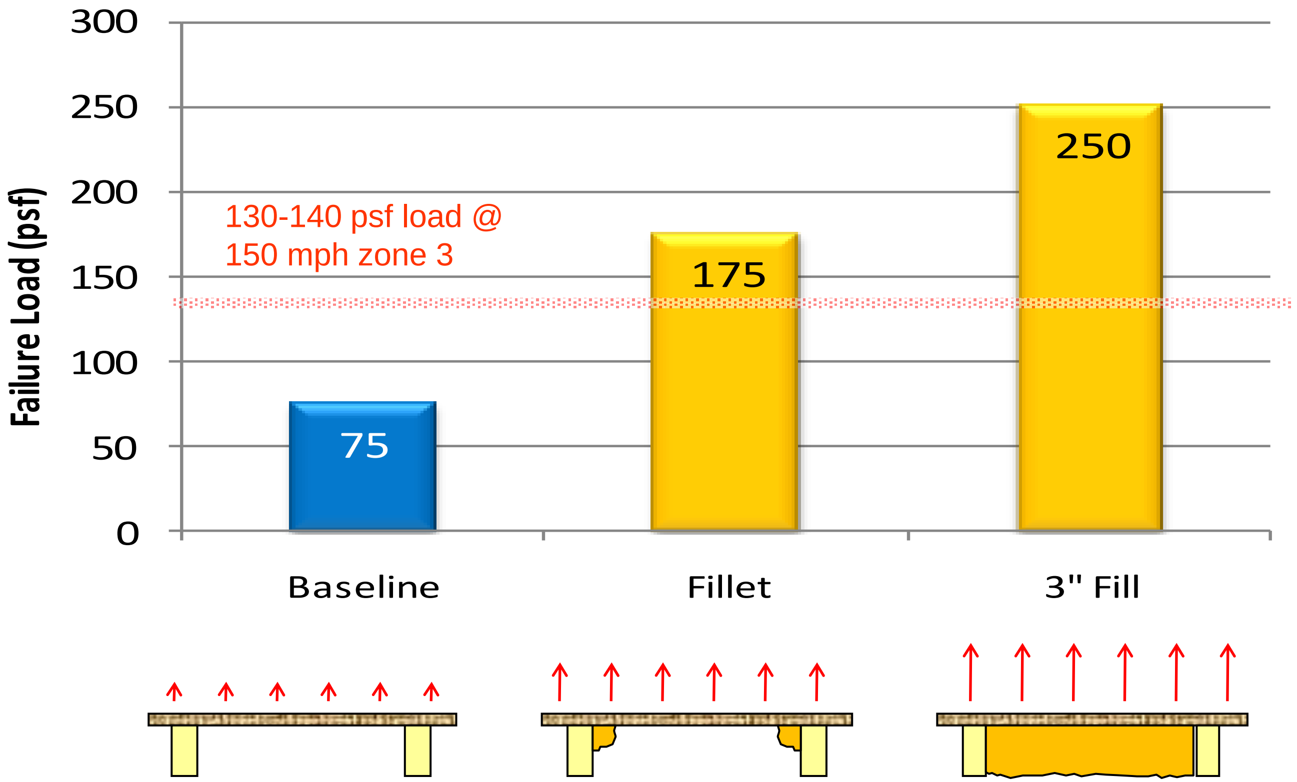
Wind Uplift Resistance

Houses with damaged or missing roof sheathing in Florida

SPF Structural Performance

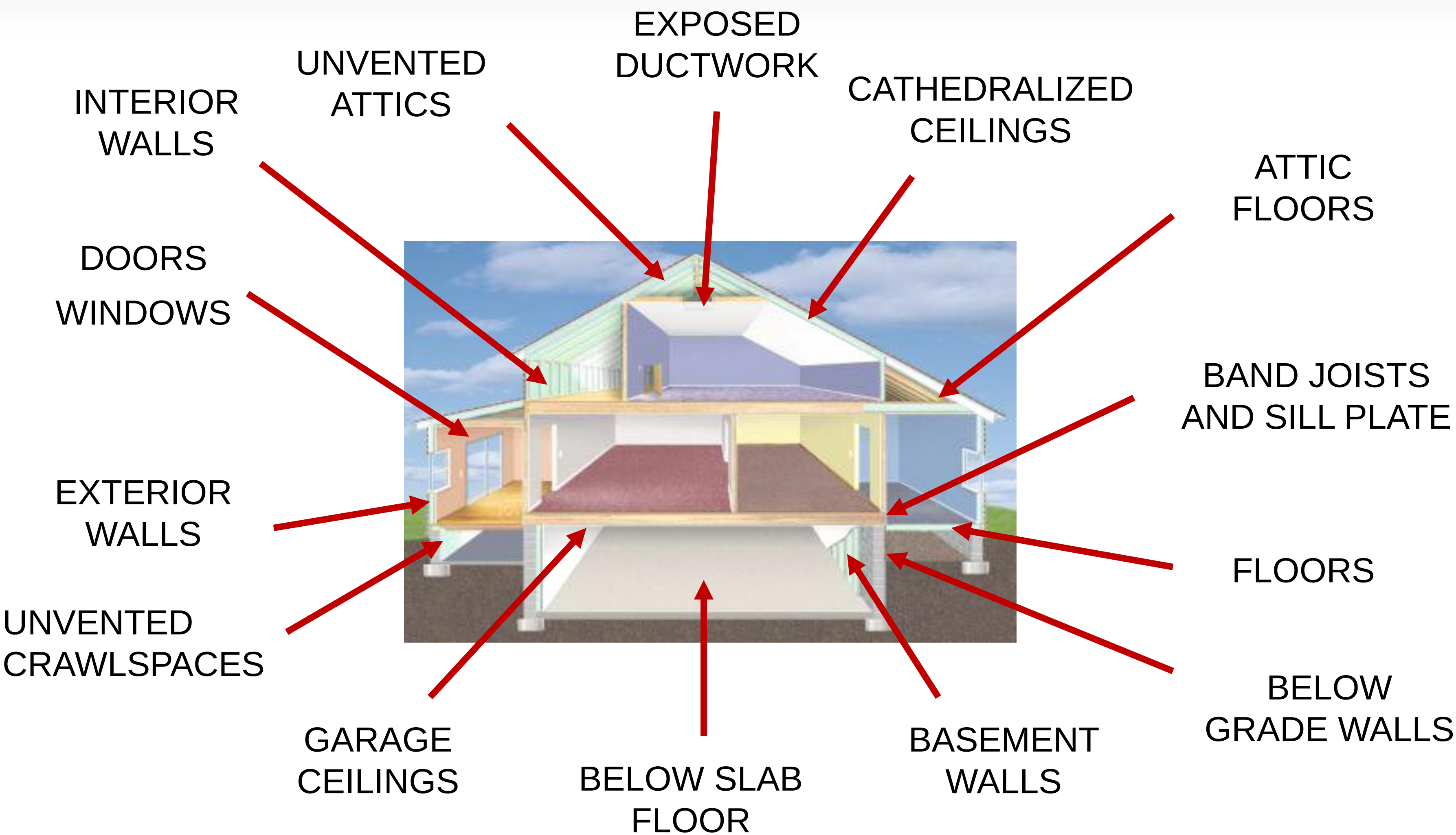
Wind Uplift Resistance

- 3x increase (2008 Prevatt and Duncan, U of Florida)



SPF Applications

Residential



R

Retrofit??

Unvented Attics

Foam type

LD
MD
Roof

Cathedralized Ceilings

LD
MD
Roof

Cathedralized Ceilings

LD
MD
Roof

R

Attic Floors

LD
MD
Roof

Exposed Ductwork

R

Rim-Band Joists / Sill Plates

LD
MD
Roof

Floors (Garage Ceiling)

LD
MD
Roof

Floors (Cantilevered)

Below Grade Walls

LD
MD
Roof

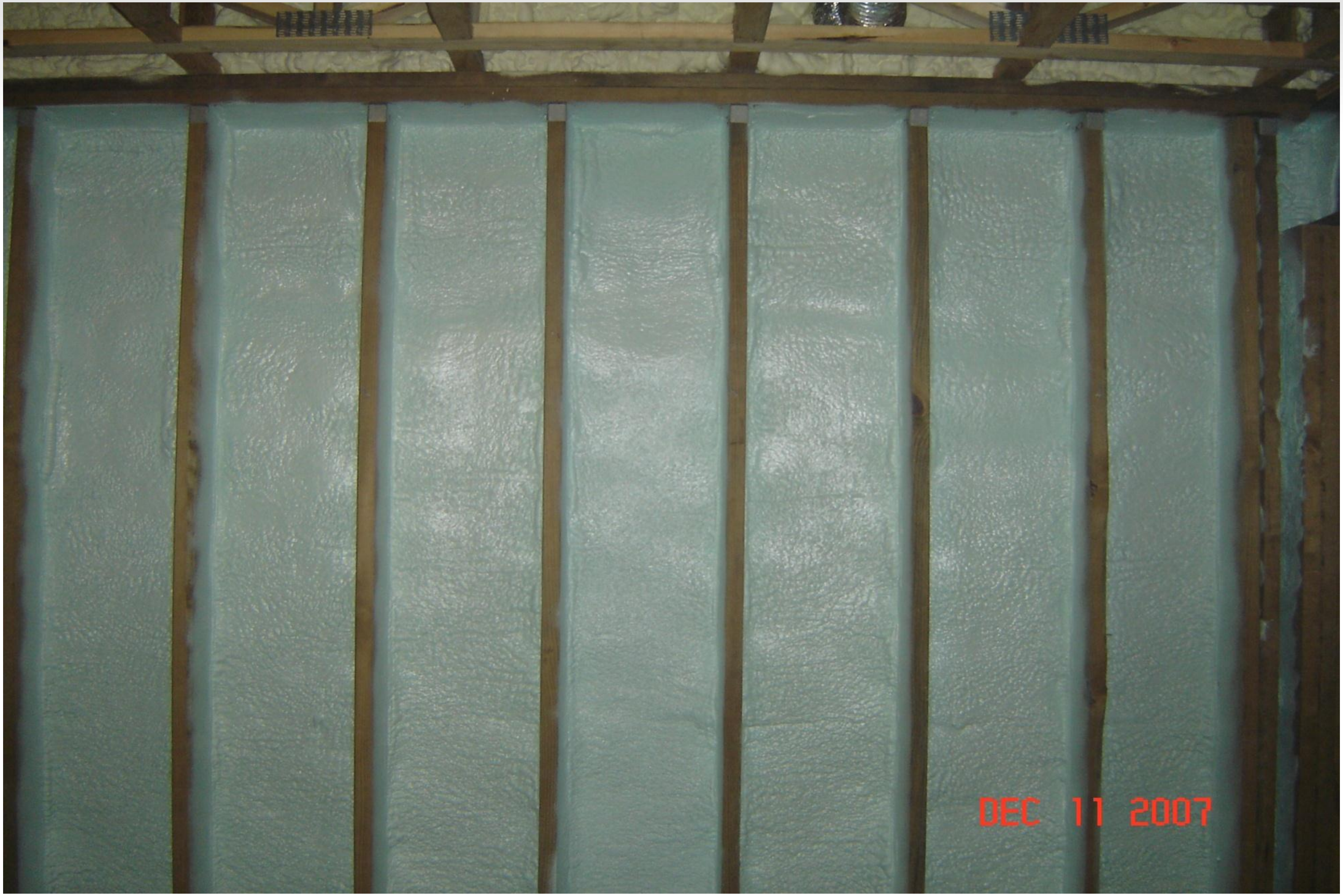
Below Slab

LD
MD
Roof

R

Basement Walls

LD
MD
Roof



R

Unvented Crawlspaces

LD
MD
Roof

Exterior Walls

LD
MD
Roof

Interior Walls

LD
MD
Roof

Door and Window Sealing

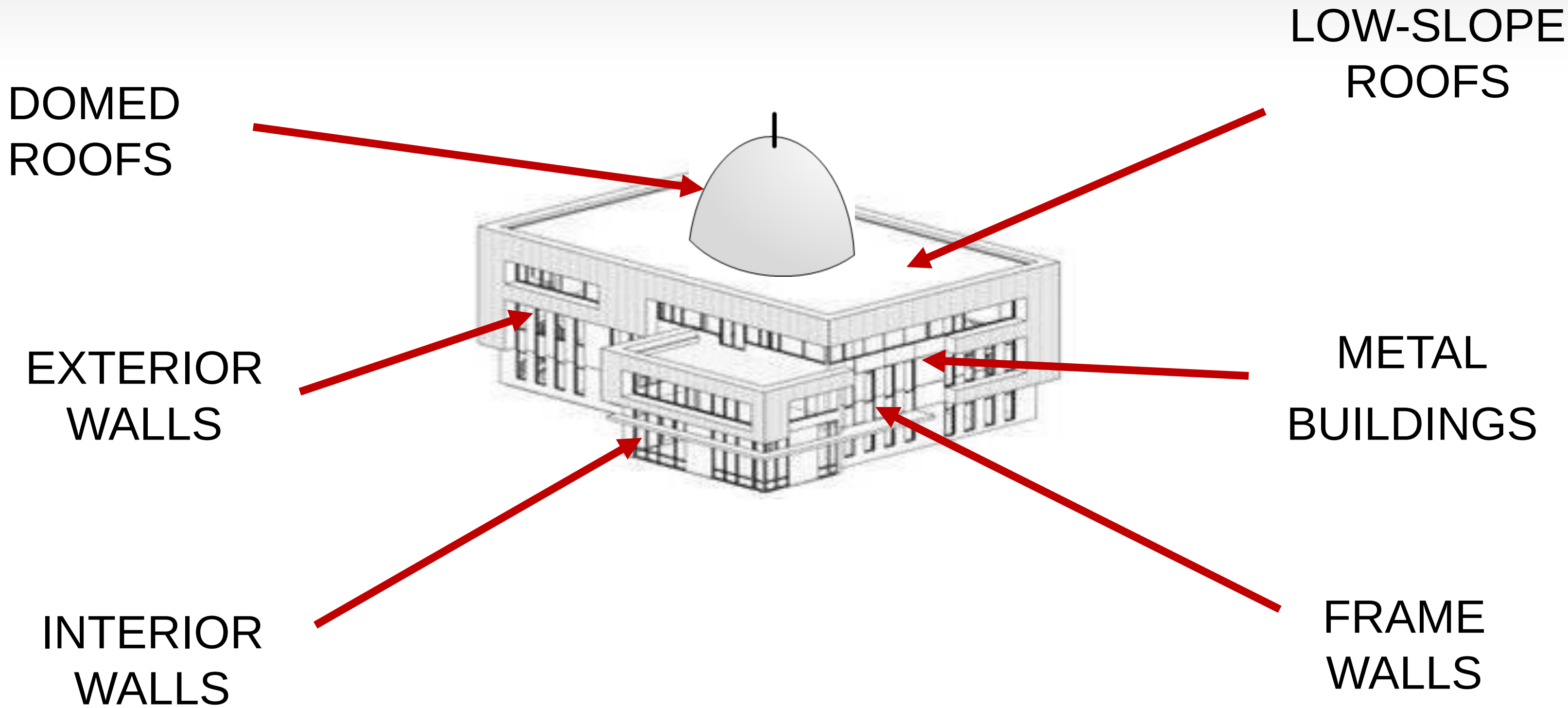
LD
MD
Roof

Low-Expansion for windows and doors

High-Expansion for cracks and gaps

SPF Applications

Commercial



Other Applications

TEMPORARY STRUCTURES

TANKS AND VESSELS

Exterior Walls

LD
MD
Roof

Exterior Walls

LD
MD
Roof

R

Low-Sloped Roofs

LD
MD
Roof

R

Domed Roofs

LD
MD
Roof

R

Metal Buildings

LD
MD
Roof

Temporary Structures

LD
MD
Roof

Tanks and Vessels

LD
MD
Roof

SPF and the International Codes

- Code Sections
  - Separate from ‘traditional’ insulations
  - IBC: Ch 26, Section 2603 Foam Plastic Insulation
  - IRC: Ch 3, R316 Foamed Plastic
- Code Focus
  - Fire Protection
  - Thermal Performance
  - Moisture Control

Fire Testing

Surface Burning Characteristics

- Steiner Tunnel Test [IBC 2603.3 / IRC R316.3]
  - ASTM E84 / UL 723 Steiner Tunnel Test
    - Flame Spread Index (FSI)
    - Smoke Developed Index (SDI)
    - FSI/SDI is 0/0 for fiber-cement
    - FSI/SDI is 100/100 for red oak
    - Limited to 4” thickness
  - Class II – FSI ≤ 75, SDI ≤ 450
  - Class I – FSI ≤ 25, SDI ≤ 450
  - Roofing – FSI ≤ 75, SDI unlimited
  - **CHECK with manufacturer or ESR for testing >4”**

Fire Safety

15-Minute Thermal Barriers

- Thermal Barrier Requirement [IBC 2603.4 / IRC R316.4]
  - Separates insulation from interior of building
  - Approved 15 minute thermal barrier
    - ½" gypsum wallboard is most commonly used
    - Others to be tested per ASTM E119 and/or full-scale fire tests
  - Exceptions to Thermal Barrier requirement…

Fire Safety

Additional Requirements: Commercial

- Special Requirements for SPF in Type I-IV Construction [IBC 2603.5]
  - ASTM E119 or UL 263 required for fire-resistance rated wall assemblies
  - Thermal barrier required
  - NFPA 259 test data corresponding to SPF tested per NFPA 285
  - Class I per ASTM E84 (<25 FS, <450 SD)
  - NFPA 285 test data for each wall assembly
  - Labelling of product
  - NFPA 286 test data showing no sustained flaming

Fire Safety

Thermal Barrier Exceptions

- Inside masonry or concrete walls [IBC 2603.4.1.1 / IRC R316.5.2]
- Cooler and freezer walls* [IBC 2603.4.1.2-3]
- Laminated metal wall panels-one story [IBC 2603.4.1.4]
- Roofing assembly* [IBC 2603.4.1.5 / IRC R316.5.2]
- Entry doors [IBC 2603.4.1.7-8 / IRC R316.5.5]
- Garage doors [IBC 2603.4.1.9 / IRC R316.5.6]
- Siding backer board [IBC 2603.4.1.10 / IRC R316.5.7]

* SPF applications

Fire Safety

Thermal Barrier Exceptions

- Sill Plates and Headers [IBC 2603.4.1.13 / IRC R316.5.11]
  - Limited to Type V construction
  - Max thickness 3.25”
  - Class I Foam (LD and MD)

Fire Safety

Thermal Barrier Exceptions

- Attics and Crawl Spaces [IBC 2603.4.1.6 / IRC R316.5.3]
  - Entry is made only for service of utilities (no storage)
  - Ignition barrier is required separating attic/crawlspace space from foam
  - Thermal barrier required between attic/crawlspace and occupied space

Fire Safety

Ignition Barrier Requirements

- Ignition Barrier [IBC 2603.4.1.6 / IRC R316.5.3]
  - Prescriptive:
    - 1.5” mineral fiber insulation
    - 0.25” wood structural panels
    - 0.375” particleboard
    - 0.25” hardboard
    - 0.375” gypsum board
    - Corrosion-resistant steel having base metal thickness of 0.016 “
    - 1.5” cellulose fiber insulation (IRC 2012 only)
  - Alternative Assemblies by Special Approval Testing

Fire Safety

Ignition Barrier Tests

- Special Approval Tests [IBC 2603.9 / IRC R316.6]
  - NFPA 286 - Contribution of Wall and Ceiling Interior Finish to Room Fire Growth (with the acceptance criteria of Section 803.2/R315.4)
  - FM 4880 - Fire Rating of Insulated Wall or Wall and Roof/Ceiling Panels, Interior Finish Materials or Coatings, and Exterior Wall Systems
  - UL 1040 - Safety Fire Test of Insulated Wall Construction
  - UL 1715 – Fire test of interior finish material
  - *End-use fire tests*




Fire Safety

Ignition Barrier End-Use Fire Tests

- Special Approval for Foam In Attics and Crawlspaces
  - End-use fire tests...
    - Qualifies assembly (foam alone or foam with intumescent coating)
    - See AC-377 June 2009 for updated testing requirements

New modified NFPA 286 baseline test

Thermal and Moisture

Code Requirements

- Thermal Performance, R-value

  [IBC 1301 → IECC 102.1.1 / IRC N1102.1 / 16CFR Part 460]

  – Measure per ASTM C 518 or C 177
  – At installed thickness or extrapolated from R-value at representative thickness per FTC rule; Refer to ESR
  – Must be aged R-value for SPF, as applicable

- Moisture Permeance [IECC 402.5 / IRC R318]
  – Measure per ASTM E 96 dry cup (method A)
  – Approximately 2 inches of closed-cell SPF provides ≤ 1 perm

SPF and the I-Codes

Verifying Compliance

- ICC-ES Acceptance Criteria
  - AC-12 for Foamed Plastic: XPS, EPS, PIR
  - AC-377 for Froth and Spray Polyurethane Foams: -- NEW 3/1/08
- (A) ICC-ES Reports
  - Required Data
    - R-value, Surface Burning Characteristics (at thickness), Physical Properties
  - Optional Data
    - Air permeance, Water absorption, WVTR, Full-scale fire tests,...
  - Go to www.icc-es.org for full list of ESRs for SPF
- (B) Alternate Product Documentation
  - Code-compliance research reports, 3rd Party Test Data, Product Data Sheets also acceptable

On The Jobsite

Labelling and Certificates

- Product Labelling

[IBC 2603.2 / IRC R316.2]

  - Containers on job site shall have mfg name, product ID, product listing, suitability for use

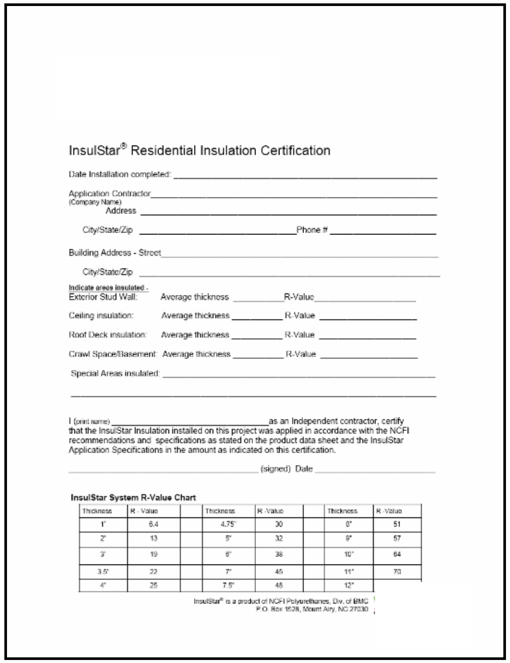
- Installation Certificate

[IECC 401.3 / IRC N1101.8]

  - Provided by contractor to builder/homeowner
  - Thickness, R-value and product listing or data sheet
  - Placed on electric service panel or other conspicuous location

Get product data sheet, ESR and/or certification from builder/designer

[IRC N1101.8]



InsulStar® Residential Insulation Certification

Date Installation completed: ____________________

Application Contractor ____________________
(Company Name)
Address ____________________

City/State/Zip ____________________ Phone # ____________________

Building Address - Street ____________________

City/State/Zip ____________________

Indicate areas insulated -
Exterior Stud Wall: Average thickness ________ R-Value ________

Ceiling insulation: Average thickness ________ R-Value ________

Roof Deck insulation: Average thickness ________ R-Value ________

Crawl Space/Basement: Average thickness ________ R-Value ________

Special Areas insulated: ____________________

I (print name) ____________________ as an Independent contractor, certify that the InsulStar Insulation installed on this project was applied in accordance with the NCFI recommendations and specifications as stated on the product data sheet and the InsulStar Application Specifications in the amount as indicated on this certification.

____________________ (signed) Date ____________________

InsulStar System R-Value Chart

Thickness	R - Value		Thickness	R -Value		Thickness	R -Value
1"	6.4		4.75"	30		8"	51
2"	13		5"	32		9"	57
3"	19		6"	38		10"	64
3.5"	22		7"	45		11"	70
4"	25		7.5"	48		12"	

InsulStar® is a product of NCFI Polyurethanes, Div. of BMC
P.O. Box 1528, Mount Airy, NC 27030

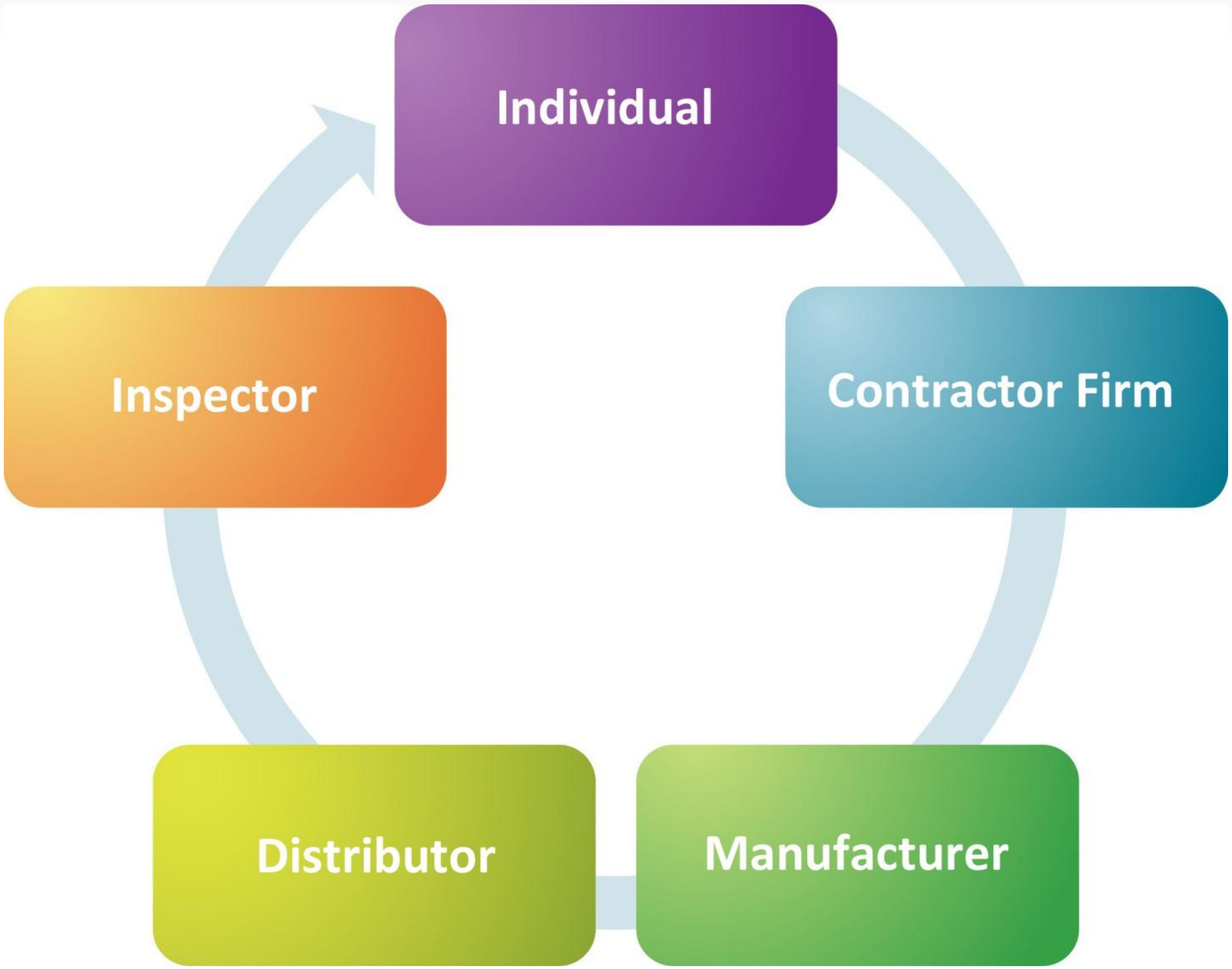
Quality Installation

SPFA Certification

- Establishes Clear Path to Professionalism
- Establishes Expectations
  - Among Industry Professionals
  - Among Customers
  - Among Partners (Arch / Design Build / GC / Etc)
- Standards-Driven (ANSI/ISO 17024)
- Uniform and Consistent Measures
- Consequences for Failure (Enforcement)
- Regular Continuing Education Required for Recertification
- Provides Further Market Differentiator for Company and Individuals
- Heavy Focus Upon H+S Throughout

Quality Installation

SPFA Accreditation / Certification



Summary

- Types of spray polyurethane foams
- Safety requirements
- Environmental impact
- Benefits
- Applications
- Building codes

For More Information…

- SPFA Accreditation Training
- SPFA Website and Annual Conference
- Formulators and Systems House Suppliers

SPFA Website:
www.sprayfoam.org

URL for certificate of attendance:
http://www.cvent.com/d/jcqdsx

Thank You!

Questions?

Next month's webinar:
Building Science Primer
Tuesday, January 8, 1:00 PM
Register at: www.engr.psu.edu/phrc/Training/Webinars.htm