



Misapplied Spray Polyurethane Foam – Troubleshooting and Remediation

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Presentation Summary

- Spray Foam basics
- Misapplied spray foam (MSPF)
- Physical Properties and Chemistry
- Problem Recognition and Site Inspection
- Interim Management
- Mitigation and Clearance
- Risk Assessment

Misplaced Polyurethane Spray Foam (MSPF) - Presentation Goals

Presentation is designed to ensure Industrial Hygienists are familiar with:

- Troubleshooting
 - Emissions
 - Introduce HAM – Heat, Air and Moisture (HAM) movement throughout the building
 - IAQ
- Spray foam Techniques- Spray polyurethane (SPF) insulation applied per-specification
- Remediation

SPF and MSPF

- Compounds and Concentrations vary
 - Product Formulation (Two large classes - Closed and Open Cell Foam)
 - Application Procedures
 - Environmental Conditions
 - Time Elapsed Since Installation



Polyurethane Spray Foam

- Insulator
- Air Barrier
- Weatherization
- New Construction
- Attics
- Walls
- Basements
- Crawl Spaces



Polyurethane Foam Physical Properties

Closed Cell (ccSPF)

- Primary Use: Thermal Barrier (R-Value)
- Problems – Underfill, Thermal Breaks
- Applied by operators with varying levels of understanding
- A chemistry experiment in an occupied space

Open Cell (ocSPF)

- Primary Use: Air Barrier (ACH)
- Problems – Poor application in different climate zones- e.g. Hot Humid Climate - blocking in the wrong place at roof to wall interface
- Prone to Air leakage
- Doesn't control humidity
- A chemistry experiment in an occupied space

SPF Application

- Two mixed components
- Many formulations
- Most installations save energy without causing IAQ problems



Polyurethane Foam Chemistry— (ccSPF)

- Side A - Isocyanate
- Primary Hazard: Operators exposure to isocyanates – HDI, MDI, TDI
- Well Studied – ASTM, CDC, OSHA MANUFACTURERS
- Needs More Studies – Blowing Agents, Relationship of Chamber Studies to Occupant Exposures
- Side B – Polyol Resin
- Primary Hazard: Flammable in large spray operations, skin irritants
- Well studied – Amines, Hydro fluorocarbons (HFC 245fa), Trace VOC's
- Needs More Studies – Byproducts of reaction with other building materials, humidity related damages

Exposure to in-place SPF: Not Significant if SPF Cures

OFF-GASSING (e.g. TRACE VOCs)

- **Catalysts (amines)**
 - *Odor generally not detected within a few days*
 - *New reactive formulations control amine emissions*
- **Blowing agents (hydrofluouocarbons)**
- **Flame retardants**
 - *Replaced Brominated*
- **Trace VOCs**

Causes Of Incompletely Cured SPF

- Layers too thick or too quick
- Wrong ratio
- Incorrect temperature
- Incomplete mixing

When SPF does not fully react- ?MSPF?

- Foam does not perform as intended by specifications
- Increased off-gassing
 - *Unreacted components*
 - *Reactants*
- Ongoing “fishy” odor
- Potential Irritants
- Duration: months to years
- Increased Heat / Fire potential

MSPF – Misplaced Spray Foam

- Product failure – Excess humidity, air leakage
- Emissions
- VOC's Associated with:
 - Blowing Agents
 - Catalysts
 - Emulsifiers
 - Flame Retardants
 - Surfactants
 - **Byproducts**

Off-ratio foam



- Should be 50/50 of A&B
- Not enough of the A or B side to fully react the other chemicals creates curing problems and off gassing



SPF EMISSIONS

- Generally in ppb range
- Compounds and concentrations vary widely:
 - *Product Formulation,*
 - *Application Procedures,*
 - *Environmental Conditions, and*
 - *Time Elapsed since Installation.*
- Most of emissions not unique to SPF:
 - *in background IAQ data or*
 - *emissions from other sources*
- Most MSPF VOCs also occur in applied-per-spec SPF.

Emissions Unique to MSPF?

- Background
- IAQ
- Other Sources

VOCs associated with SPF, MSPF & background IAQ (1)

	SPF	MSPF	Non-SPF Sources
Catalysts			
Bis(2-dimethylaminoethyl) ether - BDMAEE	X		
N,N-Dimethylethanamine – DMEA	X	X	
Flame Retardants:			
tris(1-chloro -2-propyl) phosphate – TCPP	X		
Triethyl phosphate -TEP	X	X	Plastics, pesticides
Blowing Agents:			
1,2-Dichloroethylene – DCE	X	X	

VOCs associated with SPF, MSPF & background IAQ (2)

Surfactants:	SPF	MSPF	Background	Non-SPF Sources
Decamethylcyclopentasiloxane		X		Cosmetics, dry cleaning residue
By-Products:				
1,4 Dioxane	X	X	X	Adhesives, cosmetics, inks
2-Ethyl-1-hexanol	X	X	X	
Acetaldehyde	X	X	X	Environmental Tobacco Smoke and Vapors (ETSV)
Formaldehyde	X		X	ETSV

MSPF Emissions

	IMMEDIATELY AFTER APPLICATION (ppb)		10 DAYS AFTER APPLICATION (ppb)	
	SPF	MSPF	SPF	MSPF
Diisocyanates	ND	ND	ND	ND
Polyols	ND	ND	ND	ND
Amines	2,500	5,000	ND	ND
Triethyl phosphate	2,000	3,500	ND	1,000
Hydroflouorocarbons	1,500	1,500	ND	45,000

MSPF Characteristics

- Some studies found MSPF emissions higher than that from the same applied-per-spec product
- Genz:
 - *MSPF 180°C vs. 80°C SPF*
 - *Strong Odor*
- Icnene:
 - *Off-ratio Foam*
 - *No Isocyanates after 2 hours*
 - *Several VOCs at 24 hrs.; non-detect at 72 hrs.*
 - *Ongoing amines up to 35µg/m³*

Problem Recognition



- Primarily Physical Testing and Visual Analysis
- Ambient air testing inconclusive
- Suspect vs. unrelated odor?

Site Inspection

1. Systematic odor evaluation
 - *Close doors and windows; warm up*
2. Surface inspection – attic or crawl space
3. Remedial specifications development
 - *Identifying material for removal*
 - *Containment*
 - *Phasing*

Surface inspection

- Discoloration
- Discontinuities





Core Sampling

- Visual
- Odor
- Emission Testing
- Density

MSPF Myths

Spray Polyurethane Foam
Alliance Study Guide – SPF
Insulation Project Manual.
(1)Pp. 48-49 and (2) 61

- Myth 2- Spray foam when fully cured doesn't off gas

Answer - The ppb level of gases varies but the primary compounds are likely trace hydrocarbons and hydrofluorocarbons in blowing agents which are 'trapped' inside the cells of closed-cell foams purposefully to improve R-value.(2)

- Myth 1 – The water damage impacts from Air and Moisture leakage in MSPF installations are caused simply by condensation

Answer – Water is introduced indoors as a solid, liquid or gas and transfers in and out of assemblies from a thermal, pressure and a composite of stack effect, wind effect and mechanical devices.(1)

Interim Management

While awaiting full mitigation:

1. Isolate MSPF areas:

- *Containment*
- *Exhaust ventilation*

2. Seal MSPF

- *Plastic*
- *Sealant*



MSPF Replacement

- Challenges
- Historical Development
- Techniques

Site Precautions



- PPE
- Containment
- Confined Space
- Heat Stress
- Ventilation
- Cleanup

Verification

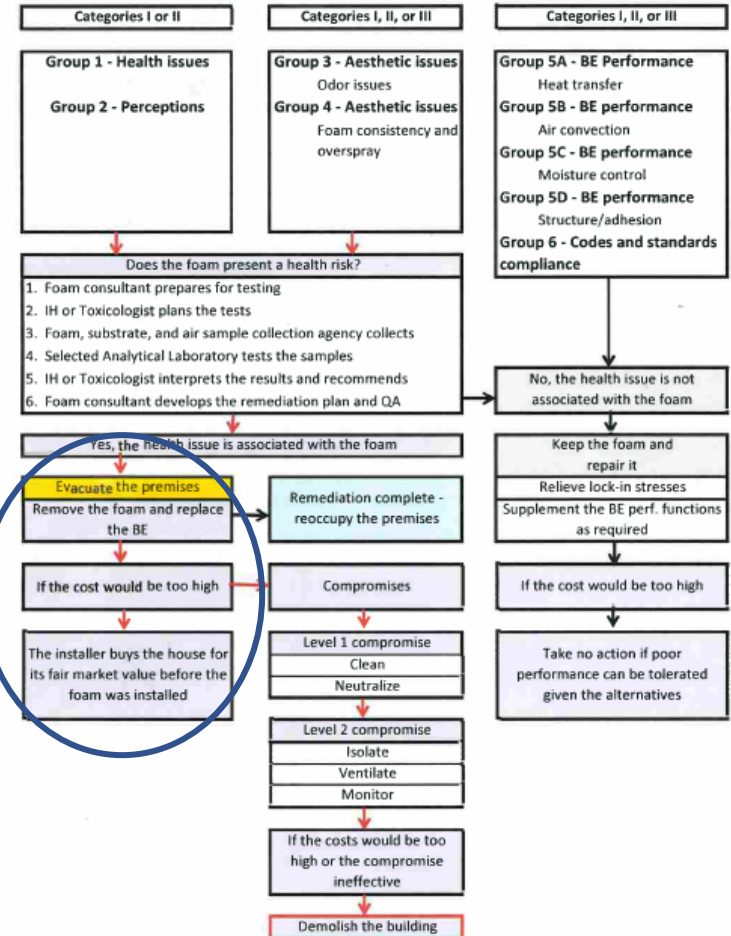
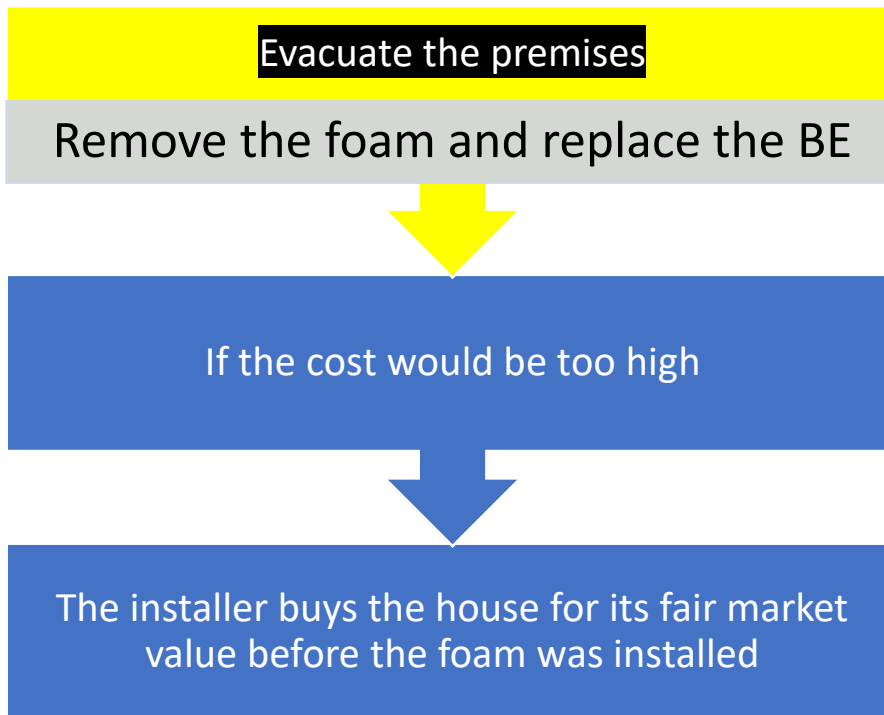
- Confirmation of work practices
- Visual:
 - *Specified Material Removed?*
 - *Dust Eliminated?*
- Odor Evaluation
- Air Sampling ?

Risk Assessment

- Can't be quantified:
 - *No established health effects at IAQ concentrations*
 - *Air sampling inconclusive due to:*
 - *Environmental Variability*
 - *Limited sensitivity and selectivity*
- Qualitative:
 - *Exposure Estimate*
 - *Non-specific Symptoms*
 - *Differential Diagnosis*
 - *Causation?*

2018 Guidelines*

HCF foam failure decision flow chart



*Fennel and Thompson

Alternate Interim Protocol

1. Inspection to delineate areas for MSPF removal
2. Remove foam in a contained area:
 - *HVAC off/vents sealed*
 - *Exhaust Ventilation*
 - *Dust Control*
3. Clean up
4. Exhaust air until no detectable odor.

Protocol (cont.)

5. Re-apply SPF (with reactive catalyst)
6. Re-clean
7. Re-evaluate for odor:
 - *Area closed off*
 - *No Ventilation*
8. Repeat steps 2 – 7 if odor still detected

RECOMMENDATIONS

1. Conduct studies to:
 - *Fully Characterize SPF and MSPF emissions*
 - *Assess health risks*
2. Develop protocols for:
 - *Air sampling*
 - *Emissions testing*
 - *Odor evaluation*
2. Reformulate SPF products to control emissions of:
 - *Tertiary amines*
 - *1,4-Dioxane.*

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<http://www.icynene.com>

Spray Polyurethane Foam Alliance Study Guide – SPF Insulation Project Manual

THANK YOU!

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Presentation Summary



SPRAY FOAM
BASICS



MISAPPLIED SPRAY
FOAM (MSPF)



PHYSICAL
PROPERTIES AND
CHEMISTRY



PROBLEM
RECOGNITION AND
SITE INSPECTION



INTERIM
MANAGEMENT



MITIGATION AND
CLEARANCE



RISK ASSESSMENT



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