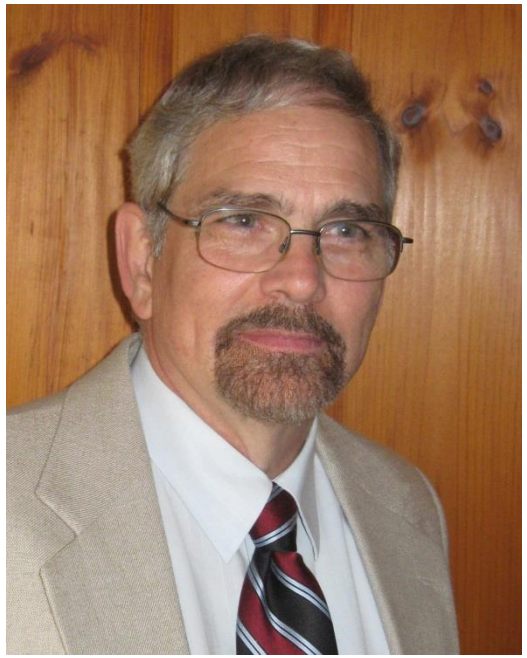
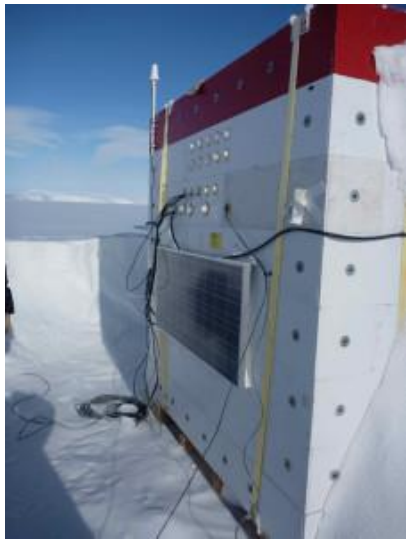
Henri Fennell, CSI/CDT

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.



Net-zero energy research structure in Antarctica



The Big Dig in Boston, MA

HCF foam experience

1. First spray foam project was in 1971
2. Foam manufacturing from 1973 to 1979
3. Foam contracting and BE consulting from 1979 to 2009
    - Developed the method for injecting closed-cell foam on site
    - Installed ~ 5 million pounds of foam
4. Foam and BE commissioning from 2009 to present
5. Noteworthy foam projects include:
    - 1977 net-zero solar project in Boston, The Big Dig, Four American Ski Grande Hotels in the Northeast, 2005 Net-zero energy weather station in Antarctica, The Guggenheim Museum
6. Two US patents and numerous technical papers related to foam & foam QA

Copyright Materials

How to Determine if Spray Foam Insulation is a Source of Toxic Vapors Using Air Testing Combined with Off-Gas Sampling

Maine IAQ and Energy 2023

October 30, 2023 | Portland, ME

Presented by: Henri Fennell, CSI/CDT

H C Fennell Consulting, LLC

Introduction

- There are a lot of slides, so I will go fast, but feel free to ask questions as we go. Better to understand most of it clearly than to have a poor foundation for the whole program.

SPF Failure Causes

Why are there odor complaints about spray foam materials?

1. There are no standards for SPF.
2. Most installers have short employment durations, so SPF quality varies.
3. Poor product quality can produce odors.
4. SPF is manufactured on site, not in factories with ISO quality control programs that govern how the SPF chemicals are manufactured.
5. Homeowners assume quality, not that they have to shop for quality, rather than just for price.
6. Products vary on their ventilation requirements and how Installers meet them (or don't).
7. SPF installations provide insulation (R-value), but also make homes tighter which can change IAQ.

Why are there odor complaints about spray foam?

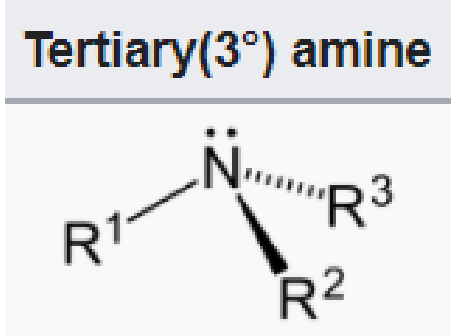
1. SPF is made from two reactive chemicals (A & B) that must be combined and installed properly
    a. Requires proper installation technique and environmental conditions
    b. Requires equipment that is operating precisely
    c. Problems with either requirement can produce odors/vapors
2. The A side is typically one chemical compound (MDI)
3. The B side is made up of at least six chemical compounds

Why are there odor complaints about spray foam?

1. The B side is made up of at least six chemical compounds. These include:
    a. Polyols
    b. Surfactants
    c. Catalysts
    d. Fire retardants
    e. Blowing agents
    f. Fillers (to increase the recycled content)
    g. Dyes
    h. Other chemicals

Side B - Catalysts

Liquid amines have a distinctive "fishy" smell.



2-Dimethyl**amino**ethanol	108-01-0
1,4-Diazabicyclooctane (triethylene di**amine**)	280-57-9
Bis(2-dimethyl**amino**ethyl) ether	3033-62-3
Pentamethyldiethylenetri**amine**	3030-47-5
N'-(30(dimethyl**amino**)propyl)-N,N-dimethylpropane-1,3 **diamine**	6711-48-4
2-((2-(2-(dimethyl**amino**)ethyoxy)ethyl)methyl **amino**) ethanol	83016-70-0
Cyclohexan**amine**, N-Cyclohexyl-N-Methyl-	7560-83-0
Pentamethyldipropylene tri**amine**	3855-32-1
Amine Catalyst	33329-35-0
N,N,N',N',N",N"-Hexamethyl-1,3,5-triazine-1,3,5(2H, 4H, 6H)-tripropan**amine**	15875-13-5
Trimethyl**amine**	75-50-3
N,N-Dimethyl-Cyclohexan**amine**	98-94-2
N-Ethyl-Ethan**amine** (diethyl **amine**)	109-89-7
2-Methyl-Benzen**amine**	95-53-4
N-Methyl-2-Propan**amine**	4747-21-1
alpha-(2-**Amino**emthylethyl)-omega-(2-**amino**methylethoxy)-poly(oxy(methyl-1,2-ethanediyl))	9046-10-0
Ethanol, 2-[[2-(dimethyl**amino**)ethyl]methyl**amino**]-	2212-32-0
Diethyltoluened**iamine**	68479-98-1
Diethanol**amine**	34354-45-5

Side B – Blowing agents/propellants

Chlorodifluoromethane	75-45-6
1-Chloro-1,1-Difluoroethane	75-68-3
Dichlorofluoroethane	1717-00-6
1,1,1,3,3-Pentafluoropropane	460-73-1
Pentafluorobutane (icynene)	406-58-6
Propane, 1,1,1,2,3,3,3-heptafluoro-	431-89-0
1,1-Dichloroethene	75-35-4

More recently, liquid Hydrofluoroolefin (HFO) propellants have become more widely adopted in aerosol systems due to their relatively low vapor pressure, low global warming potential (GWP), and nonflammability.

Side B – Flame Retardants

Brominated flame retardants, which have received the most scrutiny, can build up in tissue, cause cancer, disrupt hormones, harm the reproductive system and cause neurodevelopmental problems, at least in animals and perhaps humans too.

Trans 1,2 dichloroethylene	156-60-5
Tris-(2-chloroisopropyl)-phosphate (TCPP)	13674-84-5
Tetrabromophthalate diol	20566-35-2
1-Propanol, 2,2-dimethyl-, tribromo derivative	36483-57-5
Triethyl Phosphate	78-40-0

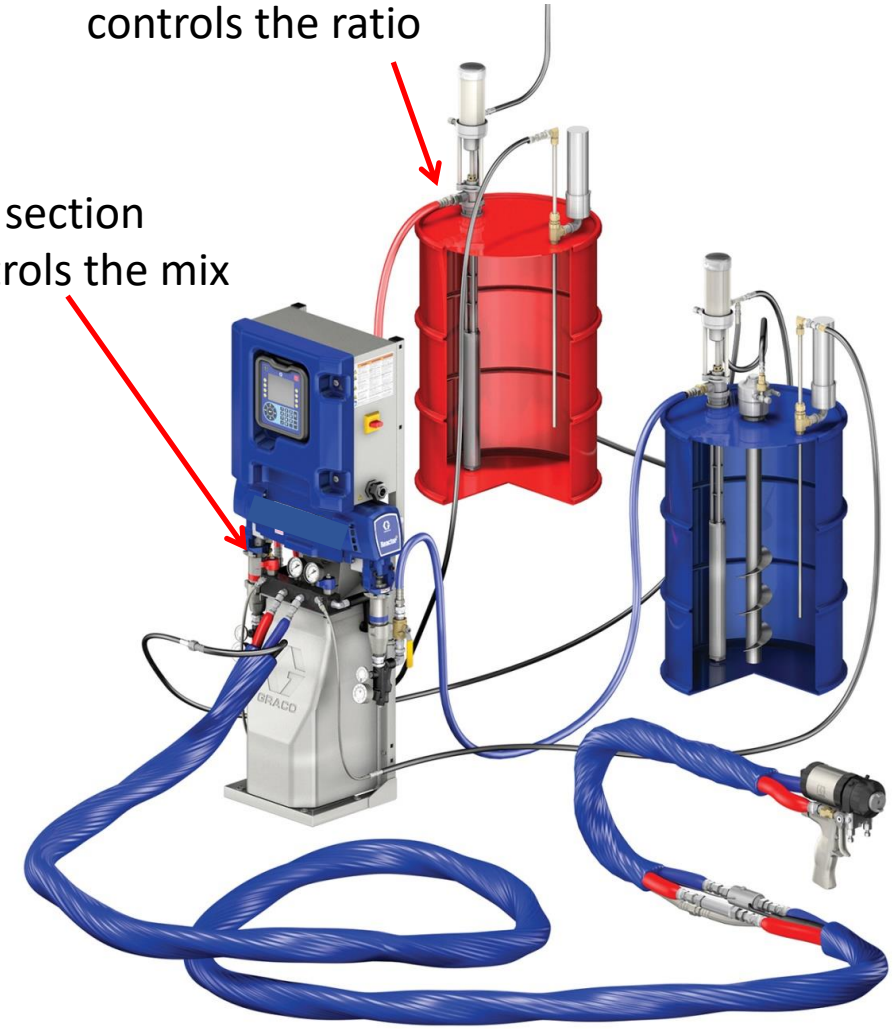
Why only a small percentage (<1%) of projects have product quality problems

- Sophisticated processing equipment - positive displacement design normally performs within an acceptable tolerance, but requires regular maintenance and quality assurance verification.
- Ambient conditions are generally favorable - Climate Zones 1-3 and spring, summer, and fall in Climate Zones 4-6.
- Methods are relatively well developed after 75 years.
- Product chemistry can tolerate off-ratio processing within a small tolerance; however, most chemical manufacturers do not provide this tolerance to their installers.

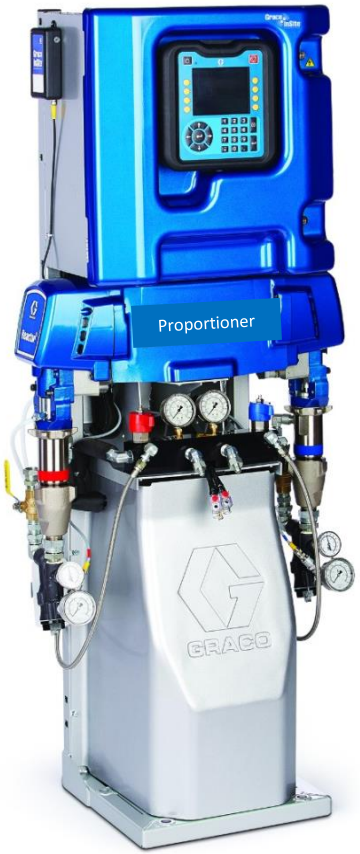
The processing system

This section controls the ratio

This section controls the mix



The spray foam industry relies on this equipment to provide consistent processing quality



Courtesy: Graco, Inc.

Supply chemical heating is required

This heating blanket wouldn't warm the chemicals, even if it was plugged in!

Site Protection - Ventilation

In addition to properly manufacturing the SPF, the site must be protected.

1. Proper ventilation is an industry-standard best practice and required by the chemical manufacturers.
2. Homeowners often are not evacuated during the installation; therefore, they can become sensitized to SPF chemical compounds.

Site Protection - Ventilation

- The application of polyurethane foam presents ventilation challenges because every job site will have different room sizes and shapes.
- In addition, frequent movement of the workers results in vapors, mists, dusts, and particulates being generated throughout the work zone.
- While a properly planned ventilation system can help protect workers and building occupants, an improperly implemented system could make matters worse.
- The industry recommends a ventilation rate of 10 air changes per hour. Many installers can’t achieve this rate with their standard equipment.
- Some chemical manufacturers have other recommendations and different re-occupancy periods, most of which are not achievable!

Ventilation

Guidance on Ventilation During Installation of Interior Applications of High-Pressure Spray Polyurethane Foam

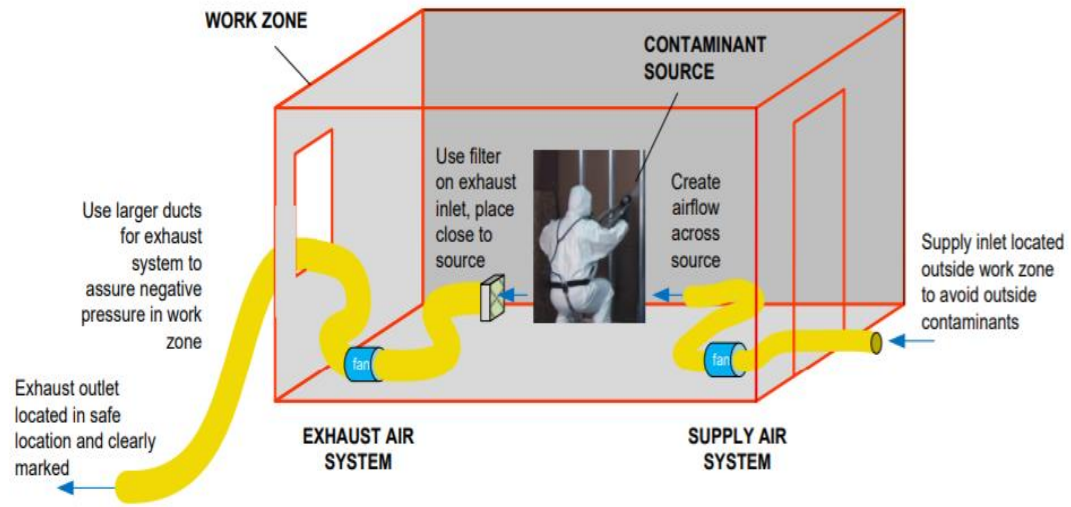


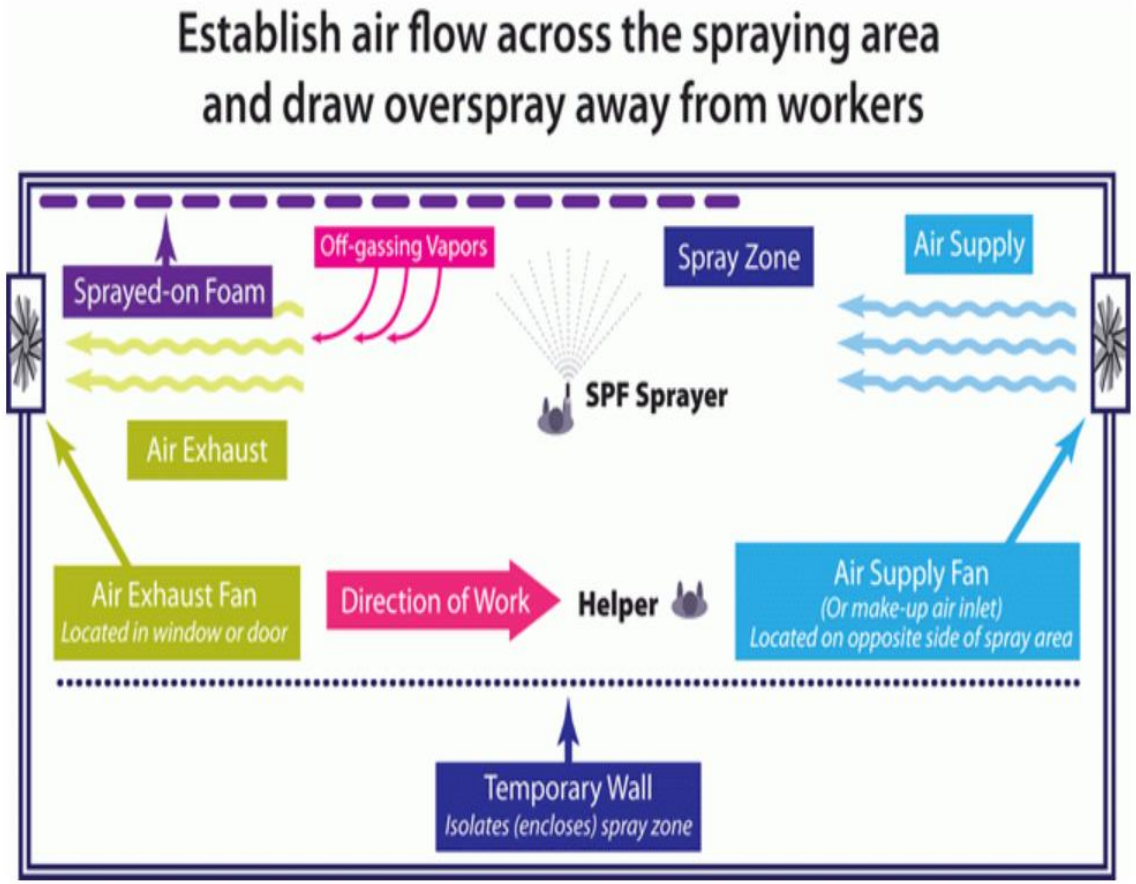
FIGURE 4 - Example of a Two-Fan Ventilation System (active exhaust and supply systems) for Interior SPF Application.

1. Ventilation must establish air flow across the spraying area.
2. A fundamental consideration of any ventilation system is that the system creates an air flow from the make-up air entry location to the exhaust collection point .

Ventilation

The air supply fan should have an output slightly below that of the air exhaust fan.

Ventilation also keeps vapors from clinging to surfaces in the work zone.



Source: Guidance on Ventilation During Installation of Interior Applications of High-Pressure Spray Polyurethane Foam, March 2016

Spray Foam Coalition of the ACC Center for the Polyurethanes Industry

SOLUTIONS – Site Protection - Ventilation

Enclose the spray zone as much as possible.

- Supply the air at one end of spray zone.
- Direct the airflow through the spray zone from clean to contaminated.
- Filter and exhaust the air at opposite ends of the spray zone.
- Create negative pressure within the enclosure (remember CAZ safety).
- The negative pressure must be with respect to the occupied spaces.

Use air movers to exchange air in the spray zone.

- Reduce airborne chemical concentrations.
- Air supply and exhaust are needed.
- Filter and exhaust the air to unoccupied location.

Residential fresh air ventilation standards

- ANSI/ASHRAE Standard 62.2-2016 is written in enforceable mandatory language to facilitate adoption into the codes.
- Fresh air ventilation is even more important after installing SPF as air leakage is reduced by SPF.
- CAZ safety is even more important after installing SPF as air leakage is reduced by SPF.

SPF failure types

1. Odors
2. Health issues
3. Poor building performance

Off ratio processing – the ratio varies

“Peanut brittle” layer of A-rich material sprayed without the B-side, then covered up without remediation

Off ratio processing – consistently

This ceiling was finished, but…

Condensation drips from the recessed lights gave this one away.

But, removal was easy!

Why are there odor complaints about spray foam materials?

When SPF is misapplied, odors can occur due to:

a. Unreacted chemical compounds
    - Off-ratio processing
    - Poorly mixed chemicals
b. Overheated chemical compounds
    - Too-thick passes
    - Too-short dwell time

Off ratio processing can look like this

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

This is rare, but misapplied foam can produce off gassing

Why are there odor complaints about spray foam materials?

Odors can be due to pre-existing conditions (mold, mildew, vermin, etc.)

a. Spray foam tightens up a house.

b. “Homes almost never have the recommended minimum mechanical fresh air ventilation levels, so tighter houses may have staler air.” (ASHRAE)

c. Pre-existing odors that were naturally “ventilated out” before the foam was installed, now become concentrated inside and more apparent.

d. Because an odor becomes apparent after the foam is installed, it is assumed that the foam is the source of the odor. Installers don’t prepare homeowners for tight-house issues.

Why are there odor complaints about spray foam materials?

This means we have to determine the source of the odor, proving or disproving that the odor is coming from the bulk (physical) foam itself, rather than from something else.

Vapors off gassing from SPF

Odors can be benign, or they can indicate a health hazard. Some compounds do not have an odor, but they can still be toxic.

Standard VOC Tests

Are vapors off gassing from SPF?

Air quality tests determine which compounds are in the air.

a. TVOCs is the total of all of the compounds in the air, no matter what the source or how much of each is in the total.
b. Air samples are collected in glass vials with carbon in them. Air flows through them at a known rate which allows the lab to calculate the concentration in the air from what is in the carbon.
c. When TVOCs are elevated after foam is installed in the residence it is assumed that the foam is the source of the VOCs, not that non-foam compounds are elevated because the house is tighter.
d. Some compounds can have more than one source.

Are vapors off gassing from SPF?

ENTHALPY ANALYTICAL
formerly *Prism Analytical Technologies*

Client Sample ID: Bedroom
Laboratory ID: 6010-3

Analytical Report
Sample Report

Quantitative Results		Sample Concentration		Reporting Limit	
Compound	CAS	ng/L	ppb	ng/L	Additional Information
o-Xylene	95-47-6	14	3.2	0.4	
Styrene	100-42-5	2.5	0.6	0.4	
n-Propylbenzene	103-65-1	2.3	0.5	0.4	
1,3,5-Trimethylbenzene	108-67-8	3.2	0.6	0.4	
1,2,4-Trimethylbenzene	95-63-6	12	2.4	0.4	
p-Isopropyltoluene	99-87-6	3.0	0.5	0.4	
Naphthalene	91-20-3	1.5	0.3	0.8	

Semiquantitative Results		Sample Concentration		Reporting Limit		
Compound	CAS	ng/L	ppb	ng/L	RI	Additional Information
Acetaldehyde	75-07-0	0	0	0	402	
2-Methylbutane	78-78-4	0	0	0	446	
Pentane (C 5)	109-66-0	0	0	0	481	
C4-C6 Hydrocarbon	N/A	0	N/A	0	501	At least one degree of unsaturation; possibly cyclic
Ethanol	64-17-5	0	0	0	508	
C4-C6 Hydrocarbon	N/A	0	N/A	0	514	At least one degree of unsaturation; possibly cyclic

Are vapors off gassing from SPF?

This report shows high TVOCs (6,900), but the organic compounds that are high are not related to SPF. The testing agency said that the SPF should be removed without identifying the sources of the organic compounds that were high or severe.

Your Indoor Air Quality Report Summary

Your Indoor Air Quality Report has several sections describing different aspects of your home's air quality. A summary of this data is provided below, additional information and descriptions are included in the full report.

Total Volatile Organic Compounds (TVOC) Level

TVOC is a general indicator of the IAQ in your home (see page 2). **Total VOCs 6900 ng/L**

Total Mold Volatile Organic Compounds (TMVOC) Level

TMVOC is an assessment of the actively growing mold in your home (see page 3). **Total MVOCs 18 ng/L**

Contamination Index (CI) Level

The CI shows the types of air-contaminating products and materials that are present in your home (see pages 7, 8, and 9). These levels are estimates based on common home products and activities.

Building Related Sources		Mixed Building and Lifestyle Sources		Lifestyle Related Sources	
See page 7 for more detail.		*See page 8 for more detail.*		*See page 9 for more detail.*	
H	Coatings (Paints, Varnishes, etc.)	N	Building Materials-Toluene Based	E	Personal Care Products
H	PVC Cement	N	Gasoline	N	Alcohol Products
N	HFCs and CFCs (FreonsTM)	N	Fuel Oil, Diesel Fuel, Kerosene	H	Odorants and Fragrances
		N	Moth Balls (Naphthalene Based)	N	Dry Cleaning Solvents
		N	Moth Crystals (p-Dichlorobenzene Based)	N	Medicinals
		N	Light Hydrocarbons		
		N	Light Solvents		
		N	Methylene Chloride		

Note: Severity levels begin at Normal or Minimal and progress through Moderate, Elevated, High and/or Severe. The color progression from green to red indicates results that are increasingly atypical and suggest potentially higher risk.

Normal | Moderate | Elevated | High | Severe

VOCs From Building Materials

- **Flooring**
  - Formaldehyde, solvents
- **Vinyl Flooring**
  - Tetradecane
- **Cabinetry**
  - Formaldehyde, toluene, xylenes
- **Paint**
  - Texanols, butyl cellusolve, hydrocarbons
- **PVC Cement**
  - Tetrahydrofuran, methylethylketone
- **Plastic Materials**
  - Phthalate esters
- **HVAC**
  - Freons, HFC, CFC
- **Insulations**
  - Phenol/formaldehyde
  - Freons, HFC, CFC, HFOs
  - Styrene
  - TCPP
- **Adhesives**
  - Toluene, Xylenes

Vapors off gassing from SPF

Some testing agencies and laboratories rely on the SPF products' SDSs to determine which chemical compounds in the air are coming from SPF.

a. However, many SPF chemical manufacturers hide the chemical information from their installers, labs, and Homeowners.
b. Many compounds have other sources than SPF so those compounds are not necessarily a specific indication of off-ratio or misapplied foam.

Undisclosed SPF products

1. Some installers don’t provide documentation of any kind to their customers – I had one who I asked for documentation, and they said they wouldn’t bid the job because it wasn’t worth the risk to disclose the product to the homeowner.
2. Always ask for product information and insurance certificates.
3. A written safety plan is an OSHA requirement (it’s the law), and it is best practice to provide SDS and product information to the consumer.

Installation Certificate

This citation is specifically from the 2015 IRC but this requirement has been around since at least 2009. A code-required permanent insulation certificate is required for every project which has new insulation or an energy upgrade. The 2015 IRC version of this code requirement can be found in N1101.14 (R401.3) Certificate (Mandatory).

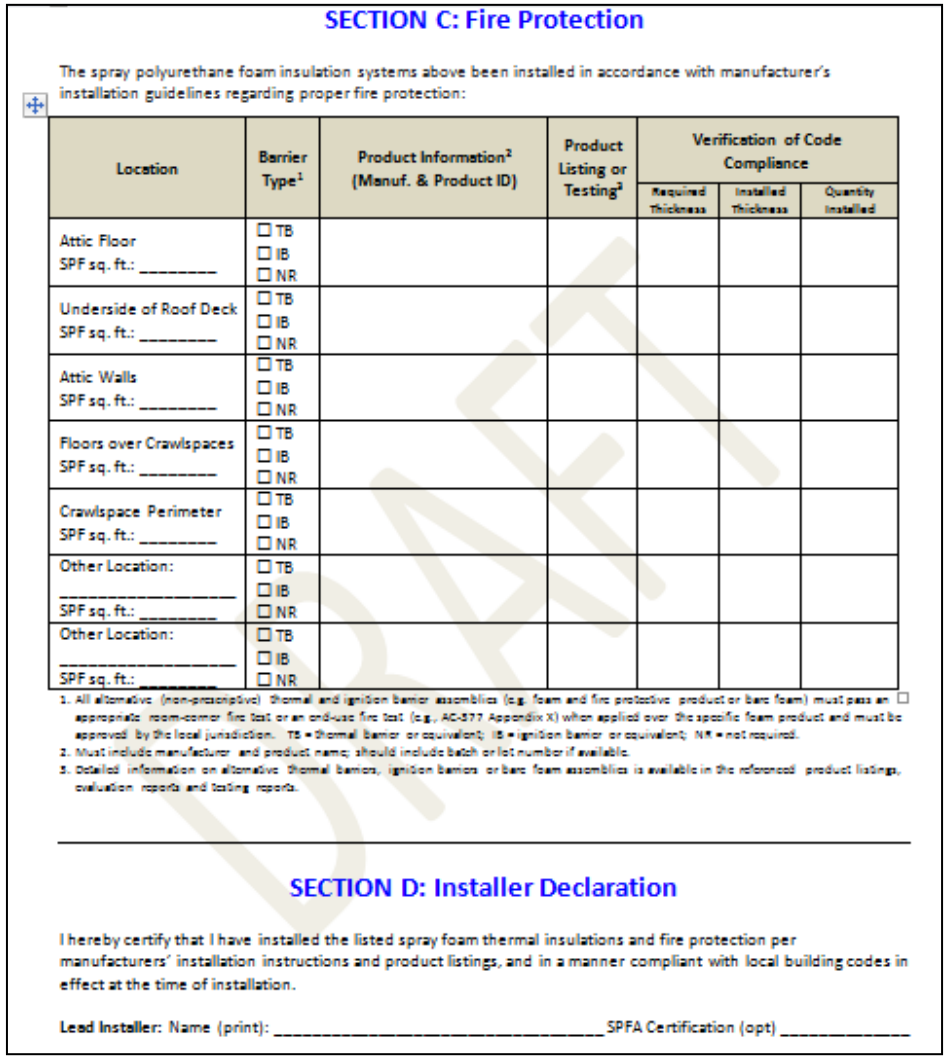
N1101.14 (R401.3) Certificate (Mandatory).
A permanent certificate shall be completed by the builder or registered design professional and posted on a wall in the space where the furnace is located, a utility room or an approved location inside the building. Where located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. The certificate shall list the predominant *R*-values of insulation installed in or on ceiling/roof, walls, foundation (slab, *basement wall*, crawl space wall and/or floor) and ducts outside conditioned spaces; *U*-factors for fenestration and the solar heat gain coefficient (SHGC) of fenestration, and the results from any required duct system and building envelope air leakage testing done on the building. Where there is more than one value for each component, the certificate shall list the value covering the largest area. The certificate shall list the types and efficiencies of heating, cooling and service water heating equipment. Where a gas-fired unvented room heater, electric furnace, or baseboard electric heater is installed in the residence, the certificate shall list "gas-fired unvented room heater," "electric furnace" or "baseboard electric heater," as appropriate. An efficiency shall not be *listed* for gas-fired unvented room heaters, electric furnaces or electric baseboard heaters.

Installation Energy Certificate

Actual photo of the SPF trade organization's sample certificate provided to help members comply with the code.

This document should be on every project after completion in addition to what is provided to the Owner prior to the installation.
Note that this section includes fire protection information.

Courtesy SPFA



SECTION C: Fire Protection

The spray polyurethane foam insulation systems above been installed in accordance with manufacturer's installation guidelines regarding proper fire protection:

Location	Barrier Type[1]	Product Information[2] (Manuf. & Product ID)	Product Listing or Testing[3]	Verification of Code Compliance		
				Required Thickness	Installed Thickness	Quantity Installed
Attic Floor SPF sq. ft.: _____	☐ TB ☐ IB ☐ NR					
Underside of Roof Deck SPF sq. ft.: _____	☐ TB ☐ IB ☐ NR					
Attic Walls SPF sq. ft.: _____	☐ TB ☐ IB ☐ NR					
Floors over Crawlspaces SPF sq. ft.: _____	☐ TB ☐ IB ☐ NR					
Crawlspace Perimeter SPF sq. ft.: _____	☐ TB ☐ IB ☐ NR					
Other Location: _____ SPF sq. ft.: _____	☐ TB ☐ IB ☐ NR					
Other Location: _____ SPF sq. ft.: _____	☐ TB ☐ IB ☐ NR					

1. All alternative (non-prescriptive) thermal and ignition barrier assemblies (e.g. foam and fire protective product or barc foam) must pass an ☐ appropriate room-corner fire test or an end-use fire test (e.g., AC-377 Appendix X) when applied over the specific foam product and must be approved by the local jurisdiction. TB = thermal barrier or equivalent; IB = ignition barrier or equivalent; NR = not required.
2. Must include manufacturer and product name; should include batch or lot number if available.
3. Detailed information on alternative thermal barriers, ignition barriers or barc foam assemblies is available in the referenced product listings, evaluation reports and testing reports.

SECTION D: Installer Declaration

I hereby certify that I have installed the listed spray foam thermal insulations and fire protection per manufacturers' installation instructions and product listings, and in a manner compliant with local building codes in effect at the time of installation.

Lead Installer: Name (print): _____ SPFA Certification (opt) _____

SDS with undisclosed compounds

Actual photo of one mainstream SPF manufacturer's SDS

SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

Composition/information on ingredients	%W/W	CAS No.	Hazard Statement(s)
Chlorinated phosphate ester	25 - 35	Trade Secret	This information may disclose the product name but does not disclose the specific chemical compound.
Surfactant	11 - 18	Trade Secret	
Proprietary amine	1 - 8	Trade Secret	
Proprietary amine	1 - 5	Trade Secret	
Proprietary amine	0.5 - 4	Trade Secret	
Polyol resin	< 40	Trade Secret	
Proprietary silicone polymer	0.5 - 2	Trade Secret	
Water	< 30	7732-18-5	

SDS with unhelpful information

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

Appearance	Liquid
Color.	Clear to amber
Odor	Slightly ammoniacal
Solubility (Water)	Soluble
Solubility (Other)	Not available.
Partition Coefficient (n-Octanol/water)	Not available.
Auto Ignition Point (°C)	Not available.
Decomposition Temperature (°C)	Not available.
Kinematic Viscosity (cSt)	~ 183 @ 25 °C
Explosive properties	Not explosive.
Oxidizing properties	Not oxidizing.

Other information Not available.

SECTION 10: STABILITY AND REACTIVITY

Reactivity	Stable under normal conditions.
Chemical stability	Stable.
Possibility of hazardous reactions	This product will react with isocyanates. The reaction is very exothermic and may produce excessive amounts of heat.
Conditions to avoid	Incompatible materials.
Incompatible materials	Isocyanates.
Hazardous decomposition product(s)	Combustion or thermal decomposition will evolve toxic and irritant vapours; acrid smoke. Carbon monoxide, Carbon dioxide, nitrogen oxides.

Vapors off gassing from SPF

EPA Methods

VOCs **Method TO-17**

2.5 The target compound list (TCL) is the same as listed in Compendium Method TO-15 (i.e., subsets of the 97 VOCs listed as hazardous pollutants in Title III of the Clean Air Act Amendments of 1990). Only a portion of these compounds has been monitored by the use of solid adsorbents. This method provides performance criteria to demonstrate acceptable performance of the method (or modifications of the method) for monitoring a given compound or set of compounds.

The TO-17 method with 86 target chemicals still missed many of the SPF formulation compounds.

We compiled a list of chemicals in all of the SPF SDSs available and compared them to the TO-14, TO-15, and TO-17 lists. At least fifteen SPF SDS compounds and all of the "trade secret" compounds were not in these TO lists.

Compiled nearly 50 Formulations Safety Data Sheets with over 65 different compounds plus the Trade Secret components

Compound	Polymer	Tertiary Amine	Ester derivative	Chlorinated Phosphate Ester	Brominated Flame Retardant	Flame Retardant	Proprietary Additives	Catalyst	Surfactant	Pigment	Hydroxyl Terminated Poly (Oxyalkylene) Polyether	1,1,1,3,3-Pentafluoropropane	Tris-(2-chloroisopropyl)-phosphate	1,1,1,3,3-pentafluorobutane	1,1,1,4,4,4-hexafluorobut-2-ene	Triethyl Phosphate	Trans 1,2 dichloroethylene	Bis(2-dimethylaminoethyl) ether	2-Dimethylaminoethanol	Pentamethyldiethylenetriamine	Cyclohexanamine, N-Cyclohexyl-N-Methyl-	N,N,N',N',N",N"-Hexamethyl-1,3,5-triazine-1,3,5(2H, 4H, 6H)-tripropanamine	2-Butoxyethanol	Ethylene Glycol	Oxirane, 2-methyl-, polymer with oxirane, ether with 2,6-bis[[bis(2-hydroxyethyl)amino]methyl]-4-branched	Diethylene Glycol	Dipropylene Glycol
CAS (TS=Trade Secret)	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	460-73-1	13674-84-5	406-58-6	407-60-3	78-40-0	156-60-5	3033-62-3	108-01-0	3030-47-5	7560-83-0	15875-13-5	111-76-2	107-21-1	940912-28-7	111-46-6	25265-71-8
Make/Formula		**13**	**1**	**3**	**3**	**5**	**4**	**4**	**9**	**1**	**1**	**21**	**23**	**1**	**0**	**7**	**8**	**4**	**5**	**5**	**3**	**3**	**3**	**12**	**3**	**11**	**3**
	x	xx	x									x	x										x				
		xx		x	x							x												x			
		x		x	x							x												x			
												x	x			x									x		x	
													x												x			
	x	x				x	x					x	x				x											
													x					x									x	
	x					x		x	x			x							x								x
	x					x		x	x	x									x								
													x	x														
	x					x		x	x			x							x					x			x
	x	x									x	x	x															
	x						x					x	x															
												x																
												x																
	xx	x							x			x	x			x	x											
	x	x							x			x	x				x											
													x			x								x		x		
												x	x			x	x					x		x		x		
	x	x				x			x																			
													x															
		x																		x						x		
		x																		x						x		
B												x					x											

Brands not available due to NDAs

IAQ Testing for SPF Compounds

Identifying vapors off gassing from SPF

In many cases, the SPF product installed in a house is unknown.

1. Some Laboratories do air tests that only “look” for chemicals that are specified by the EPA and ASTM; therefore, they do not have lists that are all inclusive.
2. Many SPF compounds are not included in the EPA (Compendium) and ASTM lists.
3. Some laboratories are limited to what they can test for by state regulations.

Are vapors off gassing from SPF?

- Given that we have no SDSs, we initially weren't sure what compounds to look for.
- I had to find a lab that would test for everything in the foam! What I found was a lab that would determine what is in the foam by making it off gas and determining what compounds actually come from the foam, no matter what brand, what third-party compounds, and no matter how it was misapplied.
- So, I started to always test both the SPF that is actually in the building, and the air in the same location in the building.

Taking air quality samples

The sample vial (thermal desorption tube) with carbon in it

The air pump that maintains a constant flow through the tube

Bulk Foam Tests

Identifying vapors off gassing from SPF

Traditional VOC Testing

TO-15 and TO-17 Methods only list 50-90 compounds.

Unfortunately, many SPF compounds are not included in the EPA and ASTM lists.

There are no IAQ requirements for residential.

Identifying vapors off gassing from SPF

To make matters worse, in many cases the SPF product installed in a house is unknown.

a. The house has been sold and the SPF product and the fire protection coating were not disclosed to the new owner.
b. Some Installers do not provide owners with proper documentation.
c. Many Installers do not provide the code-required insulation certificate.
d. Spray foam products, especially in this era of supply chain shortages, could be contraband, untested, or undocumented.
e. The chemicals in the SPF can react with substrate materials creating “third-party” compounds.
f. Therefore, we don’t have legitimate verifiable documentation to use in identifying all of the compounds in the spray foam.

Identifying vapors off gassing from SPF

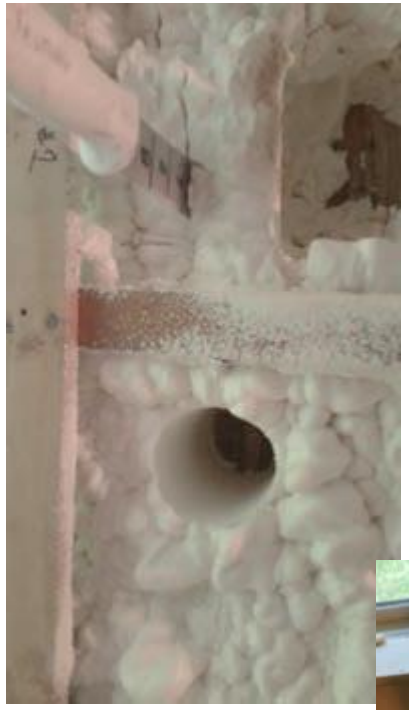
1. This meant that I had to figure out which brand and SPF formulation was used in any given house without documentation.
2. Ultimately, the solution to the lack of documentation is to test the bulk foam itself to determine which chemical compounds can off-gas from it.

3. Therefore, every air quality test should be coupled with an off gas test of the bulk foam in that location to make sure all of the foam's compounds are being compared to the IAQ results from that location.
4. Compounds from the off gas tests are not quantitative (not related to the concentration in the air); it just shows that the compound was detected and that the SPF is a possible source.

Taking bulk foam core samples

3” diameter 12” hole saw

Taking bulk foam core samples



Bulk foam material off gas analysis

1. Bulk foam samples should be approximately 2’’ x 2’’ or a 3” cylinder of material (a “core sample”).
2. Cut the sample the full depth of the foam (top to substrate).
3. Place the sample into a thick plastic bag (doubled up) or a small glass mason jar for transit to the lab (ideally a vapor impermeable and air-tight container).
4. The samples are weighed and put in to a small off gas chamber at the laboratory.
5. The samples are kept at room temperature and nitrogen is flowed through the chamber - exhaust air is pulled through a thermal desorption tube for analysis as usual for the GC/MS instrumentation.

Bulk foam material off gas analysis

A4-MS Off Gas Analysis

Off gas performed in accordance with ASTM method D7706-11 (modified) with reference to ASTM method D5116-10. Analytical methods include (with relevant modifications) US EPA TO-17 and ISO 16000-6. A scan was made for all compounds contained in the Air Survey Analysis List (TB503, Quantitative and Semiquantitative List). All compounds detected are listed below.

General Notes

A 0.58 g sample was off gassed under a flow of helium at 50 deg C for 7 minutes. The values reported do not represent total off gas.

Quantitative Results

Compound	CAS	Concentration ng/g	Reporting Limit ng/g	RI	Additional Information
Toluene	108-88-3	530	8.6		

Semiquantitative Results

Compound	CAS	Concentration ng/g	Reporting Limit ng/g	RI	Additional Information
2-Butoxyethanol	111-76-2	1300	170	938	
C10-C12 Hydrocarbon	N/A	1100	170	996	
C10-C12 Hydrocarbon	N/A	1400	170	1047	Contains oxygen; possibly an alcohol
C11-C13 Hydrocarbon	N/A	760	170	1059	
C11-C13 Hydrocarbon	N/A	880	170	1078	At least one degree of unsaturation; possibly cyclic
C12-C14 Hydrocarbon	N/A	1100	170	1123	Sum of at least three overlapping hydrocarbons
Butoxyethoxyethanol	112-34-5	910	170	1228	
Tridecane (C 13)	629-50-5	720	170	1256	
Tetradecane (C 14)	629-59-4	1400	170	1352	
Texanol-A	74367-33-2	1800	170	1423	

Comparing Reports

What the results tell us

1. This method allows us to compare the bulk foam off-gassing test results to the air quality test results.
   a. The lab identifies identical compounds on the two test reports.
   b. The lab creates a summary that flags compounds that are in both the bulk foam and in the air.

2. It is possible to determine if the matching compounds can also be from other materials or can only be from the SPF.

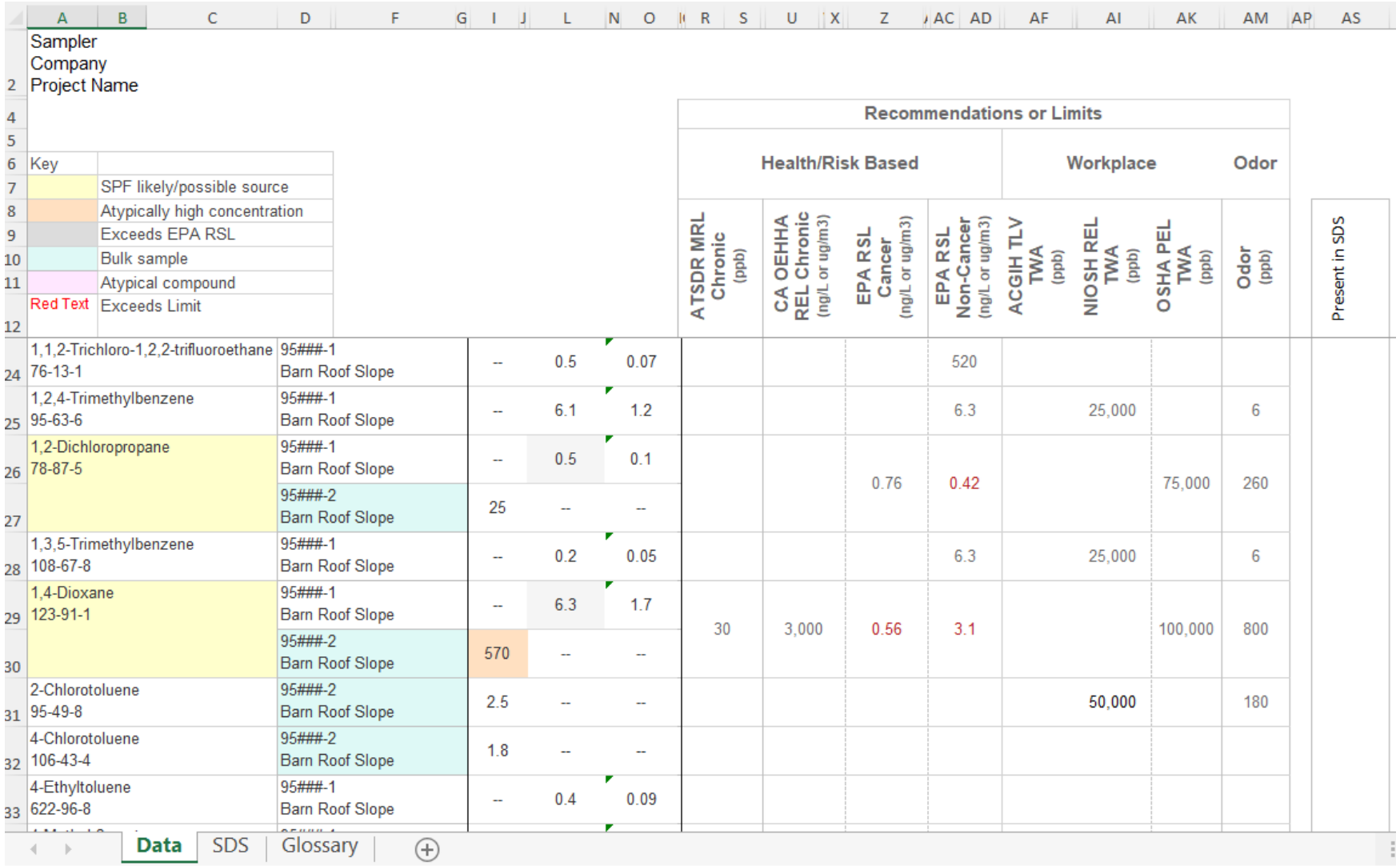
3. It is possible to determine if the matching compounds are at levels that are above the recognized permissible exposure level (EPA published PEL limits).

What the results tell us

1. Beyond exposure levels: Discuss the various PEL sources (Worker vs. Homeowner, etc.)
2. Determine if the compounds that have high exposure levels are the cause of any medical/health issues.
    - Have the Homeowner tested for chemical sensitivities. Sensitivity varies by individual.
    - Consult a toxicologist (or another medical consultant) to determine if there are known PELs that are not readily available to the public.

What the results tell us

This report is generated in the laboratory's database using a proprietary query. It is available to anyone using this laboratory for air and bulk foam testing.



Sampler
Company
Project Name

Key	
	SPF likely/possible source
	Atypically high concentration
	Exceeds EPA RSL
	Bulk sample
	Atypical compound
Red Text	Exceeds Limit

						Recommendations or Limits								
						Health/Risk Based				Workplace			Odor	
						ATSDR MRL Chronic (ppb)	CA OEHHA REL Chronic (ng/L or ug/m3)	EPA RSL Cancer (ng/L or ug/m3)	EPA RSL Non-Cancer (ng/L or ug/m3)	ACGIH TLV TWA (ppb)	NIOSH REL TWA (ppb)	OSHA PEL TWA (ppb)	Odor (ppb)	Present in SDS
24	1,1,2-Trichloro-1,2,2-trifluoroethane 76-13-1	95###-1 Barn Roof Slope	--	0.5	0.07				520					
25	1,2,4-Trimethylbenzene 95-63-6	95###-1 Barn Roof Slope	--	6.1	1.2				6.3		25,000		6	
26	1,2-Dichloropropane 78-87-5	95###-1 Barn Roof Slope	--	0.5	0.1			0.76	0.42			75,000	260	
27		95###-2 Barn Roof Slope	25	--	--									
28	1,3,5-Trimethylbenzene 108-67-8	95###-1 Barn Roof Slope	--	0.2	0.05				6.3		25,000		6	
29	1,4-Dioxane 123-91-1	95###-1 Barn Roof Slope	--	6.3	1.7	30	3,000	0.56	3.1			100,000	800	
30		95###-2 Barn Roof Slope	570	--	--									
31	2-Chlorotoluene 95-49-8	95###-2 Barn Roof Slope	2.5	--	--						50,000		180	
32	4-Chlorotoluene 106-43-4	95###-2 Barn Roof Slope	1.8	--	--									
33	4-Ethyltoluene 622-96-8	95###-1 Barn Roof Slope	--	0.4	0.09									

Data | SDS | Glossary

Thank you for your time!

QUESTIONS??

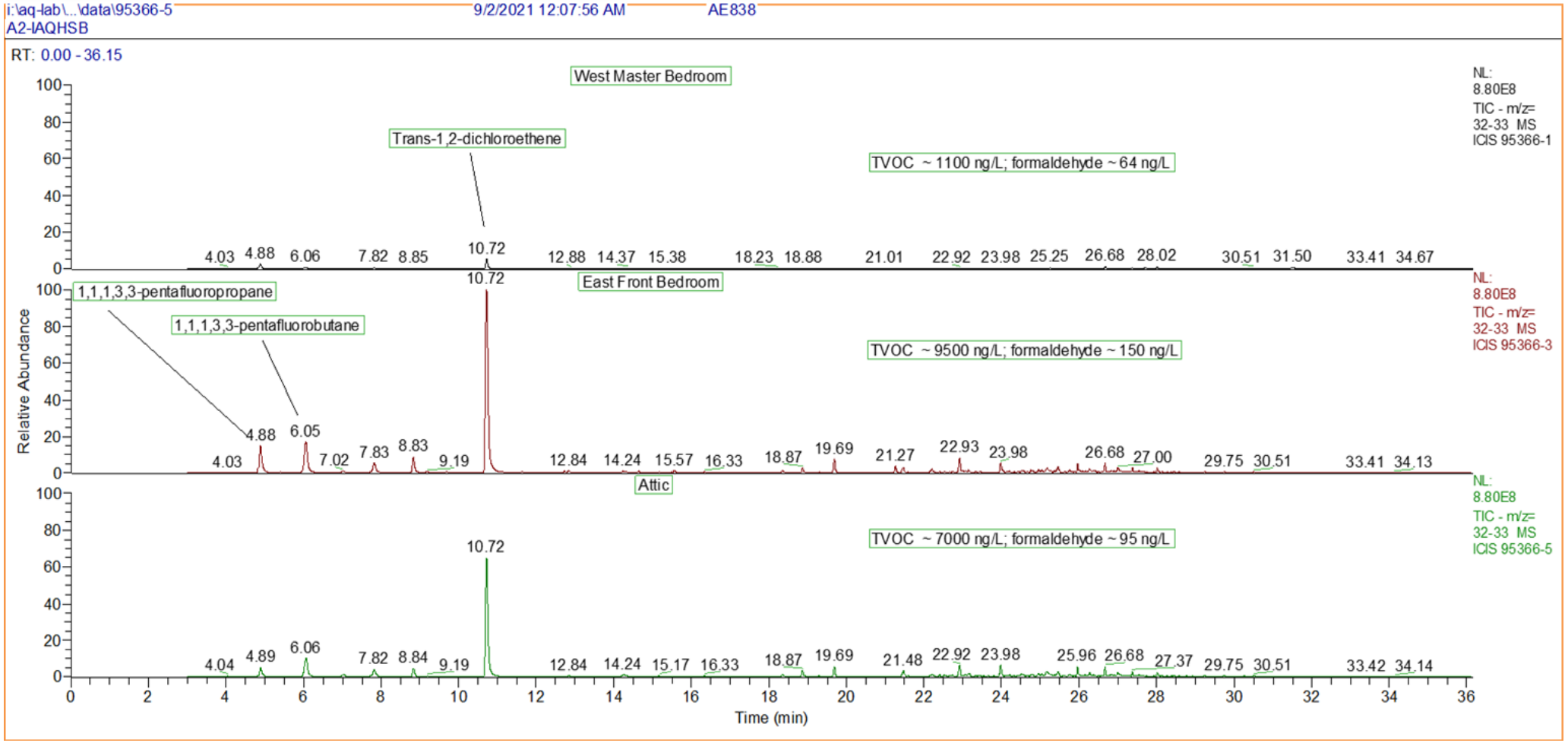
By: Henri Fennell, CSI/CDT

www.polyurethanefoamconsulting.com
Cell: 802-222-7740

Case Study #1

- Odor Complaint from home where both open-cell and closed-cell SPF installed in October 2018
- The house interior was painted November 2020
- Air samples were taken in August 2021
- Homeowners still experiencing odors, especially in front bedroom; suffering respiratory distress.

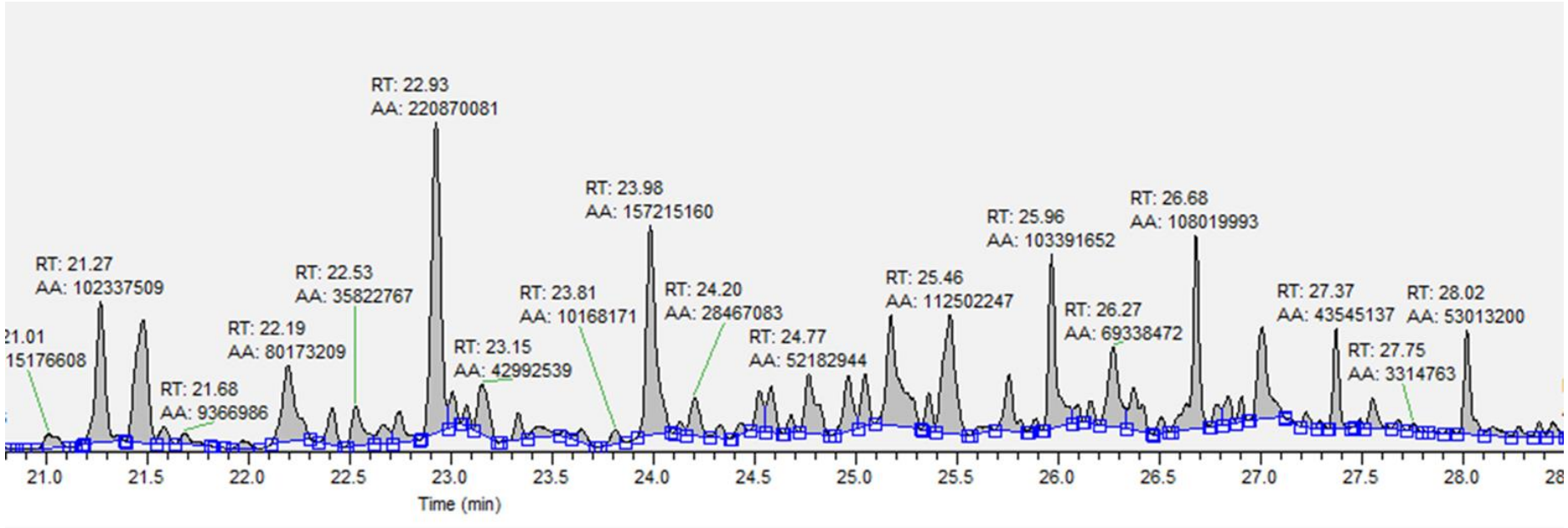
Comparison of Results from Air Samples with SPF Odor Complaints



VOCs Summary

	Master BR	Front BR	Attic
Trans-1,2-Dichloroethene	**140 ng/L**	**3300 ng/L**	**2000 ng/L**
1,1,1,3,3-penta-Fluoropropane	**39**	**240**	**76**
1,1,1,3,3-penta-Fluorobutane	**29**	**690**	**310**

Baseline of Chromatogram at later retention time



Evidence for VOC contributions from paints and coatings in the bedroom

Summary of Case Study #1

High SPF VOC levels three years after installation suggests SPF issues and possibly ventilation imbalance or insufficient ventilation.

Trans-1,2-dichloroethene levels are elevated (sharp, harsh odor)

Other VOCs from MOCs (paint, etc.) were also present in the air sample

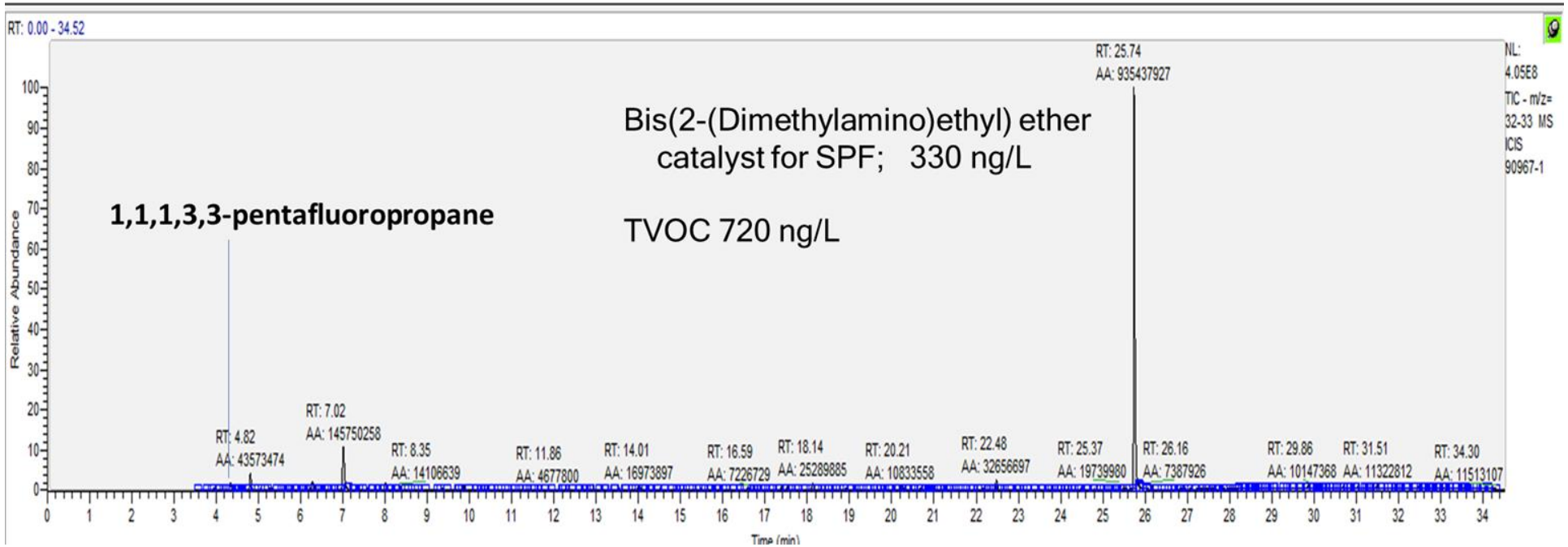
Case Study #2

Odor detected in Living room of home

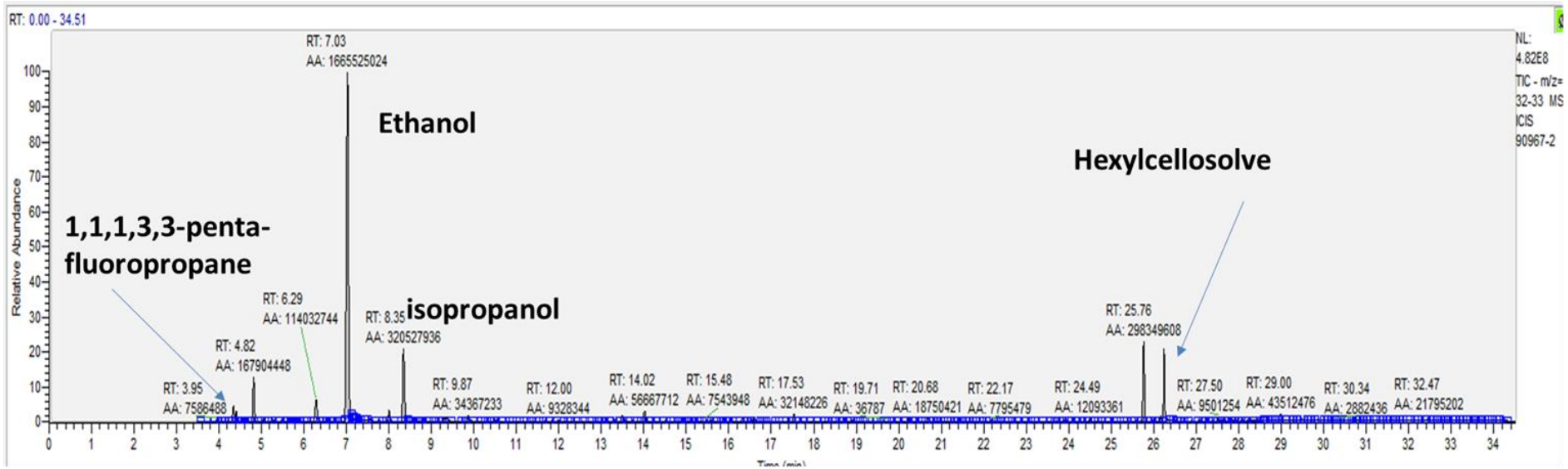
Recent SPF application (within 1-2 months) under roof of home in the attic

Assumed that SPF VOCs were responsible for the residual odor in the home.

Air Sample - Attic



Air Sample - Living Room



Minor peak associated with SPF; major products are personal care Products and no/low VOC paints and coatings; TVOC 1100 ng/L

Summary of Case Study #2

- Odor detected in living room did not correlate with volatiles associated with SPF
- Attic sample had substantial catalyst present; this did not show up in living room sample, suggesting effective isolation of environments.
- VOC analysis can help guide remediation. No removal necessary.