HIGH PRESSURE SPF INSULATION IN NEW HOME CONSTRUCTION AND RETROFIT APPLICATIONS: WORKER AND HOMEOWNER HEALTH AND SAFETY INFORMATION

American Chemistry Council | Spray Foam Coalition

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1. EXECUTIVE SUMMARY

This document has been created to provide practical information on potential worker exposure to SPF chemicals and to characterize potential SPF emissions that a home owner may encounter.[1] Since 2010, the American Chemistry Council's Center for the Polyurethanes Industry (CPI) has been engaged in a three tiered work plan to expand the spray polyurethane foam (SPF) industry's product stewardship program. The work plan includes: training, outreach, and research. To address training and outreach, CPI created a website providing details on health and safety practices and a training program housed at www.spraypolyurethane.org. To date, approximately 25,000 individuals have completed the health and safety training.

CPI has sponsored four research projects to enhance understanding of the characterizations of SPF emissions. Two of these projects have resulted in the publication of two ASTM standards that provide standardized methods to measure SPF emissions shortly after spraying. SPF manufacturers can use the results of these two methods to develop appropriate reoccupancy times for the use of SPF in retrofit applications. Work is on-going to develop a full scale spray booth standard method that can be used to measure SPF emissions during application. SPF manufacturers will be able to use the results of his method to set appropriate worker reentry times. Data emerging from these research projects has shown that emissions from SPF are generally low, and below levels expected to cause harm to workers or building occupants – after the appropriate reentry and reoccupancy times have elapsed.

1 This information is presented in good faith and believed to be accurate, but may be incomplete or inapplicable to all situations potentially encountered. No representation, guarantee or warranty is made as to the accuracy, reliability or completeness of the information or that its use will prevent hazards, accidents, damages or injury to persons or property. Readers must satisfy themselves as to the applicability and suitability of the information for their intended purposes prior to use.

2. INTRODUCTION

SPF is a spray-applied product that is widely used to insulate buildings and seal cracks and gaps, making the building more energy-efficient and comfortable. SPF insulation is known to resist heat transfer extremely well, and offers a highly effective solution in reducing unwanted air infiltration through cracks, seams, and joints. SPF insulation has been used in new home construction in the United States for over 40 years and its use has increased at a rate of 10 to 15% per year from 2008 to 2018[2] due, in part, to more stringent energy efficiency requirements for the thermal envelope and consumers demanding more energy efficient homes. SPF is spray applied, on site, as a liquid that quickly reacts to form polyurethane foam. This unique application process allows SPF to adhere to the building substrate and expand to fill small gaps and cracks in the building envelope. SPF is unique because it is a highly efficient insulator and helps seal a home. Sealing a home reduces air infiltration making a home more energy efficient. The U.S. Department of Energy states that air leaks can waste up to 40% of the energy used to heat and cool a typical home.[3]

Because SPF is formed on-site, questions on the potential for chemical emissions and possible associated health risks are reasonable areas of inquiry for workers and building occupants. Further, homeowners are becoming increasingly interested in exposure to chemicals from products in their homes.

One of the most successful ways to manage exposure potential associated with SPF's application and indoor air quality post-application is to hire a trained professional to apply SPF according to the manufacturer's recommendation.

3. REENTRY AND REOCCUPANCY

SPF manufacturers recommend workers and building occupants to adhere to reentry and reoccupancy times in areas where their products are applied. These times are designed to provide for the safety of trade workers and building occupants.

Reentry Time is the time elapsed after the installation of SPF in a building when it is deemed safe for SPF applicators, helpers and other trade workers to enter the building and resume operations without the need for personal protective equipment (PPE).

Reoccupancy Time is the time elapsed after the installation of SPF insulation in a building when it is deemed safe for building occupants or residents to resume normal building operations and activities.

Industry practice emphasizes the importance of having unprotected trade workers adhere to the manufacturer recommended reentry time and ventilation process, and the general public or building occupants adhere to the manufacturer recommended reoccupancy guidance. Normally, reoccupancy times have building occupants wait a minimum of 24-hours after application of high pressure SPF to reoccupy the area, but recommendations may vary.[4] Reoccupancy times are generally most applicable to retrofit applications of SPF. Given that SPF is often installed in new construction significantly before the home is occupied, reoccupancy times are generally not as relevant for production building.

2 American Chemistry Council Spray Foam Coalition's Statistics Program. Available at: https://polyurethane.americanchemistry.com/Foam-Statistics/

3 Energy Star - Tight Construction. Retrieved March 20, 2019, from https://www.energystar.gov/index.cfm?c=new_homes_features.hm_f_reduced_air_infiltration

4 Reoccupancy Related to Spray Polyurethane Health and Safety. Retrieved March 20, 2019, from https://www.spraypolyurethane.org/reoccupancy/

4. BACKGROUND

SPF is formed by a reaction between two liquid components: polymeric methylene diphenyl diisocyanate (pMDI or MDI), commonly referred to as the "A-side" and a polyol blend commonly referenced to as the "B-side" mixed at a 1:1 ratio. The polyol blend is formulated by the product manufacturer and contains other key chemical components important to the product's performance, which can include surfactants, emulsifiers, blowing agents (only in closed cell SPF), catalysts, and a flame retardant. More information on the specific chemical components can be found on the product data sheet and safety data sheets provided by the product manufacturer.

At the work site, the "A-side" and "B-side" components are heated, mixed, and forced by pressure through a spray gun by specialized SPF equipment. The aerosols, vapors, and spray mist generated during the application process can potentially result in chemical exposure to the worker via inhalation (breathing) and skin or eye contact. SPF contractors are trained on the potential health impacts that may occur during and immediately following product application. In addition, the U.S. Occupational Safety and Health Administration (OSHA) recommends SPF contractors use ventilation and appropriate personal protective equipment, including but not limited to respirators, gloves, and coveralls to help control the potential for chemical exposure during and shortly after application. Although the liquid chemical components react quickly to form inert rigid foam insulation, the freshly sprayed foam will release various chemical emissions, which may produce an odor for a short period of time after application. The length of time that odors may be detected in the work area often depends on the amount and quality of on-site ventilation or air exchange in the work area, created by natural air movement and fans. Applying mechanical ventilation at prescribed levels has been found to reduce the chemical exposure time period significantly.[5]

To minimize exposure risks, it is important that: workers adhere to reentry recommendations; building occupants are not present on the job site during application; and building occupants do not return until after the manufacturer recommended reoccupancy time has elapsed.

5. SPF RESEARCH

CPI has spent the last decade researching SPF to help ensure workers and homeowners are appropriately informed of potential health and safety impacts associated with SPF insulation. During this time, CPI has provided regular updates to federal agencies as work progressed. The engagement between CPI and federal agencies resulted in a three tiered work plan that includes training, outreach, and research. CPI has sponsored four research projects evaluating SPF chemical emissions including:

The Ventilation Research Project

The Ventilation Research Project measured SPF emissions from three generic SPF formulations developed for research to determine if airborne concentrations of chemicals during high pressure and low pressure SPF application could be managed through engineering controls, such as ventilation. The study determined that increasing ventilation during application reduces airborne concentrations of SPF chemicals. However, it is difficult to effectively maintain airborne concentrations below occupational exposure limits by ventilation alone. Therefore, SPF applicators rely on both PPE and ventilation to reduce the potential for chemical exposure.

The Product Emissions Project

The Product Emissions Project focused on developing a standardized method to measure SPF emissions from freshly sprayed foam to set appropriate reoccupancy times for building occupants. This research resulted in the development of a suite of ASTM consensus standards that are used to prepare and to test cured SPF insulation samples using micro-scale environmental test chambers.

In 2017, ASTM published D8142, *Standard Test Method for Determining Chemical Emissions from Spray Polyurethane Foam (SPF) Insulation using Micro-Scale Environmental Test Chambers.*[6] This test method is to be used in conjunction with D7859, *Standard Practice for Spraying, Sampling, Packaging, and Test Specimen Preparation of Spray Polyurethane Foam (SPF) Insulation for Testing of Emissions Using Environmental Chambers.*[7]

5 Wood, R. (2014). CPI Ventilation Research Project for Estimating Re-Entry Times for Trade Workers Following Application of Three Generic Spray Polyurethane Foam Formulations (Tech.). Retrieved March 20, 2019, from https://polyurethane.americanchemistry.com/Products-Resources-and-Document-Library/CPI-Ventilation-Research-Project-for-Estimating-Re-Entry-Times-for-Trade-Workers-Following-Application-of-Three-Generic-SPF-Formulations.pdf

6 Standard Test Method for Determining Chemical Emissions from Spray Polyurethane Foam (SPF) Insulation using Micro-Scale Environmental Test Chambers. Available at: https://www.astm.org/Standards/D8142.htm

7 *Standard Practice for Spraying, Sampling, Packaging, and Test Specimen Preparation of Spray Polyurethane Foam (SPF) Insulation for Testing of Emissions Using Environmental Chambers.* Available at: https://www.astm.org/Standards/D7859.htm

The results from the CPI Product Emissions Project will allow researchers to generate emission rates for each chemical identified in the emissions profile. The chemical emission rates are then used in mathematical models for exposure assessment purposes. Work is on-going at ASTM to develop emission and fate models for SPF.[8]

Trade Worker Reentry Study

The purpose of the Trade Worker Reentry Study was to provide a method for generating air monitoring data that could be used to determine reentry times for trade workers (that is, workers not involved in SPF application) following SPF application.

During the project, air monitoring was conducted in a ventilated spray room to measure chemical emissions from the three generic SPF formulations beginning one hour after SPF application. Air sampling was then repeated periodically throughout a 12-hour period. The results showed that MDI reacts quickly and is not detected shortly after SPF application. However, some chemical components in the "B-side" or polyol blend may emit from the insulation product and should be evaluated to determine when it is appropriate for other trade workers to return to the work area. Chemical emissions from SPF insulation after application can vary depending on ventilation rates in the area where the SPF was applied and the SPF chemical formulation. Work is on-going at ASTM to develop a consensus standard, based on the large-scale emissions project.[9]

SPF Dust/MDI Study

A common task performed shortly after SPF application is trimming and cutting work to remove excess foam insulation that has expanded out beyond wall studs and could interfere with drywall installation. Trimming and cutting work can be conducted on both open-cell and closed-cell SPF insulation in interior applications. The SPF Dust Study evaluated dust levels and airborne MDI concentrations while using power tools (planer/wire brush and sander) and hand tools (hand saw and scrapers) to conduct trimming work. The study showed that use of certain tools can produce high levels of SPF dust/particulate requiring workers to wear respiratory protection. The study also concluded that MDI could not be detected in any of the personal or area air samples collected during trimming of 2-component open-cell and closed-cell foam insulation when trimming is conducted one hour or more after application of the product.[10]

8 New Practice for Conducting Emission and Fate Modeling for Spray Polyurethane Foam (SPF) Insulation in an Indoor Environment. Available at: https://www.astm.org/DATABASE.CART/WORKITEMS/WK58356.htm

9 New Test Method for Measuring Chemical Emissions from Spray Polyurethane Foam (SPF) Insulation Samples in a Large-Scale Spray Room. Available at: https://www.astm.org/DATABASE.CART/WORKITEMS/WK58354.htm

10 Spence, M., & Graham, C. (2010). Evaluation of Particulates Generated During Trimming and Cutting of Spray Polyurethane Foam Insulation (Tech.). Washington, DC: American Chemistry Council. Retrieved March 20, 2019, from https://polyurethane.americanchemistry.com/Resources-and-Document-Library/Evaluation-of-Particulates-Generated-During-Trimming-and-Cutting-of-Spray-Polyurethane-Foam-Insulat.pdf

6. HAZARDS OF SPF CHEMICALS

Identified hazards listed in the table below are associated with the primary SPF chemical components.

CHEMICAL	PURPOSE	POTENTIAL HAZARD*
Methylene diphenyl diisocyanate (MDI)	Polyurethane Building Block	Skin and respiratory tract irritation and sensitization
Amines	Catalyst	Irritation to the eyes, skin and respiratory tract. Some amines may also be skin and respiratory tract sensitizers
Tris(1-chloro-2-propyl) phosphate (TCPP)	Flame Retardant	Irritation to the skin and respiratory tract
Hydrofluorocarbon (HFC) or Hydrofluorolefin (HFO)	Blowing Agent	Irritation to the eyes, skin and respiratory tract

*See manufacturer safety data sheets for additional health effect information

Potential health effects may result if workers are exposed to SPF chemicals by skin contact or if airborne concentrations are in excess of occupational exposure limits (OELs). Worker exposure to SPF may occur as chemicals are handled during set-up and clean-up, SPF application, or in the event of a chemical spill.

Post-spray emissions from cured SPF have been shown to be generally very low, below concentrations anticipated to cause adverse health effects to workers. Specific information is included in sections 7 and 8. However, it is important to follow manufacturers' recommended reentry times to determine when it is safe for other trade workers to return to areas where SPF has just been applied without wearing PPE. It is also important for members of the general public to follow recommended reoccupancy times to determine when it is safe enter the work area after SPF application.

7. POTENTIAL WORKER EXPOSURE

Because application of SPF insulation involves the use of a spray gun, both chemical vapors and spray mist particles are a source of potential exposure for workers. The vapors and spray mist generated during spray application are an inhalation (breathing) and skin or eye contact hazard. MDI is typically the greatest concern during spray application for workers. It is essential that the applicator spraying foam wear personal protective equipment that includes chemical resistant gloves, full body disposable clothing, and respiratory protection. Although MDI has potential hazards, it reacts quickly with the polyol to form the polyurethane foam and is no longer present in its original form within the final product (similar to an egg not being present in a baked cake). Other chemicals such as the flame retardant, amine catalysts and blowing agents may also be present at elevated concentrations during application. Protective equipment used by the applicator for protection against the potential exposure of MDI will also help protect workers against the potential exposure to other SPF chemical components.

The U.S. Environmental Protection Agency's (EPA) *Ventilation Guidance for Spray Polyurethane Foam Application*[11] recommends general ventilation practices, such as opening doorways and windows, and the use of mechanical ventilation, such as exhaust fans or blowers, to lower concentrations of chemical emissions during SPF application. It is a good practice to continue to ventilate the SPF application area after installation of the product, while the SPF contractor may be conducting post clean-up activities. Many applicators will ventilate the area for at least 1 to 2 hours. Even with the use of ventilation control measures, it is important to restrict unprotected workers and other non-trade workers from entering the SPF work area during and after application until the prescribed reentry time.

8. POTENTIAL LONG TERM EXPOSURE TO BUILDING OCCUPANTS

The U.S. EPA has stated "completely cured [polyurethane] products are fully reacted and therefore are considered to be inert and non-toxic."[12] In addition, there is a reduced potential for exposure to occupants from SPF because it is generally found in spaces that homeowners do not access regularly— behind walls, in crawlspaces, and attics. As stated previously, MDI reacts quickly and research indicates it is not a long-term exposure concern. Some

11 Ventilation Guidance to Promote the Safe Use of Spray Polyurethane Foam (SPF) Insulation. Retrieved March 20, 2019, from https://www.epa.gov/saferchoice/ventilation-guidance-promote-safe-use-spray-polyurethane-foam-spf-insulation-incluyendo

12 Methylene Diphenyl Diisocyanate (MDI) And Related Compounds Action Plan [RIN 2070-ZA15] (Tech.). (2011). Washington, DC: U.S. Environmental Protection Agency. Retrieved March 20, 2019, from https://www.epa.gov/sites/production/files/2015-09/documents/mdi.pdf

additive chemicals, such as flame retardants, amine catalysts, and blowing agents may emit from the cured foam after application at measurable quantities, but will steadily decrease to non-detectable levels with time.

- Tris (1-chloro-2-propyl) phosphate (TCPP), a common flame retardant has been shown to emit in concentrations of 1 part per billion (ppb) (0.013 mg/m3) to 3 ppb (0.040 mg/m3) during the first 8 hours following application,[13] significantly below a level expected to cause harm. For comparison purposes, the European worker Derived No Effect Level (DNEL) for TCPP is 8.2 mg/m3 (612 ppb).[14] These concentrations are 200-600 times lower than the respective DNELs.

- Some amine catalysts are not totally reacted within the product after the application of SPF and therefore can emit from the foam over the course of several hours to days, depending on the vapor pressure of the amine catalyst and the type of spray foam. These catalyst emissions are often greater in open cell formulations where closed cell formulations trap the amine in the cellular structure of the foam. Once released to the atmosphere, several of the amines have an ammonia-like odor that may be detected at airborne concentrations below occupational exposure limits. Proper mechanical ventilation of freshly sprayed areas, or in the case of new home construction, natural ventilation, can address these odor concerns. Over the last several years, new reactive or non-emissive catalysts have been developed that are bound to the polyurethane polymer during the reaction and do not emit from the product.

- Hydrofluorocarbon or newer hydrofluoroolefin blowing agents used in closed cell SPF formulations help to form the polyurethane cells and raise the insulation qualities of the foam. Small amounts of these blowing agents can be emitted from cured foam over time. Blowing agents typically have toxicity profiles of low concern as well as recommended OELs in the range of 300 parts per million (ppm) to 800 ppm.[15] Concentrations of blowing agents used in high pressure formulations measured from one to eight hours following application typically range from approximately 2 ppm and decline to approximately 0.10 ppm.[16] These concentrations are 200-300 times lower than the respective OELs.

9. MISAPPLIED FOAM

SPF requires a 1:1 volume ratio of "A-side" and "B-side" chemicals. If the foam is applied off-ratio, the insulation product will not cure properly and unreacted chemicals may be emitted. Fortunately, high pressure spray equipment is available today that has been developed to automatically shut-down if the pressure drops or the 1:1 ratio is not maintained. SPF that is misapplied or off-ratio is often easy to detect by visual inspection. The choice of selecting a properly trained and experienced SPF applicator is very important since following proper procedures in SPF application is essential to avoid misapplication problems.

10. CONCLUSION

The use of trained professional applicators who employ proper workplace controls such as ventilation and PPE has been a successful component to controlling exposure risks. As part of a well-designed approach, other trade workers and homeowners remain well away from the SPF application work area during and for a period of time after SPF application. Trade workers should adhere to manufacturer recommended reentry times prior to reentering the SPF work area. Building occupants should adhere to the manufacturer recommended reoccupancy time prior to retuning to the SPF work area.

Airborne MDI concentrations have been shown through monitoring tests to be well within OELs shortly after SPF application. Other SPF components may emit at low airborne concentrations for a period of time after the product has been installed. With good ventilation practices, airborne concentrations of these other chemicals have been demonstrated to be below levels anticipated to cause concern to workers or building occupants.

Installing SPF in a home helps seal the structure and reduce airflow. Proper mechanical ventilation is needed to maintain a healthy living space and is key to sustained indoor air quality.

13 Wood, R. (2014). CPI Ventilation Research Project for Estimating Re-Entry Times for Trade Workers Following Application of Three Generic Spray Polyurethane Foam Formulations (Tech.). Retrieved March 20, 2019, from https://polyurethane.americanchemistry.com/Products-Resources-and-Document-Library/CPI-Ventilation-Research-Project-for-Estimating-Re-Entry-Times-for-Trade-Workers-Following-Application-of-Three-Generic-SPF-Formulations.pdf

14 European Chemicals Agency REACH Dossier on TCPP: https://echa.europa.eu/registration-dossier/-/registered-dossier/27081/7/1

15 OEL values for blowing agents are specific to each chemistry. Please contact the product manufacturer for specific values.

16 Wood, R. (2014). CPI Ventilation Research Project for Estimating Re-Entry Times for Trade Workers Following Application of Three Generic Spray Polyurethane Foam Formulations (Tech.). Retrieved March 20, 2019, from https://polyurethane.americanchemistry.com/Products-Resources-and-Document-Library/CPI-Ventilation-Research-Project-for-Estimating-Re-Entry-Times-for-Trade-Workers-Following-Application-of-Three-Generic-SPF-Formulations.pdf