

EnviroSeal

by Quadrant

Validated Safety

A Comprehensive Chemical Emission Analysis of
EnviroSeal Insulation



Contents

1. Executive Summary.....	3
2. Introduction	4
3. Chemical Composition and Application Process	5
3.1 Component A: Isocyanate.....	5
3.2 Component B: Polyol Resin Blend.....	6
3.3 Application and Curing Dynamics.....	6
3.3.1 Greenguard Certification.....	8
3.4 VOC Emission Profiles During Application.....	8
3.5 Isocyanate Emissions and Their Control.....	9
4. Chemical Emissions Characterization in Field Studies and Real-World Installations	10
4.1 MDI.....	10
4.1.1 Sampling Methodology Overview	11
4.1.2 Analytes & Method.....	12
4.1.3 Test Setup	13
4.1.4 Residential Installation Simulation – Active Ventilation	15
4.1.5 Residential Installation Simulation – No Ventilation.....	19
4.1.6 Chemical Spill Simulation	19
4.1.7 MDI Airborne Emissions Discussion	21
4.2 Volatile Organic Compound Analysis.....	22
4.2.1 Study Methodology	24
4.2.2 Results.....	27
4.2.3 VOC Analysis Discussion.....	34
5. Summary.....	36

1. Executive Summary

Spray foam insulation continues to gain widespread adoption across residential, commercial, and industrial markets due to its superior air-sealing performance, high R-value, and contribution to long-term energy efficiency. As application volumes increase to meet evolving building code energy efficiency requirements, concerns have also grown regarding trade workers and occupant safety, particularly the risk of exposure to hazardous substances such as isocyanates or volatile organic compounds (VOCs).

This white paper presents a comprehensive analysis of chemical emissions associated with spray foam application, incorporating laboratory studies, field measurements, and rigorous comparisons to established indoor air quality standards. The findings demonstrate that the EnviroSeal spray foam insulation formulations pose no measurable health risk to trade workers and building occupants when installed according to manufacturer guidelines.

- Airborne MDI concentrations remain far below the OSHA legal airborne permissible exposure limit (PEL) even without ventilation while the spraying is occurring
- All VOC concentrations meet GREENGUARD Gold program criteria within 4-hours post application.

EnviroSeal spray foam insulation cures into an inert, odorless material through a highly efficient chemical reaction that incorporates nearly all raw components into the finished foam. Any VOCs detected shortly after installation are minor byproducts of unintended side reactions associated with the high-pressure application process rather than constituents or impurities of the product itself. Using ultra-low-VOC catalyst technology and high-purity raw materials, EnviroSeal is specifically designed to minimize these emissions as the foam rapidly cures. When installed in accordance with recommended ventilation and re-entry guidelines, emissions decrease quickly and do not present a detectable risk to trade workers or building occupants, as supported by the data and methodology presented in this report.

2. Introduction

Spray foam insulation has become one of the fastest-growing building materials in both residential and commercial construction. Its ability to create an airtight, energy-efficient building envelope has driven widespread adoption, supported by rising energy costs, stricter building codes, and the expanding focus on sustainable construction practices. In the U.S. market, adoption rates are especially strong—over 54% of new homes and 49% of commercial buildings now incorporate some type of spray foam insulation, with retrofit usage increasing by 41% across major metro areas.

Retrofit applications in particular have emerged as one of the strongest drivers of market expansion. Across both residential and commercial sectors, spray foam is being used to upgrade older buildings to modern energy-efficiency standards without major structural changes. Industry data shows that retrofit and renovation projects have become a key adoption trend, as property owners seek improved thermal performance, reduced energy costs, and better indoor comfort with minimal disruption. Manufacturers and analysts report that retrofitting older buildings with spray foam has grown significantly, with one global market assessment noting a 24% increase in spray-foam retrofits between 2021 and 2023. Additionally, spray foam's performance is especially valued in hard-to-reach cavities and irregular building geometries, making it an ideal solution for retrofit applications where traditional insulation cannot be effectively installed.

Despite the energy efficient benefits some homeowners, builders, and manufacturers of competitive forms of insulation products raise concerns about the chemicals involved and the possible chemical emissions during spray foam applications. These concerns typically center on the presence of reactive components—such as isocyanates—and whether their use poses a risk of hazardous chemical exposure. Additional fears often involve lingering odors, off-gassing beyond the curing period, or potential respiratory irritation following installation.

Some of these concerns stem from inconsistent installation practices in the field, while others are amplified by online anecdotes rather than scientific data.

Meanwhile, the industry's expansion reflects increasing confidence in the material's performance and safety, supported by continued improvements in formulation chemistry. Manufacturers are rapidly adopting low-VOC technology and advancements in installation equipment continually monitor and actively prevent installation errors.

With these recent advancements, this white paper directly addresses the questions surrounding other trade worker isocyanate exposure and the chemical emissions of EnviroSeal spray foam insulation products manufactured by Quadrant Performance Materials. This paper presents controlled laboratory data, field measurement results, and comparisons to established indoor air quality standards. The sections that follow will detail the research methodology, chemical emission profiles, and validated safety conclusions—providing clarity for decision-makers seeking high-performance, low-risk insulation solutions.

3. Chemical Composition and Application Process

Spray foam insulation is produced through an on-site chemical reaction between two primary liquid components—commonly referred to as Component A and Component B—that combine at the spray gun and expand into a rigid or semi-rigid cellular foam. Each component serves distinct chemical and functional roles:

3.1 Component A: Isocyanate

Component A typically consists of methylene diphenyl diisocyanate (MDI) or a blend of MDI isomers and derivatives. Isocyanates are highly reactive compounds that drive the polymerization process that creates polyurethane foam. Key characteristics include:

- **Reactivity:** MDI reacts rapidly with polyols to form polyurethane linkages, generating the foam structure.
- **Safety Considerations:** MDI (Methylene Diphenyl Diisocyanate) exposure primarily poses significant risks to the respiratory system and skin, acting as a potent sensitizer. Inhalation of vapors or aerosols can cause asthma,

severe chest tightness, and, in rare cases, fatal reactions. Once sensitized, even minute future exposures can trigger severe, potentially permanent allergic reactions and chronic breathing issues. Although isocyanates are potent respiratory sensitizers in their uncured form, they transform during the curing process and become chemically bound into a stable polymer matrix.

3.2 Component B: Polyol Resin Blend

Component B is a carefully formulated mixture of various ingredients that each play an important function in the forming of the final foamed plastic structure. Modern formulations increasingly incorporate low GWP blowing agents, bio, and low VOC additive packages to reduce environmental impact and improve indoor air quality.

Polyol Resin Blend

- Blend of:
 - Polyols – Provide the backbone for the polyurethane polymer.
 - Catalysts – Accelerate reaction rates between isocyanates and polyols.
 - Blowing Agents – Produce gas that expands the foam.
 - Surfactants – Control cell structure and foam stability.
 - Fire Retardants – Assist the foam in meeting code required fire performance standards.
- Reactivity: Only reacts with A-side chemicals
- Safety Considerations: Potential for skin sensitization, eye irritation, and respiratory irritation.

3.3 Application and Curing Dynamics

When Components A and B combine at the spray gun, several simultaneous chemical reactions occur. Professional spray foam systems rely on high-pressure plural-component equipment, which ensures precise mixing ratios, temperature control, and atomization for faster reaction and more efficient mixing.

Atomized isocyanates pose a far greater health hazard than their liquid or solid forms because the spraying process creates fine aerosol droplets that are easily inhaled, allowing them to penetrate deep into the lungs where they are rapidly absorbed. These tiny particles can bypass the body's natural respiratory defenses, leading to immediate sensitization and potentially irreversible respiratory illness.

Because chemical reactions produce temporary airborne by-products ventilation strategies such as mechanical exhaust, cross-flow ventilation, temporary negative-pressure zones are recommended during and after application until the foam reaches a stable cure.

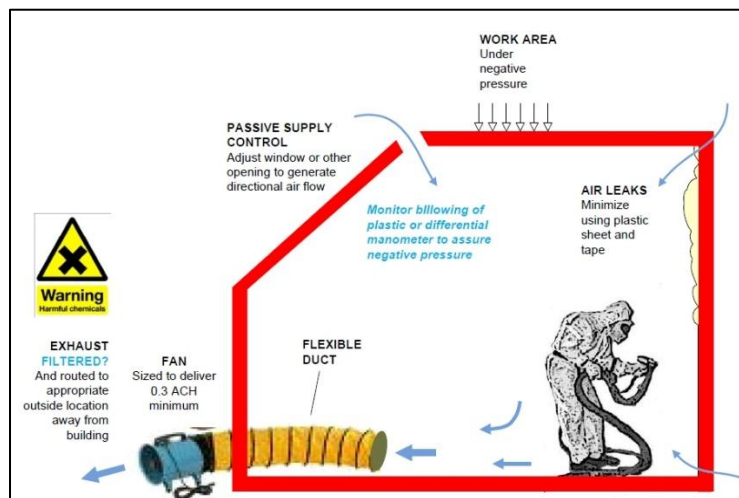


Figure 1: Ventilation recommendations during SPF installation

Once installed, the foam undergoes a rapid curing phase during which reactive isocyanates become fully polymerized and VOC concentrations drop sharply to baseline levels. Well-designed formulations and proper application practices ensure that the transition from reactive liquid components to fully stable polyurethane occurs efficiently. When these conditions are met, the resulting cured foam is chemically inert, does not off-gas hazardous chemicals, and maintains long-term stability without degradation under normal building conditions.

3.3.1 GREENGUARD Certification

The UL GREENGUARD program certifies products for low chemical emissions, ensuring they contribute to healthier indoor air quality by testing for Volatile Organic Compounds (VOCs) and other pollutants, with GREENGUARD Gold offering even stricter standards for sensitive environments like schools and healthcare facilities. Administered by UL Solutions, it helps consumers identify products like furniture, building materials, and flooring that meet rigorous criteria for supporting well-being, reducing indoor air pollution, and offering an advantage in sustainable building.

Some spray foam insulation products exploit non-emissive catalyst technology to meet or exceed the UL GREENGUARD and GREENGUARD Gold program requirements further substantiating the inert quality and VOC emission profile of cured spray foam insulation.

3.4 VOC Emission Profiles During Application

During installation of spray polyurethane foam (SPF), emissions originate primarily from the chemical reactions that occur as Components A (isocyanate system) and B (polyol resin blend) mix, atomize, expand, and cure. These emissions consist of:

- Unreacted isocyanates (present only during the early application window)
- Amines, catalysts, and low-volatility additives that may volatilize in trace amounts
- Blowing-agent vapors released during cell formation
- Transient volatile organic compounds (VOCs) formed as intermediates during polymerization
- Water vapor and CO₂ gas produced by the blowing reaction
- Side-reactions that generate new volatile compounds

Understanding the timing, magnitude, and decay of these emissions is essential for clarifying occupant-safety considerations and aligning installation practices with recognized indoor air quality principles.

Professional emission studies typically evaluate spray foam off-gassing using a combination of controlled environmental chamber testing, on-site field measurements, and time-resolved air sampling techniques. These studies show that emissions are transient and diminish rapidly as the foam stabilizes.

Immediately following application, VOC concentrations exhibit a short-lived rise due in the first 20–40 minutes post-application, that coincides with the highest exothermic activity. As the foam transitions from a reactive liquid into a solid polyurethane matrix:

- VOCs drop sharply as polymerization completes
- Blowing agents become trapped within closed-cell structures or dissipate quickly in open-cell foams
- Reactive by-products convert into non-volatile polymer structures

The majority of measurable VOCs typically decline within one to four hours after application, depending on the formulation. As the foam reaches full cure emissions stabilize at levels comparable to baseline indoor air. At this point, polymerization is complete, any remaining emission potential is negligible, and the cured foam behaves as an inert, dimensionally stable polymer. This stabilization represents the long-term indoor air quality condition of the building.

3.5 Isocyanate Emissions and Their Control

Isocyanates do not remain free or airborne once polymerization begins, as their high reactivity causes them to rapidly bind with polyols or atmospheric water vapor. As a result, the presence of airborne isocyanates is limited to the spraying period, the immediate vicinity of the spray plume, and surfaces receiving overspray prior to cure. These characteristics highlight that potential exposure concerns are primarily associated with installers rather than building occupants. To mitigate exposure during application, industry-standard controls include the use of full respiratory protection for installers, implementation of

engineered ventilation within the application space, and restriction of access until the foam completes its initial cure. Following polymerization, free isocyanates are no longer present in the cured foam material.

4. Chemical Emissions Characterization in Field Studies and Real-World Installations

This section describes the air-monitoring program conducted to evaluate potential airborne methylene diphenyl diisocyanate (MDI) concentrations associated with spray foam application and volatile organic compounds under typical residential-type installation conditions. The following subsections outline the monitoring scenarios, sampling methodology, and assumptions used to characterize potential residential exposure conditions.

4.1 MDI

Air monitoring was conducted to evaluate potential airborne methylene diphenyl diisocyanate (MDI) concentrations associated with spraying operations and a simulated spill event under conditions intended to replicate spraying activities in a residential home environment. The sampling program was designed to represent realistic residential scenarios where ventilation may be limited, intermittent, or absent, and where emissions may persist after spraying activities have ceased.

Monitoring was performed under three controlled scenarios:

- Spraying operations with ventilation **on**
- Spraying operations with ventilation **off**
- A simulated MDI spill under unventilated conditions

The study evaluated background conditions, active spraying emissions, and the persistence and decay of airborne MDI following completion of spraying or spill cleanup. Sampling times, intervals, and conditions were selected to reflect residential use patterns, including delayed re-entry and limited mechanical air movement.

4.1.1 Sampling Methodology Overview

To simulate realistic residential conditions and evaluate potential worst-case accumulation, all sampling inlets were positioned no higher than 12 inches above the ground. This near-floor sampling strategy was selected as a conservative approach appropriate for residential environments, where MDI vapors, aerosols, and reaction byproducts may be heavier than air or may temporarily accumulate near floor surfaces in enclosed spaces with limited air movement. The sampling pump and tubing were elevated off the floor using a 5-gallon bucket solely as a support platform to prevent contact with the ground surface while maintaining consistent inlet height; the bucket did not restrict airflow or interfere with sample collection.

The testing scenarios were intentionally designed to replicate residential spray foam application conditions, where factors such as room size, airflow limitations, and delayed ventilation are commonly encountered. Spraying durations, ventilation on/off conditions, and post-application sampling intervals reflected realistic residential use patterns, including continuous spraying for approximately two hours, limited or absent mechanical ventilation to simulate homes without active exhaust systems, and extended post-application monitoring periods of up to 24 hours to assess airborne persistence during typical residential occupancy and re-entry timeframes. A spill simulation was also included to represent a plausible residential incident involving accidental release and cleanup of MDI on interior surfaces.

Near-floor sampling additionally reflects potential occupant exposure scenarios during re-entry, cleanup, or residential activities involving seated or kneeling positions. Consistent sampler placement across all tests ensured comparability between ventilated and unventilated conditions and supported evaluation of concentration decay under realistic residential air-exchange conditions. The combined use of background samples, field blanks, and staggered post-activity sampling intervals supports data quality objectives and allows differentiation between ambient conditions, active emissions, and residual airborne concentrations following spray application or spill cleanup.

4.1.2 Analytes & Method

Air monitoring targeted MDI using Supelco ASSET EZ4-NCO samplers analyzed by ALS Global using the ALS-Supelco analytical method. All samples were collected using calibrated air sampling pumps operated at a flow rate of 200 mL/min with a 15-minute sampling duration per sample.

Background samples and field blanks were collected to establish baseline conditions and assess potential contamination of sampling media. Chain-of-custody procedures were maintained for all samples, including sample identification, media type, and analytical method.

- Analytes: MDI
- Analytical Method: ALS-Supelco Method
- Collection Media: Supelco ASSET EZ4-NCO Sampler
- Testing Laboratory: ALS Global, 960 W. LeVoy Drive, Salt Lake City, Utah 84123

Air samples for isocyanates were collected using ASSET™ EZ4-NCO dry samplers designed to capture both vapor-phase and particulate isocyanates during sampling. The samplers employ a dibutylamine (DBA)-impregnated denuder and filter to derivatize isocyanates in situ (Figure 2), enabling collection of monomeric and oligomeric forms without the need for field extraction or additional reagents. Samples were stored and transported under ambient conditions in accordance with the analytical method until laboratory analysis.

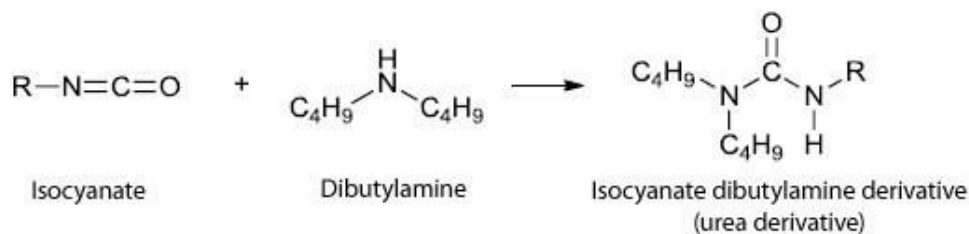


Figure 2: In-situ derivatization of isocyanate for sample collection

4.1.3 Test Setup

The MDI air analysis was conducted in a 3,000-cu. ft polyethylene tent that was sealed to the floor to minimize air leakage. The tent volume and amount of foam sprayed in each test condition was selected to replicate a typical attic installation of foam usage. Each test setup used 1.71 bdft of EnviroSeal OC Platinum per cubic foot of volume.



Figure 3: EnviroSeal OC Platinum A-side and B-side drum labels



Figure 4: MDI Emissions Testing Set Up

4.1.3.1 Limitations and Assumptions

This sampling program was conducted to represent controlled residential-type scenarios and includes the following assumptions and limitations:

- Results are representative only of the specific materials, application methods, durations, and environmental conditions evaluated during testing.
- Near-floor sampling was selected to assess potential worst-case accumulation and may not directly represent breathing-zone exposures for standing adults.
- Residential airflow conditions vary widely; actual homes may experience different dilution rates depending on room geometry, leakage, HVAC operation, and occupant behavior.
- Sampling durations assume concentrations during each interval were reasonably stable and representative of that period.
- Analytical results are dependent on laboratory detection limits, media performance, and proper sample handling as documented through chain-of-custody records.

Despite these limitations, the sampling design provides a conservative and structured assessment of airborne MDI behavior under conditions intended to replicate residential spraying and spill scenarios, offering meaningful insight into potential exposure persistence following application.

4.1.4 Residential Installation Simulation – Active Ventilation

Objective: Evaluate airborne MDI concentrations during spraying operations with ventilation active.

Proper ventilation during spray foam insulation installation is critical for managing airborne chemicals, protecting workers, and ensuring safe re-entry for occupants. Recommended practice includes providing at least 10 air changes per hour (ACH) during application to effectively dilute and remove vapors, using cross-ventilation combined with negative pressure to direct fumes away from the work area and exhaust them to a secure outdoor space. Ventilation should continue for at least one hour after spraying at the same minimum rate to ensure remaining vapors dissipate fully. In addition, job sites should be isolated to keep bystanders and occupants out of the work zone, and contractors should clearly communicate ventilation plans and safe

re-occupancy times in accordance with EPA guidance¹ and manufacturer safety instructions.

4.1.4.1 Test Conditions

EnviroSeal OC Platinum was continuously applied to cardboard panels for 1-hour to saturate the air to replicate an attic application in new residential construction. The tent was actively ventilated during application at 10 ACH. A sample was taken at the 1-hour mark. Spraying continued for an additional hour then ceased. Samples were collected at 15 mins, 30-mins- and 60 mins post application. Ventilation was then turned off and samples were collected at the 1-hour, 2-hour-0 and 4-hour periods. Stopping ventilation 1 hour after spraying is designed to replicate the spray foam installers packing up ventilation equipment after the application is complete and to replicate typical reentry and re-occupancy recommendations.



¹ U.S. EPA Working Draft 01-22-2015. For more information, visit http://www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html



Figure 5: EnviroSeal OC Platinum Application with Active Ventilation

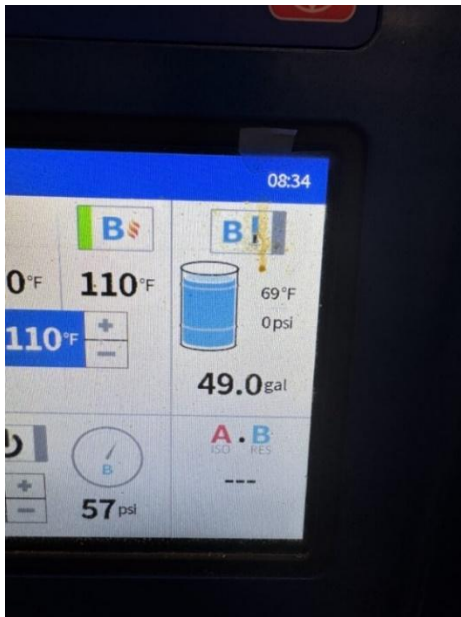


Figure 6: Proportioner Screen showing 22.0 gallons of EnviroSeal OC Platinum used



Figure 7: Image showing the quantity of EnviroSeal OC Platinum used in each study

4.1.4.2 Results

Table 1 summarizes the measured MDI air concentrations with active ventilation during and after the spray foam application.

Table 1: Results of MDI Analysis with Active Ventilation

Date	Time	Sample ID	Sample Description	MDI Result ($\mu\text{g}/\text{sample}$)
11/4/2025	9:00 AM	1.1-FB	Field Blank	< 0.021
Spraying Starts for 1-hour - Ventilation On				
11/4/2025	10:40 AM	1.2	1 hour in spray	1.2 (or 0.012 ppm)
Spraying Continues for 1-hour & Stops - Ventilation On				
11/4/2025	11:35 AM	1.3	15 mins after spray stops	< 0.021
11/4/2025	11:50 AM	1.4	30 mins after spray stops	< 0.021
11/4/2025	12:20 PM	1.5	60 mins after spray stops	< 0.021
Ventilation Off				
11/4/2025	1:35 PM	1.6	60 mins	< 0.021
11/4/2025	2:35 PM	1.7	120 mins	< 0.021
11/4/2025	4:35 PM	1.8	240 mins	< 0.021

4.1.5 Residential Installation Simulation – No Ventilation

Objective: Evaluate airborne MDI concentrations during spraying operations with no active ventilation.

4.1.5.1 Test Conditions

The same test procedure and conditions were repeated with EnviroSeal Open Cell Platinum but with no ventilation during the initial air saturation period or for the 24-hours after application ceased.

4.1.5.2 Results

Table 2 summarizes the measured MDI air concentrations with active ventilation during and after the spray foam application.

Table 2: Results of MDI Analysis with No Ventilation

Date	Time	Sample ID	Sample Description	MDI Result (µg/sample)
11/5/2025	8:50 AM	2.0 - B	Background	< 0.021
11/5/2025	9:05 AM	2.1 - FB	Field Blank	< 0.021
Spraying Starts for 1-hour - Ventilation Off				
11/5/2025	10:30 AM	2.2	1 hour in spray	1.3 (or 0.013 ppm)
Spraying Continues for 1-hour & Stops - Ventilation Off				
11/5/2025	11:10 AM	2.3	15 mins after spray stops	< 0.021
11/5/2025	11:40 PM	2.4	30 mins after spray stops	< 0.021
11/5/2025	12:10 PM	2.5	60 mins after spray stops	< 0.021
11/5/2025	1:10 PM	2.6	120 mins after spray stops	< 0.021
11/5/2025	3:10 PM	2.7	240 mins after spray stops	< 0.021
11/6/2025	11:10 AM	2.8	1,440 mins after spray stops	< 0.021

4.1.6 Chemical Spill Simulation

Objective: Evaluate airborne MDI concentrations in the event of a chemical spill.

4.1.6.1 Test Conditions

MDI was poured onto a sheet of plywood and allowed to linger for 30 mins. Sample collection devices were placed a few inches above the liquid and slightly above the plywood surface 24 hours after the spill was remediated.



Figure 8: Chemical Spill Simulation prior to and after spill



Figure 9: Chemical Spill Simulation cleanup and post cleanup

4.1.6.2 Results

Table 3 summarizes the measured MDI air concentrations with active ventilation during and after the spray foam application.

Table 3: Results of MDI Analysis for Chemical Spill Simulation

Date	Time	Sample ID	Sample Description	MDI Result (µg/sample)
11/5/2025	9:00 AM	3.0 - B	Background	0.034
11/5/2025	9:05 AM	3.1 - FB	Field Blank	0.022
Spill Initiated				
11/5/2025	9:30 AM	3.2	Immediately After Spill	< 0.021
Spill Cleaned				
11/5/2025	10:15 AM	3.3	15 mins after cleanup	< 0.021
11/5/2025	10:30 PM	3.4	30 mins after cleanup	< 0.021
11/5/2025	11:00 PM	3.5	60 mins after cleanup	< 0.021
11/5/2025	12:00 PM	3.6	120 mins after cleanup	< 0.021
11/5/2025	2:00 PM	3.7	240 mins after cleanup	< 0.021
11/6/2025	10:00 AM	3.8	1,440 mins after cleanup	< 0.021

4.1.7 MDI Airborne Emissions Discussion

The OSHA Permissible Exposure Limit (PEL) for Methylene Bisphenyl Diisocyanate (MDI) is a 0.02 ppm Ceiling limit, meaning it shouldn't be exceeded at any time, with a corresponding value of 0.2 mg/m³, to protect workers from respiratory irritation, sensitization, and potential cancer risks, though NIOSH recommends lower limits for longer exposures.

The National Institute for Occupational Safety and Health (NIOSH) recommends a lower Time-Weighted Average (TWA) of 0.005 ppm (0.05 mg/m³) and a 10-minute ceiling of 0.02 ppm (0.2 mg/m³).

MDI (Methylene Diphenyl Diisocyanate) reacts rapidly and vigorously with water, a process called hydrolysis, forming inert, solid polyurea and releasing carbon dioxide gas, which can build pressure in closed containers, with reactions speeding up at higher temperatures. While overall removal from water is fast (minutes to hours, forming solids), the initial reaction rate depends heavily on conditions, becoming very fast with catalysts or heat and slow in pure water, sinking and reacting at the interface.

Atomized Methylene Diphenyl Diisocyanate (MDI) reacts extremely rapidly with water, typically within a few minutes to a few hours, to form

polyurea solids and carbon dioxide. In homogeneous conditions, the half-life of MDI in water is roughly 11 seconds at room temperature.

All three scenarios evaluated in this study confirm that airborne MDI concentrations remain far below the OSHA legal airborne permissible exposure limit (PEL) even without ventilation. The highest airborne MDI concentrations occurs during the application of the spray foam insulation but then reacts quickly with water to form the inert hydrolyzed byproduct.

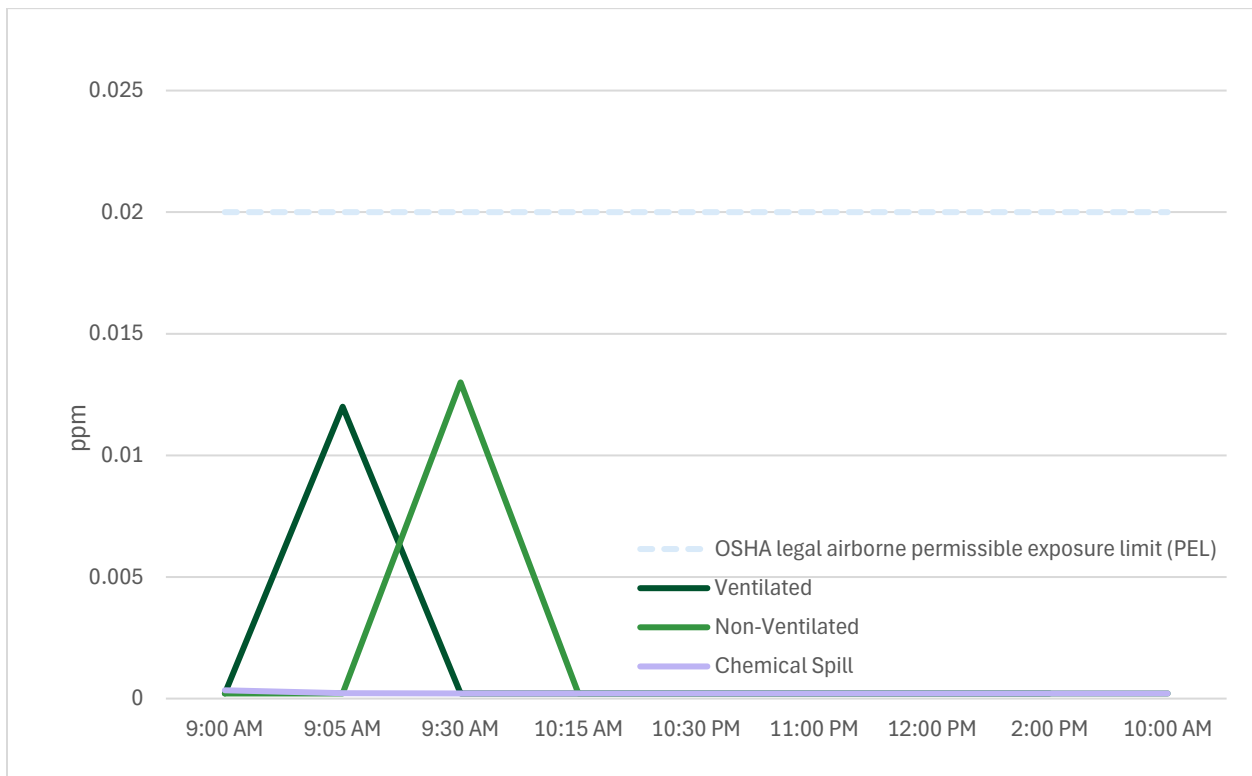


Figure 10: Summary of Airborne MDI analysis compared to OSHA Legal exposure limits

4.2 Volatile Organic Compound Analysis

Volatile Organic Compounds (VOCs) are carbon-based chemicals that easily evaporate into the air at room temperature. They are emitted as gases from many common solids and liquids, including paints, cleaners, adhesives, perfumes, building materials, and new furniture. VOCs are a major component of indoor air pollution, often found at higher concentrations indoors than outdoors, and some of which may have short- and long-term adverse health

effects. The ability of specific VOCs to cause health effects varies greatly. Some VOCs are highly toxic, while many may have no known health effect. As with other chemical exposures, the extent and nature of any health effect depends on many factors, including the chemical’s specific toxicity, its concentration in the environment, and the length of exposure time. It is very common to find trace levels of VOCs in nearly in every environment and outdoors. It is also well known that all humans naturally emit a variety of VOCs because of our bodies’ metabolic processes.

GREENGUARD Gold Certification is a premier, third-party standard ensuring products, especially furniture and materials for schools and healthcare—have very low VOC emissions to improve indoor air quality. It is stricter than standard GREENGUARD, testing for over 10,000 chemicals, including lower formaldehyde limits, making it safer for children and sensitive individuals. EnviroSeal products meet or exceed the green guard gold program requirements.

Table 4: EnviroSeal OC Platinum GREENGUARD Gold Validation

Criteria	Maximum Allowable Concentration	EnviroSeal OC Platinum
Total Volatile Organic Compounds	0.22 mg/m ³	0.021 mg/m ³
Individual VOCS	all ≤ 1/10 TLV	All ≤ 1/10 TLV
Formaldehyde	9 µg/m ³	3 µg/m ³
Total Aldehydes	0.043 ppm	0.003 ppm
4-Phenylcyclohexene	6.5 µg/m ³	Below quantifiable level
1-Methyl-2-pyrrolidone	160 µg/m ³	< 1 µg/m ³

OEHHA CREL = California Office of Environmental Health Hazard Assessment

Chronic Reference Exposure Level

ACGIH TLV = American Conference of Governmental Industrial Hygienists

Threshold Limit Values

4-Phenylcyclohexene, is associated with new carpet installation

The GREENGUARD Gold Certification annually validates the low VOC nature of finished products. This study, however, investigates the same airborne emissions but with the focus on potential airborne exposure risks to the installers and other trade workers immediately post-installation.

4.2.1 Study Methodology

The study was conducted at a single-family residence under construction in Riverside, California.

At the time of sampling, the home consisted of a concrete slab-on-grade foundation with wood framing and roofing installed. Exterior stucco, interior drywall, windows, and exterior and interior doors had not yet been installed, which is typical at the stage when spray foam insulation is applied. As a result, the structure was well-ventilated during foam application and for several days thereafter.



Figure 11: Representative home used in the real-world VOC analysis

The residence was a two-story structure (3 bed, 2 baths, 1,919 sqft). All samples were collected at a central location on the second floor, directly below the area where spray foam was applied to the underside of the roof. One set of each sample type was collected at the following intervals:

- Prior to foam installation
- 1 hour post-installation
- 2 hours post-installation
- 4 hours post-installation

Each sampling interval lasted 15 minutes, except for volatile organic compound (VOC) samples, which were collected as grab samples.

One set of outdoor background samples was collected for VOCs and particulate matter to establish baseline conditions; these samples were collected over approximately 8 hours. Outdoor background sampling was not conducted for aldehydes or 1-methyl-2-pyrrolidone, as their presence in ambient outdoor air would be atypical.

All indoor samples were collected at least two feet above the floor and were obtained by an ABIH-Certified Industrial Hygienist in accordance with standard industrial hygiene practices.

Volatile Organic Compounds

GHSC conducted air sampling for volatile organic compounds (VOCs) using EPA Method TO-15, a highly sensitive laboratory analysis commonly used in indoor air quality studies. Air samples were collected in non-reactive SUMMA canisters and analyzed by gas chromatography/mass spectrometry (GC/MS) to identify and quantify more than 60 common VOCs, as well as to tentatively identify additional compounds detected. EPA Method TO-15 provides high sensitivity and low analytical interference, offering a comprehensive assessment of VOCs present in the sampled environment. For this project, pre-calibrated flow controllers were used to collect integrated air samples over approximately eight hours.

L.A. Testing of Huntington Beach, California provided the SUMMA canisters and flow controllers and performed the EPA Method TO-15 laboratory analysis. The laboratory holds accreditation from the American Industrial Hygiene Association (AIHA) and the National Environmental Laboratory Accreditation Program (NELAP) for the analysis of environmental air samples.

After completing on-site sampling activities, GHSC personnel hand-delivered the filled TO-15 SUMMA canisters to L.A. Testing the following day in accordance with established chain-of-custody procedures.

Aldehydes

GHSC conducted aldehyde sampling in accordance with National Institute for Occupational Safety and Health (NIOSH) Method 2016. This method uses a glass sorbent tube containing silica gel coated with 2,4-dinitrophenylhydrazine, through which GHSC personnel actively drew air using calibrated SKC XR5000 personal sampling pumps. GHSC calibrated the pumps before and after sampling with a BIOS Defender 510 calibrator that met the manufacturer's annual calibration requirements. GHSC maintained the sample media and collected samples under chilled conditions at all times except during active sampling, as required by the method. Following sample collection, GHSC transported the chilled samples the next day to L.A. Testing of Huntington Beach, California, an American Industrial Hygiene Association-certified laboratory, using proper chain-of-custody procedures. The laboratory desorbed the samples with acetonitrile and analyzed them using high-performance liquid chromatography to quantify aldehyde concentrations, with a one-week analytical turnaround time requested by the Client.

1-Methyl-2-pyrrolidone

GHSC measured n-methyl-2-pyrrolidone in air using NIOSH Method 1302, which employs activated-carbon sorbent tubes and calibrated SKC XR5000 personal sampling pumps. GHSC calibrated the pumps before and after sampling with a BIOS Defender 510 within the manufacturer's recommended calibration period and maintained all samples under chilled conditions except during active sampling, as required by the method. After field activities, GHSC shipped the samples under appropriate chain-of-custody procedures via overnight chilled delivery to Galson Laboratories in East Syracuse, New York, an AIHA-certified laboratory, where the samples were desorbed with methylene chloride and methanol and analyzed by gas chromatography to quantify n-methyl-2-pyrrolidone concentrations.

Respirable Dust

For this assessment, GHSC utilized DustTrak aerosol monitors, direct-reading instruments manufactured by TSI Inc. in Shoreview, Minnesota. The DustTrak is a portable, battery-powered laser photometer designed to measure and log

airborne particulate concentrations in real time. Collected data are stored internally and later downloaded for review and analysis using TSI TrakPro software. The instruments are factory-calibrated for respirable particulate matter representative of typical ambient aerosols. GHSC owns the DustTrak monitors used for this study, and all units were calibrated in accordance with the manufacturer’s recommended schedule and field-zeroed prior to deployment.

4.2.2 Results

This section describes the results of the air-monitoring program conducted to evaluate potential volatile organic compounds.

4.2.2.1 Volatile Organic Compounds

Total VOCs are a good measure of general indoor air quality with respect to the amount of volatile organic chemicals that are present.

Table 5: Total VOC Concentration

Time Period	Results (mg/m ³)
Outdoors Baseline	0.067
Prior to application	0.100
1 hour after application	0.210
2 hours after application	0.240
4 hours after application	0.120
GREENGUARD Threshold	0.220

The California Department of Health Services (DHS) Indoor Air Quality Section has issued guidance indicating that total VOC concentrations below 0.5 mg/m³ may be characterized as “clean,” while concentrations between 0.5 mg/m³ and 1.5 mg/m³ may be described as “less clean.” DHS further advises that total VOC levels exceeding 1.5 mg/m³ warrant further evaluation to identify and mitigate potential emission sources. These values represent guidance levels only and do not constitute enforceable exposure limits, as Cal/OSHA has not established an occupational exposure standard for total VOCs.

All measured concentrations during this study fell within the range DHS considers “clean” and were also below the GREENGUARD guideline of 0.22 mg/m³. VOC concentrations appeared to reach a maximum approximately two hours following foam application before declining thereafter.

Table 6: Five Highest Identified Concentrations vs. Cal-OSHA PELs and GREENGUARD

	Chemical	Result (ppm)	Cal-OSHA PEL (ppm)	Percent of PEL	GREENGUARD Guideline (ppm)	Percent of GREENGUARD
Outdoor Baseline	Acetone	0.014	500	< 0.01	2.5	0.56
	Ethanol	0.003	1000	< 0.01	10 ¹	0.03
	Isopropyl Alcohol	0.003	400	< 0.01	1.42	0.21
	Acetic Acid, 2-ethylhexyl ester	0.002	-	-	-	-
	Methyl Ethyl Ketone	0.001	200	2.20	2.20	0.05
Prior to Foaming	Acetone	0.012	500	2.5	2.5	0.48
	Pentane	0.007	800	10	10	1.07
	Acetonitrile	0.005	40	0.020	0.020	25
	Ethanol	0.004	1000	10 ¹	10 ¹	0.04
	Alpha Pinene	0.003	-	-	-	-
1 Hour after Foaming	Acetonitrile	0.026	40	0.07	0.020	130
	Iso-butane	0.013	600	< 0.01	10 ¹	0.13
	Acetone	0.011	500	< 0.01	2.5	0.44
	Toluene	0.006	10	0.06	0.21	2.85
	Pentane	0.005	800	< 0.01	10	0.05
2 Hours after Foaming	Acetonitrile	0.047	40	0.12	0.020	235
	Acetone	0.013	500	< 0.01	2.5	0.52
	Pentane	0.007	800	< 0.01	10	0.07
	Alpha Pinene	0.004	-	-	-	-
	Isopropyl Alcohol	0.004	400	< 0.01	1.42	0.28
4 Hours after Foaming	Acetonitrile	0.014	40	0.04	0.020	70
	Iso-butane	0.010	600	< 0.01	10 ¹	0.1
	Acetone	0.009	500	< 0.01	2.5	0.36
	Pentane	0.005	800	< 0.01	10 ¹	0.05
	Isopropyl Alcohol	0.002	400	< 0.01	1.42	0.14

PEL = Permissible Exposure Limit, i.e., the regulatory maximum allowed.

NA = Not applicable, no Cal-OSHA PEL.

1 = ACGIH 15 minute STEL used; no 8 Hour TLV available.

The concentrations of the individual chemicals detected in all cases were all much less than their established corresponding Cal-OSHA PELs. In addition, the concentrations were all less than the GREENGUARD criteria, except for Acetonitrile, which was higher than the GREENGUARD criteria at the 1-and 2-hour mark after foaming, but was below the criteria at four hours after foaming.

The California Office of Environmental Health Hazard Assessment (OEHHA) list, officially known as the Proposition 65 list, is a regularly updated, comprehensive roster of over 900 chemicals known to the state to cause cancer, birth defects, or reproductive harm. Created under the Safe Drinking Water and Toxic Enforcement Act of 1986, it mandates warnings for exposures to these substances in products, workplaces, or the environment.

The OEHHA's Recommended Exposure Limit ("REL") for chronic (i.e., long term) exposure almost always establishes a lower threshold concentration than that for acute risks. The VOC constituents and concentrations identified in the samples were compared to the OEHHA's Recommended Exposure Limits.

Table 7: VOCs - Identified Concentrations vs. OEHHA List

	Chemical	Result µg/m ³	Chronic REL, µg/m ³	Percent of REL
Outdoor Baseline	Isopropyl alcohol	7	3200 ¹	0.22
	Methyl ethyl ketone	2.4	13000 ¹	0.02
Prior to Foaming	Isopropyl alcohol	3.5	3200 ¹	0.11
	Methyl ethyl ketone	2.8	13000 ¹	0.02
1 Hour after Foaming	Isopropyl alcohol	10	3200 ¹	0.321
	Methyl ethyl ketone	4.3	13000 ¹	0.03
	Toluene	21	300	7.00
	Chlorobenzene	3.7	1000	0.37
2 Hours after Foaming	Isopropyl alcohol	10	3200 ¹	0.31
	Methyl ethyl ketone	3.4	13000 ¹	0.03
	Chlorobenzene	3.6	1000	0.363
4 Hours after Foaming	Isopropyl alcohol	6.6	3200 ¹	0.21
	Methyl ethyl ketone	2.0	13000 ¹	0.02

¹The acute REL was used, as it is lower than the chronic REL, or there is no chronic REL.

All detected constituents were well below their corresponding Office of Environmental Health Hazard Assessment (OEHHA) recommended exposure limits for both acute and chronic health effects and are therefore not expected to pose a health risk to building occupants under either short-term or long-term exposure scenarios. The highest concentration measured was toluene one hour following foam application, which reached approximately 7 percent of the applicable threshold level and was not detected in subsequent samples. Chlorobenzene concentrations were also very low, with measured values not exceeding 2.5 percent of the GREENGUARD criterion of 150 µg/m³, indicating no level of concern.

4.2.2.2 Aldehydes

Formaldehyde is the most common and abundant aldehyde indoor air pollutant, originating from pressed wood products (particleboard, plywood), furniture, and adhesives. Other significant indoor aldehydes include acetaldehyde (from combustion/smoking) and acrolein. The GREENGUARD

certification program evaluates formaldehyde and total aldehydes as part of its product certification criteria. Table 8 summarizes the results from the aldehyde scan.

Table 8: Aldehyde Scan results in (ppm)

Aldehyde	Prior to Foaming	1 Hour after Foaming	2 Hours after Foaming	4 Hours after Foaming	Cal-OSHA PEL	IEQ Recommended Maximum
Formaldehyde	0.010	0.0021	0.011	0.010	0.75	0.0073 ¹
Acetaldehyde	0.0053	0.011	0.0080	0.0065	25	0.08 ¹
Acetone	0.083	0.032	0.13	0.14	500	1.35 ⁵
Acrolein	ND	ND	ND	ND	0.1	0.00015 ^{1,4}
Benzaldehyde	ND	ND	0.0019	0.0022	NA	2.0 ²
Butyraldehyde	ND	ND	ND	ND	NA	20.0 ³
Crotonaldehyde	ND	ND	ND	ND	0.3 (ceiling)	2.0 ^{2,3}
Propionaldehyde	ND	0.0042	0.0045	ND	NA	20.0 ²

IEQ = Indoor Environmental Quality
 1= California OEHHA recommended level for chronic exposure; Also, the GREENGUARD criteria.
 2= American Conference of Government Industrial Hygienists Threshold Limit Value (workplaces)
 3= American Industrial Hygiene Association (workplaces)
 4 = In this case, the detection limit is more than the recommended OEHHA exposure limit.
 5 = Federal EPA Region 9 Risk Screening Level for non-carcinogen exposure
 6 = German time weighted average (workplaces)

Formaldehyde was detected in all samples at concentrations exceeding the OEHHA recommended levels and the GREENGUARD criteria. However, similar formaldehyde concentrations were measured in the sample collected prior to spray foam installation, indicating that the detected formaldehyde was likely not attributable to the foaming activity.

4.2.2.3 1-Methyl-2-pyrrolidone

1-Methyl-2-pyrrolidone (NMP) is a volatile organic compound (VOC) often used as a solvent in consumer products like paint strippers, adhesives, and cleaning products. It poses significant indoor air quality risks due to its toxicity, particularly regarding reproductive and developmental hazards.

Table 9: n-Methyl-2-Pyrrolidone Sampling Results

Time Period	Results (mg/m ³)
Prior to application	Not Detected
1 hour after application	Not Detected
2 hours after application	Not Detected
4 hours after application	Not Detected
GREENGUARD Criteria	0.160
Cal-OSHA PEL	4.0
Proposition 65	3.2

4.2.2.4 Respirable Dust

Particulate matter (PM), often called particle pollution, consists of a diverse blend of solid and liquid particles that remain suspended in the air. These particles differ widely in their physical characteristics, including size, shape, and chemical composition. Of particular concern are particles with diameters of 10 micrometers or less, as they can be inhaled into the respiratory system. Inhalation of these particles may adversely affect the cardiovascular and pulmonary systems and, in some cases, lead to significant health consequences. The health impacts associated with exposure to outdoor particulate matter are well documented and form the basis for health-based outdoor air quality regulations, such as the National Ambient Air Quality Standards (NAAQS). Particulate matter is also present in indoor environments, where concentrations may equal or exceed outdoor levels and applicable NAAQS thresholds. However, the health effects specifically associated with indoor particulate matter exposure are less well understood.

Table 10: Particulate matter results

Time Period	Average (mg/m ³)	Maximum (mg/m ³)
Outdoor Baseline	0.073	0.268
Prior to application	0.055	0.076
1 hour after application	0.047	0.055
2 hours after application	0.037	0.039
4 hours after application	0.026	0.028
GREENGUARD Criteria	5 mg/m ³	
Cal-OSHA PEL	0.020 mg/m ³	

Indoor particulate measurements were considerably below the Cal-OSHA permissible exposure limit (PEL) for respirable particles. When compared to the GREENGUARD criteria, however, the measured concentrations consistently exceeded the applicable threshold. It is important to note that (1) the GREENGUARD standard is not intended to serve as an occupational exposure limit for workers, and (2) outdoor background particulate levels also surpassed this criterion and represented the highest values observed during monitoring. These findings indicate that ambient airborne dust is a substantial contributor to particulate concentrations at the construction site, which is an expected condition for this type of environment.

4.2.3 VOC Analysis Discussion

This VOC assessment extended the GREENGUARD program framework by measuring chemical emissions from EnviroSeal spray-applied polyurethane foam insulation immediately following installation. The primary objective was to evaluate potential airborne exposure conditions for workers entering the space after installation, with secondary consideration given to overall indoor air quality. The target analytes were selected based on Underwriters Laboratories' GREENGUARD certification criteria for building materials and finishes.

It's important to be cautious when reviewing individual VOC test results. Reading about the potential health effects of chemicals can understandably be concerning, but simply finding a chemical in the air does not automatically mean it is harmful. Health effects depend on how much of a chemical is present and how long someone is exposed to it. When exposure levels are low and short-term, health impacts are unlikely. Many of the substances detected in this study are commonly found in everyday indoor environments, including homes, without causing problems. In addition, California health guideline levels are intentionally conservative and designed to protect the most sensitive individuals, so exceeding these values does not necessarily mean that health effects will occur.

At the sampled homes, VOC testing detected acetonitrile at levels exceeding the GREENGUARD criteria at one and two hours following foam application. By four hours post-application, acetonitrile concentrations had decreased to below the GREENGUARD threshold. These levels are expected to continue declining over time and are not expected to pose a concern when the home is ready for occupancy or for other trade workers.

Importantly, the measured acetonitrile concentrations represented only a small fraction of the Cal-OSHA permissible exposure limit (PEL) for workers and therefore do not present a concern for occupational exposure.

As noted previously, formaldehyde was present in the home prior to foam installation. Measured concentrations were well below the Cal-OSHA permissible exposure limit (PEL). From a worker exposure perspective, formaldehyde is not considered a concern, and the detected levels do not appear to be attributable to the foam application. Other aldehydes were detected only at trace or insignificant concentrations.

The analysis did not detect the presence of any n-Methyl-2-Pyrrolidone therefore, and the results of respirable particulate monitoring were all acceptable and less than the Cal-OSHA PEL for workers.

5. Summary

EnviroSeal spray foam insulation is designed to be a completely odorless and inert product. The installation and curing process are remarkably efficient reactions where almost all the components are fully reacted and incorporated into the finished foam. None of the analytes evaluated in this study are individual components in the A or B side chemicals, nor are they recognized impurities in any of the raw materials. Instead, any VOCs present during and within the first 4 hours of spray foam installation are generated from unintended side reactions that occur due to the complex nature of the high pressure atomized chemical installation process. EnviroSeal spray foam insulation is engineered to minimize these unintended side reactions to ensure long term occupant comfort, trade worker safety, and home builder productivity.

The findings reinforce that EnviroSeal spray foam insulation does not create hazardous indoor environments and does not pose health risks to trade workers or building occupants.