SPF RESEARCH ON AIR QUALITY – PART 1

REDUCING OCCUPATIONAL EXPOSURE DURING OPEN CELL INSTALLATIONS

BY **DAN NELSON, GACO WESTERN**

Research being conducted with open cell foam installation is expected to lead toward reductions in occupational, trade and occupant exposure to chemicals with the potential for substantially reduced re-entry times. Per ongoing air studies being performed by Gaco Western, self-compressing polyurethane foam technology – when used along with a pre-installed membrane – has equated to better air quality during open cell foam installations.

The research, thus far, has consisted of third-party air sampling, under the direction of an industrial hygiene consultant, without the use of any mechanical airflow in order to magnify the collection of emissions and the resultant exposure potential. Side by side homes were sprayed – one was free sprayed with conventional open cell foam and the other using a low-emission foam and membrane (in this case, the GacoProFill® System). Air samples were collected during the installation only, in order to evaluate potential contractor occupational exposure to the chemicals released during application.

The results have shown that the low emission foam, when injected behind the pre-installed membrane, results in a better-controlled and safer spray-foam installation. For foam applications performed behind a membrane, both gaseous and droplet exposures (aerosolized liquid) have been reduced and regulated chemical reductions in the range of 73-100% have been seen. This approach also has the potential of increasing contractor product yields by up to 20% by elimination of wall trimming and disposal. By not trimming, contractors would also avoid another potential concern – airborne foam dust that can be inhaled or may blow into adjacent areas.

INTRODUCTION AND SCOPE

Contractors installing conventional polyurethane foam by normal free-spray methods utilize pressures in the range of 800-1300psi. This high pressure results in the formation of very fine airborne liquid droplets which, for poorly protected workers, can easily come into contact with the human body resulting in adverse skin, lung and allergy related effects.

Specifically, these droplets contain unreacted chemicals such as amine catalysts, isocyanate, and fire retardants which may travel some distance from the applicator, and can be drawn through the air by exhaust fans and other air currents, potentially to nearby areas.

Due to the above resulting concerns, Gaco Western has applied significant effort and creativity involving new approaches toward the reduction of these hazards. One of these approaches is described herein.

Project – Phase 1: Field Sprays and Air Quality Collections. Focus: Occupational exposure. Completion Date: August 2015.

Project – Phase 2: Controlled Chamber Sprays and Air Quality Collections. Focus: Occupational, trade, occupant exposure and reentry. Completion Date: December 2015.

The two types of membranes that Gaco Western uses are GacoProWeb (pictured), an open mesh spun-bond polypropylene for moderate and southern climates, and GacoProFilm, a continuous fiber reinforced polyethylene film that is a class 1 vapor retarder suitable for northern climates.

Sprayfoam is injected into the membrane system.

CONVENTIONAL FREE SPRAYFOAM INSTALLATION

High pressure spray-tip atomization and droplet velocities cause the sprayed liquid to bounce-back off the substrate. A cloud of unreacted chemicals then forms, especially around the spray-foam installers and becomes the source for droplet and volatilized occupational chemical exposure.

MEMBRANE INSTALLATIONS

The membrane installation process involves applying one of two different membrane types over the face of the wall studs or cathedral ceiling rafters, then inset stapling the membrane to just below the surface of the studs to ensure drum-like tightness. The recessed position of the membrane ensures that drywall can be flush applied over the membrane following the foam installation.

Once the fabric is installed, the foam rig can move into action. The spray gun pour tip pierces the membrane, foam is injected into the cavity behind the membrane and allowed to rise within the enclosed cavity volume until full. Overfilling is not usually of concern as the foam is designed and has been shown to self-compress. There's no trimming, and therefore there is minimal waste and disposal. Typically, once the job is complete, a single small trash bag is partially filled with foam waste from a 2500 sq. ft. house.

Additionally, this is the only half-pound foam installation that, due to the membrane, ensures full adhesion of the foam to the OSB or other wall surface – without voiding.

Contractors who choose not to inset staple have the option of using the GacoProCap system, whereby long aluminum U shaped channels are screwed onto each stud after the membrane has been laid over the studs. This pushes the membrane to a subsurface distance similar to that of inset stapling. A minute or two after the foam has been injected, the channels are unscrewed and moved to the next stud areas where the process is repeated. The cured foam then holds the membrane in place, acting as a urethane adhesive with no post installation fasteners.

SPRAYFOAM INSTALLATIONS

Both membranes, once properly installed, provide a barrier of protection

Gaco Western's GacoProFill polyurethane half-pound open cell foam was developed to be low-emissive as well as self-compressing for cavity fill applications. It has achieved a GREENGUARD GOLD certification from Underwriters Laboratories (UL) due to its very low emissions following application.

between the spray-tip and the installer during sprayfoam installations. The foam application occurs behind the membrane. As the air emissions data in this report demonstrates, this system blocks airborne droplets and even most gas phase evaporative chemicals from entering the worker's air space.

FIELD INSTALLATIONS

For this project, a side by side duplex was insulated for an apples-to-apples comparison between a conventional free-spray application and a GacoProFilm membrane installation via emissions related air sampling. A third location was insulated using GacoProWeb in a cathedral ceiling; this represented a worst case scenario in terms of potential for exposure and emissions – given the membrane breathability, the 45° ceiling angle, the 12" pass thickness and the extremely low air exchange rate.

The bar chart below shows actual results that provide an overall graphical perspective and comparison for the extent of reduction for the tested chemicals – Total Amines, 4,4-MDI and TCPP – during application (only) of the GacoProFill System. OSHA and ACGIH occupational exposure limits are included for selected chemicals (BDMAEE and 4,4,-MDI) as horizontal colored lines. Samples were collected by individual sampling equipment worn by the applicator and worn by the helper. o

TO BE CONTINUED....

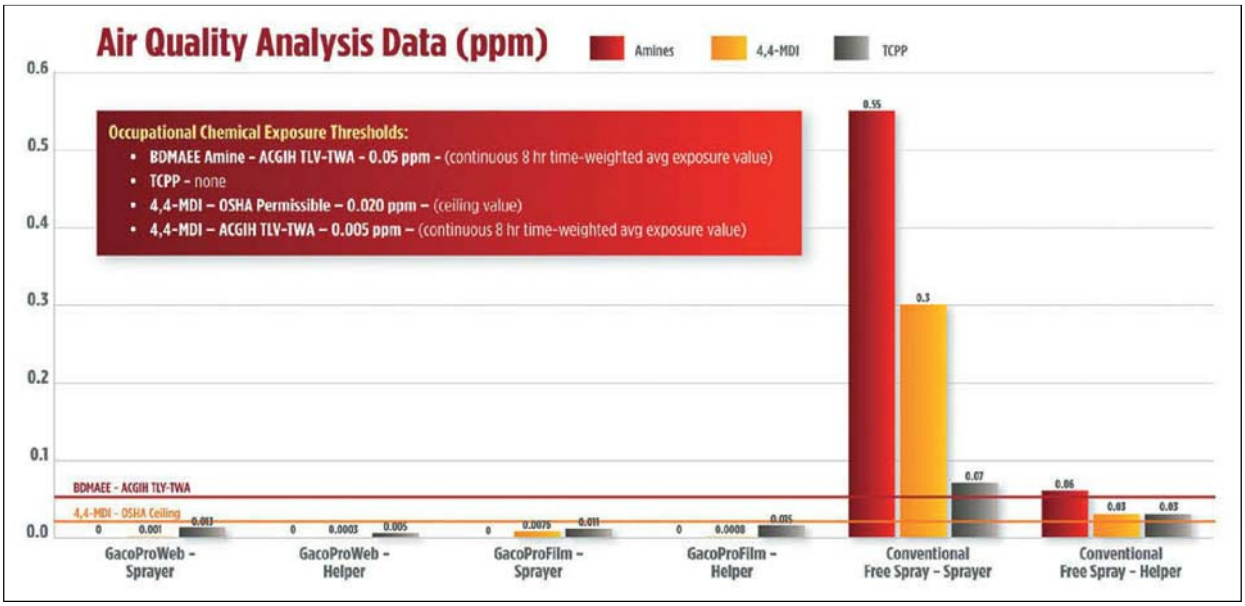
Part 2 of this phase 1 study will appear in the next issue of *SPRAYFOAM Professional* and will include more specific and detailed occupational exposure results for both the sprayer and the helper, which resulted from this study.

This article does not represent the opinion of SPFA, and the research and results were not confirmed by SPFA; SPFA does not endorse any particular product, brand or manufacturer.

Additional Foam Installation and Air Quality Measurement Details

	Home #1	Home #2	Cathedral Ceiling
Installation Type	GacoProFilm	Free Spray	GacoProWeb
Foam Used	GacoProFill	Conventional half-pound	GacoProFill
Foamed Wall Area	4,978 bd-ft	4,681 bd-ft	16,583 bd-ft
Wall Type (Wood Studs)	2x6 Vertical, OSB	2x6 Vertical, OSB	2x12 Cathedral, Metal
ACH – Air Exchanges/Hour (no fans used)	0.070 upstairs 0.130 downstairs	0.400	0.042

Results



Important Note: At this time, and until the full completion of this project, proper ventilation is still recommended during the installation of the GacoProFill System. Specifically, air flow rates of 10 ACH or higher are recommended during the installation and for 24 hours following installation. Worker re-entry times and re-occupancy times remain at 24 hours.

SPF RESEARCH ON AIR QUALITY – PART 2

REDUCING OCCUPATIONAL EXPOSURE DURING OPEN CELL INSTALLATIONS

BY **DAN NELSON, GACO WESTERN**

In the previous issue of *SPRAYFOAM Professional* (Winter 2015) results of research being conducted with open cell foam installation was introduced. This research is expected to lead toward reductions in occupational, trade and occupant exposure to chemicals with the potential for substantially reduced re-entry times. Per ongoing research being performed by Gaco Western, self-compressing polyurethane foam technology – when used along with a pre-installed membrane – has equated to better air quality during open cell foam installations. Detailed occupational exposure results for both the sprayer and the helper, which resulted from this study, are outlined in Part 2 of this article.

As the summary chart from Part 1 showed, dramatic reductions in occupational chemical exposure resulted from the installation of foam utilizing Gaco's new ProFill membrane system.

Air Sampling and Hazard Analysis

All installations were performed under conservative scenarios such as utilizing minimal air flow (low ACH ranging from 0.042 to 0.400). In this regard and contrary to normal and recommended practices, *no exhaust fans were used*. All windows were either closed or sealed over with plastic. Front doors were open to receive hoses, otherwise the structures only exhibited ventilation through seams and unsealed penetrations. All personnel in the area wore all appropriate PPE at all times.

Air sampling was performed ONLY during the foam application period. Spray times and proportioner stroke counts were monitored during foam installations.

Air sampling tubes were attached to both the sprayer and the helper, with tube openings near their breathing zones. The collection tubes were attached to an air pump attached to each individual's belt.

The isocyanate sampling method uses a dry sampler that is composed of two sections: a filter located at the base of the sampler and a denuder section that runs the length of the sampler. The resulting collections were analyzed analytically by LC/MS.

TCPP and amines are also collected and were later analyzed by GC with an NPD detector.

Note that during the installations of the GacoProFill foam, there were instances where the applicator triggered the gun too early (prior to penetrating the membrane) or held the trigger as the gun was being pulled back. This causes a small amount of foam to splatter onto the sprayer, and potentially released volatiles into the air that would not have been released if procedures were more carefully followed. The air quality analysis results include these "real world" installation errors.

Air Sampling Collection Tubes.

Results – Combined

Occupational Chemical Exposure Thresholds:

- BDMAEE Amine – ACGIH TLV-TWA – 0.0 5ppm – (continuous 8 hr time-weighted avg exposure value)
- TCPP – none
- 4,4-MDI – OSHA Permissible – 0.020 ppm – (ceiling value)
- 4,4-MDI – ACGIH TLV-TWA – 0.005 ppm – (continuous 8 hr time-weighted avg exposure value)

Detailed Results – Amines*

	Installer	**GacoProFill Reduction vs Conventional Foam Spray**	Helper	**GacoProFill Reduction vs Conventional Foam Spray**
Conventional Free Spray**	0.41 ppm		0.06 ppm	
Conventional Free Spray***	0.14 ppm		ND	
GacoProFilm	ND	-100%	ND	-100%
GacoProWeb	ND	-100%	ND	-100%

ND = Below Detection Limits

The air testing results from the conventional free spray show airborne amines at levels above the OSHA ceiling value in the vicinity of the sprayer and helper during the course of the installation. These amine levels are expected to decay over time, after installation.

GacoProFilm and a reduction of between 81 and 83% for the GacoProWeb. We would expect a similar decay period following installation. No exposure limits have been identified for TCPP.

We believe the reason that the GacoProFilm was, in this case, less efficient than the GacoProWeb for the the injection hole after the trigger was released increasing the exposure level a bit. This was not aerosolized material, just some large blobs and droplets. This points to the need for a modification to one of our installation process steps.

The air testing results from the conventional free spray show volatilized

Specific Results – TCPP

	Installer	**GacoProFill Reduction vs Conventional Foam Spray**	Helper	**GacoProFill Reduction vs Conventional Foam Spray**
Conventional Free Spray	0.070 ppm		0.030 ppm	
GacoProFilm	0.011 ppm	-84%	0.015 ppm	-50%
GacoProWeb	0.013 ppm	-81%	0.005 ppm	-83%

No detectable airborne amines were detected during the installation of the GacoProFill. This was true for both the GacoProFilm as well as for the GacoProWeb installations. There will therefore be no decay period following installation.

* *One amine catalyst used in the conventional foam was proprietary and therefore was not included in the air sampling study. Estimated likely total amine exposure levels which include the proprietary amine were calculated to be approximately 0.96 ppm for the installer and 0.11 ppm for the helper.*

** *Reactive Amine*

*** *BDMAEE*

The air testing results from the conventional free spray show airborne fire retardant in the vicinity of the sprayer and helper during the course of the installation. This fire retardant level is expected to decay over time, after installation.

The air testing results from the GacoProFill installations show a reduction of between 50 and 84% for the fire retardant emissions reduction, was due to the need for better cavity ventilation for the GacoProFilm during installation. There were occasions where the rising foam spurted out of

isocyanate monomer in the vicinity of the sprayer and helper during the course of the installation. This free isocyanate level is expected to decay over time, after installation.

Specific Results – 4,4-MDI - OSHA Permissible – 0.020 ppm – (ceiling value),
ACGIH TLV-TWA – 0.005 ppm – (continuous 8 hr time weighted average)

	Installer	**GacoProFill Reduction vs Conventional Foam Spray**	Helper	**GacoProFill Reduction vs Conventional Foam Spray**
Conventional Free Spray	0.3000 ppm		0.0300 ppm	
GacoProFilm	0.0076 ppm	-97%	0.0008 ppm	-73%
GacoProWeb	0.0010 ppm	-99%	0.0003 ppm	-99%

The air testing results from the GacoProFill shows a dramatic reduction in volatilized isocyanate in the vicinity of the installer and helper during the course of the installation. This was true for both the GacoProFilm (73-97% reduction) as well as for the GacoProWeb (99% reduction). We would expect a similar decay rate for any remaining 4,4-MDI, as above, after installation.

Summary and Conclusions

The results from Phase 1 (published as Parts 1 and 2) of this project demonstrate that the GacoProFill System, when used according to published instructions, effectively reduces both evaporated chemicals AND aerosolized chemical droplets in the vicinity of the sprayer and helper. Occupational chemical exposure reductions of nearly 100% for amines, and 73%-99% for MDI were achieved. This supports a likely "safe" reduction in re-entry times as well as a possible "safe" reduction in applicator and helper PPE. There were also reductions for TCPP fire retardant exposure, but no exposure thresholds currently exist in the U.S. for this material.

There have been recent industry attempts toward substantiating reduced re-entry times following conventional sprayfoam installations through the use of engineered ventilation of the job site. These attempts have both pros and cons associated with them due to the contractor cost hurdles, inconvenience, and the relatively high level of technical knowledge required to actually achieve a safe re-entry time.

A contractor's ability to achieve a safer work space using the GacoProFill System is NOT based on their engineered air flow calculations or a necessarily high skill level.

The GacoProFill System has resulted in air quality measurements that demonstrate significant reductions in airborne chemicals in the vicinity of the sprayer as well as other room occupants – even during the SPF application. This greatly reduces, and in some cases eliminates, the chemicals entering the home or workspace – beyond the face of the wall studs. A benefit of this new patent pending approach is that it doesn't become necessary to utilize the same high CFM fans to remove the airborne chemicals from the workspace – since most of the chemicals aren't airborne in the first place. Once both phases of this project are completed and the results fully assessed, the GacoProFill System should eliminate:

1) dangerous fan sizing miscalculations,
2) all the work areas with non-uniform airflow,
3) inhalation hazards from off-ratio spraying,
4) variable humidity effects,
5) exposure to potentially hazardous trimming dust, and to non-determined ACH requirements to ensure all dust is expelled from the workspace,
6) overall reduction of uncertainty regarding re-entry times.

Completion of Phase 1 of this project has now triggered the start of the next phase of the project. This involves effectively repeating all three foaming applications (conventional free spray, and applications behind the GacoProWeb and GacoProFilm membranes) in a controlled third-party spray booth/air chamber. This will generate data that will further substantiate results from Phase 1, and will align well with previously reported industry methodology. The results from both phases of this project will then be brought together to form the basis for confident and safe reductions to recommended worker and occupant re-entry times following GacoProFill installations.

Important Note: At this time, and until the full completion of this project, proper ventilation is still recommended during the installation of the GacoProFill System. Specifically, air flow rates of 10 ACH or higher are recommended during the installation and for 24 hours following installation. Worker re-entry times and re-occupancy times remain at 24 hours.

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