# CPI Ventilation Project Phase 1 and Phase 2 Update

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**ABSTRACT**

The Center for the Polyurethanes Industry (CPI) Product Stewardship Committee has asked the CPI Ventilation Research Task Force to develop test protocol to evaluate the effect of ventilation rates on airborne concentrations of specific Spray Polyurethane Foam (SPF) chemical components during application. The Ventilation Research Task Force is comprised of health and safety and technical experts from companies that supply raw materials and formulate SPF products. This study will evaluate vapors and particulates from low density half pound foam, medium density two pound foam, and low pressure kit formulations. Research elements include the development and testing of generic formulations, monitoring of SPF components under controlled conditions, and field monitoring to verify airborne concentrations at specified ventilation rates. This paper will discuss the results of generic formulation and spray equipment evaluation. It will also review research protocol for air monitoring under controlled conditions. Research activities have been initiated; however, is in the early stages of completion with no conclusive information generated at this time. Results will be reported as data becomes available.

**INTRODUCTION/BACKGROUND**

There is limited information regarding the effects of specific ventilation rates to control workplace emissions during the application of SPF formulations. By improving our understanding of the impact of air exhaust rates and distribution during high and low pressure application, appropriate ventilation controls can be established. Once determined, the information may be used to recommend appropriate PPE for applicators and assistants, as well as estimate re-occupancy times for workers involved in associated trades. The objective of this study is to evaluate the impact of changes in ventilation rates on the concentration of spray polyurethane foam (SPF) chemical vapor and particulates emitted during SPF application. The Ventilation Research Task Force has developed generic SPF formulations and an air monitoring protocol that will be used to measure emissions from low density (0.5 pcf), medium-density (2-pcf), and a low pressure 2 component kit formulation in the laboratory and field environments. The chemical ingredients to be monitored represent those typically present in SPF formulations. Chemical substances include: methylene diphenyl diisocyanate (MDI), polymeric methylene diphenyl diisocyanate (pMDI), amine catalysts, chemical blowing agents, and flame retardants.

The investigation includes 3 phases.

- ***Phase 1:*** Development and testing of generic high pressure low density, medium density and low pressure kit formulations and the evaluation of spray foam equipment using the formulations under typical spray conditions.
- ***Phase 2:*** Conduct air monitoring in a fabricated spray room to measure chemical emissions during application of the generic formulations under controlled environmental conditions.
- ***Phase 3:*** Air monitoring in the field, such as a medium-sized residential building, to measure chemical emissions during SPF application.

**PHASE 1**

The purpose of this phase of the study was to develop and test generic formulations that were representative of formulations currently available in the SPF marketplace. The second aspect of Phase 1 was to evaluate spray equipment to verify consistency of application and performance under similar operating conditions.

Generic formulations representative of low density high pressure formulations, medium density high pressure formulations, and low pressure kit formulations were developed and prepared by members of the CPI Ventilation Research Project Task Force. The formulations do not reveal confidential information of formulations sold in the marketplace today; rather they represent typical commercial systems in terms of their density, reactivity and volume ratios. While not completely optimized, these formulations were judged to be representative of commercial formulations and are suitable for the Phase 2 and Phase 3 studies.

Following the development of the generic formulations, the second segment of Phase 1 was carried out by spraying the low density high pressure and medium density high pressure foam using standard spray equipment at five industry laboratories. The low pressure kit formulations were tested by two separate industry laboratories. The test laboratories were requested to report the weight of the spray foam used, foam reactivity and general comments about the appearance. Laboratories were also requested to report the ratio of the A and B sides. Each laboratory followed the same standard work procedure for preparing equipment and spraying the generic formulations. The work procedure specified the availability of pertinent safety and health information, personal protective equipment and clean-up procedures should they be required. Also specified were the type of spray machine (H20-35 Pro or equivalent), spray gun and tip.

The substrate to be sprayed consisted of a stud wall with at least 2 spray cavities lined with cardboard. The cavities were spaced 16 inches apart and were 7 ft in height. Each formulation was sprayed in one pass at a nominal thickness of 2 inches for the medium density formulation, 4 inches for the low density formulation and 4 inches for the low pressure kit formulation.

**Conclusions – Phase 1:**
Following testing, each of the industry laboratories reported test results to the Ventilation Research Project Task Force. Upon review, the Task Force approved the generic formulations listed in Table 1 for use in Phase 2 and Phase 3 studies.

| Table 1 : Generic SPF Formulations | | |
|---|---|---|
| **Low Density (1/2 pound) High Pressure SPF Formulation** | **Medium Density (2 pound) High Pressure SPF Formulation** | **Low Pressure (2 Component) Kit Formulation** |
| A-side | | |
| 100% pMDI | 100% pMDI | 92.5% pMDI<br>Blowing Agent 134a (7.5% ) |
| B-side | | |
| Polyether Polyol (34%) | Aromatic Polyester Polyol (36.39%)<br>Aromatic Amino Polyether Polyol (33.61%) | Polyester Polyol (23%)<br>Polyether Polyol (23%) |
| NPE Emulsifier (11.9%) | | |
| Blowing agent Water (20%) | Blowing agent<br>HFC-245fa (6.97%)<br>Water (2.53%) | Blowing Agent<br>134a (17%) |
| Fire Retardant<br>Tris-(1-chloro-2-propyl) phosphate (TCPP) (25.2%) | Fire Retardant<br>Tris-(1-chloro-2-propyl) phosphate TCPP (15.91%) | Fire Retardant<br>Tris-(1-chloro-2-propyl) phosphate TCPP (30%) |
| Silicone Surfactant (1.0) | Silicone Surfactant (1.0) | Silicone Surfactant (2%) |
| Catalyst<br>Bis (2-Dimethylaminoethyl) ether (BDMAEE) (0.9%)<br>Tetramethyliminobispropylamine (TMIBPA) (3.0%)<br>N,N,N-Trimethylaminoethylethanolamine (TMAEEA) (4.0%) | Catalyst<br>Bis (2-Dimethylaminoethyl) ether (BDMAEE) (0.7%)<br>Bis (dimethylaminopropyl) methylamine (DAPA) (2.59%)<br>N,N,N-Trimethylaminoethylethanolamine (TMAEEA) (0.3%) | Catalyst<br>Pentamethyldiethylene triamine (5%)<br>(ethylhexanoic, 2-, potassium salt/ Oxybisethanol, 2,2') |

**PHASE 2**

Proposed Monitoring Protocol
The experimental protocol described in the ventilation research project proposal may be summarized as follows: Personal and area air monitoring will be conducted as each of the three (3) generic SPF formulations is applied to test panels inside a spray room. The spray room is approximately 8 ft x 8ft x 8ft and is supplied with make-up air introduced on one side of the room and exhausted though 4ft x 8ft filter bank on the opposite wall of the room. The spray substrate is located parallel to the air flow and consists of five 2x6 inch studs, 7 feet in height, spaced 16 inches apart, providing 2 cavities lined with cardboard for SPF application. (Figure 1 and Figure 2)

1. Three (3) to four (4) sessions of personal and area samples will be collected as each generic SPF formulation (low density high pressure SPF, medium density high pressure SPF, and low pressure kit SPF) is applied to the spray substrate.
2. One set of personal samples will be collected and one to two area samples will be collected during each monitoring session.
3. SPF formulations will be applied at ventilation rates of 0.3, 2, 5, and 10 Air Changes per Hour (ACH). Testing at higher ventilation rates may be required based on initial sample results.
4. SPF formulations will be applied for 10 to 15 minutes for each air sampling test, with at least 2 hours between sessions.
5. The spray room will be purged between sessions at a ventilation rate of 10 ACH or greater.
6. A direct reading organic vapor analyzer will be used to estimate residual organic vapor concentrations prior to each SPF spray session.
7. The SPF spray applicator will wear portable sampling pumps with the sampling media placed in the vicinity of the breathing zone. Area samples will be located to approximate a worker's breathing zone, in an area behind the applicator where spray foam emissions are anticipated. The industrial hygiene laboratory will analyze all samples according to the methods listed in Table 2.

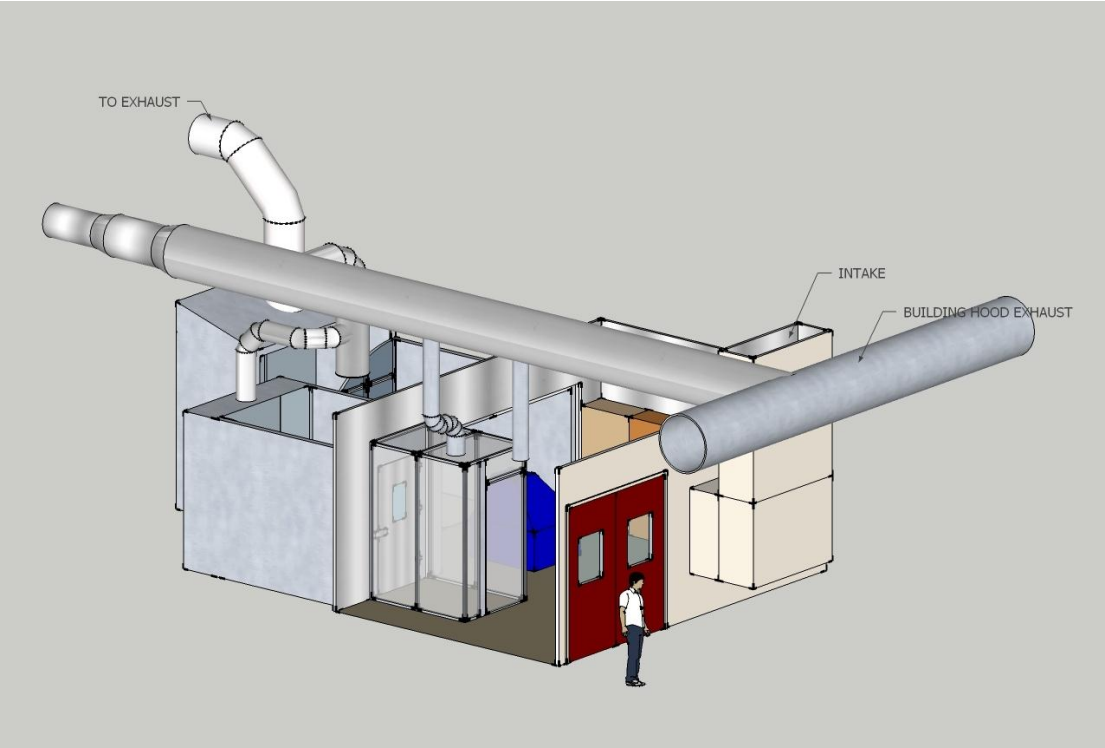

Figure 1 Ventilated Spray Room - Courtesy of Air Products and Chemicals, Inc.

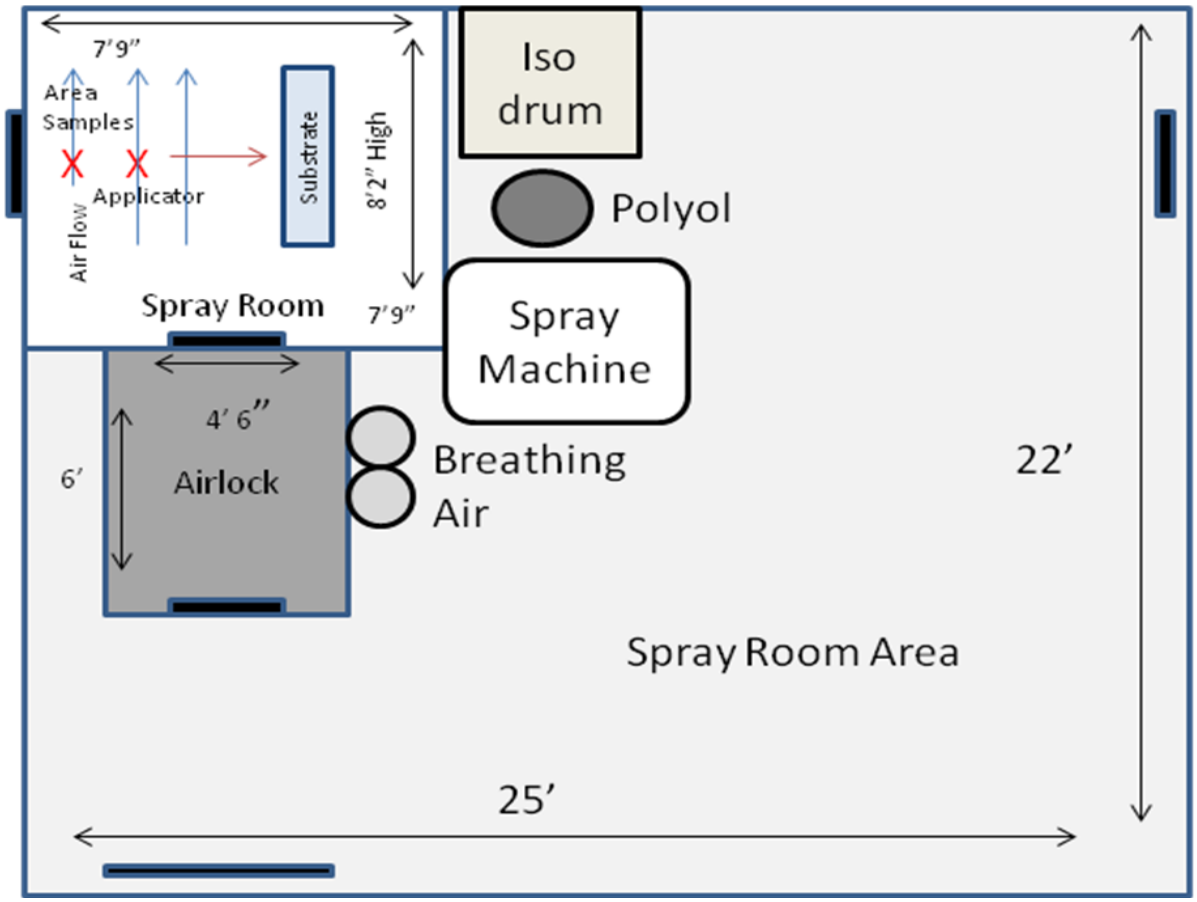

Figure 2 Ventilated Spray Room - Courtesy of Air Products and Chemicals, Inc.

| Table 2: Air Sampling and Analytical Methodology for Select SPF Constituents. | | | | |
|---|---|---|---|---|
| CAS # | Analyte | Analytical Method | Flow Rate | Sampling media |
| 101-68-8 | Methylene bisphenyl isocyanate (MDI) | Urea derivatives analyzed by High Pressure Liquid Chromatography (HPLC) with UV Detection according to Bayer Material Science Industrial Hygiene Laboratory Method Nos: 1.20.0 and 1.7.7 | 1.0 Lpm | Midget impinger with 15 mL toluene / 1-(2-pyridyl) piperazine; followed by: 13 mm glass fiber filter treated with 1-(2-pyridyl) piperazine and diethyl phthalate housed in a Swinnex cassette. |
| 9016-87-9 | Polymeric MDI (pMDI)<br><br>(3-ring and larger oligomers of MDI) | | | |
| 460-73-1 | 1,1,1,3,3-Pentafluoropropane | Modified OSHA 7 (diffusive sampler) | | Diffusive sampler Assay Technology |
| 811-97-2 | 1,1,1,2-Tetrafluoroethane | | | |
| 13674-84-5 | Tris-(1-chloro-2-propyl) phosphate (TCPP) | ICL-IP Method Number CG024-1<br><br>Desorption with Toluene. Analysis by Gas Chromatography with Nitrogen/Phosphorous detector (GC/NPD) | 1.0 Lpm | XAD-2 tubes |
| 3033-62-3 | Bis (2-Dimethylaminoethyl) ether | Bayer Method No. 2.10.3<br><br>Desorption with acetone and analyzed by GC/NPD | 0.20 Lpm to 1.0 Lpm | XAD-2 tubes |
| 6711-48-4 | Tetramethyliminobispropylamine | | | |
| 2212-32-0 | N,N,N-Trimethylaminoethylethanolamine | | | |
| 3855-32-1 | Bis (dimethylaminopropyl) methylamine | | | |
| 3030-47-5 | Pentamethyldiethylenetriamine | | | |

**Phase 2 Project Initiation**

Phase 2 studies were recently initiated. Following a review of study conditions, the Ventilation Research Project Task Force recommended the initial evaluation be conducted using the generic medium density formulation at an air exchange rate of 10 air changes per hour (ACH).

In preparation for the study, three modifications were made to the proposed monitoring protocol. The first related to the air exchange rate in the ventilated room. When confirming air flow rates prior to the study, the nearest rate to the proposed air flow of 10 ACH was determined to be 10.5 ACH. This air exchange corresponds to a calibrated volumetric flow rate of 86 cubic feet per minute (CFM). The second change was the decision to collect one set of stationary/area samples during SPF application due to the limited floor space in the ventilated room, rather than the two sets listed in the proposal. The third modification was to collect a set of stationary samples 30 minutes after the completion of the spray session. The post-application samples were to be collected for a period of 1 hour while the ventilation continued to operate at 10.5 ACH and sprayed inserts remained in the room.

Four SPF application and air monitoring sessions were conducted during the initial testing for the purpose of assessing variation in work practices and application times. The spray applicator's exposure and room concentrations of MDI, pMDI, amine catalyst, blowing agent, and fire retardant were measured during the experiment. SKC Aircheck 52 (Model 224-52) and SKC AirLite pumps were used to collect MDI, pMDI, amine catalyst and fire retardant samples. Assay Technology passive air samplers (No. 548) were used collect blowing agent samples. Photo 1 represents the location of personal samples on the spray foam applicator while Photo 2 represents air monitoring during SPF application.

**SPF Spray Application Procedure**

1. The SPF applicator sprayed the formulation using a Graco Fusion Air Purge 01 round tip spray gun.
2. The formulation was applied under ambient conditions at an air temperature of 75°F with 50% relative humidity using manufacturer recommended pressure and temperature.
3. The spray equipment pressure was approximately 1500 psi and the spray formulation temperature was set at 135°F.
4. A 12 to 24 inch distance from the substrate was maintained while spraying.
5. The applicator sprayed 2 inserts, removed the inserts, placed the sprayed inserts behind the substrate structure, placed new cardboard inserts in the substrate, and repeated the process
6. A maximum of 12 inserts were sprayed during each of the four monitoring sessions. The amount of foam used (lbs) and the densities of the foams sprayed were recorded. The time required from the beginning to the end of the monitoring session was approximately 20 minutes. Personal breathing zone samples collected during Session 1 were stopped short of the desired 20 minute sampling period due to a sample pump malfunction. The remaining 3 sessions were monitored as 12 inserts were sprayed.

Photo 1 Air sampling media


Photo 2 Air monitoring during SPF application

**Discussion**

The two day Phase 2 monitoring session was the first in a series of planned exposure evaluations. The initial findings are currently under review and not available for publication at this time. The Ventilation Research Task Force intends to report all findings as sample results are validated and the study has been completed. All findings will be compared to samples collected during future investigations using the generic medium density formulation at specified air exchange rates. In the near term, additional baseline monitoring will be conducted during the spray application of the low density high pressure formulation and the low pressure kit formulation at the 10.5 ACH ventilation rate. The Task Force will also consider ventilation rates beyond 10.5 ACH for future testing of the medium density formulation to define the minimum level of ventilation required to evaluate the effect of higher air flow rates through the spray area on airborne concentrations of SPF chemicals. All future data will be collected in accordance with the monitoring protocol at ventilation rates and environmental conditions specified by the CPI Ventilation Research Task Group.

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