Introduction – Draft Ventilation Guidance for Spray Polyurethane Foam Application

The attached draft fact sheet is being submitted on behalf of the Environmental Protection Agency's (EPA's) Spray Polyurethane Foam (SPF) workgroup, working in partnership with the National Institute for Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA), and the Consumer Product Safety Commission (CPSC). Spray polyurethane foam (SPF) is a widely used and highly-effective insulator and sealant for homes, schools and buildings. However, eye, skin, and inhalation exposures to its key ingredient, isocyanates, and other chemicals in SPF products in the form of vapors, aerosols, and dusts during and for a period of time after SPF installation can cause:

- Sensitization and asthma, a potentially life-threatening disease
- Respiratory problems and other breathing difficulties
- Skin and eye irritation
- Other potential adverse health effects

The SPF workgroup is working closely with the polyurethanes industry and other interested parties to address the following:

- Improve the availability of accurate and comprehensive hazard and risk information
- Develop and communicate "Best Practices" to prevent exposure to isocyanates and other SPF chemicals, including applicator training and the use of proper engineering controls and personal protective equipment
- Addressing the widespread use of inaccurate or misleading marketing claims
- Addressing exposure assessment data gaps and other research questions through further research

In May 2010, NIOSH convened a meeting with industry, federal participants, and others to discuss the challenges of deploying ventilation technologies in the SPF application environment. Discussions included the variability of SPF operations, applications, and worksites; typical practices; re-occupancy; overspray and barriers; and, the use of natural and mechanical ventilation.

As follow-up to the May, 2010 meeting, EPA volunteered to draft a guidance document for SPF applications that describes ventilation principles and design considerations. Because the dynamic nature of most SPF application sites precludes a one size fits all ventilation approach, the attached draft guidance document educates readers on key ventilation principles and practices so they will be better equipped to design more effective ventilation systems in the wide variety work configurations they are likely to face.

EPA's Design for the Environment created a similar document widely used by the automotive refinishing industry. That document, "*Breathing Easy… Ensuring Proper Ventilation of Paint Mixing Rooms in Auto Refinishing Shops*" (EPA 744-F-02-008) can be found at:
http://www.epa.gov/dfe/pubs/auto/bp_mixing/ventilation.pdf

For further information, please visit EPA's spray polyurethane foam web site at:
http://www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html

The intent of this ventilation guidance document is to provide on-site support to applicators which can be achieved by including it in MSDS notebooks or other guidance materials housed on the SPF rig. As additional information and practices on ventilation become available, this fact sheet as well as additional supplementary information will be made available at the EPA's SPF web site. Note that NIOSH, OSHA, and industry are conducting ongoing research on SPF workplace exposure potentials and related ventilation approaches. This draft fact sheet will be updated as appropriate to ensure it reflects current Best Practices.

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Ventilation Guidance

design FOR THE ENVIRONMENT *for* Spray Polyurethane Foam Application

EPA's Design for the Environment (DfE) Program

The DfE Program promotes safer chemicals and best practices that reduce exposures to chemicals of concern in the workplace and community. This Fact Sheet describes basic ventilation principles and strategies to help protect workers and building occupants and promote the safe use of spray polyurethane foam (SPF) insulation.

What is Spray Polyurethane Foam (SPF)?

SPF is a widely used and highly-effective insulation and sealant material that is spray-applied to walls, ceilings, attics, basements, crawl spaces, and roofs. The two-component SPF systems (both high and low pressure) contain isocyanates (the A-side) and a polyol blend (the B-side). The A and B sides are fed through hoses to a spray gun where they are mixed and sprayed under pressure, rapidly reacting and expanding in volume to form polyurethane foam.

Does SPF Application Present any Health Risks?

Yes, exposure to SPF chemicals poses health risks such as irritation and chronic lung disease to workers or others in the area if they are not adequately protected from skin, eye, and inhalation exposure.

SPF spray application on wall

In addition, isocyanates (A-side) are strong sensitizers that can cause an allergy-like response in certain people and are the leading chemical cause of work-related asthma. A person can become sensitized after long term or even initial exposure and a sensitized person can suffer a severe or fatal asthma attack if exposed even at very low levels. In addition, the polyol blend (B-side) contains blowing agents, amines, flame retardants, and other chemicals, which may also cause adverse health effects.

Why is Ventilation Important?

Properly designed ventilation can reduce airborne levels of aerosols, mists, and vapors generated during spray application and can help protect SPF applicators, helpers, and others who may be working in adjacent areas.

During and after spray application, vapors and mists, as well as particulates and dust from trimming or sanding the foam, may linger until the area is ventilated and fully cleaned.

Construction activities should be carefully scheduled so that no other trades or occupants are in the building during SPF Installation.

Fundamentals of Ventilation

Ventilation is a method of controlling worker exposure to airborne hazardous chemicals or flammable vapors by exhausting contaminated air away from the work area and replacing it with clean air. There are two basic types of ventilation—general exhaust ventilation and local exhaust ventilation.

Overview of Key Principles

Establish air flow across the entire spraying area

- ☐ Direct fans to establish the air flow
- ☐ Draw vapors, mists and dusts away from workers
- ☐ Begin working at the exhaust end and progress downstream (away) from exhaust
- ☐ Keep exhaust collection point as close to the source as possible

Establish enclosures to isolate and contain the work area

- ☐ Place warning signs on entrances to the enclosure
- ☐ Maintain a negative pressure in the enclosure
- ☐ Avoid openings that short circuit the ventilation
- ☐ Seal off HVAC openings to prevent migration of contaminants

Direct exhaust to a safe location outside the building

- ☐ Direct exhaust away from workers or other people
- ☐ Direct exhaust away from air intakes for neighboring buildings
- ☐ Establish control zones and post warning signs if needed
- ☐ Filter exhaust air with particulate filters to protect nearby vehicles and other property
- ☐ Place the filter before the exhaust fan to ensure continued fan efficiency

Continue ventilating the area after application

- ☐ Check with the manufacturer to determine safe re-entry times
- ☐ Minimize worker re-entry during this time
- ☐ Ensure that those entering have proper protective equipment
- ☐ Restrict occupant re-entry until after the building has been fully ventilated and cleaned

EPA United States Environmental Protection Agency

General exhaust ventilation systems typically consist of an exhaust fan, mounted in the ceiling or wall that pulls air out of the room and discharges it outdoors. Replacement air is brought into the area by either natural means, such as windows, doors, and exterior vents (e.g., attic vents) or could include a separate make-up air fan, duct work, and air registers that provide clean air to the room. General exhaust ventilation, also known as "dilution ventilation," dilutes contaminated air by mixing it with cleaner room air.

General exhaust systems are not recommended as the sole source of ventilation when hazardous vapors or mists are present, because they do not immediately remove contaminants from the work space.

Local exhaust ventilation systems remove chemicals and other contaminants at their source. In these systems, the exhaust hood or vent is placed as close as possible to where the work is performed to capture and remove contaminants before they mix with the rest of the air in the room. Local exhaust ventilation systems are recommended for controlling hazardous vapors, mists, dusts, and particulates because, if designed properly, they remove the contaminants before workers are exposed.

For an SPF application project, a local exhaust system would be appropriate during the application process to capture vapors, mists, dusts, and particulates at the source as they are emitted during the spraying and trimming processes. General ventilation would be appropriate after the insulation is applied to ventilate the entire work area and building before other workers or occupants enter the area.

SPF Ventilation Challenges

A ventilation system is normally designed to serve a specific location or room where the operation is well defined. For example, a spray booth used for spraying truck bed liners will always have the same room dimensions (i.e., volume and geometry) and the application process will always be the same. As a result, an effective ventilation system can be designed and installed to the exact specifications of the room.

The application of SPF to walls, ceilings, attics, and basements within multiple job sites, however, presents ventilation challenges because every job site will have different room sizes and shapes. In addition, the process requires frequent movement of the workers as the work progresses resulting in vapors, mists, dusts, and particulates being generated throughout the room. This work area variability and movement prevents a "one size fits all" approach and presents challenges associated with designing a "booth-like" enclosure and ventilation system that can capture vapors, mists, dusts, and particulates at the source (i.e., the point of application).

Because of this, it is important for SPF insulation applicators to understand some basic ventilation principles so they can implement effective ventilation controls in the wide variety of work configurations that they face. While a properly designed ventilation system can help protect workers and building occupants, an improperly designed system could make matters worse.

Protective Clothing and Equipment

The Occupational Safety and Health Administration (OSHA) requires that engineering controls such as ventilation and enclosures be used to reduce worker exposures to acceptable levels. When engineering controls alone are not sufficient to reduce exposures to acceptable levels (typically the case for indoor applications of two component SPF systems), OSHA requires that workers wear appropriate protective equipment to prevent inhalation of and skin contact with contaminants. SPF manufacturer's recommendations for proper respiratory and other protective equipment can be found in the product's material safety data sheet (MSDS). Generally, these recommendations will include the use of full facepiece or hooded supplied air respirators.

Basic Ventilation Design Principles

Because the source of emissions moves as the work progresses in SPF applications, designing a local exhaust system can be difficult. In fact, in many cases the system may look more like a general exhaust system. There are some tips to consider, however, to maximize the system's effectiveness. The key to understanding and applying these tips is understanding the three important components of a ventilation system and how they work together. These components include:

- **The work space**, room, or enclosure to be exhausted.
- **The exhaust system**—including a hood or exhaust vent, ductwork, and fan—that captures contaminants at the source and transports them to a location outside the building away from HVAC air intakes and occupied areas.
- **The make up air** which is the fresh air to the room or work area that replaces the exhausted air. This can either be forced make up air (air forced into the room with a fan) or passive make-up air (air drawn into the room through openings such as doors, windows, or exterior vents).

How you design or place each of these components will determine the effectiveness of your system.

Establish Air Flow Across the Spraying Area

A fundamental consideration of any ventilation system is that the system creates an air flow from the make-up air entry location to the exhaust collection point (e.g., hood or vent). It is important that this flow of air:

- Flows across the entire work space to be ventilated (see figure 1). This is achieved by ensuring the make-up air entry location is on the opposite end of the work area from the exhaust hood or vent.
- Draws contaminants away from the workers. When possible, applicators should begin spraying near the exhaust hood or vent and progress away from that point so that off-gassing from applied SPF is drawn away from the applicator. Helpers should also work upstream from the sprayer (see figure 1).

Related tips:

- **Avoid improper placement and direction of fans.** Simply pointing fans at the work area without establishing a directed air flow pattern will only stir up the air creating a greater potential for workers to breathe the contaminants. This could also lead to the unintended escape of contaminants to other work areas.
- **Remember to place the exhaust hood or vent as close to the point of application as possible.** As an applicator moves around a working area, reposition the fans (so they remain close to the application process) if possible to account for a moving application point. Placing the exhaust fan close to the source of emissions minimizes the potential for the contaminants to mix with the rest of the air in the room.

Establish Enclosures to Isolate and Contain the Work Area

Establishing enclosures around the work area serves two important purposes:

- Prevents migration of contaminants to other areas of the building. This protects workers in other areas and minimizes the need for more wide spread building ventilation during the application process and prior to occupancy.
- Improves the efficiency and effectiveness of the ventilation system by minimizing the size of the area to be ventilated (which affects the number and size of fans needed) and by helping to direct or channel the airflow to the exhaust vent or hood.

In some cases the configuration and size of the room where the application will occur may be sufficient to isolate the work area. In other cases, it may be necessary to construct temporary enclosures. Such enclosures typically include plastic sheeting with overlapped seams sealed with tape.

Remember to place warning signs on entrances to the enclosure or work area to alert other workers of the hazard and prevent them from entering the area.

Related tips:

- **Maintain a negative pressure in the work area or enclosure.** This is accomplished by ensuring that you exhaust more air from the room than you supply. A negative pressure in the enclosure will prevent contaminated air from escaping the enclosure by ensuring that if there are any leaks, the leaks will be into rather than out of the enclosure. If you use forced supplied air, you can maintain a negative pressure by ensuring that your exhaust fan capacity (CFM) is greater than your make up air fan (a good rule of thumb is for your exhaust fan capacity to be 10 percent greater than your supply fan). If you use passive supplied air, your exhaust fan alone should be sufficient to create a negative pressure. A smoke tube can be used as a basic tool to evaluate whether the enclosure is under negative pressure.
- **Avoid openings that will short circuit your ventilation system.** Remember that because you have a negative pressure in your room or enclosure, air will be drawn into the room from any opening (intentional or unintentional). Poorly placed openings can short circuit your intended flow of air and create dead spaces (see figure 2). This is particularly important with passive make up air systems.
- **Remember to shut down and seal off HVAC openings in the work area** to prevent migration of contaminants to other areas of the building, as noted earlier. Don't forget to unseal and restart the HVAC system prior to re-occupancy after the SPF has fully cured and the work area has been ventilated and cleaned.

Direct Exhaust to a Safe Location

Always remember to direct exhaust to a safe location outside the building, away from areas where other workers or people are or could be present. If the exhaust is at ground level or at other areas where people could enter, you should also establish a control zone using warning signs and physical barriers around the exhaust area to prevent personnel access. You should also be aware of where air intakes are for neighboring buildings and direct your exhaust away from these areas.

Figure 1. Establish air flow across the spraying area and draw overspray away from workers

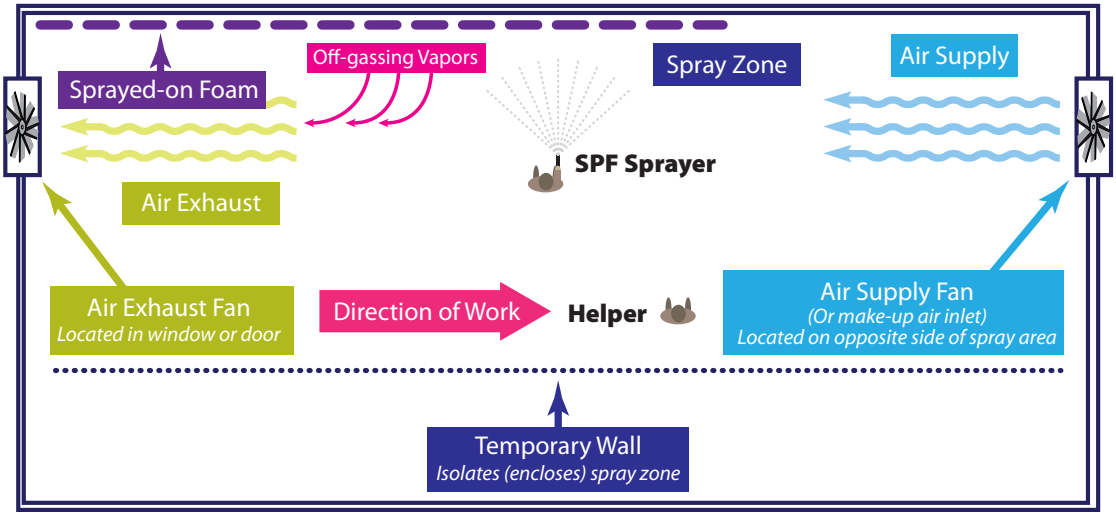
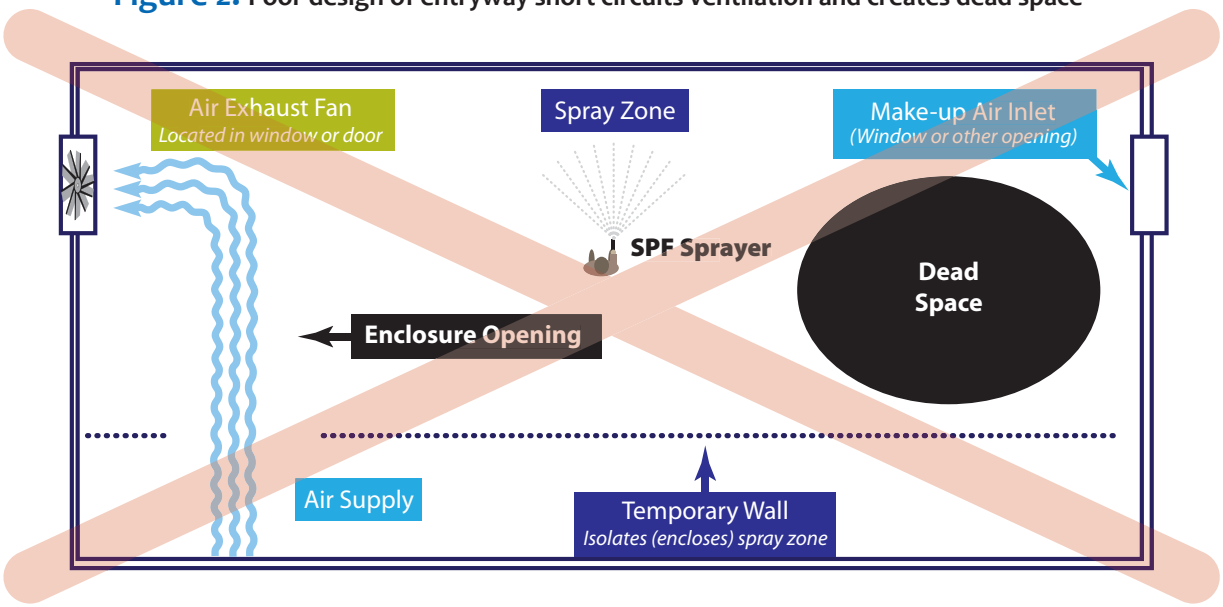


Figure 2. Poor design of entryway short circuits ventilation and creates dead space



Related tips:

- **Particulate exhaust filters should be used to remove SPF dusts and mists from the exhaust air.** This not only helps to minimize hazardous air contaminants in the exhaust air but can also prevent SPF from settling on nearby vehicles or other property. Note that SPF can also buildup on the exhaust fan blades significantly reducing the exhaust fan's efficiency over time. For this reason, the exhaust filter should be installed in front of the fan to remove the dusts and mists before they reach the fan. Clogged filters can also reduce efficiency, so remember to follow the filter manufacturer's recommendations for filter replacement.
- **Some SPF vapors and mists can present explosion hazards at certain concentrations.** As a result, you may need to use a fan rated for use in explosive environments. Check with SPF manufacturer to determine if certain uses of the product pose this hazard.

Ensure Adequate Ventilation Following Application

Always remember to continue ventilating the area following application until the material has fully cured, off-gassing has stopped, and vapors have been removed. During this time, worker re-entry should be kept to a minimum and should only include those with appropriate respiratory protection (and skin protection if contact with the SPF is possible). Occupant re-entry should only occur after the building is fully ventilated. The amount of time needed for this depends on several factors including:

- SPF formulations and related cure times as specified by the manufacturer
- Accurate proportioning and mixing of A-side and B-side
- Ventilation rate
- Temperature and humidity

Check with the manufacturer of your SPF product to determine an appropriate re-occupancy time and ventilation rate.

How Can I Get More Information on SPF ventilation and other important health and safety practices?

- Talk to your SPF product manufacturer or vendor.
- Consult the National Institute for Occupational Safety and Health (NIOSH) by either calling 1-800-CDC-INFO or by visiting their website at http://www.cdc.gov/niosh/topics/isocyanates/
- Visit the following websites:
  - **EPA's Design for the Environment (DfE) SPF website at** http://www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html
  - **NIOSH Alert on Spray-on Truck Bed Lining Operations at** http://www.cdc.gov/niosh/docs/2006-149/default.html
  - **OSHA's isocyanates website at** http://www.osha.gov/SLTC/isocyanates/index.html
  - **American Chemistry Council—Center for the Polyurethanes Industry (CPI) website at** http://www.polyurethane.org/
  - **Spray Polyurethane Foam Alliance's website at** http://www.sprayfoam.org/
  - **OSHA's Green Jobs Hazards website at** http://www.osha.gov/dep/greenjobs/index.html

Ongoing research at NIOSH and the CPI will continue to provide updated information on appropriate ventilation rates and isolation and capture methods.