

# Ventilation Considerations for Spray Polyurethane Foam

## GUIDANCE ON VENTILATION DURING INSTALLATION OF INTERIOR APPLICATIONS OF HIGH-PRESSURE SPRAY POLYURETHANE FOAM

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## Guidance on Ventilation During Installation of Interior Applications of High-Pressure Spray Polyurethane Foam

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The Spray Foam Coalition (SFC) champions the use of spray polyurethane foam in U.S. building and construction applications and promotes its economic, environmental and societal benefits while supporting the safe manufacture, transport, and application of spray polyurethane foam. SFC consists of manufacturers of spray polyurethane foam systems as well as suppliers of raw materials and machinery used to apply the foam.

## Guidance on Ventilation During Installation of Interior Applications of High-Pressure Spray Polyurethane Foam

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This document is intended to provide general guidance on ventilation during installation of interior applications of high-pressure spray polyurethane foam (SPF) in new residences and buildings and during renovation and weatherization projects in existing homes and buildings. Each jobsite must be evaluated to determine appropriate ventilation system design.

SPF is a widely used and highly effective insulation and sealant material that is spray-applied to walls, ceilings, attics, basements, and crawl spaces. Application of SPF can seal the building enclosure below the minimum ventilation rates required by building codes or recommended design requirements. This document does not discuss permanent mechanical ventilation systems, but in certain cases, the use of such systems may need to be considered. Consult with a design professional to determine if permanent mechanical ventilation is appropriate.

### Why use work zone mechanical ventilation during and after SPF installation

Work zone mechanical ventilation during and after SPF installation is designed to help reduce the airborne chemical concentrations associated with SPF application and keep the SPF work zone under a slight negative pressure with respect to the surrounding environment.<sup>a</sup> Properly designed mechanical ventilation can also be useful in determining appropriate re-entry/re-occupancy times. Potential health effects from exposure above recommended levels or the occupation exposure limits (or “OEL”) can range from no effects to slight irritation of the eyes, skin or respiratory system to the development of chronic lung or pulmonary disease depending on the individual person and level and duration of overexposure.<sup>1, 2</sup>

The A-side material used to make SPF is polymeric methylene diphenyl diisocyanate (pMDI, commonly referred to as MDI). MDI is a skin, eye and respiratory tract irritant. Exposure to high airborne concentrations of MDI (above the OEL) can lead to respiratory sensitization, which may result in occupational asthma. Exposure of a sensitized individual to MDI can result in skin and/or respiratory reactions. Respiratory effects (asthma attacks) can be severe (or fatal) even at very low levels of exposure in sensitized individuals.

The B-side material (polyol or resin blend) used in SPF is a formulated product that contains polyols, blowing agents, catalysts, flame retardants, surfactants and other additives. Exposure above recommended levels to these component materials can result in irritation of eyes, skin and respiratory system. A temporary condition referred to as “Blue Haze” or “Halovision” can also result from exposure to some amine catalysts. For more information on chemical health and safety, consult “Health and Safety Product Stewardship Workbook for High-Pressure Application of SPF.”<sup>2</sup> Important information concerning health and safety is available online, including the Center for the Polyurethanes Industry’s Chemical Health and Safety Training for both high-pressure SPF and low-pressure SPF here: [www.spraypolyurethane.org](http://www.spraypolyurethane.org).

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<sup>a</sup> Appendix A provides a list of factors that may be considered to determine whether conditions exist that require work zone mechanical ventilation or whether such ventilation is feasible.

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When SPF is applied using high-pressure application equipment, some SPF component chemicals may be present in the form of aerosol mists and vapors over the OEL or at levels that could be harmful to some individuals.<sup>b</sup> Engineering controls including containment and properly designed ventilation systems should be used with proper personal protective equipment (PPE).<sup>3</sup> These protective measures can help prevent SPF applicators, helpers and others who may be working in adjacent areas from potential exposures. In addition, restricting unauthorized access to the SPF work zone can help to minimize potential exposures.

Studies show that the use of engineering controls alone (containment and ventilation systems) during high-pressure SPF application does not reduce airborne chemicals below OELs.<sup>4,5, 6</sup> Engineering controls and proper PPE should be used together when applying high-pressure SPF in interior applications.

### When to consider using a mechanical ventilation system during installation

Airborne SPF component chemicals can rapidly accumulate in enclosed interior spaces, depending on the ambient conditions, size of the work zone and the amount of SPF applied. Enclosed work zones include the interior space of buildings, especially in areas with minimal natural ventilation like attics and crawlspaces. Isolating and ventilating the areas of SPF application should be considered so that other trade workers and building occupants are not potentially exposed to SPF component chemicals. Alternatively, it may be necessary to exclude occupants and unprotected workers from the building for a period of time during and immediately after spray activities.

On certain construction sites, including large industrial and institutional buildings that are open to natural air flow and/or where the floor space is large enough, restricting access to the SPF work zone may be sufficient to minimize the potential exposure of personnel not involved in spray activities. For example, in a large building that is under construction, mechanical ventilation and temporary containment walls to zone off the spray area may not be feasible or necessary. Each situation must be evaluated prior to commencement of spray activities to ensure the appropriate safety measures are in place to protect all workers. Other trades and personnel should be briefed on the SPF application, the work zone restrictions, and the safety measures being employed for that project.

### Who is responsible for constructing and using containment and mechanical ventilation systems

According to OSHA regulations,<sup>7</sup> SPF contractors have a legal responsibility to provide a safe workplace for all their employees. In the case of high-pressure SPF application, use of engineering controls and proper PPE in the work zone during and immediately after spraying is an important consideration to help achieve a safe workplace. In addition, it is a good practice for the SPF contractor to advise the building owner (homeowner or general contractor) of all hazards associated with SPF application. Conduct a meeting between the SPF contractor and the building owner before SPF application to discuss potential hazards,

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<sup>b</sup> Not all SPF component chemicals have OELs.



containment and ventilation methods, the importance of vacating the SPF work zone where feasible, and when it is safe to reoccupy the building after SPF application.

### What does a SPF contractor consider when designing and constructing a containment and mechanical ventilation system

Application of SPF to walls, ceilings, attics, and basements within buildings of varying size and geometry creates some challenges for designing containment and ventilation configurations because every job site can be different. Work zones vary in size, geometry and ambient conditions. The delivery rate and position of the contaminant source (i.e., spray gun) as well as air flow is expected to change throughout the job as the applicator moves around the space.

Applicators, helpers, occupants and adjacent workers should avoid inhalation of, and skin and eye contact with, SPF component chemicals.<sup>8</sup> The following practices, including engineering controls, work practices, and PPE, are intended to reduce the potential for overexposure to SPF component chemicals via inhalation, skin or eye contact. Individuals not involved in the application process should vacate the work zone or building depending on the jobsite, and return after informed that it is safe to do so.

**Engineering Controls:** Proper containment and ventilation techniques can help prevent non-SPF workers and building occupants from potential exposure to chemicals due to SPF application, particularly in interior applications when buildings cannot be vacated. Containment and ventilation can be especially useful in large, commercial buildings where vacating the entire building or the floor of a multi-story building is not feasible. Containment creates a restricted work zone while the ventilation system helps remove SPF component chemicals from the work zone. In addition to the engineering controls, the use of PPE further reduces the potential for exposure.

- **Work Zone Containment:** Work zone containment is used in conjunction with ventilation to isolate and remove chemicals from the work zone. Work zone containment is most effective when a space is as close to airtight as can practicably be achieved. If a work zone is contained, clearly mark the area externally and take appropriate steps to restrict entry into the work zone to only personnel wearing proper PPE.
- **Ventilation Design:** Ventilation used with work zone containment removes chemicals from the isolated area via negative pressure. Negative pressure in a contained work zone will draw in air from small cracks and gaps around the work zone boundary and exhaust the work zone air. Active ventilation is achieved by using one or more fans to draw air from the work zone and create a negative pressure inside the work zone. Give careful consideration to the location of the exhaust. Release exhaust air to a location outside the building away from occupied areas to protect occupants and workers in adjacent areas from potential exposure. Exhaust air also should be positioned away from building air inlets so that contaminated air is not drawn back (or if upwind, blown) into the building. Cordon off the exhaust outlet with physical barriers to identify and prevent access to the area.

## A. Work Zone Containment

Prior to application of high-pressure SPF within a building, construct a containment or enclosure system to isolate the work zone from other parts of the building. This containment system serves several important functions:

- Prevents airborne mists and particulates from migrating to other parts of the building.
- Minimizes the need for additional ventilation outside of the work zone.
- Minimizes the total volume of the work zone for ventilation and reduces the needed size and number of fans. This also helps to direct airflow across the point of SPF application.
- Establishes a defined boundary between the work zone and other areas in the building, when properly marked with hazard signage at all entrance points, helping to prevent unauthorized entry by workers and others not wearing appropriate PPE.
- Can help to maintain a negative pressure in the work area to prevent contaminants from migrating easily into adjacent spaces.

Polyethylene sheeting (4-6 mil) is an example of a material used to build a containment area in SPF applications. Sheeting can be purchased in roll widths corresponding to the interior wall height, usually 8-10 feet high. This sheeting should be installed to help provide a negative pressure in the work zone.

In addition, all penetrations and openings to other parts of the building, including open areas between the ceiling joists above the interior walls, should be temporarily blocked with faced fiberglass batts, plastic sheeting, cardboard, landscaping cloth, or other materials and taped to minimize air flow as shown in Figure 1. All finished surfaces, such as windows and immovable furnishings and appliances, should be masked to prevent overspray.

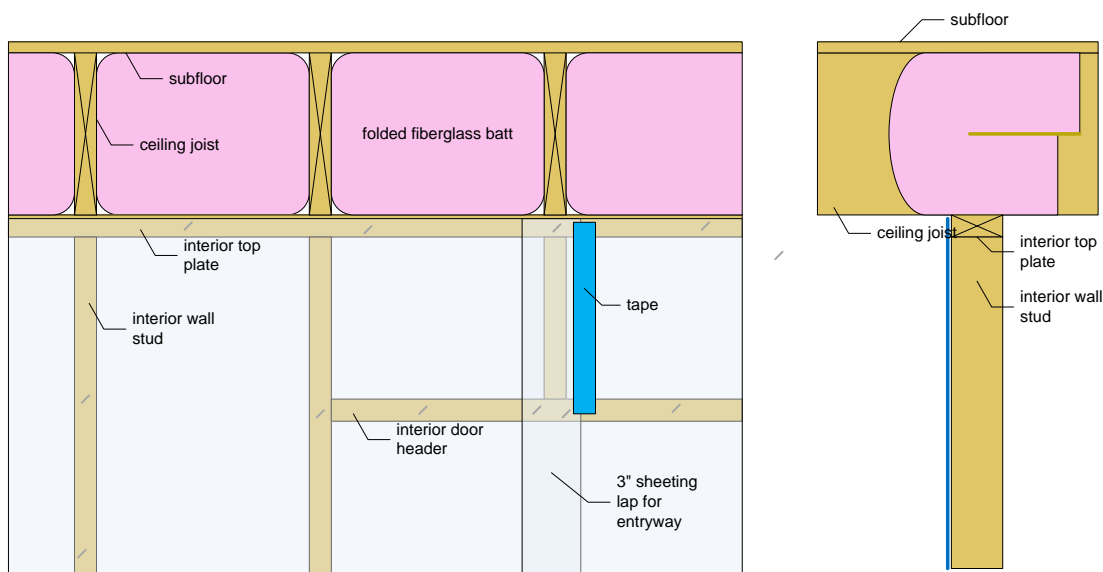
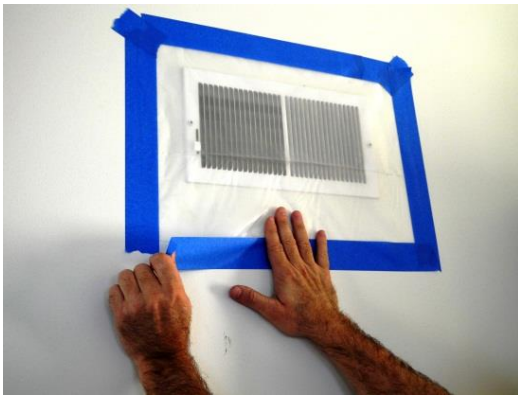


FIGURE 1 - Example of using fiberglass batts to seal openings in ceiling joists.

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**FIGURE 2 - Cover and taping all grille and register openings into containment.**



**FIGURE 3 - Deactivate and mark HVAC system at electrical panel (use LOTO procedure and indicate date, time and name of person applying the tag).**

It is also important to deactivate the HVAC system and cover HVAC registers and grilles (see Figure 2) during installation and ventilation of the work zone. Use OSHA's lock-out/tag-out (LOTO) procedures to de-energize and secure the HVAC system breakers or sub-panel and/or use a sign/tape over the switch, as shown in Figure 3. Turn the HVAC system back on, as necessary, after ventilation is stopped and prior to re-occupancy.

An adequately sealed containment system will help provide negative pressure in the work zone when proper ventilation fans are used.

## B. Ventilation Design

During SPF application, the main source of chemical vapor and particulate emissions is the spray gun. The location of the spray gun moves as the point of application progresses throughout the work zone. This movement creates unique challenges in designing and implementing an effective containment zone and ventilation system. If a single, immobile fan is used, the system may resemble a simple exhaust-only system. To maximize a system's effectiveness, one must understand the following components and how they work together:

- **Contaminant Source:** In the case of SPF, this is the spray gun and curing foam.
- **Containment Zone:** The space, room or enclosure to be ventilated, within the work zone.
- **Exhaust Air System:** The exhaust air system includes an exhaust point, ductwork and an exhaust fan that captures airborne contaminants at the source and sends them to a location outside the building away from occupied areas and air inlets.
- **Supply Air System:** The supply air system provides a source of fresh outside air into the containment zone that is needed to replace the air removed by the exhaust system. This make-up air can be provided passively through various penetrations in the containment zone (e.g., windows, doors, exterior vents and other openings) or through a dedicated active forced-air inlet system consisting of a supply point, ductwork and second supply fan. Supply air systems can be comprised of both passive and active systems.

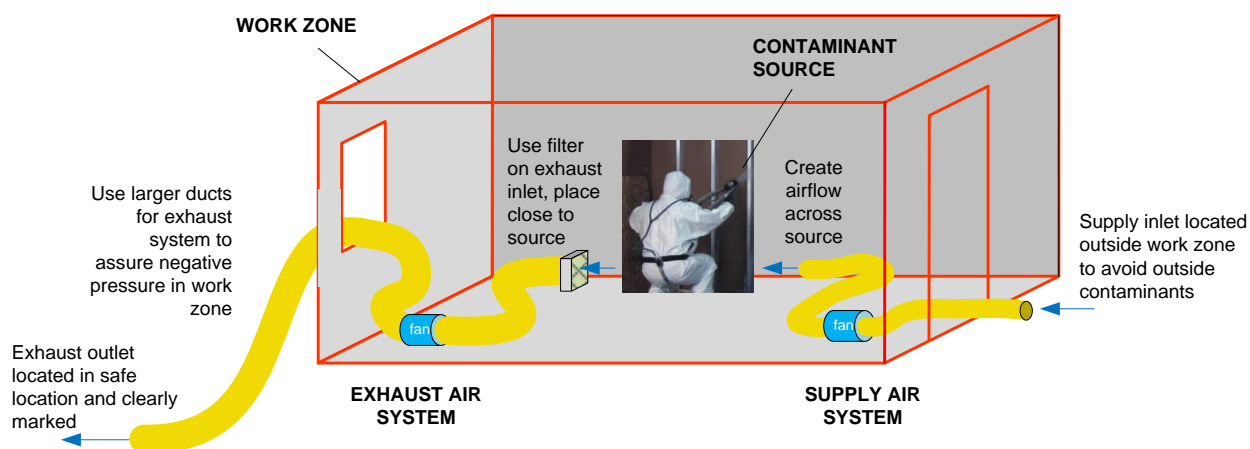
One way to think about this is to consider the exhaust and supply air systems as a “push-pull” system. The supply air system pushes air into the containment zone, delivering a positive pressure inside. The exhaust air system pulls the air from the containment zone, creating a negative pressure. To assure that a net negative pressure is created in the containment zone, the exhaust air should always be pulled from the containment zone at a higher volume than the supply air pushed into it.

The design or placement of these components will determine the effectiveness of a ventilation system. You can use a single-fan, exhaust-only system which, by default, generates a negative pressure in the containment zone. However, such systems may provide limited ventilation and air flow to some points in the containment zone due to the source (spray gun) moving in the work zone. More importantly, exhaust-only ventilation may gradually become less effective as SPF is applied, as the foam seals sources of passive air intake. Fixed, passive supply air sources such as open windows and doors are also problematic in that the ambient air temperature and humidity may be hard to control. The fixed location also may create dead air sites within the containment zone.

A ventilation system consisting of both active exhaust and supply air systems can address these issues. Figure 4 shows an example of a two-fan system.



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**FIGURE 4 - Example of a Two-Fan Ventilation System (active exhaust and supply systems) for Interior SPF Application.**

There are several key points to consider when designing this type of system:

- **Maintain a negative pressure in the containment zone.** A negative pressure within the containment zone assures that contaminants are not forced into other areas of the building. With a two-fan system, negative containment pressures can be achieved when the exhaust fan capacity (e.g., cubic feet per minute or “CFM” rating) is greater than the supply fan capacity. For most systems, it is suggested that the capacity of the exhaust fan exceed the capacity of the supply fan. Check with the fan manufacturers for assistance in determining appropriate fan capacities and how to properly select the fan.

Use caution with multi-speed fans so that the supply fan rate does not exceed the exhaust fan rate. A smoke stick is often used to visually confirm that the containment is always under a state of negative pressure. Observing an inward billowing of the plastic film used for containment can also confirm a negative pressure in the containment zone. If the plastic sheet billows outward, there is too much supply air or insufficient exhaust air.

**Remember: To create a net negative pressure the air pulled from the containment zone must exceed the air pushed into the area.**

- **Check placement and direction of fans.** Place fans in the appropriate direction. Use the larger-capacity exhaust fan for pulling air from the containment zone to the outdoor and the smaller supply fan to bring air into the area.
- **Generate and maintain air flow across the containment source.** Position the inlet of the exhaust system and the outlet of the supply system at locations on opposite sides of the contaminant source. This position helps to assure maximum airflow across the contaminant source. Move the exhaust inlet along with the applicator as necessary as the job progresses to help move contaminants away from

the applicator, and to help position the applicator on a straight line between the supply air outlet and the exhaust air inlet.

- **Avoid unwanted openings in the containment zone.** Unwanted or unknown openings through the containment zone can make the ventilation system less effective. If a negative pressure exists in the containment zone, make-up air will enter the zone from passive openings. If these openings are large enough, a direct flow of air between these openings and the exhaust air system will occur, which may create dead-air spaces in other parts of the containment zone. The ventilation system will not work efficiently if the contaminant source is not between these openings and the exhaust system (e.g., if the spray gun is in a dead space).
- **Exhaust contaminants to a safe outside location.** Air from the outlet of the exhaust system may contain elevated levels of SPF component chemicals and particulates. Direct the exhaust air outside, away from air inlet points and away from occupied areas. Cordon off the exhaust outlet with physical barriers to identify and prevent access to the area.
- **Use filtration on the inlet of the exhaust system.** During the ventilation process, mists and particulates are collected by the exhaust system. Over time, these materials can accumulate and reduce the effectiveness of the ductwork and fan of the exhaust system. Filtration is often used to reduce this accumulation of particulates in the equipment and minimize the contaminants at the exhaust outlet. A box with a replaceable filter can be used. Regularly inspect and replace the filter media for proper function of the exhaust system.

### What to consider when selecting the fan size necessary for the exhaust and supply ventilation

The effectiveness of a ventilation system is determined by the design of the containment zone and the ventilation rate. The containment ventilation rate is measured by the number of air changes per hour (ACH). ACH is how many times per hour the volume of air within the containment area is completely replaced with fresh air.

Use the SPF manufacturer's recommended containment ventilation rate to determine the size of the ventilation system fans. Generally, consider the following:

1. Determine the total volume of the containment zone to be vented. This can be done by taking the floor area in square feet (length x width of the area in feet) and multiplying it by the average height in feet of the containment zone. This provides the total volume of the zone in *cubic feet*.
2. Take the recommended ventilation rate in ACH (air changes per *hour*) and divide it by 60. This is the recommended air changes per *minute*.
3. Multiply the recommended containment ventilation rate in air changes per *minute* by the total volume of the containment in *cubic feet*. This number provides the minimum required capacity of the exhaust fan needed in cubic feet per minute (CFM).

### Example:

An individual is applying SPF to create an unvented attic in a home, as shown in Figure 5. The floor space of the attic is a simple 30' wide by 40' rectangle. The peak of the roof is 6 feet above the attic floor. Assume a ventilation rate of 30 ACH is specified by the SPF manufacturer. What size fan is needed? Assume the entire attic defines the containment zone.

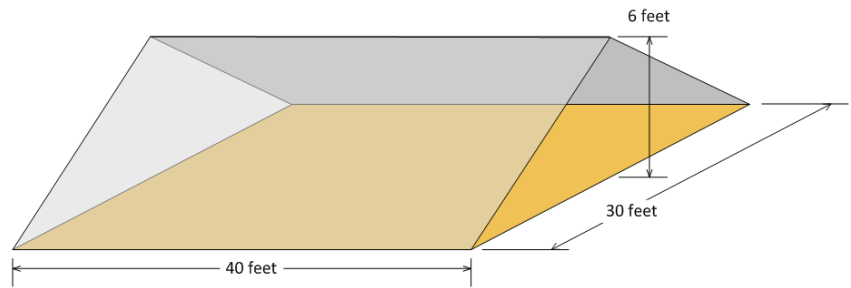


FIGURE 5 - Diagram of Attic

1. Determine the attic (containment zone) volume in cubic feet:
  - a. Area of attic floor = Width x Length = 30' x 40' = 1200 sq. ft.
  - b. Volume of attic = Area x  $\frac{1}{2}$  Height = 1200 sq. ft. x ( $\frac{1}{2}$ ) x 6' = 3600 cu. ft.
2. Convert the recommended ventilation rate to air changes per minute:
  - a. 30 ACH / 60 (min./hr.) = 0.5 air changes per minute
3. Calculate the minimum fan size (larger is better):
  - a.  $0.5 \times 3600 = \text{ACM} \times \text{Volume of Attic} = 1800 \text{ CFM}$

***This information is provided as an example only and calculations must be completed for each separate site.***

Remember the following:

1. Attachments and accessories such as ductwork, length of ductwork, bends or turns in ductwork, ductwork fittings and filters can substantially reduce the rated air flow performance of any fan system. Check with the fan manufacturers for assistance in determining appropriate fan capacities and how to properly select the fan.
2. The size of the containment zone and the desired ventilation rate may exceed the rated performance of the fan systems. In this case, multiple exhaust and supply fans may be necessary to achieve the required air flow (supply and exhaust) or the size of the containment zone may need to be reduced.

Contractors can purchase the necessary fans, ductwork and other equipment to create a complete ventilation system. For example, compact, portable and powerful fans are axial blower fans as shown in Figure 6. These fans, typically about 8-12" in diameter are easy to move around the jobsite and provide a direct controllable air flow pattern. Axial fans of this size can provide unrestricted flow rates of over 2,000 CFM. Users need to review the manufacturer's recommendations to determine the appropriate sized fan for each jobsite.



FIGURE 6 - Flexible Duct Attached to Axial Fan

Portable axial blower fans can be connected to flame-resistant flexible ducts that can be easily positioned inside the containment area, as shown in Figure 4 above. Select a duct

length that is sufficient to reach points within the containment zone to reduce the number of stagnant air spaces.

If there is no easy access to fans with two different flow rates, one can use different size ducts to provide different fan flow rates for the same fan. For example, a 12" diameter fan may be rated at 2,200 CFM of free air flow (using a 12" duct with no 90 degree elbows). The same 12" diameter fan may have a reduced flow rate of 1,700 CFM when connected to an 8" hose with an adapter. Using a 12" duct for the exhaust system, and an 8" duct and adapter for the supply system could provide the necessary flow rate difference. Alternately, the same duct sizes can be used on both the exhaust and supply system when a damper or 'valve' is placed in the supply system to throttle the supply air flow. Observe the plastic film used to isolate a spray area to see if negative pressure is being created (film tends to move inward to the space being sprayed) or use a smoke stick to check proper air flow.

Good worksite practice suggests labeling specific fans and ducts for use as the supply or exhaust system only.

In most cases, the exhaust air should be filtered. Some fan manufacturers provide filter boxes as accessories as shown in Figure 7.



**FIGURE 7 - Filtration Box for Exhaust**

The example provided about using separate supply and exhaust systems is representative. There are other ways to deliver sufficient ventilation rates and negative containment pressurization on a given SPF jobsite. Truck or rig mounted ventilation systems may be used. Another example is the use of an axial exhaust system with a blower-door fan to provide supply air. Each jobsite must be evaluated to determine appropriate ventilation system design and equipment.

### What to consider when using an exhaust and supply ventilation system during installation

The setup of the ventilation system can be challenging, especially when working in the attic or crawlspace of an existing home.

When working in an attic or crawl space of an existing home, finding the necessary openings for the supply and exhaust ducts can be difficult. Consider whether it is feasible to run both the exhaust and supply ducts through a small scuttle hatch into the attic or crawl space. If the hatch is not used for both exhaust and supply, consider connecting the supply duct to an existing external opening, such as a gable or soffit vent or an attic fan opening. If this option is selected, consider spraying a piece of foam (or use boardstock foam) that can be cut to fit into and seal the opening after the ventilation time period is completed. Consider using a low-pressure spray foam system to adhere the foam "patch" in place and caulk the crack between the patch and the remainder of the surface. Another option is to create a supply duct opening in the ceiling of a concealed area like a closet (with the owner's permission). In all cases direct the exhaust duct to a safe outside location. An example is provided in Figure 8.

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Remember that the ducts in the work zone can create excessive trip hazards or limit emergency egress. Consider routing fans through temporary openings in soffits or gable end walls to help reduce trip hazards or improve emergency egress.

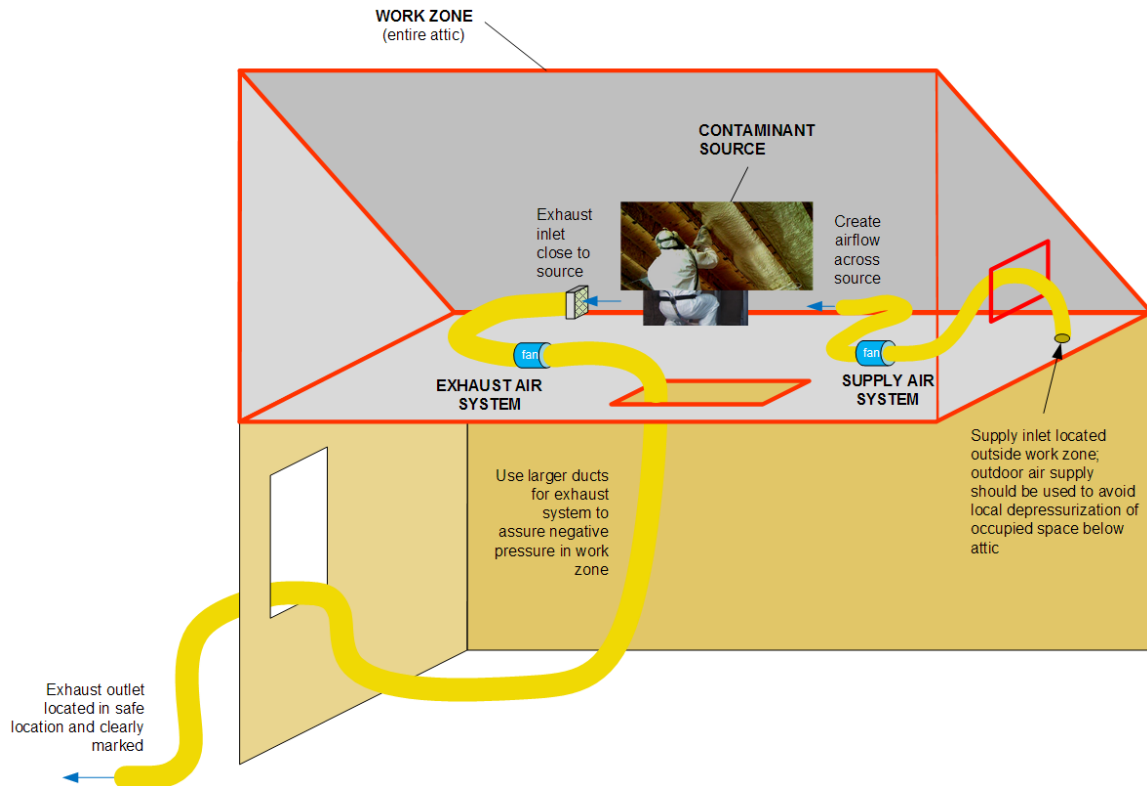


FIGURE 8 - Two-Fan Ventilation System for SPF Application in an Unvented Attic

### What to consider when determining how long to continue ventilation after installation

After SPF is applied, continue to follow the manufacturer's instructions regarding ventilation rate and duration of ventilation in the work zone. Some of the factors affecting the ventilation period include specific SPF formulations and cure times, ventilation rate and ambient temperature and humidity inside the containment area. During this time, reentry includes only workers with appropriate PPE. Other trades can re-enter after the manufacturer's stated reentry time.

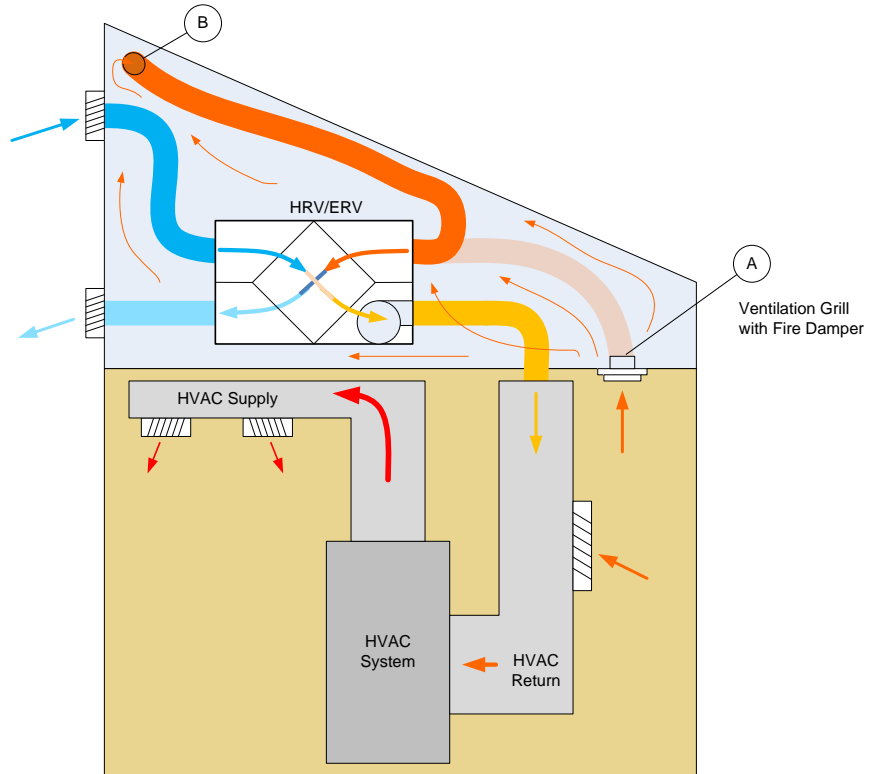
### What to consider when thinking about extended ventilation

In some cases, extended ventilation may be helpful or desired. For example, older homes may have odors in the attic from mold, rodent and bat droppings and other contaminants. In these cases, extended ventilation may be helpful. Contractors may opt to leave existing permanent balanced ventilation systems in place, or may choose to use an alternate system such as an exhaust-only system. Check with the SPF manufacturers for extended ventilation



rates, which may be much lower than the rate used during and immediately after SPF application.

For extended ventilation, a smaller exhaust-only system may be used where the outlet of the exhaust only system is positioned in a proper location. Another option is to use a heat recovery ventilator (HRV) or energy recovery ventilator (ERV) installed inside the containment area, which is an example of an energy-efficient means to provide extended ventilation (shown in Figure 9). If this option is utilized, the exhaust line is disconnected from the vent opening (A), a fire-damper grille is installed on the opening, and the exhaust line is positioned in the attic (B) far from the disconnected vent. Read and follow the HRV/ERV manufacturer's recommendations if this extended ventilation option is utilized. This configuration can provide extended ventilation for several days after which the contractor re-installs the exhaust duct when the extended ventilation is complete.



**FIGURE 9 - Extended Ventilation using HRV/ERV System**

### In Summary:

- During and immediately after high-pressure SPF installation in indoor applications, some SPF component chemicals may be present in the form of mists and vapors over the occupational exposure level (OEL) or at levels that could be harmful to some individuals.<sup>c</sup>
- To protect workers and others against exposure, the SPF contractor is required by OSHA to establish engineering controls and ensure proper personal protective equipment is utilized by their employees in the work zone.
- Engineering controls for high-pressure SPF application can include establishing a containment zone that is mechanically ventilated using adequately-sized exhaust and supply air systems.
- Ventilate the SPF work zone during application and adhere to manufacturer re-entry/re-occupancy guidance after spray activities are complete.
- On some construction sites, the use of mechanical ventilation and/or temporary containment walls during SPF application may not be feasible or necessary. Consult Appendix A for list of suggested factors to consider when determining the proper safety measures for a specific job.
- Consult with the SPF manufacturer to determine the recommended re-entry and re-occupancy times for the particular job and SPF formulation.
- Consider extended ventilation to temporarily increase the air exchange rate within the structure and help remove existing odors and other contaminants.

### How Can I Get More Information on SPF Ventilation

- Contact the SPF product manufacturer or supplier, or contact an industrial ventilation equipment supplier.
- Refer to information posted on CPI's SPF chemical health and safety website at [www.spraypolyurethane.org](http://www.spraypolyurethane.org).
- Consult the National Institute for Occupational Safety and Health (NIOSH) by either calling 1-800-CDC-INFO or by visiting the NIOSH website.
- Refer to EPA's Ventilation Guidance for Spray Polyurethane Foam Application.<sup>1</sup>
- Refer to the Spray Foam Coalition's Guidance on Best Practices for the Installation of SPF.<sup>9</sup>

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<sup>c</sup> Not all SPF component chemicals have OELs.

### References

- <sup>1</sup> “Ventilation Guidance for Spray Polyurethane Foam Application,” published by the U.S. Environmental Protection Agency (EPA), online at <http://www2.epa.gov/saferchoice/ventilation-guidance-spray-polyurethane-foam-application>
- <sup>2</sup> “Health and Safety Product Stewardship Workbook for High-Pressure Application of SPF,” published by the American Chemistry Council’s Center for the Polyurethanes Industry, available online at [www.spraypolyurethane.org/Workbook/](http://www.spraypolyurethane.org/Workbook/)
- <sup>3</sup> “Personal Protective Equipment Sheet,” published by the American Chemistry Council’s Center for the Polyurethanes Industry, available online at [http://www.spraypolyurethane.org/ppe\\_sheet](http://www.spraypolyurethane.org/ppe_sheet)
- <sup>4</sup> Wood, Richard. “CPI Ventilation Project Phase 1 and Phase 2 Update.” Presented at the CPI Technical Conference, September 2012.
- <sup>5</sup> Wood, Richard. “CPI Ventilation Research Project Update.” Presented at the CPI Technical Conference, September 2013.
- <sup>6</sup> Robert, William, James Andersen, Richard Wood, and Mary Bogdan. “Ventilation and Re-Occupancy of a Residential Home Sprayed with High Pressure Polyurethane Foam.” Presented at the CPI Technical Conference, September 2012.
- <sup>7</sup> Code of Federal Regulations Title 29 CFR §1926.20 Safety and Health Regulations for Construction: General Safety and Health Provisions available online at [www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=STANDARDS&p\\_id=10606](http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10606)
- <sup>8</sup> “Good Practices - Engineering Controls and Ventilation,” published by the American Chemistry Council’s Center for the Polyurethanes Industry, available online at: [www.spraypolyurethane.org/GoodPractices#EngineeringControls](http://www.spraypolyurethane.org/GoodPractices#EngineeringControls)
- <sup>9</sup> <http://polyurethane.americanchemistry.com/Spray-Foam-Coalition/Guidance-on-Best-Practices-for-the-Installation-of-Spray-Polyurethane-Foam.pdf>

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### Appendix A

On some construction sites, restricting access to the SPF application area can be sufficient to provide for the safety of personnel not involved in spray activities. Each situation must be evaluated prior to beginning spray activities to determine the appropriate safety measures to protect all workers. Below is a list of factors that may help determine whether the use of mechanical ventilation and temporary containment zones is feasible or necessary. No one factor is determinative of the proper safety measures.

- **Size of the building.** Restricting access to the SPF application zone in large industrial or institutional buildings or multi-story buildings may protect other trades and building occupants not directly involved in the spray application.
- **Construction state.** In large buildings that are currently under construction, it may not be feasible to use mechanical ventilation or temporary containment zones due to the size of the area or amount of natural airflow in the area. Restricting access to the SPF application zone may protect other trade workers not directly involved in the spray application. Non-SPF workers should not be allowed to enter the spray area until the SPF contractor has removed all spray equipment and cleared the work zone for re-entry.
- **Amount of natural air flow.** On some construction sites, the amount of natural air flow does not necessitate the use of mechanical ventilation or makes the use of temporary containment walls not feasible. Restricting access to the SPF application zone may protect other trade workers not directly involved in the spray application.
- **Staged materials and equipment.** Ensure that all staged materials and spray equipment are masked off to prevent over spray if the use of mechanical ventilation or temporary containment zones are determined to be unfeasible or unnecessary.



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