Ventilation Considerations for Spray Polyurethane Foam

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

Spray Foam Coalition
Center for the Polyurethanes Industry

American Chemistry Council | Spray Foam Coalition

This document is intended to provide general guidance on ventilation during installation of interior applications of spray polyurethane foam (SPF) in new residences and buildings and during renovation and weatherization projects in existing homes and buildings. SPF is a widely used and highly effective insulation and sealant material that is spray-applied to walls, ceilings, attics, basements, and crawl spaces.

SPF is a highly effective sealant, and its application could 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 it is appropriate.

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

Work zone mechanical ventilation during and after SPF installation is designed to prevent workers and others in the area from being exposed to SPF chemicals above recommended or permissible levels. Potential health effects from exposure above recommended levels 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.[1, 2]

SPF chemical components include isocyanates (A-side material), which are irritants (causing effects on eyes, skin, and respiratory system) and sensitizers that may produce an allergy-like response in some people after re-exposure. Exposure of a sensitized individual has the possibility to 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. These component materials could also result in irritation of eyes, skin and respiratory system from overexposure. A temporary condition referred to as “Blue Haze” or “Halovision” could also result from exposure to catalysts. For more information on chemical health and safety, see “Health and Safety Product Stewardship Workbook for High-Pressure Application of SPF.”[2] Important information concerning health and safety is available online for free, including the CPI Chemical Health and Safety Training for both high-pressure SPF and low-pressure SPF here: www.spraypolyurethane.org.

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 occupational exposure level (OEL) or at levels that could be harmful to some individuals.[a] Engineering controls including containment and properly designed ventilation systems should be used *in tandem* with proper personal protective equipment (PPE).[3] These protective measures can help prevent SPF applicators, helpers, and others who may be working in adjacent areas from potential exposures. In addition, taking steps like access restrictions and evacuation of the home are important during and shortly after installation to minimize potential exposures.

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[a] Not all SPF component chemicals have OELs.

Current studies show use of engineering controls alone (containment and ventilation systems) during high-pressure SPF application do not sufficiently reduce airborne chemicals to below levels needed to eliminate the use of recommended PPE for those in the work zone during and shortly after spraying.[4,5] Use engineering controls and proper PPE together when applying high-pressure SPF in interior applications.

When to consider using a mechanical ventilation system during installation

Airborne SPF 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 chemicals. The need for mechanical ventilation systems during application and shortly after should be reviewed in all applications of high-pressure SPF.

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

According to OSHA regulations,[6] SPF contractors have a legal responsibility to provide a safe workplace for all employees. In the case of high-pressure SPF application, use of engineering controls and proper PPE in the work zone during and 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, containment and ventilation methods, the importance of vacating, and when it is safe to reoccupy the building during and 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 will be different. Work zones vary in size, geometry and ambient conditions, and the delivery rate and position of the contaminant source (i.e. spray gun), as well as air flow, will change throughout the job as the applicator moves around the room.

Applicators, helpers, occupants, and adjacent workers should avoid inhalation of, and skin and eye contact with, SPF chemicals.[7] The following practices, including engineering controls, work practices, and PPE, are intended to reduce the potential for overexposure to SPF chemicals via inhalation, skin or eye contact. Consider a combination of engineering controls, work practices, and PPE for SPF applications. Individuals not involved in the application process vacate the area and return after informed that it is safe to do so.

Engineering Controls: Proper containment and ventilation techniques can help prevent workers and building occupants from potential exposure due to SPF application, particularly in interior applications when buildings cannot be vacated. This can occur in large, commercial buildings where vacating the entire building is not feasible. Containment creates a restricted work zone while the ventilation system removes SPF chemicals from the work area by drawing the air out of the work zone through the use of a fan. 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 area. 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 personnel wearing proper PPE.
- **Ventilation Design:** Ventilation used with work zone containment removes chemicals from the isolated area via negative pressure. Having 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 to an unoccupied space where it is not drawn through an air intake. This also helps protect occupants and workers in adjacent areas from potential exposure.

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. Minimizing air and particulate migration not only helps prevent unwanted deposits (i.e. overspray) on finished surfaces outside of the work zone, but also prevents the spread of contaminants to those areas. Containment can minimize the need for additional ventilation outside of the work zone.
- Minimizes the total volume of the work zone for ventilation, thus reducing the size and number of fans, and 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, thus helping to prevent unwanted entry by persons not wearing PPE.

An example of a material used to build a containment area in SPF applications is 4-6 mil polyethylene sheeting. Sheeting can be purchased in roll widths corresponding to the interior wall height, usually 8-10 feet high. This sheeting should be installed to 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, are temporarily blocked with faced fiberglass batts, plastic sheeting or other materials and tape to minimize air flow as shown in Figure 1. All finished surfaces, such as windows and immovable furnishings and appliances, are masked to prevent overspray.

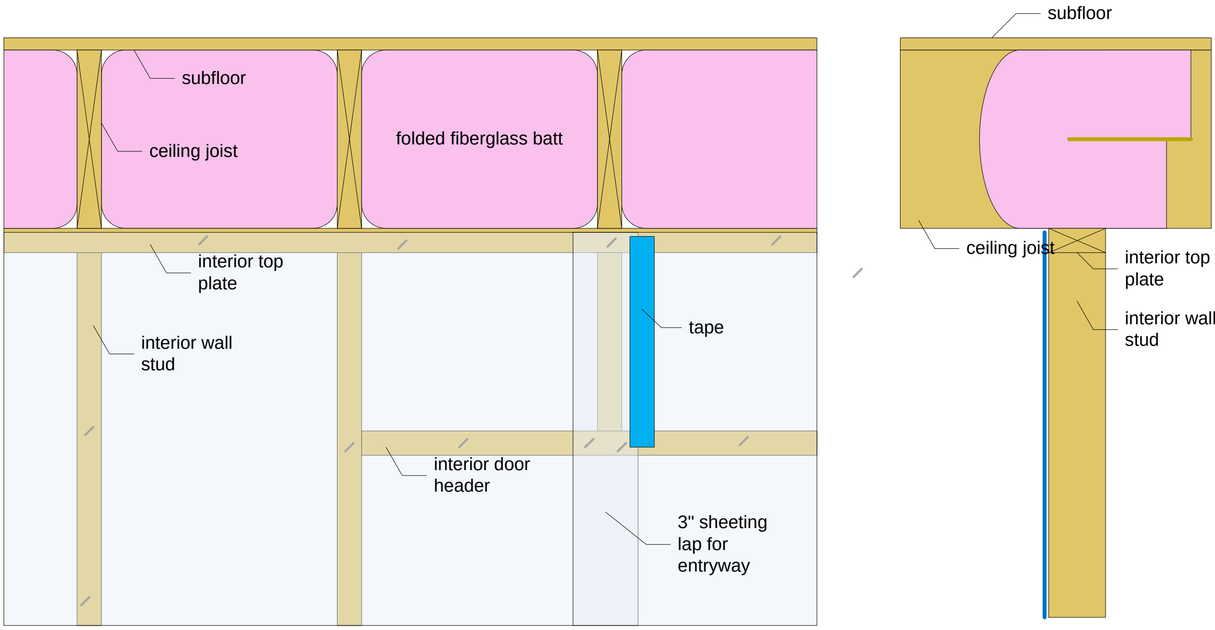

FIGURE 1 – Example of using batts to seal openings in ceiling joists

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 after ventilation is stopped and prior to re-occupancy.

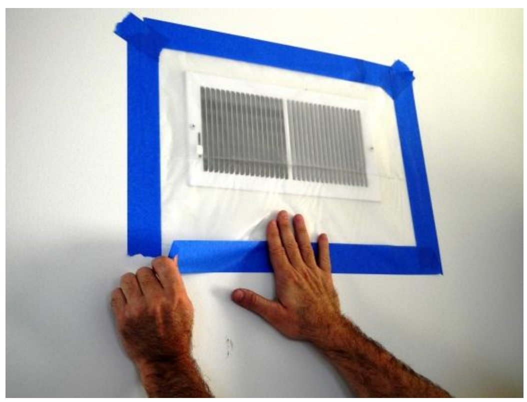

FIGURE 2 - Cover and taping all grille and register openings into containment

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

An adequately-sealed containment system will provide a negative-pressure enclosure around 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 this source (the spray gun) moves as the point of application progresses throughout the work zone. This moving of the source 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 the 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.
- **Work Zone:** The space, room or enclosure to be ventilated, within the containment area.
- **Exhaust Air System:** The exhaust air system includes an exhaust point, ductwork and an exhaust fan that captures contaminates 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 work 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 (such as 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 contained space, delivering a positive pressure inside. The exhaust air system pulls the air from the containment, creating a negative pressure. To assure that a net negative pressure is created in the containment, the exhaust air pulled from the containment should always be more than the supply air pushed into it.

How one designs or places each of these components will determine the effectiveness of a ventilation system. One can employ a single-fan, exhaust-only system which, by default, generates a negative pressure in the work zone or containment. However, such systems may provide limited ventilation and air flow to some points in the work zone due to the source (spray gun) moving in the work zone. More importantly, exhaust-only ventilation may gradually become less effect as SPF is applied, as the foam seals sources of passive make-up air. 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, and the fixed location may create dead air sites within the containment.

A ventilation system consisting of both active exhaust and supply air systems can address these issues. Figure 4 shows such a two-fan system. There are several key points to consider when designing this type of system:

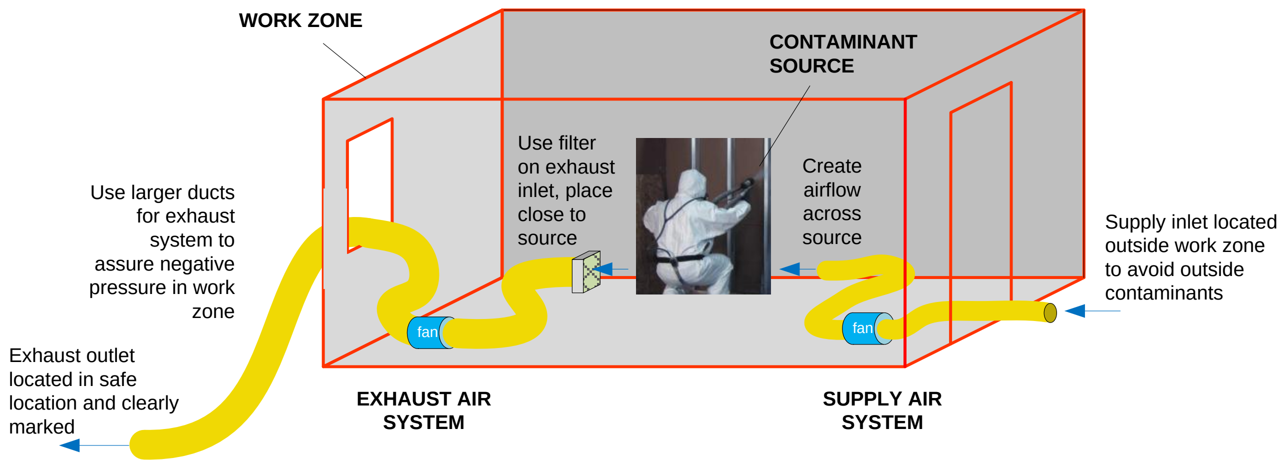

FIGURE 4 – Example of a Two-Fan Ventilation System (active exhaust and supply systems) for interior SPF Application

- **Maintain a negative pressure in the work 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 always be achieved when the exhaust fan capacity (e.g., CFM rating) is greater than the supply fan capacity. For most systems, it is suggested that the capacity of the exhaust fan exceeds the capacity of the supply fan. Use caution with multi-speed fans so that the supply fan rate does not exceed the exhaust fan rate. A smoke-pencil 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 area. 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 exceeds the air pushed into the containment.
- **Check placement and direction of fans.** Direct fans in the appropriate direction: use the larger-capacity exhaust fan for pulling air from the containment area to the outdoor and the smaller supply fan to bring air indoors.
- **Generate and maintain air flow across the spray area.** Position the inlet of the exhaust system and the outlet of the supply system at locations on both sides of the spray foam application site (contaminant source). This position helps to assure maximum airflow across the application site. 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 have the applicator (contaminant source) lined up on a straight line between the supply air outlet and the exhaust air inlet.
- **Avoid unwanted openings in the work zone.** Unwanted or unknown openings through the work containment zone can make the ventilation system less effective. If a negative pressure exists in the work zone, make-up air will enter the containment from these 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. If the SPF application site is not between these openings and the exhaust system (e.g., if the spray gun is in a dead space), the ventilation system will not work efficiently.
- **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, far away from the air inlet point and away from occupied areas. Cordon the outlet off with physical barriers to prevent access and mark it.

- **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. To reduce this accumulation of particulates in the equipment and minimize the contaminants at the exhaust outlet, filtration is often used. 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 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 to be vented. This can be done by taking the floor area in square feet (length x width of the containment floor in feet) and multiplying it by the average height in feet of the containment. This provides the total volume of the containment 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.

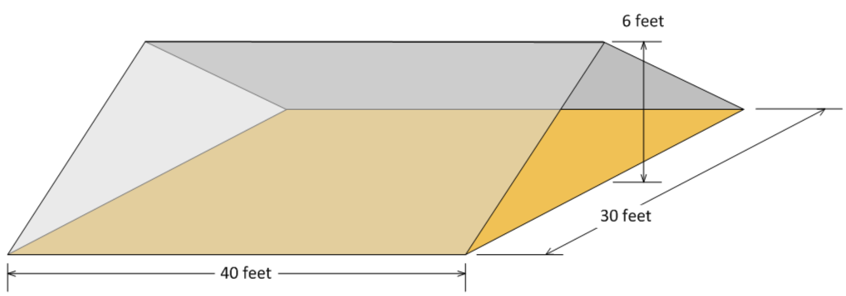

FIGURE 5 - Diagraph of Attic

1. *Determine the attic (containment zone) volume in cubic feet:*
   a. *Area of attic floor = 30' x 40' = 1200 sq. ft.*
   b. *Volume of attic = 1200 sq.ft. x (½) x 6' = 3600 cu.ft.*
2. *Convert the recommended ventilation rate to air changes per minute:*
   a. *30 ACH / 60 = 0.5 air changes per minute*

3. *Calculate the minimum fan size (larger is better):*
   a. *0.5 x 3600 = 1800 CFM*

This information is provided as an example only.

Remember the following:
1. Attachments and accessories such as ductwork, ductwork fittings and filters can substantially reduce the rated air flow performance of any fan system. Check with the fan manufacturers to confirm how to properly size the fan.
2. The size of the containment and the desired ventilation rate may exceed the rated performance of the fan systems. In this case, multiple exhaust and supply fans may prove necessary to achieve the required air flow (supply and exhaust) or the size of the containment 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 that may be adequate for small homes or partitioned containment areas in larger homes and buildings, but users need to review the manufacturer's recommendations.

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 8. Duct lengths of around 25 feet help to be able to reach more points within the containment area 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. For example, 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.

FIGURE 7 – Filtration Box for Exhaust System Inlet

Also, a good worksite hygiene practice is to consider using and labeling specific fans and ducts for supply or exhaust system use only.

Consider how to filter the exhaust air. For example, some fan manufacturers provide filter boxes as accessories as shown in Figure 7. Remember that the purpose of this filter is to protect the downstream equipment, not to remove allergens and dust.

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.

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 applying SPF in a typical room, a configuration as shown in Figure 4 may be used.

When working in an attic or crawl space of an existing home, finding the needed openings for the supply and exhaust ducts can be difficult. Consider whether it is difficult or unsafe 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 the 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, and not foam over it initially. If this option is undertaken, consider spraying a piece of foam (or use boardstock foam) that can be cut to fit into 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. An additional option is to create a supply duct opening in the ceiling of a concealed area like a closet (with the owner’s permission). With any option chosen, direct the exhaust duct to a safe outside location. An example is provided in Figure 8.

Remember that the ducts in the work zone could create excessive trip hazards or limit emergency egress.

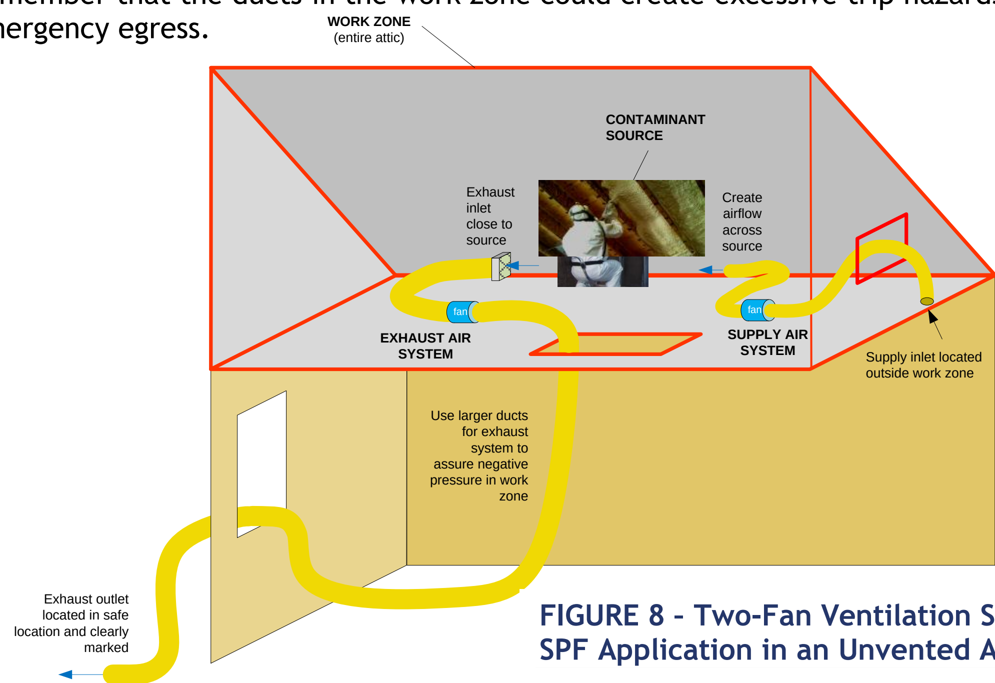

FIGURE 8 – Two-Fan Ventilation System for SPF Application in an Unvented Attic

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

After foam is applied, continue to follow the manufacturer's instructions regarding ventilation rate and duration to ventilate the work zone. Some of the factors affecting the ventilation period include specific foam formulations and cure times, ventilation rate and ambient temperature and humidity inside the containment. During this time, reentry includes only persons with appropriate PPE. Occupants 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 small animal carcasses. In these cases, extended ventilation may be helpful. Contractors may opt to leave the existing ventilation system 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 shortly 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 safe 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.

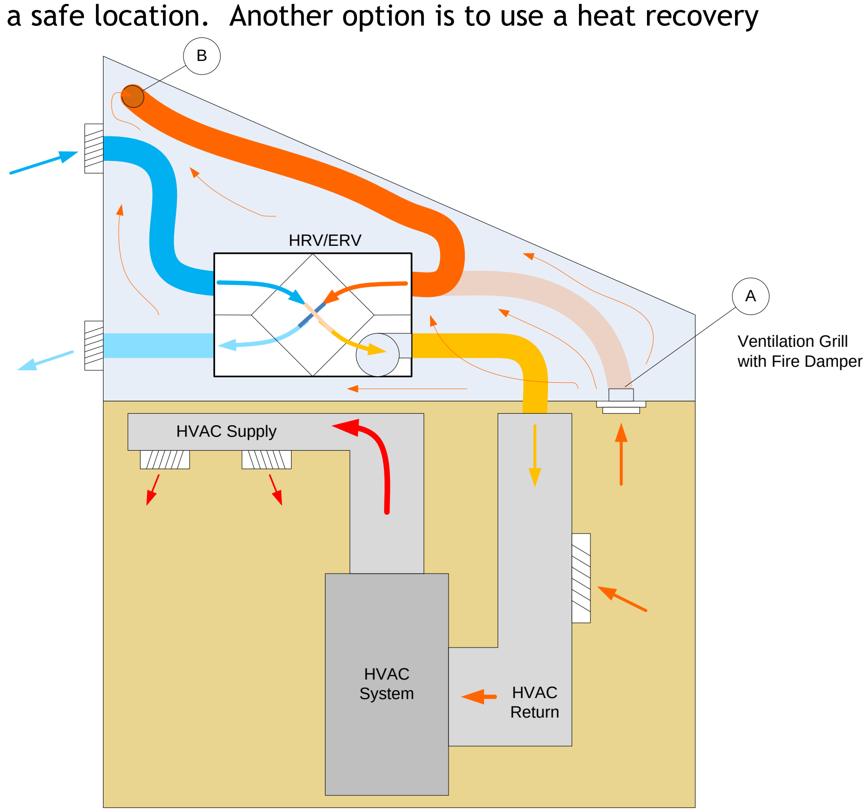

FIGURE 9 - Extended Ventilation using HRV/ERV System

In Summary:

- During and shortly after high pressure SPF installation in indoor applications aerosol mists and vapors can be generated at levels over the occupational exposure level (OEL) or at levels that could be harmful to some individuals.[b]

- 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 after spraying based on SPF manufacturer's installation instructions.

- Consult with the SPF manufacturer to determine the recommended reentry and re-occupancy times for the particular job and SPF in use.

- Consider extended ventilation to remove odors.

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.com.
- 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[1]
- Guidance on Best Practices for the Installation of SPF[8]

Disclaimer: This guidance document was prepared by the Spray Foam Coalition of the American Chemistry Council's Center for the Polyurethanes Industry. It is intended to provide general information to professional persons who may be involved in installing spray polyurethane foam. It is not intended to serve as a substitute for in-depth training or specific construction requirements, nor is it designed or intended to define or create legal rights or obligations. It is not intended to be a "how-to" manual, nor is it a prescriptive guide. All persons involved in construction projects including spray polyurethane foam have an independent obligation to ascertain that their actions are in compliance with current federal, state and local laws, codes, and regulations and should consult with legal counsel concerning such matters. The guidance is necessarily general in nature and individuals may vary their approach with respect to particular practices based on specific factual circumstance, the practicality and effectiveness of particular actions and economic and technological feasibility. Neither the American Chemistry Council, nor the individual member companies of

[b] Not all SPF component chemicals have OELs.

References

[1] "Ventilation Guidance for Spray Polyurethane Foam Application," published by the U.S. Environmental Protection Agency (EPA), online at www.epa.gov/dfe/pubs/projects/spf/ventilation-guidance.html

[2] "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/

[3] "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

[4] Wood, Richard. "CPI Ventilation Project Phase 1 and Phase 2 Update." Presented at the CPI Technical Conference, September 2012.

[5] 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.

[6] 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

[7] "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

[8] http://polyurethane.americanchemistry.com/Spray-Foam-Coalition/Guidance-on-Best-Practices-for-the-Installation-of-Spray-Polyurethane-Foam.pdf