UMassAmherst | Environmental Health & Safety

Fume Extractors

Fume extractors are useful pieces of equipment for affording protection of personnel for various activities that could release harmful fumes. Some of these activities include, but are not limited to: soldering, welding, laser cutting, and 3D printing. Use of a fume hood or other appropriate local exhaust ventilation can provide protection of personnel engaged in these activities; however, local exhaust ventilation may not always be available or feasible for a particular task. When this is the case, alternative controls must be put in place to keep personnel safe. Fume extractors that rely on filtration technologies are cost-effective and appropriate control strategies for well-defined, lower hazard operations that can be easily implemented. The various types and parameters for selection are discussed in this document.

Figure 1. Fume extractor with a snorkel attachment.

Filtration technology for particulate matter

Particulate matter includes small particles and aerosols, typically of 10 µm or less in aerodynamic diameter, that can remain airborne for significant periods of time and are capable of penetrating deep into lungs if inhaled. Exposure to particulate matter has been linked to a range of health effects including increased risk of heart attack and stroke. Sources of particulate matter can include smoke from laser cutting and other processes, 3D printing, and dust generating activities including sanding of materials and handling fine powders. Small particles and aerosols can be tricky to filter due to their variability in size and shape, and therefore, many capture technologies have been created primarily relying on four major filtering mechanisms: impaction, interception, diffusion, and electrostatic interactions.

HEPA filters, which are used in many of the tabletop and portable extractors, work on the first three of these mechanisms. HEPA filters are constructed of layers of pleated (to increase surface area) materials. The considerable thickness of the filters, where layers upon layers of these pleats create a mat of fibers that are dense and randomly arranged, increases the probability that particulate matter will be captured. Diffusion occurs when particulates that are

smaller than 0.1 µm collide, which delays their passing through the filter. This delay then allows the other two mechanisms to work on these smaller particles, thus filtering them out of the air. Interception occurs when the molecules stick to a fiber. The dense and random arrangement of these layers makes this more likely to occur when passing through the medium. Finally, larger molecules embed directly into the fibers, which is known as impaction. These mechanisms work in tandem in a HEPA filter, creating the desired effect of filtration.

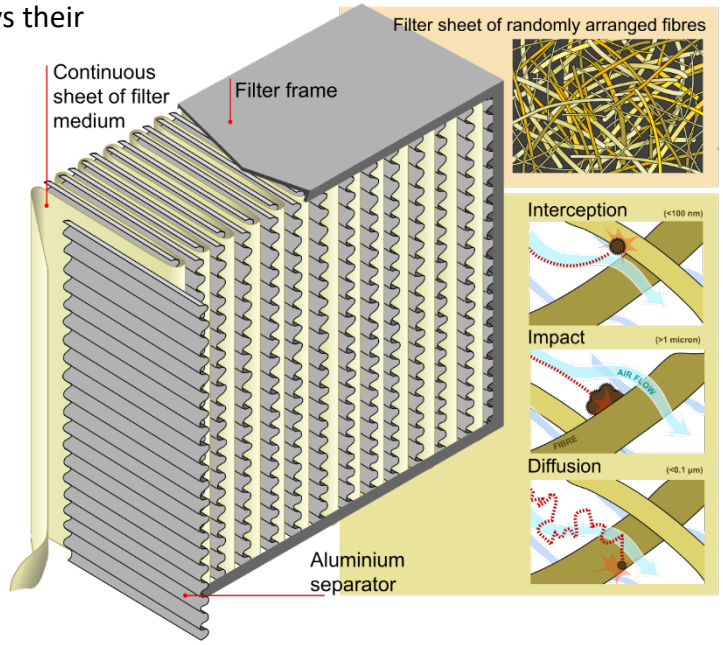

Figure 2. Diagram depicting how a HEPA filter works through impaction, interception, and diffusion.

HEPA filters are by far the most proven and widen used technology used for capturing particulate matter. Other technologies may also be effective; however, manufacturer claims of capture efficiency should be independently assessed and verified prior to relying on these for exposure prevention. Consult with EH&S if you are unsure.

Filtration technology for vapors

Many filters for vapors (including tabletop soldering as discussed below) include an active carbon component to trap these vapors from the work area. Activated carbon is carbon that has undergone a process to make it better at trapping these molecules. First, it is injected with hot air, CO_2, or steam which creates pores in the carbon, increasing the surface area for the molecules to become trapped. Then, most activated carbon is treated with a chemical that enhances its ability to filter. The pollutants in the air adsorb to the carbon, which removes them from the workspace. Over time, the pores of the activated carbon will be filled up with molecules, thus, they need to be changed periodically in order to function properly.

Limitations of Filtration Technology and Fume Extractors

While many different airborne hazards can be appropriately mitigated through the use of filtration technology, there are a few limitations to be aware of.

- HEPA filters, carbon filters, and other materials used in filters are combustible. If sparks or embers are allowed to come into contact with these items, fires can happen. Care must be taken when selecting filtration units for processes that can generate sparks or

embers, including laser cutters and welding. Consult with equipment manufacturers and EH&S before using filtration units for these applications.

- While activated carbon filters can effectively capture many different kinds of chemical vapors, not all chemicals are captured equally, and some are not captured at all. Some materials may have very low capture efficiencies and filtration technology may not be adequate to afford appropriate protection for use with those items. Consult filter manufacturers and EH&S before implementing for a particular process.
- Filters have finite lifetimes and must be changed on an appropriate schedule. HEPA filters can become clogged overtime and diminish the particle capture efficiency by reducing fan performance. Carbon filters can reach capture capacity limits and fail to absorb chemical vapors. Follow manufacturer specifications for filter change out schedules, and change filters when there is evidence that filters are no longer working (e.g., odors are observed).
- Use of single filters for capturing multiple chemicals can affect filter capture performance in unexpected ways, and as such, filtration technology is best suited to well-defined processes of limited scope. If you have questions about particular uses, please contact EH&S in consultation with the manufacturer.

In addition to the considerations of limitations of the filter technology, the fan capacity for the unit must be selected such that it affords appropriate volumetric air flow and static pressure to a given piece of equipment or process. If the fan is not powerful enough, appropriate capture of contaminants will not be achieved. Some equipment is also equipped with static pressure sensors that will prohibit the equipment from being operated if exhaust of appropriate static pressure and volumetric flow rate is not provided. Follow manufacturer's recommendations for equipment and consult with EH&S.

Tabletop soldering

When soldering is performed on a tabletop or benchtop, a small fume extractor, using both carbon and HEPA filters, can be used close to the soldering surface to remove the harmful fumes that are created. These fumes can include the metals being joined together, or other materials such as coatings, fluxes, and cleaning agents. Ideally, soldering can be done inside of a fume hood or under a snorkel, but these extractors are a great alternative if used correctly. This includes ensuring that the unit is close enough to the point of soldering to successfully collect the fumes, and not allowing them to hit the breathing zone of the user. This is typically no more than 5 inches away, but always follow the manufacturer's guidance. These are available for purchase through many vendors. If you have difficulty located a

Figure 3. Tabletop fume extractor used for soldering with a carbon filter.

product or vendor, or if you have questions about particular items, please contact EH&S. Please note that not all units contain both a carbon filter and a HEPA filter. Please be sure to select units that contain both. For additional information on soldering safety, please consult the EH&S SOP on soldering.

Portable fume extractors

When equipment cannot be directly connected to hazardous exhaust, either because of cost or availability of ventilation infrastructure, portable fume extractors can provide effective containment of fumes depending on their components, such as fan capacity, and filtering media. These can help with laser cutters, electronics, printing, 3D printing, and various other applications that create many types of fumes, provided that appropriate filters are used and the fume extractors are appropriate for the process. Please note that fume extractors may not be able to provide appropriate containment for all applications, so always consult with EH&S before implementing these as a solution.

These systems offer a variety of unique filtration apparatus through their various models that include standard, inline, and, sometimes, patented filters. There are many companies that have unique models and filtration technologies. There are even some options on Buyways through Grainger to get some simple setups that your lab may need. One brand that offers various unique systems that some labs use on campus is BOFA. EH&S is happy to consult and help your lab decide which type of filter and unit may work best in a situation.

BOFA extractors (a brand of portable fume extractors) offer many modifications to "simple" setups with various technologies to help with your lab's needs. BOFA units can be equipped with certain modifications as well to further assist with removing fumes from a room. For example, an exhaust hose can be added to the unit in order to exhaust some materials into local exhaust, which might be necessary if some materials emitted by the process are not effectively captured by the filters. There must be proper air flow from the ventilation system and the BOFA unit in order to achieve this. Consultation with EH&S would be necessary to determine what solutions would be appropriate. Ideally, equipment can be connected to directly to hazardous exhaust, but this is not always feasible or necessary.

Figure 4. Standard BOFA fume extractor that can be modified for various applications.

Laser cutters

Laser cutters should be purchased and installed through consultation with EH&S. Use of fume extractors with large and high-powered laser cutters would typically not be appropriate as it can present a risk of fire. These units require direct exhaust connections. Smaller laser cutters should only be used with a fume extractor recommended by the manufacturer after approval

from EH&S. Fume extractors used for this purpose will frequently have spark arrestors, or other features, installed to prevent risk of fire. For additional information on laser cutters, please consult the EH&S SOP on Laser Cutters.

3D printers

The risks with 3D printing come from the material being used in the process and the process itself. A majority of the emissions from plastic fed 3D printers are nanoparticles and volatile organic compounds (VOCs), which can be filtered through HEPA filters and charcoal filters, respectively, to mitigate most of the risk. A 3D printer should generally be used in a well-ventilated room. 3D printers can be used in ventilated enclosures that exhaust outdoors or are filtered either directly or with a fume extractor. Some materials used in special 3D printing scenarios, such as metals or biological materials, can produce other harmful emissions or create other risks like fires, so please consult with EH&S for these processes. Please also see the EH&S 3D Printers Fact Sheet for additional information.

Welding

Welding is a process that joins two pieces of metal by heat, pressure, or a combination of the two. Besides the heat and fire risks, fumes and gases create a large part of the risk of welding, and proper controls should be in place when performing this task. In the absence of an adequate naturally ventilated space, engineering controls must be used. Local exhaust ventilation would be the most effective means of removing contaminants and reducing the risk of fire, however, in the absence of a local exhaust system, carefully selected and specialized fume extractors can provide adequate containment of particles and hazardous fumes. Fume extractors used for welding must have components that are selected and constructed to tolerate the high heat and ensure embers and sparks do not come into contact with combustible materials. It is also important to keep in mind that a fume extractor will not remove the heat that is associated with welding, and therefore, additional thermal control measures may be necessary to implement to provide acceptable conditions for occupants. Please consult with EH&S before selecting a fume extractor for welding and for options on handling heat loads. Please also consult the EH&S SOP on welding.

Figure 5. Example of a portable fume extractor that can be manipulated and moved depending on the operator needs.

Resources

HEPA Filters

Activated Carbon

UMass EH&S Soldering SOP

BOFA Website

UMass EH&S Laser Cutter SOP

UMass EH&S 3D Printer SOP

UMass EH&S Welding SOP

Fume Extractor Webpage