Safety Solutions for 3D Additive Manufacturing Printing Processes

Long before their headline grabbing use for overcoming PPE shortages, 3D printers have been used in Maker Spaces, Engineering Labs, R&D departments, and even homes across the globe.

The Hazards

Additive Manufacturing is a marvel of the modern world. Within hours, possibly even minutes, you can hold a pre-production version of a part to be used in a new design. Additive manufacturing technology, also called Fused Deposition Modeling (FDM), significantly compresses the product development life-cycle and lowers the cost burden of exploring new ideas and designs. All of this is good, great in fact, but brings with it some new concerns for safety.

Depending upon the type of filament used for printing (e.g. PLA, ABS, Nylon, etc.), hazardous vapors, fumes and particles can be emitted in dangerous concentrations. Ultrafine Particles (UFP) present risks that are associated with lung damage and translocation to the bloodstream (NIH). Harmful Volatile Organic Compounds (VOCs) are emitted in varying degrees and are highly dependent upon the filament material being used. Frequent exposure to UFPs and VOCs is now associated with adverse health effects on the human body.

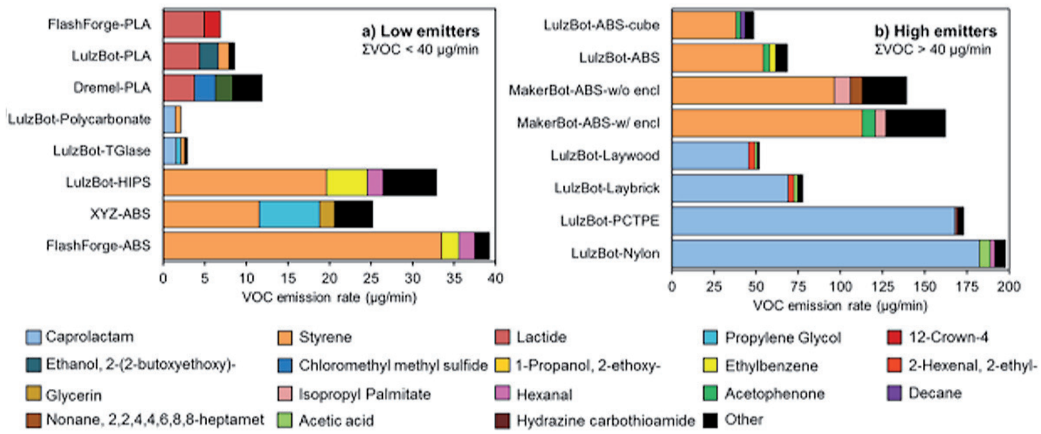

Image credit: P. Azimi, D. Zhao, C. Pouzet, N. E. Crain and B. Stephens, "Emissions of Ultrafine Particles and Volatile Organic Compounds from Commercially Available Desktop Three-Dimensional Printers with Multiple Filaments," Environmental Science and Technology, vol. 50, no. 3, pp. 1260-1268, 2016.

3D printing applications will also include post-processing methods to obtain the desired look and feel for your prototype. Cleaning, smoothing, welding, and surface finishing are all part of this process, and will require the use of chemicals (e.g. Dichloromethane, Ethyl Acetate, IPA, Acetone, THF). Such substances also pose a health hazard to the operator, which need to be addressed with safety measures.

As with most source generation, the further away you are the less concentration you'll be exposed to and therefore the safer you should be. However in many cases, the 3D printer is needed close by to the workstation or occupied areas. Therefore, most 3D printers should be housed in a protective enclosure, or equipped with an exhaust system, that will capture and remove the airborne hazards from the air you breathe.

Industry Applications for 3D Printing Include:

- Medical & Dental Labs
- Consumer Goods
- Industrial Goods
- Plastic Manufacturers
- Mechanical & Design Engineering
- Aerospace & Defense
- Automotive
- Robotics
- Education

Safely Adding 3D Printers to Your Space

Category	Feedstock Materials	Feedstock Form	Binding/Fusing	Most Prominent Potential Hazards
Material extrusion	Thermoplastics (may include additives)	Spooled filament, pellet, or granulate	Electrical heating element-induced melting/cooling	Inhalation exposure to VOCs, particulate, additives:burns
Powder bed fusion	Metal, ceramic, or plastic	Powder	High-powered laser or electron beam heating	Inhalation/dermal exposure to powder, fume; explosion; laser/radiation exposure
Vat photopolymerization	Photopolymer	Liquid resin	Ultraviolet-laser induced curing	Inhalation of VOCs; dermal exposure to resins & solvents, ultraviolet exposure
Material jetting	Material jetting Photopolymer or wax	Liquid ink	Ultraviolet-light induced curing	Inhalation of VOCs; dermal exposure to resins & solvents, ultraviolet exposure
Binder jetting	Metal, ceramic, plastic, or sand	Powder	Adhesive	Inhalation/dermal exposure to powder; explosion; inhalation of VOCs, dermal exposure to binders
Sheet lamination	Metal, ceramic, or plastic	Rolled film or sheet	Adhesive or ultrasonic welding	Inhalation of fumes, VOCs; shock, laser/radiation exposure
Directed energy deposition	Metal	Powder or wire	Laser/electron beam heating	Inhalation/dermal exposure to powder, fume; explosion; laser/radiation exposure

Reference: https://blogs.cdc.gov/niosh-science-blog/2019/04/09/am/

As our awareness of this emerging hazard increases, new test protocols and standards such as UL2904 are being developed and adopted by 3D Printer manufacturers. Additionally, customers are implementing their own safety protocols based upon best practices and discussions with their peers. For example, Cornell University's EH&S Department has developed a 3D Printer Media Review on line, listing all the hazards of each type of media (aka filament) used. The Massachusetts Institute of Technology's EH&S website lists the hazards on line also with excellent source material references.

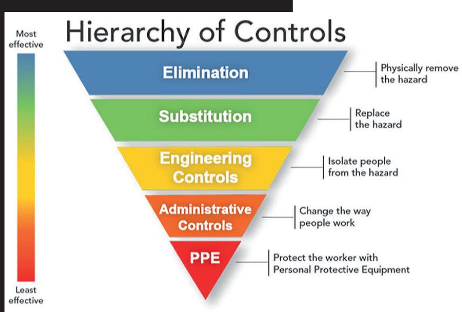

Image credit: CDC

The Hierarchy of Controls teaches us that elimination is the first step to reducing a risk. Since 3D printers are here to stay, we then must move to Substitution, the second step. Some filaments are less hazardous so substituting a lower temperature or otherwise safer filament is certainly worth investigating. But all filaments/media will emit some amount of vapors, nuisance odors and/or ultrafine particles. Distance and ventilation may be successfully used in large rooms, or areas with segregated ventilation, but in most cases capture and containment at the source is the safest path forward and this requires an engineering control, the third step in the hierarchy. Ductless filtering fume hoods are an engineering control that have been used for over 50 years.

A ductless filtering fume hood system, also known as a Containment Ventilated Enclosure (CVE), is a cost effective alternative to ducted exhaust systems which require make-up air to be brought into the room. Ductless filtering fume hoods system can be equipped with both HEPA (particulate) and carbon (chemical) filtration, thus providing total protection to the 3D Additive Printer users. This configuration allows the 3D Printer users to change filament materials and not be concerned about increasing the risk of exposure.

Simplicity by Design

With products designed with simplicity in mind, Erlab's Captair SMART CVEs require absolutely zero construction and are set-up in just minutes. This is possible due to our unique design, allowing all hoods (CVE's) to be shipped Completely Knocked Down (CKD) and re-assembled within minutes of delivery. While simple by design, all hoods maintain the most important factor – safety. All hoods meet ASHRAE 110, AFNOR NFX, and ANSI Z9.5 standards, ensuring containment and filtration efficiency.

Erlab's state of the art Research & Development Laboratory relying exclusively on filtration

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Erlab above

About Erlab

We provide safety, we protect your health

As the inventor of the ductless fume hood, Erlab is an expert in air filtration for the protection of laboratory personnel since 1968. With over 50 years of experience and 150,000 units installed in 40 countries. Erlab offers advanced technologies that protect lives, saves money, and enhances environmental sustainability. All our products are certified by experts for individual applications, ensuring that our products fully meet customer expectations.

With manufacturing facilities in the US, China, and Europe, employing highly trained engineers and scientists worldwide, we deliver solutions globally.

1 Erlab R&D Laboratory

The engineers and chemists in our state-of-the-art R&D laboratory understand molecular filtration. We are committed to designing products that are safe and of the highest quality as we strive to improve our products, and continuously develop new products that provide greater protection in the laboratory.

2 Strict Safety Standards

We hold ourselves to the highest standard and adhere to the strict AFNOR NF X 15-211: 2009 filtration safety standard as recognized by ANSI Z9.5-2012.

3 A Published Chemical Listing

It all begins here. Our chemical listing directory insures we are compliant with AFNOR NFX 15-211. Our in-house laboratory tests and independent testing verifies the retention capacity of over 700 chemicals for our filters.

4 Independent Testing

Erlab filters have been independently tested multiple times at various concentrations guaranteeing that our safety solutions adhere to the strict performance criteria of the AFNOR NF X 15-211:2009 standard ensuring that the emissions concentration at the filter exhaust will always be lower than 1% of the TLV.

5 Application Questionnaire

Our laboratory specialists will recommend the appropriate filtration fume hood, type of filter, and personalized advice.

6 Certificate of Validation for the chemicals used in the hood

A certified PhD chemist issues a Certificate of Validation with a list of the chemicals approved for use in the hood.

7 Our Safety Program

We support our products 100%. This program includes your specialized chemical evaluation, validation of your hood upon installation, and your filtration safety specialist that ensures your hood is operating to its full potential.