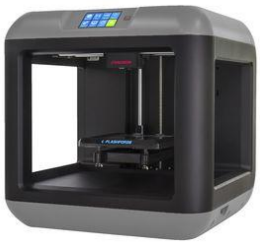
3D PRINTER SAFETY



3D printing, also called additive manufacturing, is a method of creating a three-dimensional object layer-by-layer using a computer created design. 3D printers are increasing in popularity as they can be used for rapid prototyping and small-scale manufacturing. The following provides guidance on selection, use and installation of 3D printers, as well as information on the hazards associated with these printers and how to control them.

Types of 3D Printing Processes and Associated Health Hazards

Process	Description	Types of Processes	Printer Media	Potential Health Hazards
Material Extrusion	Heated filaments dispense through a nozzle to build a piece by layers	Fused deposition modeling	ABS PLA	**Inhalation:** VOCs, ultrafine particulates
VAT Photopolymerization	UV light to fix thermoplastics	Stereolithography	Photopolymers	**Inhalation:** VOCs, ultrafine particulates **UV light exposure** **Dermal:** resins, solvents
Powder Bed Fusion*	Powder layer melted by a laser	Selective Laser Sintering	Metal Plastic	**Inhalation:** powder, VOCs **Dermal/Eye:** laser
Directed Energy Deposition*	Metal powder or wire is fed through a muzzle and heading on the build platform	Laser Metal Deposition	Metal	**Inhalation:** VOCs **Explosive dust**
Binder Jetting*	Binding agent deposited on powder layer	Powder Bed and Inkjet Head	Metal Plastic Ceramic	**Inhalation:** powder **Dermal:** binders
Material Jetting	Material deposited on platform is cured with UV light	Multi-Jet Modeling	Wax Photopolymer	**Inhalation:** VOCs, **UV light exposure** **Dermal:** resins, solvents
Sheet Lamination	Sheets of material on build platform are bonded with adhesive and cut with laser	Laminated Object Manufacturing	Paper Plastic Metal	**Inhalation:** VOCs **Explosive dust**

*Metal 3D printing requires evaluation by Yale Fire Marshals Office

Additional Hazards

Biological – With biological 3D printing, there can be a potential exposure to the aerosols generated in the process. Proper disinfection procedures of the 3D printer between prints is also of concern.

Hot Surfaces – The print head block and UV lamp generate heat. Such surfaces must be guarded and labeling must warn users of the hazards.

Flammable Dusts – finely divided metal powders can spontaneously combust, causing fires or an explosion.

Fire – the high temperatures necessary to melt materials pose a fire risk if the unit malfunctions or material ignites.

Mechanical – Moving parts must be guarded to prevent accidental contact. Guards must never be bypassed.

Electrical – Contact with energized parts can lead to injury or even death. Before each use, inspect the 3D printer for any damaged wiring and safeguards. Do not use the printer if problems are found. Ensure the printer is properly grounded and plugged directly into an outlet.

Corrosive Baths – Some 3D printers require the use of corrosive bath to remove the extra material surrounding each 3D printed item. The use of corrosive baths must be reviewed and approved by EHS to ensure proper ventilation, procedures, training, emergency equipment and personal protective equipment are provided.

REQUIREMENTS

Contact EHS prior to purchasing a 3D printer to ensure the printer and location meet all EHS requirements.

Administrative

- Totally enclosed 3D printers with interlocked guards are preferred.
- Whenever possible, purchase a 3D printer with ANSI/CAN/UL 2904 certification and Nationally Recognized Testing Laboratory for electrical and fire code compliance.
- A person must be identified as responsible for ensuring the 3D printer is properly maintained, access is controlled, users are trained and safe work practices are developed and enforced.
- Rules and procedures must be posted at the 3D printer and include approved materials for use. Any materials not approved must include a documented review and approval by EHS prior to use. A template, *Specific 3D Printer Rules*, is provided on the last page of this document.

Location and Ventilation

As 3D printers have been shown to emit ultrafine particles (UFP) and volatile organic compounds (VOCs) when operating, to manage these emissions consideration must be given to the ventilation of the space where printers are used. The ventilation in offices, libraries or meeting rooms is inadequate and not appropriate to remove continuous emissions from multiple 3D printers. In general, the ventilation options include:

- Dedicated exhaust to the outdoors, ex: snorkels, fume hood, ventilated enclosure racks
- Connecting the enclosure to a HEPA and charcoal filtration unit
- General, non-recirculating exhaust, with a minimum of 6 air changes per hour

As ventilation requirements are dependent on the number of units in one space, the location of the units in reference to occupants of the space, and the type of process and media used, it is critical to consult with EHS prior to purchasing a 3D printer to ensure that the unit is placed in an area with adequate ventilation.

General

- Complete Hazard Communication training (ehs.yale.edu), in addition to printer-specific training, prior to using the printer.
- Review Safety Data Sheets (SDSs) for materials used with the 3D printers.
- Wear personal protective equipment while using the printers.
- Never bypass interlocks or other safety controls.
- Maintain a distance from the printer while it is in operation to minimize exposure to printer emissions.
- Allow a waiting period after printing to allow cool down and contaminant dissipation before opening the printer to access the finished product.
- Clean surfaces around the printer frequently using a damp cloth. Use HEPA vacuums to clean floors or other areas with particulate.
- Wash hands with soap and water after using the printer.
- Report any concerns to the responsible person or EHS.

For More Information

- Chemical Insights – Tools for Promoting 3D Printer Air Quality Safety
  https://chemicalinsights.org/3D-printing/
- UL 200B Guidance Document – *Safe Use of 3D Printing for Institutions of Higher Education*
  https://chemicalinsights.org/wp-content/uploads/2023/05/UL-200B_1.pdf
- Environmental Science & Technology – *Emissions of Ultrafine Particles and Volatile Organic Compounds from Commercially Available Desktop Three-Dimensional Printers with Multiple Filaments*
  https://pubs.acs.org/doi/pdf/10.1021/acs.est.5b04983

SPECIFIC 3D PRINTER RULES

Location:

3D Printer Make and Model:

Responsible Person (Name and Contact Information):

- Only those trained and authorized may use the 3D printer.
- 3D printer users should avoid congregating around the printing operation to minimize the inhalation of particulates being created.
- Eating, drinking, applying cosmetics, chewing gum, or handling contact lenses in rooms that contain 3D printing operations must be prohibited. Users must wash their hands thoroughly after working with 3D printers.
- All work surfaces must be cleaned by a wet method as sweeping and other dry methods may create airborne particles.
- Review product Safety Data Sheets (SDSs) for material specific safety information before using anything in the 3D printer.
- Never bypass a safeguard.
- Before each, use inspect the 3D printer for any damaged wiring and safeguards. Do not use the printer if problems are found.
- Report all printer concerns, incidents and near-misses to the responsible person.
- Any materials not approved must include a documented review and approval by the responsible person and EHS.

Approved Materials: