Guidelines for 3D printer safety

3D printing — or additive manufacturing — refers to creating or replicating 3D objects. The table below lists the most common 3D printing types and describes the process and materials most often used.

Please contact Environmental Health and Safety with questions.

Table of contents

Types of 3D printers 1
Hazards 3
Using 3D printers 5
Personal protective equipment 6

Types of 3D printers

Process	Types	Materials	Hazards
Material extrusion Process where a filament of solid thermoplastic material is pushed through a heated nozzle to melt it. The nozzle deposits the melted material on a build platform along a predetermined path. As the material cools, the build platform lowers, and a new layer is deposited on top of the previous one.	• Bioprinting • Fused Deposition Modeling — FDM	Thermoplastics and biological materials	• Additives • Burns • Inhalation exposure to VOCs • Particulate

Vat polymerization Ultraviolet light cures or hardens resin from a vat of liquid photopolymer resin. The build platform is lowered from the top of the resin vat downwards as the UV light cures the resin layer by layer.	• Digital Light Processing — DLP • Masked Stereolithography — MSLA • Stereolithography — SLA	Photopolymer	• Dermal exposure to resins • Inhalation of VOCs • Solvents and ultraviolet exposure
Powder bed fusion A thin layer of powder is spread over the build platform, and either a laser or electron beam is used to melt and fuse the material powder. This process repeats until the entire model is created.	• Direct Metal Laser Sintering — or DMLS or Selective Laser • Electron Beam Melting — EBM • Selective Laser Melting — SLM • Selective Laser Sintering — SLS	• Aluminum • Chrome • Cobalt • Copper • Nylon • Stainless steel • Titanium	• Inhalation or dermal exposure to powder • Explosion • Fumes • Laser or radiation exposure
Material jetting Like an inkjet printer, instead of printing a single layer of ink, a layer of material is jetted onto the build platform, solidifying by either cooling or curing by UV light, and the model is built layer by layer to create a 3D object.	• Drop on Demand • Material Jetting	• ABS • EDP • HDPE • HIPS • PC • PMMA • Polypropylene • PS	• Dermal exposure to resins and solvents • Inhalation of VOCs • Ultraviolet exposure
Binder jetting Powder material is spread over the build platform, and the print head deposits the binder adhesive. This process repeats until the entire model is created.	• Metal Binder Jetting • Sand Binder Jetting	**Metals** • Stainless steel **Polymers** • ABS, PA, PC **Ceramics** • Glass	• Inhalation or dermal exposure to powder; explosion; inhalation of VOCs, dermal exposure to binders

Sheet lamination Sheets or ribbons of material are placed on a cutting bed, then another layer of material is placed on top and bonded using an adhesive or welding. The required shape is cut from the layer using a laser or knife. This process repeats until the entire model is created.	• Laminated Object Manufacturing — LOM • Ultrasonic Additive Manufacturing — UAM	Paper, plastic and metals.	• Inhalation of fumes, VOCs • Laser or radiation exposure • Shock
Directed energy deposition Feedstock material, which comes in either metal powder or wire form, is pushed through a feed nozzle where a focused heat source melts it and then added onto a build platform.	Directed Energy Deposition — DED	• Aluminum alloys • Cobalt Chrome • Copper • Nickel • Stainless steel • Titanium alloys Superalloys and other specialty materials, composites and functionally graded materials.	• Explosion • Fumes • Inhalation or dermal exposure to powder • Laser or radiation exposure • Metal powder

Hazards

Hazards can relate to the processes, techniques and materials applied, including:

- Burns from molten materials
- Electrical shock
- Electromechanical force
- Health hazards associated with inhalation of smoke, fumes and dust
- Ultraviolet light or laser beams

Biological

3D printers used to create cells or engineered tissues may expose persons to aerosols containing biological materials or release biohazardous agents.

Flammability and explosivity
3D printers using finely divided metal powders — i.e., aluminum, titanium or other resins — can create an ignitable, explosive atmosphere if dispersed. Depending on the particle size, the fine powder can spontaneously combust — pyrophoric — leading to fires.

Asphyxiation
Some 3D printers use inert gases, such as nitrogen and argon, which are usually stored in cylinders. These can leak and displace oxygen.

Sensitizers
Certain materials used in 3D printing may contain substances or produce by-products when activated by heat or UV light, which can cause allergic reactions upon contact or inhalation.

Toxicity
3D printers using certain print media have been shown to emit Volatile Organic Compounds — VOC. Some VOCs have been linked to:

- Cancer
- Damage to the liver
- Eye, nose and throat irritation
- Headaches
- Kidney and central nervous system

Some metal 3D printers may employ toxic metals or alloys, creating the potential for inhaling powders or associated fumes.

Ultrafine particles — UFP
The health effects associated with exposure to UFP — particles less than 100 nm — are currently being researched. Past studies have indicated that exposure to UFPs at high concentrations can produce inflammatory responses in the cardiovascular and respiratory systems.

Radiation
Some 3D printers use lasers, which may result in eye or skin damage. Please refer to the manufacturer's recommendations about laser safety.

Hot surfaces
Contact with the print head block or UV lamp can cause burns.

Electrical
Unguarded electrical components in some 3D printers could pose a risk of electrical shock.

Moving parts
Most 3D printers contain moving parts — pulleys, chains, belts, rods and rotors — that can cause pinching or crushing.

Using 3D printers

Please follow these recommendations for using 3D printers:

- 3D printers using inert gases in smaller spaces can consider installing an oxygen sensor. Unsafe oxygen levels will trigger an alarm.
- 3D printers using metal powders will need further controls. Contact EHS if you plan to use metal powders.
- 3D printers using powdered materials must consider outfitting them with a HEPA-filtered system to collect particles directly from the source.
- Choose a filament with lower known emission rates when possible.
- Do not alter the machine, bypass any interlocks or use a material different from the manufacturer's recommendation.
- Do not consume food or drinks in work areas.
- Do not disable or alter any manufacturer safety devices.
- Follow the manufacturer’s documentation for the safe use of 3D printers according to the National Fire Protection Association code 72.
- For FDM-type printers, use Polylactic Acid — PLA — instead of acrylonitrile-butadiene-styrene — ABS — thermoplastic filaments.
- Handle and dispose of all metal-contaminated waste materials, liquid VOC or solvent materials. This includes cleaning materials or contaminated gloves, which must be disposed of as hazardous chemical waste in compliance with all applicable federal, state and local regulations.
- It is recommended to use 3D printers in a carpet-free space.
- Keep and use 3D printers in properly ventilated areas — at least 6–10 air changes per hour and 100% exhaust.
- Keep the doors to the 3D printer enclosures closed. Enclosures for 3D printers and ventilation are used to capture chemical emissions and prevent contact with mechanical, UV and laser components.
- Maintain a clean and dust-free working area in rooms where 3D printers are housed.
- Maintain a safe distance from the printer to minimize inhalation of emitted particles.
- Minimize time spent near the printing process. You may consider monitoring the 3D printer remotely.

- Particle concentration is highest during startup. During this time, maintain a safe distance from the printer per the manufacturer's recommendations.
- Print in a negatively pressured area with a dedicated ventilation system away from other work.
- Restrict access to essential personnel.
- Select the lowest printing temperature that achieves the desired product.
- The principal investigator should establish SOPs, and all users should be trained to operate 3D printers.
- Turn off the printer if the printer nozzle jams. This allows the printer to ventilate before removing the cover.
- Use signs to alert workers of hazards and appropriate actions to protect themselves.

Personal protective equipment

All 3D printer users should have the following personal protective equipment:

- **Electrostatic dissipating shoes** are recommended if working with powdered metal printing material and waste.
- **Flame retardant lab coats** are recommended when handling powdered metal printing material.
- **Follow all engineering controls** recommended in the Safety Data Sheet — SDS — for all materials used in the 3D printing process.
- **Manufacturer-recommended gloves** must be worn while handling printing material.
- **Respirators may be required** when engineering controls cannot handle printing materials, such as metals and powdered materials. Please consult with your supervisor and EHS to assess the potential exposure type required to determine the type of respirator to be used.
- **Safety glasses or safety goggles and closed-toe shoes** must be worn in the lab and during any activity where airborne particles exist or when the material can splash. Safety goggles are required in areas with splash hazards.

Call 911 In the event of an emergency.

PDP 201-05 states you cannot print weapons using ASU's 3D printers, even if they are fake, non-operational or intended for simulation or demonstration processes. Call the ASU Police Department at 480-965-3456 if any weapons are in the process of being printed or have already been printed.