

3D PRINTING SAFETY

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I. Introduction

Three-dimensional (3D) printing involves the layering of successive layers of material to create or replicate 3D objects. Depending on the printer, 3D objects are created through extrusion, sintering or curing. 3D printing has also become common in University labs and classrooms. Though 3D printing holds considerable potential, the workplace health and safety risks are still being determined. This guide covers general procedures for the safe use and operation of 3D printers.

EHRS Contact Information

Web pages and contact information for specific issues are listed throughout this guide. See the [EHRS website](#) for a list of contact information by topic.

Environmental Health & Radiation Safety (EHRS)
Pharmacy-Allied Health Building
3307 N. Broad Street, Room B-49
Philadelphia, PA 19140
Phone: (215) 707-2520
E-mail address: ehrs@temple.edu
Website: www.temple.edu/ehrs

EHRS Resources

EHRS offers training, consultation and information regarding 3D printing safety. The EHRS website has a variety of safety information and resources. EHRS provides resources and guidance for users to stay safe and compliant with local, state and federal regulations and policies at all TU campuses and facilities. However, specific policies and procedures may vary by location.

II. Types

Multiple types of 3D-printers are available to create three-dimensional objects. The most common types of 3D printers are listed below.

Type	Description
Material Extrusion [Fused Deposition Modeling (FDM)]	FDM printers use a thermoplastic filament, which is heated to its melting point, to create a 3-dimensional object. This is the most common type of 3D printer.
Vat Polymerization [Stereolithography (SLA)]	Vat polymerization uses a liquid photopolymer resin to create a model and then cure each layer of resin using an ultraviolet (UV) laser or digital processing lamp.
Material Jetting	Material jetting selectively deposits droplets of feed material onto a build platform, allows the droplets to cool and solidify and then builds on the solidified droplets to create a 3-dimensional object.
Binder Jetting	Binder jetting distributes a layer of powder onto a building platform and then applies a liquid bonding agent (i.e., a glue) to bond the particle layers together to create a 3-dimensional object.
Powder Bed Fusion [Selective Laser Sintering (SLS)]	SLS deposits a thin layer of plastic powder that is melted by a laser on a building platform. 3D objects are created through layer-by-layer construction in the powder bed.
Directed Energy Deposition (DED)	DED uses a laser or electron beam to melt material (usually metal powders or wires) from the nozzle of a multi axis arm as it is being deposited.
Sheet Lamination	Sheet lamination creates 3D objects by using a laser or other sharp blade to cut and bond thin-layered materials (e.g., paper, aluminum foil, etc.) together layer-by-layer.

III. Hazards

3D printing involves the melting of plastics [Acrylonitrile Butadiene Styrene (ABS), Polylactic Acid (PLA), Polyvinyl alcohol (PVA), Polycarbonate (PC), etc.], metals (steel, aluminum, titanium, copper, silver, gold, nickel, etc.), composites, and photopolymers. Exposure to emissions from the melting of print media could lead to negative health effects. The hazards associated with 3D printing are listed below.

Health Hazards	
Biological	3D printers used to create cells and/or engineered tissues may release biohazardous aerosols.
Flammability	3D printers using finely divided metal powders (e.g., aluminum, titanium, etc.) or other resins can be spontaneously combustible (pyrophoric), leading to fires. Contact EHRS prior to using printers with finely divided metal powders/resins.
Sensitizers	3D printer by-products from the melting of thermoplastics and photopolymers can cause allergic reactions upon contact or inhalation.
Toxicity	3D printers using certain print media have been shown to emit volatile organic compounds (VOC's) such as formaldehyde and toluene. Some VOC's have been linked to eye, nose and throat irritation, headaches, damage to the liver, kidney and central nervous system and cancer.
Ultrafine Particles (UFPs)	The health effects associated with exposure to UFPs (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 cardiovascular and respiratory systems.

Physical Hazards	
Cuts & Abrasions	To remove the support material, spatulas, razors, scalpels and other sharps are commonly used. This can lead to cuts, abrasions and other skin injuries.
Hot Surfaces	Contact with the print head block and/or UV lamp can cause burns.
Electrical	3D printers are high voltage pieces of equipment and interaction with the UV lamp power supply or the printer power supply may result in exposure to high voltage.
Moving Parts	3D printers with ingoing nip points and/or rotating parts can cause pinch or crush injuries.
Ultraviolet Radiation	3D printers using lasers to melt print media can emit ultraviolet radiation. Exposure to ultraviolet radiation may result in acute or chronic effects on the skin or eyes.

IV. Control of Hazards

In order to reduce exposure to the hazards associated with 3D printers, the following controls are recommended.

Training
1. If your 3D printer uses hazardous materials (e.g. metals), biological materials (human cell lines or tissue), or generates hazardous waste, you must attend the required EHRS training. E-mail ehrstraining@temple.edu for more information.
2. Employees working in non-lab areas with 3D printers are required to complete Hazard Communication training through EHRS. Instructions on how to enroll in the training can be found here .
3. If your 3D printer uses a class 3B or 4 laser, you must register your printer with EHRS and attend the required laser safety training. E-mail laser@temple.edu for more information.
4. Students working with 3D printers in University- sanctioned spaces must be provided a copy of this guide to ensure awareness of the hazards.

Engineering Controls
1. Use the manufacturer-supplied cover or use 3D printers under direct ventilation to limit exposure to VOC's and UFPs.
2. Use 3D printers in well-ventilated areas. EHRIS recommends using 3D printers in rooms with 4-10 fresh air changes per hour (ACH). Contact Facilities Management to determine the ACH in your area.
3. Provide direct ventilation for ABS printers or place in a fume hood. ABS printers have been shown to emit styrene, a possible human carcinogen by the International Agency for Research on Cancer.

Work Practices
1. Install, use and maintain 3D printers as indicated by manufacturer specifications.
2. Safety Data Sheets (SDS) must be present and accessible in the immediate work area for all print media and other chemical products involved in the printing process.
3. Maintain a safe distance from the printer(s) to limit inhalation of emitted particles.
4. If the printer nozzle jams or becomes clogged, turn the printer off and allow it to ventilate before removing the cover.
5. Limit the number of printers per room. One printer per standard office space (~150ft ²) for a non-lab area can be used as a guideline. Multiple 3D printers in the same room may be possible based on the ventilation rate, enclosures and room size.
6. Store print media and other chemicals associated with the printing process as indicated by the manufacturer.
7. Choose a low-emitting printer and filament, if possible.
8. An eyewash and safety shower are required in the immediate work area if corrosive materials are present or used in the printing process. E-mail ehrsocc@temple.edu to determine if one is needed.
9. Eating or drinking is not allowed in areas where 3D printers are being used.
10. Avoid contact with heated surfaces to prevent burns.
11. 3D printers with pinch points and/or rotating parts must be properly guarded. (i.e., no exposed belts, gears, pulleys or other moving parts or points of operation). Remove or tie-back loose-fitting clothing, jewelry, and hair before operating the printer.

Personal Protective Equipment (PPE)
1. Eye protection recommended by the manufacturer in SDS/printer specifications is required (if applicable).
2. Gloves recommended by the manufacturer must be worn while handling print media and other chemicals associated with the printing process (if applicable).
3. Respirators may be necessary for use with some 3D printers (e.g., metal and ceramic powders). If employees are required or voluntarily choose to wear respirators, e-mail ehrsocc@temple.edu before purchasing or using respirators.

V. Disposal

Equipment Relocation or Disposal

3D printers that have been used with hazardous material must be decontaminated before being discarded, moved, repaired, or recycled. Complete the [Equipment Clearance Form](#) and email to ehrs@temple.edu. **An Equipment Clearance Form is required for each individual printer.**

Follow the procedure below before equipment is cleared:

- Remove all contents from the printer (e.g. media).
- Clean all surfaces of the printer that may have come in contact with hazardous materials with an appropriate cleaner.

3D printers that have been used with hazardous materials cannot be discarded, moved, repaired, or recycled until the printer has been inspected and cleared by EHRS. Once clearance is completed, the Equipment Clearance Form must be posted conspicuously on the piece of equipment. Equipment Clearance Forms are valid for 30 business days after EHRS has granted final clearance.

Contact EHRS at (215) 707-2520 for assistance if the equipment cannot be effectively decontaminated.

Surplus Equipment

The [Temple University Surplus Program](#) is responsible for removing items that are no longer in active use. Contact Surplus to arrange for the disposal of equipment that has been effectively decontaminated and cleared by EHRS.

All equipment disposed of through Surplus must be decontaminated, cleared by EHRS and have all hazard warning labels removed prior to transfer to Surplus.

Computer & Electronic Surplus Recycling

All electronics (including, but not limited to, central processing units, monitors, keyboard, printers, televisions, and scanners) must be separated from general trash and placed into a designated area for collection by the [Computer Recycling Center](#). The designated area must be under the direct control of the generators (no hallway storage). All electronics must be clearly labeled with a dated, removable sign reading “To be recycled by CRC”. Contact the Computer Recycling Center if you have questions about removing or recycling electronic equipment.

Biological Waste Disposal

Determine if any biological are usable and if you or anyone at Temple would like to keep them. Document transfer of responsibility for any identified materials to a party willing to accept them. Properly dispose of any biological materials that are not being kept.

- Place sharps (e.g. syringes, Pasteur pipettes, serological pipettes, razor blades, etc.) in a Sharps Container and properly dispose.
- Dispose of all solid media and supplies, including bioinks, in red bags as biohazardous waste.
- Dispose of all other potentially biohazardous waste in red bags as biohazardous waste.
- Decontaminate all liquid media by autoclaving or by treating for 30 minutes with a bleach solution (final concentration to be 10%) before drain disposal.
- Autoclave all semi-solid media with microbial growth (including agar plates) before final disposal.

Chemical Waste Disposal

Determine if any chemicals are usable and if anyone at Temple would like to keep them. Document transfer of responsibility for any identified chemicals to a party willing to accept them. All chemical waste must be managed according to Temple University waste disposal procedures.

At a minimum, the following procedures must be followed:

- Complete and keep hazardous waste tags/labels on all chemical waste containers. Hazardous waste labels are available free of charge by contacting EHRS.
- Keep all chemical waste in an appropriate container (i.e. screw type lid). Keep the container closed at all times.
- Keep an area designated for chemical waste only and label it with the Chemical Waste Satellite Accumulation Area poster available from EHRS.
- Place chemically contaminated sharps (e.g. syringes, Pasteur pipettes, serological pipettes, razor blades, etc.) in a Sharps Container and properly dispose.
- Complete the Chemical Waste Collection Request Form on the EHRS website.

If the user does not wish to follow the procedures above, they can utilize an outside contractor for disposal. Chemical disposal must be conducted by a University approved contractor and coordinated through EHRS. EHRS has agreements with vendors to provide this service. However, all related chemical move costs are the responsibility of the user.

VI. Emergency Procedures

Personal Injury or Contamination

- For small burns, keep affected area clean and apply burn cream or antibiotic ointment.
- For localized skin contamination, wash the impacted area with water. Refer to the SDS for further instructions. Seek medical attention.
- For eye contamination, flush with an emergency eyewash for 15 minutes. Seek medical attention.
- For widespread contamination, remove contaminated clothing and shoes and flush the body with an emergency safety shower. Seek medical attention.

Small Chemical Spills

- For minor chemical spills that can be controlled and cleaned up by employees in the area follow the steps below.
- Wear PPE, including safety goggles and gloves. Consult the SDS for PPE requirements.

- Alert people in the immediate area of the spill.
- Confine the spill to a small area with absorbent materials.
- Increase ventilation in the area of the spill (e.g. open a door).
- Avoid breathing vapors from the spill.
- Use an appropriate kit to neutralize, absorb, or contain the spill.
- Collect any residue, place in a container, and label the container with a Hazardous Waste Tag.
- Submit a waste pickup request [online](#) or by faxing the form to (215) 707-1600.

Large Chemical Spills

For large hazardous materials spills that require additional support, contact EHRS immediately or Campus Safety at (215) 204-1234 (1-1234).

Small Fires

For small fires, about the size of a typical household wastebasket, follow the steps below **only if safe to do so**.

- Keep the exit at your back.
- Use the nearest fire extinguisher.
- **Pull** the pin to break the seal.
- **Aim** at the base of the fire.
- **Squeeze** handle grips or trigger.
- **Sweep** the fire, spraying side-to-side at the base of the flames.
- Report the fire to Campus Safety at (215) 204-1234 (1-1234).

Large Fires

For large fires, larger than the size of a typical household wastebasket, follow the steps below:

- Sound the building fire alarm. Know the location of the alarm signal stations and how they operate.
- When the fire alarm sounds, leave at once. Close all doors behind you. Proceed into the fire exit and leave the building. After leaving the building, do not reenter until given permission by campus police or the Fire Department.
- Do not use the elevators. They will stop if power fails, causing occupants to become trapped. Elevator shaft ways are like chimneys. Smoke could enter the elevator shaft thereby asphyxiating the occupants trying to evacuate the building.