

 <p>Carnegie Mellon University Environmental Health & Safety FIRE LAB WORK</p>	<p>Environmental Health and Safety 3D Printing Safety - Guideline</p>
<p>Date of Issuance: March 2019</p>	<p>Revision Date: 1/14/2021</p>
<p>Revision Number: 2</p>	<p>Prepared by: EHS</p>

1. Purpose

Carnegie Mellon University has developed this guideline to cover general procedures for the safe use and operation of 3D printers.

2. Scope

This guideline applies to all Carnegie Mellon faculty, staff and students that use and operate 3D Printers.

3. Introduction

3D printing, an additive manufacturing technology, has made rapid prototyping and small-scale manufacturing easier and more accessible. However, this advancement is not without risks.

4. Roles and Responsibilities

- a. Carnegie Mellon University Environmental Health and Safety (EHS) is responsible for:
 - i. Developing the written 3D Printing Guidelines and revising as necessary;
 - ii. Completing risk assessments and reviewing manufacturer's instructions and any applicable Safety Data Sheets (SDS) when new 3D printers are obtained;
 - iii. Developing a training program on the safe use and operation of 3D Printers; and
 - iv. Conducting routine inspections to ensure the proper use and operation of 3D Printers.
- b. Departments will be responsible for:
 - i. Understanding and complying with the requirements of this guideline;
 - ii. Contacting EHS when a new 3D Printer is obtained, providing the manufacturer's instructions, SDSs and assisting in the hazard assessment review;
 - iii. Ensuring the safe use and operation of 3D Printers according to this Guideline;
 - iv. Maintaining a clean and dust free work area in rooms where 3D Printers are housed; and
 - v. Contacting EHS if assistance is needed.
- c. Faculty, Staff and Students will be responsible for:
 - i. Completing training as necessary. Training is provided on-line through [BioRAFT](#);
 - ii. Complying with the procedures outlined in this Guideline; and
 - iii. Informing their supervisor/manager of the space (faculty or staff) of any problems, defective equipment or any other issues relating to 3D Printers and associated equipment.

5. Risks

The risks addressed by this guideline include, but are not limited to, the following:

a. **Exposure to Nanoparticles**

In some 3D printing processes, thermoplastics are heated, nozzle-extruded and then deposited onto a surface to build the object. As a by-product of the process, nanoparticles (ultrafine particles less than 1/10,000 of a millimeter) are emitted.

Nanoparticles are of concern because they are very small, have large surface areas and can interact with the body's systems, including the skin, lungs, nerves and the brain.

b. **Exposure to Volatile Organic Compounds**

3D printing can release several volatile organic compounds (VOCs) including, but not limited to, acrylonitrile; 1, 3-butadiene; styrene aldehydes, including formaldehyde, acetaldehyde and isovaleraldehyde; some phthalates such as DEP, DBP, and DEHP; and VOCs such as toluene and ethylbenzene^{[2][3]}.

c. **Flammable and Reactive Dusts**

Reactive and highly combustible powdered metals are used in the fabrication of 3D-printed metal alloy tools and parts. Finely divided metal powders, such as titanium and aluminum, can spontaneously combust causing fires (pyrophoric).

d. **Other Chemical Hazards**

The thermoplastics used for 3D printing can be flammable, cause irritation, skin sensitivity and may contain small amounts of toxic components. Further, caustics such as sodium hydroxide, are sometimes used for chemical dissolution of support material.

e. **Exposure to Hot Surfaces**

3D printers may contain hot surfaces which can lead to skin injury. These surfaces include the heat block and the UV lamp.

f. **Exposure to High Voltage**

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.

g. **Exposure to UV Radiation**

Some 3D printers are equipped with UV light sources to harden resins, photopolymers and other materials. Exposure to this light source can damage eyes, lead to reddening of the skin and other effects.

h. **Exposure to Sharps**

To remove the support material, spatulas, razors, scalpels and other sharps are commonly used. This can lead to cuts, abrasions and other skin injuries.

6. Risk Controls

a. **Engineering controls**

- i. Areas where plastics, reactive metals and toxic support materials are used must be well ventilated (at least 6 air changers per hour) to reduce personnel exposures and the risk of fire or explosion.

- ii. 3D printers should only be used in work areas having a dedicated exhaust or appropriate air filtration system.
 - iii. In the absence of enclosure/ventilation, the placement of 3D printers in any area should be reviewed by EHS before proceeding. EHS will review information including, but not be limited to, the printing method, type(s) of printing materials used, size of the area and operating parameters of the area ventilation system.
 - iv. Areas where printing materials are handled or cured and/or where caustic support material is cleaned or removed should also be ventilated to control hazardous emissions.
- b. **Administrative controls**
- i. Follow the manufacturer's documentation for safe use of 3D printers.
 - ii. Register 3D printers on the appropriate groups' BioRAFT equipment page.
 - iii. Consult Safety Data Sheet (SDS) for all materials being used in the 3D printing process.
 - iv. Purchase and use the manufacturers supplied controls, such as an interlocked enclosure. (Enclosures appear to be more effective at controlling emissions than just a machine cover.)
 - v. Maintain a safe distance from the printer to minimize the inhalation of emitted particles.
 - vi. Maintain a clean and dust free working area in rooms where 3D printers are housed.
 - vii. Turn off the printer if the printer nozzle jams, and allow the printer to ventilate before removing the cover.
- c. **Training for users** (faculty, staff and students)
- i. 3D Printer Safety training must be completed by all users.
 - ii. Lab Safety and Hazardous Waste training must be completed by users in areas that are defined by the [Occupational Health and Safety Administration](#) as a laboratory.
 - iii. Hazard Communication training must be completed by users in those areas not defined by the Occupational Health and Safety Administration as a laboratory.
 - iv. Biological Safety training must be completed by users to print biological materials requiring BSL-2 containment.
 - v. Fire extinguisher training should be completed by users that use powdered metals.
 - vi. For additional information on training, please visit [BioRaft](#).
- d. **Personal Protective Equipment (PPE)**
- i. Eye Protection
 - 1. Face shields and/or chemical safety goggles must be worn when using caustic materials.
 - 2. Safety glasses must be worn when the potential for creation of projectiles exists.
 - ii. Gloves
 - 1. Chemical-resistant gloves appropriate for the chemical in use must be worn when handling chemicals or irritants/sensitizers.
 - 2. Heat-resistant gloves must be worn when there is the potential to come into contact with the print head block or UV lamp.
 - 3. Abrasion-resistant gloves must be worn when using sharps and other jagged items to remove support media.
 - iii. Laboratory coat or apron

1. Lab coats or aprons must be used when using caustic materials.
- iv. Respiratory Protection
 1. Negative pressure air-purifying respirators must be worn when loading, leveling, changing filters, extracting or cleaning that involves pyrophoric and reactive materials.
 2. Respiratory protection may also be indicated based on a risk assessment.
 3. Personnel wearing respiratory protection must be enrolled in the University's Respiratory Protection Program, and should [contact EHS](#) for additional information.
- v. Emergency Equipment
 1. Class D fire extinguishers must be present in all areas with powdered metals.
 2. Dry powder or CO2 fire extinguishers must be present in all other areas.
 3. Emergency eyewashes and showers should be present in all areas and must be present in areas with caustics and powdered metals.

7. Waste Disposal

a. Chemical Waste

- i. All chemical waste, including caustic baths, must be disposed of through the University's Hazardous Waste Program.
- ii. Please visit the [Hazardous Waste Management webpage](#) for additional information.

b. Powered Metals

- i. Powered metals used in 3D Printing are often considered hazardous because of their small mesh size. Usually classified as toxic, powered metals are also highly flammable and even potentially reactive.
- ii. [Contact EHS](#) for help in collecting waste metal powders.
- iii. Additionally, the 3D Printing Machine filters are also considered hazardous. Follow the manufacturer's SOP for change-out and [contact EHS](#) for help on disposal.

c. Sharps

- i. All sharps must be disposed of in a sharps container appropriate for the type of contamination present on the sharp.
- ii. Please [contact EHS](#) for additional information.

d. Biological Materials

- i. All biological wastes must be disposed of through the University's Biological Waste Program.
- ii. Please visit the [Hazardous Waste Management webpage](#) for additional information.

8. Emergency Procedures

a. Personal Injury or Contamination

- i. For small burns, keep affected area clean and apply burn cream or antibiotic ointment if accessible and reach out to University Police at 412-268-2323 for additional medical help if needed. Contact EHS at 412-268-8182.
- ii. For eye contamination, flush with an eyewash for 15 minutes. Contact EHS at 412-268-8182 and University Police at 412-268-2323.

- iii. For localized skin contamination, wash the impacted area with soap and water. Contact EHS at 412-268-8182 and University Police at 412-268-2323.
 - iv. For widespread contamination, remove contaminated clothing and shoes and flush body with an emergency safety shower. Contact EHS at 412-268-8182 and University Police at 412-268-2323.
 - b. **Small Chemical Spills**
 - i. Alert people in the immediate area of the spill.
 - ii. Avoid breathing vapors from the spill.
 - iii. Wear protective clothing and gloves when addressing spills.
 - iv. Confine spills to a small area.
 - v. Use the appropriate spill kit.
 - vi. Collect the residue, place in labeled container and contact EHS for disposal as hazardous waste.
 - vii. Clean the spill area.
 - c. **Large Chemical Spills**
 - i. Alert people in the immediate area of the spill.
 - ii. Attend to your own needs first and then assist injured or contaminated people.
 - iii. Control the spread of contamination if safe to do so.
 - iv. Keep people away from the location.
 - v. Stop work, turn off equipment, and close doors as you exit.
 - vi. Evacuate to a safe location.
 - vii. Contact EHS at 412-268-8182 and University Police at 412-268-2323.
 - viii. Remain safely in the area to inform emergency responders of:
 - 1. Number and extent of injured people;
 - 2. Name(s) of chemicals involved, and volume; and
 - 3. Hazards associated with the material(s).
 - d. **Powdered Metal Spills**
 - i. Clean up powder with a spark-resistant vacuum equipped with High Efficiency Particulate Air (HEPA) filtration.
 - e. **Small Fires** (a fire the size of a typical household wastebasket)
 - i. Keep the exit at your back.
 - ii. Use the nearest fire extinguisher.
 - iii. Pull the pin to break the seal.
 - iv. Aim at the base of the fire.
 - v. Squeeze handle grips or trigger.
 - vi. Sweep the fire, spraying side-to-side at the base of the flames.
 - vii. Ventilate the area after the fire is completely extinguished
 - viii. Contact University Police at 412-268-2323 and EHS at 412-268-8182 and report location, injuries and other hazards.
 - f. **Large Fires** (a fire larger than the size of a typical household wastebasket)
 - i. Activate the nearest fire alarm pull station and alert others.
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- ii. If safe to do so, assist others who may be in danger. However, do not put yourself at risk.
- iii. Evacuate the area, use stairs and close doors behind you.
- iv. Contact University Police at 412-268-2323 and EHS at 412-268-8182 and report location, injuries and other hazards.
- v. Move away from the building exterior and assemble with floor marshal.
- vi. Inform emergency responders of any hazards, injuries, or locations of persons remaining inside.
- vii. Remain outside the building until cleared for re-entry.

9. Deadly Weapons Policy

In accordance with CMU's "Deadly Weapons Policy," the following items are prohibited from 3D printing:

- a. Firearms;
- b. Pellet, flare, tranquilizer, stun, spear, and dart guns;
- c. Knives with blades larger than that of a folding pocket knife;
- d. Switchblades;
- e. Daggers;
- f. Striking instruments, including clubs, truncheons, blackjacks, metal knuckles, and sap gloves;
- g. Martial arts weapons, including nunchakus, tonfas, staffs, and throwing stars;
- h. Bow and arrow combinations; and
- i. Explosive devices, including hand grenades, bombs, black powder, smokeless powder, percussion caps, friction primers, and pyrotechnic fuses.

If any of the above items are considered for, in the process of, or have been manufactured, contact University Police at 412-268-2323.

For information on this Policy, please visit the [Deadly Weapons Policy](#).

For additional information, contact [EHS through email](#) or by calling 412-268-8182.

10. Revisions

Date	Documented Changes	Initials
May 2020	Updated Format	MAS
1/21/2021	Updated Format and Accessibility Update	MAS