UNIVERSITY OF
NORTHERN COLORADO

Environmental Health and Safety

3D Printer Procedure

September 2024

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I. Purpose

The 3D Printer Procedure establishes the minimum requirements necessary to allow for the safe use of 3D printers located in the University of Northern Colorado (UNC) facilities. The procedure is presented in recognition of the continued expansion of 3D printer use by faculty, staff and students. Studies have indicated that 3D printers are capable of generating potentially harmful concentrations of ultrafine particles (UFP) and chemical vapors during the print process and through processes used following printing to treat the finished product.

II. What is 3D Printing

3D printing, an additive manufacturing technology, has made rapid prototyping and small-scale manufacturing easier and more accessible. However, this revolutionary process does not come without hazards.

3D printing refers to various processes used to create or replicate an object by using successive layers of material (usually plastics) to create an object. Objects can be of any shape or geometry and produced from a 3D model or from a design fed into the 3D printer by a computer.

A. ABS vs. PLA Feedstock

Each 3D printer is designed to use certain types of materials. The most common type of desktop 3D printer technology joins thin strands, or filaments, made of ABS (Acrylonitrile Butadiene Styrene) or compostable materials, such as Polylactic Acid (PLA). Using a computer-generated image, a 3D printer heats and melts the feed material, placing layers of filament on top of one another to form a precise 3D replica of the image.

The materials being fed into the machine (feedstock) can have inherent hazards and may release vapors and gases that may be more hazardous, for example, after they are heated during the 3D printing process.

Generally speaking, ABS represents a greater health and safety risk than PLA media.

B. 3D Printing Emissions: Nanoparticles and Vapors

Nanoparticles

To reduce the potential for nanoparticles to aerosolize or be inhaled by users, it is best to purchase 3D printers with an enclosure, from the manufacturer. Even with an enclosure, a review will need to be performed regarding ventilation systems (see Section IV.A).

Exposures to nanoparticles at high concentrations have been associated with adverse health effects, including total and cardio-respiratory mortality, strokes and asthma symptoms. While PLA feedstock is designed to be biocompatible, the thermal decomposition products of ABS feedstock have been shown to have toxic effects on lab rodents.

Chemical Vapors

3D printers may best be used in a location that has additional ventilation.

Heating of certain thermoplastic filament can generate toxic vapors and vapors with high volatile organic compounds (VOCs). Most 3D printers do not come with an enclosure, exhaust ventilation or any filters. The following must be assessed before purchasing and installing a 3D printer:

- Building/Room where 3D printer will be located
- Placement of the 3D printer in the space itself
- Selection of printing feedstock

III. Responsibilities

A. Environmental Health and Safety (EHS)

- EHS will be responsible for the review and approval of all 3D printer purchases.
- Purchasing review will consider the type of printer, the type of print media to be used and the proposed location of the printer set-up before approval is granted.
- EHS may require the modification of proposed printer location or the addition or modification of exhaust ventilation before purchasing approval is granted. Modification of systems will be at the user's expense.
- EHS has authority to immediately halt any operations if it considers the area unsafe.

B. Deans, Directors and Principal Investigators (PI) with 3D Printer Oversight

- The PI and 3D printing managers are responsible for enforcing the provisions of this procedure including compliance with the training requirements.
- Providing required personal protective equipment (PPE) and enforcing its correct use.
- Responsible for developing their own operating procedure for the equipment.
- Ensure the equipment is used properly and by trained individuals.

C. Facilities Management

- Review all 3D printer purchase requests and provide information for proper ventilation.
- Install ventilation once the printer and ventilation upgrades are approved.

D. Purchasing Department

- Review all 3D Printer purchase requests with EHS.
- Ensure printers are not ordered until approval, from EHS, is received.

IV. 3D Printer Guidelines

A. Approval Process

All 3D printers purchased for use on campus shall have to go through an approval process. EHS shall be notified by the interested purchaser/requester of the make and model of the desired 3D printer. EHS shall research the 3D printer for safety and other concerns. If any concerns are found, the requester shall be notified by EHS of these concerns. If the 3D printer is approved by EHS, purchasing and the requester shall be notified of the approval for purchase.

B. Ventilation

3D printers using PLA media exclusively may be set-up in a workspace having at least 4 air changes per hour (ventilation may or may not be required). The number of PLA printers in one location should be limited by the size of the space. Requests for the placement of PLA printers in any space will be reviewed by EHS and FM before proceeding.

3D printers using ABS media, including printers designed and set-up to use both PLA and ABS may only be used in work areas having a dedicated exhaust system or one pass air and at least six air changes per hour. It is recommended that printers using ABS media be used within a fume hood whenever possible.

3D printers using other types of media, including but not limited to thermoplastics, photopolymers, nylon, high impact polystyrene, high density polyethylene, powdered metals, biological media or other uncommon medias shall be reviewed by EHS on a case by case basis with specific precautions required based on the hazards unique to the printing process.

C. General Safety Information

- All printers must be installed according to the manufacturer's requirements and according to NFPA 72 National Electric Code.
- Safety Data Sheets (SDS) must be obtained and kept by the department, for all print media and for any other chemical product used in the printing process. SDS must be readily accessible for review in the event of an emergency.
- Safety interlock switches must be enabled and working properly during printer operation.
- Operators must be protected from hot surfaces associated with the printers.
- If UV light is used in the curing process, personal protective equipment and/or shielding must be utilized to protect personnel.

- Turn off the printer if the printer nozzle jams, and allow the printer to ventilate before removing the cover.
- Maintain a safe distance from the printer to minimize the inhalation of emitted particles.

D. Engineering Controls

Particle emissions are the focus, especially when multiple printers are running simultaneously. Another consideration is toxic vapors that can be generated by heating plastics. Engineering controls should be considered first to assist with minimizing hazards. These may include the following:

- Use 3D printers ONLY in properly ventilated areas.
- Choose low-emitting printers and feed materials/filament when possible.
- 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. Personal Protective Equipment (PPE)

- Follow all PPE recommendations found in the Safety Data Sheet (SDS) for the specific printer media used.
- Eye protection is required during any activity where airborne projectiles may be present (i.e. cutting off rough edges of a printed item).
- A spill kit capable of neutralizing the caustic components of the alkaline bath solution shall also be available, by the department, in the area.

VI. Training and Recordkeeping

It is the responsibility of each department to ensure that their employees receive the required training. All users working directly with a 3D printer and associated media are required to have a minimum of annual hazard communication (HAZCOM) training covering any hazardous materials used in the process. Training can be provided by the Environmental Health and Safety department.

Completion of the training must be documented in writing with the records maintained by the department of the printing operations.

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3D Printing with Filaments: Health and Safety Questions to Ask

Review the questions on the left and explore different control options and other information to reduce your exposure on the right.

1 Characterization of Potential Hazards

What potential hazards are associated with 3D printing? Are there known health effects from the filaments (for example, see safety data sheets)? What is the work environment like (for example, open or isolated area)?

Potential hazards may include:

- Breathing and skin contact with volatile organic chemicals (VOCs) and particulates (printing) and other chemicals (post-printing)
- Hot surfaces and moving parts

Printing considerations:

- Printing material (e.g., use polylactic acid [PLA] filament rather than acrylonitrile butadiene styrene [ABS] when possible)
- Filaments with additives (e.g., metals, nanomaterials, carbon fibers)
- Frequency and duration of printing
- Manufacturer's recommendations for bed and nozzle temperatures

Work environment best practices:

- Print in a negatively pressured area with a dedicated ventilation system, in an area away from other work
- Reduce time spent near printing process (e.g., monitor remotely or leave area)

2 Work Activities

Could the work activity cause exposures? What is the likelihood of exposure? Can you change the way you do the activity to reduce the likelihood of exposure (high potential to low)?

Pre-printing

Higher potential for exposures:

- Cleaning printer heads/nozzles
- Heating nozzles

Lower potential for exposures:

- Loading filament into printer
- Changing printer heads/nozzles
- Prepping build plate

Printing

Higher potential for exposures:

- Using printer in general office work area
- Working near printer
- Going to printer quickly after print failures and during start up

Lower potential for exposures:

- Using video monitoring

Post-printing

Higher potential for exposures:

- Removing support structures with solvents or other chemicals
- Post-processing activities with filaments containing nanomaterials

Lower potential for exposures:

- Removing part and changing filaments
- Scraping build plate with tools

Maintenance and cleaning

Higher potential for exposures:

- Cleaning printer head/build plate with solvents

Lower potential for exposures:

- Changing filament
- Collecting waste
- Housekeeping

3 Engineering Controls

Based on the work activity, what engineering controls will reduce the likelihood of exposure? What are the key design and operational requirements for the control?

Applies to All Printing Stages

- High efficiency particulate air (HEPA)-filtered local exhaust ventilation placed near printing
- If concerned about VOCs, add gas and vapor filters to local exhaust ventilation
- Ventilated enclosure or containment (for example, fume hood)
- Local exhaust ventilation or ventilated enclosure for post-processing activities involving chemicals (for example, cleaning or spray painting parts)
- Ventilated enclosure or downdraft table for cutting and grinding parts during postprocessing

4 Administrative Controls

Have you considered your workplace practices and policies? Have you set up a plan for waste management? Have you considered what to do in case of a chemical spill?

Applies to All Printing Stages

- Incorporate 3D printing into workplace safety plans
- Develop standard operating procedures and train workers
- Do not consume food or drinks in work areas
- Select the lowest printing temperature that achieves the desired product
- When possible, choose a filament with lower known emission rates
- Use signs to alert workers of hazards and appropriate actions to protect themselves
- Restrict access to essential personnel or use remote monitoring
- Handle and dispose of all waste materials (including cleaning materials/gloves) in compliance with all applicable federal, state, and local regulations

5 Personal Protective Equipment (PPE)

If the measures above do not effectively control the hazard, what PPE can be used? Have you considered PPE for other safety hazards (for example, thermal gloves to prevent burns from hot printer heads)?

Applies to All Printing Stages

Wear PPE that is appropriate for the activities around you (for example, a coworker cleaning a printer next to your work station may require you to wear the same level of PPE). Follow proper PPE replacement practices. Do not wear PPE outside of work areas. Examples of possible PPE are:

- Nitrile or chemical resistant gloves
- Lab coat or coveralls
- Safety glasses, goggles, or face shields
- Respiratory protection when indicated and when engineering controls cannot control exposures, and in accordance with federal regulations (29 CFR 1910.134)
- NIOSH guidance on respirators can be found at www.cdc.gov/niosh/topics/respirators/

CDC NIOSH

Learn more about safely working with filaments for 3D Printing

DHHS (NIOSH) Publication No. 2020-115, https://doi.org/10.26616/NIOSHPUB2020115

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(Appendix A)