EHRS
Environmental Health & Radiation Safety
University of Pennsylvania

3D Printing Fact Sheet & Guide

DESCRIPTION

Until recently, 3D printing was primarily associated with the high-tech and manufacturing industries. Now, it is being rapidly incorporated into higher education programs. This raises concerns since the potential hazards associated with 3D printing are not always taken into consideration. Common concerns include insufficient ventilation and chemical safety.

COMMON TYPES OF 3D PRINTERS

- Fused Deposition Modeling (FDM)/Fused Filament Fabrication (FFF) - A plastic filament is heated to a semi-liquid state and deposited in layers on a build platform to create an object. This is the most common 3D printing technology used at Penn.
- Stereolithography (SLA) - Liquid photopolymer resin is deposited in layers to create an object. Each layer is cured using an ultraviolet (UV) laser or digital processing lamp.
- Selectiver Laser Sintering (SLS) - Thin layers of thermoplastic powder are deposited on a build platform. A laser fuses the powder in the shape of the object.
- Binder Jetting - A print head deposits powder onto a build platform to create an object. A liquid bonding agent (i.e., a glue) is applied to bond the particle layers together.
- Material Jetting - A print head deposts photopolymer resin on a build platform to create an object. The resin is cured and solidified using UV light.

3D PRINTING HAZARDS

- **Particulate Inhalation** - FDM/FFF printing is known to generate ultra-fine nanoscale particles. The amount varies by the type of filament, extruder temperature and specific design of the printer. These tiny particles can be inhaled deeply into the lungs. The long-term health effects are not yet understood.
- **Chemical Inhalation** - Heating plastics can generate chemical vapors including styrene, acrylonitrile, formaldehyde and many others. The chemicals released primarily depends on the media. Curing agents such as cyanoacrylate, can create potentially hazardous vapors.
- **Chemical Contact** - Chemical rinse baths, typically containing caustic sodium hydroxide, are used to dissolve binders. Direct contact can be hazardous to the eyes and skin.
- **Fire** - Malfunctions of the heated build platform, printer nozzles or internal electrical components can result in fire.

Photo Credit – hackaday.com

- **Physical Injury** - Injuries can occur though contact or pinching between moving parts of the printer.

GENERAL SAFETY

- NRTL Listing/Labeling Requirement - 3D printers must be listed or labeled by a Nationally-Recognized Testing Laboratory (NRTL). This is required by workplace electrical safety standards and fire codes. The purpose is to ensure that the printer has been tested through various failure modes and shown to be safe for use. Common examples of NRTLs are UL, TUV, CSA, ETL and FM. Note: CE is not a NRTL. Many popular consumer grade 3D printers do not carry a NRTL listing/labeling and are not appropriate for use at Penn. Be sure to confirm prior to purchase. The following link contains information on OSHA NRTLs. https://www.osha.gov/dts/otpca/nrtl/nrtllist.html

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- Chemicals - Evaluate the chemicals required for production and post processing. Appropriate chemical storage must be provided for the stock and waste. Contact EHRS for all chemical disposal, including expired base baths. Obtain and review Safety Data Sheets (SDS) for the feed stock and chemicals used for printing and processing.
- Electrical - 3D printers and related equipment must be connected directly to an electrical receptacle. Electrical components such as build platform heaters may not be modified.
- Unattended Operation - 3D printers may not be run unattended, including overnight. Plan the start of print operations accordingly.
- Emergency Irrigation - Appropriate emergency irrigation equipment, such as an eyewash or drench hose, must be available where hazardous chemicals are used.

VENTILATION GUIDELINES

- 3D printers should only be operated in well ventilated areas. The ventilation rates of offices, libraries and general classrooms are typically not sufficient to remove contaminants generated by 3D printing.
- A single desktop FDM/FFF printer using PLA filament is permitted in an average size room, office or classroom. Consult with EHRS if more than a single printer is desired or a different print media such as ABS will be used. EHRS will evaluate the ventilation and provide recommendations for safe use.

Example of exhausted enclosure.

- In new facilities or where there is a desire to have multiple printers in one location, a general ventilation rate of at least six (6) air changes per hour is recommended. This ventilation rate can be reduced if there is a provision for connecting enclosed printers to a dedicated exhaust or a HEPA/carbon filtration system.
- 3D printing processes where chemicals such as cyanoacrylate are used, may necessitate additional ventilation requirements, including dedicated exhaust.

PERSONAL PROTECTIVE EQUIPMENT

- Personal protective equipment (PPE) will vary with the type of printing and post processing. The following PPE may be required:
  - Lab coat - Required when there is potential for contact with chemicals.
  - Gloves - Required for chemical work including cyanoacrylate, sodium hydroxide base bath or alcohol. Review the chemical safety data sheet (SDS) or contact EHRS for consultation on glove selection.
  - Eye protection – Goggles, and possibly a face shield, must be worn for protection from chemical splash hazards. Safety glasses must be worn for scraping or other mechanical work where particulates may be created.
  - Respiratory protection - Not required. General ventilation and exhaust must be used to control airborne exposure to chemicals and particulates. Contact EHRS if you believe respiratory protection is needed.

TRAINING REQUIREMENTS

- Follow operator's manuals for the specific printer and processing equipment.
- Develop standard operating procedures for each printing process and ensure that all users are trained on it.
- Log into Knowledge Link and complete Penn's Hazard Communication Training-EHRS.

RESOURCES

- **NIOSH Science Blog – Characterizing 3D Printing Emissions and Controls in an Office Environment**
- **NIOSH – Filament Printing Safety Poster**