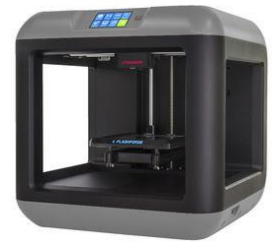


3D PRINTER SAFETY

3D printing refers to processes used to create a three-dimensional object in which material is joined or solidified under computer control to create an object, with material being added together (such as liquid molecules or powder grains being fused together). 3D printers are increasing in popularity as they can be used for rapid prototyping and small-scale manufacturing. The following provides criteria for 3D printers, 3D printing hazards and controls.



General Equipment, Installation and Use Requirements

- Totally enclosed 3D printers with interlocked guards are preferred. Such printers are classified as Tool Risk Group 2, which are not required to be in spaces meeting Yale's requirement for shops.
- A person must be identified as responsible for ensuring the 3D printer is properly maintained, access is controlled, users are trained and safe work practices are developed and enforced.
- Proper ventilation is required for 3D printer installations and must be pre-approved by EHS. Ventilation requirements may be based on equipment manufacturer specifications and anticipated usage.
- Rules and procedures must be posted at the 3D printer and include approved materials for use. Any materials not approved must include a documented review and approval by the responsible person. A template is provided below ("Specific 3D Printer Rules").

Hazards

Biological – With biological 3D printing, there can be a potential exposure to the aerosols generated in the process. Proper disinfection procedures of the 3D printer between prints is also of concern.

Nanoparticle Emissions – Nanoparticles (ultrafine particles less than 1/10,000 of a millimeter) are one of the byproducts emitted during the 3D printing process. 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 brain.

Chemical Vapors – Heating of certain thermoplastic filament can generate toxic vapors and vapors with high volatile organic compounds (VOCs). There are a variety of printing materials available for use with 3D printers, each with its own inherent hazards. The two most commonly used materials are Polylactic Acid (PLA) and Acrylonitrile Butadiene Styrene (ABS). Other printing materials used include metallic powders, which are generally used to fabricate tools and machinery parts. Please review product Safety Data Sheets (SDSs) for material specific safety information before using anything in a 3D printer.

Hot Surfaces – The print head block and UV lamp generate heat. Such surfaces must be guarded and labeling must warn users of the hazards.

Mechanical Hazards – Moving parts must be guarded to prevent accidental contact. Guards must never be bypassed.

Ultraviolet Light (UV) – UV light poses a radiation hazard that can cause damage to vision and skin. Do not look at the lamp and ensure the UV screen is intact before use.

Electrical – Contact with energized parts can lead to injury or even death. Before each use, inspect the 3D printer for any damaged wiring and safeguards. Do not use the printer if problems are found. Ensure the printer is properly grounded and plugged directly into an outlet.

Corrosive Baths – Some 3D printers require the use of corrosive bath to remove the extra material surrounding each 3D printed item. The use of corrosive baths must be reviewed and approved by EHS to ensure proper ventilation, procedures, training, emergency equipment and personal protective equipment are provided.

SPECIFIC 3D PRINTER RULES**Location:****3D Printer Make and Model:****Responsible Person (Name and Contact Information):**

- Only those trained and authorized may use the 3D printer.
- 3D printer users should avoid congregating around the printing operation to minimize the inhalation of particulates being created.
- Eating, drinking, applying cosmetics, chewing gum, or handling contact lenses in rooms that contain 3D printing operations must be prohibited. Users must wash their hands thoroughly after working with 3D printers.
- All work surfaces must be cleaned by a wet method as sweeping and other dry methods may create airborne particles.
- Review product Safety Data Sheets (SDSs) for material specific safety information before using anything in the 3D printer.
- Never bypass a safeguard.
- Before each, use inspect the 3D printer for any damaged wiring and safeguards. Do not use the printer if problems are found.
- Report all printer concerns, incidents and near-misses to the responsible person.
- The following materials are approved for use. Any materials not approved must include a documented review and approval by the responsible person.

Approved Materials: