1. Purpose of this document

This document will serve as guidance for the safe operation of makerspaces and labs with 3D printers. Hazards that may not be immediately apparent include dust accumulation, reactivischt3cs(e:)6.9 (19Tw -25.315.22

2. Makerspace Inventory

Though there are many locations with plastic filament feed type 3d printers, the following areas have been identified as Makerspaces

- Emerging Technologies Studio (Tech Hub)
- Additive Manufacturing Lab (ES 1500)

3. Types of Printers and Materials

3.1. Printers

Category	Feedstock Materials	Feedstock Form	Binding/Fusing	Most Prominent Potential Hazards
Material Extrusion	Thermoplastics (may include additives)	Spooled filament, pellet, or granulate	Electrical heating element-induced melting/cooling	Inhalation exposure to VOCs, particulate, additives; burns
Powder Bed Fusion	Metal, ceramic, or plastic	Powder	High-powered laser or electron beam heating	Inhalation/dermal exposure to powder, fume; explosion; laser/radiation exposure
Vat Photo Polymerization	Photopolymer	Liquid resin	Ultraviolet-laser induced curing	Inhalation of VOCs; dermal exposure to resins and solvents, ultraviolet exposure
Material Jetting	Material jetting Photopolymer or wax	Liquid ink		

Binder Jetting	Metal, ceramic, plastic, or sand	Powder	Adhesive	Inhalation/dermal exposure to powder; explosion; inhalation of VOCs, dermal exposure to binders
Sheet Lamination	Metal, ceramic, or plastic	Rolled film or sheet	Adhesive or ultrasonic welding	Inhalation of fumes, VOCs; shock, laser/radiation exposure
Directed Energy Deposition	Metal			

4.3.2 No modifications may be made to 3d printer laser configurations without consent from the Laser Safety Officer in EHS.

4.3.3 Laser containing equipment is regulated by the Laser Safety Program. Many devices have embedded Class 4 lasers used for metal welding, but may have integrated safety features that render the unit a Class 1 Laser system.

4.4 Ultraviolet Light

4.4.1

5. Hazard Prevention and Mitigation

5.1. Dust Accumulation and Cleanup

5.1.1. Dust collection protocols must be in place. Accumulation of dust only 1/32” over 5% of the surface area of a room is a hazard. In terms of a lab space, if your 3d printing lab is 1500 sq. ft, an accumulation of 1/32” on two standard benchtops is a hazard. Furthermore, dust accumulated on ceiling fixtures and beams can be disturbed by a small deflagration, fueling a much larger explosion.

5.1.2. A dedicated and approved combustible powder vacuum is necessary to clean powder. Generic shop vacuums or HEPA vacuums may provide that spark as they are not intrinsically safe.

5.1.3. Vacuum cleaners designe2 (a)2.8 .003 Tw 0.228 0 Td [(V)0.8 (ac)-1.9 (u)23urpoacxpxpxa2.6 (n)2

5.4.2. The presence of VOCs can often be detected by their distinct odor. Odors should be controlled by an engineering control device such as a shroud or snorkel that captures the emissions.

5.4.3. The presence of UFPs may not be noticeable as there is no distinct odor and they are usually too small to see. UFPs are less than 100 nm in size and when inhaled can enter the deepest part of the lungs, where they may enter tissues and cells. Similar to VOCs, they should be captured at the point of generation. Unlike VOCs they can become concentrated in ductwork and form explosive concentrations.

5.4.4. Air monitoring may be installed to determine background dust and accumulation amounts or the displacement of oxygen by heavy inert gases that may be used.

5.4.5. Inert gases should be removed using appropriate building ventilation. EHS and Physical Facilities can be consulted.

5.5. Personal Protective Equipment

5.5.1. Hand Protection can be utilized to prevent skin contact.

5.5.2. Body protection can be utilized to protect the users from dust exposure to clothing.

5.5.3. Respiratory protection may be required in some applications. Consultation with EHS will determine if participation in the Respiratory Protection Program is required.

5.5.4. Eye protection should be utilized to avoid dust exposure to the eyes.

6. Training

Training Topic	Responsibility
Lab Safety	EHS
Flame Resistant Clothing	PI
Respiratory Protection	

- NFPA 654, Standard for the Prevention of Fires and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids
- NFPA 61, Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities
- NFPA 655, Standard for Prevention of Sulfur Fires and Explosions
- NFPA 664, Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities
- UL 3400, "Outline of Investigation for Additive Manufacturing Facility Safety Management"
- https://www.safetyandhealthmagazine.com/articles/19406-nioshannounces-partnership-aimed-at-enhancing-safety-and-health-in-3d-printing
- https://www.ehs.harvard.edu/programs/makerspace-safety
- https://3dinsider.com/3d-printer-types/
- https://blogs.cdc.gov/niosh-science-blog/2019/04/09/am/
- https://www.sciencedirect.com/science/article/pii/S0160412018323663

Footnotes

[1] https://www.osti.gov/servlets/purl/1242062