
# Bureau of Workers' Compensation

# 3D PRINTING & ADDITIVE MANUFACTURING SAFETY

Sarah Ghezzi, CSP
614-562-6029
Sarah.Ghezzi@bwc.ohio.gov

Ohio Bureau of Workers' Compensation

# OBJECTIVES

- Define what is a 3D desktop printer
- Define additive manufacturing processes
- List health and safety concerns with these processes
- Categorize and identify control measures

# DESKTOP 3D PRINTERS

- What is it?
  - Makes a 3-dimensional object from a digital file
  - Small enough to fit on a desk/table
- Why are they popular?
  - Compact
  - Versatile
  - Relatively inexpensive

Courtesy of Institute of Museum and Library Services(IMLS.gov)

# DESKTOP 3D PRINTERS




- Where do you find them?
  - Maker Spaces
  - Schools
  - R&D departments
- How do they work?
  - Additive layers of material
  - Multiple types of materials are available
  - Energy.gov

# PRINTING MATERIALS

- Most common: plastic filament
  - PLA (Polylactic Acid)
  - ABS (Acrylonitrile Butadiene Styrene)
- Purchasing
  - Internet
  - Domestic and International sources

# ARE PRINTING MATERIALS HAZARDOUS?

Hazard Communication - Hazard Communication Pictograms | Occupational Safety and Health Administration (osha.gov)

# Material Name: PLA 3D Printer Filament/ MakerBot PLA

## Section 2 - HAZARDS IDENTIFICATION

**Classification in accordance with paragraph (d) of 29 CFR 1910.1200.**
None needed according to classification criteria

**GHS Label Elements**

**Symbol(s)**
None needed according to classification criteria

**Signal Word**
None needed according to classification criteria

**Hazard Statement(s)**
None needed according to classification criteria.

# 3DXMAX® Polycarbonate (PC)

## 2 HAZARDS INDENTIFICATION

Regulation (EC) NO 1272/2008: Not classified as a dangerous product

Physical Hazards: None

OSHA Regulatory Status: This product is not considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

# HAZARDOUS?

## QUICK SCIENCE LESSON …

# THERMAL DECOMPOSITION

- A chemical breakdown due to heat
- Thermal degradation of polymers

  Causes chemical changes
- Off-gassing

  VOCs bleed away from the plastic

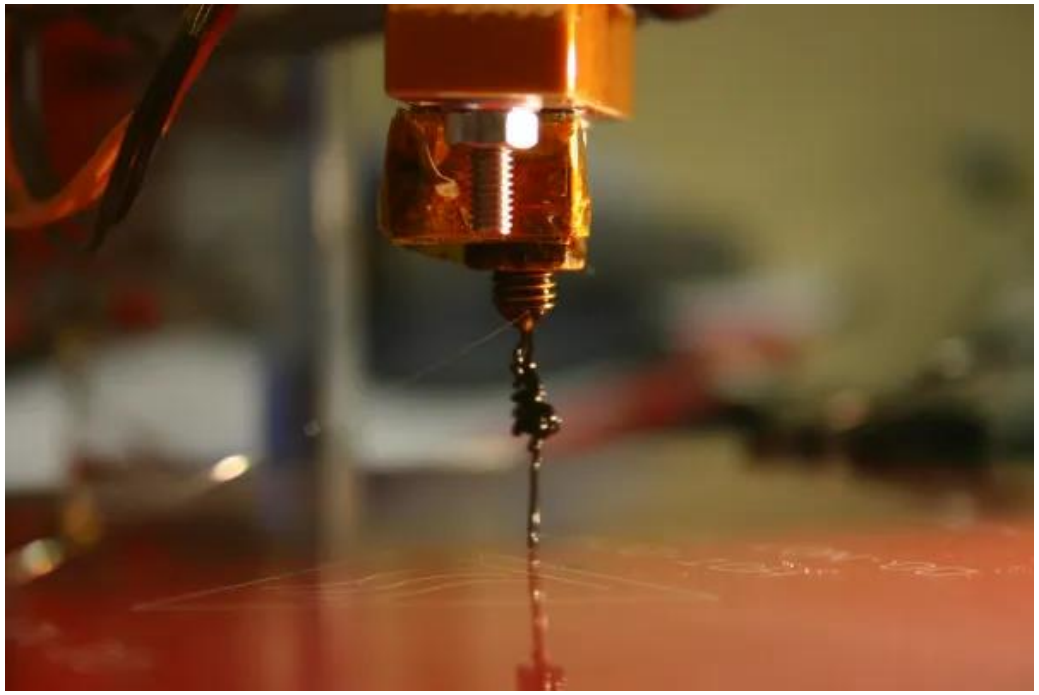
  float into the air and reduce indoor air quality

# WHAT PARTS ARE HOT?

- Printer's heated parts

  Extruder Head - 374° F to over 600° F

  Base Plate – 130 ° F to 158 ° F



# WHY THE HIGH HEAT?

- Not following manufacturer's instructions
  - Didn't read them
  - Don't care
- Troubleshooting – crank up the heat
- Jamming – filament piles up around the extruder
- Left unattended – hours to days

# REMEMBER THE SDS?

## 10 STABILITY AND REACTIVITY

Polymerization conditions to avoid: None
Chemical Stability: Stable under normal conditions
Conditions to avoid: Incompatible materials, including strong oxidizing agents
Hazardous decomposition byproducts: Thermal decomposition can yield intense heat, dense smoke, phenols, hydrogen cyanide, carbon dioxide, and carbon monoxide.

# REMEMBER THE SDS?

- Based on SDS reviewed:

  Hydrogen Cyanide (PEL 10 ppm – IDLH 50 ppm)

  Carbon Monoxide (PEL 50 ppm)

  Phenols (PEL 5 ppm Skin)

- Remember our user audience?

# OFF-GASSING

- VOC's – Volatile Organic Compounds
- Over 60 VOC's identified by Canada/ANSI
- Common health hazards include:
  - Eye, nose, throat irritation
  - Headaches, narcotic effects
  - Target organ damage (kidney, CNS, liver)
  - Carcinogen

# OTHER HAZARDS

- Cleaning chemicals
  - Acetone & solvents
- Hot surfaces
- Electrical hazards
  - Cord & plug
- Dust
  - Finishing/Polishing Activities

# HIERARCHY OF CONTROLS

# SUBSTITUTION & ENGINEERING

- Printer design
- Auto shutoff during jams
- Enclosures with extractors (interlocked)
- Increased ventilation
- Low VOC emitting filaments or natural filaments (algae, hemp, cornstarch)


Illustration by NIOSH

**Figure 10.** Drawing of a ventilated Plexiglas® enclosure surrounding a bank of 3D printers.

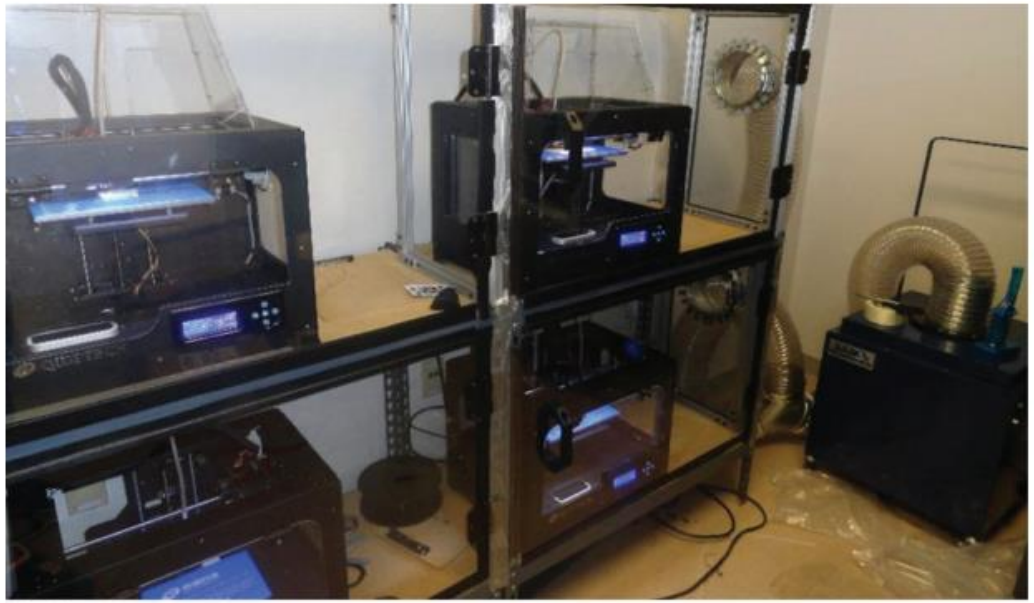


Photo by NIOSH

[Approaches to Safe 3D Printing: A Guide for Makerspace Users, Schools, Libraries and Small Businesses (cdc.gov)]

# FUTURE REGULATION?

- ANSI/CAN/UL 2904, Standard Method for Testing and Assessing Particle and Chemical Emissions from 3D Printers
- UL - 3D Printing & Additive Manufacturing Equipment Compliance Guideline
- NIOSH recommendations:

  NIOSH: Approaches to safe 3D printing: a guide for makerspace users, schools, libraries, and small businesses

  NIOSH Science Blog: Characterizing 3D Printing Emissions and Controls in an Office Environment

  NIOSH Health Hazard Evaluation report: Evaluation of 3D Printer Emissions and Personal Exposures at a Manufacturing Workplace

  3D Printing with Filaments: Health & Safety Questions to Ask.

# ADMINISTRATIVE

- Training
  - Manufacturer’s instructions
  - Hot surfaces, chemicals, LOTO, fire extinguishers
  - Don’t stand over it – ventilation requirements
- Post signs - awareness
- Choose your location wisely
- Monitor printer operations
  - Don’t leave unattended

# PPE

- Not a solution for the targeted audience at makerspaces

- Considerations
  - Acetone/solvent cleaning
  - Combustible rag disposal
  - Dust clean up - may be combustible
  - Respirators? (use ventilation)

# ADDITIVE MANUFACTURING (AM)


[Innovation in Additive Manufacturing Ecosystem (jobsohio.com)]

# 7 TYPES OF MANUFACTURING

- Material Extrusion
- Sheet Lamination
- VAT Photopolymerisation
- Material Jetting
- Binder Jetting
- Powder Bed Fusion
- Directed Energy Deposition

# AM HAZARDS – FEEDSTOCK MATERIALS

- Powders (Powder Bed, Binder, Directed Energy)
  - Silica - ceramics and sand may be used
  - Combustible Dust
  - Recycling and reusing
  - powder collection and transferring
  - Metal fumes
- Resins (Vat Photo)
  - VOC’s and Skin
  - Tank filling and cleaning
- Adhesives (Material Extrusion, Sheet Lam, Binder Jetting)
  - VOC’s and skin

# AM HAZARDS - LASERS

- Sheet Lamination
- Powder Bed Fusion
- Directed Energy Deposition

- Laser Safety Requirements - LIA Z136.9-2013 Safe Use of Lasers in Manufacturing Environments
    - Training, PPE, maintenance

# AM HAZARDS – CLEANING THE SYSTEM

- Compressed air or solvents
- Noise exposure (ototoxicants)
- Airborne dust –combustible dust
- Flammable liquids
- Dermal exposures

# AM PHYSICAL HAZARDS

- Hot surfaces
- Electrical systems
- Molten materials
- Sharp edges
- Manual material handling during loading operations

# AM REGULATION

- NFPA 1 Chapter 46 Fire Code

  Combustible dust and electrical concerns
- UL 3400 - Outline of Investigation for Additive Manufacturing Facility Safety Management
- ASTM - Proposed guide for AM: Standard guideline for the use of metallic materials

# SUMMARY

- Wide use of 3D printers expose multiple audiences
- Additive manufacturing hazards are specific to the process
- Control measures are specific to the process
- Operator training is necessary

# QUESTIONS?

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# THANK YOU

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