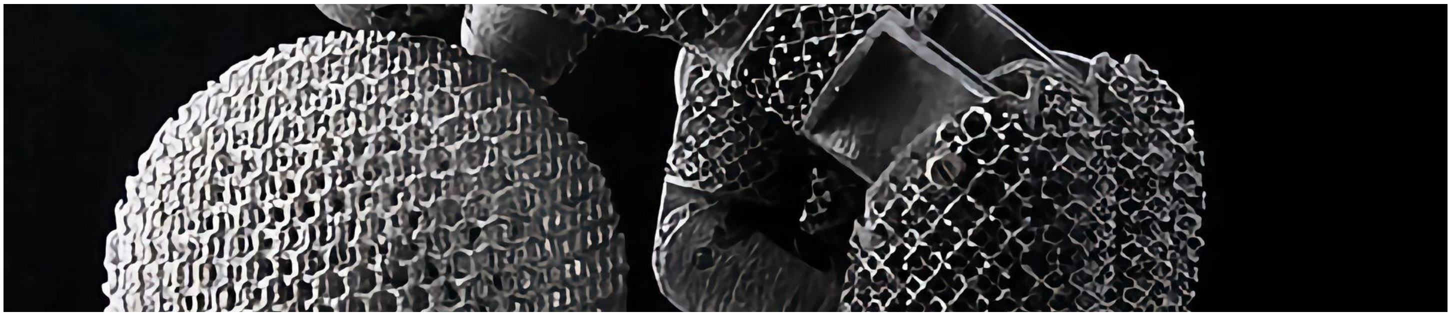
nontoxicprint

Health in the Arts



Miniature face models (from FaceGen) produced using Ceramic Based material on a Full Colour 3D Inkjet Printer

(Wikipedia)

3D Printing - Additive Sculpting of just about anything, in the 21st Century

Although commonly associated with the novelty of plastic toys and other trinkets or parts that you can custom make from digital code in a desktop machine, 3D Printing truly has the promise to become one of the most transformative methods of sculpting, engineering and making in the 21st century.

As the medium is maturing, machine parts or entire cars are 3D printed from molten metal in the car industry or in engineering, concrete structures are robotically built layer after layer in the construction industry, -- allowing for new types of shapes and forms -- and many types of plastic are added into 3D objects and visualizations of any conceivable form in smaller 3D printing devices by hobbyists, engineers, scientists, or art students.

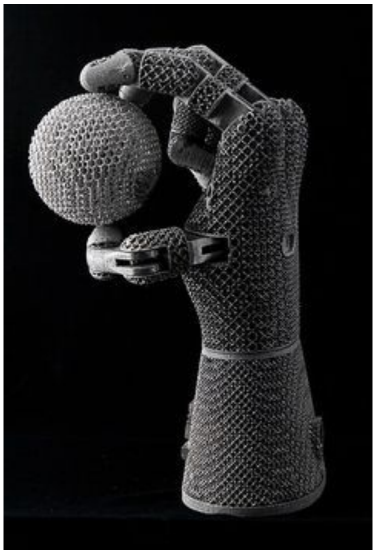
The molten plastics-type of machines are now very affordable and have become ubiquitous among hobbyists and machines can cost from as little as $ 150 upwards.

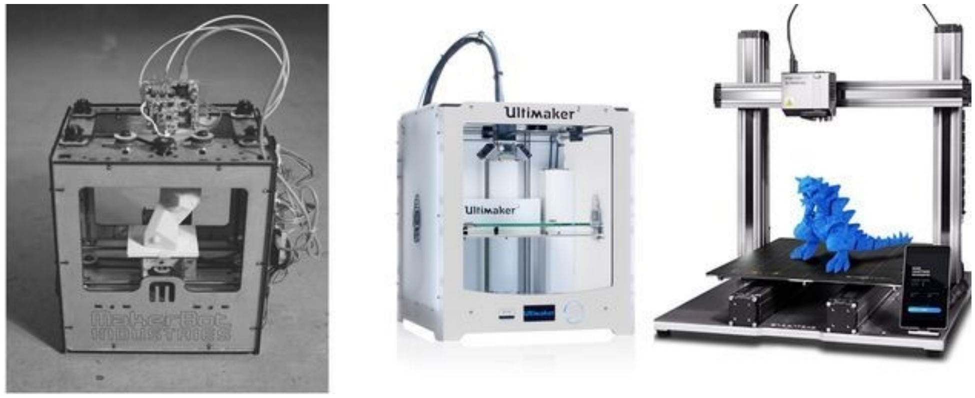
Most types of plastic filament used for molten 3D addition in these devices are bound to produce fume emissions there anything from irritant to very toxic and harmful, depending on the polymer chemistry used.

Accordingly, with the cheapest 3D plastic printers that use an open construction, fume extraction and respiratory protection are essential in order to have a safe process.

Larger, more expensive devices often use an enclosure, and ideally that should also have a vented extraction system built in to shield users from toxic emissions.

Many plastic filament printers may emit styrene which is a powerful carcinogen.





CDC 3D printer safety advice

- **Breathing in harmful materials: 3D printing can release particulates and other harmful chemicals into the air.**
- **Skin contact with harmful materials: Users can get hazardous materials, such as metal powders, solvents and other chemicals, on their skin.**
- **Static, fire and explosion: Some materials used can be flammable or combustible. High temperatures from some printers can cause burns.**

Ways to Protect Workers from 3D Printing Hazards

NIOSH has studied multiple ways to reduce exposure to 3D printing hazards. Some options include

- **Limiting equipment access to trained or authorized personnel**
- **Using enclosures for 3D printers and ventilation to capture chemical emissions**
- **Using materials with lower emissions**
- **Reducing time spent near the printer while it is running**
- **Training workers on potential hazards and how to protect themselves**
- **Wearing appropriate personal protective equipment, such as safety glasses, gloves, or lab coats**

Citation

NIOSH [2020]. 3D printing with filaments: Health and safety questions to ask. By Glassford E, Dunn KL, Dunn KH, Hammond D, Tyrawski J. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2020-115, https://doi.org/10.26616/NIOSHPUB2020115
external icon

WIKIPEDIA

Fused filament fabrication (**FFF**), also known as **fused deposition modeling** (with the trademarked acronym **FDM**), or *filament freeform fabrication*, is a 3D printing process that uses a continuous filament of a thermoplastic material.[1] Filament is fed from a large spool through a moving, heated printer extruder head, and is deposited on the growing work. The print head is moved under computer control to define the printed shape. Usually the head moves in two dimensions to deposit one horizontal plane, or layer, at a time; the work or the print head is then moved vertically by a small amount to begin a new layer. The speed of the extruder head may also be controlled to stop and start deposition and form an interrupted plane without stringing or dribbling between sections. "Fused filament fabrication" was coined by the members of the RepRap project to give an acronym (FFF) that would be legally unconstrained in its use.[2]
Fused filament printing is now the most popular process (by number of machines) for hobbyist-grade 3D printing.[3] Other techniques such as photopolymerisation and powder sintering may offer better results, but they are much more costly.

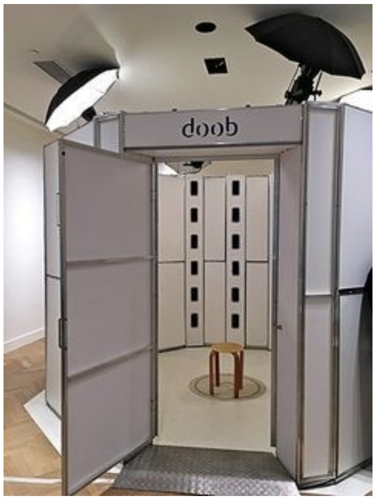
Illustration of a direct drive extruder which shows the name of parts.
The 3D printer head or 3D printer extruder is a part in material extrusion additive manufacturing responsible for raw material melting or softening and forming it into a continuous profile. A wide variety of filament materials are extruded, including thermoplastics such as *acrylonitrile butadiene styrene* (ABS),[4] *polylactic acid* (PLA), *polyethylene terephthalate glycol* (PETG), *polyethylene terephthalate* (PET), high-impact *polystyrene* (HIPS), *thermoplastic polyurethane* (TPU) and *aliphatic polyamides* (nylon).[5]

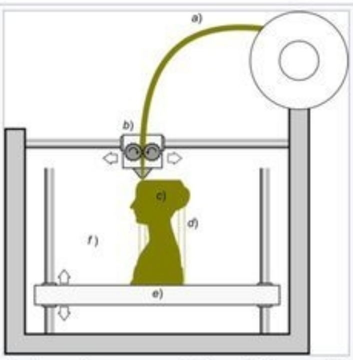
Double Extruder by ConcreteFlow

Europe's first 3D-printed residential house

https://www.cdc.gov/niosh/newsroom/feature/3dprinting.html

download pdf fact sheet
by the CDC

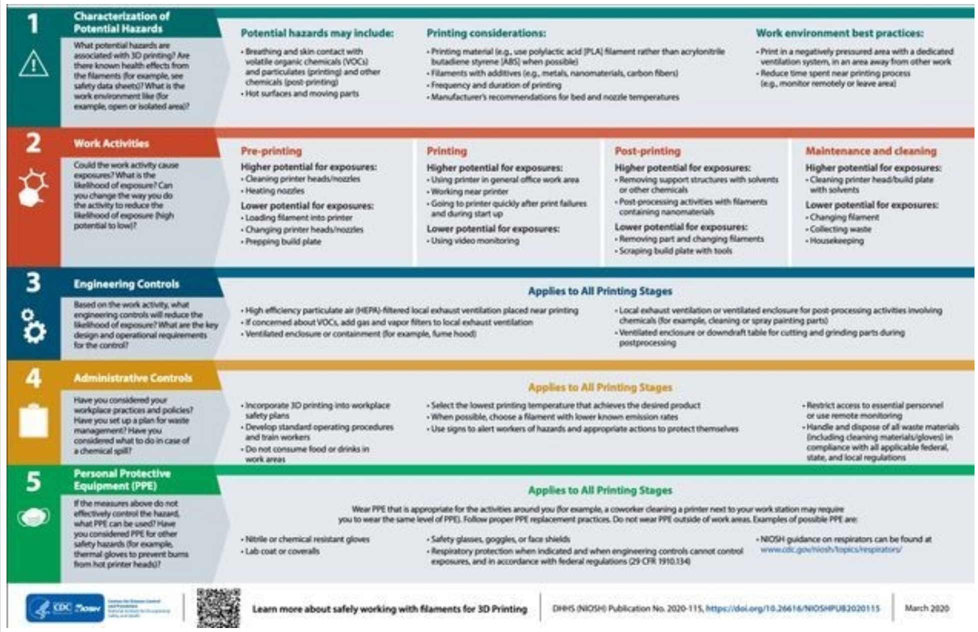




Schematic representation of the 3D printing technique known as fused filament fabrication; a filament **a)** of plastic material is fed through a heated moving head **b)** that melts and extrudes it depositing it, layer after layer, in the desired shape **c)**. A moving platform **e)** lowers after each layer is deposited. For this kind of technology additional vertical support structures **d)** are needed to sustain overhanging parts

Wikipedia

every user of 3D plastic printers should refer to copy of this well researched fact sheet published by the CDC for best practices and safe usage:



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/

Learn more about safely working with filaments for 3D Printing | DHHS (NIOSH) Publication No. 2020-115, https://doi.org/10.26616/NIOSHPUB2020115 | March 2020