



Kungliga Tekniska Högskolan

# Safe 3D printing

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## Safe 3D printing

### Introduction

The risks associated with 3D printers include exposure to potentially harmful ultrafine particles and chemical fumes released during the whole printing process, which can affect indoor air quality and cause health issues if ventilation is poor. There are also physical hazards, such as burns from the heated nozzle or build plate, and the possibility of fire if the printer is poorly maintained or malfunctions. Mechanical parts can also cause minor injuries if handled improperly.

The risks depend on the

- type of printer
- material
- placement
- ventilation.

In this brief analysis, we focused on two types of printers and specifically on exposure-related risks. Our recommendations are based on NIOSH [2023], Approaches to Safe 3D Printing<sup>1</sup>.

### Types of printers included in this analysis

#### Stereolithography (SLA)

SLA is a 3D printing technology that builds objects layer by layer by curing liquid photopolymer resin using a UV laser.

#### Fused filament fabrication (FFF)

FFF (or FDM) is a 3D printing technology in which a thermoplastic filament is melted and extruded through a heated nozzle, layer by layer, to build a three-dimensional object.

### Risks for exposure to hazardous substances

#### When may exposure occur

Pre-printing



- Inhalation risks: Cleaning printer heads and nozzles can release solvent vapours (e.g., alcohols, acetone, chloroform), which may irritate the respiratory system or cause more serious health effects depending on the chemical. During cleaning and filling of the resin tank, potential risks may arise depending on the classification of the resin.
- Skin risks: Liquid resins can cause skin irritation or sensitization (allergic reactions).

#### Printing

- Inhalation risks: Printers can emit ultrafine particles (UFPs) and volatile organic compounds (VOCs), especially in small or poorly ventilated spaces. Being close to the printer or dealing with print failures increases exposure.

#### Post-printing

- Inhalation and skin risks: Opening the print chamber, removing supports, sanding, or cleaning printed objects, especially when solvents or nanomaterial-containing filaments are used, can release additional particles and vapours. Direct handling of uncured resin can irritate skin or cause allergic reactions.

#### Maintenance and cleaning

- Inhalation risks: Cleaning components with solvents and performing printer maintenance can increase exposure to chemical vapours and airborne particles.
- Skin risks: Contact with solvents or uncured materials can cause irritation or chemical burns, depending on the substance.

#### Waste management

- According to KTH's routine.

### **Emission from materials; resin, filament, nanomaterial, cleaning chemicals**

#### Heated polymers (e.g. resin, filament)

- Release of:
  - Nanomaterial (<100 nm)
  - VOCs and semi-VOCs
- Possible risks:
  - Respiratory symptoms (cough, asthma, irritation of eyes, nose, throat)
  - Cardiovascular effects such as hypertension



## Filaments

- Risk of exposure through inhalation.
- Factors that increase emissions:
  - Material type (ABS, PLA, resin, nanomaterial-enhanced filaments)
  - Higher nozzle temperatures

## Resin

- Risk of exposure through inhalation and skin contact.
- For more detailed information, see the product's safety data sheet.
- Possible risks:
  - May cause irritation/allergic reactions upon skin contact or inhalation (see classification in the SDS)
  - e.g. ANYCUBIC Standard Resin+ (KLARA number 236862)
    - H315 - Causes skin irritation.
    - H317 - May cause an allergic skin reaction.
    - H319 - Causes serious eye irritation.
    - H335 - May cause respiratory irritation.
    - H411 - Toxic to aquatic life with long lasting effects.

## Cleaning chemicals

- Solvents such as isopropanol, ethanol, methanol, acetone, or chloroform are used for material surface finishing, vapor polishing, support material removal, or cleaning of the build plate.
- These solvents have occupational exposure limits and are flammable. Vapor formation may occur, potentially resulting in airborne concentrations that exceed the limits specified in AFS 2023:14. There is also a risk of creating an explosive atmosphere.
- For more detailed information, see the product's safety data sheet.
- Possible risks:
  - Inhalation risks: irritation, central nervous system effects, fire and explosion hazards.



- Skin risks: irritation or chemical burns.

## How to minimize the Risks

Because the short- and long-term risks associated with nanoparticles and gases generated during 3D printing are not well understood, we recommend applying the precautionary principle to both the setup and the safety measures.

### Exposure Risk by Inhalation

To reduce the risk of exposure to hazardous air during work with the 3D printer, it is recommended to:

- use an enclosed system (e.g., a 3D printer with a lid equipped with a built-in HEPA or carbon filter, or one that is directly connected to local exhaust ventilation). To minimize exposure, open the lid only after at least 20 minutes have passed since the printer completed its operation.
- install a local exhaust hood above the 3D printer connected to the process ventilation.

In addition, consider the following if you are using an FFF printer:

- Could you use a material for the filament that produces fewer nanoparticles and fumes (see information above)?
- Could you use a lower nozzle printing temperature?

All work tasks performed outside the printer that may involve exposure should be carried out in a ventilated workspace (e.g., a fume hood).

Depending on the set-up in place, it may be necessary to implement restrictions on room-use, allowing only personnel involved in the work to be present while the 3D printer is operating.

More information about engineering controls to reduce user exposures see chapter 4.4<sup>1</sup>.

### Exposure Risk via Skin Contact

Reducing airborne contaminants is also essential for minimizing skin contact, as certain substances with occupational exposure limits are readily absorbed through the skin.

Use personal protective equipment (PPE) when handling all material and chemicals according to their safety data sheet.

This should include, e.g.:

- Appropriate gloves



- Lab coat
- Safety goggles.

## Before Starting Work with a 3D Printer

It is important to assess the potential risks before beginning work with a 3D printer.

### Risk Assessment

- Conduct a risk assessment before starting work with a 3D Printer.
- Multiple risk assessments may be necessary if there are different types of printers in use.
- Investigate the risks mentioned above and determine the necessary measures to minimize them.
- **Note:** There are other hazards associated with using 3D printers beyond exposure risks, such as heat, moving parts, and UV lasers. The risk assessment should take all risks into account.
- All personnel involved must be informed about the risks.
- In some cases, it may be necessary to have a handling instruction guide available near the workstation to minimize risk.

<sup>1</sup>NIOSH [2023]. Approaches to safe 3D printing: a guide for makerspace users, schools, libraries, and small businesses. By Hodson L, Dunn KL, Dunn KH, Glassford E, Hammond D, Roth G. 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 2024-103, <https://doi.org/10.26616/NIOSH PUB2024103> .