

Guideline for Additive manufacturing / 3D-Print

Equipment for additive manufacturing (3D-printers) is used in numerous premises at ETH Zurich. As they differ greatly in their properties and thus also in their hazard potential, special safety measures – comprised within this leaflet - must be taken when using them.



Source: Harvard Campus Services EHS https://www.ehs.harvard.edu/sites/default/files/3d_printers_fact%20sheet.pdf

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Scope

These guidelines apply to all members of ETH Zurich (employees, students, apprentices, scholarship holders, visiting scientists) as well as to spin-offs and third parties working on ETH Zurich premises.

Definition / Description

Additive manufacturing processes (3D-printing) are all processes where a material is added layer by layer to produce a component. These components are created - based on data models - from liquids, polymers, powders, ribbon- or wire-shaped material via chemical and/or physical processes. [1] Figure 1 comprises the different processes.

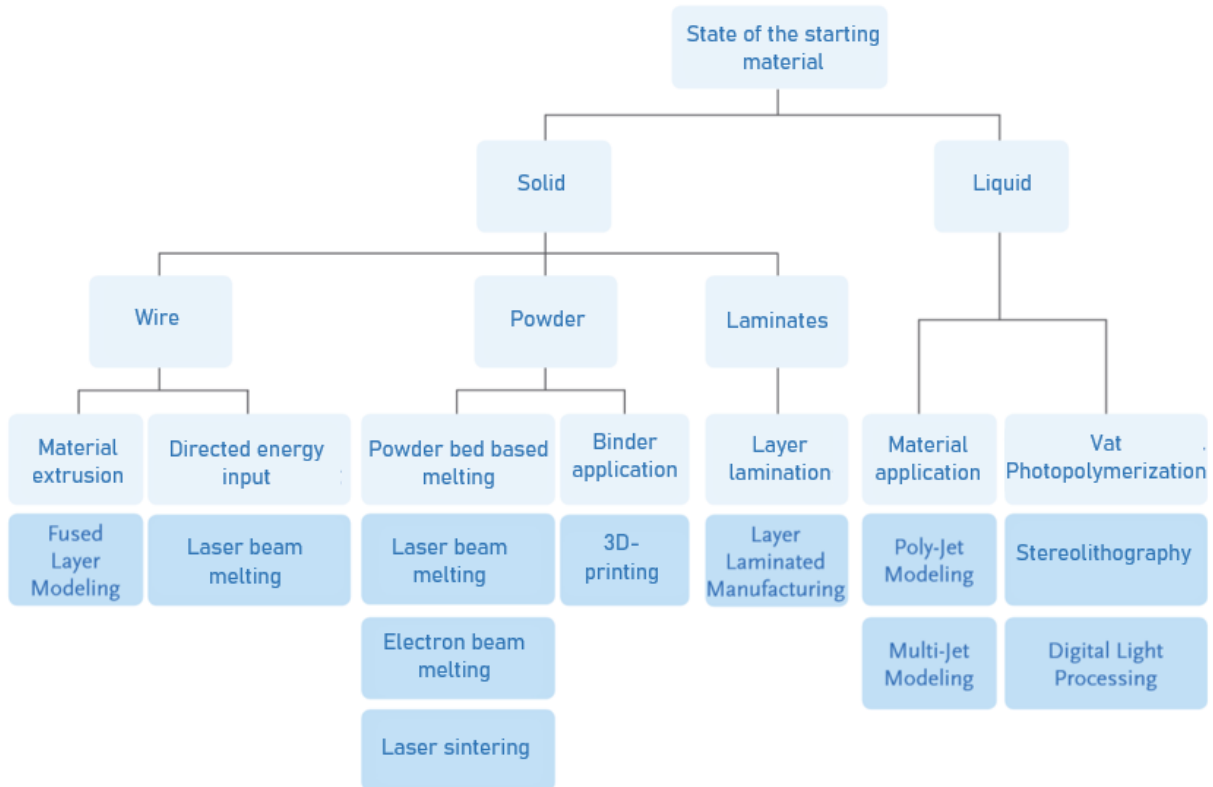


Figure 1: Subdivision of the additive manufacturing processes according to the initial material state and underlying process category [2]

Description of the procedure

- Pre-processes: Preparation of devices and starting materials, e.g. screening of specific particle sizes, filling the containers of the manufacturing machine with metallic powders.
- Construction/manufacturing processes: Depending on the printer type, heat, non-ionising or ionising radiation is used to melt the raw materials. A solid component of the raw material is obtained via passive or active cooling or via UV-polymerisation. These processes might also require the use of specific gases.
- Post-processes: Separation of the component from the building platform; cleaning by chemical etching, grinding; recycling and/or disposal of residual materials.

Declaration of conformity

At ETHZ, 3D-printers can be used if the manufacturer can prove that the basic health and safety requirements have been met. In doing so, he must provide the user / purchaser with a CE declaration of conformity and operating instructions. When purchasing such equipment, a declaration of conformity and operating instructions must be available. 3D-printers and complete kits are machines in the sense of the Machinery Directive 2006/42/EC and in Switzerland legally bound to the Machinery Ordinance (MaschV). [3] If the user alters / modifies a 3D-printer or assembles such a kit himself, he can become the manufacturer / distributor of the product. Accordingly, he assumes all manufacturer's obligations, including liability, and provides the necessary documentation for use.

Hazards

Additive manufacturing processes are constantly evolving and so are their sources of hazards. Depending on the process, hazards can occur in the pre-process, in the construction/manufacturing process as well as in the post-process:

- Health hazards due to exposure to substances such as materials, inert gases, cleaning agents, exhaust gases, hazardous waste. The absorption of substances *via* inhalation (inhalative exposure to gases, vapours, aerosols) can occur in all manufacturing processes (Fig. 1). Poisoning through skin/eye contact (dermal exposure) can occur, for example, when cleaning components with chemicals. Poisoning upon unintended swallowing (oral ingestion) might occur, for example, when taking off protective gloves incorrectly or if insufficient protective gloves are worn and consequently dirty fingers reach the lips. Particular caution must be taken when handling volatile chemicals, CMR substances (carcinogenic, mutagenic and/or toxic for the reproduction), powdered metals, ultra-fine particles, alveolene penetrant and inhalable dust as well as exhaust gases (e.g. welding smoke).
- Fire/explosion hazard due to flammable/oxidizable powders, e.g. metals or solvents used for cleaning.
- Non-ionising (microwave, infrared), ionising (UV, X-ray) radiation or heat hazards → for example burns, eye injuries, fire hazard.
- Hot machine parts (extrusion nozzle, hot wire, heated plate) may burn skin or cause fire.
- Electric hazards: Electric shock, short circuit, cable fire.
- Electromagnetic fields.
- Risk of injury: pinch points (moving machine parts), sharp edges (e.g. when removing the support structure).

Safety and protective measures

WARNING:

1. It is prohibited to print trademarks [4] and weapons.
2. The manufacturer's safety measures must always be considered. These instructions are summarised in the machine's manual; information on handling hazardous substances is provided in the corresponding safety data sheets.
3. At ETHZ the following measures apply:

Preventive protective measures

3D-printers must be placed in a separate room with good ventilation.

Once the user has performed a risk assessment, the defined preventive protective measures must be implemented according to the **STOP principle**. The acronym "STOP" stands for substitution, technical measures, organisational measures and personal measures. It determines the sequence in which protective measures against hazards have to be set up. The first step is to examine measures with the highest efficiency, i.e. with the greatest impact (highest priority: S, lowest priority: P). The table on page 5 comprises the measures according to the STOP principle.

Disposal

The printers themselves must be decontaminated and then disposed of via *Facility Management*.

Used chemicals and contaminated materials such as sand or "cleaning agents" must be disposed of as hazardous waste at ETHZ' hazardous waste disposal station →. Required containers can be obtained free of charge from the hazardous waste disposal station.

When disposing of hazardous waste, the following rules apply:

- Powdered/dusty material must be disposed of as hazardous waste in closed containers.
- Containers with liquid (dissolved) or paste-like material: Collect in closed secondary containers →
- Solid material: Collection in specific closed containers →
- Papers, cleaning cloths, PPE and other objects with chemical contamination:
 - collect in an (antistatic) plastic bag.
 - put the filled bag into a second bag or solid plastic container.
- Seal all containers tightly and label accordingly. Explicitly declare toxic contents (e.g. nickel) on the label.
- Store in a fume cupboard or similar suitable ventilated place.
- If possible, dispose of them as soon as possible at one of the ETHZ' hazardous waste disposal stations.

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| | Hazards / Risks | | | | |
|---------------------------------|---|---|--|---|--|
| | Chemicals/ Exhaust | Fire, explosion risks | Optical radiation | Risk of burns | Acoustic disturbance |
| S ubstitution | Prefer acrylonitrile butadiene styrene (ABS) printers. | Use non-flammable, -oxidizable powders. | Prefer thermal printers. | Limit heating temperature below 65°C. | Contact the SSHE department cabs@ethz.ch |
| T echnical measures | - Mechanical ventilation connected to chemical/process exhaust air with HEPA filter H14. - No exhaust air recirculation. - Air exchange rate of at least 3-fold room volume per hour. | - Work under inert atmosphere (Ar, N ₂). To be discussed with the SSHE department cabs@ethz.ch . - Source extraction/ Air exchange rate of at least 3x room volume per hour. | Limit radiation (if necessary, integrate into a UV-radiation-proof housing, fit a beam trap, use non-reflective shielding elements). | Integrate hot machine parts (extrusion nozzle, hot wire, heat plate) in a ventilated housing and prevent access. | Encapsulate the installation, if required tender using low-expansion foam. |
| | Install in a ventilated and filtered housing. | | | Contact the SSHE department (cabs@ethz.ch) if the temperature can't be lowered. | |
| | If not possible, consult the SSHE department cabs@ethz.ch . | | | | |
| O rganisational measures | Reduce the - number of 3D-printers. - number of 3D-printers running simultaneously. - number of users. - exposure duration. | - Use particles with diameter > 0.5 mm. - Dilute smaller particles in a solvent. | - Never set the light beam at eye level, neither for standing nor seated persons. - Always enclose or shield the beam path. | | |
| | | Contact the SSHE department (cabs@ethz.ch) when impossible. | - Do not wear jewellery or watches during adjustment work. - When possible, work with switched off optical beam. | | |
| | Warning sign stickers. Contact SSHE (stickers@ethz.ch) | | | | |
| P PE* | Prevention against particulate matter: FFP2-Mask. Against VOC: ABEK gas mask. | Face shield and polyvinylchlorid (PVC) apron. | Wear suitable protective goggles and heat insulation if necessary. | | Hearing protection. |

* These personal protective equipment (PPE) should be worn in addition to safety glasses, gloves and laboratory coat.

VOC: volatile organic chemicals; FFP2: filtering face piece class 2; ABEK: [Gas combination filters](#) →

Legal aspects and references

- [1] Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung, «3D Drucker,» 8 Oktober 2020. <https://www.dguv.de/ifa/fachinfos/arbeiten-4.0/neue-technologien-stoffe/3d-drucker/index-2.jsp>.
- [2] M. Schmauder; K. Höhn; I.-L. Hilgers; B. Meyer; S. Schreiber, "3-D-Druck und Produktsicherheit: Informationen für die Marktüberwachung" <https://www.baua.de/DE/Angebote/Publikationen/Fokus/3-D-Druck-Marktueberwachung.html>.
- [3] Bundesgesetz über die Produktesicherheit (PrSG)
- [4] Bundesversammlung der Schweizerischen Eidgenossenschaft, "Bundesgesetz über den Schutz von Marken und Herkunftsangaben" <https://www.admin.ch/opc/de/classified-compilation/19920213/index.html>.
- [5] Federal Act on Protection against Dangerous Substances and Preparations (Chemicals Act, ChemA)
- [6] Ordinance on Protection against Dangerous Substances and Preparations (Chemicals Ordinance, ChemO)
- [7] Ordinance on the Placing on the Market and Handling of Biocidal Products (Ordinance on Biocidal Products, OBP)
- [8] Verordnung über das Inverkehrbringen von Pflanzenschutzmitteln (Pflanzenschutzmittelverordnung, PSMV)
- [9] Verordnung über die in Lebensmitteln zulässigen Zusatzstoffe (Zusatzstoffverordnung, ZuV)
- [10] Bundesgesetz über die Arbeit in Industrie, Gewerbe und Handel (Arbeitsgesetz, ArG)
- [11] Bundesgesetz über die Unfallversicherung (UVG)
- [12] Verordnung über die Verhütung von Unfällen und Berufskrankheiten (VUV)
- [13] Arbeitsgesetz vom 13.3.1964 (Art. 6, Art. 35) und die Wegleitung zu VO 3 und 4 zum Arbeitsgesetz (Wegleitung 3 und 4 zur ArG)

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Status: October 2021, V1.0