



Exposure control in metal 3D printing work

Metal 3D printing is a rapidly evolving industry with a growing workforce. During metal 3D printing processes, ultrafine particles are released into the air and can penetrate deep into the respiratory system and other parts of the body. Learn about the measures you can take to minimize occupational exposure in the workplace.

Printing methods and materials

- Metal 3D printing using powder bed fusion is an additive manufacturing technique where material is built up layer by layer according to a computer model.
- The fine powder material loaded into the printer is hardened into the desired shape using a laser.
- Metal 3D printing work also involves handling of printing powder, such as sieving, as well as post-processing and maintenance tasks.
- Various metal powders are used in 3D printing, depending on the application. These powders may contain, for example, iron, chromium, nickel, aluminum, and titanium.

The guidelines specifically apply to powder bed fusion (PBF) printing process

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Health effects of exposure

- In metal 3D printing work, exposure to metal fumes and particles can occur through inhalation of fine and nanosized metal dust. Additionally, exposure can happen through skin contact or by transferring particles from hands to the mouth.
- Metal fumes and particles have adverse health effects, including respiratory and cardiovascular diseases, reduced lung function, and effects on the nervous system and brain.
- Certain metals are classified as carcinogenic (Category 1A/1B), such as hexavalent chromium and nickel compounds.
- The size and mass of the particles influence their aerodynamic behavior and how deeply they can penetrate into the lungs.
- When assessing the exposure, it is essential to determine the chemical properties of both the raw materials and the airborne particles released during the process.

Exposure in metal 3D printing work

In metal 3D printing, the printed material is heated, releasing particles similar to welding fumes into the air. 3D printers are typically enclosed and equipped with an exhaust duct connected to the ventilation system and/or an outgoing air filtration system. As a result, very few particles are released into the work environment during printing process.

However, fine metal particles can be released into the work environment when handling the printing powder and 3D-printed products.

Handling of printing powder

- Printing powder is handled during processes, e.g., sieving and loading the 3D printer.
- When the print powder is handled, the risk of exposure is related to dusting the powder.
- Due to the flammability and dust explosion risk of metal powders, they must be handled and stored properly.
- Pay attention to static electricity control and efficient ventilation. Always use appropriate fire suppression methods, such as Class D fire extinguishers.

Handling of printed products

- The highest risk of particle exposure in metal 3D printing occurs during post-processing.
- Post-processing tasks include cutting and grinding the printed parts. These tasks are almost always performed manually by the workers.
- Although post-processing methods vary, these tasks typically generate large amounts of ultrafine particles.

Exposure control

In order to assess the exposure and select the appropriate control measures, the hazard properties of the printing powders in use must be identified, and the risks of each task must be evaluated.

- You can utilize occupational hygiene measurements or biomonitoring of the workers.
- The STOP principle is recommended for exposure management, as it outlines the priority order of the control measures, and is based on the EU directive on chemical agents.

Substitution

- Review the hazard properties of the printing powders and their safety data sheets. Choose less harmful alternatives whenever possible.

Technical measures

- Reduce exposure by ensuring good ventilation and effective local exhaust systems in the production area.
- Enclose or isolate work processes that pose exposure risk.
- Regularly inspect ventilation and local exhaust systems. You can assign a responsible person for this task.

Organizational measures

- Train employees in safe working practices and restrict access to high-risk areas.
- Maintain cleanliness through vacuuming, wet floor cleaning, and proper hygiene practices. Pay attention to handwashing, and maintenance of protective equipment.

Personal protection

- Use a powered air-purifying respirator with particle filters (TH3P or TM3P) during work. For short tasks that do not involve powder handling or post-processing, an FFP3-class respirator is sufficient. Ensure a proper face seal.
- Wear type 5 disposable chemical protective clothing to protect against dust exposure.
- Use disposable nitrile gloves. The glove cuffs must extend well under the protective suit sleeves.
- If necessary, wear additional gloves over the nitrile gloves to protect against mechanical hazards. The cuffs should extend over the protective clothing sleeves.

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Finnish occupational exposure limits

When conducting a risk assessment, it is essential to consider the occupational exposure limit values (OELs) set for various substances in workplace air, as well as the target levels suggested by the Finnish Institute of Occupational Health (for an 8-hour exposure period).

Exposure agent	Limit value or target level (in Finland)
	OEL
Aluminum and its poorly soluble compounds	1 mg/m ³
Inorganic dust	10 mg/m ³
Chromium and its (II, III) compounds	0,5 mg/m ³
Nickel, inhalable dust	0,05 mg/m ³ (binding limit value)
Nickel, respirable fraction	0,01 mg/m ³ (binding limit value)
Iron oxide, fumes	5 mg/m ³
	Target level, general dust
Respirable fraction	0,5 mg/m ³
Inhalable dust	2 mg/m ³
	Target level, engineered nanomaterials
Particles, density > 6 000 kg/m ³	20 000 #/cm ³
Particles, density < 6 000 kg/m ³	40 000 #/cm ³

More information on biomonitoring of chemical exposure and action limits (in Finnish)

<https://www.ttl.fi/kemikaalialtistumisen-biomonitorointi>

Are you looking for guidelines on chemical safety in 3D printing, handling nanomaterials, metalworking, or selecting protecting equipment?

More information on [the Finnish Institute of Occupational Health's website](https://www.ttl.fi) (in Finnish)

<https://www.ttl.fi/malliratkaisut>



Checklist for workplaces: Metal 3D printing work

Ventilation

- ☐ Ensure effective general ventilation.
- ☐ Utilize automation and closed systems as much as possible.
- ☐ You can also limit the spread of the exposure agents by sectioning the areas and controlling pressure difference between rooms.

Work arrangements

- ☐ Pay attention to hygiene and work arrangements of the post-processing, including technical control measures.
- ☐ Avoid work methods that spread particles, such as compressed air tools.
- ☐ Organize access to printing areas through a separate changing room.
 - ✓ Store protective equipment in the changing room and wear the work clothing only before entering the printing areas.
 - ✓ Change work clothes after completing a dusty work phase.
- ☐ Ensure that no one accidentally enters the work area without protection during dusty tasks.
 - ✓ For example, ensure visibility to the workspace or indicate ongoing work phase with a sign.
- ☐ If printing powders contain carcinogenic metals, assess whether employees need to be registered in the ASA register. Also, consider the risks of working during pregnancy.

Personal protective equipment (PPE) and cleanliness

- ☐ Use appropriate PPE and ensure its compatibility.
- ☐ Take care of the cleanliness of PPE and check its condition regularly. Replace protective gear frequently enough.
- ☐ Ensure that work areas are clean and easily cleanable:
 - ✓ Clean your workstation after completing the work. Remember to protect yourself during the cleaning process as well.
 - ✓ Do not store unnecessary items in the work areas. This makes it easier to keep the premises clean.
 - ✓ Use a vacuum cleaner or wet wiping for cleaning. Avoid methods that spread particles, such as brushing or using compressed air.
 - ✓ Consider whether electrical cables could be routed overhead in the areas. Free floor surfaces are easier to clean.
- ☐ Metal dust may be transported on shoe soles. Reduce the dust transportation by placing adhesive mats between different areas.
- ☐ Wash your hands thoroughly whenever leaving the production area.
- ☐ Do not eat or drink in the production areas.

Recommendation: Personal protective equipment for metal 3D printing work

In metal 3D printing work, protection from metal dust is necessary. Some dust may remain suspended in the air as an aerosol. Be careful not to stir up dust that has already settled.



When working in production areas for less than 2 hours and not handling powder or performing post-processing, use:

- at least an FFP3-class respirator
- type 5 protective clothing, which protects against dust
- disposable nitrile gloves, safety footwear, and eye protection against coarse dust.



When working in production areas for more than 2 hours, use:

- a powered air-purifying respirator equipped with a particle filter and a hood or helmet as part of the facepiece, TH3P
- type 5 protective clothing, which protects against dust
- disposable nitrile gloves and safety footwear.



Alternative 2, when working in production areas for more than 2 hours, use:

- a powered air-purifying respirator equipped with a particle filter and a full-face mask that seals to the face, TM3P; this offers better protection than the TH3P-class respirator
- type 5 protective clothing, which protects against dust
- disposable nitrile gloves and safety footwear.