SCHICHTWERK · SICHERHEITSWERK

OCCUPATIONAL SAFETY HANDBOOK

Occupational Safety, Health Protection and Trade-Law Classification in Additive Manufacturing

Full Edition – Reference Work for FDM/FFF and SLA/DLP/MSLA

The Austrian AUVA Framework with DACH and EU Context

Legal basis · Risk assessment · Emissions · Hazardous substances · Limit values · Protective measures · Operating practice

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No cooperation with the weapons, military or defence industry

Note on scope, strand and limit values

This full edition is the detailed reference. Parts I–VII describe the state of the art and the legal situation; Part VII (operating practice) is written as an internal, company-specific implementation guide.

This document is NOT legal advice. Limit values are stated with their legal basis; the Austrian Limit Values Ordinance (GKV) is amended frequently – before binding use, verify all values against the current RIS version (GKV 2025, Annex I, Federal Law Gazette II No. 339/2025).

Schichtwerk is a contract manufacturer; the responsibility for operational implementation rests with the respective employer.

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Preface and Structure

3D printing is often perceived as a clean, quiet office device. In occupational-safety terms this image does not hold: material-extrusion and photopolymer processes release particles, volatile organic compounds and reactive chemicals, and entail thermal, optical as well as fire and explosion hazards. With increasing use in industry, education and healthcare, exposure shifts into environments without established industrial-hygiene infrastructure.

This full edition consolidates the applicable legal bases, the state of scientific emission and toxicology research and the practical protective measures into a coherent reference. It is structured into seven parts: Part I (legal framework), Part II (risk assessment), Part III (emissions and air quality), Part IV (hazardous substances and limit values), Part V (protective measures), Part VI (trade-law classification) and Part VII (operational implementation). The appendix contains the limit-value master table, a glossary and the references.

Part I
Legal Framework of Occupational Safety

1. The Austrian Employee Protection Act (ASchG)

The Employee Protection Act (ASchG, Federal Law Gazette No. 450/1994 as amended) is the Austrian counterpart to EU Framework Directive 89/391/EEC. It obliges employers to identify and assess the existing risks to the safety and health of employees and, on that basis, to define, implement and continuously adapt suitable measures. [1]

1.1 Core provisions

Section	Subject matter
§ 3	General employer duties; principle of responsibility for safety and health.
§ 4	Definition of measures (workplace risk assessment); identification and assessment of hazards.
§ 5	Safety and health documents (documentation duty).
§ 7	Principles of prevention; hierarchy of measures.
§ 12 / § 14	Information / instruction of employees.
§ 41 / § 42	Work substances; register; substitution and use restrictions.
§ 45 / § 46	Limit values and minimization; measurement obligation.
§ 82a	Preventive services; safety experts and occupational physicians.

1.2 Principles of prevention (§ 7 ASchG)

Under § 7 ASchG the employer must apply the following principles in the stated order: avoidance of risks; assessment of unavoidable risks; combating hazards at source; consideration of the human factor; adaptation to the state of the art; replacement of dangerous substances; priority of collective protection over individual protection.

From these principles derives the hierarchy of measures used in practice, the STOP principle: Substitution, Technical measures, Organizational measures, Personal measures. Technical and collective measures always take precedence over personal protective equipment. [2]

1.3 Accompanying ordinances

- Limit Values Ordinance (GKV) – MAK and TRK values for work substances (Annex I).
- Work Equipment Ordinance (AM-VO) – safe use of machines.
- Explosive Atmospheres Ordinance (VEXAT) – relevant for isopropanol (see Part V).
- Documentation Ordinance (DOK-VO) – form of safety and health documents.

2. The AUVA as Carrier of Accident Insurance

The General Accident Insurance Institution (AUVA) is the carrier of statutory accident insurance in Austria. It provides accident treatment, rehabilitation, compensation and, in particular, prevention; it offers free guidance leaflets, assessment aids and training. Accident insurance is a mandatory insurance funded by employers. [3]

2.1 Relevant AUVA publications (selection)

Number	Title / content
M 391	Safe handling of hazardous work substances (STOP principle, substitution, PPE).
M.plus 385	The safety data sheet (structure, joint storage).
M 705 / M 719	Protective gloves / respiratory filters.
M 910 / M.plus 911	Ventilation at the workplace / extraction systems.
eval.at	Assessment templates (developed with the social partners).

3. The EU Framework

- Framework Directive 89/391/EEC – basic employer duties (AT: ASchG, DE: ArbSchG).
- Directive 98/24/EC (CAD) – protection against chemical agents; basis for occupational exposure limits (IOELV).
- Directive 2004/37/EC (CMD) – carcinogens, mutagens and reprotoxic substances (binding BOELV; relevant for formaldehyde).
- REACH Regulation (EC) No 1907/2006 – safety data sheets (Annex II), DNEL, exposure scenarios.
- CLP Regulation (EC) No 1272/2008 – classification, labelling and packaging (UN-GHS).

Part II

Workplace Risk Assessment in Additive Manufacturing

4. Assessment Methodology (§ 4 ASchG)

The workplace risk assessment is the central mandatory process of the ASchG. The AUVA structures it into five steps; it is not a one-off act but an ongoing process.

1. Prepare: define work areas and activities, collect information (SDS, manuals, past incidents).
2. Identify hazards: inspection, employee survey, checklists; capture all hazard factors.
3. Assess hazards: evaluate likelihood and possible severity; check limit-value reference.
4. Define measures: per STOP principle, with responsible persons and deadlines.
5. Document and review: create the safety and health document, monitor effectiveness, update on changes.

The assessment must be repeated in particular after accidents, on suspicion of work-related illness, with new equipment, substances or processes, on changes to the working environment, and on justified request of the Labour Inspectorate. [1]

Particularly vulnerable persons (§ 4 (2) ASchG)

Young workers and apprentices, pregnant and breastfeeding workers, and workers with special needs must be considered separately.

For reprotoxic substances (e.g. individual photoinitiators), employment restrictions must be examined.

5. Hazard Catalogue for 3D Printing

Hazard factor	FDM/FFF	SLA/DLP/MSLA	Post-processing
Inhalation	ultrafine particles, VOC	resin vapours, IPA vapours	sanding dust, solvents
Dermal	low	uncured resin, IPA	resin residues, adhesives
Thermal	nozzle 200–300 °C, bed	low	hot air, tempering
Optical (UV)	–	UV curing	UV post-curing
Mechanical	moving axes, pinch points	pinch points	cutting, sanding, injuries
Fire/explosion	low	IPA vapours (VEXAT)	solvents
Ergonomic/psychological	print-farm supervision	repetitive cleaning	repetitive fine work

The IFA measurement programme on exposure in additive manufacturing shows: for powder-based processes inhalation exposure lies below the limit values, provided capture at source or encapsulation is used; for carcinogenic metal alloys, intensified measures are required. [4]

Part III

Emissions and Air Quality

6. Origin and Character of Emissions

In material extrusion, thermoplastic filament is extruded through a heated nozzle. Thermal stress partially breaks polymer chains; ultrafine particles (diameter < 100 nm) and volatile organic compounds are released. The emitted particles are predominantly ultrafine; FDM printers are classified as “high emitters” per the scheme of He et al. [5]

7. Particle Emission Rates (quantitative)

In the foundational study by Stephens et al. (2013), total ultrafine particle emission rates for ABS filament were about an order of magnitude higher than for PLA: approximately 1.9×10^{11} particles per minute versus approximately 2.0×10^{10} particles per minute. [6]

The meta-analysis by Byrley et al. (2019) found mean particle number concentrations of about 300,980 particles/cm³ for ABS and about 65,482 particles/cm³ for PLA across studies. The authors emphasize the considerable heterogeneity of measurement methods – concentration data were available from only 7 of 16 evaluated studies – and call for standardized test protocols. Some chamber studies also found higher values for PLA than for ABS. [7]

Assessment

The figures are orientation values, not limit values. The PLA/ABS ranking can vary with the setup.

Tracheobronchial deposition of ultrafine 3D-printing particles was estimated at 1–13 % depending on size; cell studies showed dose-dependent cytotoxicity and oxidative stress for ABS and polycarbonate emissions.

There is no separate air limit value for ultrafine particles; assessment relies on the minimization principle.

8. VOC Speciation by Material

Material	Lead VOC	Order of magnitude	Assessment
ABS / ASA / HIPS	styrene	~10–113 µg/min	IARC 2A; ASA also acrylonitrile
Nylon / PA, PCTPE	caprolactam	up to ~180 µg/min	respiratory/skin irritation
PLA	lactide	~4–5 µg/min	not health-critical
PETG	acetaldehyde, formaldehyde	low	low rates
POM	formaldehyde	–	carcinogenic (see Part IV)

9. Emission-Measurement Standards

ANSI/CAN/UL 2904 (1st ed. 2019, 2nd ed. 2023) defines a method for testing and assessing particle and chemical emissions from free-standing 3D printers in non-industrial indoor environments; it establishes emission criteria and measurement-quality requirements. GREENGUARD certification for non-industrial 3D printers builds on it. [8]

- Blue Angel / RAL-UZ 205 – ecolabel for printing devices with UFP/VOC requirements.
- ECMA 328 and ISO 28360 – reference standards for emission-data determination.

Part IV

Hazardous Substances and Limit Values

10. System of Austrian Limit Values

In Austria, only the MAK values (health-based) and TRK values (risk-based for carcinogens without a derivable threshold) from Annex I of the Limit Values Ordinance are binding. TMW denotes the daily average (usually 8 hours), KZW the short-term value. Labels: H = dermal absorption, S/Sa/Sh/Sah = sensitizing, E = inhalable, A = alveolar fraction. A minimization requirement applies throughout. [9]

Current version: GKV 2025, Federal Law Gazette II No. 339/2025, in force since 31 Dec 2025.

11. Limit-Value Master Table (AT / DE / EU)

Substance (CAS)	Austria (GKV)	Germany (AGW/MAK)	EU / classification
Styrene (100-42-5)	TMW 20 ppm / 86 mg/m³	AGW 20 ml/m³ / 86 mg/m³	IARC 2A; EU Repr. 2
Formaldehyde (50-00-0)	TMW 0.3 ppm / 0.37 mg/m³; KZW 0.6 ppm; III A2 (clearly carcinogenic)	AGW 0.3 ppm / 0.37 mg/m³; Carc. 1B	IARC 1; EU Carc. 1B
ε-Caprolactam (105-60-2)	TMW 5 mg/m³ (E); KZW 40 mg/m³ (E)	AGW 10 mg/m³	not carcinogenic
Isopropanol (67-63-0)	TMW 200 ppm / 500 mg/m³; KZW 800 ppm*	AGW 200 ml/m³ / 500 mg/m³	H319, H336
Acrylates (var.)	substance-specific, partly sensitizing (Sh)	substance-specific	H317 (sens.)

** Isopropanol short-term value from a manufacturer SDS with GKV reference, not directly verified from the RIS annex. For caprolactam, the Austrian TMW (5 mg/m³) is lower than the German AGW (10 mg/m³). Verify all values against the current RIS version GKV 2025 (Annex I) before binding use.*

12. Photopolymer Resins – CLP Classification and SDS

Photopolymer resins are mixtures of (meth)acrylic esters, multifunctional monomers (e.g. HEMA, TEGDMA, isobornyl acrylate, urethane diacrylates) and photoinitiators (e.g. TPO). Typical CLP classification: H315 (skin irritation), H319 (serious eye irritation), H317 (skin sensitization), H411/H412 (hazardous to the aquatic environment), partly H361f (suspected of damaging fertility). A safety data sheet per REACH Annex II must be on hand for every resin and additive. [10]

13. (Meth)acrylate Sensitization

Allergic contact dermatitis from uncured (meth)acrylates is a type IV (delayed-type) hypersensitivity. The monomers act as haptens, bind to the body’s own proteins and thus become the allergen. Sensitization is cumulative and may occur after weeks, months or years of symptom-free exposure; once established, it is permanent. [11]

Key clinical points

Pronounced cross-reactivity between related monomers – a mere product change usually does not solve the problem; complete avoidance is recommended for sensitized individuals.

Monoacrylates are strong, monomethacrylates weaker sensitizers.

Fully cured resins are rarely sensitizing; however, sanding/machining cured parts can release reactive monomers.

Part V

Protective Measures per the STOP Principle

14. S – Substitution

- PLA/PETG instead of ABS/ASA where technically possible (factor 10–100 lower UFP rates).
- For resin washing: water-based IPA mixtures or solvents with flash point > 60 °C; consider solvent-free methods. Ethanol and 2-butoxyethanol are not suitable substitutes.

15. T – Technical Measures (priority)

- Enclosed build chamber as the most important single measure; slight negative pressure for source capture.
- Source extraction before room ventilation. Externally recognized extraction solutions with documented filter performance are preferable to integrated filters – merely installing a filter without proof of effectiveness is not sufficient.
- Filtration: HEPA ≥ H13 against particles/nanoparticles and activated carbon against VOC. Maintenance, timely replacement and at least annual performance check. Activated carbon also depletes when unused.
- Closed process handling for SLA/DLP: UV protection, sealed wash-&-cure stations.

16. O – Organizational Measures

- Separate, separately ventilated installation room (especially for print farms); access restriction.
- Reduce exposure duration and number of persons; hygiene (no eating/drinking/smoking in the area; hand washing).
- Operating instructions and training; substance register; SDS on site.

17. P – Personal Protective Equipment

PPE	Specification	Note
Respiratory (VOC)	type A gas filter (organic vapours)	e.g. half mask with A filter
Respiratory (particles)	P2/P3 filter	P3 for sanding work
Gloves	nitrile or butyl rubber	no latex; observe breakthrough times, change regularly
Eye protection	safety/basket goggles	where resin/IPA splashing is possible
Skin protection	skin-protection plan, long sleeves	wash resin splashes off immediately

18. Fire and Explosion Protection for Isopropanol

Pure isopropanol (CAS 67-63-0) has a flash point of about 12 °C (closed cup), explosion limits in air of about 2.0 to 12.7 vol-%, an ignition temperature around 399–425 °C and a vapour pressure of about 43 hPa at 20 °C; the vapours are heavier than air. Explosive vapour/air mixtures form already at room temperature. [12]

Measures (VEXAT reference)

Local extraction strongly recommended; tightly sealed extracted washers; do not leave IPA open overnight in a leaking washer.

Conductive, earthed containers; drip trays; spark-free tools; explosion-protected electrics.

Create an explosion-protection document; recurring inspection. Explosive peroxide can form on prolonged storage.

19. Waste Disposal

Liquid and cured resin, IPA contaminated with resin/IPA, and contaminated wipes and filters are hazardous waste and must be disposed of via authorized contractors – not into the sewer or household waste. Resins are hazardous to the aquatic environment (H411/H412). Fully post-cure cured resin under UV before disposal.

Part VI

Trade-Law and Professional Classification

20. Austria: Regulated Craft of Plastics Processing

In Austria, the commercial production of functional 3D-printed parts (contract manufacturing) is assigned to the regulated craft “plastics processing” (proof of qualification required; access ordinance Federal Law Gazette II No. 66/2003 as amended by II No. 399/2008, based on § 18 Trade Act 1994). It is not a free trade once parts go beyond mere demonstration models. [13]

Restricted trade authorizations for 3D printing

“Copyshop”: plastics processor, restricted to operating plastics 3D printers to produce parts from provided data sets.

“Contract manufacturing”: plastics processor, restricted to producing products by plastics 3D printer.

Additional entrepreneurial examination required; final classification by the trade authority, where applicable by declaratory decision.

The competent professional organization is the Federal Guild of Plastics Processors (WKO, Crafts and Trades division). This is distinct from the printing trade (paper/film), which does not cover additive plastics 3D printing. The statistical NACE class is 22.29. Mandatory WKO membership and statutory AUVA accident insurance apply.

21. Germany: Employers’ Liability Insurance Associations (comparison)

In Germany, mandatory membership applies with the competent employers’ liability insurance association (BG) as carrier of statutory accident insurance (SGB VII; notification within one week per § 192 SGB VII). The main activity is decisive: BG ETEM is de facto leading on 3D-printing occupational safety; BG RCI is competent for chemistry/plastics-heavy operations. Exactly one BG is competent per company. [14]

Part VII

Operational Implementation (internal)

This part is written as an internal, company-specific implementation aid and is prescriptive. It is not intended for publication.

22. Assessment Checklist for the 3D-Printing Workplace

- Work area defined (printing, washing/curing, post-processing considered separately)?
- Material list with current SDS available? Substance register kept?
- High-emission materials (ABS/ASA/PA) only on enclosed machines with extraction?
- Extraction/filter installed and effectiveness documented? Last filter check?
- Resin area: sealed wash-&-cure station, UV protection, IPA explosion protection, drip tray?
- PPE provided (nitrile, goggles, A/P filter) and instruction given?
- Waste separation (resin/IPA/filter as hazardous waste) organized?
- Particularly vulnerable persons considered? Documentation created?

23. Contents of an Operating Instruction (per substance)

6. Scope and substance (designation, SDS reference).
7. Hazards to humans and the environment (H-statements, pictograms).
8. Protective measures and rules of conduct (technical, organizational, PPE).
9. Behaviour in case of danger (fire, release).
10. First aid (skin/eye contact, inhalation).
11. Proper disposal.

24. Recurring Duties (intervals)

Duty	Interval / trigger
Update assessment	on change of material/machine/process; after incidents
Check/replace filter performance	at least annually or per manufacturer
Instruct employees	at least annually and on changes
Check SDS currency	ongoing; on supplier/formulation change
Explosion-protection inspection (IPA)	recurring per VEXAT/manufacturer
Workplace measurement	on imminent limit-value exceedance (§ 46 ASchG)

Appendix

A. Glossary

Term	Meaning
UFP	Ultrafine particles (diameter < 100 nm)
VOC / TVOC	Volatile organic compounds / total value
MAK / TRK	Maximum workplace concentration / technical guide concentration (AT)
AGW	Occupational exposure limit (DE, TRGS 900)
TMW / KZW	Daily average / short-term value
IOELV / BOELV	Indicative / binding EU occupational exposure limit
DNEL	Derived No-Effect Level (REACH)
STOP	Substitution – Technical – Organizational – Personal
HEPA H13	HEPA filter class (≥ 99.95 % at MPPS)
VEXAT	Explosive Atmospheres Ordinance (AT)

B. Declarations

Conflict of interest: The author operates Schichtwerk, a service company in additive manufacturing. This work reflects the published state and was prepared without external funding.

Data availability: based on published literature, standards and legal sources; no new primary data. Limit values must be checked against the current RIS version of the GKV before binding use.

Suggested citation: [Nachname] T. Occupational Safety Handbook – Occupational Safety, Health Protection and Trade-Law Classification in Additive Manufacturing. Full edition, Version 1.0. Schichtwerk; 2026.

C. References

[1] Employee Protection Act (ASchG), Federal Law Gazette No. 450/1994 as amended. §§ 3–7, 12, 14, 41–42, 45–46, 82a. RIS – Federal Legal Information System.

[2] Labour Inspectorate / AUVA. STOP principle and principles of prevention. arbeitsinspektion.gv.at.

[3] General Accident Insurance Institution (AUVA). Leaflets M 391, M 705, M 719, M 910, M.plus 385; assessment templates eval.at. Vienna: AUVA.

[4] Institute for Occupational Safety and Health of the DGUV (IFA). Measurement programme on exposure in additive manufacturing. Sankt Augustin: DGUV.

[5] He C, Morawska L, Taplin L. Particle emission characteristics of office printers. Environ Sci Technol. 2007;41(17):6039–6045.

[6] Stephens B, Azimi P, El Orch Z, Ramos T. Ultrafine particle emissions from desktop 3D printers. Atmos Environ. 2013;79:334–339.

[7] Byrley P, George BJ, Boyes WK, Rogers K. Particle emissions from fused deposition modeling 3D printers: Evaluation and meta-analysis. Sci Total Environ. 2019;655:395–407.

[8] ANSI/CAN/UL 2904. Standard Method for Testing and Assessing Particle and Chemical Emissions from 3D Printers. 2nd ed. Underwriters Laboratories; 2023.

[9] Limit Values Ordinance (GKV) 2025, Federal Law Gazette II No. 339/2025, Annex I. RIS. German comparison: TRGS 900 (BAuA).

[10] Regulation (EC) No 1272/2008 (CLP) and Regulation (EC) No 1907/2006 (REACH), Annex II. Official Journal of the EU.

[11] Aalto-Korte K, Suuronen K, Kuuliala O, Henriks-Eckerman ML, Jolanki R. Occupational contact allergy to monomeric acrylates. Contact Dermatitis. 2010;63(6):340–346.

[12] BG ETEM. Isopropanol – hazardous post-processing of 3D prints. etem 2/2025; BG ETEM S017 “Safety and health when working with 3D printers”.

[13] Austrian Federal Economic Chamber (WKO). Federal Guild of Plastics Processors; Plastics Processing Ordinance Federal Law Gazette II No. 66/2003 as amended by II No. 399/2008; Trade Act 1994 § 18.

[14] German Social Accident Insurance (DGUV). Competence BG ETEM / BG RCI; SGB VII § 192; DGUV Rule 113-011, DGUV Information 202-103.