

ISO/ASTM 52933:2024(E)



Additive manufacturing — Environment, health and safety — Test method for the hazardous substances emitted from material extrusion type 3D printers in the non-industrial places¹

This standard is issued under the fixed designation ISO/ASTM 52933; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision.

INTRODUCTION

This document refers to the assessment of hazardous substances emitted during operation of material extrusion type AM machines, commonly known as “3D printers” installed in schools or public places for educational and hands-on purposes, and basic countermeasures for reducing the substances.

This document provides the necessary information and test procedures to reflect the characteristics of the AM process based on the previous international standards related to indoor air quality and to assess hazardous substances in the non-industrial places.

Operator, supervisor, and manager who are working at the non-industrial places will be able to use this document to measure and diagnose air quality. This document also includes appendices to help them try to reduce the hazardous substances emitted into the non-industrial spaces.

1. Scope

1.1 This document specifies a test method for measuring hazardous substances emitted during the operation of material extrusion type AM machines commonly used in the non-industrial places and includes non-normative suggestions for ways to reduce them.

1.2 This document specifies some of the main hazardous substances emitted from this type of machine during operation for currently commonly used materials, it describes the additional information and the associated test method for measuring hazardous substances, and includes considerations for reducing the hazardous substances and basic countermeasures.

1.3 This document specifies how to measure concentrations of hazardous substances generated in the non-industrial places (school, public place and so on) in which this type of machines are installed, and to maintain an acceptable work environment by managing field facilities, machines, filaments, and additive manufactured products for the reduction of hazardous substances.

1.4 However, this document does not cover all gas-phase chemical emissions. Only a range of Volatile Organic Com-

pounds (VOCs) from n-hexane to n-hexadecane, including aldehydes are included. Considerations for reducing chemical emissions and for improving the work environment are given in Annexes A and B.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Normative references

2.1 The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

2.2 ISO Standards:²

ISO 16000-2 Indoor air — Part 2: Sampling strategy for formaldehyde

ISO 16000-3 Indoor air — Part 3: Determination of formaldehyde and other carbonyl compounds in indoor and test chamber air — Active sampling method

¹ This document is under the jurisdiction of ASTM Committee F42 on Additive Manufacturing Technologies and is the direct responsibility of Subcommittee F42.06 on Environment, Health, and Safety and is also under the jurisdiction of ISO/TC 261, Additive manufacturing, on the basis of a partnership agreement between ISO and ASTM International with the aim to create a common set of ISO/ASTM standards on additive manufacturing.

Current edition approved Feb. 20, 2024. Published April 2024.

² Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <https://www.iso.org>.

- ISO 16000-4 Indoor air — Part 4: Determination of formaldehyde — Diffusive sampling method
- ISO 16000-5 Indoor air — Part 5: Sampling strategy for volatile organic compounds (VOCs)
- ISO 16000-6 Indoor air — Part 6: Determination of organic compounds (VVOC, VOC, SVOC) in indoor and test chamber air by active sampling on sorbent tubes, thermal desorption and gas chromatography using MS or MS FID
- ISO 16017-1 Indoor, ambient and workplace air — Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography — Part 1: Pumped sampling
- ISO 16017-2 Indoor, ambient and workplace air — Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography — Part 2: Diffusive sampling
- ISO 16200-1 Workplace air quality — Sampling and analysis of volatile organic compounds by solvent desorption/gas chromatography — Part 1: Pumped sampling method
- ISO 16200-2 Workplace air quality — Sampling and analysis of volatile organic compounds by solvent desorption/gas chromatography — Part 2: Diffusive sampling method
- ISO/TR 27628 Workplace atmospheres — Ultrafine, nanoparticle and nano-structured aerosols — Inhalation exposure characterization and assessment
- ISO 28439 Workplace atmospheres — Characterization of ultrafine aerosols/nanoaerosols — Determination of the size distribution and number concentration using differential electrical mobility analysing systems
- 2.3 ISO/ASTM Standard:³
- ISO/ASTM 52900 Additive manufacturing — General principles — Fundamentals and vocabulary

3. Terms and definitions

For the purposes of this document, the terms and definitions from ISO/ASTM 52900 and the following are applied. ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 *volatile organic compound (VOC)*—organic compound that is emitted from the test specimen and all those detected in the chamber outlet air.

Note 1 to entry: Due to practical reasons to be taken into account for test chambers, this definition differs from that defined in ISO 16000-6:2004. In ISO 16000-6, the definition is based on the boiling point range (50 °C to 100 °C) to (240 °C to 260 °C).

Note 2 to entry: The emission test method described in ISO 16000-9 is optimum for the range of compounds specified by the definition of total volatile organic compounds (TVOC).

[SOURCE: ISO 16000-9:2006, 3.15]

3.2 *aldehydes*—organic compounds containing formyl families.

Note 1 to entry: Formaldehyde, acetaldehyde and vanillin

are members of aldehyde families.

[SOURCE: ISO 21366:2019, 3.8]

3.3 *ultrafine particles (UFP)*—particles with a particle diameter less or equal 0.1 µm.

[SOURCE: ISO/IEC 28360-1:2021, 4.36]

3.4 *breakthrough volume*—volume of test atmosphere that can be passed through a sorbent tube before the concentration of eluting vapour reaches a predefined limit value of the applied test concentration.

Note 1 to entry: For hazardous substances in air, 5 % of the applied test concentration is a generally applied limit value.

[SOURCE: ISO 16017-1:2000, 3.1, modified — The definition was slightly reworded.]

3.5 *active sampling*—active sampling method in which sampling for collecting chemical substances is performed within an hour.

3.6 *real-time sampling*—real-time sampling method in which measuring the total number concentration of aerosol particles is performed consecutively.

4. Hazardous substance targets and major factors

VOCs, aldehydes, and UFP are currently identified as some of the potentially hazardous substances emitted during operation of material extrusion type AM machines in schools and public places. The material extrusion type AM machines which are currently used for AM process with filaments (ABS, PA, PC, etc.) can change the concentration of hazardous substances depending on the process and environment of the non-industrial places. The risk of each hazardous substance can be confirmed by referring to the hazard statement of the MSDS of the substance.

Since the following factors can increase the concentration of hazardous substances in that place, appropriate countermeasures are needed. See Annex A for information on considerations to reduce the emission concentrations of hazardous substances in the non-industrial place.

The factors are specified as follows:

- printer-related factors (e.g. design - open frame, enclosed);
- feedstock-related factors (e.g. type of polymer, colour, infill materials);
- process-related factors (e.g. extruder temperature, bed temperature, infill density);
- environmental-related factors (e.g. room size, presence of doors/windows, ventilation, temperature, humidity).

5. Relevant test standards

This document covers three main classes (VOCs, aldehydes, and UFP) of hazardous substances that can be emitted in case of using material extrusion type 3D printers and filaments. Table 1 provides a list of these hazardous substances and the recommended sampling strategy and test methods for their analysis in a workplace or indoor environment. Users should be aware that each type of emission can vary individually depending on the duration of machine operation, type of filaments, temperature, humidity of the place, etc. As such they shall each be monitored individually and proper care should be taken to ensure the monitoring plan covers the worst-case

³ For referenced ASTM and ISO/ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.