TECHNICAL BRIEF

Second Edition of ANSI/CAN/UL 2904: Standard Method for Testing and Assessing Particle and Chemical Emissions from 3D Printers

Introduction

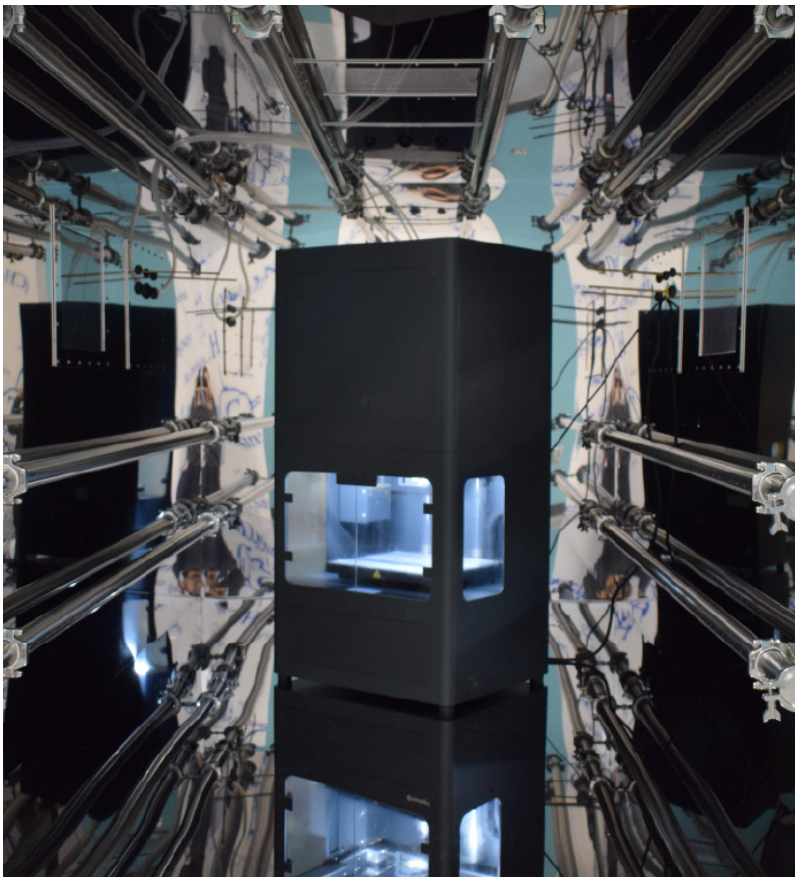
The Chemical Insights Research Institute (CIRI) of UL Research Institutes and research partners have conducted a research initiative on understanding the emissions from consumer level material extrusion 3D printers. This research was motivated by the wide use of 3D printers while their emissions were not well characterized. CIRI developed a test method on assessing particle and volatile organic compound (VOC) emissions from 3D printing using an exposure chamber setup, based on the established method for laser printers.[1] Meanwhile, CIRI has conducted hundreds of chamber tests with various 3D printers, feedstocks, and printing conditions to validate the test method and create an emission database. Research has found that high levels of ultrafine particles and numerous hazardous VOCs are emitted during normal operation of 3D printers, which may pose a health hazard to the users when inhaled. Specifically, ultrafine particles can be transported deep into the lungs, bloodstream, and even brain, and are associated with respiratory and cardiovascular diseases. In addition, the detected hazardous VOCs include irritants, odorants, developmental and reproductive toxins, and known or potential carcinogens. Therefore, it is important to minimize exposure to these emissions.

ANSI/CAN/UL 2904

The first edition of ANSI/CAN/UL 2904, "Standard Method for Testing and Assessing Particle and Chemical Emissions from 3D Printers," was published in 2019. The Standard applies to freestanding 3D printers that are typically found in schools, offices, libraries, homes, and other non-industrial indoor spaces. It provides a detailed analytical method, based on exposure chamber technology, for measuring the chemical and particle emissions released from an operating printer and also lists allowable criteria for total particles and individual VOCs of concern. The standard provides a benchmark for manufacturers and certification programs to qualify low-emitting 3D printers in the marketplace. Emissions criteria are derived from research data[2] and existing indoor air quality reference levels.

Key Updates in the Second Edition

The second edition of the Standard was published in May 2023 in response to comments from stakeholders since the initial publication. Updates address these comments and include consideration of continuing research findings.



Key methodology updates include:

- Definitions of aldehydes and VOCs are clarified. See **Section 3.7** [Definition of aldehydes (ALD)] and **Section 3.42** [Definition of volatile organic compound (VOC)] for details.
- Instructions for print objects are updated. The second edition provides two scenarios for print objects based on printer extruder design, namely single and double extrusion. For both scenarios, the Standard provides the suggested print object design, print time and print object weight. The weight requirement for a print object is lowered to 25.0 grams to account for printers with low printing speed. See **Section 6.1.1** (Print object for single extrusion printers) and **Section 6.1.2** (Print object for double extrusion printers) for details.
- Suggestions for additional particle characterizations are included, see ANNEX G (Particle characterization) for details. This informative annex summarizes the various techniques used to analyze the physical and chemical properties of particles emitted from 3D printing, which include electron microscopy, inductively coupled plasma mass spectrometry, and chromatography. A brief introduction to these techniques is included, as well as research findings reported with their applications.

Key emission criteria updates include

Two new VOCs were added to the allowable emissions criteria list:

1. Tetradecamethylcycloheptasiloxane was added due to its high detection frequency from operating printers (> 60%).
2. Tetrahydrofuran (THF), an IARC group 2B carcinogen, because of its potential health concern.

Two VOCs were removed from the allowable emissions criteria list:

1. 1,2,4-Trimethylbenzene was removed since trimethylbenzene (all isomers) is also included.
2. Diethylhexyl phthalate was removed because it is a semi-volatile organic compound that may require other detection methods.

See details in **Section 12.2** and ANNEX A.

Additional informational considerations have been added:

- Information on emerging print materials is included, see ANNEX H (New materials assessment) for details. This informative annex lists examples of emerging materials that have become available in the market but have not been well characterized. They are summarized into sustainables, composites, flame retardants, and flexibles. Brief information on the usage and properties of each material is included. Emission results and potential concerns based on available studies are also described.
- Instructions to be considered have been added for the safe operation of 3D printers, see ANNEX I (Best practices for health and safety guidance document) for details. This informative annex includes guidance information for maintaining and operating 3D printers during pre-printing, printing, and post-printing periods, to achieve healthy and safe operation in indoor environments. Specifically, it includes suggestions for printer and feedstock selection, installation location, environmental operations like ventilation and filtration, preparation and post-printing processes, storage, maintenance, and disposal.

*ANSI/CAN/UL 2904 2nd Ed. is now available for digital download and hard copy purchase through UL Standards' sales **website.***

REFERENCES:

1. BAM. Test Method for the Determination of Emissions from Hardcopy Devices within the Award of the Blue Angel Ecolabel for Equipment with Printing Function According to RAL-UZ-171; Federal Institute for Materials Research and Testing (BAM): Germany, 2012.
2. CIRI. 3D Printing Data Portal. Chemical Insights Research Institute (CIRI). https://chemicalinsights.org/data-portal/3d-printing-data/ (accessed 2023-06-02).

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