

Investigating and Mitigating Health Impacts of 3D Printer Emissions

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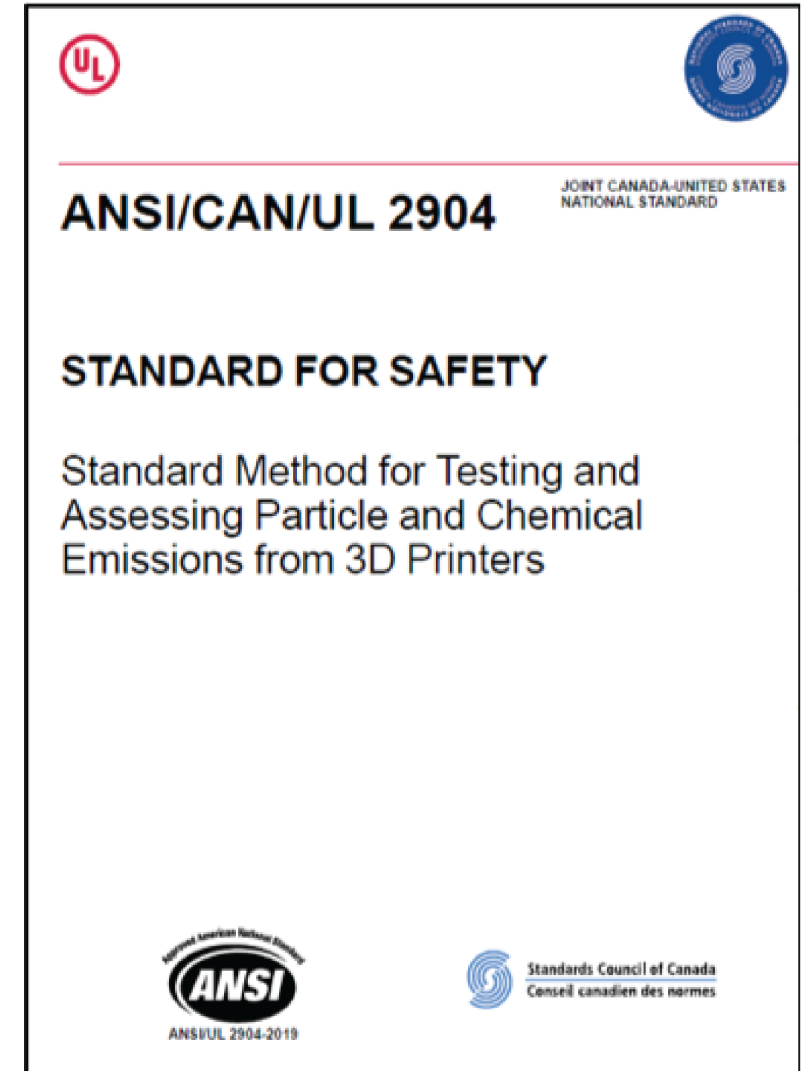
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Setting Standards: Ensuring Safety

The Standard Method for Testing and Assessing Particle and Chemical Emissions from 3D Printers

- **Objectives: Accurately measure particle and chemical emissions from 3D printers and minimize hazardous exposure to users**
- ANSI/CAN/UL consensus standard
- Standard became publicly available on 1/31/2019
- 2 parts: test method and emissions criteria

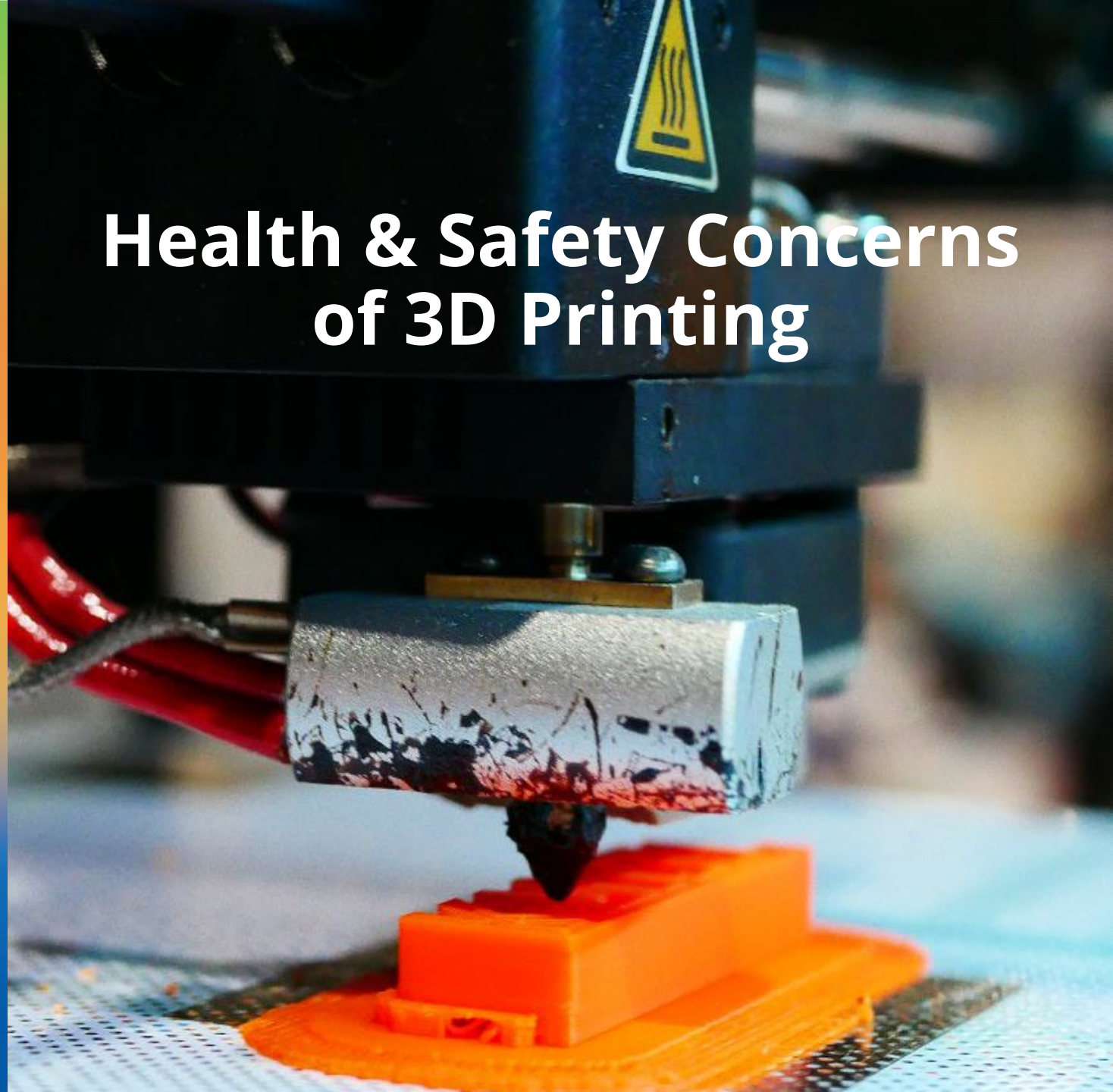


Hazards include:

Inhalation and dermal exposure to:

- Volatile organic compounds
- Semi-volatile organic compounds
- Particles, including UFPs
- Carbon nanotubes
- Powders of various metals and polymers
- Burns, explosions, UV light, laser
- Mechanical injuries, shock, fire
- Hazard control and protection
 - Engineering controls
 - PPE if necessary

Health & Safety Concerns of 3D Printing



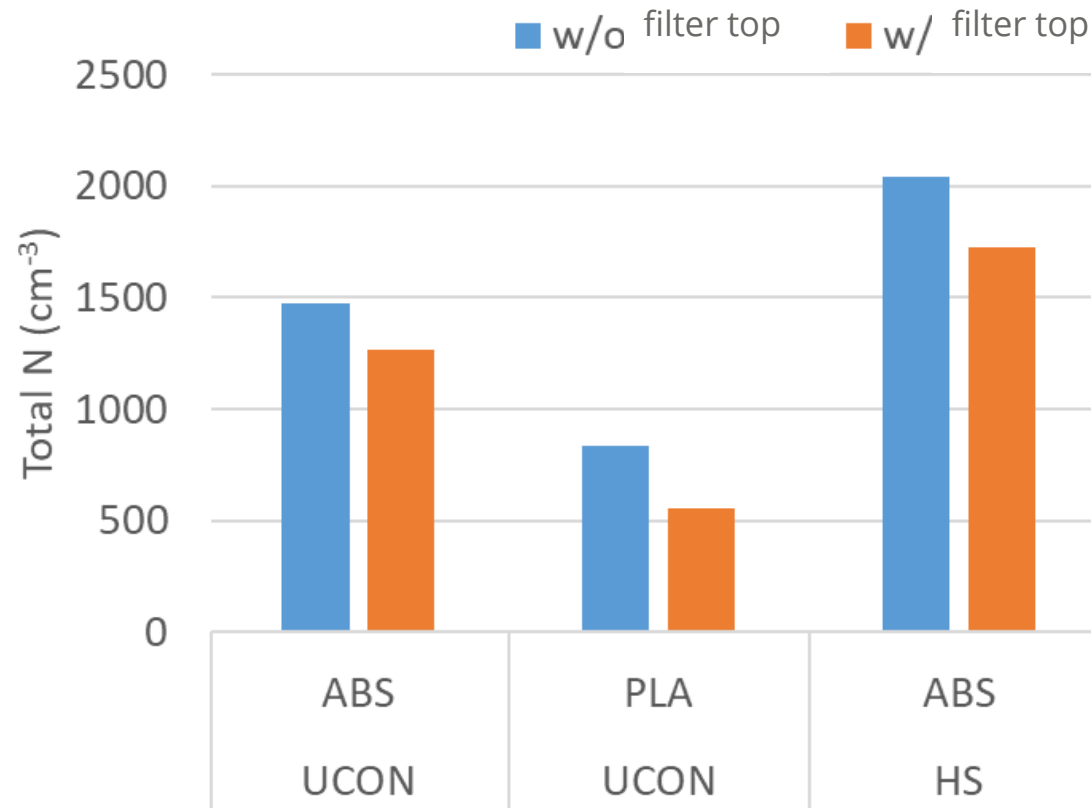
VOCs Detected During 3D Printing

Common VOCs detected from 3D printing

Chemical (health concern)	Detected from		
	ABS	PLA	Nylon
Formaldehyde (carcinogen, eye, nose, throat, skin irritation)	✓	✓	✓
Benzene (carcinogen, eye, skin, respiratory irritation, reproductive effect)	✓	✓	
Styrene (probable carcinogen, odor, eye, respiratory system, reproductive, development, nervous system)	✓		✓
Ethylbenzene (possible carcinogen, odor, liver, kidney, endocrine systems, development)	✓	✓	✓
Acetaldehyde (possible carcinogen, odor, eye & respiratory systems)	✓	✓	✓
Vinyl cyclohexene (possible carcinogen, reproductive & respiratory systems)	✓	✓	
Caprolactam (eye, skin, respiratory irritation, cardiovascular, central nervous systems, liver, kidney)			✓
Benzaldehyde (eye, skin, respiratory irritation)	✓	✓	✓
Methyl Methacrylate (odor, eyes, skin, and respiratory system)	✓	✓	✓
1-Butanol (odor, eyes, skin, respiratory system, central nervous system)	✓	✓	✓

3DP Emission Mitigation Strategy: Filtration

- **Filtration Reduces Total Particle Numbers**



- **Filtration can reduce particle concentration, but particles and VOCs are still present in the air!**

Highlights and Take-Home Conclusions

- 3D printers emit significant levels of ultrafine particles and numerous VOCs
- Emission levels vary with specific print conditions
 - Filament material/brand and nozzle temperature are critical variables
- Exposure to ABS-emitted particles are toxic and due to high emission rates and levels, filtration strategies may be necessary
- Filtration strategies can reduce particle number and toxicity of ABS-emitted particles
- Additional studies are warranted to explore other mitigation strategies and their influence on toxicological properties of 3D printer emissions

Thank You



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