3D PRINTERS AND AIR QUALITY

HEALTH EFFECTS AND MITIGATION STRATEGIES FOR USE OF 3D PRINTERS IN HIGHER EDUCATION

Chemical Insights
An Institute of Underwriters Laboratories Inc.

Introduction

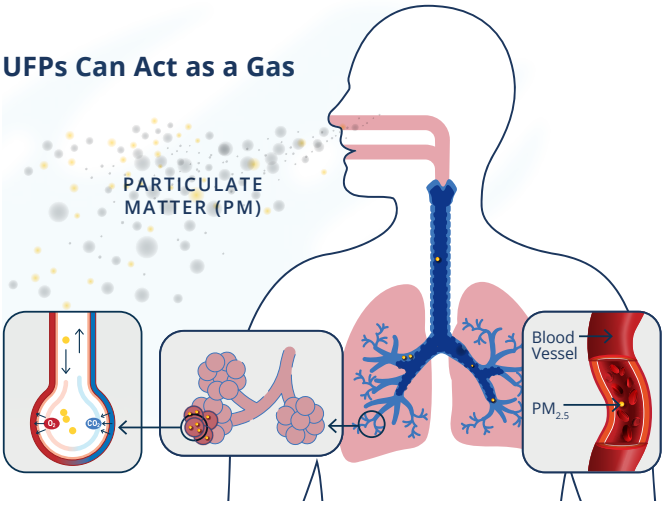
Consumer use of 3D printers is booming, particularly in institutions of higher education. Chemical Insights Research Institute of Underwriters Laboratories Inc. along with researchers from Georgia Institute of Technology conducted a multi-year research initiative on emissions from material extrusion 3D printers. The research found that during operations, 3D printers emit particles, most of which are very small in size, and volatile organic compounds (VOCs), some of which are known irritants, carcinogens and odorants. This means that exposure may present a human health hazard, in particular when a person stands next to the printer with minimal ventilation. Depending on how 3D printers are used at your institution, these findings may be especially relevant to your campus sustainability office, engineering department, design school or others.

PARTICLES

Particles are a mixture of very small solids and liquid droplets suspended in the air. The smaller the particle, the greater the health risk. Fine and ultrafine particles (UFPs) can act as a gas to penetrate deep into the lungs; UFPs, the primary type generated by 3D printers, can enter your bloodstream. Particles can cause eye, nose and throat irritation; aggravate coronary and respiratory disease symptoms; and contribute to premature death in people with heart or lung disease.

Overall, the research found that particle emissions could reach up to one trillion particles per hour and are mostly ultrafine particles that are smaller than 100 nanometers in size.

UFPs Can Act as a Gas



VOCS

VOCs are chemical compounds that evaporate into the air and can be breathed. They pose a number of health risks, including eye, nose, and throat irritation; headaches, loss of coordination and nausea; damage to the liver, kidney, and central nervous system; cardiovascular disease; cancer; and asthma.

The research found more than 200 different VOCs in 3D printer emissions, many of which are known irritants, carcinogens and odorants.

Most frequently detected and highest emitting VOCs:

1. *Styrene*
2. *Caprolactam*
3. *Benzaldehyde*
4. *Ethylbenzene*
5. *Acetaldehyde*

VOCs that exceed current recommended exposure guidelines for indoor air:

1. *Caprolactam*
2. *2-butenal*
3. *Formaldehyde*

TEN WAYS TO PROMOTE HEALTHY INDOOR AIR WHILE USING A 3D PRINTER

Whether your institution uses 3D printers in classrooms, maker centers or dorms, follow these basic strategies to mitigate exposure to emissions.

1. UNDERSTAND THE HEALTH RISKS

When in use, 3D printers release a complex mixture of pollutants into the air. These emissions include VOCs and very small particles called UFPs. VOCs can be irritants, carcinogens and odorants. UFPs are so small they can be inhaled like a gas and enter our lungs and blood.

2. CONSIDER PRINTER TYPE

3D printers are not all equal. When possible, use a printer that has been ANSI/CAN/UL 2904 certified to produce fewer emissions. Any special printer features, such as direct exhaust lines and filtration systems, should have verification available to show they are effective.

3. MINIMIZE FILAMENT EMISSIONS

Filaments vary and release different types of emissions. Of the common types, ABS filaments typically have higher emissions, followed by Nylon, and then PLA. Use PLA if possible, but always use the filament type and brand specified by the manufacturer.

4. INCORPORATE FRESH AIR

Whether natural or mechanical, good ventilation is critical. Use the 3D printer in a room with good air distribution and/or operable windows. If possible, use a local exhaust fan above the printer. Keep the printer away from return air vents.

5. KEEP PEOPLE AWAY

Locate the 3D printer away from heavily trafficked areas, such as hallways and common spaces, to minimize occupant exposure. When the printer is in use, post a sign to alert others to stay away. If the room where the printer is located has a door, close it.

6. DON'T HOVER

While it may be enjoyable to watch the action, being close to an operating 3D printer significantly increases exposure to emissions. It is best to limit direct observation and rely on cameras or viewing windows instead.

7. PROTECT YOURSELF

If you do need to check on an operating 3D printer, minimize the amount of time spent near the printer and wear protective safety glasses. Basic dust masks are not effective at preventing inhalation of VOCs and UFPs.

8. KEEP IT COOL

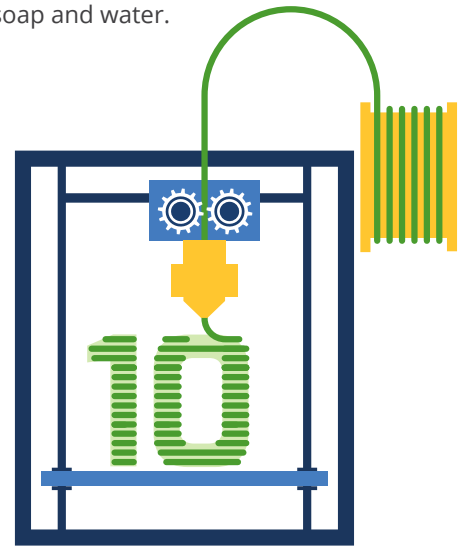
To minimize VOC and particle emissions, operate the printer extrusion nozzle and base plate at the lowest possible temperature. Operating at a higher temperature can increase emissions. But remember, always follow the manufacturer's instructions.

9. GET RID OF THE EVIDENCE

After each use, once the 3D printer has cooled down, remove any filament build-up. Specifically, clean both the extrusion nozzle and the build plate. This will minimize the airborne pollution produced next time the printer is used.

10. DON'T FORGET WHAT YOU CAN'T SEE

While you won't see any VOCs or UFPs, remember to clean up after use. Dust the printer and surrounding surfaces with a disposable wet cloth. Clean with a high-efficiency particulate filtration (HEPA) vacuum. Finally, thoroughly wash hands with soap and water.



Chemical Insights

2211 Newmarket Parkway, Suite 106, Marietta, Georgia 30067
Website: chemicalinsights.org | **E-mail:** chemicalinsights@ul.org

chemicalinsights.org/3DP

Access our collection of tools and resources on 3D printer emissions and the impact on human health.