PRINTING HAZARDS
Managing 3D Printer Emissions for Safety & Health

BY DR. MARILYN BLACK

As the world repopulates office buildings, schools, hotels and other facilities in the midst of the COVID-19 pandemic, maintaining good indoor air quality (IAQ) must be a key objective. Years of research proves designing, operating and managing buildings with a focus on good IAQ results not only in healthy, productive building occupants, but also in protected property investments and reputation.

The fundamentals of providing quality indoor air include effective ventilation with a supply of clean outdoor air; distribution of that clean air within occupied spaces; filtration of the air to remove particles and chemicals; routine cleaning and disinfection; and proper control of moisture and other sources of indoor pollutants.

Common indoor pollutants include dust particles and hundreds of different volatile organic compounds (VOCs) that can run between two and 100 times higher than those found in outdoor air. VOCs can be found in furniture, flooring materials, paints, common cleaning solutions and even popular electronics.

This includes 3D printers. While this technology is rapidly progressing in many industry sectors and is propelling workplace and educational opportunities to new heights, recent research conducted by Chemical Insights — an Institute of Underwriters Laboratories — and Georgia Institute of Technology is shedding light on the harmful IAQ impact coming from the release of ultrafine particles (UFPs) and VOCs into the air during their use.

The risks of using 3D printers in enclosed spaces, and how to minimize them

Chemical Insights and Georgia Tech discovered many desktop 3D printers generate large numbers of UFPs and VOCs while in operation, which can then be inhaled and penetrate deep into the human pulmonary system to trigger lung irritation, respiratory and chest discomfort and asthma. Long-term exposure can even lead to respiratory and cardiovascular diseases.

These health concerns are particularly worrisome when 3D printers are used in small or poorly ventilated rooms. For example, an office or healthcare practice may have a 3D printer in an enclosed personal workspace with little air flow, or even in an available closet with no ventilation. In these situations, the levels of UFPs can reach pollution values equivalent to sitting beside a major freeway with heavy vehicular traffic.

In a larger facility where numerous 3D printers are dispersed throughout, ventilation efficacy is key. This means confirming space meets ventilation rates according to ASHRAE 62.1 and ensuring a well-mixed outdoor air supply and returns that vent contaminants to the outside.

There are ways to mitigate potential IAQ issues caused by 3D printers. Consider

- placing 3D printers away from air vents,
- locating 3D printers near operable windows,
- installing local exhaust over 3D printers and
- placing 3D printers in an area with direct exhaust to the outside or within enclosures containing high-efficiency particulate (HEPA) or charcoal filtration.

Steps to take to mitigate health risks while operating 3D printers

To keep building occupants safe and mitigate risks while 3D printers are in use, FMs should confirm only those who have been properly trained to operate these machines are operating them. Chemical Insights recommends FMs ensure these occupants are:

- setting the nozzle and base plate temperatures at the lowest recommended settings that produce the desired print quality,
- limiting time spent observing the 3D printer while it is operating,
- wearing protective safety glasses when near an operating 3D printer,
- never leaving an operating 3D printer unattended and
- using PLA filaments if possible.

Strategies: Location
Adequate ventilation (outdoor air supply)
Consider a room with a fume hood or local exhaust already installed and an automated sprinkler system.
Good Air Distribution
Operable windows
Operable door
Exhaust to the outside

Strategies to Reduce Exposure to 3D Printer Emissions

Purchasing:

- Purchase printers and supplies that have been independently verified or produce lower emissions (meet the requirements of ANSI/CAN/UL 2904)

- Purchase and use only filaments recommended by the printer manufacturer

- Consider printers that use PLA filaments

Location:

- Select an appropriate location with good ventilation, operable windows, or local exhaust fans that can be placed above the printers

- Position printers so that users cannot hover over it during operation

- Avoid placing printers in heavily trafficked areas

Operation:

- Operate printers according to manufacturer's instructions

- Operate the printer nozzle at the lowest recommended temperature

- Clean the printer nozzle, build plate and surrounding area before each use

- Limit time spent observing the printer while it is operational

---

In addition, FMs can instill best practices for cleaning 3D printers and their surroundings, including:

- cleaning the nozzle before each use and the build plate after each use,

- dusting all surfaces frequently with a disposable wet cloth,

- vacuuming floors and surfaces frequently with a high-efficiency particulate (HEPA)-filtration vacuum and

- washing hands after operation to avoid hand-to-mouth transfer of chemicals and particles, especially before eating.

Consider safety when procuring a 3D printer

With hundreds of choices on the market, FMs should suggest tenants looking to purchase a 3D printer first access the Standard ANSI/CAN/UL 2904, which contains measurement and health assessment protocols for emissions that can be released from print applications with 3D printers and print media.

The standard was developed by Chemical Insights and a range of stakeholders for testing and assessing particle and chemical emissions from 3D printers. Although the research focused on fused filament fabrication technology, methods present-ed in the standard are also applicable to other printer types. While it applies to the printers typically found in schools, homes, offices, libraries and other non-industrial indoor spaces, the impact on indoor air in facilities of any size could also be similar.

In addition to observing the guidelines offered by the standard, FMs should also ensure tenants do the following when looking to purchase a 3D printer:

- Require compliance with the standard in the bidding/purchasing process.

- Purchase the filament brand specified by the printer manufacturer.

- Consider printers that use PLA filaments.

Ensure proper 3D printer protocol to enhance productivity and safety

3D printers are not going away, nor should they. The forecasted average annual growth of the 3D printing market for the next five years is 24 percent, according to the 3D Printing Trends 2020 report by 3D Hubs.[1] Further, the total value of 3D printed parts increased by 300 percent in 2019.

The 3D printing market penetrates nearly all industries, are transforming how objects are built and have opened numerous design and manufacturing possibilities.

The opportunities afforded by 3D printers are significant, so taking steps for a safe and healthy environment will help advance facility modernization while increasing creative and productive environments for building occupants. FMs should familiarize themselves with the potential health hazards associated with 3D printer usage. It is equally important to adapt facilities for ensuring safe 3D printer work areas, and to establish protocols for operator safety. Lastly, before investing in a 3D printer, make sure it adheres to the standard to guarantee it's safe enough to bring inside a building — and does not pollute the indoor air. **FMJ**

Dr. Marilyn Black *is vice president and senior technical advisor for Underwriters Laboratories, leading its research institute Chemical Insights. She is the founder and former chairperson for both UL Air Quality Sciences and the GREENGUARD Environmental Institute. She is also the founder of the Khaos Foundation, a non-profit organization dedicated to protecting the health and well-being of children through education and research. Dr. Black is an active participant in national and international scientific organizational initiatives, research projects and community outreach programs, and has presented and published more than 200 papers on IAQ and environmental exposure. She received a Ph.D. from the Georgia Institute of Technology, M.S. from the University of Florida and B.S. from the University of Virginia.*