

Emissions & 3D Printers

At Stratasys, the safe operation of our 3D printers is a primary design consideration. We are aware of the recent study conducted by the Illinois Institute of Technology regarding ultra-fine particle emissions (UFPs) in the 3D printing process.

The Illinois Institute of Technology studied UFP emissions from a 3D printer that used ABS plastic. The institute did not study emission rates of other products or processes. However, the study compared its findings with a separate study reporting similar UFP emissions from grilling food on a gas or electric stove. The study reports: *“...total UFP emission rates over the same size range [as the 3D printer study were] measured during various cooking activities.”*

The Illinois study also says that more controlled experiments would need to be conducted to better evaluate particle emissions from 3D printing technologies. To that end, Stratasys is considering whether to conduct an independent study to assess its own machines' emissions. However, there are no OSHA or equivalent standards for UFPs, so there would be no benchmark with which to compare the results.

As part of Stratasys' ongoing commitment to ensuring a safe user experience, the company completed two air quality studies last year which examined chemical emissions from thermoplastic materials used in the Stratasys Fused Deposition Modeling printing process. These studies, conducted by an independent lab, concluded that in all instances, chemical emissions were extremely low, and in most cases less than 1% of the limits set by either the American Conference of Governmental Industrial Hygienist's Threshold Limit Value (ACGIH-TLV) or OSHA Permissible Exposure Limits (OSHA-PEL).

Attached are detailed results of the Stratasys air quality studies performed in 2012.



Air Quality Datasheet

Fortus® 250/360/400/900mc systems Comparative Evaluation of Emissions

Air quality standards vary greatly with local and regional regulatory requirements. In some locations, mechanical venting may be required to meet the local requirements. You should check with the local regulatory agency overseeing air quality to ensure the system installation meets local standards.

The values provided below represent a conservative assessment of the possible contaminants released during operation of the Fortus systems as directed. The comparisons are provided for reference, and are made to exposure limits based on current American Conference of Governmental Industrial Hygienist's Threshold Limit Value (ACGIH-TLV) and OSHA Permissible Exposure Limits (OSHA-PEL), whichever is more restrictive. These limits represent the concentration of a chemical to which nearly all workers may be exposed day after day, without adverse health effects. Local jurisdiction may require comparison to different limits.

| Filament/Support Material | Chemical | Location | Measured Concentration (ppm)* | ACGIH-TLV or OSHA-PEL (ppm)* |
|------------------------------|-----------------------|----------------|-------------------------------|------------------------------|
| P430 ABS-M30 / SR-30 Support | styrene | Operator Panel | <0.11 | 20 |
| | | Exhaust Vent | <0.11 | |
| | acrylonitrile | Operator Panel | <0.12 | 2 |
| | | Exhaust Vent | <0.12 | |
| | butadiene | Operator Panel | <0.38 | 1 |
| | | Exhaust Vent | <0.38 | |
| | methyl methacrylate | Operator Panel | <0.54 | 50 |
| | | Exhaust Vent | <0.54 | |
| | n-butyl acrylate | Operator Panel | <0.17 | 2 |
| | | Exhaust Vent | <0.17 | |
| | naptha (coal tar) | Operator Panel | <0.10 | 100 |
| | | Exhaust Vent | 0.12 | |
| | petroleum distillates | Operator Panel | <0.083 | 500 |
| | | Exhaust Vent | <0.084 | |
| | methacrylic acid | Operator Panel | <0.012 | 20 |
| | | Exhaust Vent | <0.011 | |
| | phenol | Operator Panel | <0.0020 | 5 |
| | | Exhaust Vent | <0.0018 | |

| Filament/Support Material | Chemical | Location | Measured Concentration (ppm)* | ACGIH-TLV or OSHA-PEL (ppm)* |
|---------------------------|-----------------------|----------------|-------------------------------|------------------------------|
| PC / SR-100 Support | acetone | Operator Panel | <0.13 | 500 |
| | | Exhaust Vent | <0.13 | |
| | methyl methacrylate | Operator Panel | <0.56 | 50 |
| | | Exhaust Vent | <0.57 | |
| | n-butyl acrylate | Operator Panel | <0.18 | 2 |
| | | Exhaust Vent | <0.18 | |
| | naptha (coal tar) | Operator Panel | <0.11 | 100 |
| | | Exhaust Vent | 0.13 | |
| | petroleum distillates | Operator Panel | <0.088 | 500 |
| | | Exhaust Vent | <0.088 | |
| | methacrylic acid | Operator Panel | <0.011 | 20 |
| | | Exhaust Vent | <0.011 | |
| | phenol | Operator Panel | <0.0017 | 5 |
| | | Exhaust Vent | <0.0015 | |
| PC-ABS / SR-20 Support | styrene | Operator Panel | <2.9 | 20 |
| | | Exhaust Vent | <2.9 | |
| | acrylonitrile | Operator Panel | ND | 2 |
| | | Exhaust Vent | ND | |
| | butadiene | Operator Panel | <0.20 | 1 |
| | | Exhaust Vent | <0.17 | |
| | methyl methacrylate | Operator Panel | <0.57 | 50 |
| | | Exhaust Vent | <0.57 | |
| | naptha (coal tar) | Operator Panel | <0.11 | 100 |
| | | Exhaust Vent | <0.11 | |
| | petroleum distillates | Operator Panel | <0.088 | 500 |
| | | Exhaust Vent | <0.089 | |
| | methacrylic acid | Operator Panel | <0.013 | 20 |
| | | Exhaust Vent | <0.012 | |
| | triphenyl phosphate | Operator Panel | <0.045 mg/m ³ | 3 mg/m ³ |
| | | Exhaust Vent | <0.046 mg/m ³ | |

| Filament/Support Material | Chemical | Location | Measured Concentration (ppm)* | ACGIH-TLV or OSHA-PEL (ppm)* |
|-------------------------------|-----------------------|----------------|-------------------------------|------------------------------|
| Ultem 9085 / Ultem Support | naphtha (coal tar) | Operator Panel | <0.11 | 100 |
| | | Exhaust Vent | <0.11 | |
| | petroleum distillates | Operator Panel | <0.089 | 500 |
| | | Exhaust Vent | <0.089 | |
| | phenol | Operator Panel | <0.0017 | 5 |
| | | Exhaust Vent | <0.0015 | |
| | hydrogen cyanide | Operator Panel | <0.076 | 10 |
| | | Exhaust Vent | <0.076 | |

*ppm = parts per million.

mg/m³ = milligrams per cubic meter.

ND = non-detectable concentration.

< Means less than. The analyte, if present, is at a level too low to be accurately quantitated by the method used. The actual amount is less than the reported value.

Area air samples were taken at the operator control panel along the edge of the door opening and opposite the exhaust fan vents, and were considered representative of an 8-hour exposure. Samples for the various chemicals were collected and analyzed according to the following methods:

- acrylonitrile, ethylbenzene, methyl methacrylate, styrene, and VOCs - OSHA 7
- butadiene - OSHA 56
- methacrylic acid - OSHA 28 and an OSHA in-house method
- triphenyl phosphate - NIOSH 5038
- hydrogen cyanide - NIOSH 6017
- phenol – OSHA 32

The analysis was performed by an external and independent laboratory certified by the American Industrial Hygiene Association.



Air Quality Datasheet

Mojo™/uPrint®/Dimension® systems Comparative Evaluation of Emissions

Air quality standards vary greatly with local and regional regulatory requirements. In some locations, mechanical venting may be required to meet the local requirements. You should check with the local regulatory agency overseeing air quality to ensure the system installation meets local standards.

The values provided below represent a conservative assessment of the possible contaminants released during operation as directed. The comparisons are provided for reference, and are made to exposure limits based on current American Conference of Governmental Industrial Hygienist's Threshold Limit Value (ACGIH-TLV) and OSHA Permissible Exposure Limits (OSHA-PEL), whichever is more restrictive. These limits represent the concentration of a chemical to which nearly all workers may be exposed day after day, without adverse health effects. Local jurisdiction may require comparison to different limits.

Area air samples were taken at the operator control panel along the edge of the door opening and opposite the exhaust fan vents, and were considered representative of an 8-hour exposure. Samples for the various chemicals were collected and analyzed according to the following methods:

- acrylonitrile, methyl methacrylate, styrene, n-butyl acrylate, ethyl alcohol, isopropyl alcohol, isopropyl acetate, methyl ethyl ketone, and VOCs - OSHA 7
- butadiene - OSHA 56
- methacrylic acid - OSHA 28 and an OSHA in-house method
- triphenyl phosphate - NIOSH 5038
- phenol - OSHA 32

The analysis was performed by an external and independent laboratory certified by the American Industrial Hygiene Association.

Mojo

| Filament/Support Material | Chemical | Location | Measured Concentration (ppm)* | ACGIH-TLV or OSHA-PEL (ppm)* |
|--------------------------------------|-----------------------|----------------|-------------------------------|------------------------------|
| P430 ABS <i>plus</i> / SR-30 Support | styrene | Operator Panel | <0.12 | 20 |
| | | Exhaust Vent | <0.11 | |
| | acrylonitrile | Operator Panel | <0.13 | 2 |
| | | Exhaust Vent | <0.12 | |
| | butadiene | Operator Panel | <0.31 | 1 |
| | | Exhaust Vent | <0.26 | |
| | methyl methacrylate | Operator Panel | <0.57 | 50 |
| | | Exhaust Vent | <0.54 | |
| | n-butyl acrylate | Operator Panel | <0.53 | 2 |
| | | Exhaust Vent | <0.51 | |
| | naptha (coal tar) | Operator Panel | 0.24 | 100 |
| | | Exhaust Vent | 0.24 | |
| | petroleum distillates | Operator Panel | <0.088 | 500 |
| | | Exhaust Vent | <0.084 | |
| | methacrylic acid | Operator Panel | <0.012 | 20 |
| | | Exhaust Vent | <0.012 | |
| | phenol | Operator Panel | <0.0016 | 5 |
| | | Exhaust Vent | <0.0016 | |
| | ethyl alcohol | Operator Panel | <0.59 | 1000 |
| | | Exhaust Vent | <0.56 | |
| isopropyl acetate | Operator Panel | <0.098 | 100 | |
| | Exhaust Vent | <0.093 | | |
| isopropyl alcohol | Operator Panel | <0.24 | 200 | |
| | Exhaust Vent | <0.23 | | |
| methyl ethyl ketone | Operator Panel | <0.11 | 200 | |
| | Exhaust Vent | <0.11 | | |

uPrint SE/uPrint SE Plus

| Filament/Support Material | Chemical | Location | Measured Concentration (ppm)* | ACGIH-TLV or OSHA-PEL (ppm)* |
|--------------------------------------|-----------------------|----------------|-------------------------------|------------------------------|
| P430 ABS <i>plus</i> / SR-30 Support | styrene | Operator Panel | <0.12 | 20 |
| | | Exhaust Vent | <0.11 | |
| | acrylonitrile | Operator Panel | <0.13 | 2 |
| | | Exhaust Vent | <0.13 | |
| | butadiene | Operator Panel | <0.28 | 1 |
| | | Exhaust Vent | <0.27 | |
| | methyl methacrylate | Operator Panel | <0.56 | 50 |
| | | Exhaust Vent | <0.55 | |
| | n-butyl acrylate | Operator Panel | <0.53 | 2 |
| | | Exhaust Vent | <0.52 | |
| | naptha (coal tar) | Operator Panel | 0.29 | 100 |
| | | Exhaust Vent | 0.26 | |
| | petroleum distillates | Operator Panel | <0.087 | 500 |
| | | Exhaust Vent | <0.086 | |
| | methacrylic acid | Operator Panel | <0.012 | 20 |
| | | Exhaust Vent | <0.012 | |
| | phenol | Operator Panel | <0.0015 | 5 |
| | | Exhaust Vent | <0.0016 | |
| | ethyl alcohol | Operator Panel | <0.58 | 1000 |
| | | Exhaust Vent | <0.57 | |
| isopropyl acetate | Operator Panel | <0.097 | 100 | |
| | Exhaust Vent | <0.096 | | |
| isopropyl alcohol | Operator Panel | <0.24 | 200 | |
| | Exhaust Vent | <0.24 | | |
| methyl ethyl ketone | Operator Panel | <0.11 | 200 | |
| | Exhaust Vent | <0.11 | | |

Dimension Elite/SST 1200es

| Filament/Support Material | Chemical | Location | Measured Concentration (ppm)* | ACGIH-TLV or OSHA-PEL (ppm)* |
|------------------------------|-----------------------|-------------------------|-------------------------------|------------------------------|
| P430 ABSplus / SR-30 Support | styrene | Operator Panel | <0.12 | 20 |
| | | Exhaust Vent | <0.12 | |
| | acrylonitrile | Operator Panel | <0.13 | 2 |
| | | Exhaust Vent | <0.13 | |
| | butadiene | Operator Panel | <0.63 | 1 |
| | | Exhaust Vent | <0.59 | |
| | methyl methacrylate | Operator Panel | <0.59 | 50 |
| | | Exhaust Vent | <0.57 | |
| | n-butyl acrylate | Operator Panel | <0.56 | 2 |
| | | Exhaust Vent | <0.54 | |
| | naptha (coal tar) | Operator Panel | 0.31 | 100 |
| | | Exhaust Vent | 0.31 | |
| | petroleum distillates | Operator Panel | <0.092 | 500 |
| | | Exhaust Vent | <0.089 | |
| | methacrylic acid | Operator Panel | <0.012 | 20 |
| | | Exhaust Vent | <0.012 | |
| | phenol | Operator Panel | <0.0015 | 5 |
| | | Exhaust Vent | <0.0016 | |
| | ethyl alcohol | Operator Panel | <0.61 | 1000 |
| | | Exhaust Vent | <0.59 | |
| isopropyl acetate | Operator Panel | <0.10 | 100 | |
| | Exhaust Vent | <0.099 | | |
| isopropyl alcohol | Operator Panel | <0.26 | 200 | |
| | Exhaust Vent | <0.25 | | |
| methyl ethyl ketone | Operator Panel | <0.12 | 200 | |
| | Exhaust Vent | <0.11 | | |
| triphenyl phosphate | Operator Panel | <0.041mg/m ³ | 3mg/m ³ | |
| | Exhaust Vent | <0.042mg/m ³ | | |

*ppm = parts per million.

mg/m³ = milligrams per cubic meter.

ND = non-detectable concentration.

< Means less than. The analyte, if present, is at a level too low to be accurately quantitated by the method used. The actual amount is less than the reported value.