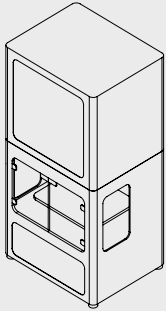


# A Safer Metal 3D Printing Solution

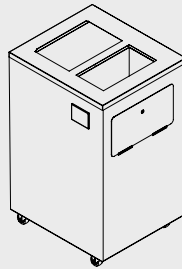
## Environmental, Health, and Safety Guidelines for the Metal X System

The Markforged Metal X is a new kind of metal printer. By printing metal powder bound in a plastic matrix, Markforged has become the first company to eliminate the safety risks associated with traditional metal 3D printers. That means no loose powder, no lasers, and none of the traditional safety precautions. It's safe to use in a shop environment with minimal facility upgrades.

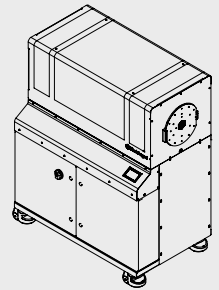
This guide gives an EHS overview of the Metal X System — including PPE recommendations and key safety feature overviews for each machine in the system.



① Metal X



② Wash-1



③ Sinter-2

### ① Metal X

The Metal X machine poses minimal safety risk for operators and is completely office friendly — you can place it in an office, classroom, lab, or similar work space with a ventilation system.

#### Recommended PPE

- Safety glasses are recommended while loading material and performing maintenance.
- A vacuum with a HEPA Filter should be used for general cleanup.

#### Hot Zones Safety

With the Metal X doors closed, all three hot zones — the print bed, nozzles, and chamber heater — are inaccessible.

#### Emission Safety Analysis

The Metal X printer emits 36x less total particles and 28x less Total Volatile Organic Compounds (TVOC) than the ANSI/CAN/UL 2904 recommended safety standard.

Particle Emission Rate (particles/hour)	Total Volatile Organic Compound (TVOC, mg/hr)
ANSI/CAN/UL 2904 (Standard) <b><math>3 \times 10^{11}</math></b>	ANSI/CAN/UL 2904 (Standard) <b>10.4</b>
METAL X <b><math>8.16 \times 10^9</math> (36x lower)</b>	METAL X <b>0.36 (28x lower)</b>

## ② Wash-1

The Wash-1 is a solvent-based debinding system. It primarily uses Opteon SF-79, a high-performance fluid designed to offer superior cleaning power, higher efficiency, and safety in an environmentally sustainable way — Opeton SF-80 or Tergo Metal Cleaning Fluid can be substituted if needed.

### Recommended PPE

- Safety glasses should be worn whenever using the Wash-1.
- Laminate film solvent resistant gloves [included] should be used when adding or removing solvent, as well as loading or unloading parts.

### Harmful Vapor Prevention

Markforged conducted 3rd party tests on trans-1,2-dichloroethylene (1,2-TCE) concentrations when operating the Wash-1 with Opteon SF-79. All concentrations were at least 2x below the OSHA threshold of 200 ppm, even when the sensor was placed inside the machine.

### Solvent Flammability Analysis

All three solvents are classified as non-flammable liquids by NFPA and DOT and exhibit no closed or open cup flash point. Vapor from any of the three is not considered flammable at the concentrations observed around the Wash-1: each has a vapor flammability range between 7-15.4%, and observed concentrations are below 1%.

Location	Concentration
OSHA (Standard)	<b>200 ppm</b>
Machine operator	<b>2.3 ppm (87x lower)</b>
Highest concentration around machine	<b>7.4 ppm (27x lower)</b>
Above open lid (max exposure)	<b>25-96 ppm (8x - 2.1x lower)</b>

## ③ Sinter-2

The Markforged Sinter-2 is a high temperature furnace. It is safe to use but should be operated with care. Use your organization's policies while working with gas supply and cryogenic liquid cylinders.

### Recommended PPE

- Safety glasses should be worn whenever using the Sinter-2.
- Heat resistant gloves [included] should be used when loading/unloading the furnace and handling recently sintered parts.
- General purpose work gloves should be used during maintenance when handling sheet metal access panels.

### Failsafes and Harmful Vapor Prevention

All exhaust from the furnace is filtered and vented through a system similar to a household dryer, ensuring that users are not exposed to sintering gasses. The machine has a mechanical door lock to prevent users from opening the machine during sintering. In the event of a failure, it automatically floods itself with inert gas and purges any mix gas to mitigate any potential exposure.

### Hot Zones Safety

All commonly handled surfaces on the Sinter-2 remain at a safe temperature during operation. However, Markforged strongly discourages touching or leaving any objects on the Sinter-2 during a run.

Location	Observed Temperature
Retort Door	<b>45-47°C</b>
Retort Door Handle	<b>35-37°C</b>
Upper Cover*	<b>100-102°C</b>
Cooling Fan Exhaust (into vent stack)	<b>30-33°C</b>

\*The top surface of the Sinter-2 is labelled as a "Hot Surface" on the machine and should not be touched during operation.