Standard Operating Procedure for Plasma Enhanced FFF Printer

**Potential Hazards and PPE**

Potential Hazard 1: High Voltages are used to generate the plasma. Ensure all connections are secure. Never touch the plasma generator, or parts of the printer connected to it, while it is on. (Max Voltage Produced= 50 kV, 5-30 W). Shock to the human body will cause discomfort, but the greatest risk comes from electrical shock interfering with pacemakers.

Potential Hazard 2: Plasma generator has an output in the radio frequency level. Do not use near someone who has a pacemaker. Place signs around the experiment, ensuring everyone is aware. (Frequency ~4-5 MHz)

Potential Hazard 3: Ozone may be generated by the plasma generation process. Ensure printer is in a well ventilated area. Ensure the ozone sensor\* is on and operating properly (at least one of the LEDs on the display is lit). Do not unplug ozone sensor as it takes minimum 8, ideally 24 hours to warm up. To limit ozone build up, us e the recommended duration (under 20 minutes) in a well ventilated area.

Potential Hazard 4: FFF printing processes use high heat to melt the plastic during printing. Be sure not to touch the hot end\* (Max Heating = 275 C) or the build plate (Max Heating = 100 C) during printing.

Potential Hazard 5: Moving parts on the printer can cause pinch points. Do not attempt to touch printer while running. Be sure to pause the print before making and adjustments.

Potential Hazard 6: Do not operate in or around flammable liquids or gases as spark ignition may occur. Be aware of flammable gas tanks in the high bay (make sure no one is turning them on).

PPE: safety glasses, material dependent PPE (reference SDS)

\* For clarity on equipment nomenclature and location, please refer to diagrams on the final page of this SOP

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**Prior to Experimentation**

0) Place “No Pacemaker” signage in the area so people are aware of experimentation; they should be easily readable from all doors into the high bay. They can be found under the concrete table in the high bay.

1) Turn on printer by plugging it in.

2) Ensure ozone sensor is on. If it is not, it will need to warm up for 8-24 hours. Do not print unless the ozone sensor is on and working properly.

3) Ensure filament is loaded properly. Filament is loaded from the back access hatch to the printer. An optional filament brush is mounted on the frame in line with the extruder. Ensure that the extruder bearing is hand tightened to the filament.

4) Load gcode. Do not print longer than 20 minutes as you can damage the plasma generator as well as build up ozone.

5) Ensure the front door and rear access hatch are securely closed.

6) Set up HD FLIR camera with close up lens, using the T-Slot Aluminum mount. Focus on desired location using a previously printed component. Select temperature range of 80 - 200 C.

**Experimentation**

1) Start the desired print using the printer’s user interface. To do this, press the knob to the get to the menu. Navigate and select “Print from SD”. Locate your print and start. USB Interface with the printer should only be used to update the firmware and perform diagnostics. It should never be used while using the plasma generator to prevent damage to the computer.

2) Allow for printer to preheat. Do not leave printer unattended while running.

3) When printer is done preheating and is navigating to the print area:

* Hit record on FLIR software
* Turn on plasma generator by flipping the power switch which is access through the back hatch

4) Allow for print to finish. Do not open the door or adjust printer during the duration of the print other than Z-babystepping.

5) Stop the FLIR recording.

**After Experimentation**

1) Turn off the plasma generator.

2) Turn off the printer by unplugging it, let cool for 3 minutes prior to touching part. Be aware that hot end and print bed will still be hot.

3) Remove printed sample. Store in a properly labeled zip lock bag.

4) Allow plasma generator to cool for 20 minutes before running it again.

5) Store the “No Pacemaker” signage under the concrete table.

**Before Leaving be sure to Check**

* Plasma Generator is off
* FLIR is store away properly
* Signage is returned to storage area
* Sample is stored properly
* Printer is off
* Ozone sensor is **ON**

**In Case of Emergency**

1) Power down the printer and plasma source via unplugging the power strip or flipping its switch to off.

2) Call Jeff Rhoads (517)775-0243. If in need of emergency medical services, call 911.

**Pictures of Printer for Nomenclature Clarity**





