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# **BIO X EMD Printhead**

## **User Manual**





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# 01

## Package contents

# 01 Package contents

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Item	Part number	Quantity
EMD Printhead	000000020566	1
EMD accessory tool	000000020557	1
Luer lock adaptor	D16110020558	1
Cartridge airline adapter with transparent tube 3cc 12 cm	000000010040	1
EMD microvalve	000000020551	1
Threaded nozzle (needleless)	D16110020555	1
Threaded nozzle (with needle)	000000020560	1
Needle cap	000000020556	1
Flushing tube with Luer adaptor, 20 cm	D16110020912 + 000000010110	1
3cc cartridge (inside EMD)	CSC010300102	1

# 02

## Technical specifications

## 02 Technical specifications

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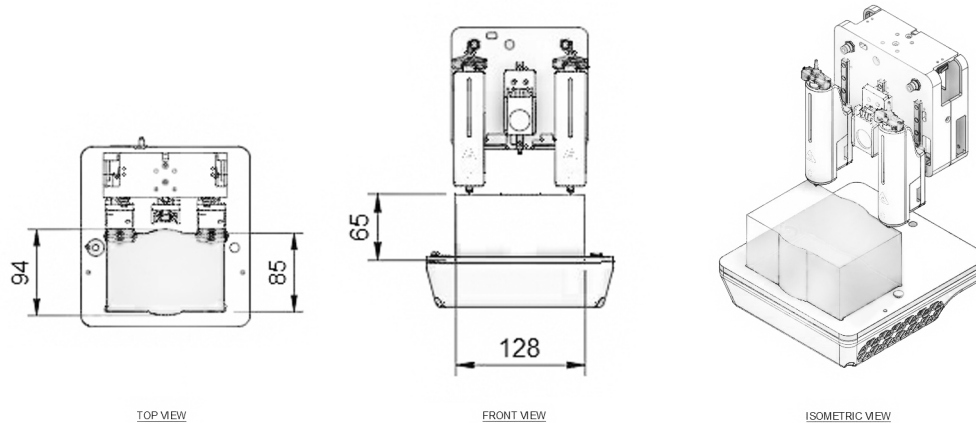
- Compatible with 3-mL cartridge.
- Maximum bioink volume in cartridge: 3 mL.
- Dimensions (height x width x depth): 118 x 30.5 x 37.5 mm.
- Weight: 132 g.
- Maximum pressure: 700 kPa.
- Material composition:
  - External surfaces: Powder-coated aluminum.
  - Internal surfaces: Aluminum.
  - Internal fluid chamber (valve): Stainless steel.
- Recommended operating temperature: 20-23 degrees Celsius.

**NOTE:** We recommend operating BIO X in temperatures between 20 and 23 degrees. In normal operating conditions, the chamber temperature of the BIO X will heat up 2-3 degrees above room temperature.

- Running temperature (in recommended conditions): 26-32 degrees.
- Heating capacity and rate:
  - Total heating range: 30-60 degrees.
  - Heating rate: Room temperature -40 degrees (10 minutes).
  - Heating rate: 40-65 degrees (12 minutes).
- Cooling capacity: N/A.
- Build volume (X, Y, Z): 128 x 85 x (65 - A) mm (A = tip length).



## 02 Technical specifications



**Figure 1:** Theoretical maximum build volume shown from the top and side view using the EMD Printhead (assuming a nozzle length of 0 mm). Exact build volume depends on the cartridge's position in the printhead and the nozzle/needle used. Build volume may be lower when combining the EMD Printhead with a printhead that restricts printhead movement. Please consult manuals for the specific printheads used to determine potential restrictions.

# 02 Technical specifications

**Table 1:** Theoretical build volume based on nozzle length. Actual volume may vary based on build plate's thickness, size, shape and level, as well as on cartridge position and tightness of the nozzle. X, Y and Z are measured from the front left corner of the printbed.

Nozzle Type	Tip Length	Nozzle/ Needle Length	X	Y	Z	Build Volume
Standard	4 mm	4 mm	12.8 cm	8.5 cm	6.5 cm	702.2 cm <sup>3</sup>

# 03

## **Safety information**

## 03 Safety information

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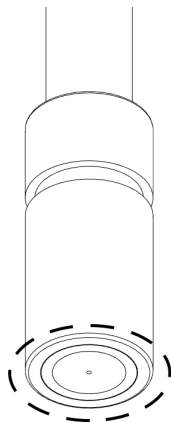
### 3.1 BIO X system warnings

- Please consult the BIO X manual for BIO X-specific and general warnings and safety procedures.

### 3.2 EMD Printhead warnings

- Do not clean the printhead by submerging it in liquid or using excessive spraying. Liquid inside the printhead can damage the circuitry and motor. To clean the EMD valve, you must remove it from the printhead and follow instructions in the **Maintenance section**.
- The LED on the printhead will turn yellow to indicate a warm printhead and red to indicate a hot printhead. Do not touch the printhead when the LED is red. Touching a hot printhead risks serious injury.
- Do not manually move the printhead mount. Moving the printhead mount manually will damage the motor. If the mount needs to be moved, place the printhead in the loading position described in the Getting Started section.
- Use the proper method to load and unload the EMD Printhead onto the BIO X printhead mounts. Instructions are outlined in the Getting Started section. While loaded on the BIO X, do not pull or push the printhead with excessive force, especially when the BIO X system is turned on. Doing so will damage the motor and its guides.
- Do not use a jerking motion to remove the printhead. Using a jerking motion risks hitting and damaging the HEPA filter.
- Handle the threaded nozzle and needle with care or the needle may bend and affect dispensing.
- Handle the microvalve end with care. When inserting and removing the valve, do not touch the outlined area (Figure 2).
- Avoid using tools or excessive force to tighten the nozzle into the printhead.

## 03 Safety information



**Figure 2:** Do not touch the outlined area of the EMD microvalve.

## 03 Safety information

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- Do NOT remove the valve, nozzle or cartridge from the EMD printhead while it is attached to the printhead mount. The cartridge will be pressurized upon attachment and untwisting these components will result in bioink leakage.
- Particles or pigment contained in the bioinks can limit the lifetime of the microvalve.
- Contaminants or dirt particles can clog the microvalve and other components of the EMD Printhead.

# 04

## Getting started

## 04 Getting started

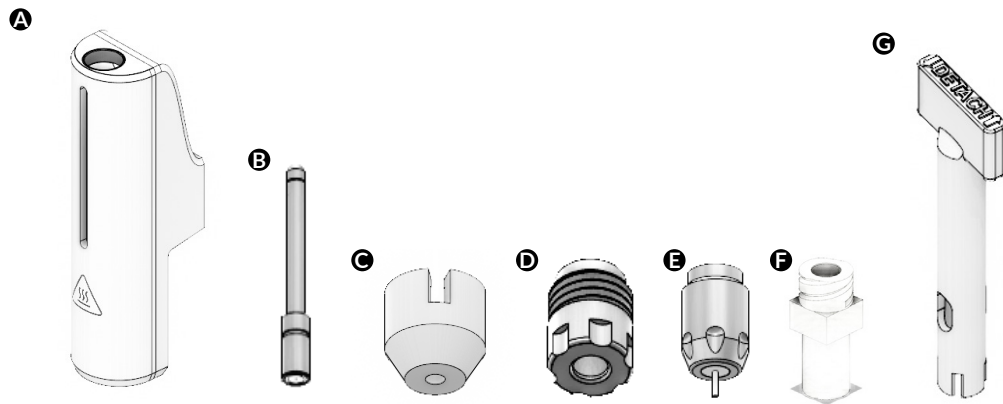
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**NOTE:** The printing parameters displayed on this manual might not be *accurate for your specific protocol*. For recommended parameters please consult the documentation for the bioink being used.

### 4.1 Unpacking

1. Open the package. Remove the pre-assembled EMD Printhead and other components (Figure 3).
2. The pre-assembled EMD printhead contains components A, B, C, D and F. Component E is provided in a separate protective container, and component G is a tool for the removal of component F.





**Figure 3:** Package contents include:

A. EMD Printhead body.

B. Microvalve.

C. Nozzle cover for storage.

D. Threaded nozzle.

E. Needleless threaded nozzle.

F. Luer lock adapter.

G. EMD accessory tool.

# 04 Getting started

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## 4.2 Installing, raising, lowering and uninstalling the printhead

1. To install the printhead in the BIO X, stabilize the bottom of the printhead mount with one hand to avoid straining the motor. Align the printhead above the desired printhead mount and push downward using your opposite hand (Figure 4).

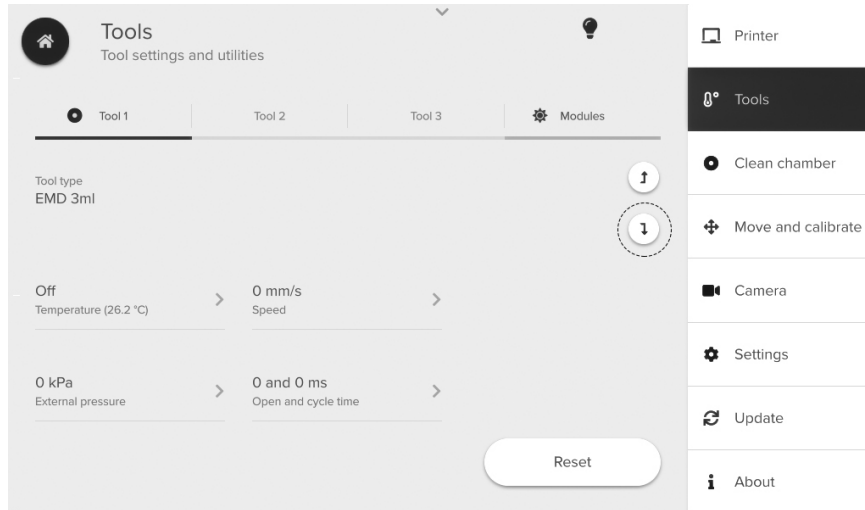
Note: for more information on how to assemble the printhead, see Section 4.3.



**Figure 4:** Inserting the EMD Pneumatic Printhead into the BIO X system.

## 04 Getting started

2. On the user interface, navigate to the Utilities menu and then go to the Tools submenu.
3. Lower the desired printhead mount into the active or loading position by pressing the down arrow (Figure 5).



**Figure 5:** Lowering the printhead into the active position.

## 04 Getting started

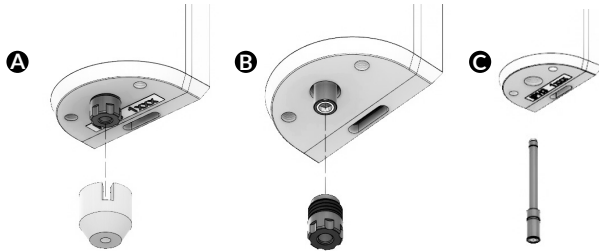
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4. Press the up arrow to return the printhead to the nonactive position.
5. To remove the printhead, use one hand to stabilize the printhead mount and the other hand to push the printhead slightly upward.

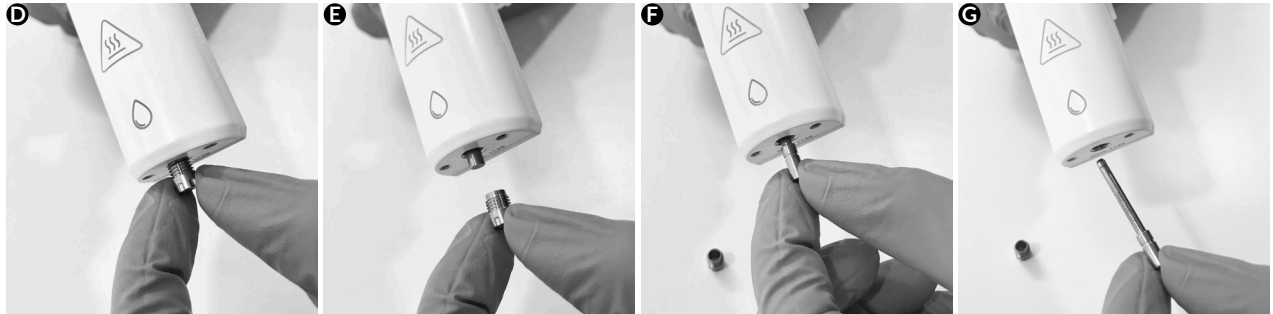
### 4.3 Removal and insertion of microvalve and nozzle

1. Ensure the printhead has been removed from the BIO X (Section 4.2).
2. Remove the nozzle cover from the EMD Printhead to reveal the nozzle (Figure 6A).
3. Unscrew and remove the threaded nozzle (Figure 6B, D, E).
4. Grip the edge of the microvalve (Figure 6F) being careful not to contact the glass tip (Figure 2). Pull straight down to remove the microvalve from the EMD Printhead (Figure 6C, G). If necessary, twist to remove it.

## 04 Getting started



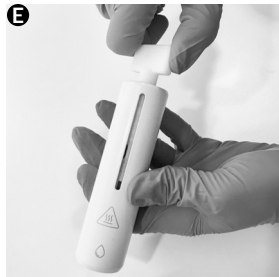
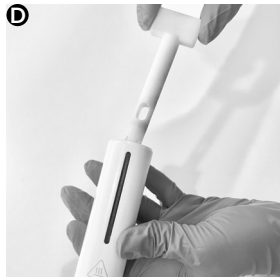
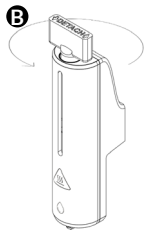
**Figure 6:** (A) Removing the nozzle cover from the EMD Printhead. (B, D, E) Removing the nozzle from the EMD Printhead. (C, F, G) Removing the microvalve from the EMD Printhead.



## 04 Getting started

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5. Insert the adapter tool into the printhead (Figure 7 A, D). Twist the tool counterclockwise while securing the printhead with your other hand (Figure 7 B, E). Pull the tool out with the Luer lock attached (Figure 7 C, F).

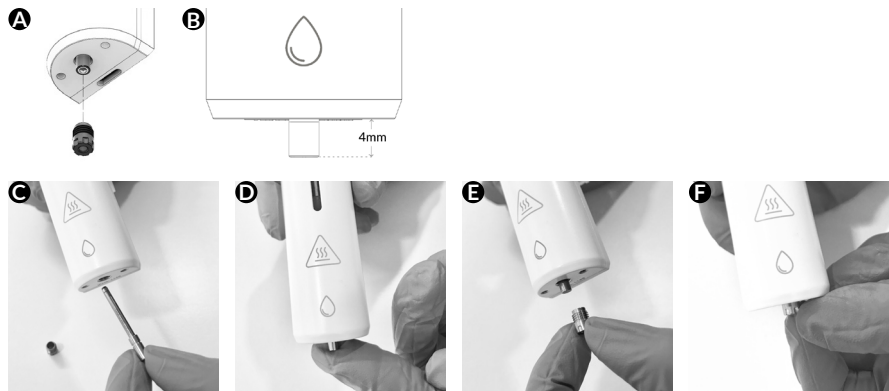


**Figure 7:** Removing the Luer lock adapter. (A, D) Insert the removal tool into the EMD printhead. (B, E) Fit the Luer lock and twist counterclockwise until loose. (C, F) Pull out and remove the adapter.

### 4.4 Reassembling the printhead

1. Use some force to push the microvalve into the printhead until approximately four millimeters of the valve are protruding (Figure 8 C, D). Do not apply pressure on the glass end (Section 3.2).
2. Screw the threaded nozzle by turning it clockwise until you feel resistance.

**NOTE:** It's normal for a few threads to be visible. Do not use excessive force or tools, but ensure the nozzle is tight, as a loose nozzle can unscrew during printing (Figure 8 A, B, E, F).



**Figure 8:** Assembling the EMD Printhead. (A) Inserting the microvalve into the EMD Printhead. (B) Gently push until resistance is felt. (C, E) Align and tighten the nozzle to the printhead. (D, F) Tighten the nozzle until approximately four millimeters of the nozzle are protruding.

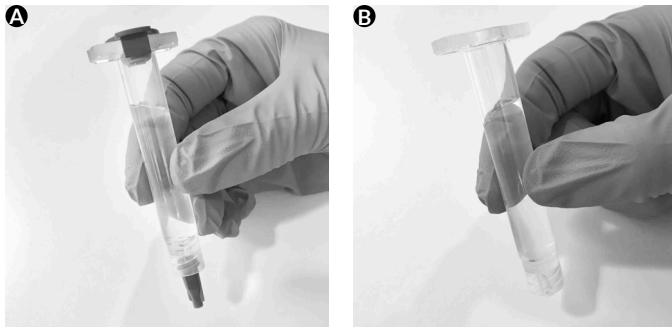
## 04 Getting started

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3. Reinsert the Luer lock adapter by reversing the steps outlined in Section 4.3 and Figure 7. Do not overtighten or the threads on the adapter may be stripped and leakage could occur.

### 4.5 Loading a cartridge

1. Obtain a prefilled bioink cartridge or fill a 3-mL cartridge with a low-viscosity bioink (Figure 9A).
2. Remove the end (top) cap (Figure 9B).



**Figure 9:** Preparing the cartridge for insertion into the EMD Printhead.



## 04 Getting started

3. Insert the cartridge into the EMD Printhead (without connecting the printhead to the BIO X) (Figure 10).

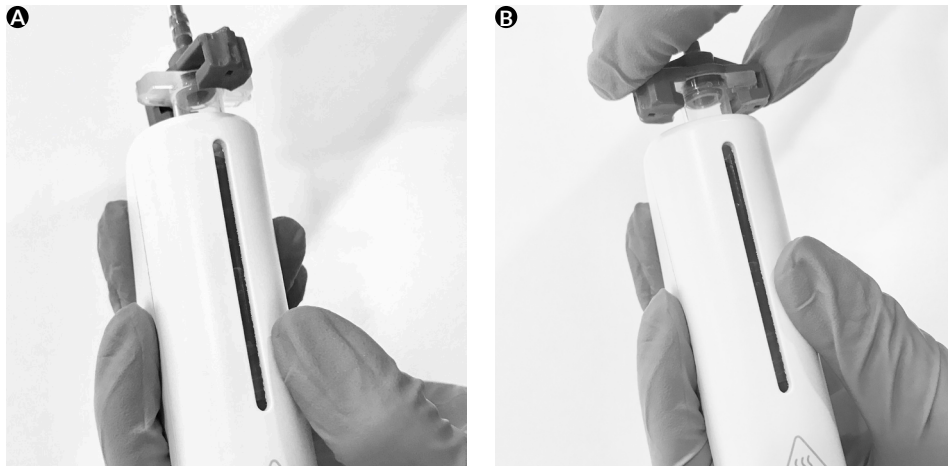


**Figure 10:** Inserting and tightening the cartridge into the EMD Printhead.

## 04 Getting started

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4. Connect the cartridge to the pneumatic adapter by twisting the adapter on the end of the cartridge (Figure 11).



**Figure 11:** Attaching the 3-mL pneumatic adapter to the cartridge.

## 04 Getting started

5. Connect the air tubing to the respective air inlet on the printbox above the respective printhead (Figure 12).

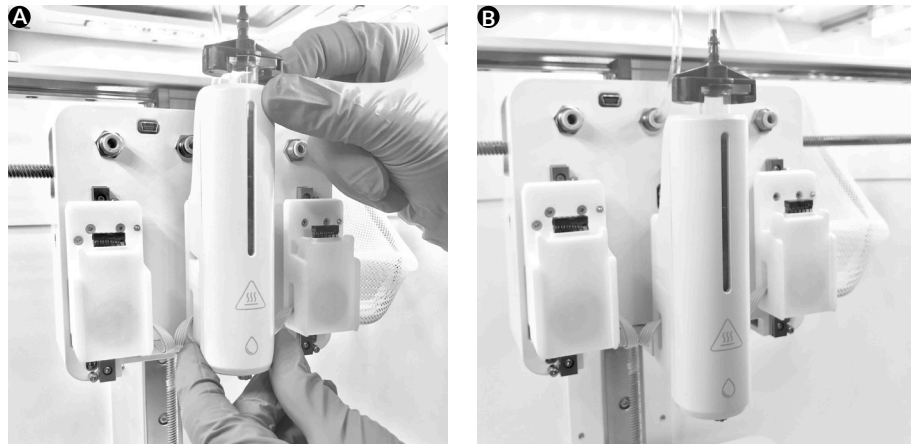


**Figure 12:** Attaching the EMD Printhead to the BIO X printhead mount.

## 04 Getting started

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6. Connect the printhead to the BIO X while stabilizing the mount. Follow the instructions in Section 4.2 (Figure 13).

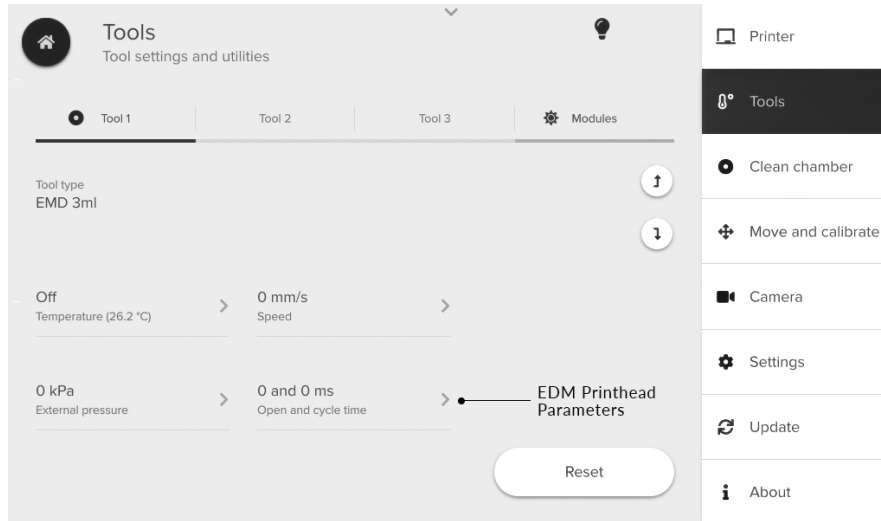


**Figure 13:** Connect the printhead to the BIO X.

## 04 Getting started

### 4.6 Testing Extrusion

1. Navigate to the Utilities menu and select the Tools submenu.

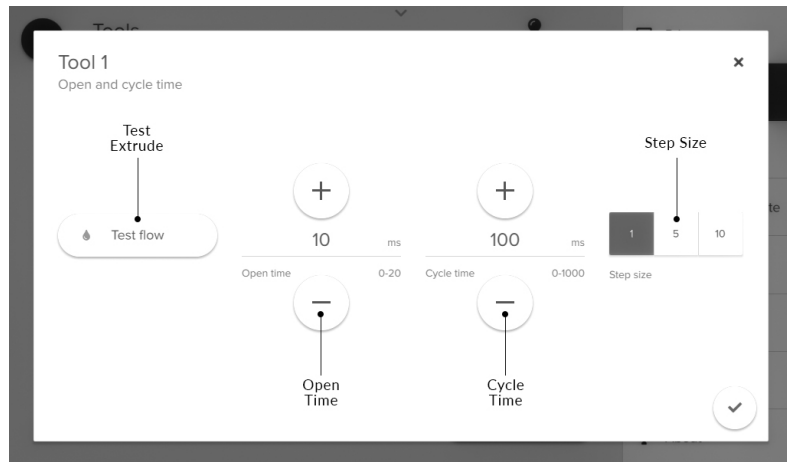


**Figure 14:** Adjusting the EMD Printhead parameters in the Utilities menu.

## 04 Getting started

2. Select the EMD Printhead parameters button to adjust the open and cycle time (Figure 15)

- **Open time:** The length of time the valve is open during one cycle.
- **Cycle time:** The time between each opening that determines the droplet deposition frequency.



**Figure 15:** Adjustable parameters for the EMD Printhead.

3. The pressure can be adjusted within the cartridge to control the expulsion rate of the droplet.

- Certain bioinks require a minimum pressure to be expelled.
- A pressure that is too high can cause an expulsion rate that is too high, resulting in splattering of the droplet on the surface.
- A pressure that is too low might cause material to accumulate at the valve tip, or deflected droplets.

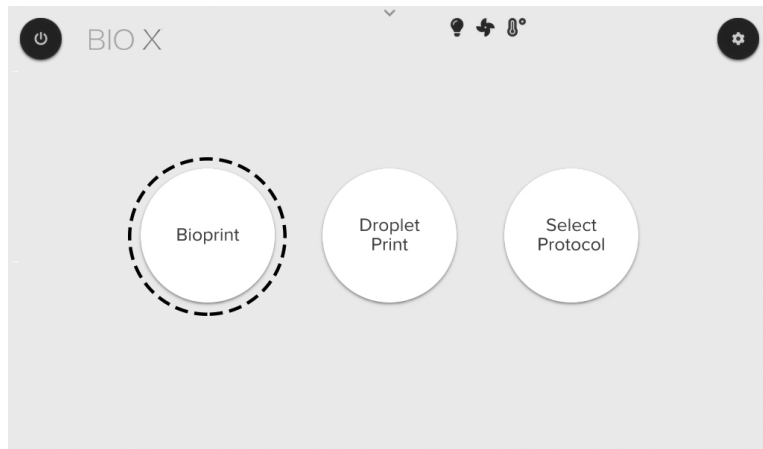
4. Use the Dispense button to test droplet expulsion and optimize your printing parameters.

## 04 Getting started

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### 4.7 Your first bioprint

1. Prepare the cartridges (Section 4.5).
2. Select Bioprint from the Start menu (Figure 16).



**Figure 16:** Start menu. Select Bioprint to proceed print to setup.



## 04 Getting started

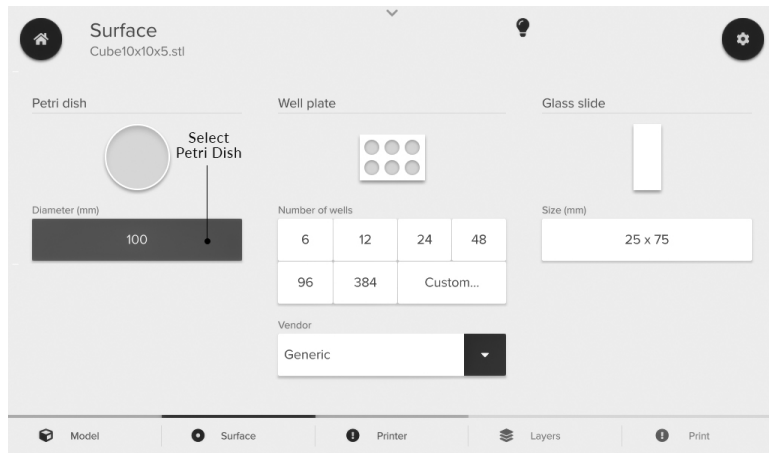
3. Select an STL file (extension .stl) from the Model menu and proceed to the next menu (Figure 17).



**Figure 17:** Selecting STL file from the Model tab.

## 04 Getting started

4. Select a surface to print on. Proceed to the next menu (Figure 18).



**Figure 18:** Select a print surface from the Surface menu.

## 04 Getting started

5. Select printhead positions that have been set up. Make sure the EMD Printhead is selected under the tool type (Figure 19).

6. Enter the desired printing parameters for the printhead (Figure 19) and proceed to the Layers menu. Parameters necessary for the EMD Printhead include:

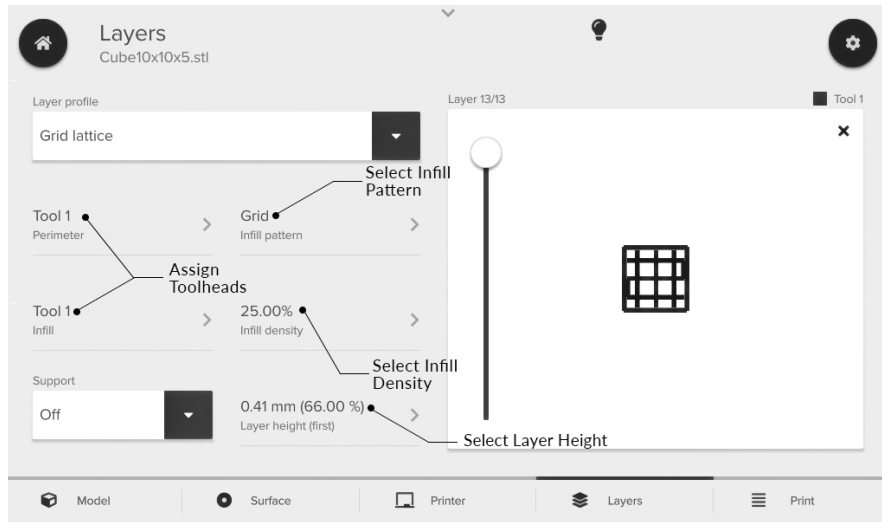
- Pressure.
- Print speed.
- Open time.
- Cycle time.



**Figure 19:** Printing parameters to set on the Printer menu.

## 04 Getting started

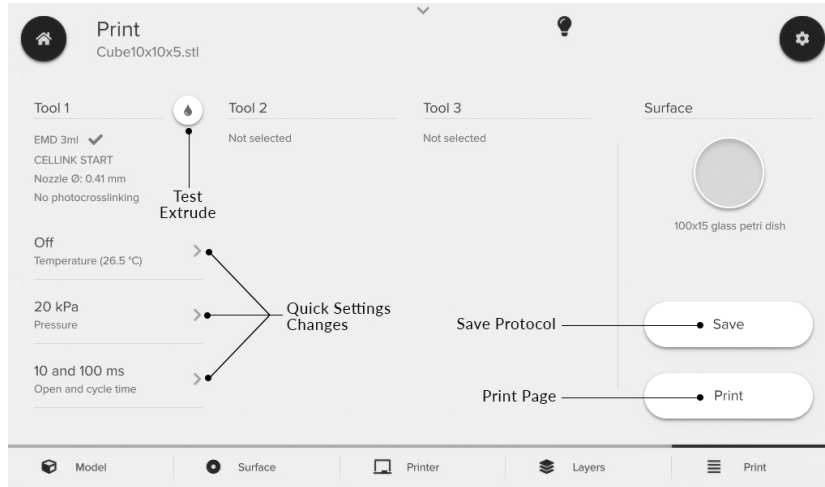
7. Assign the enabled printhead to the respective layer characteristics and proceed to the next menu (Figure 20).



**Figure 20:** Layer menu. You can assign toolheads to respective print areas like perimeter, infill and support. You can select the infill pattern and density and preview the layers.

## 04 Getting started

8. Prime the nozzle/needle and test bioink flow by using the Drop button next to the pressure setting (Figure 21). Press Print to proceed to the calibration page.

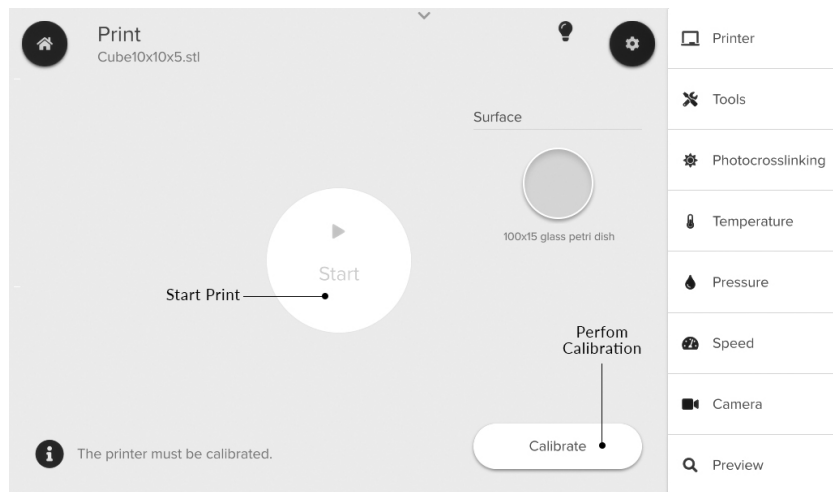


**Figure 21:** Print menu. You can preview your printing parameters and test the pressure. You can also adjust parameters on this menu. Press Print to proceed to the calibration page and press Save to save the configuration as a protocol.

## 04 Getting started

9. Select Calibrate to calibrate the system. Set the EMD Printhead to the desired printing height (Figure 22). A calibration height of 1-3 cm is recommended for the needleless threaded nozzle, and 0 mm for the needle threaded nozzle.

10. Start the bioprinting process (Figure 22).



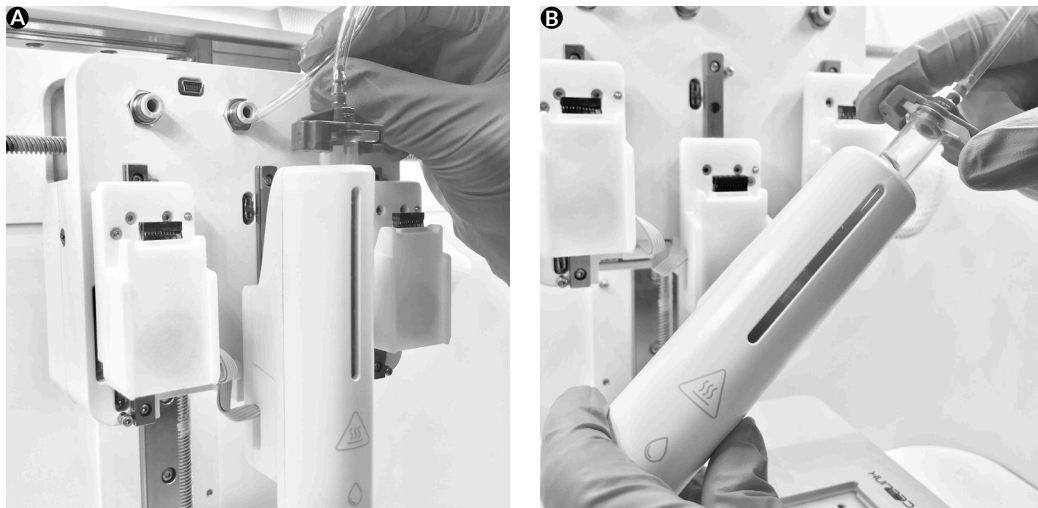
**Figure 22:** Bioprint menu. You can calibrate the system and begin the bioprinting process.

### 4.8 Removing printhead

1. Wipe any excess bioink from the nozzle tip using a delicate task wipe.
2. Cover the nozzle with the nozzle cover.
3. Depressurize the cartridge by detaching the airline from the printer (Figure 23A).
4. Remove the printhead from the BIO X. Use one hand to secure the printhead mount and the other hand to remove the printhead.
5. Disconnect the tubing by twisting the cartridge adapter and lifting it off the cartridge (Figure 23B).
6. Twist and remove the cartridge. The Luer lock adapter will be removed in one piece with the cartridge.

## 04 Getting started

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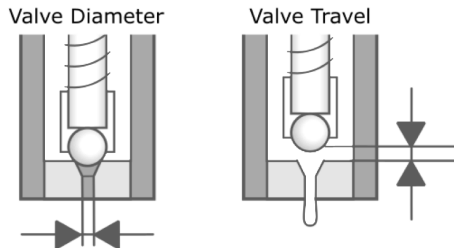
**Figure 23:** Depressurizing and removing the EMD Printhead.



### 4.9 Printing optimization

The EMD Printhead uses an electromagnetically actuated valve to form droplets in the micro- and nanoliter range. Pressurized fluid can flow when the valve is open, and the flow stops when it is closed. An optimal nozzle diameter, valve travel speed and actuation yield the minimal dispensing volume. The BIO X allows the user to enter the open time and the cycle time.

Due to the technique used to form the droplets, this printhead might be incompatible with highly viscous materials. However, adding heat to thermosensitive materials can lower the viscosity enough to make them compatible. Larger nozzle diameters and valve travel are recommended when using larger flow volumes and high-viscosity fluids, while smaller diameters with smaller valve travel are recommended when using small dispensing volumes and low-viscosity fluids.



**Figure 24:** Diagram of valve diameter and valve travel.

## 04 Getting started

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Unlike pneumatic-based bioprinting, this technique results in small droplets instead of filaments. The translational speed of the bioprinting process will affect the pitch between droplets. A low speed might result in the droplets merging together or aggregating, while a high speed will result in a larger distance between droplets.

The EMD Printhead includes a noncontact nozzle and a contact nozzle. The contact nozzle must be calibrated to the height of the surface, while the noncontact nozzle must be calibrated between one and three centimeters away from the surface. The contact nozzle has a needle which can extrude droplets or filaments depending on the parameters set.

In addition, EMD bioprinting can be used in combination with other extrusion techniques to coat or place specific cell patterns.

# 05

## **Relevant G-code commands**

## 05 Relevant G-code commands

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Commands	Description
<b>G1 Xnnn Ynnn Ennn Fnnn</b>	When used in combination with the G90 command, which defines absolute coordinates, G1 is the absolute move command. The values of the X and Y parameters are the coordinates (in mm) directing where to move. E tells the BIO X to open the valve for extrusion. The F parameter is the speed of the printhead in mm/min.
<b>G1 Znnn Ennn Fnnn</b>	When used in combination with the G90 command, which defines absolute coordinates, G1 is the absolute move command. The value for the Z parameter indicates the coordinate (in mm) directing where to move. E tells the BIO X to open the valve for extrusion. The F parameter is the speed of the printhead in mm/min.
<b>G4 Snnn Pnnn</b>	The G4 command instructs the system to dwell. The S command is the wait time in seconds and P is the wait time in milliseconds.
<b>G7 Xnnn Ynnn Ennn Fnnn</b>	When used in combination with the G90 command, which defines absolute coordinates, G7 is the relative move command. The values for the X and Y parameters are the coordinates (in mm) directing where to move relative to the current position. E tells the BIO X to open the valve for extrusion. The F parameter is the speed of the printhead in mm/min.
<b>G7 Znnn Ennn Fnnn</b>	When used in combination with the G90 command, which defines absolute coordinates, G7 is the relative move command. The value for the Z parameter indicates the coordinate (in mm) directing where to move relative to the current position. E tells the BIO X to open the valve for extrusion. The F parameter is the speed of the printhead in mm/min.

## 05 Relevant G-code commands

<b>G92 Xnnn Ynnn Znnn</b>	G92 sets the current position of the printhead to the specified X, Y and Z coordinates. If no values are given, the position is assumed to be 0, 0, 0 (this will also change the Z position).
<b>Tx</b>	Tx switches to printhead (x), where 0, 1 and 2 designate printheads 1, 2 and 3.
<b>M771 Tx Pyy</b>	M771 turns on the heater in printhead Tx at temperature Pyy, where yy is a temperature between 30 and 65 degrees Celsius.
<b>M750 Tx Py Dz</b>	Extrude from printhead x at pressure y for z milliseconds.
<b>M751 Tx</b>	Stop extrusion from printhead x.
<b>M2065 Tx Sy</b>	Set valve open time of printhead x to y microseconds.
<b>M2067 Tx Sy</b>	Set valve cycle time of printhead x to y microseconds.
<b>M400</b>	M400 command causes all G-code processing to pause and wait until the printer finishes all movement (i.e., the planner queue is empty).



# 06

## Frequently asked questions

## 06 Frequently asked questions

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- **What is the mechanism that enables bioprinting with this printhead?**

This printhead compresses the bioink within a cartridge. The cartridge is connected to an electromagnetic valve that can open and close for a set length of time. Droplets are expelled from the printhead at the open and close rates set by the user.

- **What do the LED colors indicate?**

The printhead LED will change depending on its status. When the printhead is first put on the printhead mount, the light will turn white to indicate that it is initializing. Once recognized, the LED will turn blue. The blue light also indicates a temperature below 35 degrees Celsius. When the temperature of the printhead is between 35 and 50 degrees, the light turns yellow to indicate that the printhead is warm. The light turns red at temperatures above 50 degrees to indicate that the printhead is hot.

- **Can I use various printhead and printhead types simultaneously?**

You can use multiple printheads in the same printing protocol to generate multimaterial constructs. However, you cannot print simultaneously as pressure can only be provided to one printhead at a time.

- **My bioink is not extruding.**

The needle/nozzle may be clogged due to the bioink being used or a pause in its use. Replace the needle/nozzle. If your bioink contains aggregates, ensure that they are of a sufficient size to pass through the needle/nozzle without clumping and blocking it. If using a thermosensitive bioink it may have gelled in the tip. Consider using the Temperature-controlled Printhead to print thermosensitive bioinks.

- **The droplets are not landing where they are supposed to on the surface.**

If the droplets are deflecting away or not getting dispensed at all, you might not be using enough pressure. Try increasing the pressure or using a contact nozzle with a needle.



# 07

## Maintenance

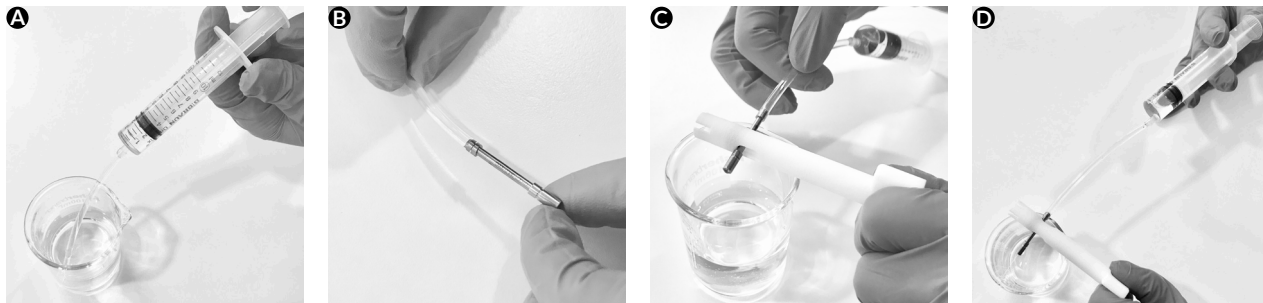
## 07 Maintenance

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### 7.1 Cleaning

1. After printing, flush the microvalve, nozzle and Luer lock adapter to clean them and prevent clogging.
2. Disassemble the printhead (Section 4.2).
3. Mount the Luer lock adapter to a syringe loaded with deionized water or ethanol.
4. Flush the Luer lock adapter to remove residue. Let it air dry.
5. Connect a clean syringe to the provided pneumatic tubing.
6. Pour deionized water or ethanol into a plastic cup. If using water, use a mild temperature.
7. Retract the water/ethanol into the syringe (Figure 25A).
8. Connect the end of the tubing to the microvalve (Figure 25B).
9. Pressurize the syringe by pushing on the plunger and inserting the microvalve into the adapter tool. (Figure 25 CD). Fluid will flush the valve when the valve opens (Figure 26).

## 07 Maintenance



**Figure 25:** Preparing the microvalve for cleaning.



**Figure 26:** Flushing the microvalve.

## 07 Maintenance

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10. Repeat steps 7 to 8 with air instead of water/ethanol to dry the microvalve.
11. Disconnect the microvalve and let it air dry.
12. Connect the nozzle to the provided tube. Use the syringe to flush with water or ethanol, then water. Hold the nozzle tightly when flushing to prevent it from disconnecting from the tube (Figure 27).
13. When the parts have dried, reassemble the printhead for storage (Section 4.2).



**Figure 27:** Connecting the nozzle for cleaning.

### 7.2 Long-term maintenance

- The threaded nozzles and Luer lock adapter can be autoclaved and cleaned with ethanol. They have sufficient chemical resistance to ethanol and are temperature-resistant for autoclaving.
- Regularly clean the printhead with a damp cloth to remove any dust or debris.



# **Appendix A: Consumables— needles and nozzles**

# Appendix A: Consumables — needles and nozzles

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## Available nozzles and part numbers

- Available nozzles for contact dispensing (inner diameters):
  - 0.10 mm.
  - 0.15 mm.
  - 0.30 mm (standard. Art. no. D16110020555).
- Available microvalves for contact and noncontact jetting. Threaded sleeve used for noncontact jetting where fluid is shot directly from microvalve end.
- Available microvalve diameters:
  - 0.10 mm.
  - 0.15 mm.
  - 0.20 mm.
  - 0.30 mm (standard).
  - 0.45 mm.
  - 0.60 mm.
- Valve travel (stroke):
  - 0.03 mm.
  - 0.06 mm.
  - 0.10 mm (standard).
  - 0.15 mm.



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## **Appendix A: Consumables – needles and nozzles**

Common and proven valve diameter/travel combinations:

- 0.1 / 0.06 travel.
- 0.1 / 0.03 travel.
- 0.15 / 0.03 travel.
- 0.15 / 0.06 travel.
- 0.2 / 0.06 travel.
- 0.2 / 0.1 travel.
- 0.3 / 0.1 travel (standard. Art. no. 000000020551).
- 0.6 / 0.15 travel.

## Appendix A: Consumables – needles and nozzles

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### Compatible consumables

<b>CSC010300502</b>	Empty cartridges 3cc – 50 pcs
<b>CSC010300102</b>	Empty cartridges 3cc with end and tip caps – 10 pcs
<b>CSC010311502</b>	Empty cartridges 3cc with end and tip caps – 50 pcs
<b>CSO010311102</b>	UV-shielding cartridges 3cc with end and tip caps – 10 pcs
<b>CSO010311502</b>	UV-shielding cartridges 3cc with end and tip caps – 50 pcs
<b>OH000000010</b>	Female/female Luer lock adapter – 10 pcs
<b>OH000000050</b>	Female/female Luer lock adapter – 50 pcs
<b>PSB030000502</b>	Beige pistons, 3cc 50 pcs
<b>PSO030000502</b>	Orange pistons, 3cc 50 pcs

## Support information

- Official site: [www.cellink.com](http://www.cellink.com)
- Contact: [support@cellink.com](mailto:support@cellink.com)
- Contact: [sales@cellink.com](mailto:sales@cellink.com)
- Web store: [www.cellink.com/store](http://www.cellink.com/store)



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