BIO X Thermoplastic Printhead

User Manual

CELLINK®

Contents

01
Package contents

01 Package contents

Item	Part number	Quantity
Thermoplastic Printhead	000000020347	1
Metal cartridge	000000020358	1
4-mm tube connector M3 (straight stainless)	000000010160	1
Thermoplastic Printhead top cap	000000020363	1
Locking ring	000000020361	1
Plunger	000000020362	1
Plunger removal tool (160 mm)	000000020373	1
Blue tubing (150 mm)	000000010109	1
Wrench	000000020537	1

02
Technical specifications

02 Technical specifications

- **Compatible with CELLINK thermoplastic cartridge.**
- **Dimensions (height x width x depth):**
  - **With cartridge (no tubing or nozzle): 165 x 32.5 x 44 mm.**
  - **Without cartridge or nozzle: 129.5 x 32.5 x 44 mm.**
- **Weight: 260 g.**
- **Maximum recommended pressure: 700 kPa. We recommend using an external pump with the Thermoplastic Printhead.**
- **Material composition:**
  - **External surfaces: Stainless steel.**
  - **Internal surfaces (metal cartridge): Stainless steel.**
  - **Insulators: Polyether ether ketone (PEEK).**
- **Recommended operating temperature: 20-23 degrees Celsius.**
- **Running temperature (in recommended conditions): 26-32 degrees.**
- **Heating capacity and rate:**
  - **Total heating range: 30-250 degrees.**
  - **Heating rate: Room temperature-250 degrees (15 minutes).**
- **Cooling capacity: N/A.**
- **Build volume (X, Y, Z): 128 x 85 x (37–A) mm (A = tip length).**

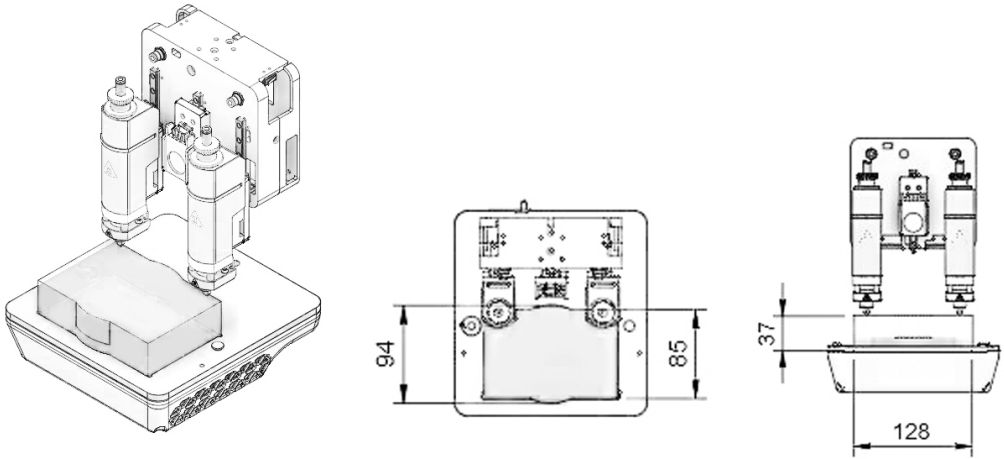


Figure 1: Theoretical maximum build volume shown from the top and side view using the Thermoplastic Printhead (assuming a nozzle length of 7 mm). Exact build volume depends on the cartridge's position in the printhead and the nozzle/needle used. Build volume may be lower when combining the Thermoplastic Printhead with a printhead that restricts printbox movement. Please consult the printhead manual for the printheads being used for specific limitations.

02 Technical specifications

Table 1: Theoretical build volume based on common tip lengths. 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.

Tip Type	Tip Length	Nozzle/Needle Length	X	Y	Z	Build Volume
Metal M6	7mm	7mm	12.8 cm	8.5 cm	3.7cm	402 cm^3

03
Safety information

03 Safety information

3.1 BIO X system warnings

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

3.2 Thermoplastic Printhead warnings

- Clean the printhead using instructions in the Maintenance section. Do not clean the printhead by submerging it in liquid or using excessive spraying. Liquid inside the printhead can damage the circuitry and motor.
- The Thermoplastic Printhead operates at very high temperatures. 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.
- Only load the cartridge with dry thermoplastic granulate. Ensure the cartridge is clean and dry before loading the granulate. Only use the cartridge with CELLINK-supplied thermoplastic granulates or granulates from our recommended suppliers.
- Load and unload the Thermoplastic Printhead onto the BIO X printhead mounts using guidelines in the Getting Started section. Do not pull or push the printhead with excessive force while it's loaded on the BIO X. Using excessive force risks damaging 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
- DO NOT touch a moving printhead. Fingers can be crushed between the printhead base and motor arm and can result in serious injury.

04

Getting started

04 Getting started

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 and installation

1. Open the package. Remove the pre-assembled Thermoplastic Printhead.

2. Check for all components of the Thermoplastic Printhead and accessories (Figure 2).

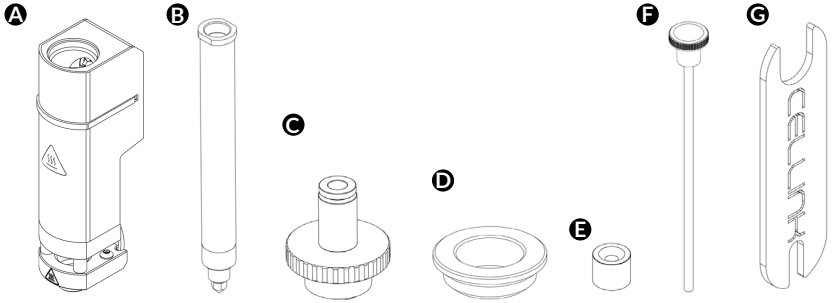
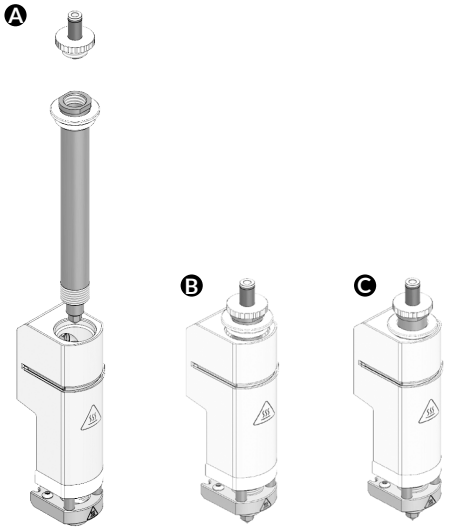


Figure 2: Thermoplastic Printhead components. These include: (A) Thermoplastic Printhead body, (B) the stainless-steel cartridge with nozzle, (C) the top cap, (D) the insulated locking ring, (E) the stainless steel plunger, (F) the plunger removal tool and (G) the wrench for tightening the cartridge and the nozzle.

3. Assemble the Thermoplastic Printhead (Figure 3).



• Place the plunger inside the metal cartridge. Attach the top cap. (Plunger use is optional.)

• Insert the assembled cartridge into the Thermoplastic Printhead (Figure 3A). Twist until the cartridge is screwed into place. Use the wrench to tighten (Figure 3B).

• Position the insulated locking ring downward to secure the assembled cartridge to the Thermoplastic Printhead (Figure 3C).

Figure 3: Thermoplastic Printhead assembly.

4. Attach the Thermoplastic Printhead to the BIO X printbox. Align the printhead above the desired printhead mount and push downwards using one hand (Figure 4A). Secure the bottom of the printhead mount with your opposite hand to prevent straining the motor (Figure 4B).

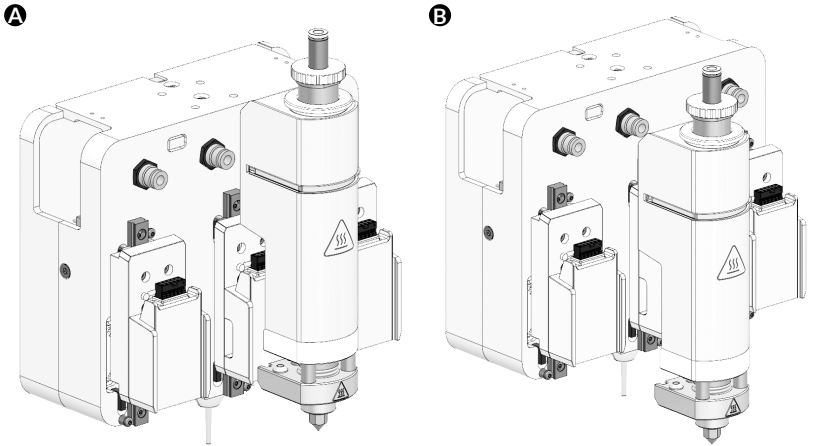


Figure 4: Attaching the Thermoplastic Printhead to the BIO X. (A) Line up the printhead with a mount on the printbox. (B) Slide the printhead down with one hand and secure the bottom of the printhead mount with the other hand. Once attached, the lights on the printhead will turn from white to blue.

4.2 Heating the Thermoplastic Printhead

NOTE: The steps under this section will test the temperature functionality of your Thermoplastic Printhead. It is only necessary to follow these steps once, after receiving your new printhead.

1. Assemble and attach the Thermoplastic Printhead (Section 4.1).

2. Go to the Utilities Menu and then the Tools submenu.

3. Set the printhead temperature (Figure 5).

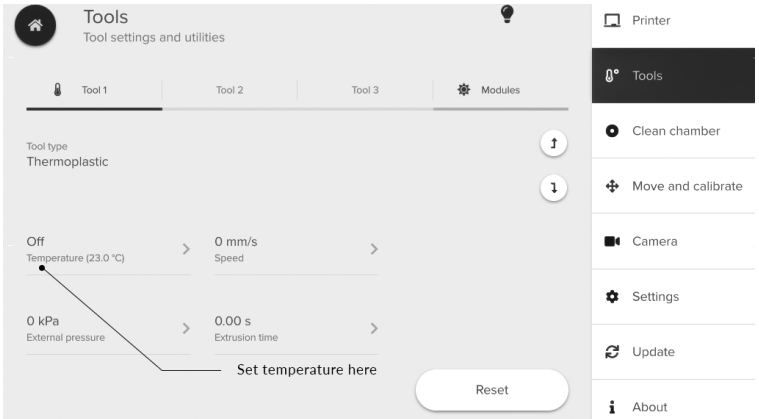


Figure 5: Presetting temperature for the Thermoplastic Printhead.

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4. Set the temperature of the printhead to 150 degrees Celsius.

5. Allow the printhead to heat up to 150 degrees.

WARNING: Do not touch the printhead while heating. Doing so risks serious injury.

6. Once the printhead reaches 150 degrees, set the temperature to 250 degrees.

7. Once it reaches 250 degrees (± 5 degrees), turn off the printhead temperature and allow it to cool down to room temperature.

NOTE: A faint burning smell can be caused by dust and other residue and is not necessarily a cause for concern.

8. After cooling, remove the printhead from the printhead mount.

4.3 Recommendation: Using external air supply

NOTE: The BIO X internal air supply provides up to 200 kPa of pressure. We recommend using an external air supply with the Thermoplastic Printhead due to the high viscosity of thermoplastic materials.

NOTE: Inconsistent prints can indicate internal air reservoir exhaustion. In these cases, an external air supply is recommended.

NOTE: The maximum pressure that the BIO X can withstand is 700 kPa whether you use an external pump, building air supply or compressed air tank. Contact support@cellink.com and we can recommend the best connection for your pressure source. Always place a secondary regulator between the system and the external air supply to protect the valves from pressure spikes beyond the recommended limit of 700 kPa.

1. **Connect the external air supply to the BIO X through the pneumatic connector on the back of the device. The connector requires a 4-mm air tube (Figure 6).**

Figure 6: External air supply inlet. A 4-mm air tube can be inserted into the BIO X using the pneumatic connector located on the back of the device.

2. **Navigate to the Utilities menu and select the Tools submenu. Select Pressure and toggle the External Pump. Toggle the External Pump setting to enable the external air supply in the Utilities menu. The system will reflect the new maximum pressure that can be set from the external air supply (Figure 7).**
3. **Use a secondary regulator on the external air supply to ensure that the pressure load does not exceed 700 kPa.**

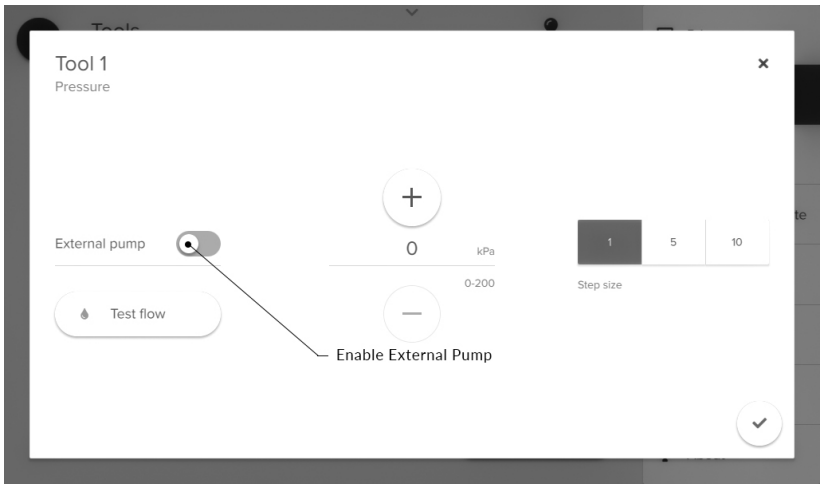

Figure 7: Enabling the use of the external air supply through the Utilities menu.

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4.4 Loading the granulate

1. If hot, allow the PH to cool to room temperature.
If plunger is inserted, remove it using the plunger retrieval tool.
Fill the cartridge with thermoplastic granulate.

NOTE: Don't overfill the cartridge. Too much granulate can lengthen preheating time and clog the cartridge.

NOTE: Evaluate melting times and characteristics before using a new type of polymer.

2. Insert the steel plunger with the threaded hole facing upward and away from the thermoplastic granulate (Figure 8A).
3. Push the plunger down using the plunger removal tool until it contacts the granulate (Figure 8B). Compress the granulate with the plunger to ensure that the granulate is tightly packed.
4. Firmly screw the top cap onto the cartridge (Figure 8C).
5. Slide the cartridge down through the printhead. Turn the cartridge clockwise until the threads engage. Tighten with the wrench (Figure 8C).

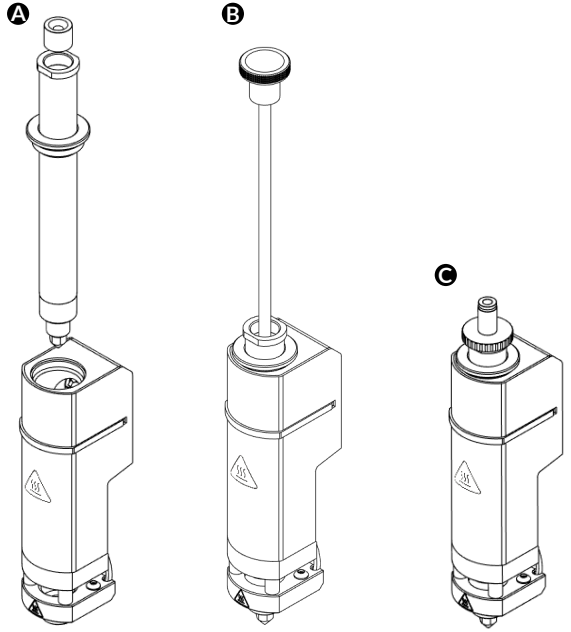

Figure 8: Loading the Thermoplastic Printhead with granulate.

04 Getting started

6. Attach the printhead to the printhead mount (Section 4.1). Navigate to the Tools menu to lower the printhead mount. Select the tool to use and tap the downward arrow (Figure 9). Once the mount is lowered, attach the air tube to the pneumatic connector on the printbox.

Figure 9: (A) Attaching the Thermoplastic Printhead to the mount. (B) Attaching the airline to the printbox. (C) Lowering the printhead to the active position.

7. Preheat the printhead to the desired temperature (Section 4.2).
8. Wait 15-20 minutes. Test the extrusion of the melted granulate using the Tools submenu (Figure 10).
9. If the granulate is not extruding, adjust the temperature and pressure.
10. Consult Section 6 for common troubleshooting tips if more help is needed.

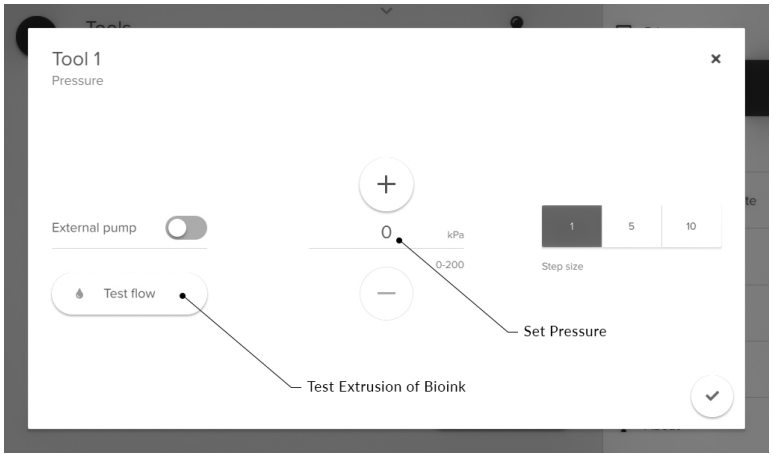

Figure 10: Set pressure and test flow of melted thermoplastic granulate.

04 Getting started

4.5 Your first bioprint

1. Prepare the printhead and granulate (Sections 4.1 and 4.4). Set up the external air supply if needed (Section 4.3).

2. Ensure that the thermoplastic granulate is melted and flowing normally (Section 4.4).

3. Select Bioprint from the Start menu (Figure 11).

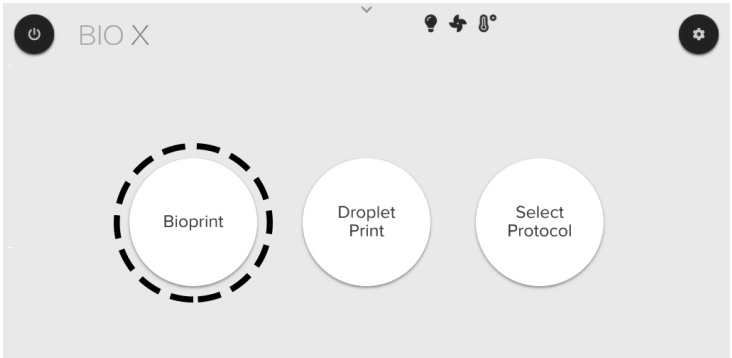

Figure 11: The Start Menu. Select Bioprint to proceed to print setup.

4. Select an STL file (extension .stl) from the Model menu and proceed to the next menu (Figure 12).

Figure 12: Selecting an STL file from the Model menu.

5. Select a surface to print on. Proceed to the next menu (Figure 13).

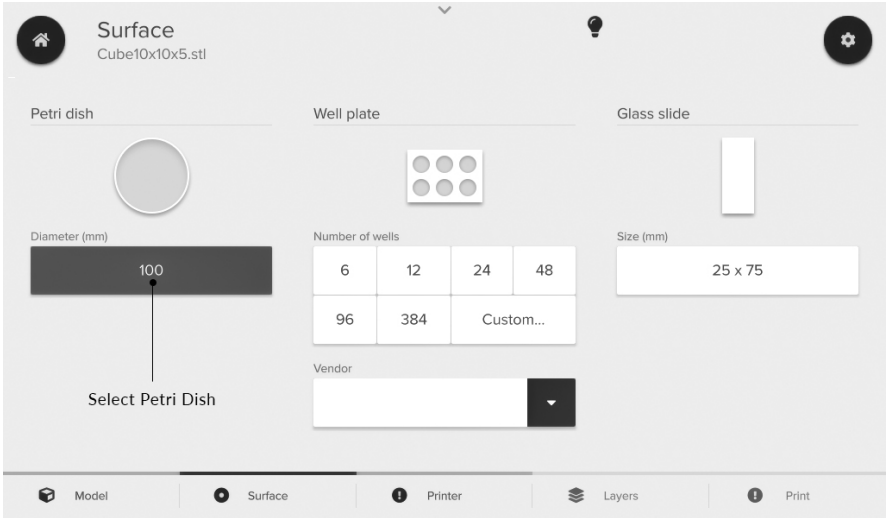

Figure 13: Select a print surface from the Surface menu.

6. **Select printhead positions that have been set up.**
7. **Ensure that Thermoplastic is selected under Tool type. Enter the printing parameters for the printhead (Figure 14). Proceed to the Layers menu. Parameters necessary for the Thermoplastic Printhead include:**

- **Nozzle diameter.**
- **Pressure.**
- **Print speed.**
- **Pre-flow delay.**
- **Post-flow delay.**
- **Temperature.**

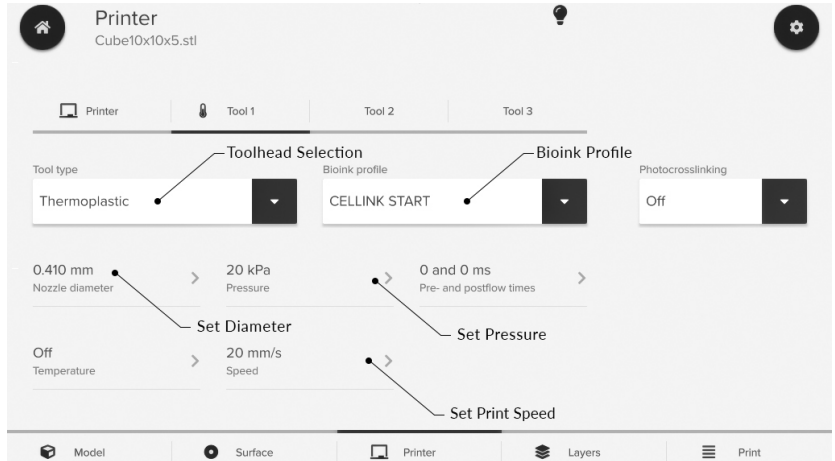

Figure 14: Printing parameters to set on the Printer menu.

8. Assign the enabled printhead to the respective layer characteristics and proceed to the next menu (Figure 15).

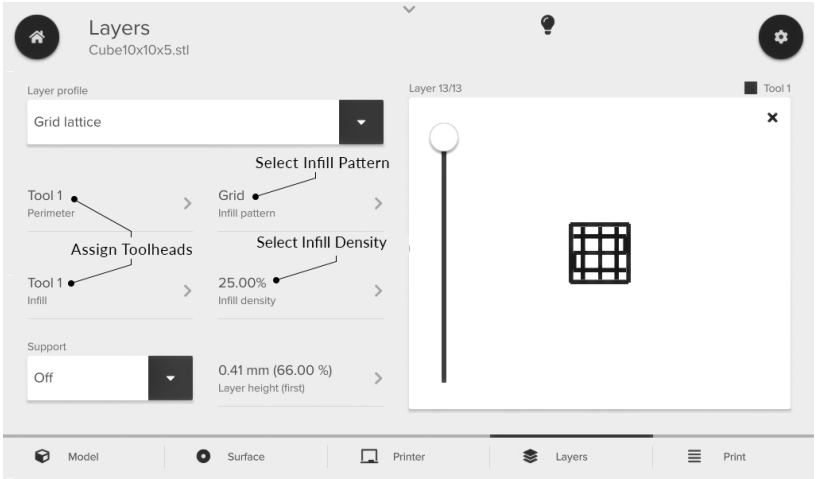

Figure 15: Layer menu. Toolheads can be assigned to respective print areas such as perimeter, infill and support. You can select the infill pattern and density and preview the layers.

9. Select the Drop button to prime the nozzle/needle and test bioink flow (Figure 16). Clean the extrusion tip using a metal tool, such as tweezers. Press Print to proceed to the calibration page.

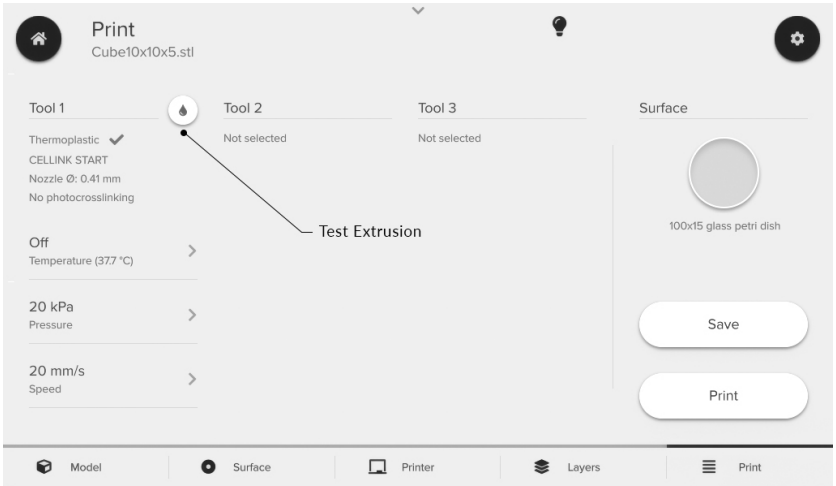

Figure 16: Print menu. You can preview your printing parameters and test the pressure. You can also adjust parameters on this menu. Press Print to proceed to the calibration page and press Save to save the configuration as a protocol.

10. Select Calibrate (Figure 17). Bring the tip of the nozzle/needle to your desired starting position. We recommend making sure that the tip touches the surface of your printing substrate.
11. Start the bioprinting process (Figure 17).

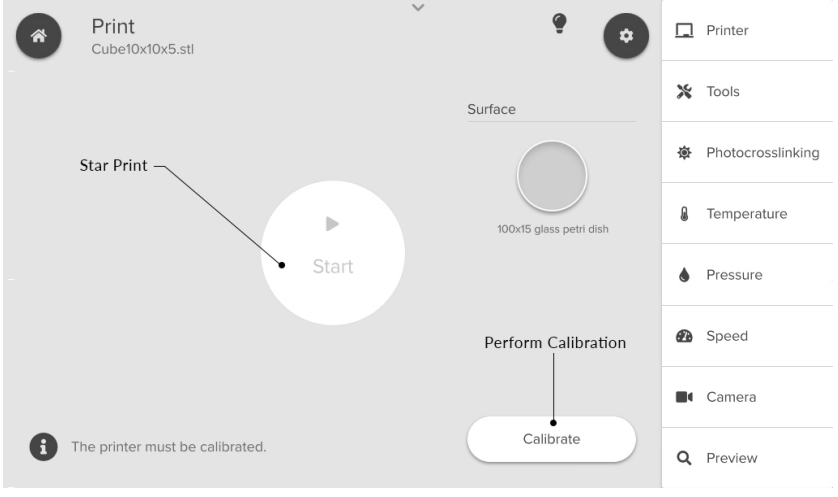

Figure 17: Bioprint menu. You can calibrate the system and begin the bioprinting process.

4.6 Refilling

CAUTION: Printhead may be very hot when changing material or refilling.

If you used the plunger:

1. **Remove the printhead from the printhead mount. To prevent motor damage, use one hand to secure the top of the printhead mount while sliding the printhead upward with the other hand.**
2. **Unscrew the top cap.**
3. **Gently insert the plunger retrieval tool into the cartridge and find the threaded hole in the plunger.**
4. **Turn the plunger retrieval tool clockwise at least five turns to screw into the plunger.**
5. **Firmly pull the plunger up to retrieve the plunger.**
6. **Let the printhead and metal cartridge cool down before loading more granulates to prevent material from melting on the sides of the cartridge. Add thermoplastic granulate to the cartridge o refill. Reassemble the printhead (Section 4.4).**
7. **Set the desired temperature of the printhead using the Utilities menu. Wait for the new material to melt. Begin printing.**

If you did not use the plunger:

1. **Unscrew the top cap. There is no need to remove printhead from its mount.**
2. **Let the printhead and metal cartridge cool down before loading more granulates, or use a funnel to prevent material from melting on the sides of the cartridge. Add thermoplastic granulate to the cartridge to refill and then reassemble the printhead (Section 4.4).**
3. **Set the desired temperature of the printhead using the Utilities menu. Wait for the new material to melt. Begin printing.**

05
Cleaning

05 Cleaning

1. Remove the printhead from the printhead mount. To prevent motor damage, use one hand to secure the top of the printhead mount while sliding the printhead upward with the other hand.
2. Remove the nozzle with the wrench while the printhead is still warm.
3. Return the printhead to the mount and reheat the Thermoplastic Printhead.
4. Wait 15 minutes to ensure the granulate is fully melted.
5. Apply pressure to the printhead to extrude the excess material until only air is expelled (Figure 10).
6. Remove the printhead from the printhead mount.
7. Unscrew the top cap.
8. Gently insert the plunger retrieval tool into the cartridge and find the threaded hole in the plunger.
9. Turn the plunger retrieval tool clockwise at least five turns to screw into the plunger.
10. Firmly pull the plunger up to retrieve the plunger.

CAUTION: Plunger and melted thermoplastic residue may be very hot. Touching hot surfaces and objects can result in serious injury.

11. Use the wrench to loosen the cartridge.
12. Disable the temperature using the Tools option on the Utilities menu.
13. Wait for the Thermoplastic Printhead to cool to room temperature.
14. Remove the cartridge once cooled.
15. Clean the nozzle, cartridge and plunger using a solvent compatible with stainless steel. Perform the following steps in a fume hood using protective equipment:

    - Fill a container with a solvent that can dissolve thermoplastic material. Make sure the container is made of borosilicate glass or another material strong enough to endure corrosion.
    - Insert the metal parts you want to clean.
    - Close the container tightly. Let it sit for 8-24 hours or until the parts appear clean.
    - Use tweezers to carefully pull out the metal parts. Let the solvent evaporate and rinse with water. Be careful not to heat up the parts until solvent has been cleared out.

06
Printing optimization

06 Printing optimization

When bioprinting with the Thermoplastic Printhead, the print surface, nozzle diameter and pressure source all affect material extrusion.

We recommend using glass as a print surface. Glass adheres to thermoplastic filament more than a plastic surface does. Commonly used plastic surfaces risk melting from contact with the nozzle. Also, the printed filament may be thermally bound to the plastic piece, making removal difficult. To improve surface adhesion, if material allows sterilization post-printing, cover the print surface using textured tape (i.e. painter's tape) instead of a Petri dish. Keep in mind tape residue can affect seeded cells. Depending on the material used in the Thermoplastic Printhead, the printbed may have to be heated to facilitate attachment and mitigate contraction during the cooling process.

We recommend using a layer height that is smaller than the nozzle diameter to improve the thermoplastic material's adhesion to the surface of each layer. Consider adding a pause between bioprinting each layer to enable the deposited filament to cool. If the deposited polymer is not cooled, it may deform due to printhead movement. The printed construct may also contract as it cools. Further optimization may be necessary to account for this.

We recommend using an external pressure source when printing with the Thermoplastic Printhead. This is due to the high viscosities of the melted thermoplastic that may require pressures beyond those provided by the internal pump and air reservoir. Please contact support@cellink.com so we can provide you with the proper solution regarding an external pump or using your building's air supply. It is necessary to ensure that a secondary regulator is placed between the external air supply and the system to protect the valves from pressure

spikes beyond the recommended limit of 700 kPa.

After loading the thermoplastic granulates into the cartridge, use the plunger to compact the material to improve melting and material extrusion. Please refer to the material guides for more detailed instructions. We recommend letting the printhead and material preheat for at least 15 minutes to ensure that the thermoplastic has melted completely prior to printing.

07
Relevant G-code commands

07 Relevant G-code commands

Commands	Description
G1 Xnnn Ynnn Ennn Fnnn	G1 is the absolute move command. The values for 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. F is the movement speed of the printhead in mm/min.
G1 Znnn Ennn Fnnn	G1 is the absolute move command. The value for the Z parameter is the coordinate (in mm) directing where to move. E tells the BIO X to open the valve for extrusion. F is the speed of the printhead in mm/min.
G4 Snnn Pnnn	The G4 command tells the system to dwell. S is the wait time in seconds and P is the wait time in milliseconds.
G7 Xnnn Ynnn Ennn Fnnn	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. F is the speed of the printhead in mm/min.
G7 Znnn Ennn Fnnn	G7 is the relative move command. The value for the Z parameter is the coordinate (in mm) directing where to move relative to the current position. E tells the BIO X to open the valve for extrusion. F is the speed of the printhead in mm/min.

G92 Xnnn Ynnn Znnn	G92 sets the current position of the printhead to the specified X, Y and Z coordinates. If no parameters are given, the position is assumed to be 0, 0, 0 (this will also change the Z position).
Tx	Switch to printhead (x). 0, 1 and 2 designate printheads 1, 2 and 3.
M771 Tx Pyy	M771 turns on the heater in printhead Tx at temperature Pyy; yy is a temperature between 30 and 250 degrees Celsius.

08

Frequently asked questions

08 Frequently asked questions

• What do the LED colors indicate?
The printhead LED will change depending on its status. When the printhead is first mounted, the light will turn white to indicate that it is initializing. Once it is recognized, the LED will turn blue. 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. When the printhead is above 50 degrees, the light will turn red to indicate that the printhead is hot.

• Can I use multiple printheads and printhead types simultaneously?
You can use multiple printheads within the same printing protocol to generate multimaterial constructs. You can't print simultaneously because the pressure can only be provided to one printhead at a time.

• What is the mechanism that enables bioprinting with this printhead?
This printhead leverages compressed air to actuate a plunger in the cartridge to compress the melted thermoplastic. This causes the material to be extruded through the nozzle. The extrusion rate is proportional to the applied pressure, viscosity of the melted thermoplastic and the nozzle diameter.

• My thermoplastic is not extruding.
This could happen for several reasons. The cartridge may be empty, the nozzle may be blocked, the plunger may be stuck, the bioink may not have melted completely or the pressure applied may be insufficient.

If there is a sound of air coming out of the nozzle, or the molten thermoplastic is sputtering out of the nozzle, the cartridge may be empty. It is also possible that the granulate is not molten enough. Check the cartridge and refill it if necessary. Be careful not to touch any of the metal components of the Thermoplastic Printhead when refilling, as they may be hot.

If the cartridge has material in it but it is still not extruding, the material may not be sufficiently melted. Partial melting of the material can block the plunger from compression. Before extrusion, allow more time for the thermoplastic to fully melt or increase the temperature of the printhead.

If the material is extruding too slowly, the applied pressure may be too low. Increase the pressure to improve extrusion.

The nozzle could also be blocked or not clean. Scrub the nozzle with a brush to remove residue. Be careful not to touch the nozzle directly because it is extremely hot when it is in use.

• My extrusion rate is not consistent.
The material being used may not have uniform properties.

If you're using the internal pump to extrude high-viscosity materials, inconsistent extrusion can result from gradual internal pressure failure and consequent air reservoir depletion. Try using an external pump.

• My thermoplastic filament is not attaching to the surface during the printing process.
The layer height of the print may be too high. Decrease the layer height to ensure proper adhesion. Perform automatic bed-leveling to ensure that the printbed is even before printing.

08 Frequently asked questions

• My needle is dragging through my printed structure during travel movements.
A low layer height or print speed can result in thicker-than-expected filaments that the needle subsequently touches when moving. Try raising the parameters to compensate.

• What is the best way to clean the extruder nozzle?
The best way to clean the nozzle is with a nozzle-cleaning needles set. The extruder nozzle can be heated to melt the polymer, and the needle can be used to unclog the nozzle or wipe off the leaking polymer.

• What do I do if my thermoplastic sprays from the nozzle?
When spraying is observed during printing, stop the print and heat the nozzle to 250 degrees for 15 minutes. Then, unscrew the nozzle tip and use the threaded rod to manually extrude some molten polymer to push out air bubbles. Once you observe a smooth polymer flow, reassemble the components and resume printing.

• How can I best print 3D structures?
While printing structures with multiple layers, we recommend incorporating a pause between each layer in the G-code. For the first few layers, the pause can range between 45 to 60 seconds. As distance from the printbed increases, a longer time is needed. We recommend

increasing the pause time by 15 seconds for each layer after the first three layers.

- **Why is my material dripping out of the cartridge with no pressure?**
The weight of the plunger is enough to extrude low viscosity thermoplastics. Remove the plunger and/or switch the nozzle to a smaller diameter.

09
Maintenance

09 Maintenance

9.1 Post-printing instructions

- If enabled, turn off temperature regulation using the Utilities menu.
- Wait until the Thermoplastic Printhead cools down.
- Remove the air line from the printhead inlet.
- Remove the printhead from the system.

9.2 Long-term maintenance

- Regularly clean the printhead with a damp cloth to remove any dust or debris.

Appendix A: Consumables

Appendix A: Consumables

Table 2: Compatible nozzles.

PART NUMBER	TYPE	COLOR	INNER DIAMETER (MM)	LENGTH (INCHES)
000000020619	Metal nozzle	-	0.2	-
000000020620	Metal nozzle	-	0.3	-
000000020420	Metal nozzle	-	0.4	-
000000020621	Metal nozzle	-	0.6	-
000000020622	Metal nozzle	-	0.8	-

Table 3: Compatible cartridges and accessories.

PART NUMBER	DESCRIPTION	QUANTITY
000000020358	Thermoplastic cartridge	1
D16110021361	External air compressor	1

Support information

- Official site: **www.cellink.com**
- Contact: **support@cellink.com**
- Contact: **sales@cellink.com**
- Web store: **www.cellink.com/store**

Store

Sales

Official site

Support