Printing Advanced Medical Models

Supplementary User Guide
for the
J750 Digital Anatomy Printer

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Overview

This J750 Digital Anatomy printer brings life-like product reality to the medical industry. It offers specially blended materials with a unique combination of stiffness and flexibility. These characteristics make it ideal for producing biologically-similar parts, thereby significantly increasing the availability to practice medical procedures without limitation.

The unique software is a Voxel-based engine which generates micro-structures automatically. This allows you to apply complex, sophisticated structures to the inner layers of an object to achieve life-like look and feel of the model. You can simulate the softness of organic tissues, and toughness of bones, using the new materials:

- TissueMatrix™ MED310—
  For realistic simulation of soft anatomies, such as soft tissues, myocardium, soft organs, muscle and internal organs.
- BoneMatrix™ RGD516—
  For realistic simulation of bone-like models.
- GelMatrix™ FLG110—
  A gel-like support material used inside blood vessels and similar and enables easy removal without rupturing the blood vessel.

Figure 1: Structural hearts printed with TissueMatrix material[1]

This document describes the method for achieving the desired results with optimum quality and advanced mechanical properties when printing anatomical models.

1. The hearts shown in Figure 1 were colored with an orange dye as part of the post-processing performed on the models.

Supported Materials and Printing Modes

This solution can be used on Stratasys J750 Digital Anatomy printers only.

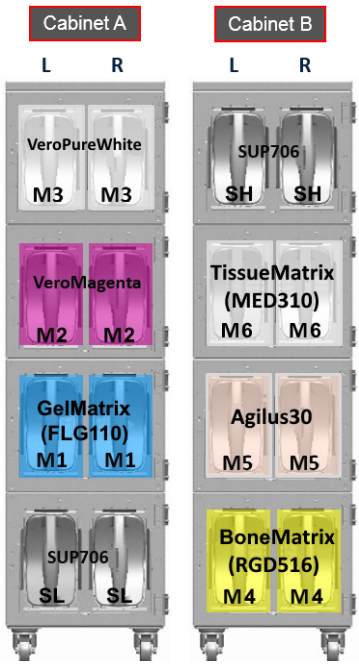
Anatomical Model	Material Type	Printing Mode	GrabCAD Print™	Support Material
Musculoskeletal (Bone)	• BoneMatrix • VeroPureWhite	• High Speed • High Mix	• Version 1.32 and above	• SUP706/B
Structural Heart	• TissueMatrix • Agilus30 Clear	• High Mix (High Quality and High Speed are not supported.)		
Blood vessel	• GelMatrix • Agilus30 Clear	• High Speed • High Mix		

Preparing for Printing

- Anatomical models use SUP706/B. SUP705 is not supported.
- For a better surface finish, prefer a matte finish.
- For increased strength when printing blood vessels, prefer a glossy finish.

- Whether printing bones, hearts, or blood vessels, always load the materials as follows in the material cabinet (the circled materials are required locations, the others are recommended):

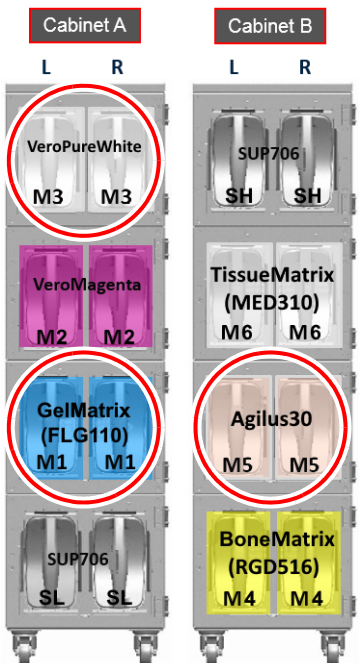
Figure 2: Material cabinet loaded for **all** anatomical models in High Mix mode



Note: The locations of the following materials are fixed:

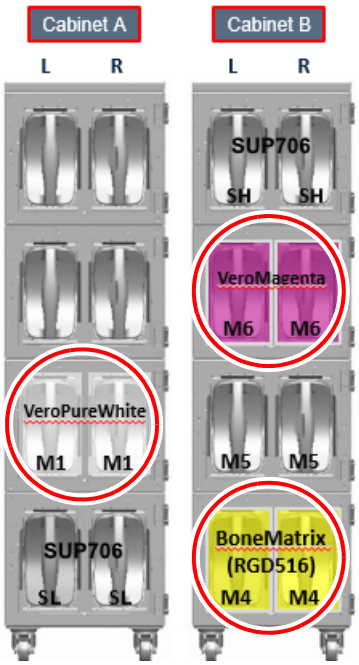
- GelMatrix
- BoneMatrix
- TissueMatrix

Figure 3: Material cabinet loaded for High Speed mode for blood vessels only



Note: The location of GelMatrix is fixed.

Figure 4: Material cabinet loaded for High Speed mode for bones only



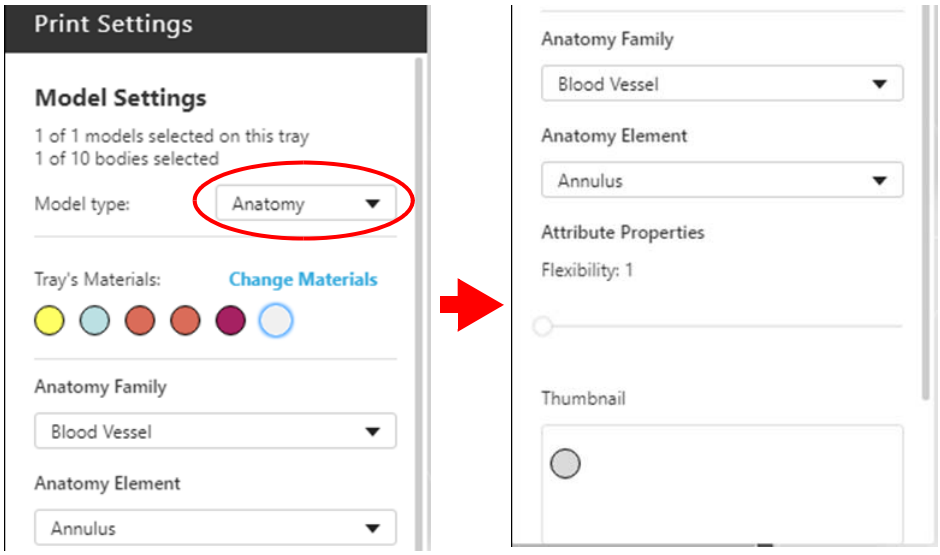
Printing with the Digital Anatomical Materials

This section describes the following topics:

Configuring GrabCAD Print

1. Open GrabCAD Print.
2. In the *Print Settings* dialog box, verify that **Anatomy** is selected from the *Model type* dropdown list to enable printing anatomical models.

Figure 5: *Print Settings* > *Model Settings* dialog box in GrabCAD Print.



3. Select an option from the *Anatomical Family* dropdown list, shown in Figure 5, and then select an option from the *Anatomy Element* dropdown lists.
4. Set the **Attribute Properties** (if available), and select an option under **Thumbnail** (Figure 5).

Using TissueMatrix MED310

- Must only be loaded in the M6 slots of the material cabinet.
- TissueMatrix is not printed alone. It is only used as a component (digital material) in different anatomies.
- For printing structural hearts and other soft tissues, use Agilus30Clear, TissueMatrix, and VeroPureWhite in High Mix mode.
- You can set different softness levels in GrabCAD Print.
- Standard grid is the default when using TissueMatrix.
- TissueMatrix is printed using only 1 UV lamp.
- If the printer stops for any reason for more than a very short time when printing soft anatomies, a liquid film may form on the top layer and will prevent the following layer from binding with it. Therefore, before resuming:

  a. Purge the print heads (press F4 on the printer keyboard) to warm them.

b. Remove the liquid film by wiping the top layer of the model with a fiberless cloth and ethanol.

c. Resume printing immediately.

- Surface ripple and color changes may appear in models printed with TissueMatrix after several months.
- TissueMatrix has a shelf life of 12 months.

Using BoneMatrix RGD516

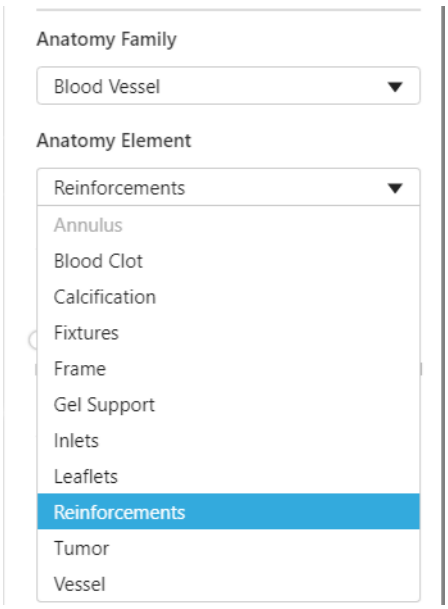
- Must only be loaded in the M4 slots of the material cabinet.
- For printing bone anatomies, use BoneMatrix and VeroPureWhite.
- BoneMatrix supports screw insertions, drilling, reaming, cutting, etc. without cracking.
- BoneMatrix is not printed alone. It is only used as a component (digital material) in different anatomies.
- Standard grid is the default when using BoneMatrix. You can also use Lite grid if needed.

Using GelMatrix FLG110

- Must only be loaded in the M1 slots of the material cabinet.
- For printing blood vessels, use GelMatrix with Agilus30 Clear and VeroPureWhite.
- GelMatrix is not printed alone. It is only used as a component (digital material) in different anatomies.
- GelMatrix, shown as Gel Support in GrabCAD Print, should only be used for supporting/filling thin, flexible tubes to enable cleaning with low water pressure. You can assign GelMatrix only after you insert a model into GrabCAD Print. Do not assign it as a general Support material.
- The maximum amount of GelMatrix (Gel Support) allowed per tray is 550g. This prevents the roller waste collector from overflowing. GrabCAD Print notifies you if the tray contains more than this amount.
- Wall thickness of blood vessels/tubes should not be less than 1mm.

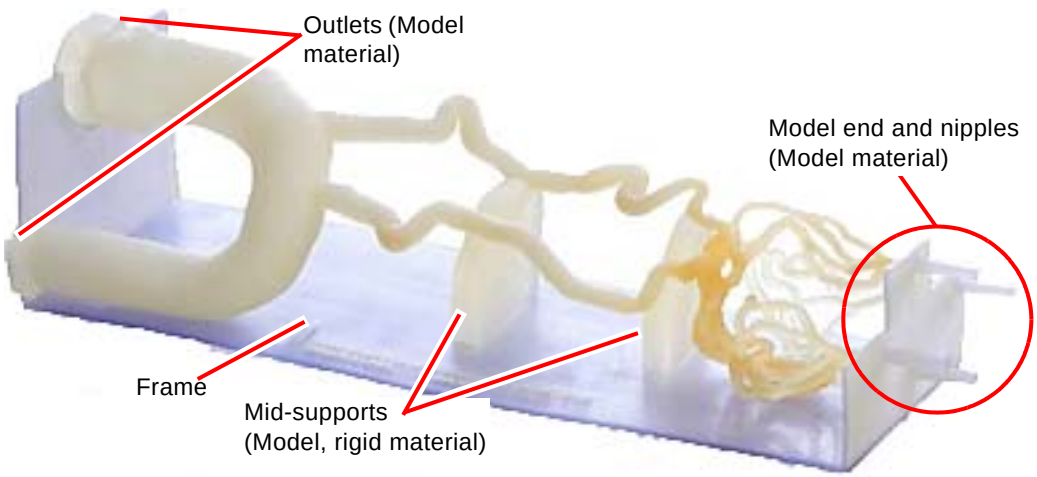
- When designing sharp curves, select **Reinforcements** from the *Anatomical Element* list in GrabCAD Print.

Figure 6: *Print Settings* > *Model Settings* dialog box in GrabCAD Print.



- To hold both ends of the blood vessels, design a frame with a base and supporting structures at both ends, as shown below. If the model is larger than half of the width of the build tray along the X-axis, add supports in the middle.
- To connect blood vessel models to the blood vessel cleaning apparatus (BVCA) tubes, design the blood vessels models with inlets (nipples), and large outlet openings to remove the gel. For more information, refer to the Technical Application Guide for Printing Advanced Anatomical Models.

Figure 7: Sample blood-vessel model with supporting frame showing end and mid-supports



Maintaining the Printer

To ensure optimum quality, follow these instructions:

- Clean the print heads before and after printing each job.

  The print head life is approximately 750 hours for print heads using TissueMatrix (print head H2-H3).

- GelMatrix (Gel Support) causes the roller waste collector to fill more quickly than other materials. Clean the roller waste collector as follows:
  - At least every 40 hours when printing in High Speed mode
  - At least every 80 hours when printing in High Mix mode
  - For optimal use, clean the roller waste collector after printing each tray containing GelMatrix.
- Clean the roller after every print job to prevent the accumulation of residue when printing with GelMatrix.
- In addition to the above, perform routine maintenance as described in the J750 User Guide.

Removing Support Material

You need to use different methods for removing the Support material, depending on the type of model you printed.

Removing Support Material from General and Bones Anatomical Models

- Do not apply consistent high pressure on parts that have elements that include soft, thin walled ligaments, such as discs, spinal cord, and facets.
- Bones do not have any restriction on cleaning.

Removing Support Material from Structural Heart Models

Proper handling and cleaning of structural heart models is required for best results.

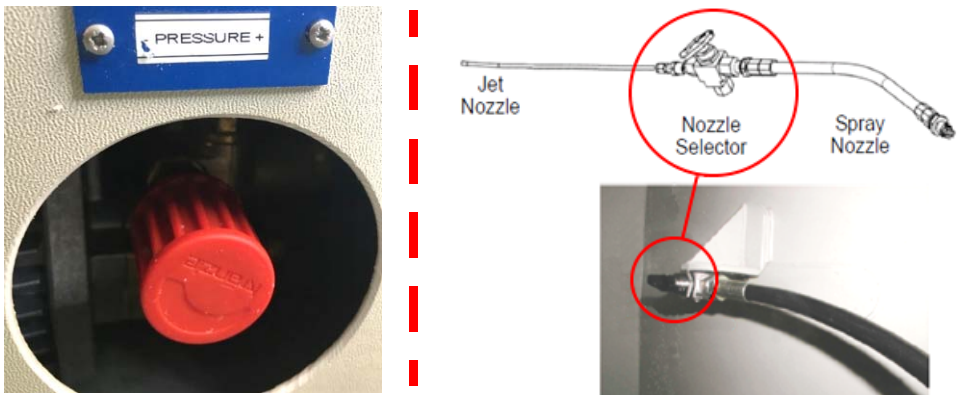
Important:

Structural heart models have thin walls and complex inner constructions that damage easily. Clean these models slowly and carefully.

1. Allow the model to cool down approximately 3 hours after printing before removing Support material.
2. Remove the large pieces of Support material manually.

3. Soak the model in a solution of 1-2% caustic soda for 1-2 hours, depending on the model.
4. Remove the remaining Support material as follows:
   a. Adjust the pressure regulator on the Balco WaterJet to approximately minimum pressure, and carefully clean the model using the spray nozzle.

Figure 8: Balco pressure regulator (20-120 bar) on back panel (Left), and nozzle selector in the washing chamber (Right)



   b. Then use the jet nozzle to remove the remaining Support material.

Important:

- Work slowly. If one of the heart chambers or tubes begins to expand due to the water pressure, stop cleaning, and drain the water from the chamber to prevent damaging the model. Continue cleaning only after the chamber or tube has drained.
- If necessary, try gently squeezing the heart chambers and tubes to break the Support material inside and push the Support material out of the openings in the model. Some of the models have fragile internal strings (‘chords’) holding the leaflets of the heart. Do not apply too much force squeezing the models. Try massaging the hearts to gently push the Support material out of the openings.

5. After the Support material is removed, clean the model carefully using either mild air pressure or running water.
6. Let the model dry. If needed, you can use mild air pressure to remove water from the model to decrease the drying time.

Removing Support Material from Blood Vessels

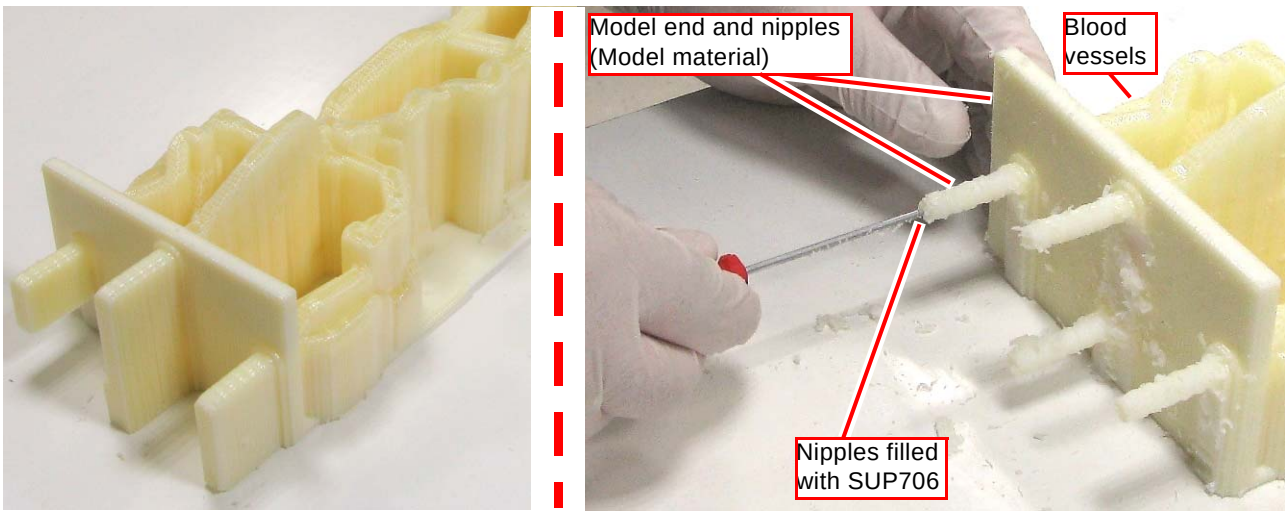
During printing, SUP706 and GelMatrix (if assigned) are used as Support material, and are applied to the model, as follows:

- The blood vessels are filled with GelMatrix.
- The nipples and blood-vessel outlets are filled with SUP706 to prevent the GelMatrix from exiting the model during printing.
- The surrounding support structure is made of SUP706.

Warning: Toxic and Corrosive Materials

Prolonged contact with resins could cause skin irritation. Wear protective gloves before continuing.

Figure 9: SUP706 around and under nipples (left) and after removal (right)



1. Allow the model to cool down approximately 3 hours after printing before removing Support material.
2. Fill the CSIIP cleaning station tank, and add the alkaline cleaning solution. For instructions, see the CSIIP CleanStation User Guide.

   The following step through step 12 (manual cleaning) are optional, and recommended for models with small-diameter tubes.

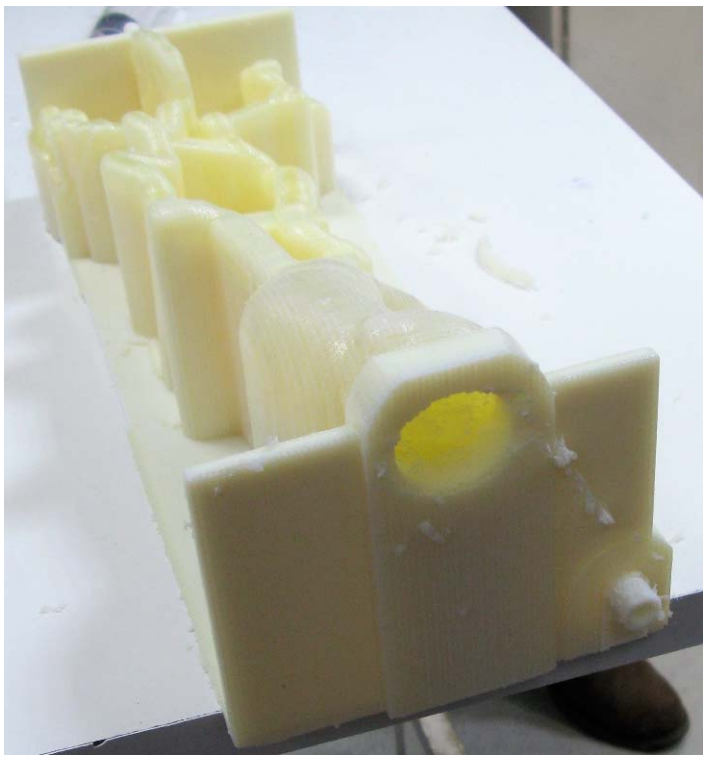
   If you want to perform automatic cleaning only, using the BVCA apparatus, continue with step 14 (page 16) below.

3. Using a small-tipped screwdriver, remove the SUP706 from under and around the nipples at the inlet-side of the blood-vessel model.

4. Using a small hex key, remove the SUP706 from inside the nipples and openings on both ends of the model, until you reach the gel.

Important:
Remove the SUP706 carefully, so as not to damage the blood vessels (see Figure 9).

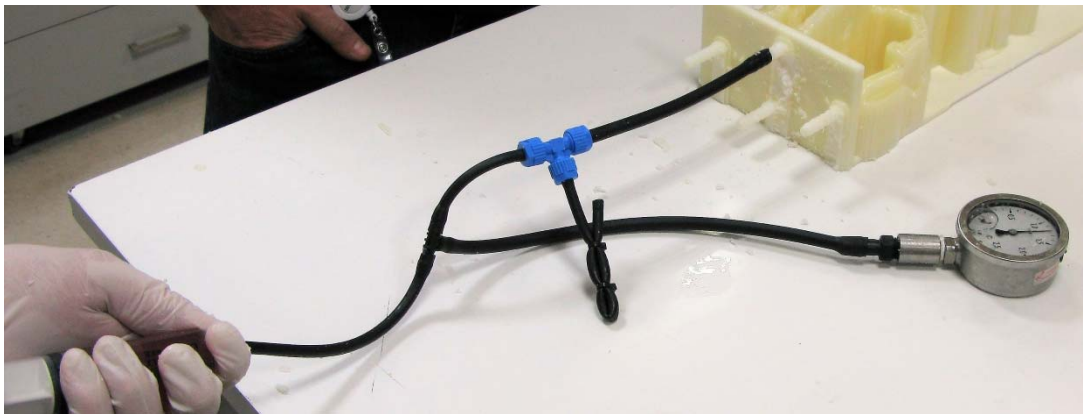
Figure 10: SUP706 removed from inside the blood-vessel outlets



5. Place the model on a table, with the blood-vessel outlets hanging slightly over the edge of the table.
6. Place a bucket or other container below the end of the model, to catch the gel and liquid that will exit the blood-vessel outlets.

7. Prepare 2 tubes with a T-fitting connecting them, and connect a 2-bar pressure gauge to the T-fitting with another tube.

Figure 11: T-fitting with pressure gauge



8. Fill a 50-cc syringe with dyed water (dye is optional, red is recommended), and connect it to the tube. The dye helps view if there are blockages in the tubes.
9. Connect the open end of the tube to a nipple on the model.
10. Press on the syringe until the gauge shows approximately 1 bar, and maintain this pressure.

Important:

The pressure you should use depends on the thickness of the blood-vessel walls:

- For 1.0–1.4 (<1/16 inch) mm wall thickness: do not exceed 1.0 bar
- For 1.5 mm (1/16 inch) wall thickness: do not exceed 1.5 bar.

Above these pressures you could rupture a blood vessel in the model.

The gel should begin exiting the model, and you should see the liquid moving through the blood vessels.

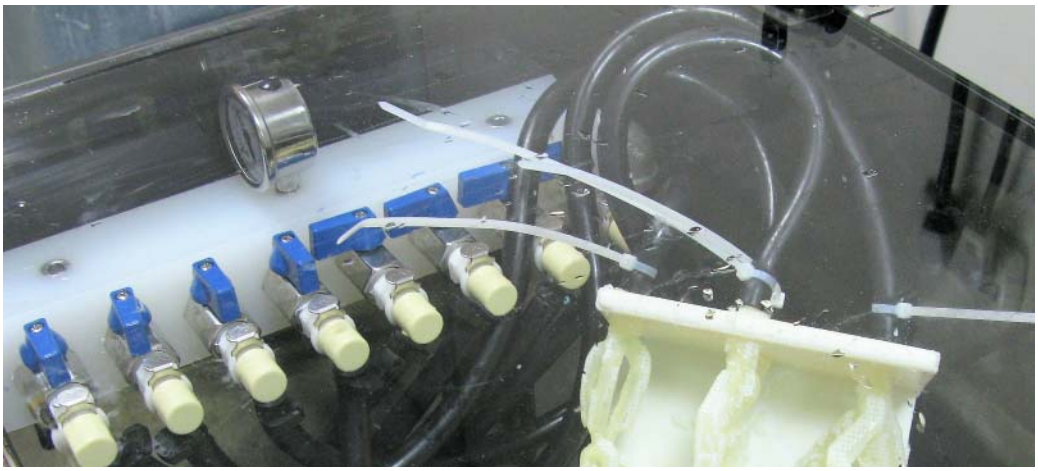
This will cause the pressure on the gauge to drop. Press harder on the syringe to maintain the pressure.

If the liquid does not flow, gently and carefully press or massage the blood vessels at the location of the blockage while applying pressure with the syringe.

11. Repeat the above step several times for each of the nipples on the model, until the liquid flows through each of the blood vessels freely with the syringe.
Remove the SUP706 from inside each nipple using a small hex key before connecting the syringe.
12. Gently squeeze the large tubes, at the end of the model where the fluid exits, and push as much of the remaining gel out of the large tubes as possible.
13. If you have a CSIIP cleaning station with the BVCA kit installed, continue with the steps below. If not, repeat the steps above until you have removed all of the gel from inside the tubes.

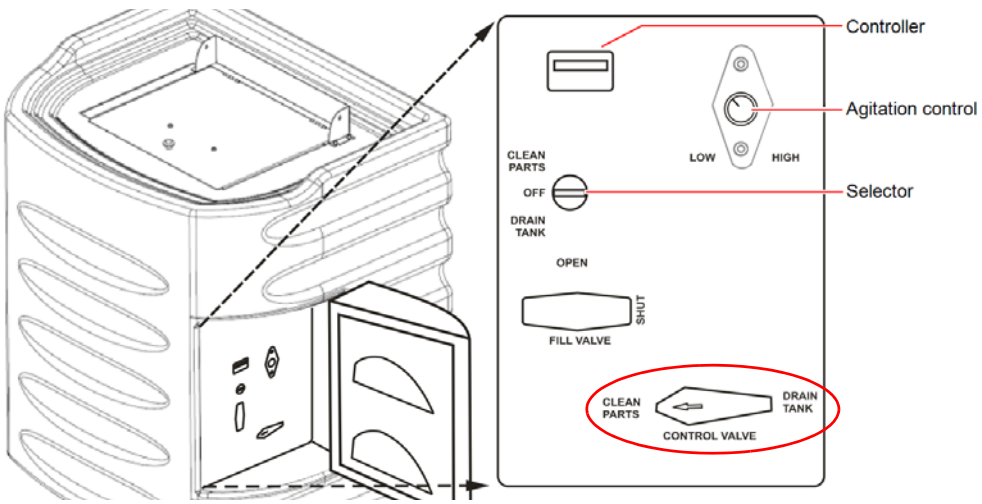
14. Insert the model into the CSIIP cleaning station with the BVCA kit installed, and connect tubes from the manifold to the nipples on the inlet side of the model.
    If the model is too large to lay flat at the bottom of the tank, position the model in the tank with the larger opening of the model facing down.

Figure 12: Model connected to tubes in CSIIP



15. Secure the tubes connected to the nipples with tie-wraps, as shown in Figure 12.
16. Close the valves on the manifold to the unconnected tubes.
17. Close the valves to the connected tubes half-way.
18. Close the BVCA safety cover.
19. On the CSIIP operator panel, set the Control Valve to CLEAN PARTS, and the Agitation control to LOW.

Figure 13: CSIIP CleanStation operator panel



20. Set the Selector switch to CLEAN PARTS.

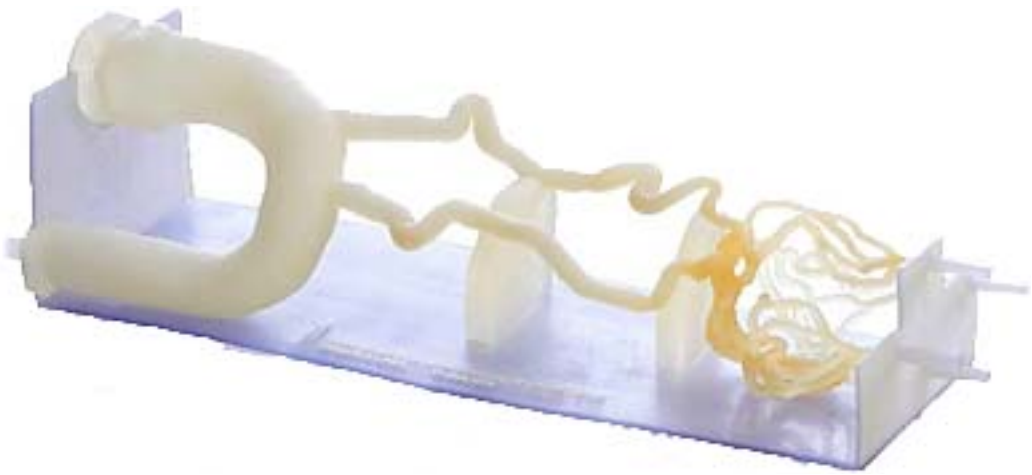
    The CSIIP cleaning station pumps the alkaline solution through the tubes into the model.

21. Verify that the alkaline solution is flowing out of the outlets of the model freely, and that the blood vessels are not swelling from the pressure.
22. On the CSIIP operator panel, set the selector switch to OFF.
23. Open the safety cover and open fully each of the valves connected to the model. Verify that the blood vessels do not swell.
24. Close the safety cover.
25. Turn the Agitation control to LOW.
26. Set the Selector switch to CLEAN PARTS.
27. Raise the Agitation control slowly to increase the pressure to HIGH.

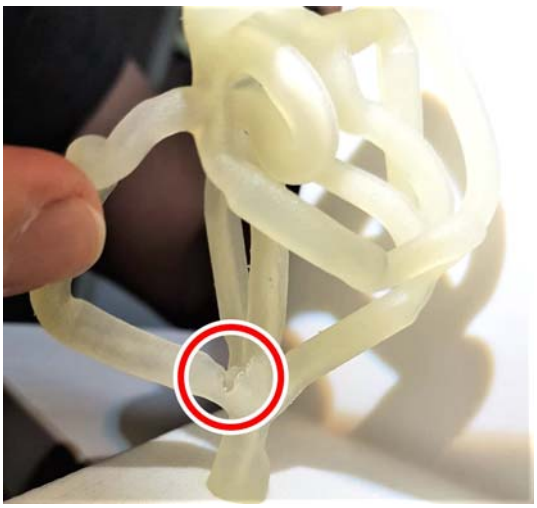
> The pressure on the gauge should only rise to 0.9 bar at HIGH. If the pressure rises above this, lower the Agitation control so that the pressure is 0.9 bar. You may need to calibrate the pressure (refer to the CSIIP CleanStation User Guide).

28. Verify that the alkaline solution is flowing freely through the model.
29. Set the timer on the CSIIP operator panel to 4 hours.
30. Verify the blood vessels are fully cleared from all gel afterwards.
31. Using a WaterJet, remove the model from the CSIIP cleaning station and rinse the outer surface of the model.
32. Gently spray water into the outlet openings to rinse the alkaline solution out of the tubes.
33. Using a WaterJet, remove the SUP706 from around the outside of the model, and under and around each of the blood vessels.

Figure 14: Support material around and under blood vessels removed



Repairing Models



If models are damaged while cleaning, you can glue the tears/holes using the following glues:

For rigid models:

- LOCTITE® 401 – medium viscosity
- PERMABOND® 792 – ultra fast cure time, general purpose
- Al-fix – comes with activator
- KLEIBERIT® 851.0 – with easy to use applicator cap

For flexible models:

- SICOMET® 8300 and High Speed Accelerator Spray – good for elastomers
- PERMABOND® 737 for flexible parts

For more information, refer to the Application Note on Gluing PolyJet Parts.

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