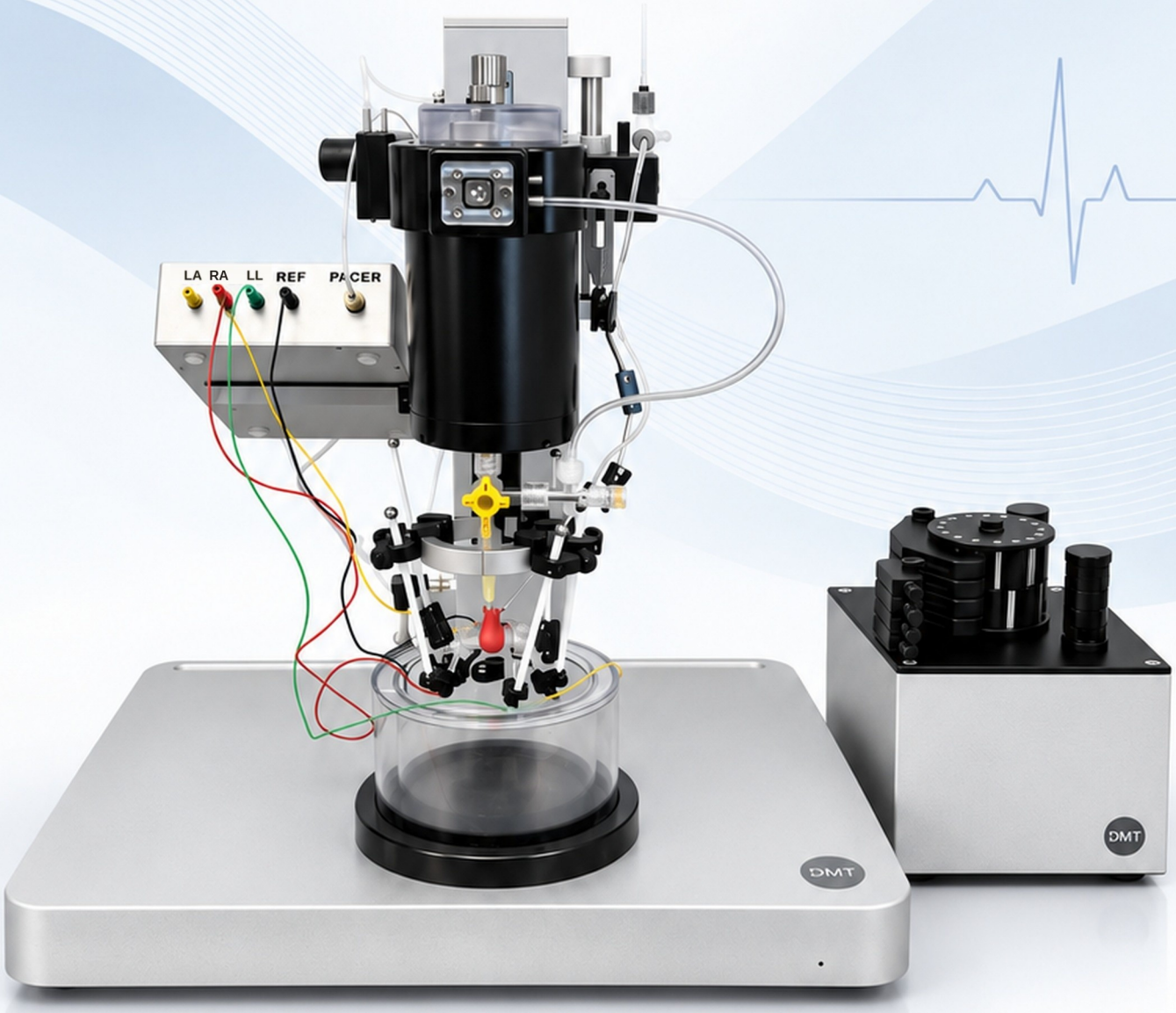
Danish Myo Technology A/S

LANGENDORFF SYSTEM

Model 900L

USER MANUAL



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Disclaimer

Every effort has been made to ensure the accuracy of this manual at the time of release. However, hardware, software, and product specifications may change without notice. Updated information may be provided separately.

Document Information

Product	Langendorff System
Model	900L
Manufacturer	Danish Myo Technology A/S
Address	Rho 14, 8382 Hinnerup, Denmark
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This manual describes the installation, operation, maintenance and calibration of the DMT Langendorff System, Model 900L. Keep the manual available for reference throughout the service life of the system.

Safety Information

Intended Use

The DMT Langendorff System, Model 900L, is designed for isolated perfusion of mouse and rat hearts in laboratory research. It supports constant-pressure and pump-controlled constant-flow perfusion. Depending on configuration, optional functions include left ventricular pressure (LVP), ECG, and electrical pacing.

FOR LABORATORY RESEARCH USE ONLY. NOT FOR HUMAN OR VETERINARY CLINICAL USE.

General Safety Precautions

- Only trained laboratory personnel should operate the system.
- Prime the entire fluid path and confirm that it is free of air bubbles before connecting a heart.
- Monitor aortic pressure throughout operation, especially in Constant Flow mode.
- Start constant-flow operation at a low pump setting and increase gradually while monitoring pressure.
- Avoid contact with heated liquids and components; prevent liquid ingress into electrical connectors.
- Follow DMT instructions for cleaning, maintenance and calibration.
- Follow institutional laboratory safety and animal-research requirements.

WARNING — In Constant Flow mode, increased coronary resistance may cause a rapid pressure rise. DMT identifies a 300 mmHg pressure transducer limit; this is NOT an acceptable operating target. Prevent excessive pressure and stop operation if pressure rises unexpectedly.

Safety Notices

WARNING	Potential risk of personal injury.
CAUTION	Potential equipment damage or harm to the experimental preparation.
NOTE	Additional information for correct operation.

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Chapter 1 – Introduction

1.1 About the Langendorff System

The DMT Langendorff System – Model 900L is designed for the perfusion and functional assessment of isolated mouse and rat hearts under controlled laboratory conditions.

Using the Langendorff technique, researchers perfuse the isolated heart retrogradely through the aorta, allowing them to study cardiac function independently of systemic circulation and external physiological influences.

The system controls perfusion conditions and measures key cardiac parameters, making it suitable for cardiovascular physiology, pharmacology, and preclinical research.

1.2 System Features

The 900L system offers the following capabilities:

- **Constant-pressure perfusion:** Maintains a selected perfusion pressure while coronary flow varies according to vascular resistance.
- **Constant-flow perfusion:** Delivers a selected flow rate using a peristaltic pump while perfusion pressure varies according to coronary resistance.
- **Temperature control:** Controls the temperature of the perfusion solution and heart chamber.
- **Aortic pressure monitoring:** Provides continuous measurement of perfusion pressure.
- **Left ventricular pressure (optional):** Enables assessment of ventricular contractile function using an intraventricular balloon.
- **ECG recording (optional):** Enables monitoring of the heart's electrical activity.
- **Electrical pacing (optional):** Allows controlled stimulation of the isolated heart.
- **Data acquisition:** Supports recording and analysis of experimental parameters through compatible acquisition software and interfaces.

System capabilities depend on the installed configuration and optional accessories.

1.3 Applications

The Langendorff System is suitable for a range of experimental applications, including:

- Cardiac contractility and ventricular function
- Coronary vascular function and resistance
- Ischemia and reperfusion studies
- Cardiac electrophysiology and arrhythmia research
- Pharmacological evaluation of cardiac responses
- Investigation of cardiovascular disease mechanisms

The system is intended exclusively for laboratory research and is not designed for clinical or diagnostic use.

1.4 About This Manual

This manual provides information for installation, operation, and routine maintenance of the DMT Langendorff System – Model 900L.

It includes instructions for system setup, perfusion control, heart mounting, experimental measurements, data acquisition, cleaning, maintenance, and calibration.

Users should familiarize themselves with system components, safety precautions, and operating procedures before performing experiments.

For technical assistance, please contact Danish Myo Technology A/S or your authorized DMT representative.

1.5 Related Documentation

The following companion documents provide experimental examples and additional scientific background. They do not replace the 900L operating and safety instructions.

AN-900L-01 — Isolated Heart Preparation and Mounting

AN-900L-02 — Perfusion Buffers and Reagents

AN-900L-03 — Manual Coronary Flow Measurement

Chapter 2 – Unpacking and System Setup

2.1 Unpacking and Inspection

Inspect the new 900L system for damage from handling and shipping before you set anything up.

1. Check the packaging and the system for damage. If you suspect damage, contact DMT immediately.
2. If the packing material is damaged, keep it until any claim has been settled.
3. Check the contents against the packing list and the products you ordered. If anything is missing, contact your DMT sales representative.
4. Keep the packing material for future transport. If the original material is gone, contact the DMT Sales Department for packing advice.

2.2 System Overview

A complete setup consists of the 900L system, a computer running MyoHEART, a carbogen supply, a vacuum source with a waste bottle, the peristaltic pump and a water bath for the perfusion buffer. Optional data-acquisition equipment connects to the analog BNC outputs (Chapter 7).

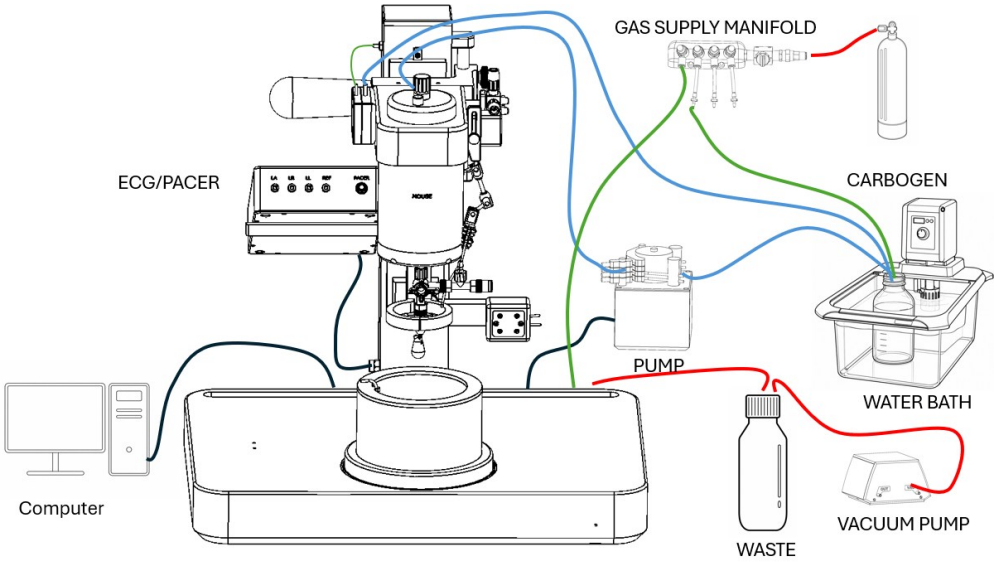


Figure 2.1 – Typical 900L setup with computer, gas supply, pump, water bath and vacuum. Black; cords, Blue: buffer tubings, Green: Carbogen gas lines, red: Vacuum tubings

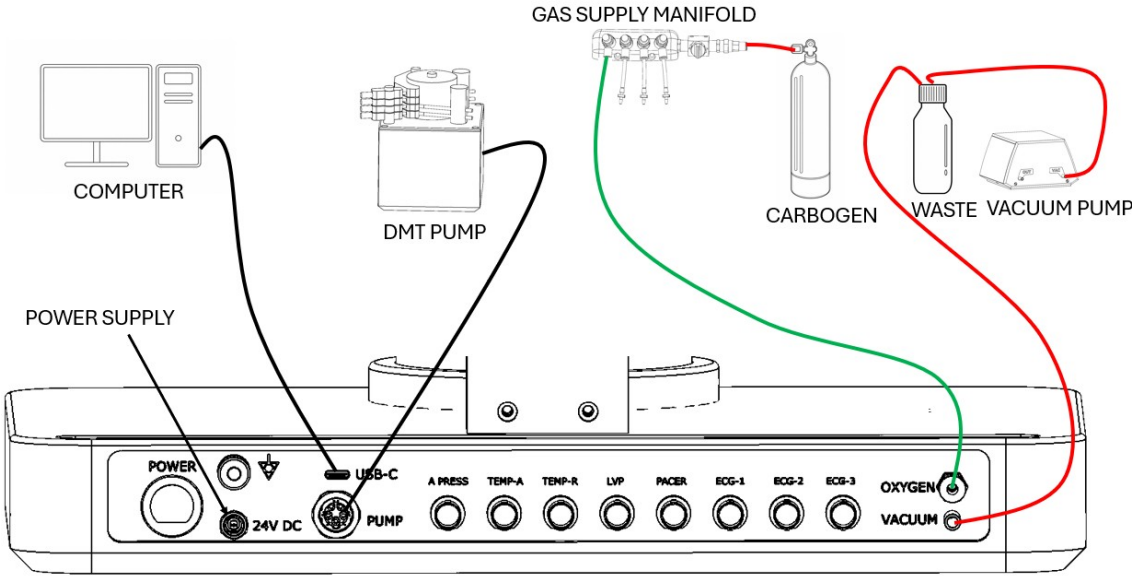


Figure 2.2 – Connections on the back of the 900L: power, USB-C, pump, oxygen and vacuum.

2.3 Positioning the Tower

The 900L ships with the tower tilted horizontally. Turn it upright and fix it before first use.

1. Pull the tower slightly and turn it to the vertical position (Figure 2.3).
2. Secure the cover plate to the tower with the four screws (Figure 2.4).
3. Place the 900L near the dissection area, with the water bath for pre-warming the perfusion buffer close by.

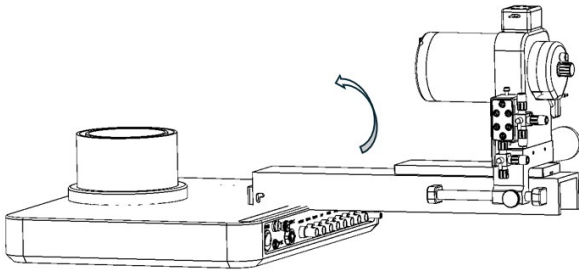


Figure 2.3 – Tower in the shipping (horizontal) position.

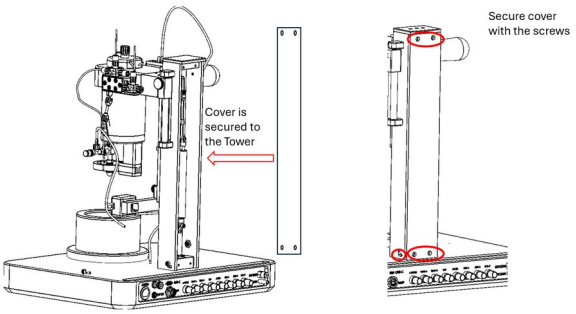


Figure 2.4 – Cover plate secured with four screws.

CAUTION Support the tower while you turn it upright. Keep your fingers clear of the hinge.

2.4 Connecting Gas, Power, Computer and Vacuum

Gas supply

1. Connect the carbogen source to the 4-channel Gas Supply Manifold (#300295) with the supplied fittings and tubing.
2. Connect one manifold line to the main pressure inlet marked **OXYGEN** on the 900L (Figure 2.5).
3. Use another manifold line to gas the perfusion buffer in the water bath.
4. Set the supply pressure between **0.5 bar and 2.0 bar** (maximum).

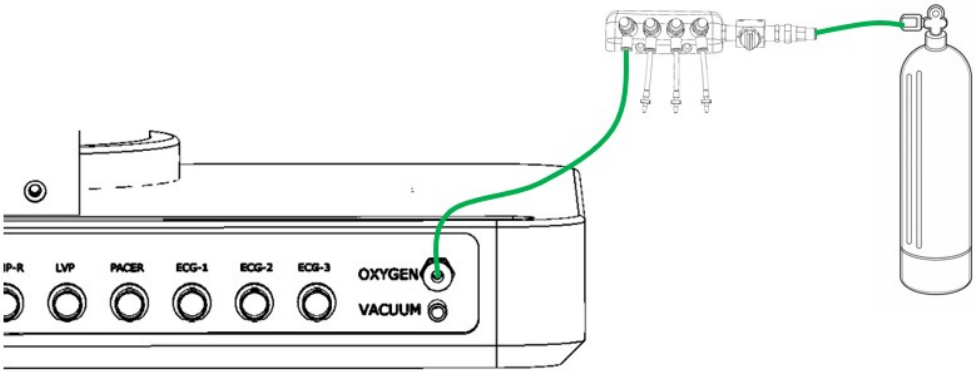


Figure 2.5 – Carbogen supply through the gas manifold to the OXYGEN inlet.

WARNING Carbogen is oxygen-enriched (95% O_2, 5% CO_2). Secure gas cylinders upright, use a regulator, keep oil, grease and open flames away from the fittings, and use the system in a ventilated room.

Power and computer

1. Connect the power supply to the power plug on the back of the 900L.
2. Connect the computer to the 900L with the supplied USB-C cable.

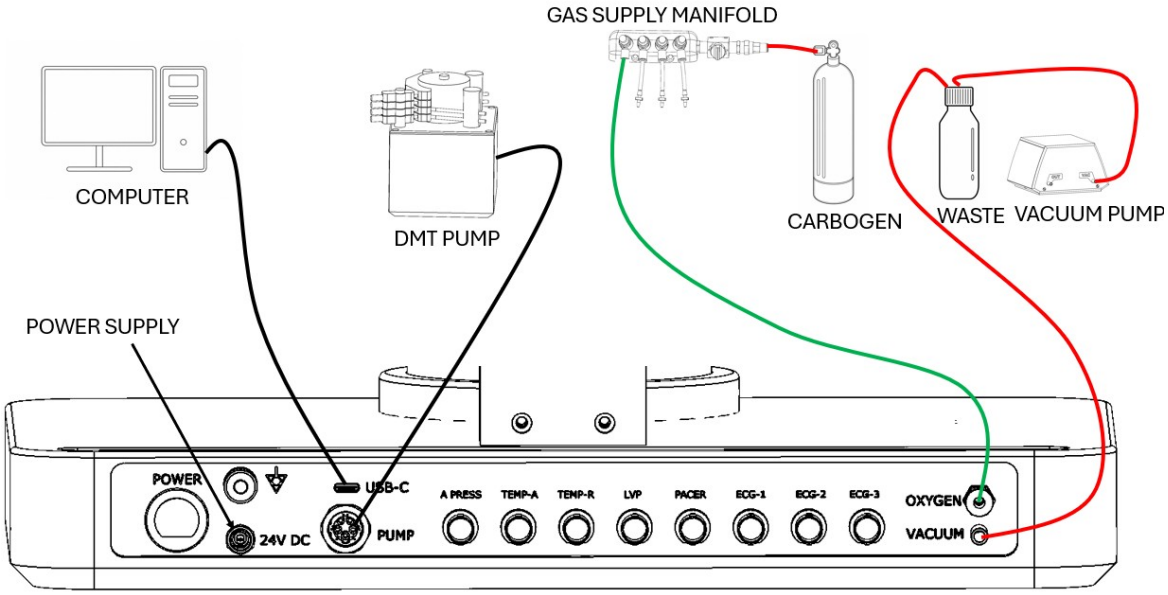


Figure 2.6 – Power, USB-C, pump, gas and vacuum connections.

Vacuum

1. Connect a vacuum source to the vacuum pipe of the 900L. Place a vacuum trap (the 5 L waste bottle) between the vacuum source and the 900L.
2. The DMT Vacuum package contains the pump, the 5 L waste bottle and all fittings.

The vacuum empties the reservoir and the double-jacketed chamber, and prevents overflow of the reservoir in the submerged heart configuration. Keep the waste bottle empty before each experiment.

2.5 Reservoir Rings and Covers

1. Push the two reservoir rings to the bottom of the reservoir holder (Figure 2.7). Together they form the double-jacketed reservoir.

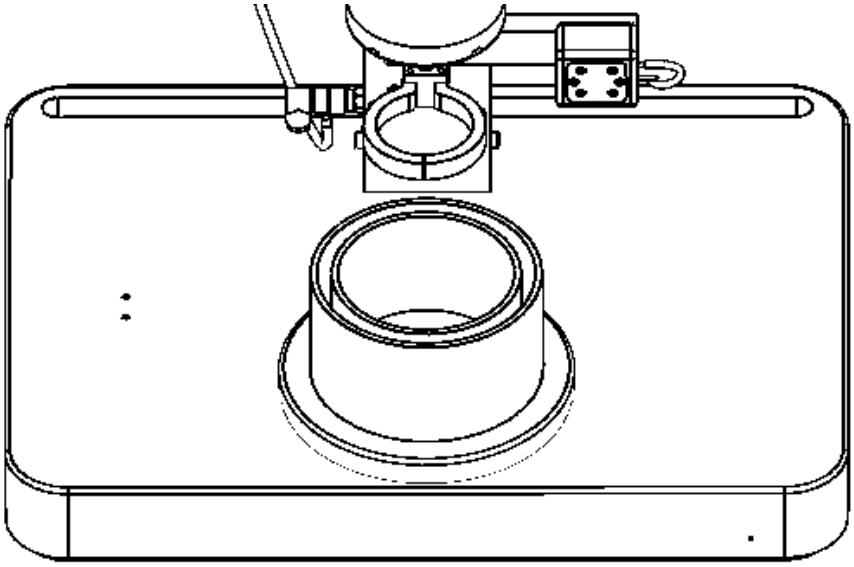


Figure 2.7 – Reservoir rings pushed to the bottom of the reservoir holder.

The 900L runs with the heart submerged in heated buffer or free-hanging. Choose the cover that matches:

Configuration	Cover and notes
Submerged	Cover for the two reservoir rings with an overflow pipe. It reduces heat loss, blocks access to the double-jacketed compartment, and the overflow pipe prevents the reservoir from overflowing. Connect the overflow pipe in the cover to the overflow pipe in the base of the reservoir (Figure 2.8). Required for ECG recording.
Free-hanging	Two-part cover with slits for the LVP catheter and the pacer electrode (Figure 2.9). It is mandatory: it keeps the air in the reservoir at 37 °C. ECG recording is not possible.

NOTE ECG recording requires the submerged configuration with the cover on the double-jacketed compartment. It cannot be done free-hanging.

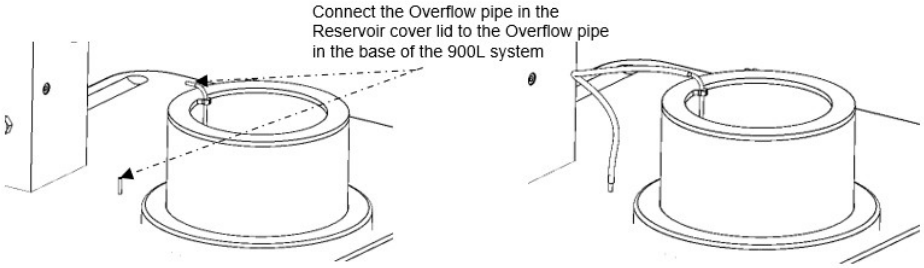


Figure 2.8 – Connect the overflow pipe in the reservoir cover to the overflow pipe in the reservoir base.

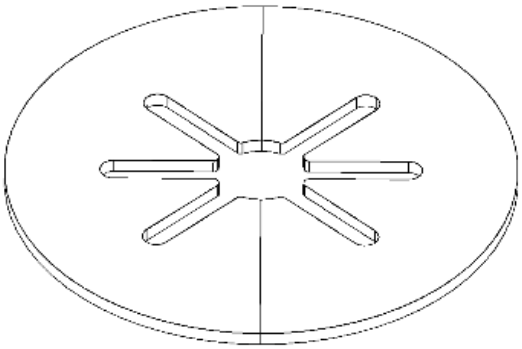


Figure 2.9 – Two-part cover for the free-hanging configuration, with slits for the LVP catheter and pacer electrode.

2.6 Stopcock and Compliance Unit

1. Connect the stopcock unit to the Luer lock of the compliance unit (bubble trap) (Figure 2.10).
2. Connect the tubing from the aortic pressure transducer housing to the stopcock unit.

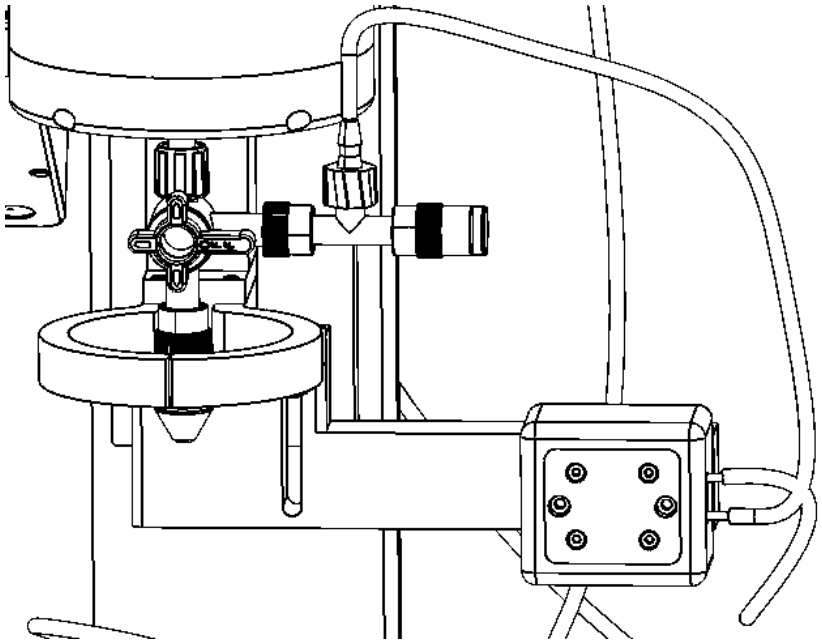


Figure 2.10 – stopcock unit on the compliance unit, with tubing to the aortic pressure transducer housing.

Stopcock positions A to D, used in Chapters 3, 8 and 9, are defined in Section 3.4.

2.7 Peristaltic Pump and Tubing

1. Connect the DMT peristaltic pump to the connector labeled **Pump** on the back of the 900L.
2. Connect the airtight outlet tubing from the pump to the perfusion-buffer inlet pipe of the compliance unit (Figure 2.11).
3. Connect a 3 mm silicone tube to the overflow pipe of the pressure regulator (Figure 2.12). Place the other end in the perfusion-buffer flask to save buffer in Constant Pressure mode, or in a waste bottle if recirculation is not wanted.
4. **Optional recirculation:** connect the vacuum pipe to the pump tubing that returns to the buffer bottle in the water bath. Open the reservoir drain valve in MyoHEART.

> **NOTE** A peristaltic pump from another supplier cannot be controlled from MyoHEART. You must control it on the pump itself.

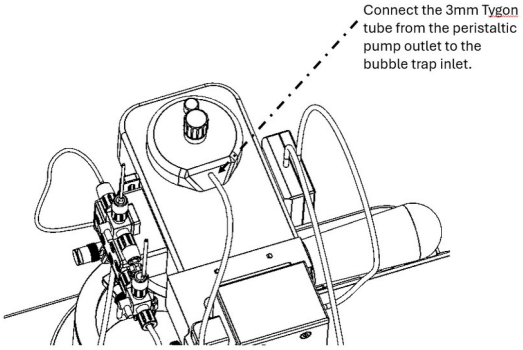


Figure 2.11 – Pump outlet tubing connected to the bubble trap inlet.

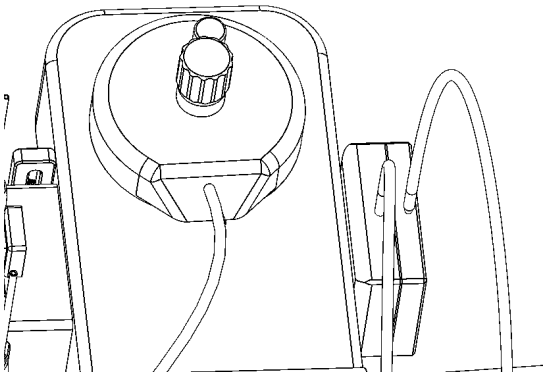


Figure 2.12 – Overflow pipe of the pressure regulator.

2.8 Software and First Power-On

1. Install MyoHEART on the computer. Without a license code MyoHEART works only as the 900L controller. To use it for data acquisition, enter a license code.
2. Switch on the 900L with the power switch on the right-hand side of the back panel.
3. Start MyoHEART. With a data-acquisition license it searches for the 900L and shows the screen in Figure 2.13.
4. Without a license, the start-up screen looks like Figure 2.14.

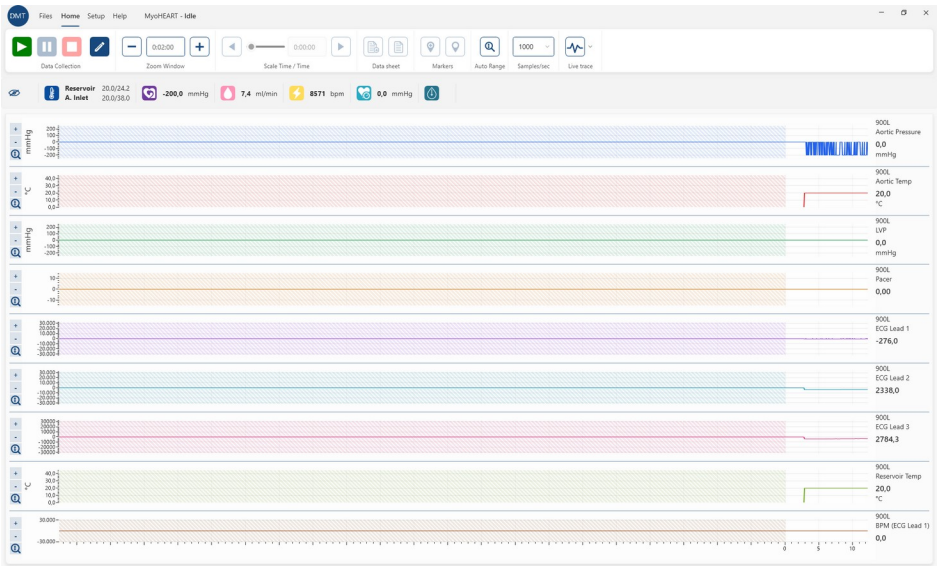


Figure 2.13 – MyoHEART with data acquisition after it has found the 900L.

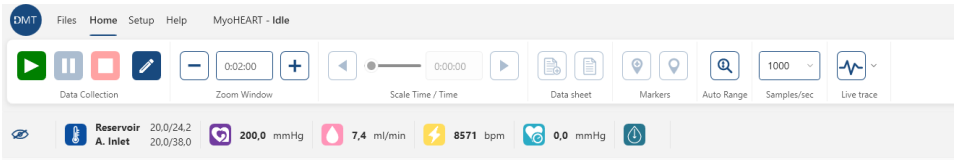


Figure 2.14 – MyoHEART running as controller only (no data-acquisition license).

If MyoHEART does not find the 900L

MyoHEART shows the screen in Figure 2.15. Check the following in order:

1. The 900L is switched on and the USB-C cable is plugged in at both ends.
2. Restart MyoHEART.
3. If the 900L is still not found, check that the 900L and computer are connected with the supplied USB-C cable.

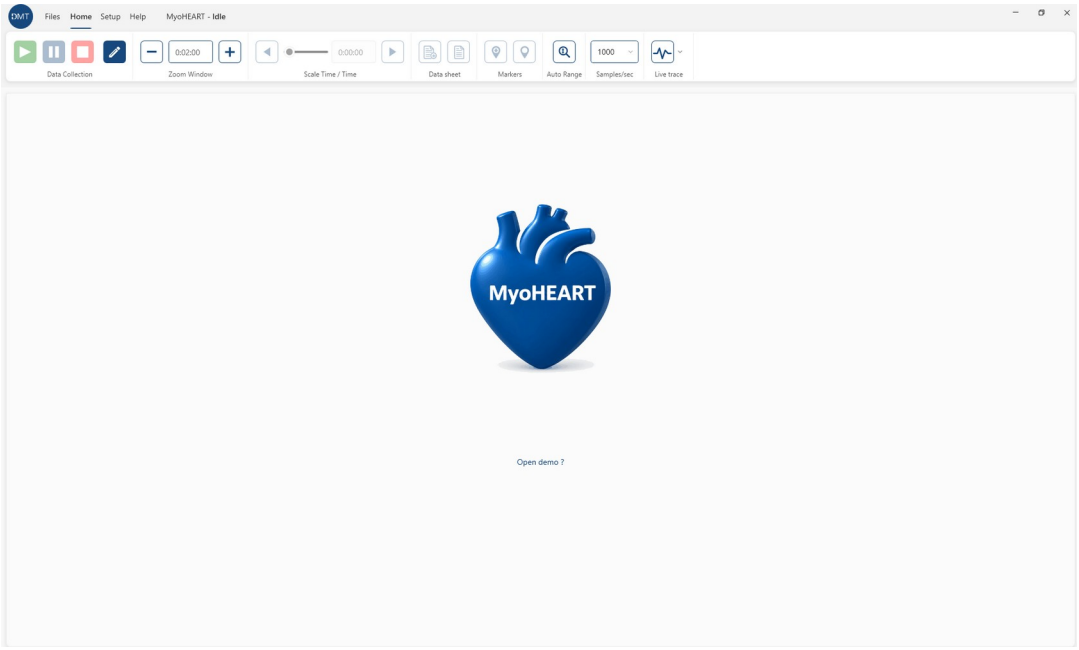


Figure 2.15 – MyoHEART when the 900L is not found.

2.9 Setup Checklist

- ☐ Tower upright, cover plate screwed on.
- ☐ Carbogen connected, supply set to 0.5–2.0 bar.
- ☐ Power, USB-C and pump connected.
- ☐ Vacuum connected, waste bottle empty.
- ☐ Reservoir rings seated, correct cover for the configuration.
- ☐ Stopcock and compliance unit connected.
- ☐ Pump outlet and overflow tubing connected.
- ☐ MyoHEART installed and finds the 900L.

Chapter 3 – Starting Up the System

3.1 Before You Start

This chapter takes the 900L from switched off to primed, heated and ready for a heart. Follow it in the order shown on every experiment day. Installation is covered in Chapter 2, perfusion modes in Chapter 4, mounting in Chapter 5 and the calibration procedures in Chapter 9.

Have ready

- Perfusion buffer, prepared and bubbled with carbogen (recipes are in application note AN-900L-02). Mouse hearts use about 1 L per experiment. Rat hearts use about 2–4 L, depending on how long the experiment lasts.
- Water bath (DMT #400738 or #400740) and a 1 L bottle with about 200 mL distilled water for the reservoir jacket.
- Pump tubing set for the species and mode (Section 3.4).
- The supplied manometer and the 1.5 mm aortic cannula, for the aortic transducer calibration.
- An empty beaker and a balance, for the pump calibration.
- A waste bottle for the overflow tube if buffer is not recirculated. Vacuum pump on and vacuum waste bottle empty.

Start-up sequence

The order matters. Heating takes the longest, so it starts first. The aortic transducer and the pump are calibrated after priming, with a primed system.

#	Action	Section	Why in this order
1	Switch on the 900L and start MyoHEART	3.2	Everything below is controlled from MyoHEART.
2	Start heating	3.3	Heating takes longest. Work on the next steps while it warms up.
3	Fit the pump tubing and check the pump direction	3.4	Needed for priming and pump calibration.
4	Prepare and calibrate the LVP transducer (if fitted)	6.1, 9.3	Independent of priming. Can be done while heating.
5	Prime the system	3.5	Start when the set temperatures have been reached.
6	Calibrate the aortic pressure transducer	9.2	Needs a primed system without air bubbles.
7	Calibrate the pump	9.4	Needs a primed system and the fitted tubing set.
8	Set mode, lid and starting values	3.6, Ch. 4	Match the mode to the experiment.
9	Connect the mounting tube extension	3.7	Keeps the line warm and free of air until mounting.
10	Complete the ready-for-experiment checklist	3.8	Do not mount a heart until every item is ticked.

> **NOTE** Always calibrate the aortic pressure transducer, the pump and the LVP transducer (if used) before an experiment.

3.2 Switching On

1. Check that the carbogen supply is open, that the inlet pressure is between 0.5 bar and 2.0 bar, and that the power and USB-C cables are connected.
2. Switch on the 900L with the power switch on the right-hand side of the rear panel.
3. Start MyoHEART and confirm that the 900L is detected (Chapter 2).
4. Open the Setup menu, click the 900L device to open the 900L settings and select **Constant Pressure**. Always use Constant Pressure mode when priming.

5. Check that the compliance-unit lid is in the Constant Pressure position (Figure 4.1).

> **NOTE** A continuous buzzing tone means that the gas inlet pressure is too low. Check the regulator, tubing and connections. The inlet pressure must be 0.5 bar to 2.0 bar.

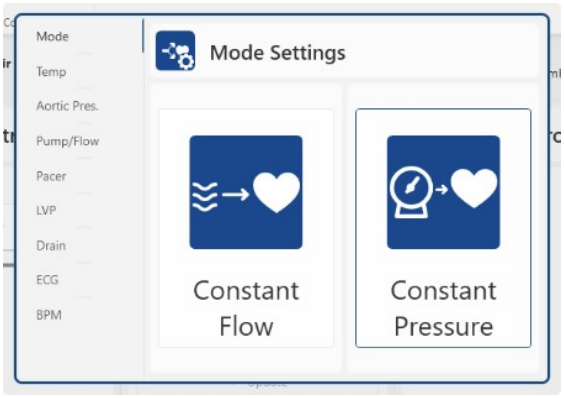


Figure 3.1 – Mode Settings with Constant Pressure selected.

3.3 Heating the System and the Buffer

The heating procedure is the same in both modes. The 900L heats two things: the perfusion buffer on its way into the heart (the aortic inlet temperature) and the water in the reservoir jacket, which keeps the heart chamber at temperature.

Prepare the water bath

1. Switch on the water bath at 37 °C, or at the temperature your experiment requires.
2. Place the container with perfusion buffer in the bath and bubble it with carbogen.
3. Place a 1 L bottle with about 200 mL distilled water in the bath for pre-heating.

Set the temperatures

1. In MyoHEART, open Temperature Control and set the Aortic Inlet and Reservoir temperatures.
2. Switch heating **ON** for both.
3. Press the settings icon to open Temperature Settings. Leave both offsets at 0.0 °C for now.

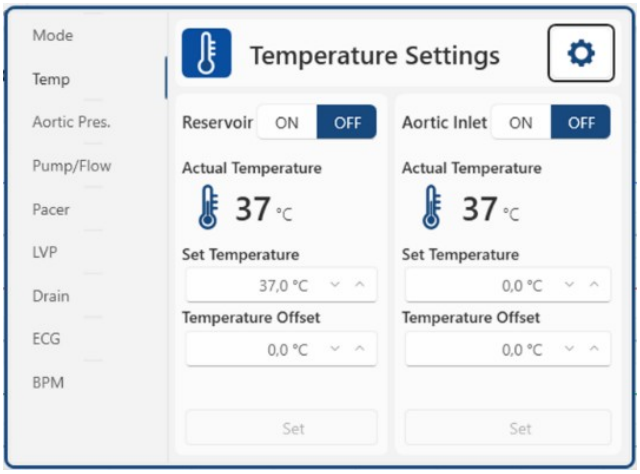


Figure 3.2 – Temperature Settings: heater switches, set temperatures and offsets.

Choose the reservoir configuration

	Submerged (recommended)	Free-hanging
Heart	Hangs in about 300–350 mL of preheated buffer	Hangs in the heated, empty reservoir
Temperature	Very stable	Depends on the cover and the air temperature

	Submerged (recommended)	Free-hanging
Cover	Double-jacket cover lid with overflow pipe	Two-part cover with slits for the LVP catheter and the pacer electrode. The cover is mandatory.
ECG recording	Possible	Not possible
Before lowering the heart	Switch on the overflow drain	Fit the cover

Fill the reservoir jacket

1. When the water in the bath has reached the set temperature, pour about 150 mL of the preheated distilled water into the space between the two reservoir rings (Figure 3.3).
2. Check that Reservoir heating is ON.
3. Fit the cover for your configuration.

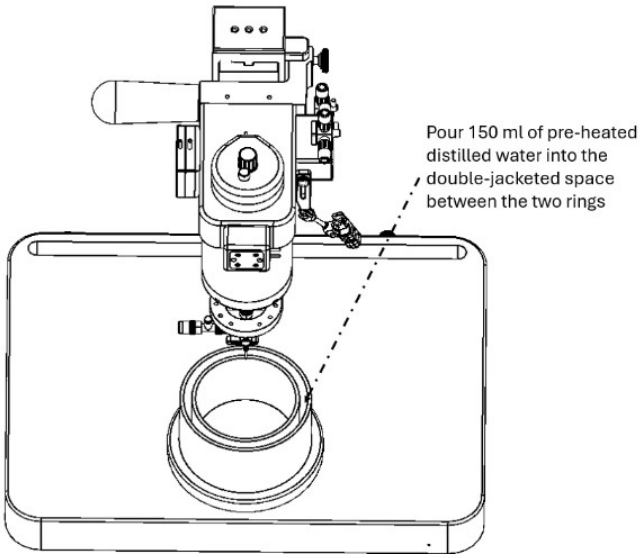


Figure 3.3 – Pour preheated distilled water into the space between the two reservoir rings.

Submerged heart

1. Add about 300–350 mL of preheated perfusion buffer to the reservoir, or enough to reach the overflow pipe of the cover.
2. Wait about 15 min, then measure the buffer temperature in the reservoir with a thermometer.
3. If the reading differs from the set Reservoir temperature, enter the difference as the Reservoir offset. Example: set 37.0 °C and measured 36.0 °C: enter an offset of +1.0 °C.
4. After about 15 min, measure again and adjust if needed.

CAUTION Before you lower a mounted heart into the buffer, switch on the **Overflow** drain in the Drain Control menu (Figure 3.4). Otherwise the buffer can overflow the reservoir.

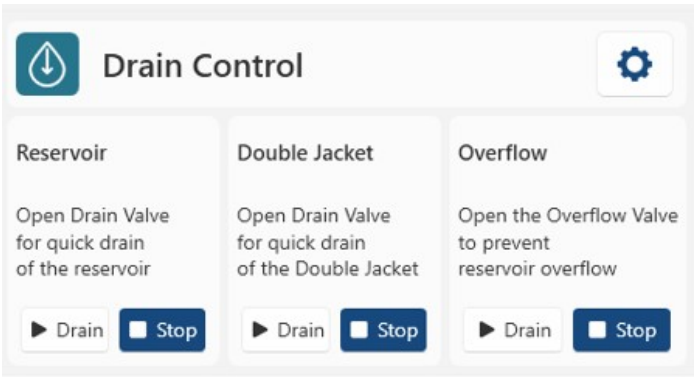


Figure 3.4 – Drain Control menu.

Free-hanging heart

1. Fit the two-part cover on the reservoir.
2. Wait about 15 min. Insert a thermometer made for measuring **air** through the cover, wait 2 min and read the temperature.
3. If the reading differs from the set Reservoir temperature, enter the difference as the Reservoir offset. Example: set 37.0 °C and measured 36.0 °C: enter +1.0 °C.
4. After about 15 min, measure again to confirm.

> **NOTE** Air temperature can only be measured reliably without turbulence around the system. Use a thermometer that is suitable for air, not only for liquids.

About offsets

- The **Aortic Inlet offset** is 0.0 °C by default, because the aortic heater keeps the buffer at the set temperature. Example: set 37.0 °C and offset 0.5 °C: the buffer is warmed to 37.5 °C.
- The **Reservoir offset** compensates for heat lost between the jacket water and the heart chamber. In the example above (+1.0 °C), the jacket water is heated to 38.0 °C so that the chamber reaches 37.0 °C.

3.4 Pump Tubing and Pump Settings

Use the tubing set that matches the perfusion mode and the species.

Part no.	Mode	Species
100342	Constant Flow	Rat
100378	Constant Flow	Mouse
100387	Constant Pressure	Mouse
100388	Constant Pressure	Rat

1. Fit the tubing set in the pump head. The DMT pump is a low-pulsation pump with shifted rollers. Fit the double tubing in positions 1 and 3, or in positions 2 and 4. Never use positions 1 and 2, or 3 and 4 (Figure 3.6)
2. Engage the compression arms before use.
3. In MyoHEART, open Pump Settings and check that the pump direction is Clockwise (Figure 3.5).
4. Put the pump inlet tubes into the preheated perfusion buffer (1 L to 5 L, in the water bath, bubbled with carbogen).
5. Put the overflow tube from the pressure regulator unit back into the buffer container to save buffer. If the buffer must not be recirculated, put the tube in a waste bottle.
6. After use, release the compression arms to extend the life of the tubing.

NOTE The delivered flow depends on the setting of the finger screws on the compression arms and on how long the tubing set has been in use. Calibrate the pump with the fitted tubing set before each day of use (Section 9.4). DMT recommends replacing the tubing set after 5 days of use (about 40 hours), even if the flow check passes.

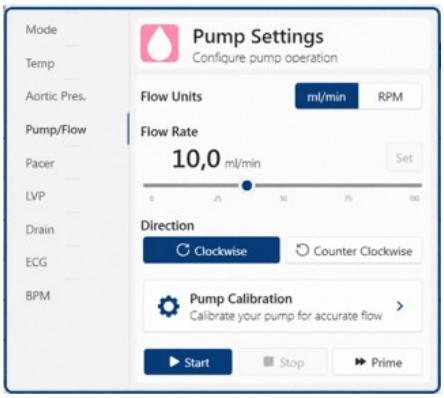


Figure 3.5 – Pump Settings: flow units, direction and pump calibration.

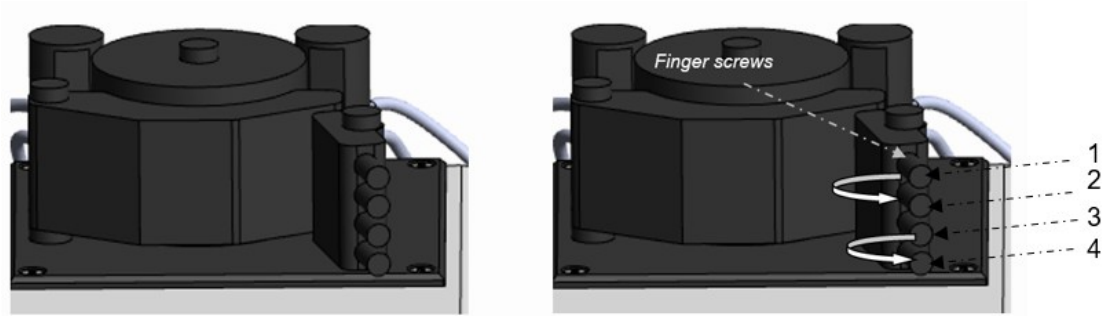


Figure 3.6 – Pump head with compression arms and finger screws.

WARNING The pump head has moving rollers that can trap fingers, hair and loose clothing. Stop the pump before you fit or change tubing, and switch it off before cleaning or service. Follow the safety instructions supplied with the pump.

3.5 Priming the System

Priming fills the aortic line, the pressure-transducer line and the compliance unit (also called the bubble trap) with buffer and removes all air. Start priming when the set temperatures have been reached.

CAUTION Never prime with a heart connected, and prime only when the set temperature is reached. The Prime function runs the pump at maximum speed.

Stopcock positions

The stopcock at the aortic inlet has three ports: Bubble Trap (the compliance unit), Pressure Transducer Housing and Aortic Inlet. The arm of the handle marked OFF points to the closed port. This manual uses four positions, A to D (Figure 3.7).

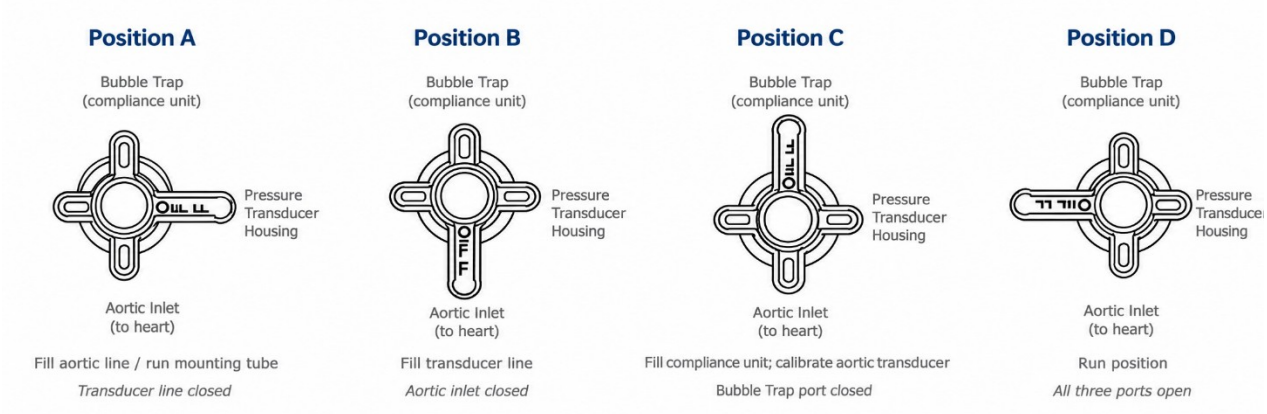


Figure 3.7 – Stopcock positions A to D (schematic).

Position	OFF arm points to	Flow open between	Used for
A	Pressure Transducer Housing	Bubble Trap and Aortic Inlet	Priming the aortic line. Pump calibration. Emptying the aortic line during cleaning.
B	Aortic Inlet	Bubble Trap and Pressure Transducer Housing	Filling the pressure-transducer line. Emptying it during cleaning.
C	Bubble Trap	Pressure Transducer Housing and Aortic Inlet	Filling the compliance unit/Bubble trap. Aortic pressure calibration.
D	None (all ports open)	All three ports	Zero Aortic Pressure. Final flush. Flow through the mounting tube extension while the heart is prepared and mounted.

Prepare

1. Check that Constant Pressure mode is selected and that the compliance-unit lid is in the Constant Pressure position.
2. Check that the pump inlet tubes are in the preheated buffer and that the overflow tube is in the buffer container or in the waste bottle.
3. Set the stopcock to **position A** (OFF toward the Pressure Transducer Housing).
4. Open Aortic Pressure Control (Figure 3.8). Set a target pressure, for example 100 mmHg, and press **Pressure Control ON**. A green icon shows that pressure control is on.

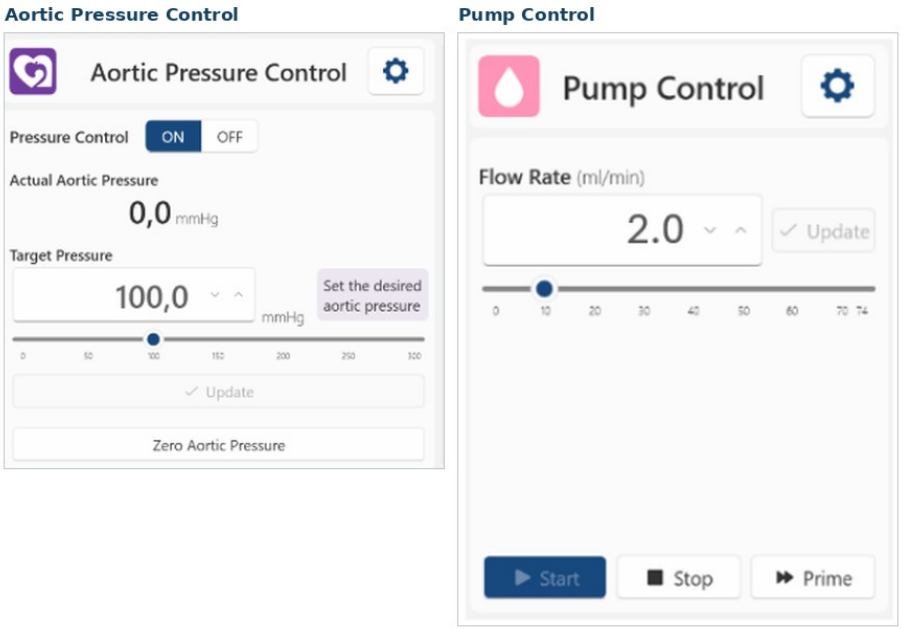


Figure 3.8 – Aortic Pressure Control and Pump Control menus.

Prime the aortic line

5. In Pump Control, set a flow of 4–6 mL/min for the mouse compliance unit and 10–20 mL/min for the rat compliance unit and press **Start**.
1. When buffer runs out of the aortic cannula, press **Prime** for 1–2 min. Prime runs the pump at maximum speed and drives out the air in the tubing.
2. Press **Stop**.

Prime the pressure-transducer line

1. Set the stopcock to **position B** (OFF toward the Aortic Inlet).
2. Remove the clamp from the outlet of the pressure-transducer housing.
3. Start the pump. Let buffer fill the line and the housing until no air can be seen.
4. With the pump still running, put the clamp on the Pressure Transducer housing outlet.
5. Remove the drug inlet port, fill its dead volume with a pipette and refit it.
6. Check the tubing, the transducer housing and the drug inlet port for air bubbles (Figure 3.9). Repeat the steps above if you see any.

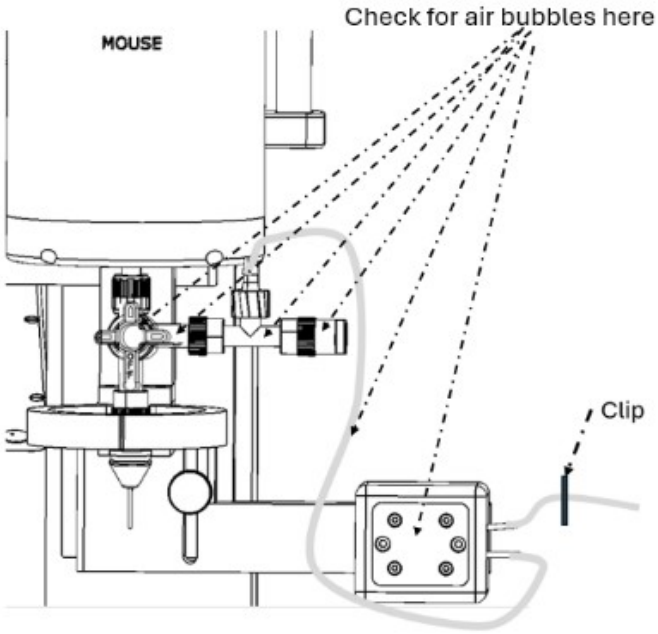


Figure 3.9 – Places to check for air bubbles.

Fill the compliance unit

1. Set the stopcock to **position C** (OFF toward the Bubble Trap).
2. Open the Bubble Trap valve on top of the compliance unit (Figure 3.10).
3. Start the pump at 4–8 mL/min for the mouse compliance unit and 10–20 mL/min for the rat compliance unit. Buffer collects in the compliance unit. It does not enter the overflow tube at this stage.
4. **Constant Pressure experiments:** close the Bubble Trap valve when the buffer fills 1/3 to max 1/2 of the compliance unit (Figure 3.10).
5. **Constant Flow experiments:** fill the compliance unit completely. Close the Bubble Trap valve when buffer comes out of it. Check that there are no air bubbles in the unit. To remove a bubble, empty the unit and fill it again.
6. Buffer now flows through the pressure regulator unit into the overflow tube.

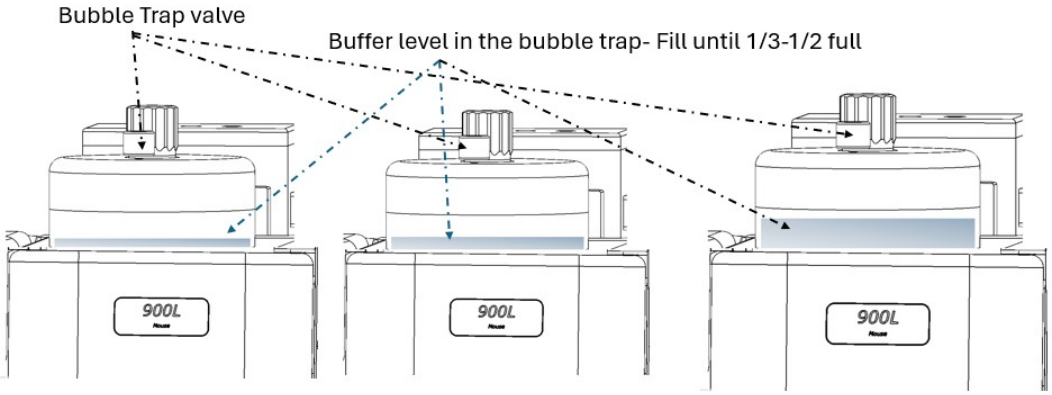


Figure 3.10 – Buffer level in the compliance unit for Constant Pressure: fill to 1/3–1/2 using the Bubble Trap valve.

Zero the aortic pressure

7. Make sure the aortic pressure transducer housing is at the same height as the place where the heart will be mounted.
8. With the stopcock in position D, stop the pump, wait 10 seconds and press **Zero Aortic Pressure**.

Final flush

1. Press **Prime** for 30 s to flush out remaining air.
2. Set the stopcock to **position D** (all ports open).
3. Press **Prime** for 30–60 s. Press **Stop**, or press Prime again.
4. Inspect all tubing and connections for air bubbles. Repeat the relevant steps above if you find any.

The system is now primed.

3.6 Setting Mode and Starting Values for Mounting

Set the mode and the starting values you want while the heart is mounted. The procedures for each mode are in Chapter 4.

- **Constant Pressure:** set the aortic pressure and a pump flow. For mouse hearts, a starting pressure could be 60 mmHg and a flow of 6 mL/min. For rat hearts, a starting pressure could be 60 mmHg and a flow of 30 mL/min. After mounting the heart, adjust the pressure and flow gradually. It is very important that the flow is high enough to force buffer into the overflow tube from the pressure regulator unit.
- **Constant Flow:** set a low pump flow. For mouse hearts, start at 0.5–1.0 mL/min. For rat hearts, start at 5–8 mL/min. Increase the flow gradually after mounting until the appropriate Aortic Pressure is reached.

3.7 Connecting the Mounting Tube Extension

The Mounting Tube Extension Kit has a 5 m tube with an aortic cannula adaptor at one end and an aortic cannula at the other. It lets you cannulate the heart at the dissection area and keep it perfused until it is mounted on the 900L.

1. Check that the tube is long enough to reach from the Aortic Inlet to the place where the heart is excised. If it is too long, cut it shorter. Do not use a tube that is too short.
2. Select the aortic cannula that fits the heart and connect it to the cannula adaptor of the kit.
3. Connect the kit to the Aortic Inlet of the 900L.
4. Start the pump. Press **Prime** to fill the tube faster. Check that there are no air bubbles.
5. Put the cannula in the perfusion-buffer container in the water bath. The buffer now recirculates and keeps the tube warm.
6. Set a low flow and let the pump run until the heart is ready for mounting. Keep the stopcock in position D.

3.8 Ready-for-Experiment Checklist

- ☐ Aortic Inlet and Reservoir temperatures are at the set values, checked with an independent thermometer.
- ☐ Aortic pressure transducer calibrated (and LVP transducer, if used), and quality readings accepted.
- ☐ Pump calibrated with the fitted tubing set.
- ☐ Gas supply stable at 0.5–2.0 bar, and no buzzing tone.
- ☐ All fluid and pressure lines free of air bubbles.
- ☐ Compliance unit filled to the level for the chosen mode, and its valve closed.

- ☐ Mode in MyoHEART matches the lid position.
- ☐ Overflow tube unobstructed. Overflow drain switched on (submerged configuration).
- ☐ Mounting tube extension connected, free of air and recirculating.
- ☐ Vacuum pump on and vacuum waste bottle empty.

Chapter 4 – Perfusion Modes and Control

4.1 How the Two Modes Work

The 900L perfuses the heart in one of two modes. Choose the mode before you prime the system, because the compliance unit and the lid are set up differently for each mode.

	Constant Pressure	Constant Flow
You set	The aortic pressure	The pump flow
The 900L	Keeps the set pressure. The pump delivers more than the heart needs and the surplus leaves through the overflow tube	Delivers the set flow with the peristaltic pump
What varies	Coronary flow	Aortic pressure, depending on coronary resistance
Compliance unit	Filled 1/3–1/2	Filled completely
Lid position	Constant Pressure: pressure can escape	Constant Flow: pressure cannot escape
Pump flow shown	Not the coronary flow, because part of it leaves through the overflow tube	The delivered flow, if the pump is calibrated
Main risk	Pressure falls if the pump flow is too low	Pressure can rise quickly and damage the aortic pressure transducer and the mounted heart

Always prime in Constant Pressure mode (Section 3.5).

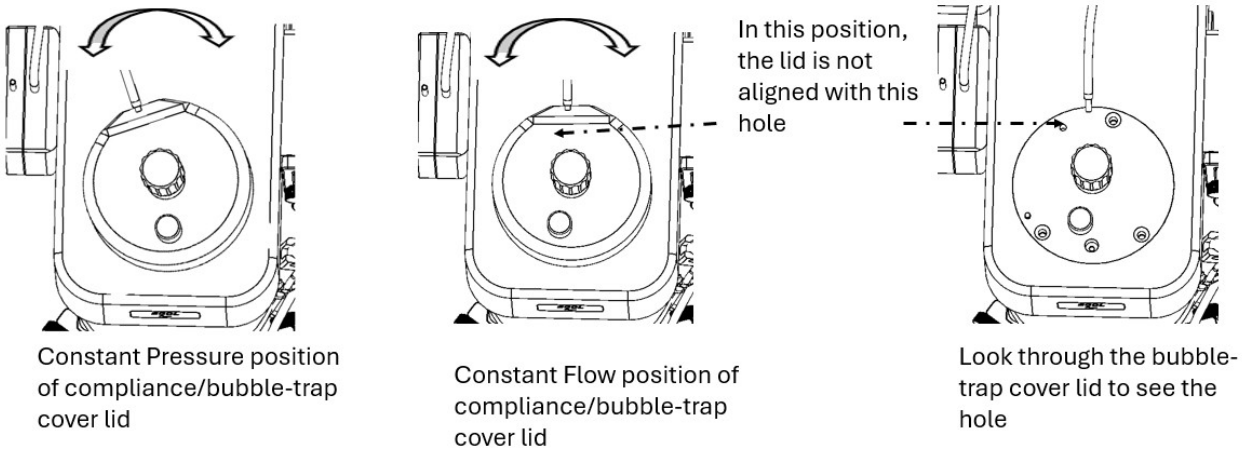


Figure 4.1 – Compliance-unit lid. Left: Constant Pressure position. Middle: Constant Flow position. Right: looking through the lid to see the hole.

In the Constant Pressure position the lid is aligned with the hole. In the Constant Flow position it is not aligned with the hole.

4.2 Constant Pressure Mode

1. Open the Setup menu, click the 900L device and select **Constant Pressure** (Figure 3.1).
2. Turn the compliance-unit lid to the Constant Pressure position (Figure 4.1).
3. Check that the compliance unit is filled 1/3–1/2 and that its valve is closed (Section 3.5).
4. Set the stopcock to position D (all ports open).
5. Open Aortic Pressure Control, set the target pressure and press **Pressure Control ON**.
6. Set the pump flow so that buffer runs continuously through the overflow tube.
7. Check the overflow tube during the experiment, and again after every change of the target pressure.

> **CAUTION** If no buffer comes out of the overflow tube, the pump flow is too low and the 900L cannot hold the set pressure. Increase the flow.

The overflow tube can return buffer to the buffer container, which saves buffer, or lead to a waste bottle.

4.3 Constant Flow Mode

> **CAUTION** With the lid in the Constant Flow position, pressure cannot escape. If the flow is too high, the pressure can exceed 300 mmHg and damage the aortic pressure transducer. Always start with a low flow and increase it slowly until the appropriate Aortic Pressure is reached. 300 mmHg is the transducer limit, not an operating pressure. Recommended maximum operating pressure is 250 mmHg.

1. Prime the system with the compliance unit completely filled (Section 3.5, "Fill the compliance unit").
2. Stop the pump.
3. Open the Setup menu, click the 900L device and select **Constant Flow**.
4. Leave the lid in the Constant Pressure position while you mount the heart.
5. After mounting, start at a low flow and increase it slowly while you watch the aortic pressure.
6. When the flow gives the pressure you want, turn the lid to the Constant Flow position.
7. Watch the aortic pressure continuously. Stop the pump if the pressure rises quickly or without a clear reason.

The delivered flow equals the set flow only if the pump has been calibrated with the fitted tubing set (Section 9.4). The short-term flow stability is ±2 %.

4.4 Changing Mode

Change the mode only before a heart is mounted. Changing the mode with a heart mounted is not described in this manual.

1. Stop the pump.
2. Select the new mode in the 900L settings (Setup menu, 900L device).
3. Set the compliance unit to the level for the new mode (Section 3.5, "Fill the compliance unit").
4. Turn the lid to the matching position (Figure 4.1).
5. Check that the software mode, the lid position and the compliance-unit level agree before you restart the pump.

4.5 Reading the Numbers

- **Aortic pressure** is measured just above the heart.
- **In Constant Pressure mode** the pump flow shown in MyoHEART is not the coronary flow, because part of it leaves through the overflow tube. Measure the coronary flow by collecting the effluent (application note AN-900L-03).
- **In Constant Flow mode** the pump flow is the delivered flow only if the pump is calibrated. Tubing stretches with use, so calibrate every day of use and replace the tubing set at the recommended interval.
- Record the pump setting, the aortic pressure, the mode and the lid position for every experiment.

Chapter 5 – Heart Mounting and Experimental Procedures

This chapter covers mounting a heart on the 900L, from the checks before the experiment to the end of the experiment. Animal preparation techniques, including in-situ cannulation and ventilation, are described in application note AN-900L-01, Isolated Heart Preparation and Mounting.

> **WARNING** Animal procedures must follow your approved ethics protocol and local regulations. Treat all biological material as potentially infectious and wear gloves and eye protection.

5.1 Before You Mount

Do not start the dissection until every item is ticked.

- ☐ The aortic perfusion buffer and the reservoir are at the set temperature.
- ☐ The correct peristaltic tubing is fitted in the pump and the pump is calibrated.
- ☐ The pump tube is in the bottom of the bottle of preheated perfusion buffer (1–5 L) in a 37 °C water bath, bubbled heavily with carbogen. Mouse hearts use about 1 L. Rat hearts use about 2–4 L, depending on how long the experiment lasts.
- ☐ All air is removed from the tubing, stopcock, aortic pressure transducer housing and, if used, the LVP housing.
- ☐ The mounting tube extension is connected to the Aortic Inlet with the right-size aortic cannula and the pump runs at a low flow to keep the buffer warm in the tube and the Stopcock is in position D. To save buffer, the cannula can sit in the buffer bottle in the water bath.
- ☐ The main gas pressure is on.
- ☐ The flow (Constant Flow) or pressure and flow (Constant Pressure) are set to the values you want for mounting.

5.2 Instruments and Aortic Cannulas

Item	Details
900L Dissection Kit	1 surgical forceps, 2 large hemostats/clamps, 1 small scissors, 2 blunt-ended fine curved forceps, 1 eye scissor (#100073)
Silk suture	DMT #100341
Mouse Aortic Cannula set (#100357)	0.6 mm (23 G), 0.8 mm (21 G), 1.0 mm (19 G), 1.2 mm (18 G), 1.5 mm (17 G)
Rat Aortic Cannula set (#100358)	1.2 mm (18 G), 1.5 mm (17 G), 2.0 mm (14 G), 2.5 mm, 3.0 mm (11 G)
Dissection stereomicroscope (#400598)	Recommended for new users. Makes dissection and cannulation much easier.

Choose a cannula that fits the aorta without forcing it. The suture must sit in one of the three grooves on the cannula.

5.3 Excise and Cannulate the Heart

This is the quick-excision method with cardiac arrest in ice-cold buffer.

1. Place ice-cold buffer in a small beaker on ice.
2. Fit the right-size aortic cannula to the mounting tube extension kit. Flush the tubing and cannula with buffer so that no air bubbles remain.
3. Anesthetize the animal according to your protocol. Check the depth of anesthesia, for example with the corneal or pedal withdrawal reflex.
4. Open the chest quickly, cut out the heart and lungs together and transfer them to the ice-cold buffer.
5. Move the heart to a second tray of ice-cold buffer. Trim away lungs, veins and other tissue until the aorta is clearly visible and easy to reach. Keep the heart submerged at all times.
6. Stop the pump.

7. While the heart is submerged, push the aorta onto the cannula and tie a double knot around aorta and cannula. The suture must catch one of the grooves, and the cannula must not go too far into the aorta.
8. Lift the mounted heart out of the ice-cold buffer

CAUTION Do not let air enter the aorta or the cannula. Air bubbles block the coronary vessels.

5.4 Transfer the Heart to the 900L

9. Start the pump to start the flow through the mounting tube extension at the pressure or flow you chose for mounting.
10. Swap the cannula with the mounted heart onto the 900L aortic inlet connector, replacing the Mounting Extension tube cannula. Before you push the cannula with the mounted heart onto the 900L system let buffer run into the cannula that carries the heart, before you connect the two. This stops air from being trapped in the cannula and pushed into the heart.
1. Check that coronary perfusion starts. Contractile function and a regular rhythm return. It can take a few minutes to reach maximum function.
2. Rotate the heart around the cannula if needed to place it in a suitable position.

5.5 Lower the Heart into the Reservoir

Configuration	Preparation before lowering
Submerged	Fill the reservoir with prewarmed buffer (300–350 mL). Fit the reservoir cover. Switch on the **Overflow** drain in Drain Control before you lower the heart (Section 3.3).
Free-hanging	Leave the reservoir empty. Fit the two-part cover. Check that the air in the reservoir is at 37 °C.

1. Loosen the lift screw (Figure 5.1) and lower the mounted heart into the reservoir.
2. Tighten the screw when the heart is in position.
3. Increase the pressure or flow to the value you want for the experiment.

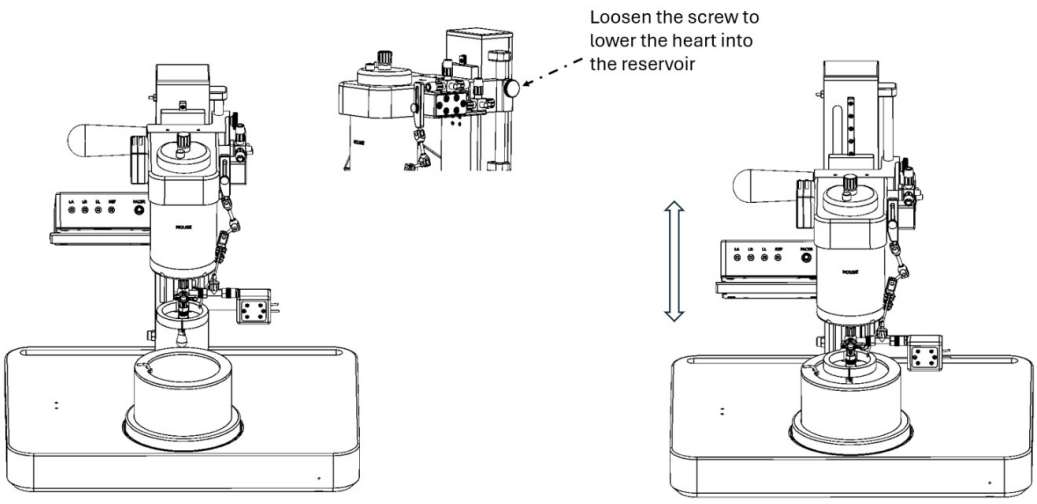


Figure 5.1 – Manual lift: loosen the screw to lower the mounted heart into the reservoir.

CAUTION Do not lower the heart in submerged mode before the overflow drain is on. The buffer can overflow the reservoir.

5.6 During the Experiment

- Watch the aortic pressure, flow, aortic temperature and reservoir temperature in MyoHEART.
- In Constant Pressure mode, keep the overflow tube running and check that the compliance unit stays 1/3–1/2 full.
- In Constant Flow mode, keep the compliance unit completely filled.

- Add an LVP balloon, ECG electrodes or the pacer electrode as described in Chapter 6.
- To measure coronary flow by hand in Constant Pressure mode, see application note AN-900L-03.

> **NOTE** Flow equals the set value only after the pump has been calibrated with the fitted tubing set (Section 9.4).

5.7 End of the Experiment

1. Stop any stimulation and remove the LVP balloon and electrodes.
2. Reduce the flow, lift the heart out of the reservoir and remove it.
3. Dispose of the heart and contaminated material as biological waste.
4. Clean the system as described in Chapter 8.

Chapter 6 – Optional Measurements and Accessories

This chapter covers the optional left ventricular pressure (LVP) package, the ECG/Pacer package, beats-per-minute detection and the pacer. LVP calibration is described in Section 9.3.

6.1 Left Ventricular Pressure (LVP)

LVP is measured with a compliant balloon in the left ventricle, usually thin silicone rubber (cling film can also be used). It is suited to isovolumic left ventricular function and also gives the heart rate. The LVP package (#100331) is mounted on the right side of the 900L (Figure 6.1) and can be bought from DMT and fitted later.

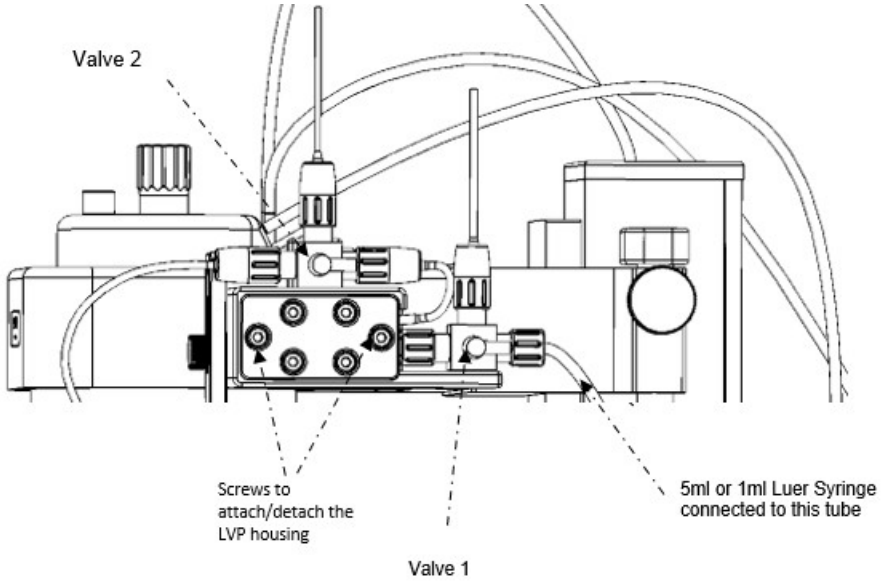


Figure 6.1 – LVP package on the right side of the 900L.

The two 3-way valves are closed in the direction they point (Figure 6.2).

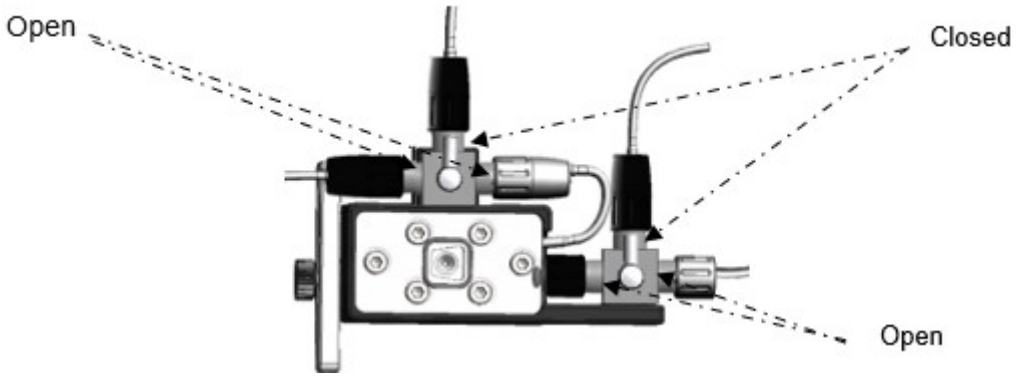


Figure 6.2 – Valve 1 and valve 2 on the LVP housing. Each valve is closed in the direction it points.

Prepare the lines

1. Mix ethanol (96%) and distilled water 1:1 (5–10 mL). Warm the solution to 37.0 °C.
2. Fill the 5 mL syringe with more than 2 mL of the warm mixture. Remove air bubbles and connect it to the tubing to the LVP housing.
3. Open valve 2 toward the catheter and close valve 1 toward the LVP housing (Figure 6.3).
4. Fill the tube until the mixture is seen in the short upward tube (blue circle in Figure 6.3).
5. Open valve 1 toward the LVP housing and close valve 2 toward the catheter (Figure 6.4).
6. Fill the LVP housing until the mixture is seen at the upward outlet of valve 2 (blue circle in Figure 6.4). Make sure no air bubbles are trapped in the housing.

7. Open valve 2 toward the catheter (Figure 6.5) and fill the catheter until 20–30 drops have dripped from it.
8. Close valve 2 toward the catheter (Figure 6.6).

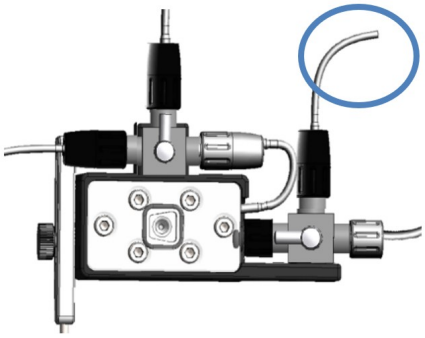


Figure 6.3 – Valve 2 open, valve 1 closed toward the LVP housing.

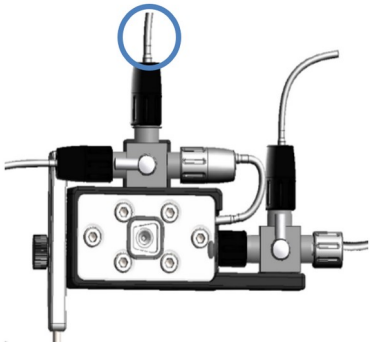


Figure 6.4 – Valve 1 open toward the housing, valve 2 closed toward the catheter.

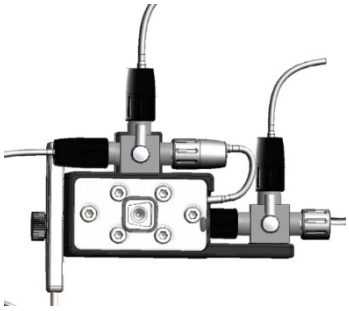


Figure 6.5 – Valve 2 open toward the catheter.

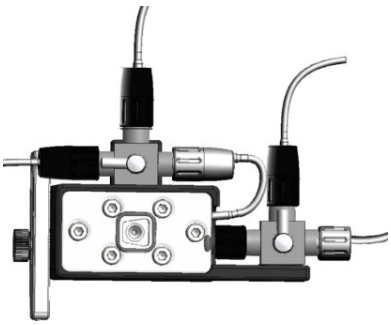


Figure 6.6 – Valve 2 closed toward the catheter.

CAUTION Ethanol is flammable. Keep it away from flames and heat. Use only the small volume needed.

Mount the balloon on the catheter

1. Attach the right-size balloon to the LVP catheter. Position the catheter at the bottom of the balloon (Figure 6.7).
2. Open valve 2 and fill the balloon with the mixture (Figure 6.8). Avoid trapping air. Fill until the LVP is about 100 mmHg. Follow the pressure in the LVP Control menu or the LVP trace.
3. Close valve 2 toward the catheter (Figure 6.6).
4. Press air bubbles out of the balloon with your fingers. If you see air, open valve 2 (Figure 6.5) and refill. Repeat until no air is left.
5. Secure the balloon to the catheter with a suture (double knot). Check that no air is left in the housing or tubing.
6. Place the mounted balloon at the same height as the mounted heart.

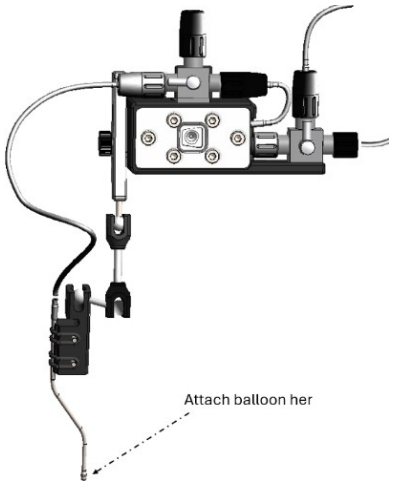


Figure 6.7 – Balloon attached at the tip of the LVP catheter.

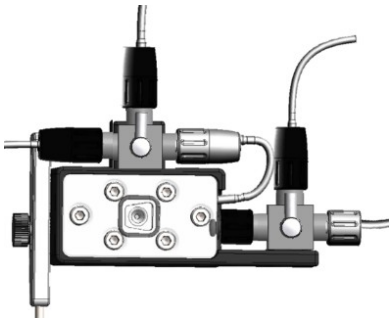


Figure 6.8 – Filling the balloon through valve 2.

Zero the pressure

1. Fill the 1 mL LVP spindle syringe with 1 mL of the mixture and replace the 5 mL syringe with it. Close valve 1 towards the LVP housing (Figure 6.3). Fill the tubing toward valve 1 until no bubbles are seen.
2. Close valve 1 toward the 1 mL syringe to release excess pressure from the balloon (Figure 6.9).
3. Press **Zero LVP Pressure** in the LVP menu in MyoHEART (Figure 6.10).
4. Open valve 1 toward the LVP housing (Figure 6.11).
5. Deflate the balloon with the 1 mL syringe.
6. Close valve 1 toward the LVP housing.

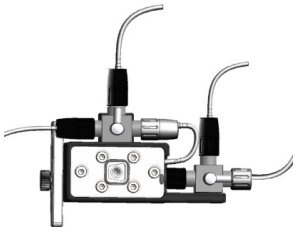


Figure 6.9 – Valve 1 closed toward the syringe.

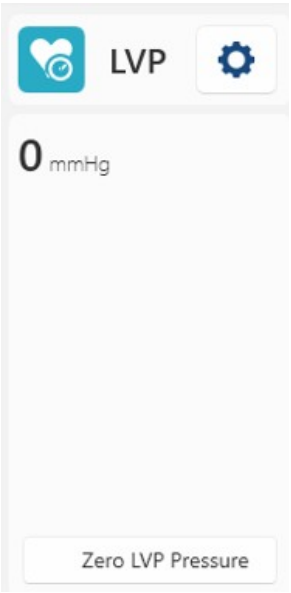


Figure 6.10 – LVP Control menu with Zero LVP Pressure.

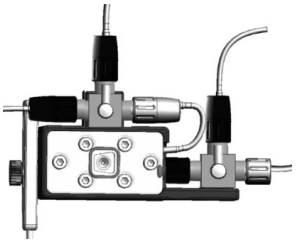


Figure 6.11 – Valve 1 open toward the LVP housing.

Place the balloon in the left ventricle

1. Remove the left atrial appendage to clear the view.
2. Introduce the deflated balloon through the mitral valve into the left ventricle (Figure 6.12). Check the direction of the cannula and balloon before you enter.
3. Inflate the balloon until the pressure is about 0–10 mmHg with the balloon in the ventricle.

4. Close valve 1 toward the LVP housing. Turn the valve clockwise to avoid pressure loss. The correct LVP pressure is now shown.
5. Adjust the balloon volume until you see the maximum LVP response. Repeat the inflation steps as needed.

Figure 6.12 – Balloon introduced into the left ventricle through the mitral valve.

CAUTION Insert and secure the balloon with care. It is very easy to damage the heart.

6.2 ECG Recording

ECG needs the ECG/Pacer package (#100317). The 900L records three leads using the Wilson coupling. ECG requires the submerged configuration (Section 2.5).

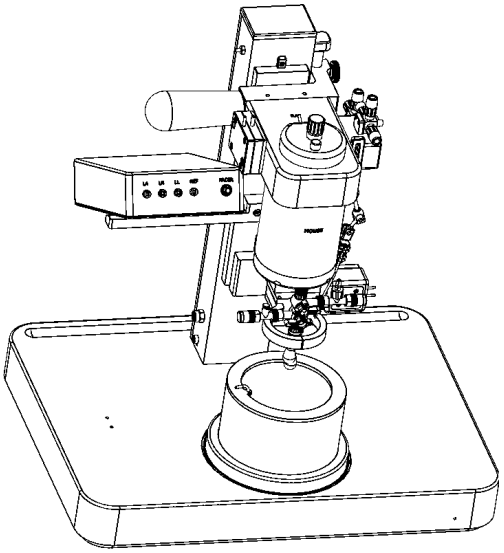


Figure 6.13 – 900L with the ECG/Pacer package fitted.

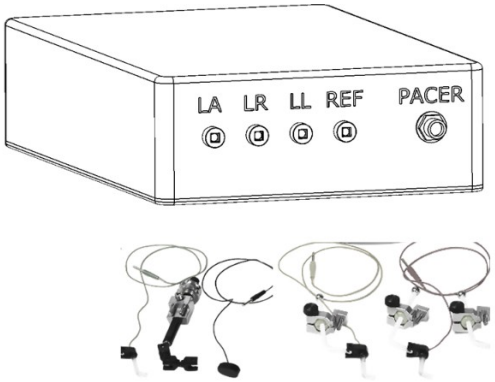


Figure 6.14 – ECG/Pacer unit with electrodes. Plug colors match the unit.

Connect the electrodes

1. Connect the ECG/Pacer unit to the connector on the left side of the 900L.
2. Connect the ECG electrodes and the reference electrode to the unit. The plug color must match the color on the unit.
3. Attach the electrode holders to the electrode holder ring (Figure 6.15).
4. Open the ECG Settings menu from the settings icon and set the amplification for each lead (Figure 6.16). The default is 600x. The options are 100, 200, 400, 600, 800 and 1200x.

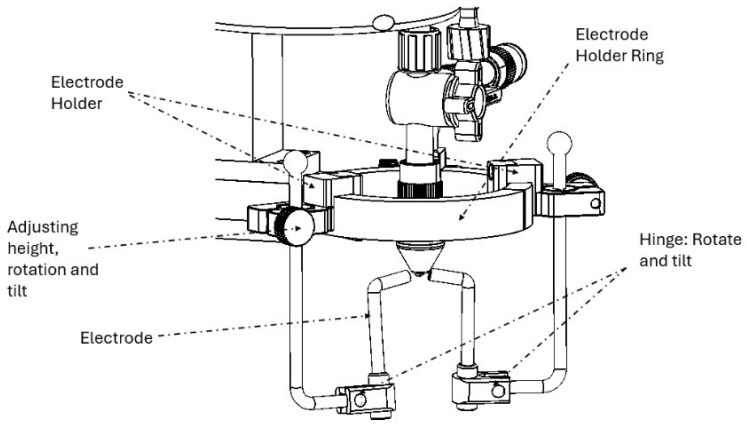


Figure 6.15 – Electrode holder ring. The holders adjust in height, rotation and tilt.

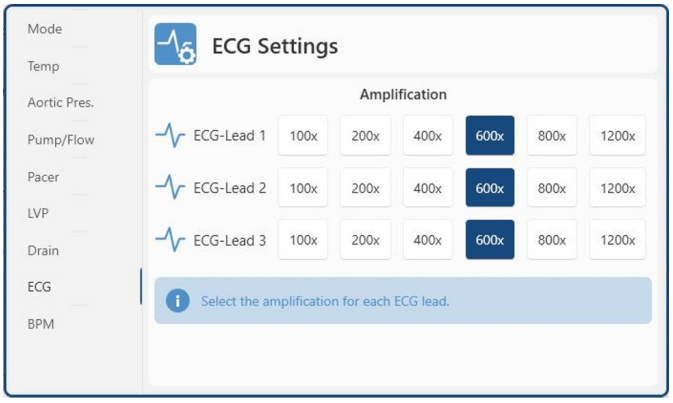


Figure 6.16 – ECG Settings: amplification per lead.

Place the electrodes

All three electrodes (LA, RA and LL) must be connected to get a good signal.

1. Place the electrodes 0–2 mm from the mounted heart while it is submerged.
2. Place LA (yellow), RA (red) and LL (green) on the heart as in Figure 6.17.
3. Place the REF electrode (black) 5–10 mm below the heart, centered.
4. View the ECG trace in MyoHEART, or in your data-acquisition system through the BNC outputs. Use Swipe mode in MyoHEART.
5. Adjust LA, LL and RA until the trace is clear (Figure 6.18).

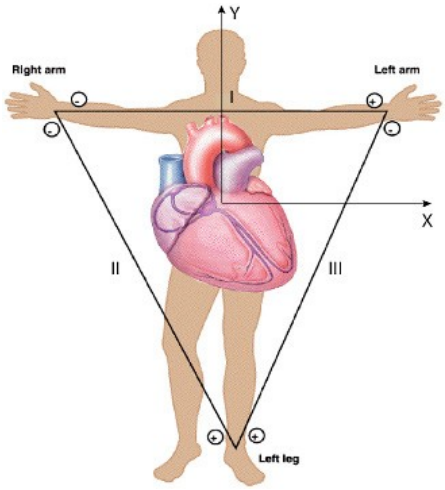


Figure 6.17 – Electrode placement for the Wilson ECG.

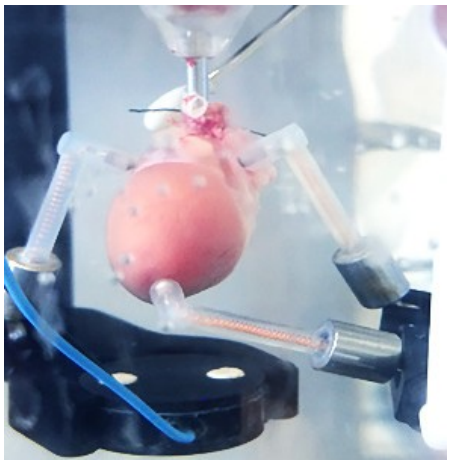


Figure 6.18 – ECG and reference electrodes on a mounted heart.

NOTE The holders are fully flexible, and very small movements can change the ECG a lot. The three leads appear as ECG Lead 1, 2 and 3 in MyoHEART, LabChart and on the BNC outputs. Only one lead shows a perfect ECG signal.

Electrode care

1. If the AgCl part turns gray or black, remove the debris with sandpaper (grain 1000 or finer).

6.3 Heart Rate (BPM)

MyoHEART can calculate BPM from the LVP trace or from an ECG lead.

MyoHEART

1. Open Setup, then BPM Settings (Figure 6.19).
2. Select the channel to measure from (ECG Channel 1, 2 or 3, LVP or Aortic Pressure).
3. Select the species.
4. Look at the trace in the BPM Settings window (Figure 6.20). Circles mark the beats the algorithm found.
5. Adjust the standard deviation (S.D.) until every beat is marked. Lower S.D. is more sensitive and may detect noise. Higher S.D. is less sensitive and may miss beats.
6. When the BPM is correct, press **Update**. The BPM trace now shows the heart rate.

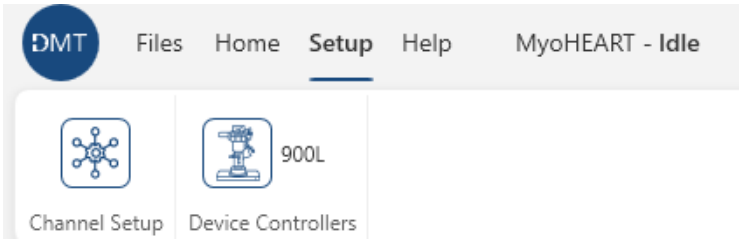


Figure 6.19 – Setup menu with BPM settings.

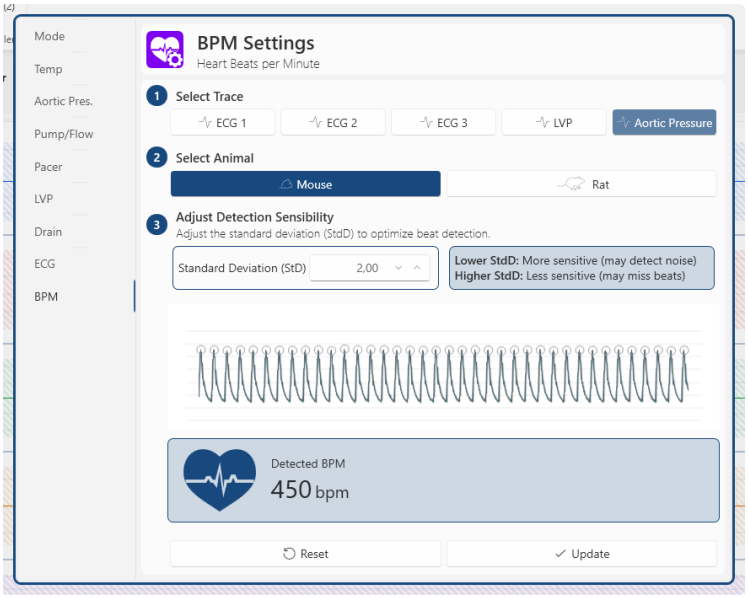


Figure 6.20 – BPM Settings: detected beats marked on the trace.

LabChart

1. Create a new channel in LabChart. Choose ECG Lead 1, 2 or 3 as the source and name it BPM.
2. Open Cyclic Measurements (Figure 6.21) and select the rate.
3. Check that every ECG peak is detected. If not, change the S.D. In the example in Figure 6.22, the S.D. is changed from 3.25 to 1.75.
4. Set decimal places to 0 and click OK.

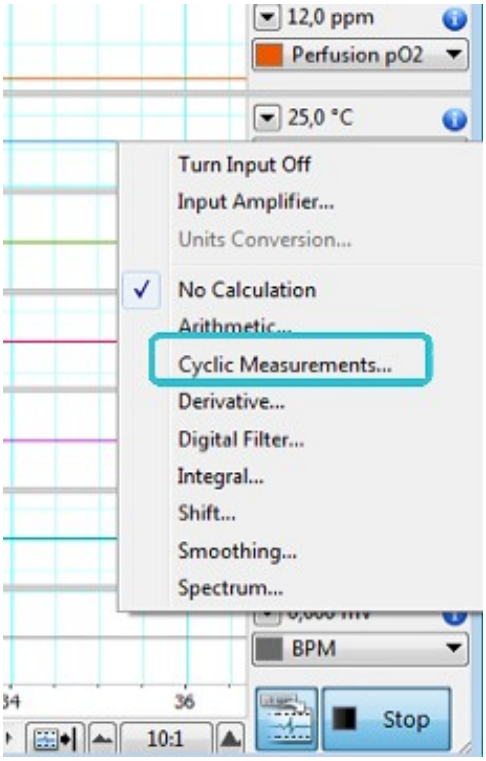


Figure 6.21 – LabChart: Cyclic Measurements on the BPM channel.

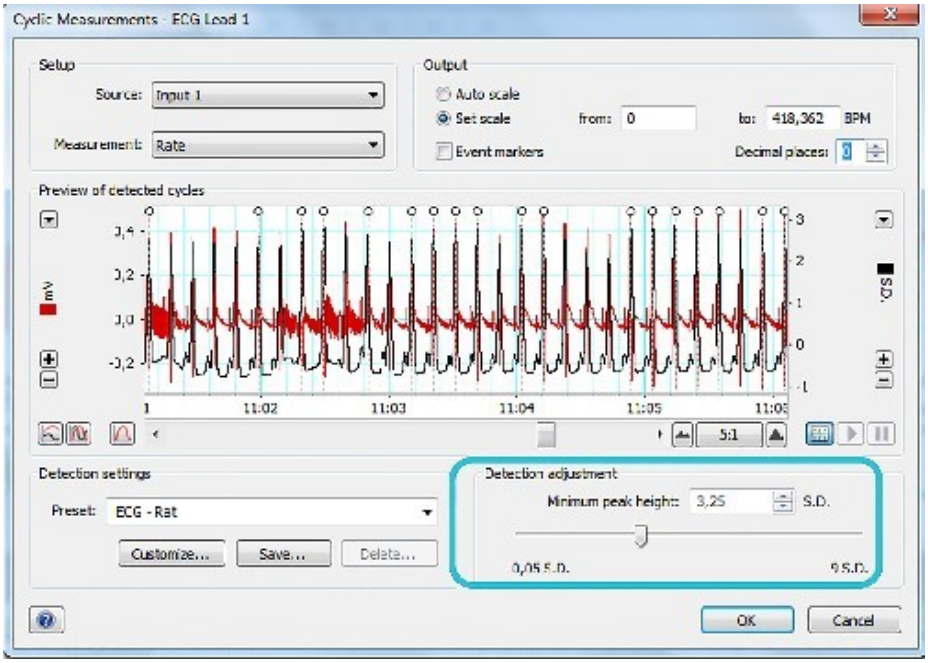


Figure 6.22 – LabChart: detection settings with S.D. adjusted.

6.4 Pacer

The isolated heart beats slower with time and below its in-vivo rate. For rat hearts, with an in-vivo rate of 350–400 beats/min, expect 250–320 beats/min. To get an in-vivo-like rate, pace the heart. The pacer is built into the ECG/Pacer unit (#100317, Figure 6.23).

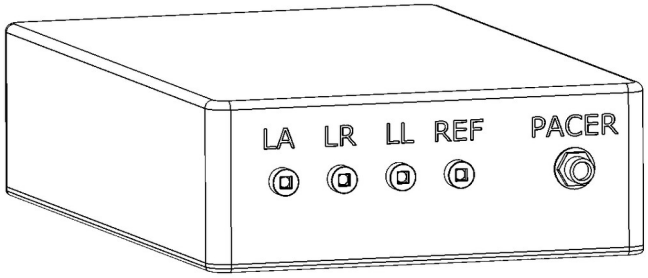


Figure 6.23 – ECG/Pacer unit with the PACER output.

Set the pacer

1. Open the Pacer Control menu in MyoHEART (Figure 6.24). It shows the BPM and pulse width. You can change them and start stimulation here.
2. To change the output mode, amplitude or pulse width, press the settings icon to open Pacer Settings (Figure 6.25).
3. Set the parameters in the table below.
4. Press **Update** to send the values to the stimulator. The Update icon turns gray when the values have been uploaded (Figure 6.26).
5. Press **Start** to start stimulation. It runs until you press **Stop**.

Parameter	Range
Output mode	Volt or Ampere
Volt / Ampere	0–15 V or 0–15 mA
Pulse width	0.1 ms to 1000 ms
BPM	6–1200 BPM (0.1–20 Hz). The 900L keeps the pulse width constant.
Pulse shape	Bipolar

The Pacer trace in MyoHEART shows the signal in volts or amperes and the pulse width.

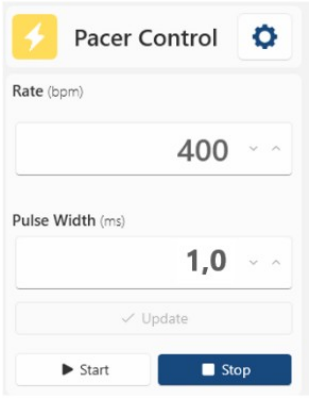


Figure 6.24 – Pacer Control menu.

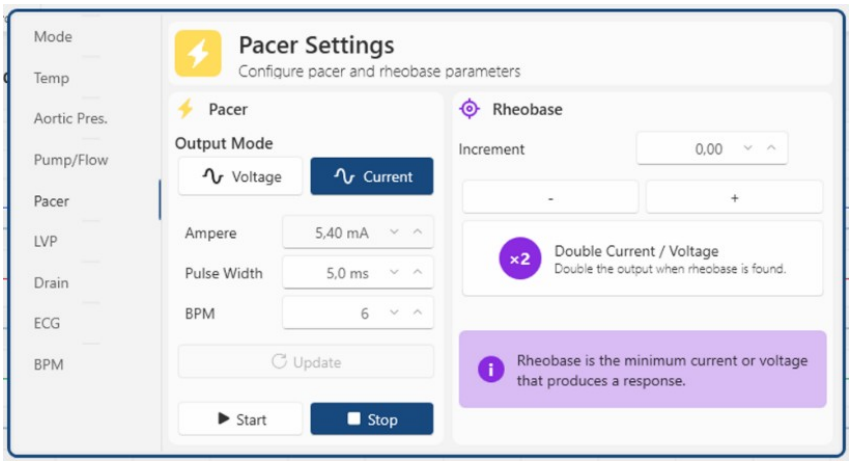


Figure 6.25 – Pacer Settings: output mode, amplitude, pulse width, BPM and rheobase.

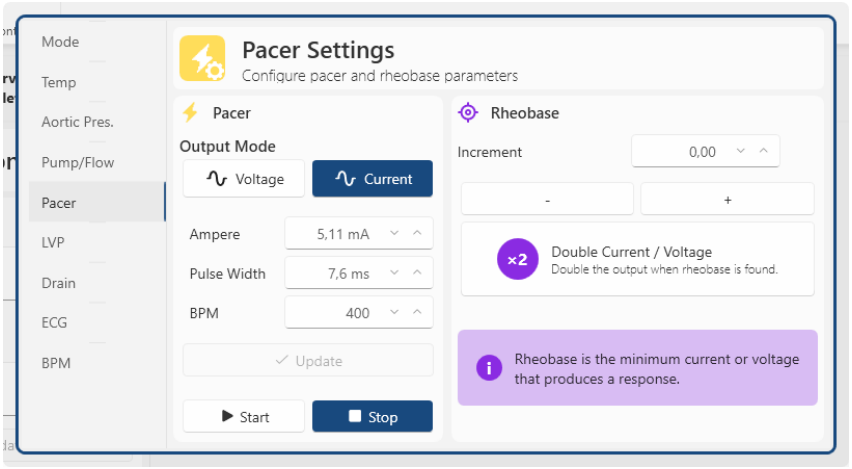


Figure 6.26 – Pacer Settings with the values uploaded.

CAUTION Place the pacer electrode on the atria, never on the ventricle.

Find the rheobase

Rheobase is the minimal current amplitude of infinite duration that reaches the depolarization threshold of the cell membranes. The 900L finds the minimum voltage or current that lets the pacer take over the heart rhythm.

1. Place the pacer electrode on the atria.
2. Follow the heart's natural BPM (Section 6.3).
3. Choose a pacer BPM that differs from the natural BPM so you can see when the pacer takes over. For example, if the natural BPM is 250, choose 300.
4. Set volt or ampere to 0, BPM to 300 and pulse width to 1 ms. Set the increment (for example 0.2 V). Start stimulation.
5. Press the **+** icon in the Rheobase panel (Figure 6.27). Each press raises the stimulation by one increment.
6. When the BPM trace changes from 250 to 300, the pacer has taken over. This is the rheobase.
7. Press **Double current/voltage** to double the rheobase value. This keeps the pacer in control throughout the experiment.

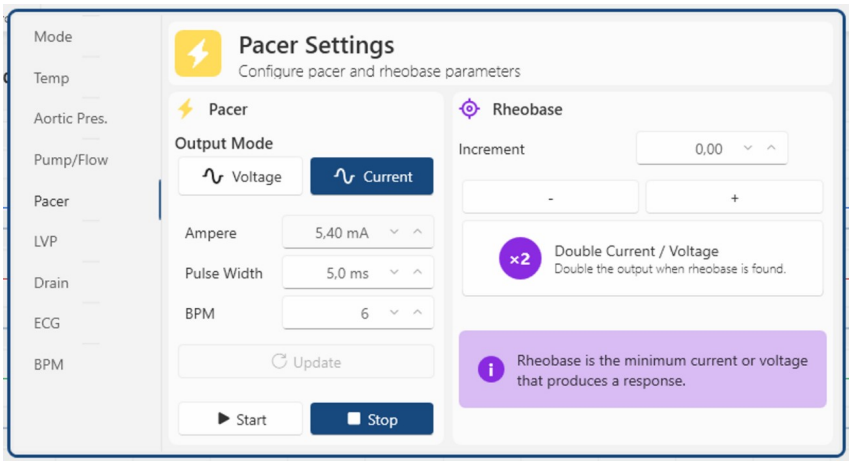


Figure 6.27 – Pacer Settings with the rheobase controls.

Chapter 7 – Data Acquisition and Software

7.1 Choose a Data Acquisition Method

Method	Channels	Requirements
MyoHEART with data acquisition	Up to 9 (including BPM)	MyoHEART license code
LabChart	Up to 8	DMT Device Enabler for LabChart installed on the computer
Analog BNC outputs	8 analog outputs	Your own analog data-acquisition system

All parameters are converted to digital data and sent to the computer over the USB cable. The LVP and ECG/Pacer channels are present only if those modules are fitted.

7.2 MyoHEART with Data Acquisition

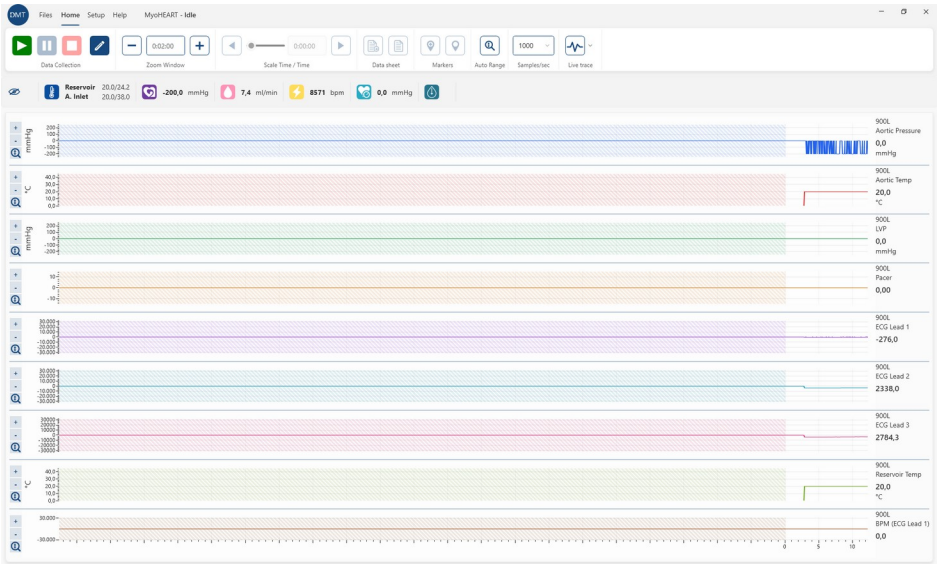


Figure 7.1 – MyoHEART with all nine channels.

Channel	Description
Aortic Pressure	Pressure measured just above the mounted heart (mmHg).
Aortic Temp	Temperature of the perfusion buffer just before it enters the heart (°C).
LVP	Left ventricular pressure, measured with a balloon in the left ventricle (mmHg). See Section 6.1.
Pacer	Voltage or current given to the heart, and the pulse width.
ECG Lead 1, 2, 3	Three leads from the Wilson coupling. Only one lead shows a perfect ECG signal. See Section 6.2.
Reservoir Temp	Temperature of the reservoir in the submerged method (°C).
BPM	Heart rate calculated from the LVP, an ECG lead or Aortic Pressure. See Section 6.3.

Show the aortic pressure as a mean value

1. Open **Setup**, then **Channel Setup** (Figure 7.2).
2. In the Calculation column, select **Mean** for Aortic Pressure.
3. In the time column, select the time the mean is based on. For example, 1 s means the mean uses 1 s of data.

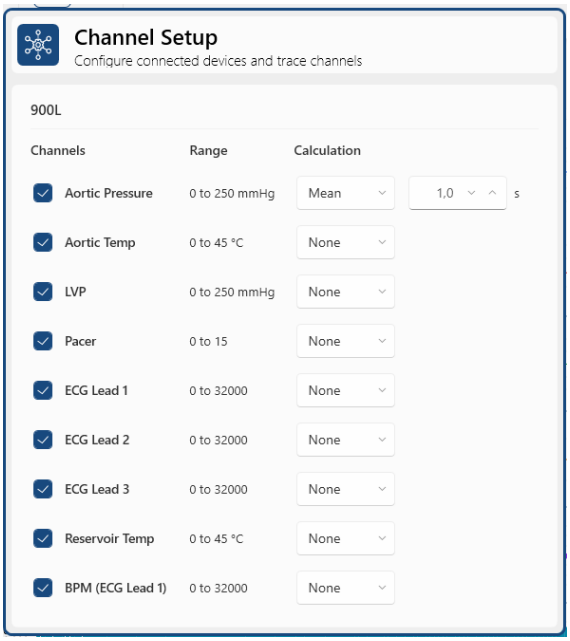


Figure 7.2 – Channel Setup with the mean calculation selected.

7.3 LabChart with the DMT Device Enabler

LabChart shows up to eight channels: Aortic Pressure, Aortic Temp, LVP, Pacer, ECG Lead 1, 2, 3 and Reservoir Temp. Arrange the MyoHEART controller window and LabChart on the screen yourself (Figure 7.3 and Figure 7.4).

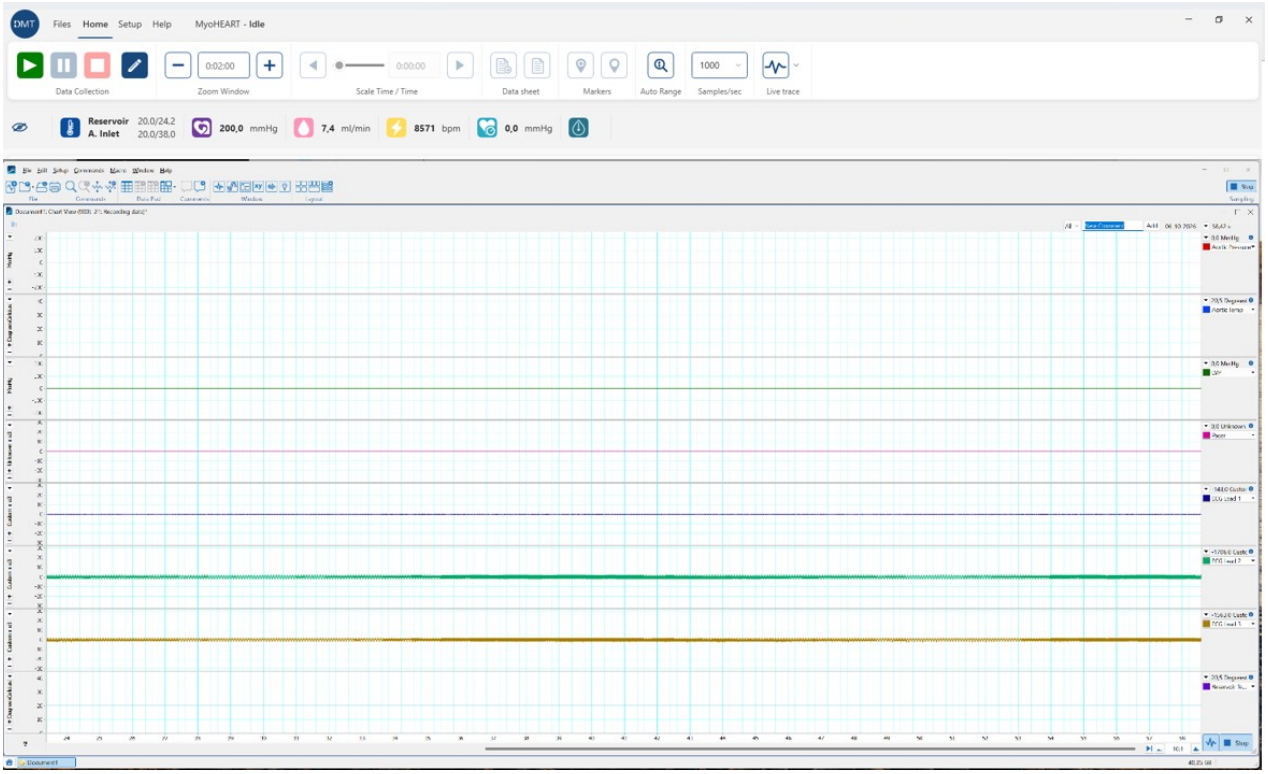


Figure 7.3 – LabChart with the 900L channels.

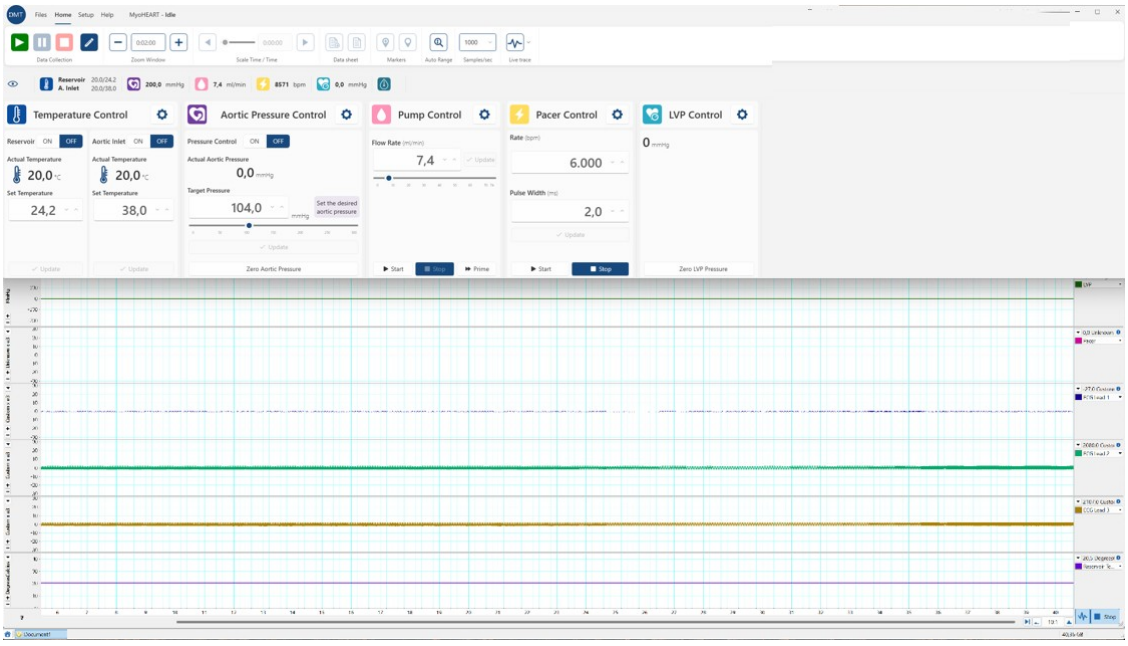


Figure 7.4 – MyoHEART controller windows next to LabChart.

7.4 Analog BNC Outputs

The 900L has eight analog BNC connectors on the back (Figure 7.5). All outputs are within −2.5 to +2.5 V. The pressure, temperature, LVP and pacer outputs use the scaling below.

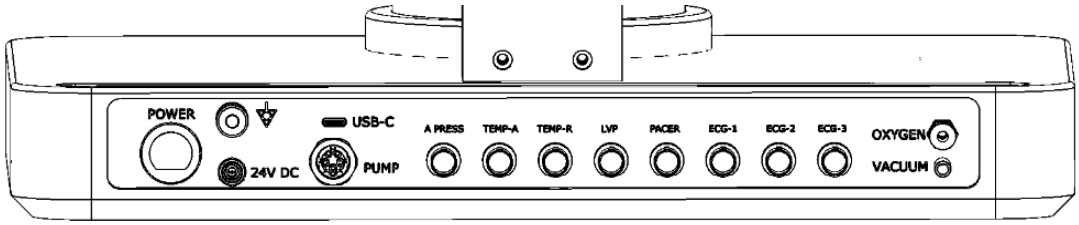


Figure 7.5 – Analog BNC connectors on the back of the 900L.

Connector	Signal	Scaling
A.Pressure	Aortic pressure	0 V = 0 mmHg, 2.5 V = 250 mmHg
TEMP-A	Aortic temperature	0 V = 0 °C, 2.5 V = 45 °C
TEMP-R	Reservoir temperature	0 V = 0 °C, 2.5 V = 45 °C
LVP	Left ventricular pressure	0 V = 0 mmHg, 2.5 V = 250 mmHg
PACER	Pacer output	0 V = 0 V or 0 mA, 2.5 V = 15 V or 15 mA (depends on the unit set in the Pacer menu)
ECG-1, ECG-2, ECG-3	ECG leads 1, 2 and 3	±2.5 V

Connect the BNC outputs to an analog-to-digital converter (for example PowerLab), as in Figure 7.6.

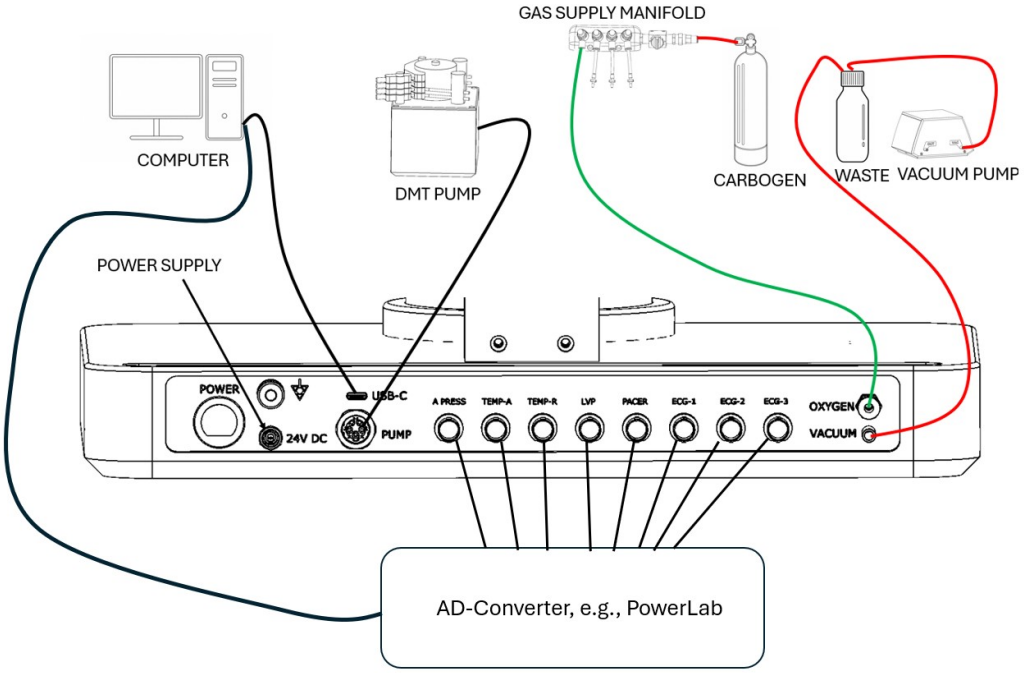


Figure 7.6 – BNC outputs connected to an A/D converter.

Chapter 8 – Cleaning and Maintenance

Clean the 900L after every use. This keeps the system working for years. The procedure first empties the buffer, then flushes the lines with distilled water, then empties the system. Stopcock positions A to D are defined in Section 3.4 (Figure 8.1).

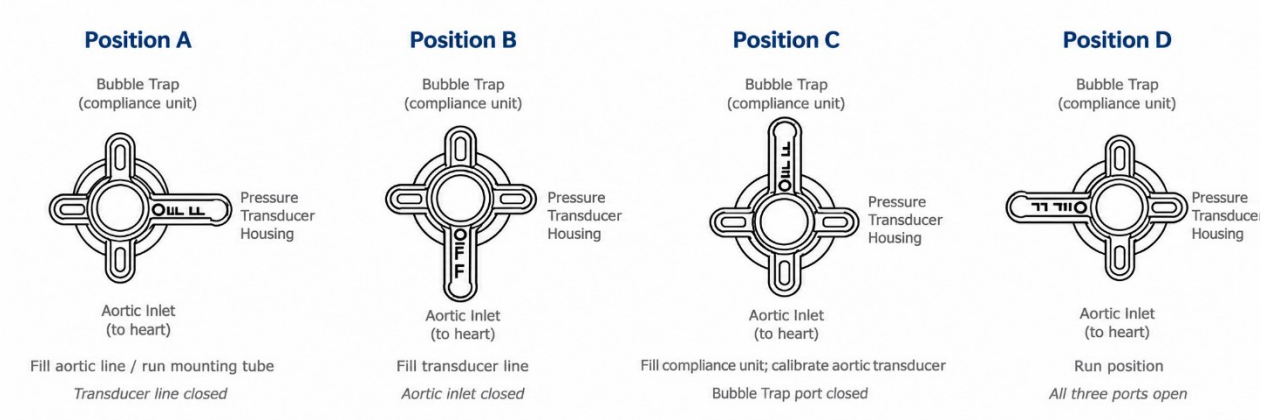


Figure 8.1 – stopcock positions A to D (same as Figure 3.7).

WARNING Do not clean the system with a heart mounted. Wear gloves. Treat buffer that has passed through the heart as biological waste.

8.1 Prepare

1. Make sure the 900L is in Constant Pressure mode and the compliance-unit lid is in the Constant Pressure position.
2. Set the pressure to 100 mmHg.
3. Place the overflow tube from the pressure regulation unit in a waste bottle.
4. Switch on the vacuum pump and check that the vacuum waste bottle is empty.
5. Switch off the reservoir heater and the aortic buffer heating in the Temperature menu (Figure 8.2).

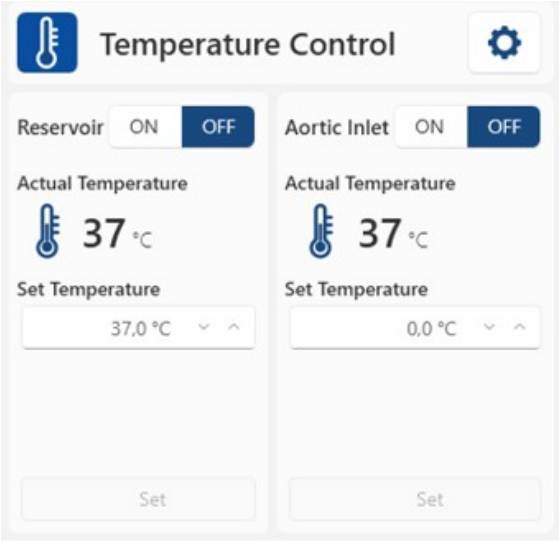


Figure 8.2 – Temperature Control with both heaters off.

8.2 Empty the Buffer

6. Press **Drain** for the reservoir and the Double Jacket in the Drain Control menu (Figure 8.3) and drain the buffer and water into a waste container.
1. Move the pump tubing from the perfusion-buffer bottle into an empty bottle (Figure 8.4).
2. Start the pump.
3. Set the stopcock to **position A**.

4. Press **Prime** in the Pump Control menu. The line to the aortic outlet empties into the reservoir.
5. When the line is empty, set the stopcock to **position C**.
6. The overflow tubing and pressure-controlling unit now empty through the overflow tube. Stop the pump when no buffer comes out of the overflow tube.
7. Set the stopcock to **position B**. Remove the clamp from the aortic pressure transducer housing outlet.
8. Start the pump at 10 mL/min to push the buffer out of the tubing and transducer housing. Stop the pump when both are empty.

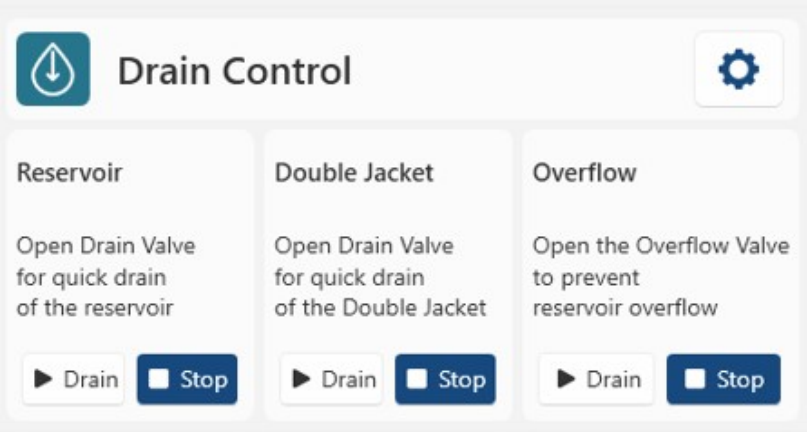


Figure 8.3 – Drain Control menu.

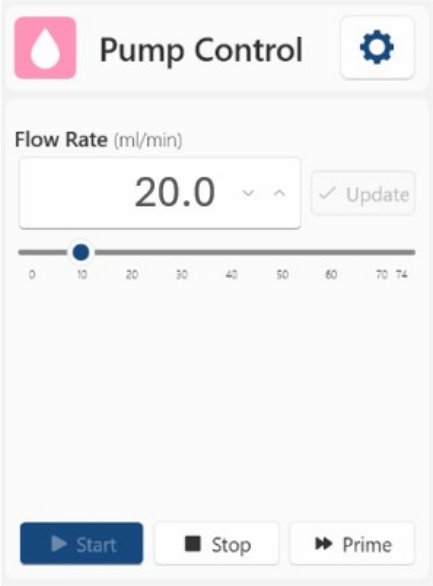


Figure 8.4 – Pump Control menu. Flow, Start, Stop and Prime.

8.3 Flush with Distilled Water

1. Place the pump tubing in a bottle of distilled water and start the pump.
2. Set the stopcock to **position A**.
3. Press **Prime** in the Pump Control menu for 60 s.
4. Open the Bubble Trap valve on top of the bubble trap (Figure 8.5).
5. Set the stopcock to **position C**. The bubble trap fills with distilled water.
6. When it is full, close the Bubble Trap valve on top of the bubble trap and set the stopcock to **position A** and stop the pump. The bubble trap empties.
7. When it is empty, open the valve on top and set the stopcock to **position C.** Start the pump.
8. Repeat the previous two steps twice, so you fill and empty the bubble trap two times.
9. With the stopcock in **position C**, let distilled water flush the overflow tubing and pressure-controlling unit through the overflow tube. Stop the pump after 60–120 s.

10. Set the stopcock to **position B** and remove the clamp from the aortic pressure transducer housing outlet.
11. Start the pump at 10–20 mL/min and flush the tubing and the housing with distilled water for 60 s. Stop the pump.

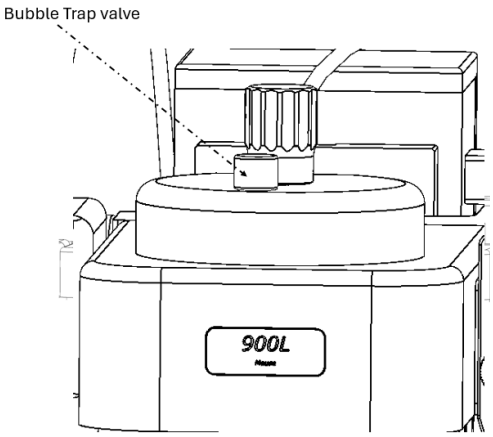


Figure 8.5 – Bubble Trap Valve on top of the bubble trap.

8.4 Empty the System

1. Place the pump tubing in an empty bottle.
2. Start the pump and press **Prime**. Stop the pump when all distilled water has left the transducer line and housing.
3. Set the stopcock to **position A**.
4. Start the pump and press **Prime**. When all distilled water has emptied into the reservoir, set the stopcock to **position C**.
5. Press **Prime** in the Flow menu to empty the overflow tubing and the pressure-controlling unit. Stop the pump when no water comes out of the overflow tube.
6. The internal tubing is now clean.

8.5 Drain and Switch Off

1. Drain the reservoir in the Drain Control menu. Make sure the vacuum pump is on and the waste bottle is not full.
2. Rinse the reservoir with distilled water and drain it again.
3. Press **Drain** for the double-jacketed reservoir. Stop the drain when it is empty.
4. Remove the double-jacketed rings and wipe them clean with a napkin. Put them back.
5. Turn off aortic pressure in the Aortic Pressure Control menu.
6. Turn off the gas pressure at the tank or source.
7. Switch off the 900L with the main power switch.

8.6 Peristaltic Pump Tubing

The 900L comes with six sets of pump tubing. Flow accuracy depends on how worn the tubing is. Check it as follows:

1. Weigh an empty container.
2. In Constant Flow mode, set a flow (for example 10.0 mL/min) and collect the flow for 1 minutes in the container.
3. Weigh the container again. Compare the collected volume with the set flow multiplied by the time (1 g = 1 mL).
4. If the difference is too high, recalibrate the peristaltic pump. If this still is vary too much replace the tubing set.

DMT recommends replacing the tubing set after 5 days of use (about 40 hours), even if the flow check passes.

Chapter 9 – Calibration and Verification

9.1 Overview

Calibrate before every experiment day, in the order shown in Section 3.1.

Item	When	You need	Section
Aortic pressure transducer	Before each experiment	Supplied manometer, 1.5 mm aortic cannula. Primed system without air bubbles.	9.2
LVP pressure transducer (if fitted)	Before each experiment	Supplied manometer. LVP system filled.	9.3
Peristaltic pump	Before each experiment , and when the tubing set is changed	Beaker and balance. Primed system.	9.4

CAUTION Do not start an experiment if a calibration fails or a reading is not plausible.

Record every calibration (Section 9.5).

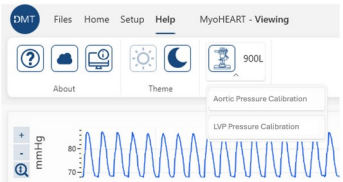
9.2 Aortic Pressure Transducer

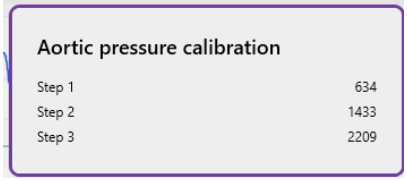
Always prime the system with buffer before performing the pressure calibration.

1. Attach the 1.5 mm aortic cannula to the Aortic Inlet (Figure 9.1).
2. Check that the tubing from the cannula to the outlet of the pressure-transducer housing is without any air bubbles. Remember to fill the Drug Inlet port. Remove the Drug Inlet port at fill the air-pocket close to the injection port with a pipette and reattach the Drug Inlet port.
3. Set the stopcock to **position C**: open between the aortic cannula and the pressure-transducer housing, closed toward the Bubble Trap.
4. Zero the Aortic Pressure in the Aortic Pressure Control menu.
5. Attach the manometer to the end of the aortic cannula (Figure 9.2).
6. In MyoHEART, open Aortic Pressure Control and press the settings icon (Figure 9.3).
7. Press **Pressure Calibration**.
8. Follow the on-screen steps (Figure 9.4). Apply 50 mmHg, 125 mmHg and 200 mmHg with the manometer. Press **Finish** at step 4.
9. At each pressure step, check the quality reading shown on screen. It must increase for each of the three pressure steps.
10. If the readings are constant or do not rise, check the connections, the stopcock position and the clamp, and repeat the calibration.
11. If the readings still do not rise, contact your DMT representative. The transducer may be damaged.
12. Release the pressure and remove the manometer.

CAUTION Apply only the pressures that the calibration screen asks for (maximum 200 mmHg). The transducer limit is 300 mmHg.

The Aortic Pressure transducer values are saved in MyoHEART. Go to the Help menu and select the 900L system. The last Aortic Pressure transducer calibration data will be shown. Share these values with your DMT representative if there is a problem with the Aortic Pressure calibration.





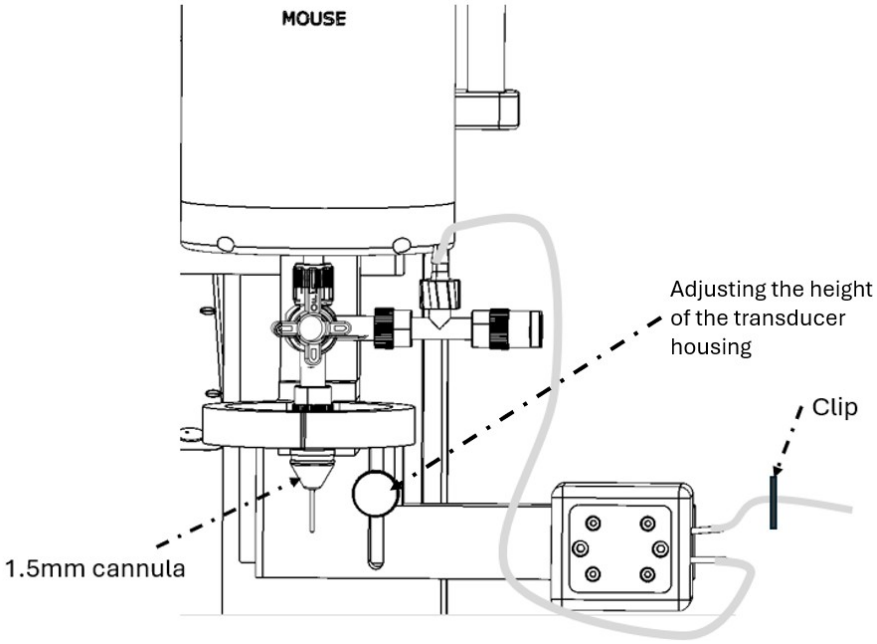


Figure 9.1 – 1.5 mm aortic cannula fitted for the calibration.

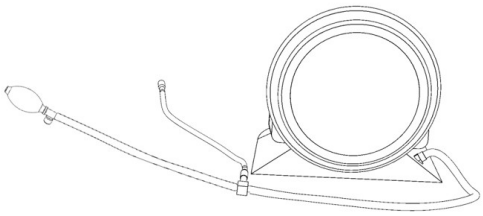


Figure 9.2 – Manometer.

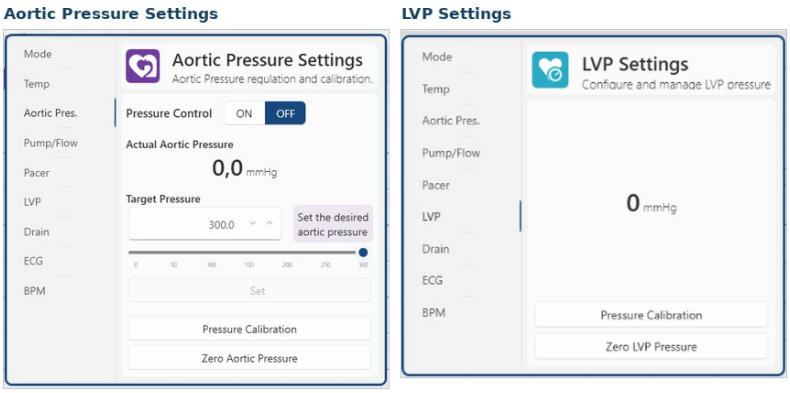


Figure 9.3 – Aortic Pressure Settings and LVP Settings menus.

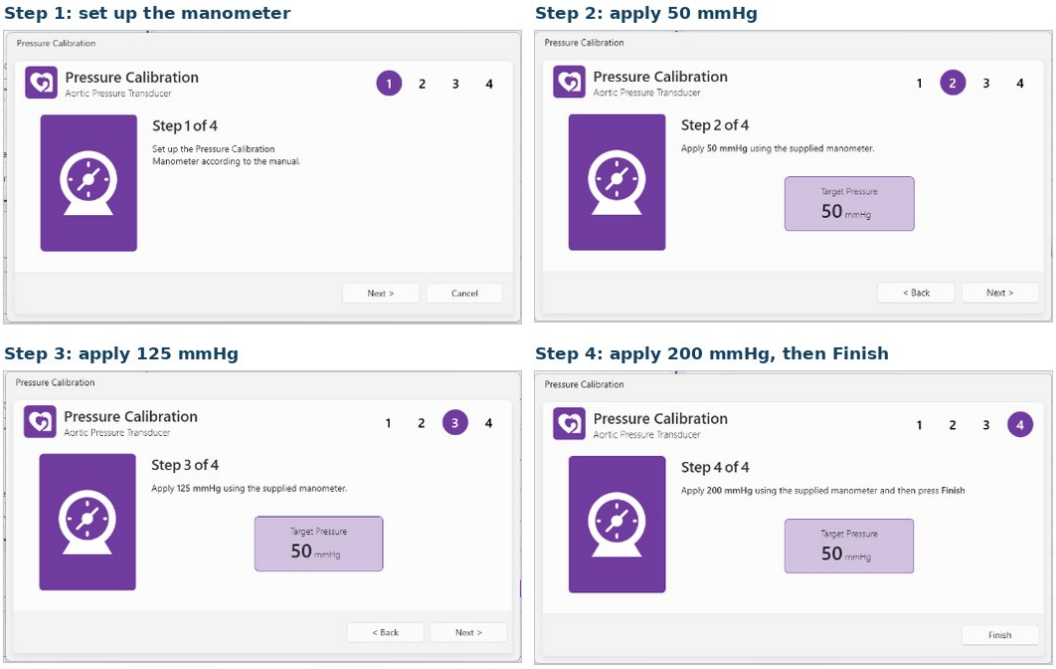


Figure 9.4 – Aortic pressure calibration steps.

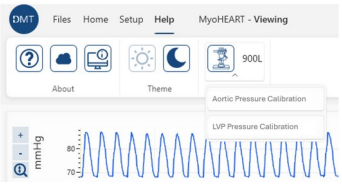
9.3 LVP Pressure Transducer

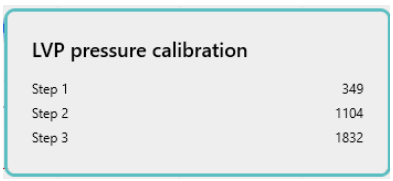
Do this when the LVP system has been filled with the ethanol/water mixture (Section 6.1).

1. Check that the LVP housing and the LVP catheter are filled with the 1:1 ethanol/water mixture and contain no air bubbles.
2. Attach the manometer to the end of the LVP catheter or directly to the LVP housing (Figure 9.5).
3. Set valve 2 open toward the LVP catheter and valve 1 closed toward the LVP housing (Figure 9.5).
4. In MyoHEART, open LVP Control and press the settings icon (Figure 9.3).
5. Press **Pressure Calibration**.
6. Follow the on-screen steps (Figure 9.6). Apply 50 mmHg, 125 mmHg and 200 mmHg with the manometer. Press **Finish** at step 4.
7. At each pressure step, check the quality reading shown on screen. It must increase for each of the three pressure steps.
8. If the readings are constant or do not rise, check the connections and the positions of valves 1 and 2, and repeat the calibration.
9. If the readings still do not rise, contact your DMT representative. The transducer may be damaged.
10. Release the pressure and remove the manometer.

CAUTION Apply only the pressures that the calibration screen asks for (maximum 200 mmHg). The transducer limit is 300 mmHg.

The LVP transducer values are saved in MyoHEART. Go to the Help menu and select the 900L system. The last LVP transducer calibration data will be shown. Share these values with your DMT representative if there is a problem with the LVP calibration.





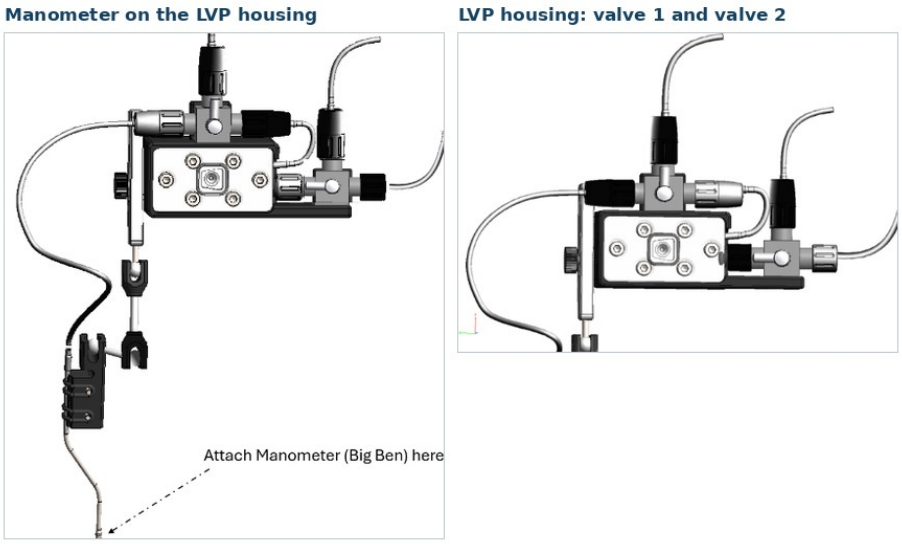


Figure 9.5 – LVP calibration setup.

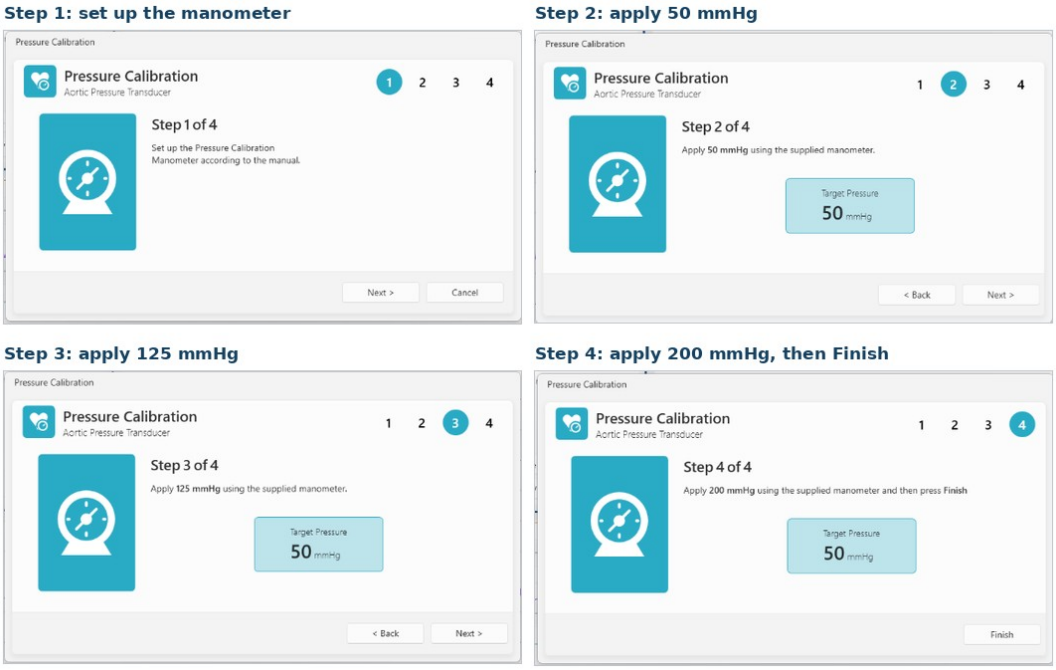


Figure 9.6 – LVP pressure calibration steps.

9.4 Peristaltic Pump

Calibrate the pump with the primed system, after the temperature has reached the set value. Calibrate again whenever you change the tubing set or the compression setting.

1. Weigh an empty beaker. Note the weight, or tare the balance.
2. Set the stopcock to position A (flow out of the Aortic Inlet) and place the beaker under the outlet.
3. Open Pump Settings and press **Pump Calibration** (Figure 3.5).
4. Press **Start**. The pump runs at 50 rpm for 60 s and then stops.
5. Weigh the collected buffer.
6. Enter the weight in the weight field and press **Set Weight**. Example: 11.00 g is entered as 11.00.
7. The screen shows Calibration Complete. You can now set the pump in mL/min instead of rpm.

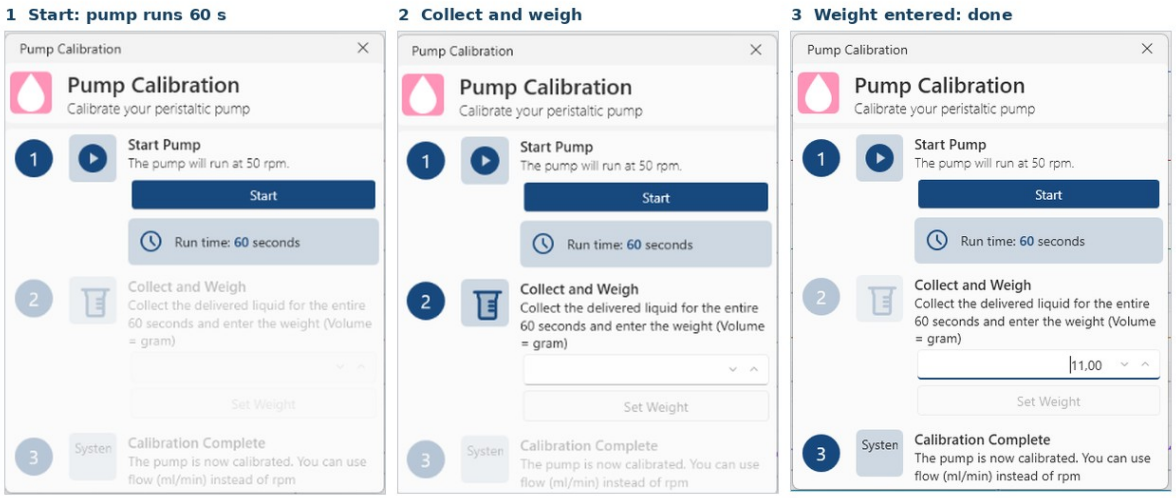


Figure 9.7 – Pump calibration steps.

Checking the flow (optional)

1. Select Constant Flow mode and set a flow, for example 10.0 mL/min.
2. Collect the flow for 1 min in a pre-weighed container.
3. Weigh the container. Calculate the actual flow: collected mass (g) divided by time (min).
4. Compare with the set flow. If the difference is larger than 5%, replace the tubing set and calibrate again.

9.5 Calibration Records

Keep a record of each calibration.

Date	Operator	900L serial no. and MyoHEART version	Quality readings (aortic, LVP)	Pump: tubing set and weight (g)	Pass / fail

9.6 When a Calibration Fails

Symptom	Likely cause	Action
Quality readings do not change with increasing pressure	Loose connection, damaged transducer	Check connections and stopcock position. Repeat.
Quality reading does not rise by at least 50 per step	Manometer not connected, leak, damaged transducer	Check the manometer and connections. Repeat. Contact DMT if it persists.
Collected weight is far from the expected value	Air in the system, worn tubing, wrong tubing set or compression setting	Prime again. Check the tubing set and pump direction. Fit new tubing. Repeat.

Chapter 10 – Troubleshooting

The checks below are first-line inspections. They are not a complete fault-code list. Stop the experiment if a condition may damage the instrument or the specimen.

10.1 MyoHEART does not detect the 900L

Possible issue: Power or USB connection; software communication not established.

First check: Check that the 900L is powered, verify USB-C connection and restart MyoHEART.

10.2 Gas pressure warning / buzzing

Possible issue: Insufficient gas inlet pressure.

First check: Check regulator, tubing, connectors and gas input against the approved pressure range.

10.3 Aortic pressure rises unexpectedly

Possible issue: Flow too high, increased vascular resistance or incorrect cover/mode configuration.

First check: Stop the pump, check mode and physical bubble-trap position, and investigate obstruction.

10.4 Inadequate pressure in Constant Pressure mode

Possible issue: Insufficient pump supply / missing regulator overflow/Pressure is not ON in the Aortic Pressure menu.

First check: Check pump operation, tubing and overflow path.

10.5 Air bubbles in perfusion / pressure signals

Possible issue: Incomplete priming, loose connectors, air trapped in the tubings or Stopcock unit.

First check: Do not connect the heart. Re-prime relevant lines and inspect stopcock, drug inlet and transducer.

10.6 Unstable pump flow

Possible issue: Tubing condition, compression or calibration mismatch.

First check: Inspect tubing placement, compression and pump calibration.

10.7 Reservoir temperature not matching setpoint

Possible issue: Insufficient equilibration, cover configuration or offset mismatch.

First check: Verify real temperature with appropriate probe, wait for equilibrium and review documented offset steps.

WARNING If the problem persists, discontinue use and contact DMT technical support. Do not dismantle gas, electrical or pressure-sensing modules beyond the authorized service procedure.

Appendix A – Technical Specifications

Source: DMT MyoHEART II Customer Specification Sheet, 19 June 2026.

A.1 General

Parameter	Specification
Working mode	Software-selectable Constant Pressure or Constant Flow
Hearts	Mouse, rat
Heart chamber	Free-hanging heart in heated compartment, or heart submerged in heated buffer
Data acquisition (digital)	MyoHEART over USB. Full control of the system, including the DMT peristaltic pump, pacer, ECG, temperatures and pressures
Data acquisition (analog)	Eight BNC outputs, −2.5 to +2.5 V: Aortic Pressure, Aortic Temp, LVP, Pacer, ECG Lead 1, 2, 3, Reservoir Temp

A.2 Temperature

Parameter	Specification
Heart chamber heating	Electric, built in
Heart chamber temperature range	20–50 °C
Heart chamber resolution	0.1 °C
Heart chamber stability, free-hanging	±0.3 °C
Heart chamber stability, submerged	±0.1 °C
Perfusion heating	Electric, built in
Perfusion temperature range	20–50 °C
Perfusion resolution	0.1 °C
Perfusion stability	±0.2 °C

A.3 Pressure and Flow

Parameter	Specification
Perfusion pressure range	0–250 mmHg
Perfusion pressure resolution	0.1 mmHg
Pressure transducer safety limit	300 mmHg
Peristaltic pump	0–100 rpm
Flow range	0–100 mL/min
Pump flow calibration	Yes
Pulsation-free pump	Yes

A.4 Pacer Module

Parameter	Specification
Output	Voltage or current (software selectable)
Pulse shape	Bipolar
Voltage range	0–15 V (resolution 0.01 V)
Current range	0–15 mA (resolution 0.01 mA)
Pulse width	0.1–1000 ms
Frequency	0.1–20 Hz (6–1200 BPM)

A.5 ECG Module

Parameter	Specification
Recording principle	Wilson coupling, three leads
Gain (selectable)	100–1200

A.6 LVP Module

Parameter	Specification
LVP pressure transducer	0–250 mmHg
LVP pressure resolution	0.1 mmHg

Analog output scaling is given in Section 7.4.