



# TRADEMARKS

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# SAFETY

## POWER BRICK ENCLOSED WITH THE MYOHEART SYSTEM

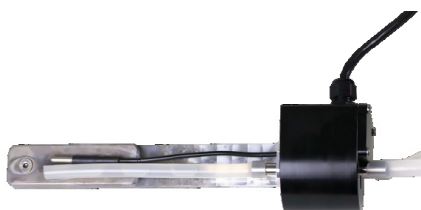


### CAUTION:

- Risk of electric shock. Dry location use only.
- Never cover the power brick with anything.
- Risk of overheating.

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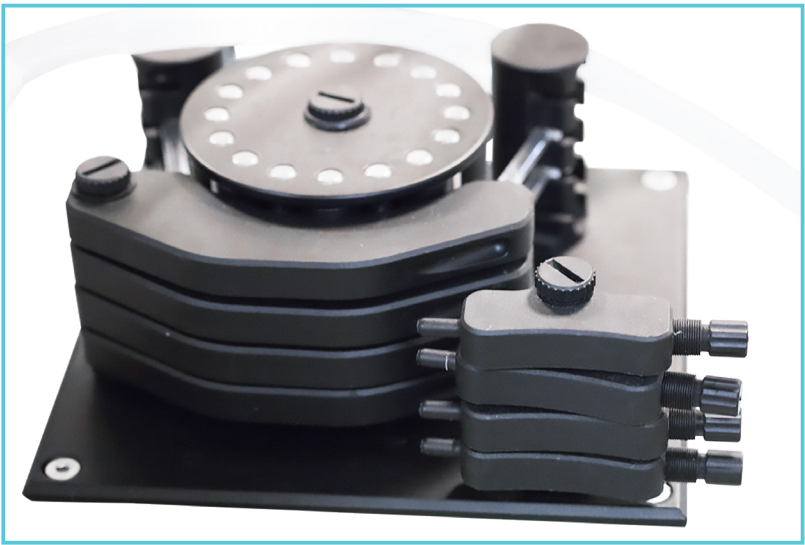
## HEATING ROD FOR HEATING OF WATER JACKETED BUFFER RESERVOIR



### CAUTION:

- The heating must always be turned off when the Heating Rod is NOT in the Heating Bottle with distilled water.
- The Heating Rod will have temperatures up to 70°C. High risk of burning accidents by handling when the heating is turned on.
- DO NOT turn on the heating before the Heating Rod is placed in the Heating Bottle with 1 liter distilled water.

PERISTALTIC PUMP ON THE MYOHEART SYSTEM



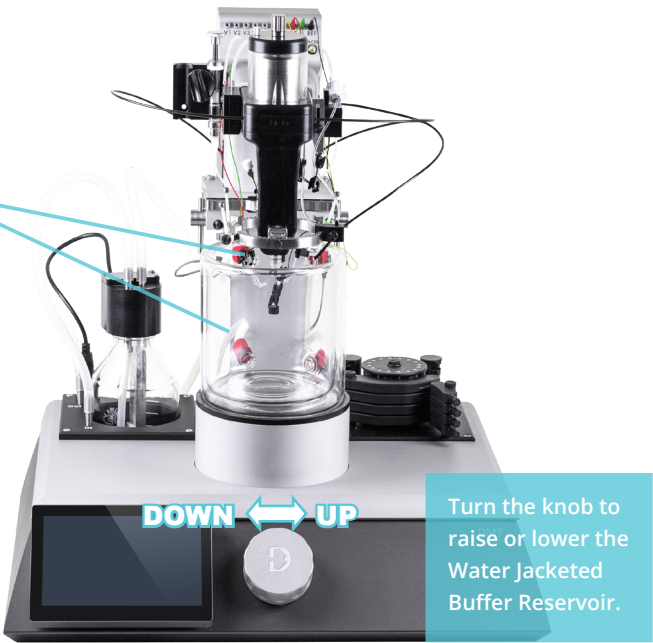
See Appendix C. for safety instructions.

THE MYOHEART LIFT SYSTEM FOR THE WATER JACKETED BUFFER RESERVOIR



CAUTION:

- Risk of getting fingers and hand caught between the Water Jacketed Buffer Reservoir and the steel ring for the ECG, temperature and pacer holders when raising the lift.



DOWN ↔ UP

Turn the knob to raise or lower the Water Jacketed Buffer Reservoir.

# EC DECLARATION OF CONFORMITY

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DMT A/S, Skejbyparken 152, 8200 Aarhus N., Denmark,  
hereby declares its responsibility that the following product:

## **MyoHEART 900MH System**

Restrictive use: Only for laboratory use.

.....

Conforms with the essential requirements of the EMC Directive 2004/108/EC.  
Based on the following specifications applied by:

EN 61326-1:2013  
EN 61326-2-6:2013

And with the LVD Directive 2006/95/EC.  
Based on the following specifications applied by:

EN 61010-1:2010  
EN 61010-2-030:2010

# UNPACKING THE MYOGRAPH SYSTEM

Take a few minutes to carefully inspect your new MyoHEART 900MH system for damage which may have occurred during handling and shipping. If you suspect any kind of damage, please contact DMT immediately and the matter will be pursued as soon as possible. If the packing material appears damaged, please retain it until a possible claim has been settled. We recommend that you store the packing material for any possible future transport of the MyoHEART 900MH system. In case of transport and the original packing material is unavailable, please contact DMT Sales Department for advice and packing instructions. After unpacking your new MyoHEART 900MH system, please check the packing list with the products ordered. If any products are missing please contact DMT your sales representative.

# CHAPTER 1 - SYSTEM OVERVIEW

## MYOHEART SETUP OUTLINE

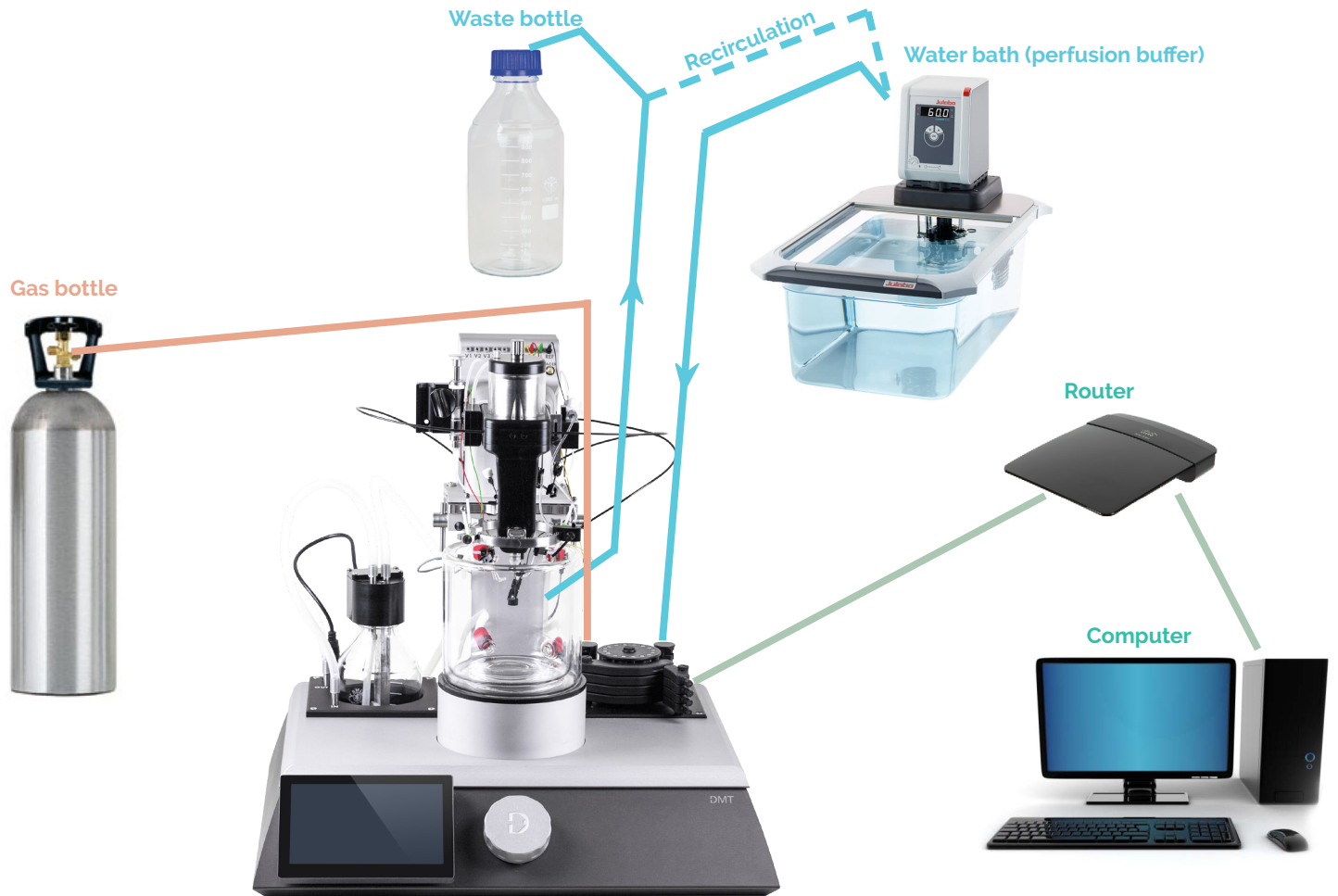


Fig. 1.A.: MyoHEART System setup overview-1.



## MYOHEART SETUP STEP BY STEP



*Fig.2.: The MyoHEART system when unpacked and ready for setting up the complete system.*

- Place the DMT MyoHEART system close to the place for dissection of the mouse/rat or guinea pig heart and a water bath for heating of the perfusion buffer.
- Connect a pressure source to the main pressure inlet pipe marked AIR on the MyoHEART system (see fig. 3A, 3B and 4). The pressure

source must deliver a pressure between 0.5bar and maximum 2bar. If only one gas tank with carbogen is available to supply the pressure to the MyoHEART system, then split the carbogen source using the two supplied T-splitters shown below. One has a needle valve to regulate the gas going into the perfusion buffer. See fig. 3.B.



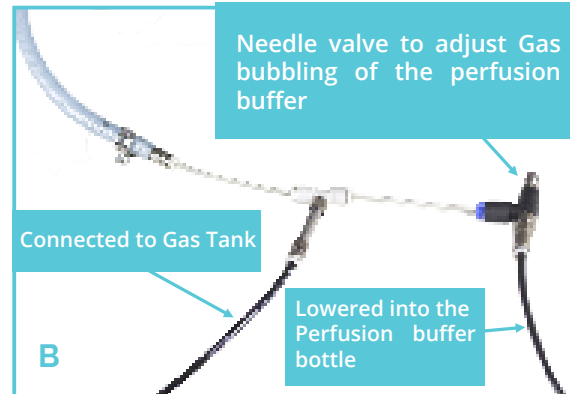
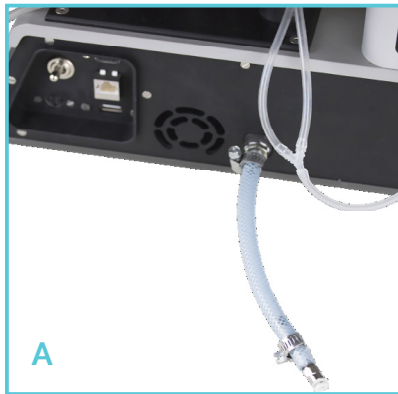


Fig.3.A. and 3.B.: Connect the gas supply to the steel pipe marked Air. 3B: How to split one gas supply to the MyoHEART system and to the Perfusion buffer flask.

- Connect the Power supply to the Power cable plug on the back side of the MyoHEART system.

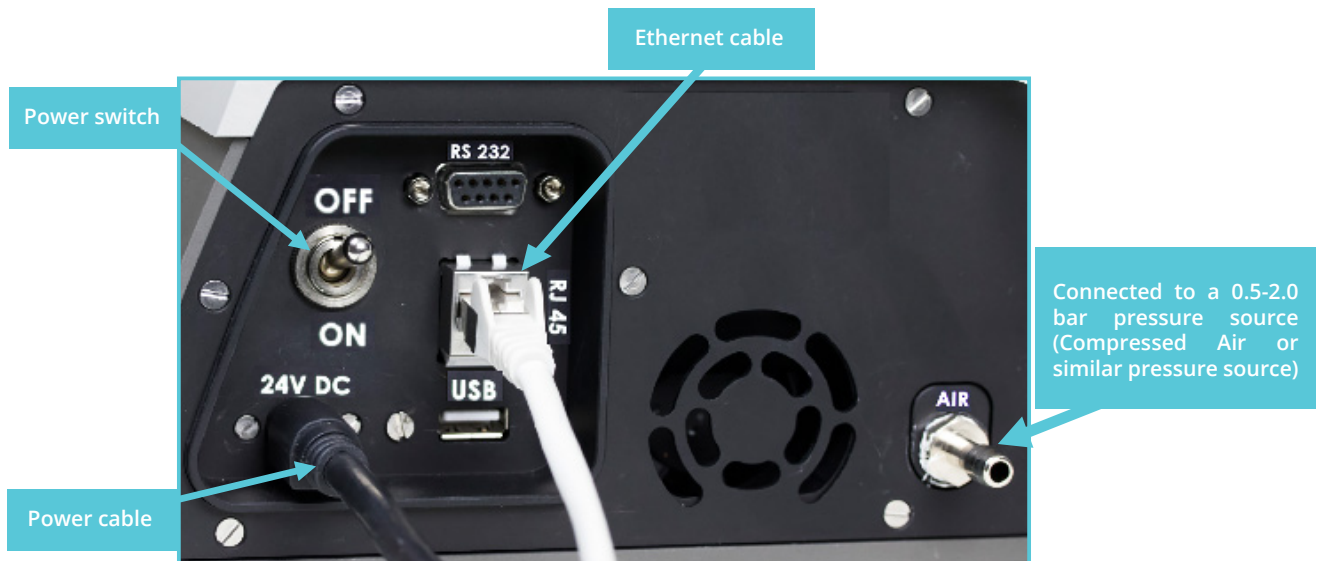


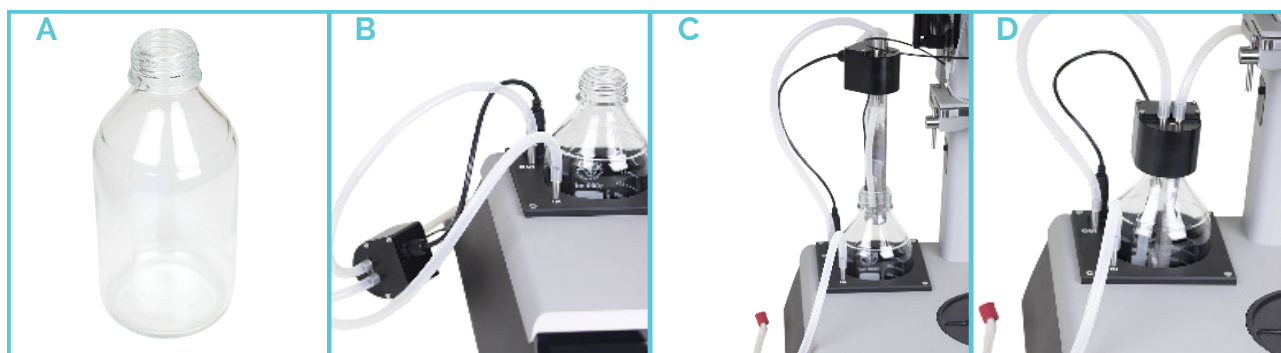
Fig.4.: Connecting ports and pipes on the back side of the MyoHEART system.

- Connect your computer and the MyoHEART system to your local network (see fig.4.) using the two Ethernet cables delivered with the system. It is very important that the computer and MyoHEART system is connected to the same local network. If a network is not available, then use the router supplied with the MyoHEART system.



*Fig.5. If a local network is not available, then connect the computer and MyoHEART system to the supplied Router using the Ethernet cables.*

- Connect the computer and the MyoHEART system to the supplied Router as shown above in fig.5. if a local network is NOT available.
- Place the Heating Bottle (fig.6.A.) in the MyoHEART System as shown in fig. 6.B. to fig.6.D.



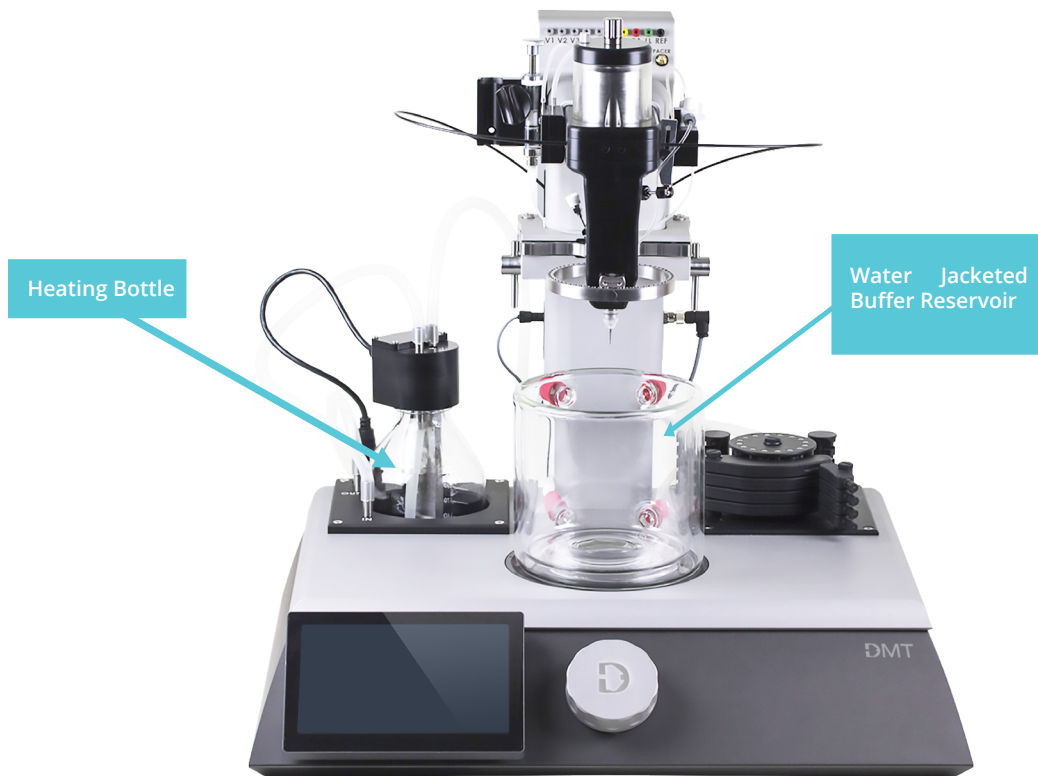
*Fig.6. In fig.6.A. the Heating Bottle is shown. In fig.6.B. to 6.D. shows how to connect the Heating Rod and place it in the Heating Bottle.*

- Place the Water Jacketed Buffer Reservoir (fig.7.A.) on the MyoHEART system (fig.7.B.)

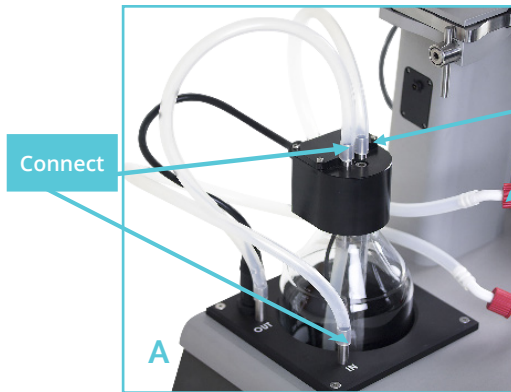


*Fig.7. Place the Water Jacketed Buffer Reservoir on the MyoHEART system.*

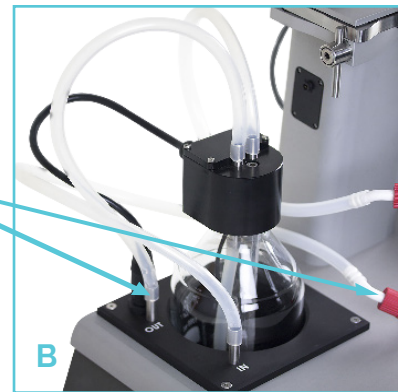
- Connect the tubing between the Heating Bottle and the Water Jacketed Buffer Reservoir as shown in fig.9.A. to 9.C.



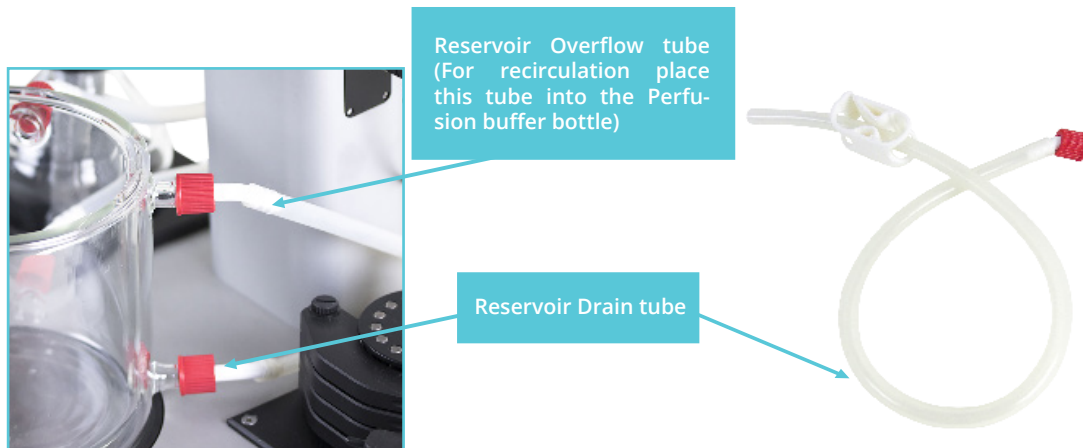
*Fig.8.: The MyoHEART system with the Heating Bottle and Water Jacketed Buffer Reservoir.*



*Fig.9.A.: Connect the silicone tube and the heater Inlet steel pipe marked 'IN' to the left-hand side Heater Rod steel pipe as shown in the above picture. Connect the Reservoir Buffer Bowl outlet to the right-hand side Heater Rod steel pipe as shown in the above picture.*



*Fig.9.B.: Connect the Water Jacketed Buffer Reservoir inlet to the heater outlet steel pipe marked 'OUT' as shown in the above picture.*



*Fig.9.C.: Connect a long silicone tube to the Water Jacketed Buffer Reservoir Overflow outlet. This silicone tube has to be long enough for reaching a waste bottle/tank/sink or back into the Perfusion Buffer Bottle in the water bath for recirculation. Connect the Reservoir Drain Tube to the Water Jacketed Buffer Reservoir Drain outlet as shown above. Make sure the clamp is tight otherwise it will leak from the reservoir.*

- Recirculation of the Perfusion buffer is obtained by connecting the Reservoir Overflow Tube to the peristaltic pump tubes going back into the Perfusion Buffer Bottle in the water bath.
- Install the four Optical Light Fibers on the MyoHEART system if needed. The Optical Light Fiber connector is found on the right side of the MyoHEART Tower (fig.10.A.-E).

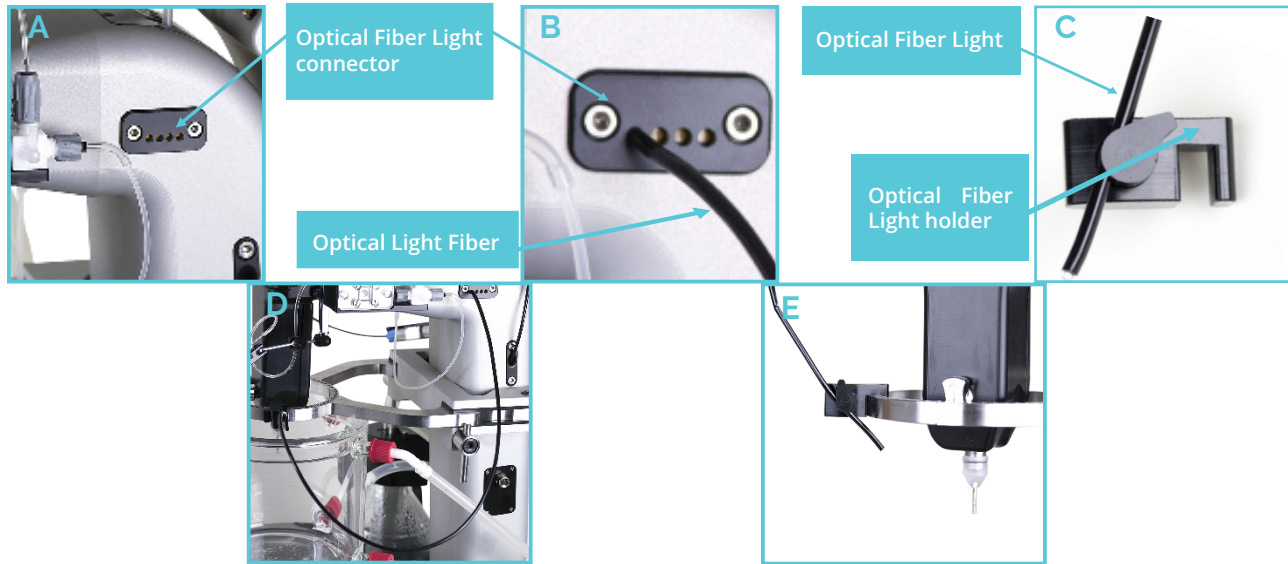


Fig. 10.A.-E.: How to connect the Optical Light Fiber to the MyoHEART system. The Optical Light Fibers can be used to have light on the mounted heart.

- Attach the Infrared (IR) temperature sensor as shown in fig.11.A.-C. The IR-temperature sensor can be used to measure the buffer temperature and also the surface temperature of the heart in a free hanging setup or checking the temperature of the reservoir buffer.

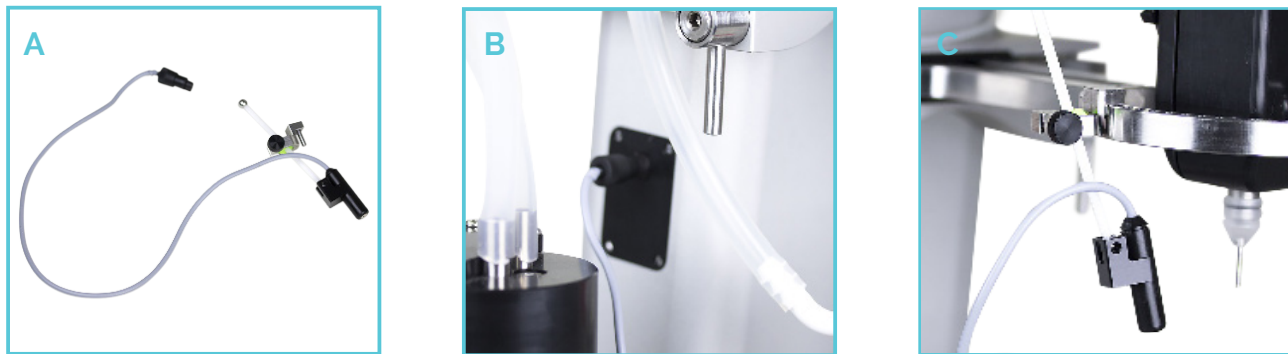


Fig. 11.A.-C.: How to connect the Infrared (IR) temperature sensor to the MyoHEART system. A) Infrared temperature sensor in the fitting. B) Connect the IR-sensor to the MyoHEART system. C) IR-sensor on the MyoHEART system.

- Install the Labchart Pro software on the computer.
- Turn on the power of the MyoHEART system using the Power switch on the right hand backside of MyoHEART system.
- If the Router has been used turn on the power of the Router.
- Start Labchart on the computer. Labchart will search for the MyoHEART system and show it as shown in fig.12.A. Click OK.

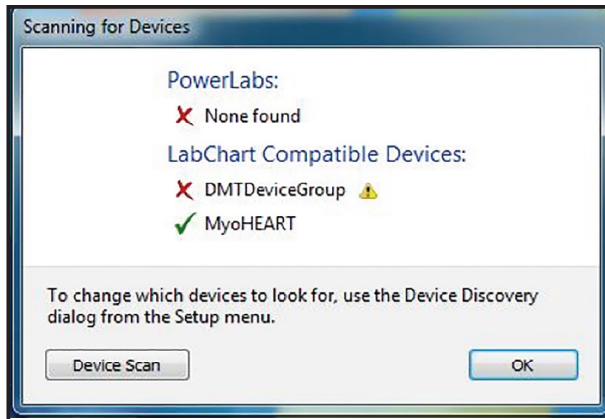


Fig. 12.A.: Scanning for Devices, - MyoHEART is found.

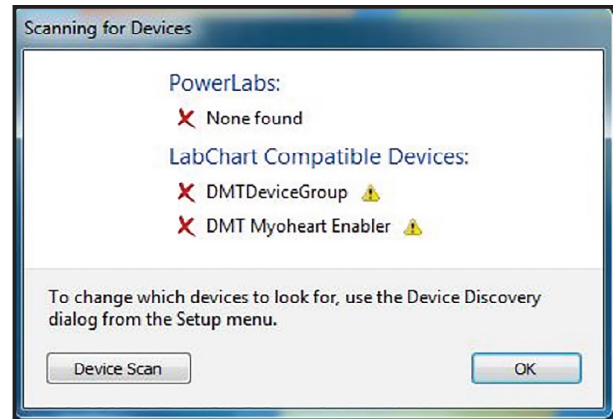


Fig. 12.B.: Scanning for Devices, - MyoHEART is not found.

- If MyoHEART is not found as shown in fig.12.B., then check if the MyoHEART system is turned on
- Restart Labchart. If Labchart still do not find the MyoHEART system, then make sure that

the MyoHEART system and the computer is connected to the same local network. If the router is used, then make sure the Power of the router is on.

- Restart Labchart.

If Labchart finds the MyoHEART system, then Labchart will open and show the channel/parameters selected to be exported in the MyoHEART Settings (See page 93-98).



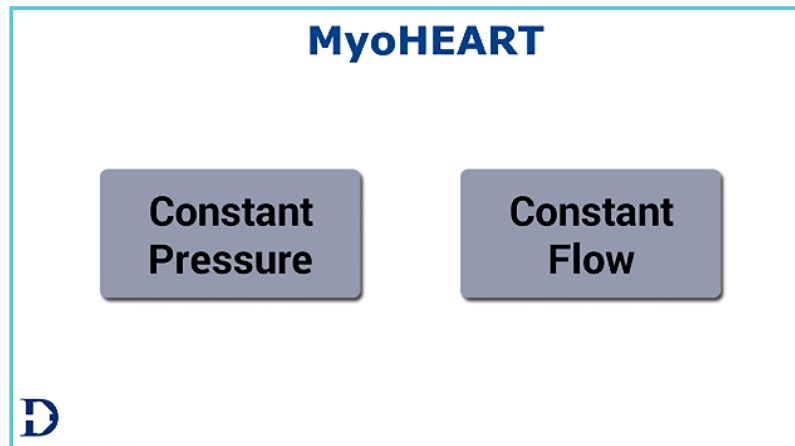


## CHAPTER 2 - STARTING UP THE MYOHEART SYSTEM

Turn on the power of the MyoHEART system using the power switch on the back of the MyoHEART system (see fig. 4.)

The MyoHEART system is a dual system able to perform Constant Pressure and Constant Flow protocols. To be able to measure coronary flow

using the Constant Pressure module, purchase of a Flowmeter (#100.316) for the MyoHEART system would be mandatory. The startup screen is shown below in figure 15. Select the type of protocol either Constant Flow or Constant Pressure.



*Fig. 15.: Start up screen in MyoHEART.*

- Select either Constant Pressure or Constant Flow.

To perform Constant Pressure experiments, press Constant Pressure. The Constant Pressure Main menu is shown in fig.16.



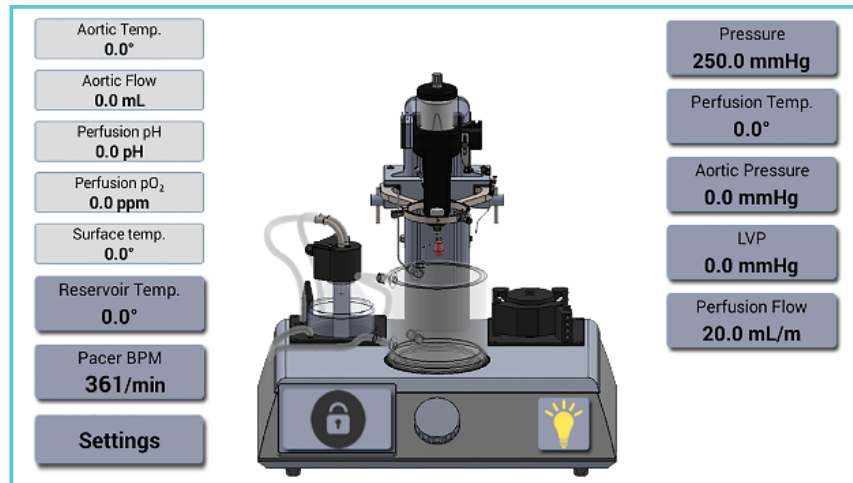


Fig.16.: Main Menu in the Constant Pressure mode.

NOTE: To be able to measure coronary flow in the Constant Pressure Mode a Flowmeter has to be built into the MyoHEART system. If the Flowmeter has not been ordered before delivery of the MyoHEART system, then contact your DMT sales representative.

Fig.17. Indicates the position where the various parameters are measured

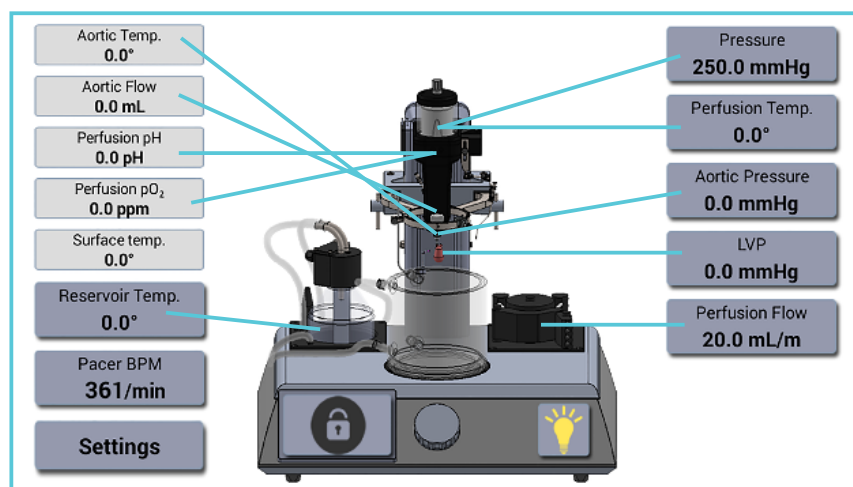


Fig.17.: Main menu in the Constant Pressure mode where the blue lines indicate where the various parameters are recorded.

To perform Constant Flow experiments, press Constant Flow. The Constant Flow main menu is shown in fig.18.

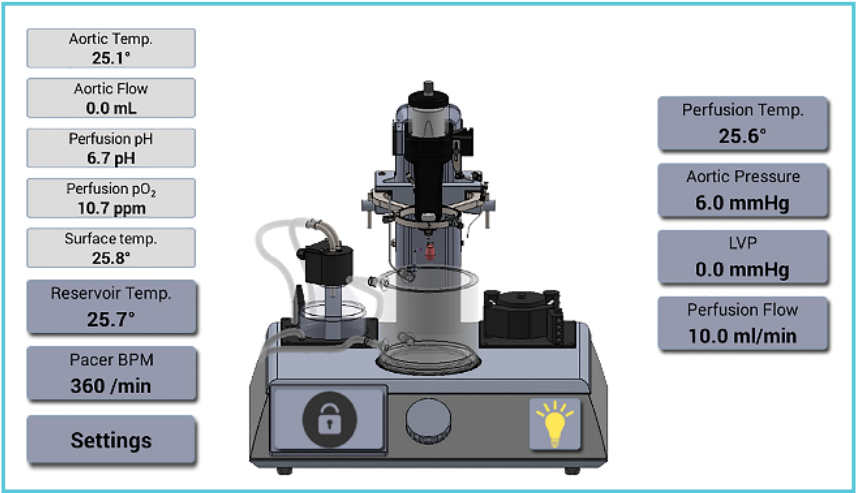


Fig.18.: Main menu in Constant Flow mode.

Fig.19. below indicates the position where the various parameters are measured in Constant flow mode.

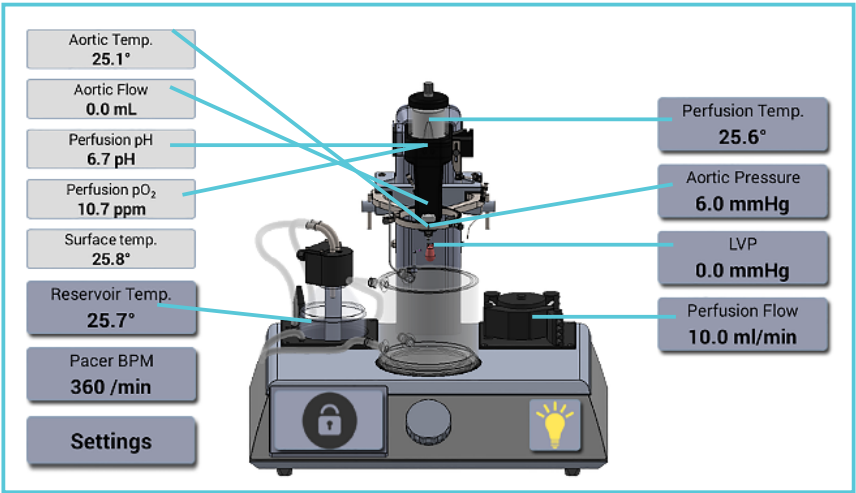


Fig.19.: Main menu in the Constant Flow mode where the blue lines indicate where the various parameters are recorded.

## HEATING UP THE MyoHEART SYSTEM AND BUFFER

- The heating up procedure of the MyoHEART system is the same procedure in Constant Pressure and Constant Flow mode. In the examples below, we have used the Constant Pressure mode but the same menus are used in the Constant Flow mode.
- The MyoHEART perfusion buffer heater is an internal heating system that heat and adjust the perfusion buffer to the setting temperature, ensuring that the perfusion buffer temperature entering the mounted heart is at the setting temperature and constant.
- Turn on the water bath to 37°C or the appropriate temperature for your experiment (the water bath (#100.133) is an accessory not included in the Basic MyoHEART setup). Place the appropriate amount of perfusion buffer e.g. Krebs-Henseleit solution (See appendix A) and a 1l bottle with 1000ml distilled water for the Heating Bottle in the water bath.
- Turn on the heating unit of the perfusion buffer in the Perfusion Temp. menu shown in the Main menu on the right side (fig.20.).

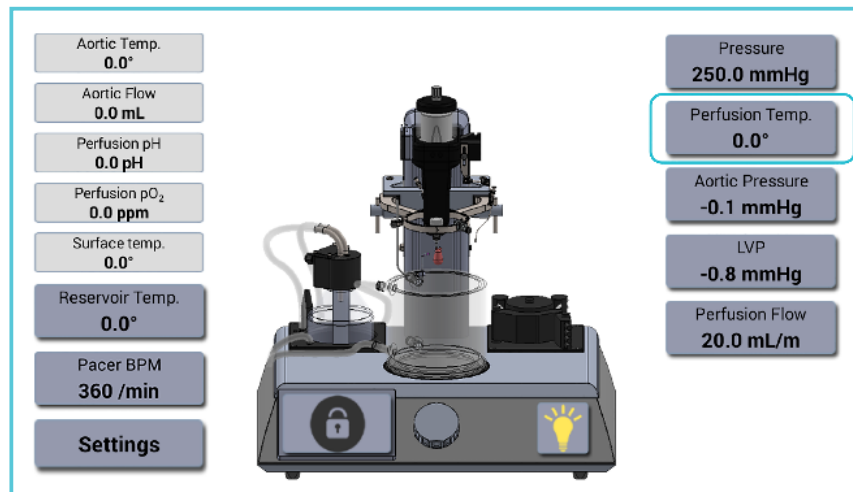


Fig. 20.: The Perfusion Temp. menu.

In the Perfusion Temp menu, the appropriate temperature for the perfusion buffer is selected by scrolling to the setting temperature e.g. 37.0

or by pressing the actual number to show a numeric keyboard to enter the values, as shown in the fig.21.A, B. and C.

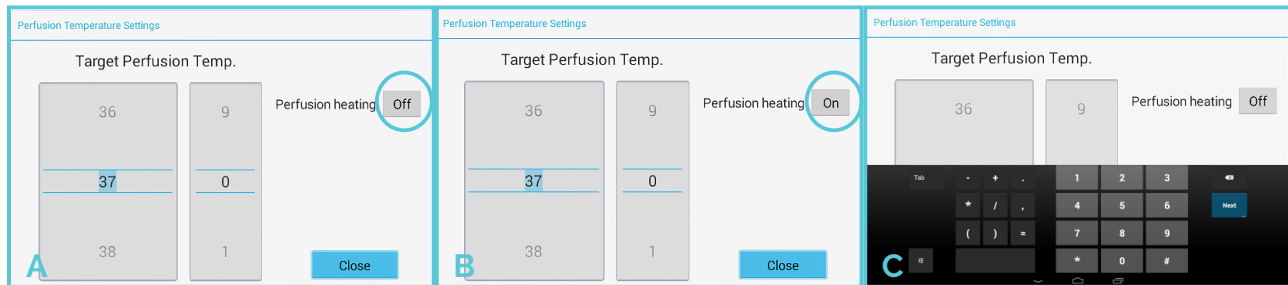


Fig. 21.: A., B. and C.: Entering the Perfusion buffer temperature.

- Turn on the heating unit by activating Perfusion Heating by pressing the Off icon. The icon will change to On as shown in fig.21.B.
- Press Close to close the Perfusion Temperature setting menu and return to the Main menu.
- Now the Perfusion Heating unit will turn blue on the MyoHEART system as shown in fig. 22, indicating that the system has not reached the setting temperature but that the heating is on.

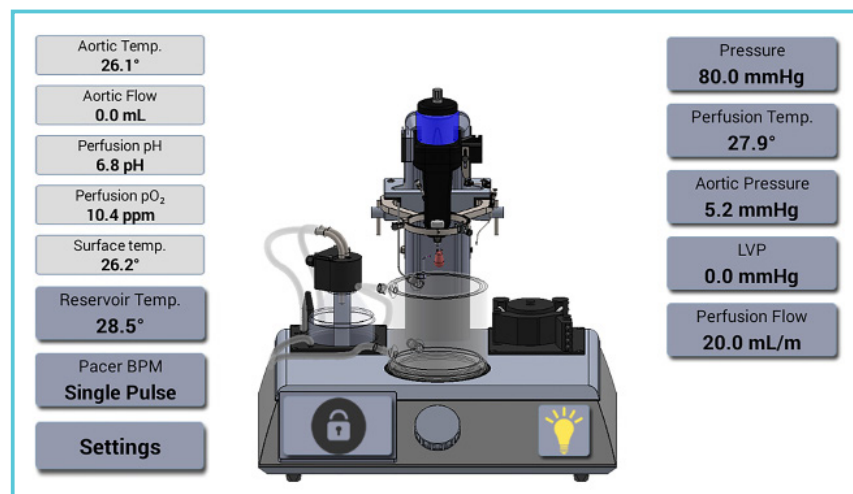


Fig.22.: The blue color of the perfusion heating unit indicate that the actual temperature is lower than the setting temperature.

The Perfusion Heating unit will have no color if the heating is Off.

When the Perfusion Heating unit has reached the setting temperature the perfusion heating unit will turn green as shown in fig.23.

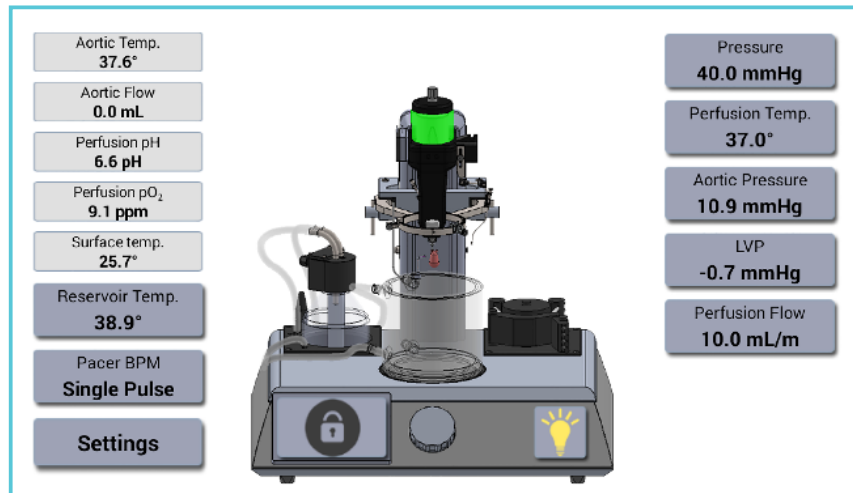


Fig.23.: The green color of the perfusion heating unit indicate that the setting temperature have been reached.

If the actual temperature of the perfusion buffer is higher than the setting temperature, then the Perfusion Heating unit will turn red (fig.24.).

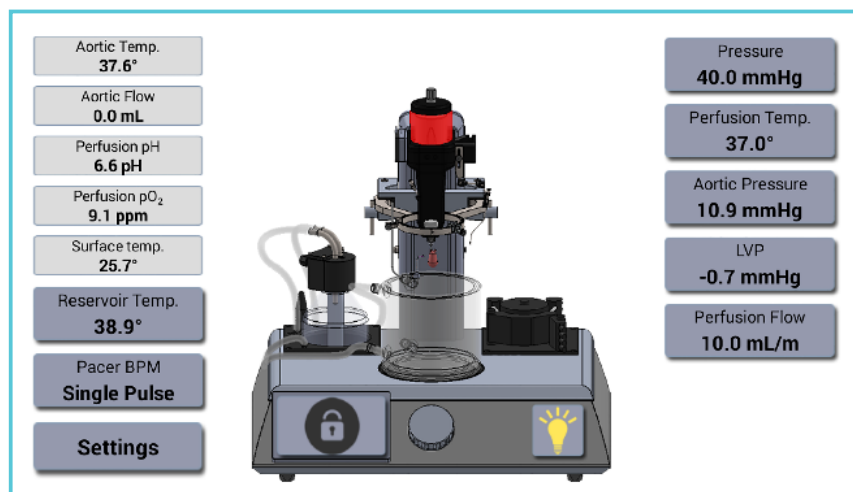


Fig.24.: The red color of the Perfusion Heating unit indicate that the actual temperature is higher than the setting temperature.

The actual temperature of the Perfusion Heating unit will always be shown on the main menu in the Perfusion Temp. menu (fig.25.)

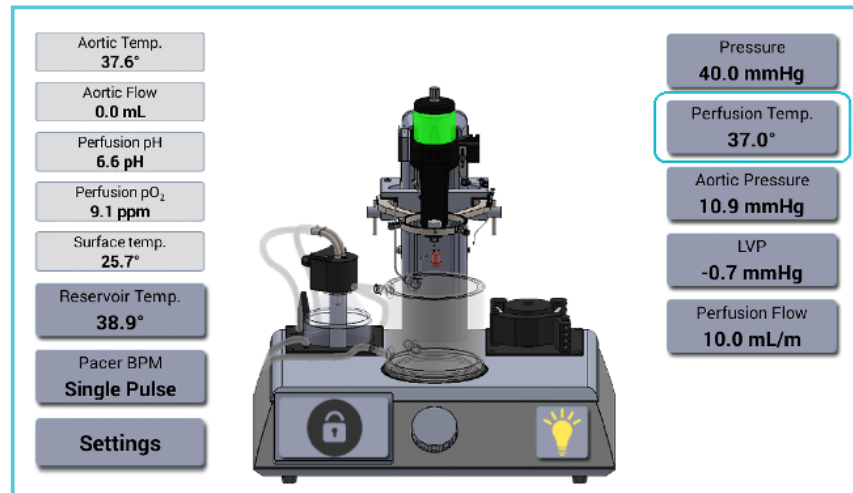


Fig.25.: The green color of the perfusion heating unit indicate that the actual temperature has reach the setting temperature.

The Perfusion Heating unit also function as a bubble trap.

The temperature of the perfusion buffer right before it enters the mounted heart are shown in the top left corner of the Main Menu as the Aortic Temp (fig.26.).

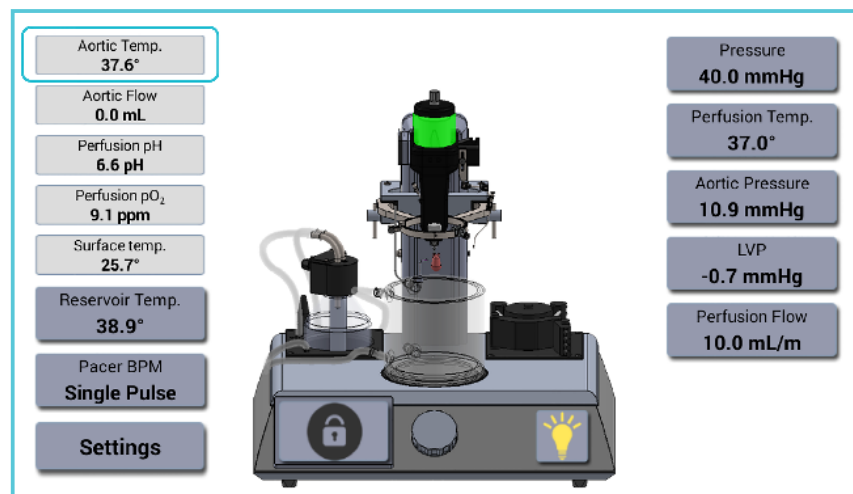


Fig.26.: The temperature of the perfusion buffer just before it enters the mounted heart is shown in the Aortic Temp. field in the Main Menu.

If the Aortic Temp. is not exactly right, then adjusting it with the appropriate temperature difference in the Settings Menu.

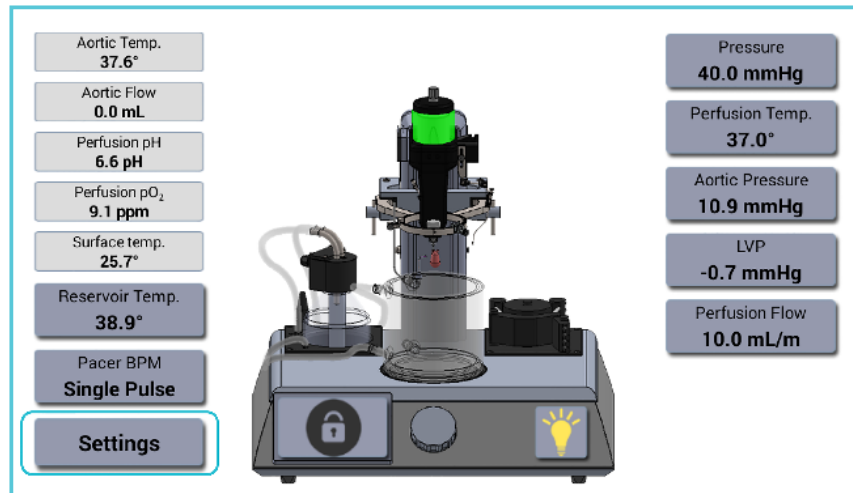


Fig.27.: The Settings menu is found in the lower left corner of the Main Menu.

If the Aortic Temp. e.g. is 1.0°C lower than the Perfusion Temp. in the Main Menu, then adjust the Perfusion temp. diff. (o) to 1.0°C. This means that by setting the Perfusion Temp. in the Main

Menu to 37.0°C degrees the system will heat it up to 38.0°C and thereby taking into account the 1°C temperature loss from the Perfusion Heating unit to the Aortic mounting tip (Aortic Temp.).

**IMPORTANT:** The real Aortic Temp. can only be evaluated when the Perfusion buffer is running through the Aortic cannula tip.

Fig.28.: The Temp. Differences menu.

The Temp. Differences menu is used for adjusting the Perfusion and Reservoir temperature difference between the setting temperature and the measured actual temperature.

The MyoHEART reservoir heating unit is a built-in heating system that will heat distilled water in the heater bottle (see fig.29. and 30.A - B.) and recirculate the heated water between the heater bottle and the Water-Jacketed Buffer Reservoir.

This will keep the reservoir buffer at a given temperature ensuring that the mounted heart will be lowered in buffer at the right temperature.

- Fill the heater bottle with 1000ml pre-heated distilled water.
- Place the Heating Rod, tube and temperature sensor into Heating Bottle as shown in fig.29. and 30.A. and B.

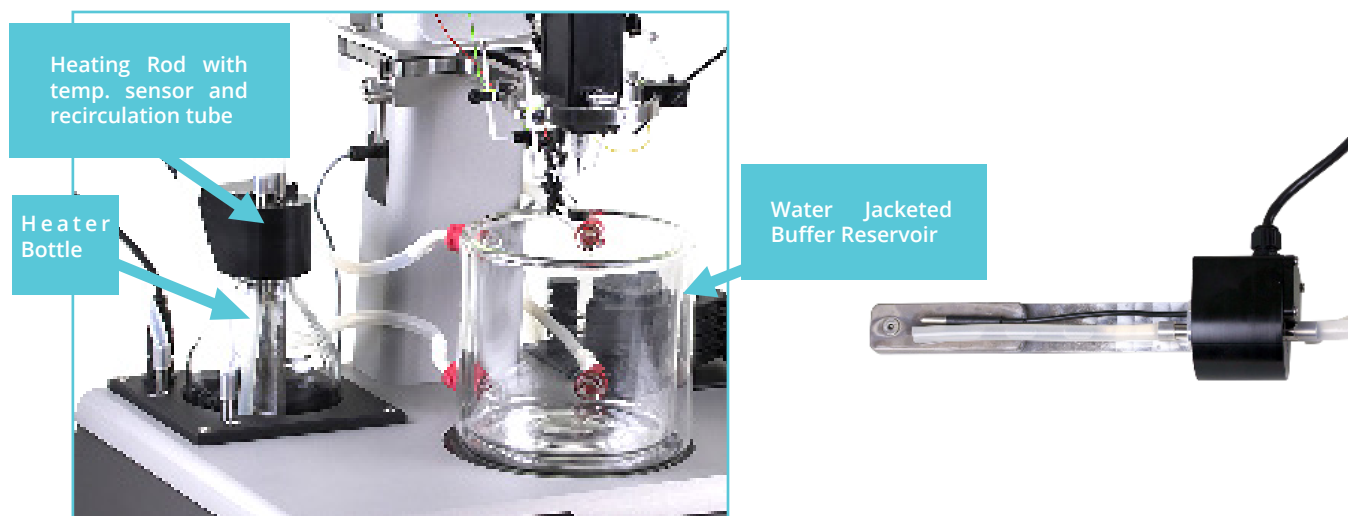
**NOTE:** Attach the power cord and tubing to the Heating Rod, the Water Jacketed Buffer Reservoir and the MyoHEART system as outlined in the System Setup section.



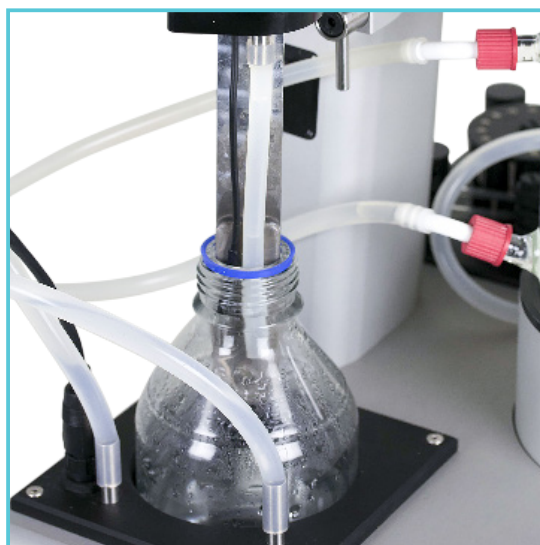
**CAUTION:**

- The heating must always be turned off when the Heating Rod is NOT in the Heating Bottle with distilled water.
- The Heating Rod will have temperatures up to 70°C. High risk of burning accidents by handling when the heating is turned on.
- DO NOT turn on the heating before the Heating Rod is placed in the Heating Bottle with 1liter distilled water.





*Fig.29.: Heating Rod with tubing and temperature sensor.*



*Fig.30.A.-B.: Heating Rod is lowered into the Heating Bottle with 1000ml pre-heated distilled water.*

- Reservoir Temp. menu is used to turn ON and set the temperature of the Water Jacketed Buffer Reservoir.
- Turn on the reservoir heating unit by choosing the Reservoir Temp. menu in the Main Menu left side (fig.31.).

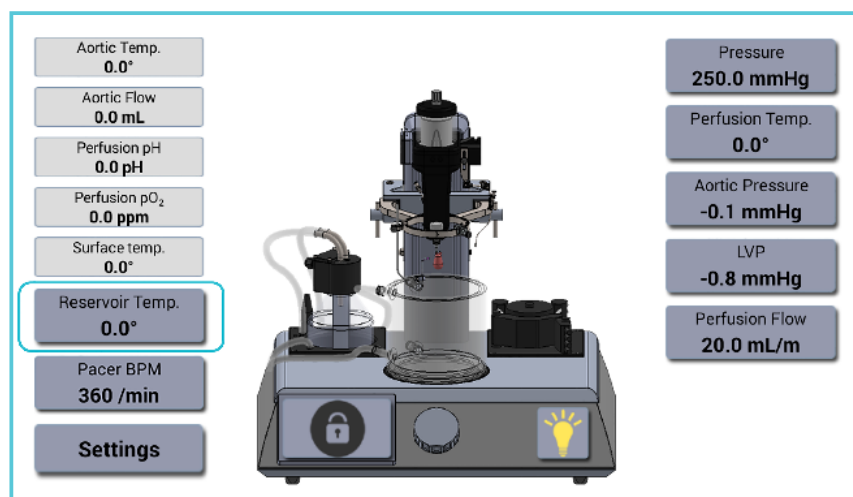


Fig.31. Reservoir Temp. menu.

- Select the appropriate temperature of the Reservoir Temp. by scrolling to the preferred temperature e.g. 37.0°C.
- Set the temperature of the Reservoir by scrolling (fig.32.A.) or by pressing the actual number to show a numeric keyboard to enter the values, as shown in fig.32.B.

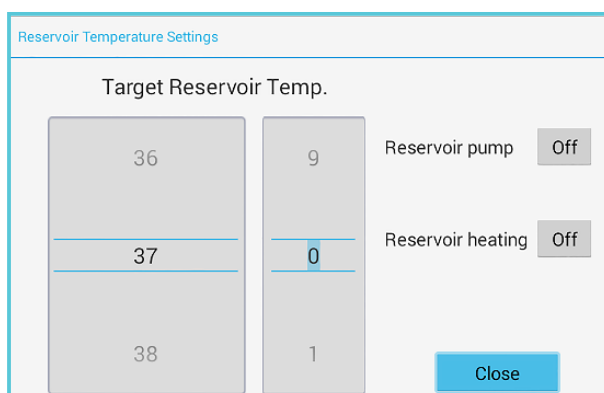


Fig. 32.A.: Reservoir Temperature Settings.

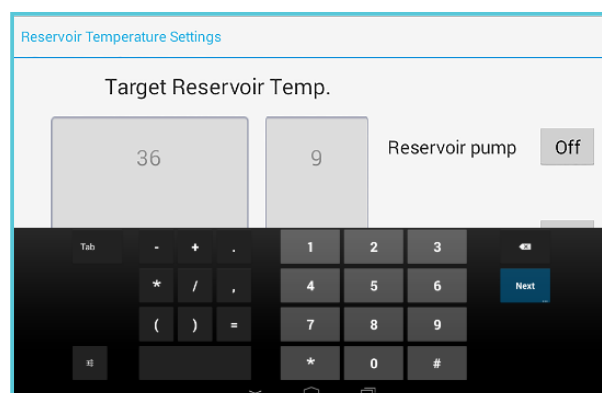


Fig. 32.B.: Reservoir Temperature Settings.

- Turn on the Reservoir Pump by pressing the Off icon (fig.33). The Reservoir Pump will now be On and the distilled water will now re-circulate between the Heating Bottle and the Water Jacketed Buffer Reservoir filling up the reservoir jacket with the preheated distilled water.
- Turn on the Reservoir Heating by pressing the Off icon (fig.33). The heating of the Heating Bottle is now On as shown on the screen.
- Return to the Main Menu by pressing the Close icon.

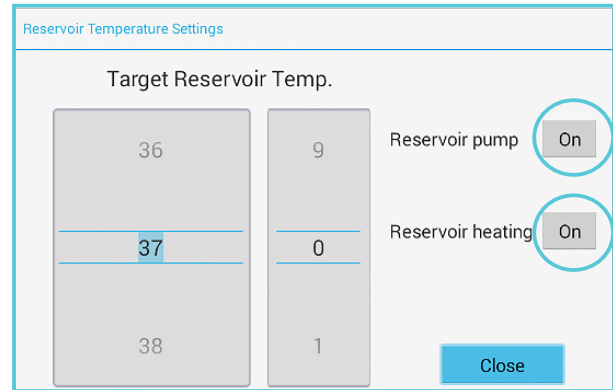
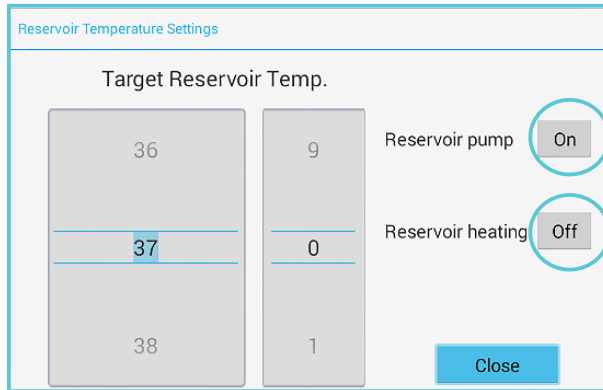


Fig.33.: Reservoir Temperature Settings.

- In the Main Menu the Heating Bottle will turn blue as shown in the figure below, indicating that the temperature is below the setting temperature (fig.34.).

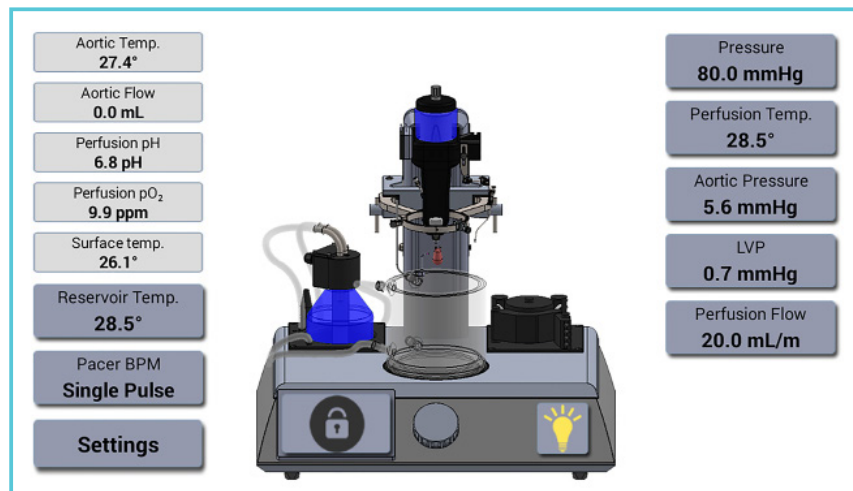


Fig.34. The blue color of the heating bottle indicate that the actual temperature is lower than the setting temperature.

- Add approximately 1.3 liter preheated perfusion buffer or just enough perfusion buffer to reach the overflow outlet in the Water Jacketed Buffer Reservoir (see fig.34.).

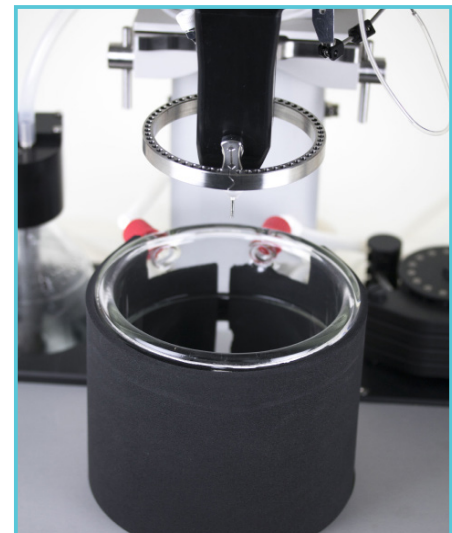


*Fig.35.: Overflow outlet of the Water Jacketed Buffer Reservoir is marked with the blue circle.*

- Fill the Water Jacketed Buffer Reservoir with perfusion buffer up to the overflow outlet as indicated in fig.35.
- Place the Reservoir Insulation Jacket around the bowl as shown in fig.36.A. and 36.B. below.



*Fig.36.A.: The Reservoir Insulation Jacket.*



*Fig.36.B.: The Reservoir Insulation Jacket placed around the Water Jacketed Buffer Reservoir.*

When the temperature in the Water Jacketed Buffer Reservoir has reached setting temperature the color of the Heating Bottle will turn green (fig.37.) and then remove the Reservoir Insulation Jacket from the Bowl.

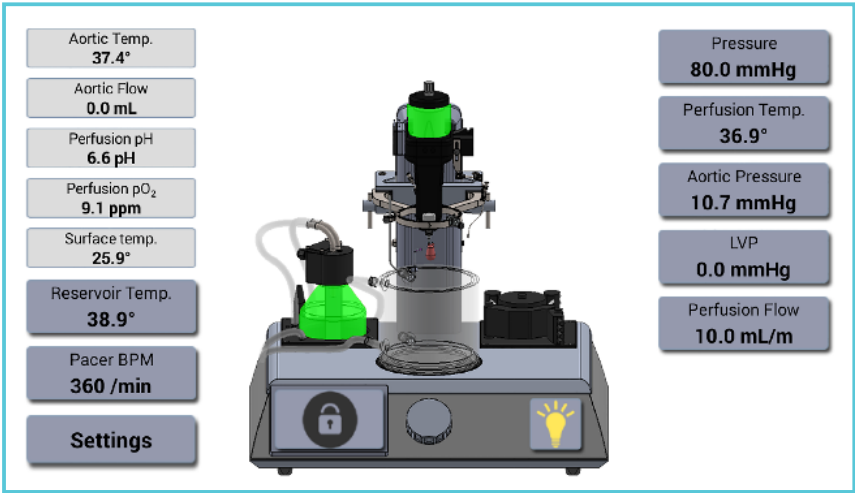


Fig.37.: The green color of the Heating Bottle indicate that the actual temperature has reached the setting temperature.

If the Water Jacketed Buffer Reservoir temperature will go above the setting temperature the color of the Heating Bottle turns red (fig.38.).

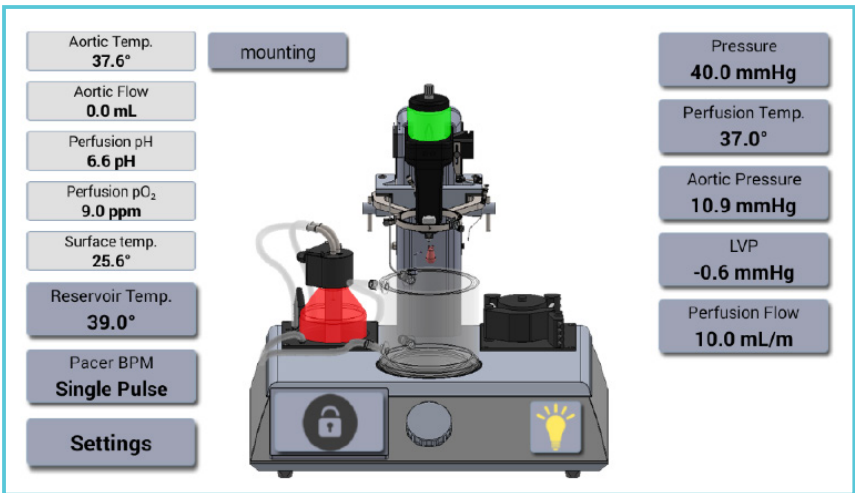


Fig.38.: The red color indicate that the actual temperature is higher than the setting temperature.

When the Setting temperature in the Water Jacketed Buffer Reservoir have reached the setting temperature, then remove the Reservoir Insulation Jacket. Wait 5 minutes and then check the actual buffer temperature in the reservoir with the an external thermometer. The temperature can also be checked with the IR Temp sensor shown in fig.39.



Fig.39.: The IR Temperature sensor.

Fig.40.: The Temp. Differences menu used for entering the off-set temperatures of the Perfusion Buffer and the buffer in the Water Jacketed Buffer Reservoir.

The Temp. Differences menu is used for adjusting the Perfusion and Reservoir temperature difference between the setting temperature and the measured actual temperature.

If the actual temperature of the buffer in the Water Jacketed Buffer Reservoir is 34°C and the

setting is 37°C then add 3°C to the **Reservoir temp diff.(°)** and press **Change**. Now the 3°C is added to the 37°C setting temperature and the heater bottle will now heat the distilled water to 40°C and the buffer in the Water-Jacketed Buffer Reservoir will reach 37°C (see fig.41.).

The screenshot displays the MyoHEART software interface. On the left, a vertical menu contains buttons for 'ECG Settings', 'Export Channels', 'Change license', 'Change workflow', 'Configure Actions', 'Configure pH', and 'Configure O2'. The main area is divided into three sections: 'Device Name' with a text field 'Name' containing 'MyoHEART' and a 'Change' button; 'Pacer Settings' with radio buttons for 'Pacer Voltage Output' (selected) and 'Pacer Current Output', and a 'Rheobase Step' field set to '0.10' with a 'Change' button; and 'Temp. Differences' with fields for 'Perfusion temp. diff. (°)' set to '1.00' and 'Reservoir temp. diff.(°)' set to '3.00', each with a 'Change' button. On the right, there are three status boxes: 'Software Ver. 1.0.0' with a 'Search' button, 'Aortic Mean Flow' at '5.0 secs.', and 'Aortic Mean Pressure' at '5.0 secs.'. Below these are 'BPM ECG Channel' set to 'ECG Lead 1' and a 'Back' button at the bottom right.

Fig.41.: In the example above 1°C is added to the Perfusion temperature and 3°C to the Reservoir temperature as off-set temperatures.

## PURGING THE MyoHEART SYSTEM WITH PERFUSION BUFFER

When the perfusion heating unit temperature and the buffer in the Water Jacketed Buffer Reservoir has reached the setting temperature, then lower the perfusion inlet tubes from

the peristaltic pump unit into 1000 – 5000ml preheated perfusion buffer placed in a water bath (see fig.42.).

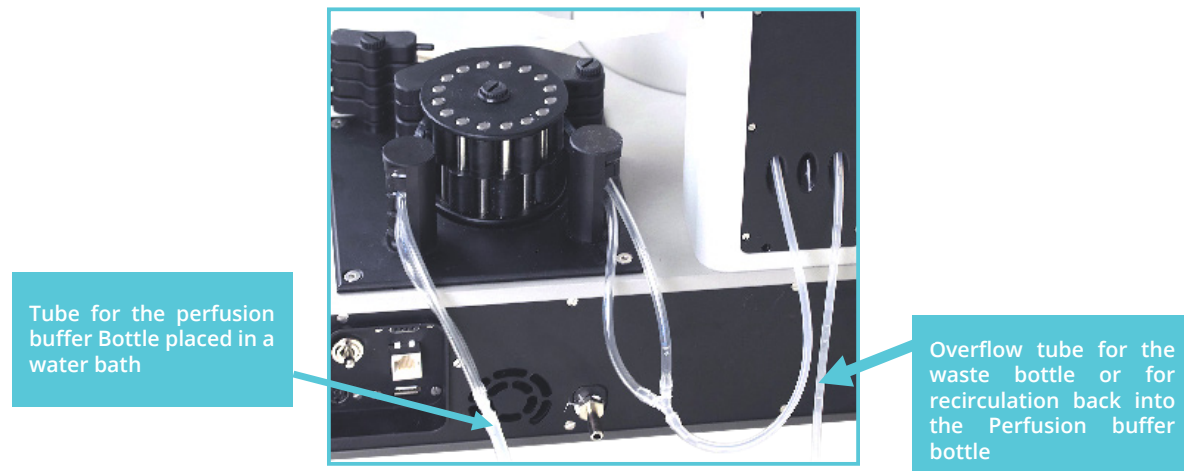


Fig.42.: Overview of where to place the tubes for the perfusion buffer and the overflow tube.



The overflow tube coming back from the pressure regulator can either be placed in a waste bottle or back into the perfusion buffer bottle in the water

bath for recirculation. DMT recommend to place the overflow tube back into the perfusion buffer bottle in the water bath to save buffer.

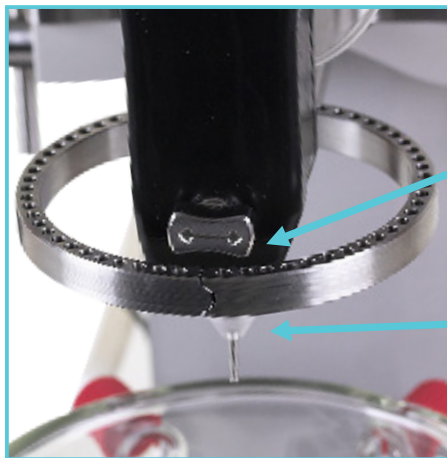


Fig.43.A.: Aortic stopcock closed position.

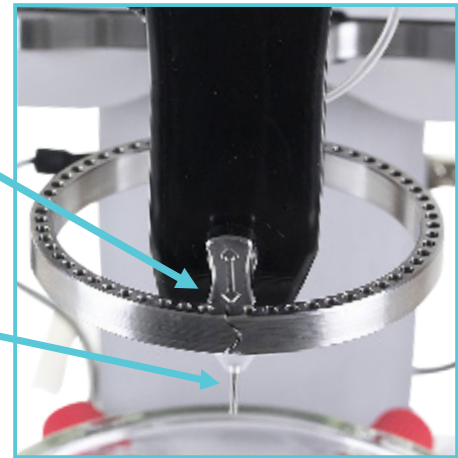


Fig.43.B.: Aortic stopcock open position.

1. Turn the stopcock to close the flow towards the aortic inlet and stop the flow into the aortic cannula. (fig.43.A. and 43.B.)
2. In Constant Pressure mode turn on the MyoHEART Main Pressure in the Main Menu. In Constant Flow mode go to point 5.

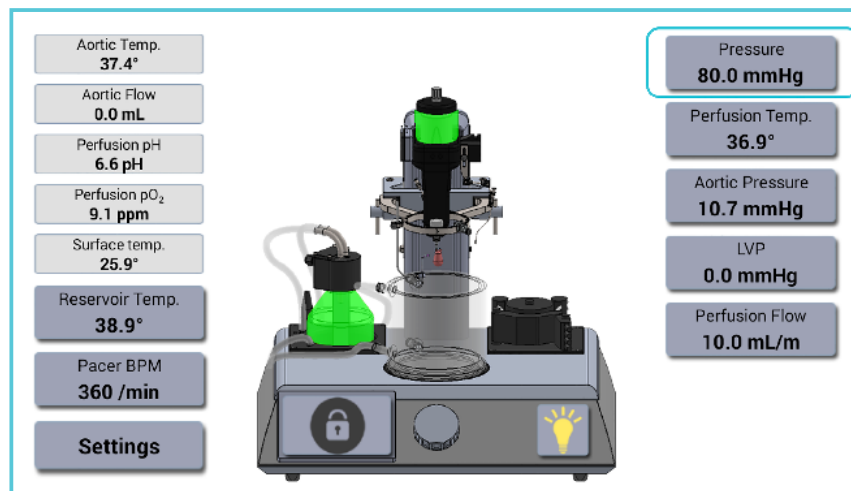


Fig.44.: The Pressure menu.

The Pressure menu in the Main menu (Constant Pressure Mode) is used to turn on the Main pressure of the MyoHEART system.



3. Select the appropriate pressure by either scrolling or enter the value using the numeric keypad (Press on the value and the keypad will show).

4. Press the Off icon and the Main Pressure will be On as in fig.45.B.

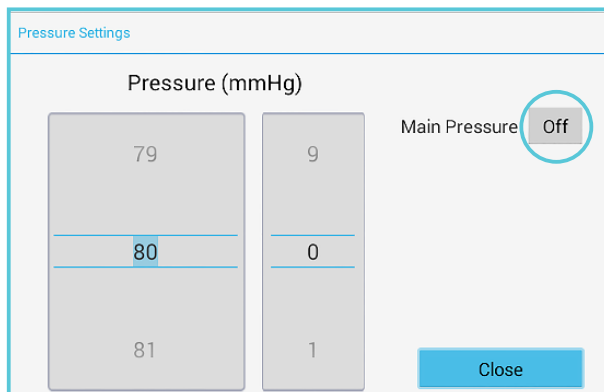


Fig.45.A.: Pressure menu.

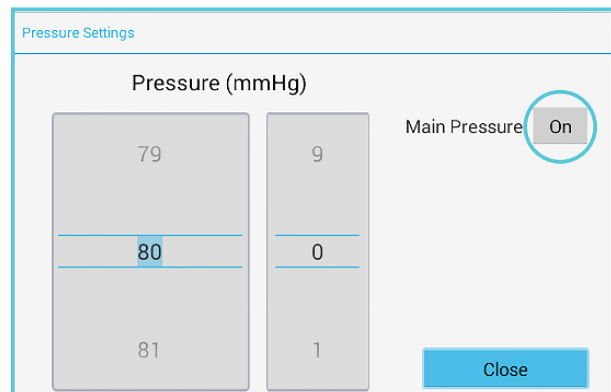


Fig.45.B.: Pressure menu.

NOTE: If a buzzing sound appears, then check if the pressure source (e.g. gas tank) have been connected to the steel pipe marked AIR on the backside of the MyoHEART system, and that the gas supply has been opened (0.5 - 2.0 bar).

In the Main Menu a green icon will be shown in the Pressure field (see fig.46.).

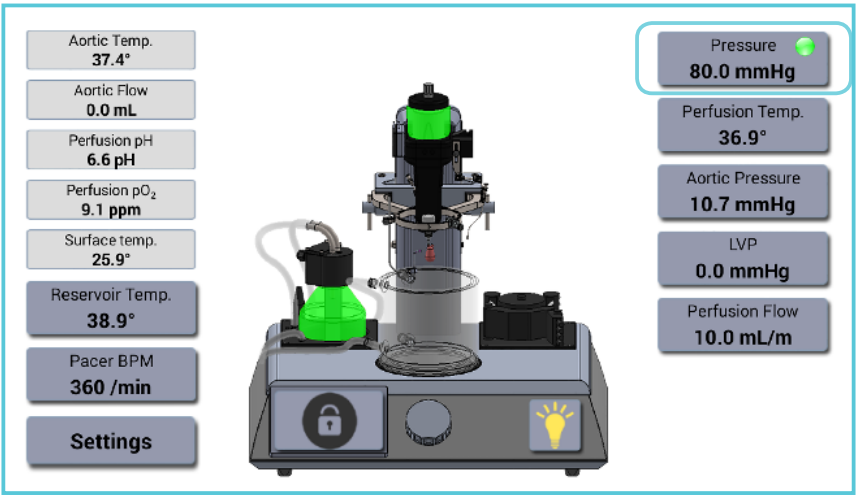


Fig.46.: Green ON icon is shown in the Pressure menu when the pressure is on.

When the main pressure of the MyoHEART system have been turned ON a green icon will appear in the Pressure menu.

For the MyoHEART system to be able to keep the pressure at a given pressure two things has to be checked carefully:

- a. A pressure source has to be connected to the main pressure inlet pipe marked AIR on the MyoHEART system with a pressure source providing pressures between 0.5bar and 2bar (see fig.47.).

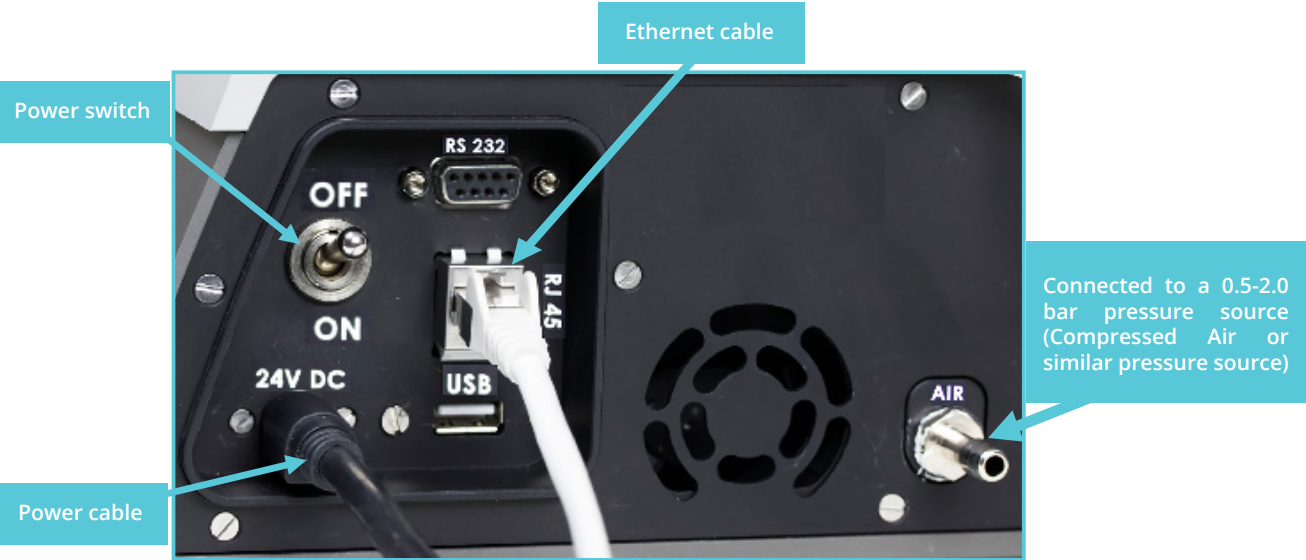


Fig.47.: Connection for a 0.5 – 2.0bar pressure source.

- b. The perfusion flow has to be turned on. If the flow is too low the pressure cannot be maintained. If the flow is too high a lot of perfusion buffer will be 'pushed' into the overflow tube running either into the perfusion buffer bottle in the water bath (recirculation option) or into the waste. It is important that the flow always is high enough to push perfusion buffer into the overflow

tube, therefore check the tube after you have changed pressures or if you observe that the MyoHEART system cannot maintain a given set pressure. If so, then the flow may need to be increased in the Perfusion Flow menu (see below). An appropriate perfusion flow is needed to keep the pressure at a certain set pressure and will be dependent on how much buffer the mounted heart will 'consume' per

5. Set the Perfusion Flow to an appropriate flow per minute to purge the system. The Perfusion Flow menu is shown in the Main Menu.

6. Press the Perfusion Flow menu.

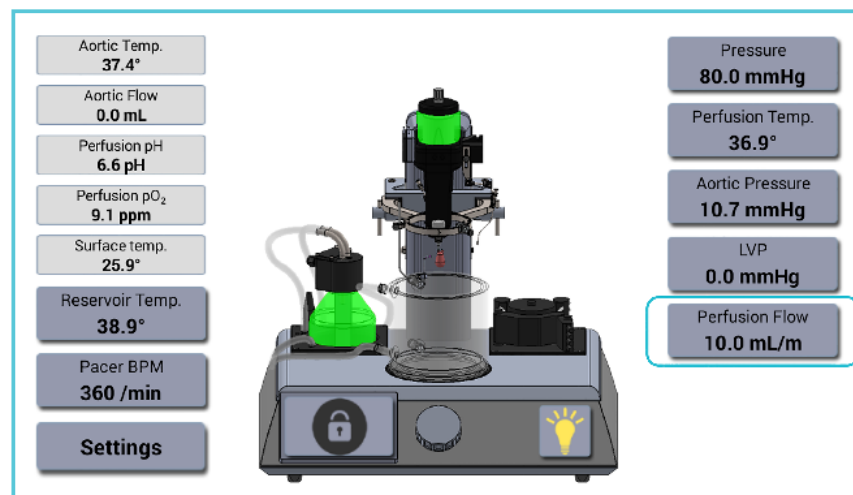


Fig.48.: Constant Pressure Mode. Turn on the Perfusion Flow.

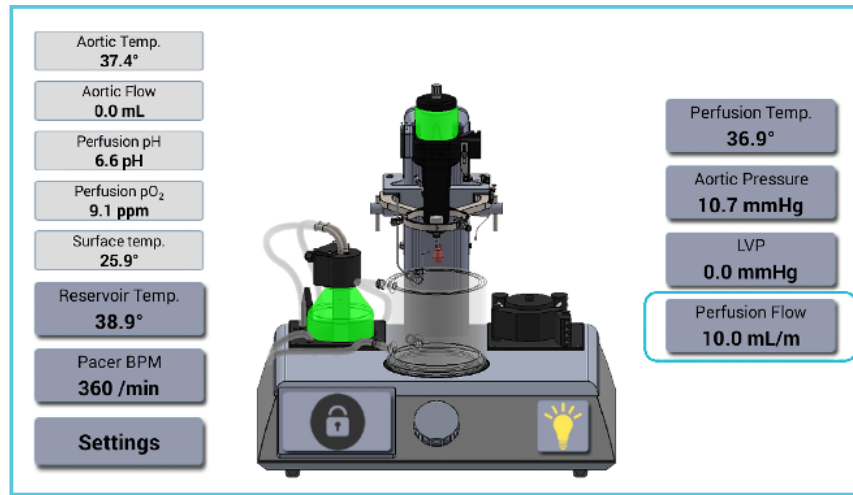


Fig.49.: Constant Flow Mode. Turn on the Perfusion Flow.

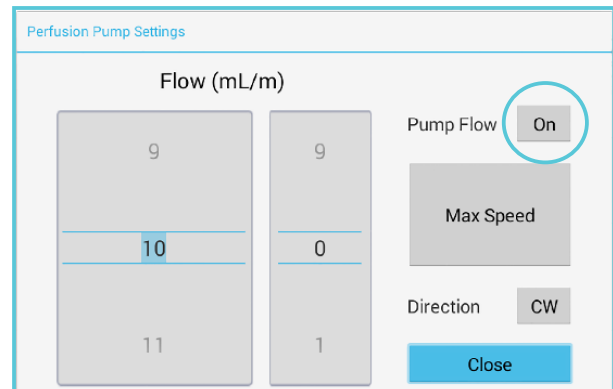
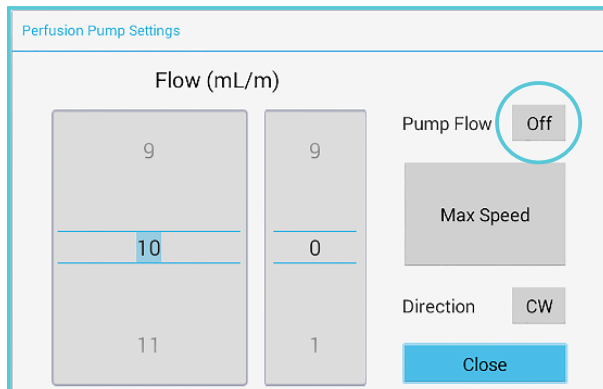


Fig.50.A., B.: Perfusion Pump Settings menu.

## 7. Turn On the perfusion flow (ml/min) by starting the peristaltic pump.

The Flow is set using the scrolling option or by pressing the value and entering the new flow using the numeric keypad (see the fig.51.). The Pump is turned on by pressing the Off icon, then the icon will change to On (see fig.50.A. and 50.B.).

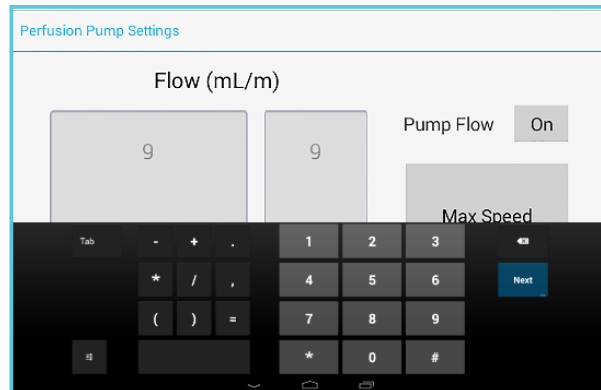


Fig.51.: setting the flow using the key pad option.

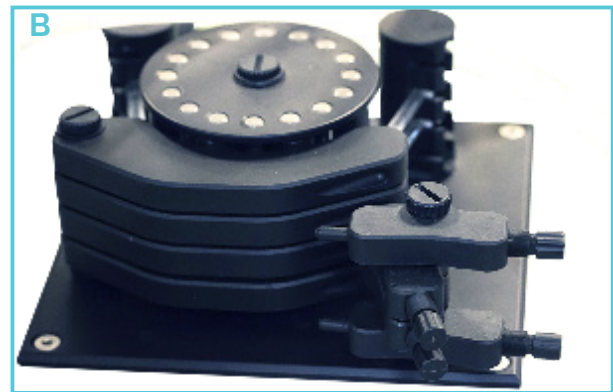
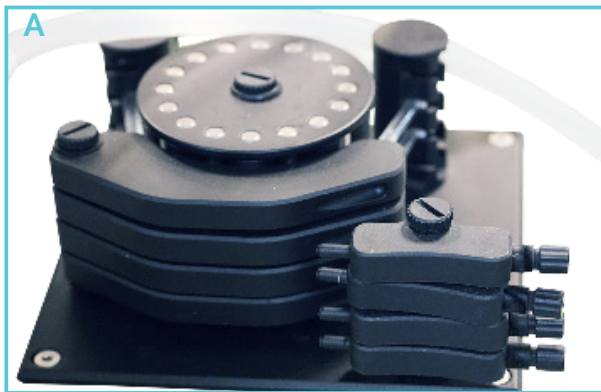


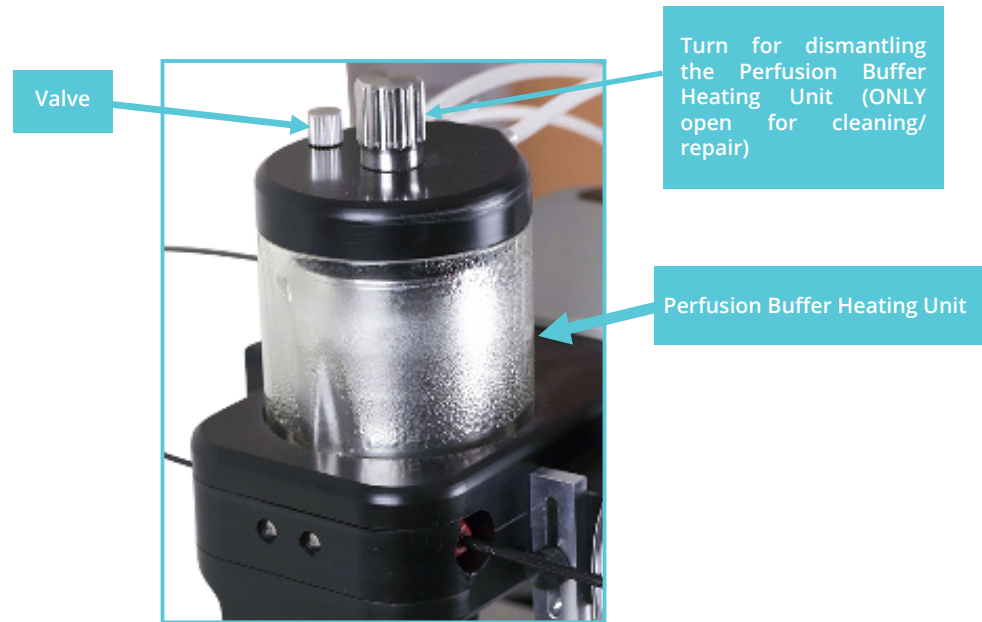
Fig.52.: A) Compression arms on the peristaltic pump are open and no compression on the tubes are made in this position and thereby no flow. B) The compression arms are turned in and the right compression on the tubes can be adjusted using the finger screws.

8. Make sure the compression arms on the peristaltic pump are in the position as shown in fig.52.B. when the pump is used. After use remember to release the compression arms to preserve a longer lifespan of the tubes in the peristaltic pump as shown in fig.52.A.

The perfusion buffer will now be forced into the overflow tube (see fig.53.). If this is not the case, please read the above again carefully.

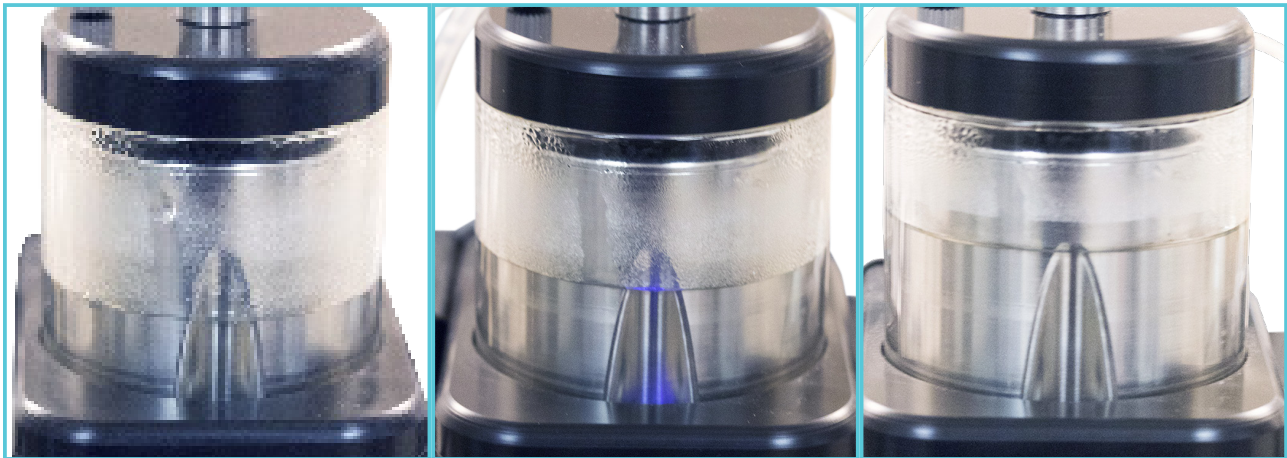
NOTE: Remember to 'flip-in' the appropriate compression arms on the roller pump to make a pressure on the two tubes as shown in fig.52.A. and 52.B. below, otherwise the flow will be zero.

9. Open the valve on top of the Perfusion Buffer Heating Unit (see picture below)



*Fig.53.: The Perfusion Buffer Heating Unit.*

The perfusion buffer will not enter the overflow tube but build up in the Perfusion Buffer Heating Unit as shown below in fig.54.A., B. and C.



*Fig. 54.A., B. and C.: Filling the Perfusion Buffer Heating Unit with perfusion buffer.*

10. Close the valve when the perfusion buffer has reached the top of the groove made in the steel block in the Perfusion Buffer Heating Unit as shown in fig.54.C. The level of the perfusion buffer does not have to be very precise. Now the Perfusion Buffer Heating Unit will operate as a bubble trap, as a compliance chamber and also heat the perfusion buffer to the set temperature.

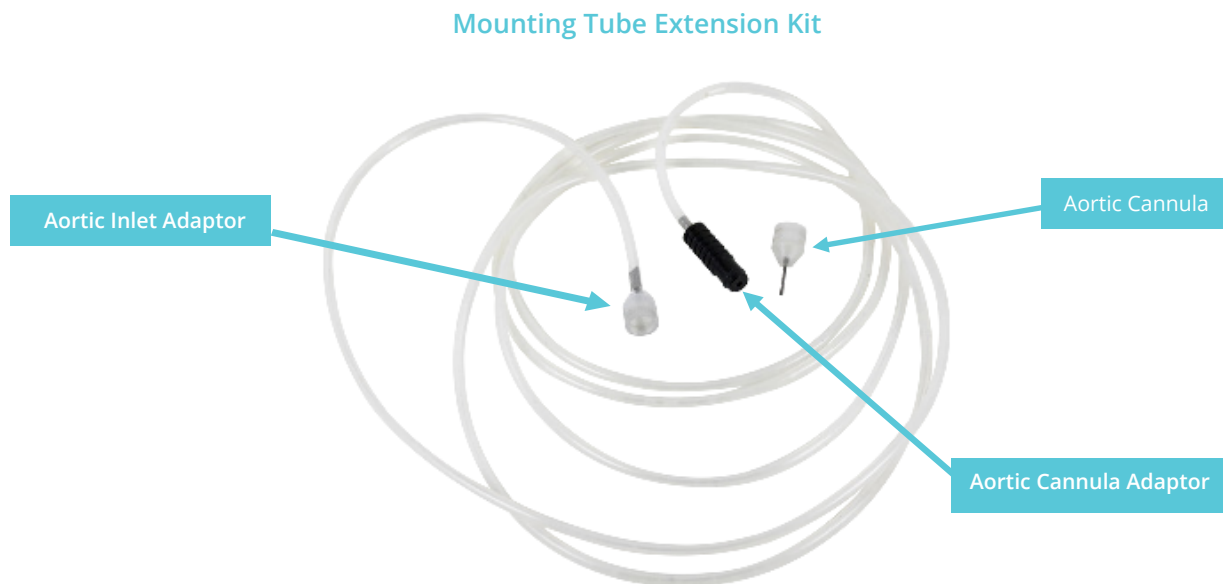
11. The perfusion buffer will now run into the overflow tube which can be placed into the perfusion buffer bottle in the water bath or into the waste.

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## PREPARE THE MyoHEART SYSTEM FOR THE HEART EXCISION AND MOUNTING

The Mounting Tube Extension Kit has a 5m tube with an Aortic Cannula adaptor in one end and an Aortic Inlet Adaptor at the other end (fig.55.). Make sure that the tube is long enough to reach

from the MyoHEART Aortic Inlet to where the heart is excised, - if not then cut a new piece of tubing with the right length. The tube can always be cut shorter if needed.



*Fig.55.: Mounting Tube Extension Kit.*

- Select the right size Aortic Cannula for the heart and connect it to the Aortic Cannula Adaptor on the Mounting Tube Kit (fig.56.A.).
- Connect the Mounting Tube Extension Kit to the Aortic Inlet as shown below (fig.56.A. and B.).



*Fig.56.: A) Mounting Tube Extension Kit with an Aortic Cannula mounted.*



*Fig. 56.B.: Mounting Tube Extension Kit attached to the Aortic Inlet of the MyoHEART system.*

- Open the aortic inlet stopcock to fill the Mounting Tube with perfusion buffer. To fill the Mounting Tube Extension Kit faster press, the Max Speed button in the Perfusion Flow menu.
- Place the Aortic Cannula back in the perfusion buffer bottle, when the mounting tube is free of air bubbles and filled with perfusion buffer.
- Set the flow to an appropriate flow. This will keep the perfusion buffer in the mounting tube warm and ready for mounting the heart.



# MyoHEART ACTION BUTTONS

There are various preferences for pressure and flow supply through the Aorta Cannula in the mounting tube when mounting the heart. Here are some examples:

- a) No Flow and pressure
- b) Low flow and low pressure e.g. 10ml/min and 40mmHg for rat heart
- c) Normal flow and pressure e.g. 20-30ml/min and 80-100mmHg

NOTE: DMT recommend that the heart is always mounted with a flow to avoid blood clotting in the cannula.

In MyoHEART it is possible to predefine up to three Action Buttons with a given flow and pressure that can be used e.g. during the heart

mounting process. Use the Action Buttons in the Settings Menu.

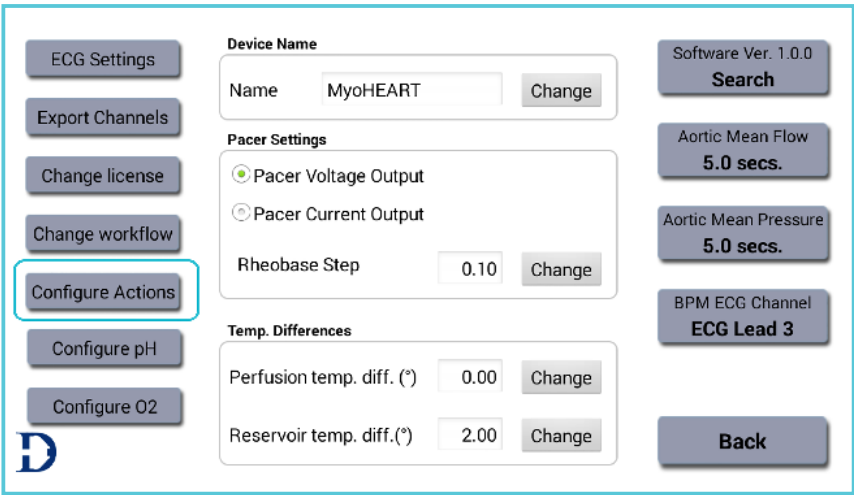


Fig. 57: The Configure Action buttons menu.

The Configure Actions menu is used to predefine flow and pressures assigned to a short-cut key/icon in the Main Menu.

## CONFIGURE ACTION BUTTONS IN THE CONSTANT PRESSURE MODE

- Press the Configure Actions icon to enter the Configure MyoHEART Actions menu (fig.58.).

Configure MyoHEART Actions

Action Button 1 ☐ Enabled Action Name

**Perfusion Flow Settings**

☒ Flow Enabled

Value ml/min.

**Pressure Settings**

☒ Pressure Enabled

Value mmHg

Cancel Save

Fig.58.: The Configure Actions menu in the Constant Pressure Mode.

In the Constant Pressure mode, it is possible to change and set the pressure and flow (the flow is to maintain the given set pressure) whereas in the Constant Flow mode it is only possible to set and change the flow.

Changing the flow parameter in the Constant Pressure mode could be necessary for the

MyoHEART system to be able to maintain a new given pressure. Therefore, always check if the MyoHEART system is able to keep a given set pressure. If there is no perfusion buffer pushed into the over- flow tube then the flow is too low and need to be increased.

CONFIGURE ACTION BUTTONS IN THE CONSTANT FLOW MODE

In Constant Flow mode the Action Buttons' menu is shown as in the fig.59.

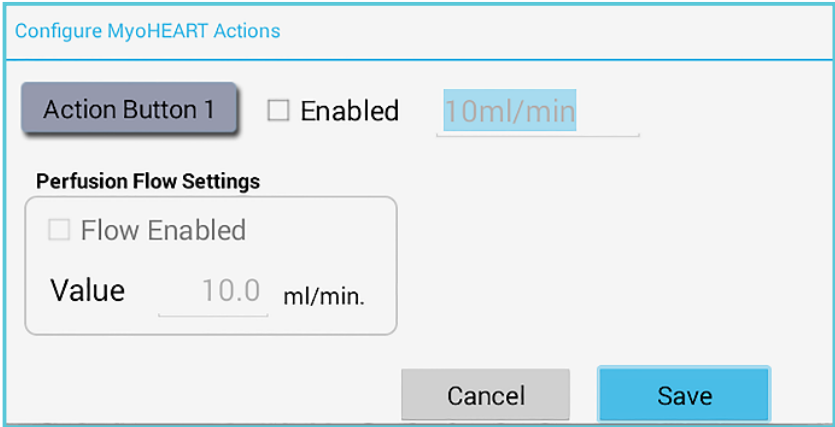


Fig.59.: The Configure Actions menu in the Constant Flow Mode.

Changing the flow parameter in the Constant Flow mode will change the rpm speed of the peristaltic pump. The flow delivered by the pump defined by

the tubing-set used in the peristaltic pump will be shown in the Main menu of MyoHEART (fig.60.).

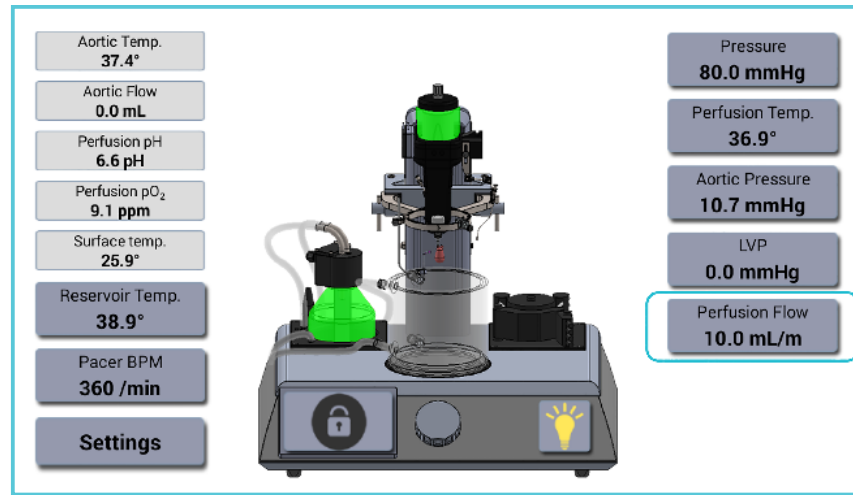


Fig.60.: The Perfusion Flow menu.

The Perfusion Flow menu is used to turn ON and set the Perfusion Flow.

The flow settings are indirectly the speed of the peristaltic pump and not the actual real flow. The actual real flow can only be measured with an internal 901FM flowmeter (#100.316) which is an add-on to the MyoHEART system. Even with an internal flowmeter the flow set in the Action Buttons is still the speed of the peristaltic pump that will deliver the approximately flow set in the Perfusion Flow Settings. This flow is based on the rpm of the pump and the diameter of tubing-set on the peristaltic pump.

If the internal flowmeter has been added to the MyoHEART system, the flowmeter can be used to adjust the Perfusion Flow Setting to a value that will give the approximately ml/min. An example could be that the Perfusion Flow Setting is 10.0ml/min but the internal flowmeter shows a flow of

9.1ml/min. The Perfusion Flow Setting could then be raised until the Aortic Flow shows 10.0ml/min



**NOTE:** Do this before the heart is mounted.

The flow rate is dependent on the pressure being adjusted at the finger screw on the peristaltic pump and the time period of operation of the tubing-set. Over time the tubing is stretched and will alter so that the long-term stability declines. DMT recommend that the tubing-set is replaced after 5 days' use. The flow stability (short term) is +/- 2%. To get a precise measurement of the real flow a flowmeter can be integrated into the system. If the flowmeter is added to the MyoHEART system, the real flow can be seen in the Main Menu of MyoHEART as the Aortic Flow (fig.61.).

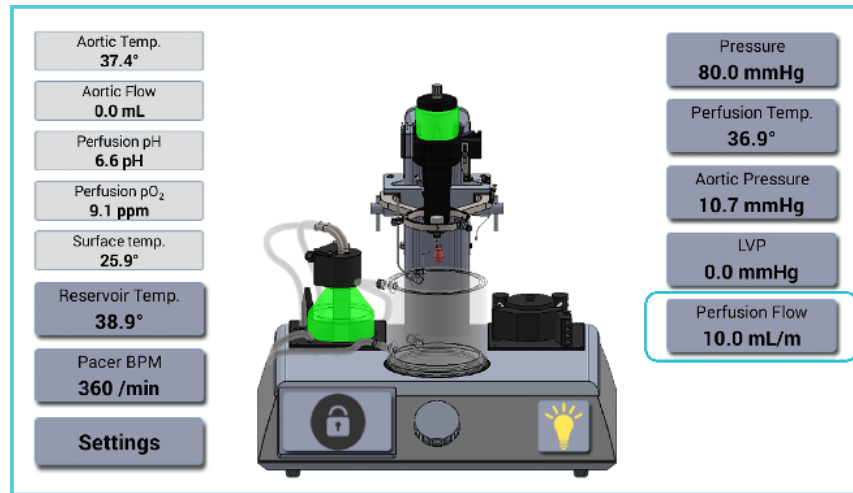


Fig.61.: The actual Perfusion Flow into the mounted heart shown in the Aortic Flow menu.

To be able to change and set the Pressure/Flow in the Action Buttons menu mark the Enable box. After the Action Button has been enabled the name of the Action button can be entered/

changed (has to be filled in). By enabling the flow and pressure, an appropriate flow and pressure value can be entered and saved as shown in fig.62.A.- C.

Configure MyoHEART Actions

Action Button 1 ☒ Enabled

**Perfusion Flow Settings**

☒ Flow Enabled

Value  ml/min.

**Pressure Settings**

☒ Pressure Enabled

Value  mmHg

**A**

Configure MyoHEART Actions

Action Button 1 ☒ Enabled

**Perfusion Flow Settings**

☒ Flow Enabled

Value  ml/min.

**Pressure Settings**

☒ Pressure Enabled

Value  mmHg

**B**

Configure MyoHEART Actions

Action Button 1 ☒ Enabled

**Perfusion Flow Settings**

☒ Flow Enabled

Value  ml/min.

**Pressure Settings**

☒ Pressure Enabled

Value  mmHg

**C**

Fig.62.A., B., C.: Configure MyoHEART Actions.

In the Main Menu the Action Button will now be shown at the top of the Main Menu (see fig.63.).

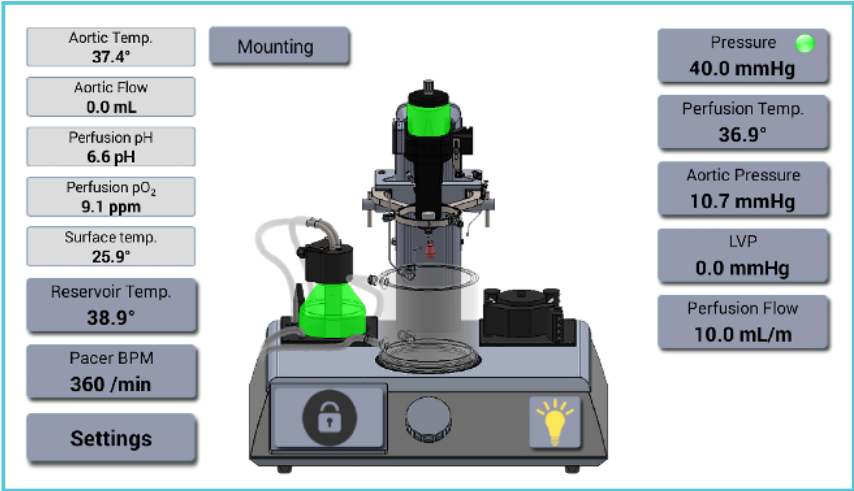


Fig 63: Constant Pressure Mode: The define Action button 'Mounting' shown in the main menu.

By pressing the Action Button “Mounting” in Constant Pressure mode, the flow will be changed to 10ml/min and the pressure to 40mmHg.

To define a second Action Button press Action Button 1 and select the Action Button 2. Shown

in fig. 64.A. and 64.B. and fig. 65.A. and 65.B. is an example of three defined action buttons “Mounting”, “20/80” and “25/100” in the main menu where 20/80 is action button 2 define as 20ml/min and 80mmHg and the 25/100 define as 25ml/min and 100mmHg.

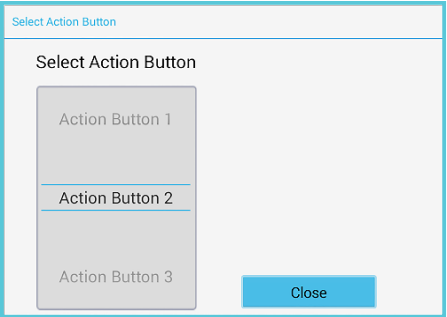


Fig. 64.A.-B.: Configuration of MyoHEART action button 2.

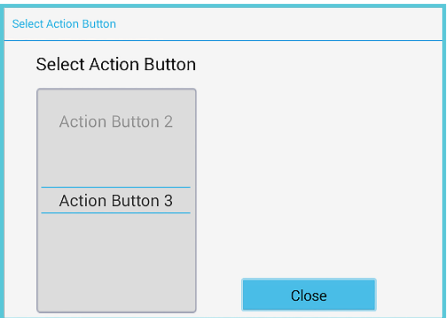
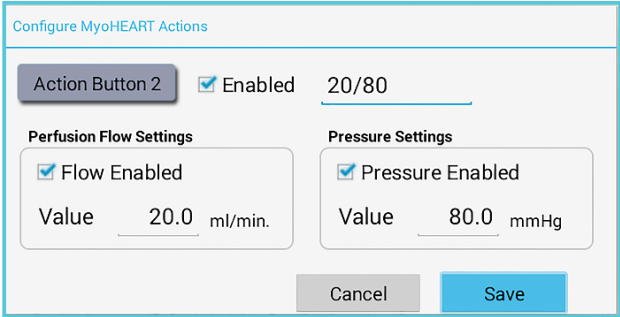
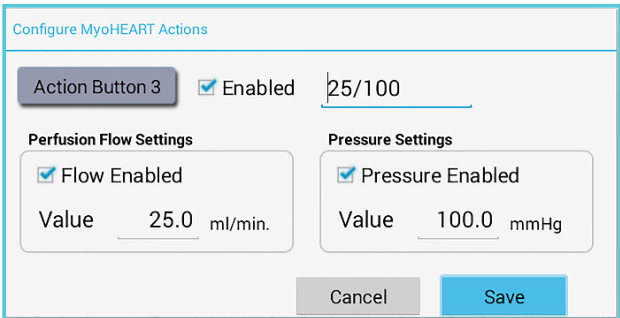


Fig. 65.A.-B.: Configuration of MyoHEART action button 3.



All three Action Buttons will now be shown in the Main Menu as shown in fig.66.

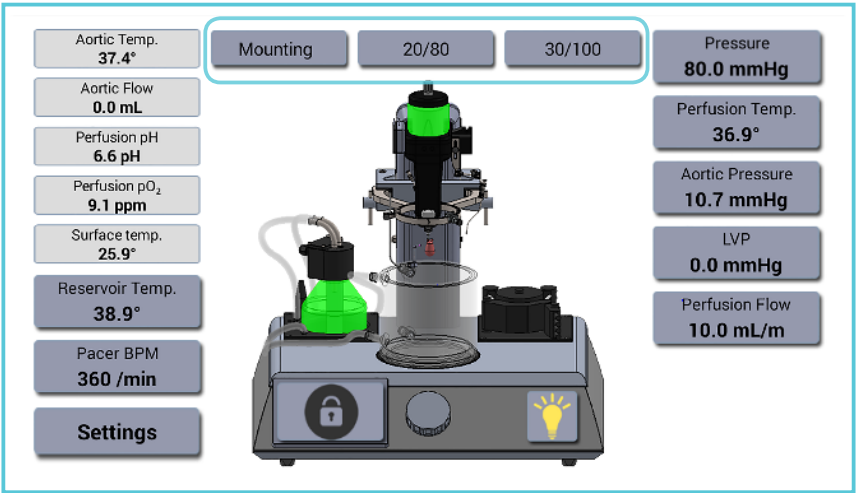


Fig.66.: Constant Pressure Mode: The three Action buttons 'Mounting', '20/80' and '25/80' shown in the main menu.

Similar can be entered/changed in the Constant Flow mode. In the example below in fig.67. the three action buttons have been entered as 10ml/min, 20ml/min and 30ml/ml.



Fig.67.: Configure MyoHEART Actions.

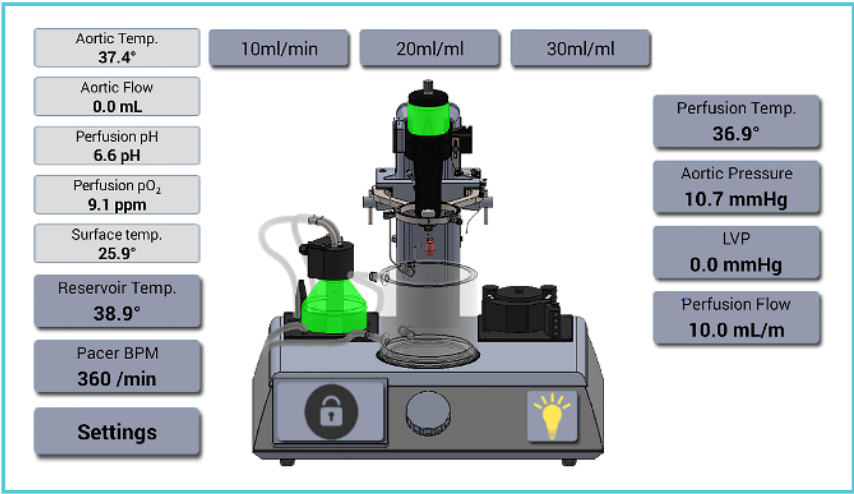


Fig.68.: Constant Flow Mode: The three Action buttons 'Mounting', '20ml/min' and '30ml/ min' shown in the main menu.

By pressing a single icon in the Main Menu, the use of the Action Buttons makes it very fast to change both pressure and flow in the Constant Pressure mode and flow in the Constant Flow mode. This is very useful when mounting the

heart, because a low flow and pressure e.g. 10ml/min and 40mmHg normally is used. Increase the flow and pressure to e.g. to 20ml/min and 80mmHg after the suture has been fasten.



## CHAPTER 3: MOUNTING THE HEART

Make sure that:

1. The temperature of the perfusion buffer and the buffer reservoir is at the setting temperature.
2. The peristaltic pump tube for the perfusion buffer is placed in the bottom of the bottle with the pre-heated perfusion buffer (2000 - 5000ml) placed in a water bath at 37°C.
3. The mounting tube is connected to the Aortic Inlet with the right size of Aortic Cannula and the peristaltic pump is running at a low flow to keep the perfusion buffer warm inside the tube. To save perfusion buffer the Aortic cannula can be placed in the perfusion buffer bottle placed in the water bath (recirculating the buffer until mounting of the heart)
4. The Main Pressure is now ON.
5. The appropriate flow (Constant Flow mode) or pressure and flow (Constant Pressure mode) is set to values preferred during mounting of the heart.
6. The appropriate MyoHEART Action Buttons has been defined and visible on the Main Menu.

If the above is OK, then continue with the dissection and mounting of the heart.

MOUNTING PROTOCOL FOR MyoHEART

The following section is an example of the basic technique of mounting a heart in the MyoHEART System.

In Appendix A is an example of a MyoHEART Langendorff experiment on a Guinea Pig heart described in detail.

MOUNTING PROTOCOL FOR MYOHEART

Surgical instruments (MyoHEART Dissection Kit) :

- 1 surgical/ anatomic forceps
- 2 hemostats/ clamps (big)
- 1 small scissor
- 2 blunt-ended fine curved forceps
- 1 Eye scissor (#100073)
- Silk suture (DMT #100341)

Aortic Cannula  
Aorta cannula diameter:

- *Mouse Aortic Cannula set (#100357)*
  - 0.6mm –Gauge 23
  - 0.8mm – Gauge 21
  - 1.0mm – Gauge 19
  - 1.2mm – Gauge 18
  - 1.5mm – Gauge 17

- *Rat/ Guinea Pig Aortic Cannula set (#100358)*
  - 1.5mm – Gauge 17
  - 2.0mm – Gauge 14
  - 2.5mm – n.a
  - 3.0mm – Gauge 11

## MOUNTING TUBE EXTENSION KIT



*Fig.69.: Mounting Tube Extension Kit with an Aortic Cannula mounted.*

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## DISSECTION STEREOMICROSCOPE (#100.36g & 100.370)

For new users and inexperienced users, a dissection stereomicroscope is very useful and makes the dissection of the heart and mounting

of the heart onto the aortic cannula much easier. Contact your DMT Sales Representative to get pricing and information.

## EXCISION AND MOUNTING OF THE HEART:

### Anesthesia:

- Induce anesthesia with e.g. Ketamine/xylazine.
- Induction of anesthesia should be as swift as possible; with the perception of pain completely suppressed.
- Control adequacy of anesthesia by monitoring stimulus such as corneal reflex or pedal withdrawal reflex
- Supplement if necessary.

### Anticoagulant (Optional):

- It is recommended to administer an intravenous dose of heparin or another anticoagulant into the femoral vein, to prevent formation of thrombi in the excised heart.

NOTE: Heparin has a lipolytic action when studying lipid or fatty acid metabolism and it is advisable to choose another anticoagulant.

## INTRATRACHEAL INTUBATION:

DMT recommends that the animal is intubated and artificially ventilated to maintain a constant oxygen level in the blood. When the chest is opened the lungs will collapse, and the animal will suffocate slowly.

DMT offers a rodent ventilator (#100.371), please contact your sales representative to get information and pricing.



*Fig.70.: Rodent Ventilator for mice, rats and guinea.*

Intubate the animal using an endotracheal tube

### Size:

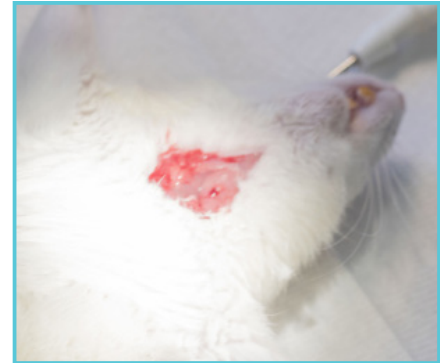
- Mouse: 20G
- Rat: 16G

- After adequately inducing anesthesia, fixate the legs to a plate e.g. strings and pins as shown in fig.71.

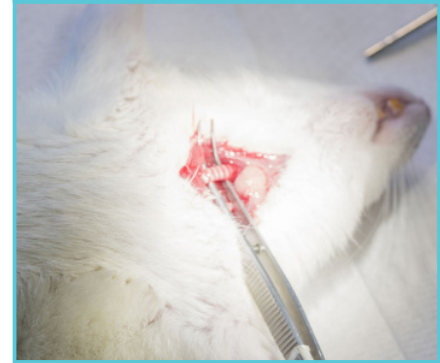
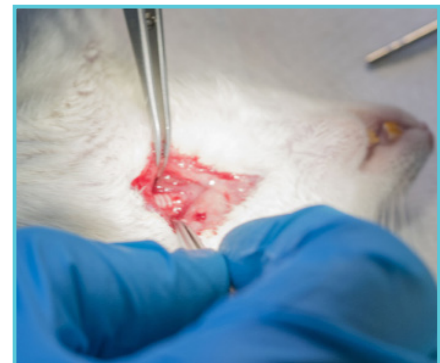


*Fig.71.: Fixation of the animal.*

- Clean/wipe the breast with disinfectant e.g. 70% ethanol.
- Cut the skin above sternum.



- .....
- Expose trachea using blunt-ended fine curved forceps.



- .....
- Gently slide a suture (silk) underneath trachea.



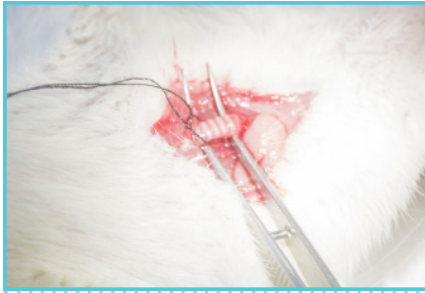


Fig. 72.:

1. Tie a loose knot

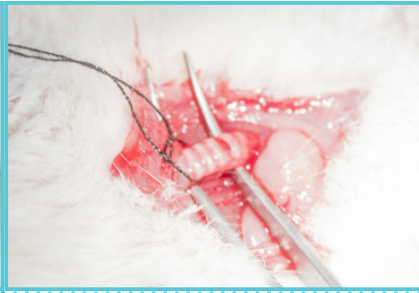


Fig. 73.:

2. Make a small horizontal incision on trachea.

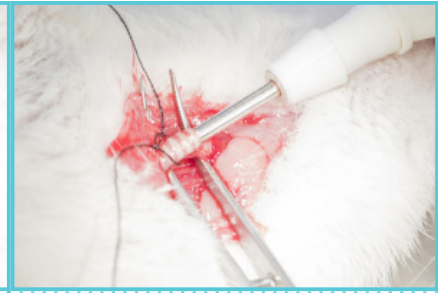


Fig. 74.:

3. Insert the endotracheal tube.



Fig. 75.:

4. Tie a double knot to firmly attach the tube and trachea.



5. Connect to a rodent ventilator.

1. Start the rodent ventilator.

3. Volume 8 ml/kg, rate 60 strokes/min.

2. Ventilate with a mixture of e.g. 95%O<sub>2</sub> + 5%CO<sub>2</sub> or normal air.

4. Check that the chest is raised on both sides.

## IN SITU CANNULATION OF THE AORTA PRIOR TO EXCISION OF THE HEART:

1. Clean/wipe the breast with disinfectant e.g. 70% ethanol.
2. Cut the skin along sternum and along the lower ribs



- .....
3. Open thorax by an incision along the lower ribs.

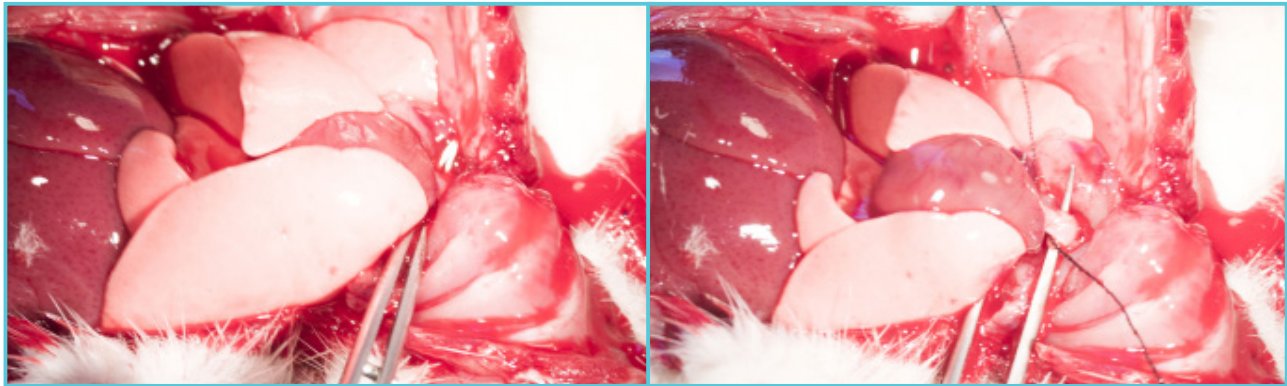


- .....
4. Cut along sternum to expose the thoracic cavity.
  5. Move the thoracic cavity over the animal's head to expose the heart.
  6. Make a transabdominal incision for access to the diaphragm.



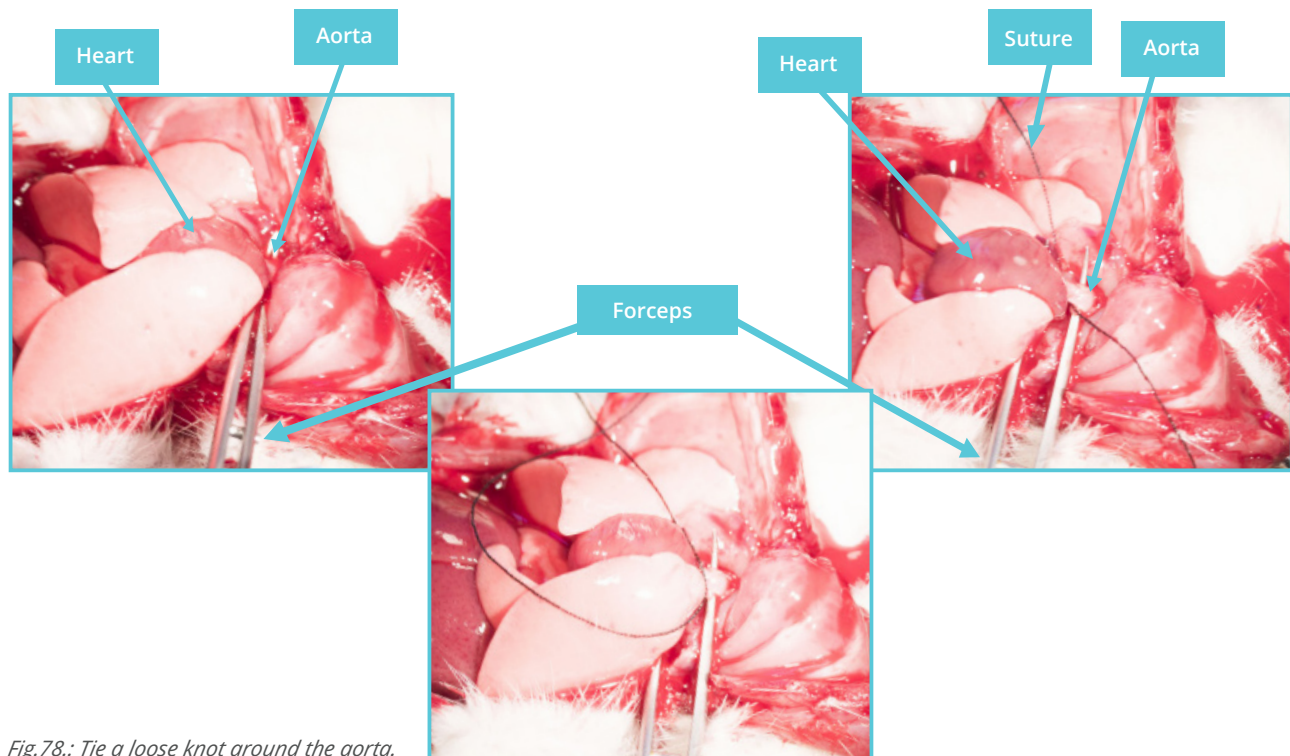
Fig.76.:





*Fig.77.: Place a forcep underneath the aorta and grab the suture.*

- Dissect aorta and remove surrounding tissue, using blunt-ended fine curved forceps.



*Fig.78.: Tie a loose knot around the aorta.*

- Gently slide a suture (silk) underneath the aorta and tie a loose knot.
- Make sure the flow is ON e.g. 2-5ml/min and the perfusion fluid is dripping from the aortic cannula placed on the mounting tubing kit

prior to cannulation. This helps minimize the risk of air emboli at the time the heart is attached to the aortic cannula. The pressure/ flow values can be entered as an Action Button in MyoHEART.



*Fig.79.: Make a small horizontal incision on the aorta large enough for inserting the aorta cannula.*

- Gently slide blunt-ended fine curved forceps under aorta and leave it in that position.
- Make a small horizontal incision on aorta as far up the aortic arch as possible.

**! NOTE:** Only cut the aorta halfway through.

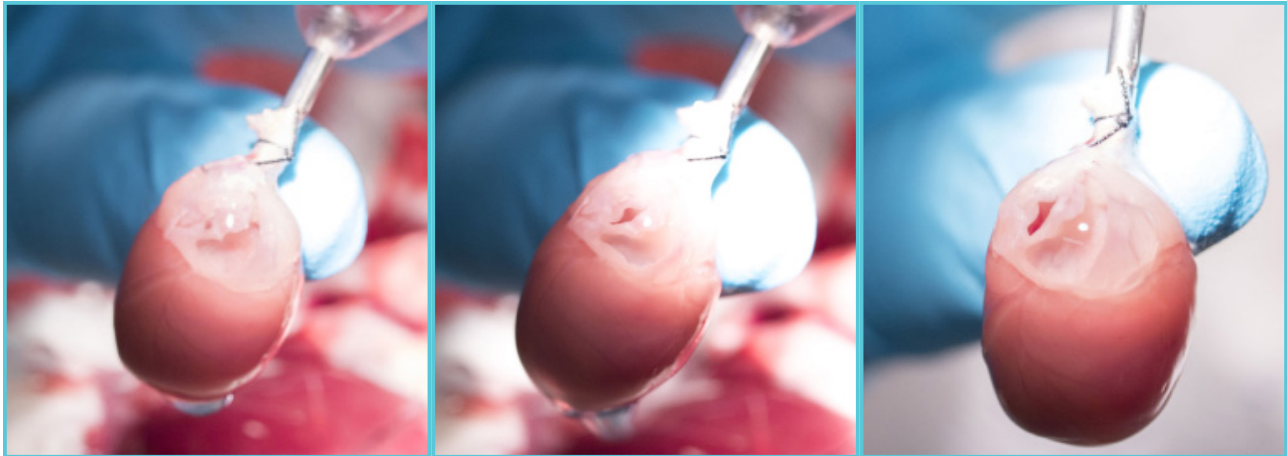
- Insert the aortic cannula and tie a double knot around both aorta and cannula.

**IMPORTANT:** Make sure the suture knot is made in one of the grooves of the cannula to prevent the heart from being “pushed” off when the flow/pressure is increased.



*Fig.80.: Insert the aorta cannula and tie the suture knot securely into the grooves of the cannula.*

- Turn on appropriate flow in the Constant Flow module and the appropriate Pressure in the Constant Pressure mode by pressing an Action Button as soon as the heart is securely attached to the cannula, to avoid unintentional ischemic preconditioning or even stunning.
- Trim away surplus tissue (such as bits of thymus, fat or lungs) once the heart is securely attached to the cannula.
- Make a small incision in the base of the pulmonary artery to facilitate adequate drainage of coronary perfusate from the right side of the heart.



*Fig.81.: Mounted rat heart with a small incision in the base of the pulmonary artery to facilitate adequate drainage of coronary perfusate from the right side of the heart. Pressure set at 100mmHg and 20ml/min.*

- When cannulation is completed and coronary perfusion initiated, contractile function and regular heart rhythm will return. However, it may take a couple of minutes before maximum function is established
- Rotate the heart around the cannula if required, to place the heart in a suitable position.

NOTE: If the flow from the coronary arteries is low:

Check the position of the cannula in the aorta. If the aortic cannula is too far into the aorta, the cannula blocks the entrances (ostia) of the coronary arteries and the flow of perfusion fluid into the coronary arteries and the cardiac musculature is reduced. If the reduction in coronary flow is significant, the cardiac muscle could suffer from hypoxia and start to die and the heart would get a darker red color.

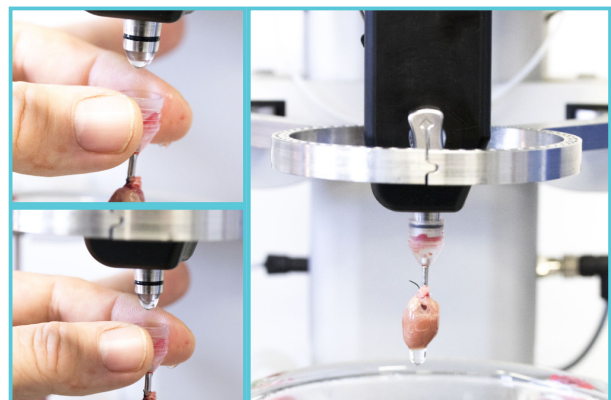
- Lower the reservoir lift.
- Open the arm locks as shown below and open the arm-holders to make space for attaching the Aortic Cannula to the Aortic Inlet.



*Fig.82.: For better access to the aortic inlet when mounting the heart on the MyoHEART systems, the arm-holders can be opened by releasing the locks as shown.*

NOTE: Before attaching the Aortic Cannula to the aortic inlet, let the perfusion buffer drip/run into the Aortic Cannula to make sure no air is trapped in the Aortic Cannula before connecting it securely to the aortic inlet.

- Swiftly replace the Aortic Cannula with the mounting tube in the aortic inlet (see fig.83.).



*Fig.83.: Transfer the Aortic cannula from the Mounting Tube Extension to the Aortic Inlet of the MyoHEART system.*



- Close the 'arms' and secure with the locks.
- Raise the reservoir lift until the heart is submerged in the reservoir buffer (fig.84.).
- Press the MyoHEART Action Button with the flow and pressure values of choice.



Fig.84.: Raise and lowering the Water Jacketed Buffer Reservoir using the knob on the front of the MyoHEART system.

## LVP MOUNTING AND MEASUREMENTS

### Left Ventricular Pressure Measurements (LVP):

The preferred procedure involves the insertion of a compliant intraventricular balloon. These balloons are often made from thin silicone rubber alternative cling film can be used. Not only is this ideal for the measurement of isovolumic left ventricular function but it is also convenient in means of measuring heart rate. If the MyoHEART system do not already have the LVP package attached to the system, it can be purchased from DMT and installed by the user (#100331 LVP Package). The LVP package is shown in fig.85.

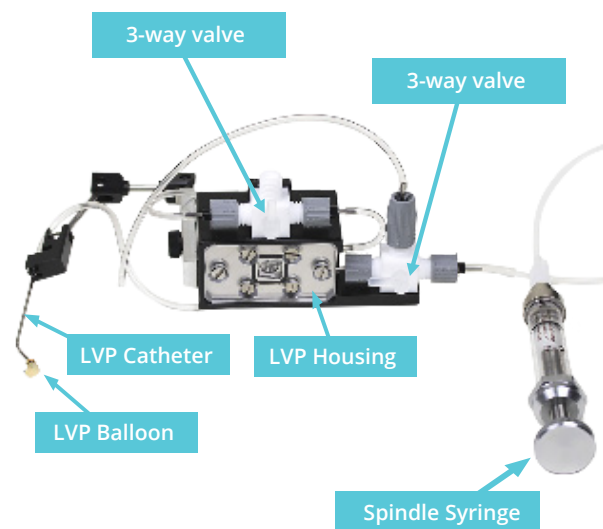


Fig.85.: The LVP Package.

The LVP Package is attached to the right side of the MyoHEART system and the spindle syringe is locked into the syringe holder at the left side of the MyoHEART system as shown in fig.86..

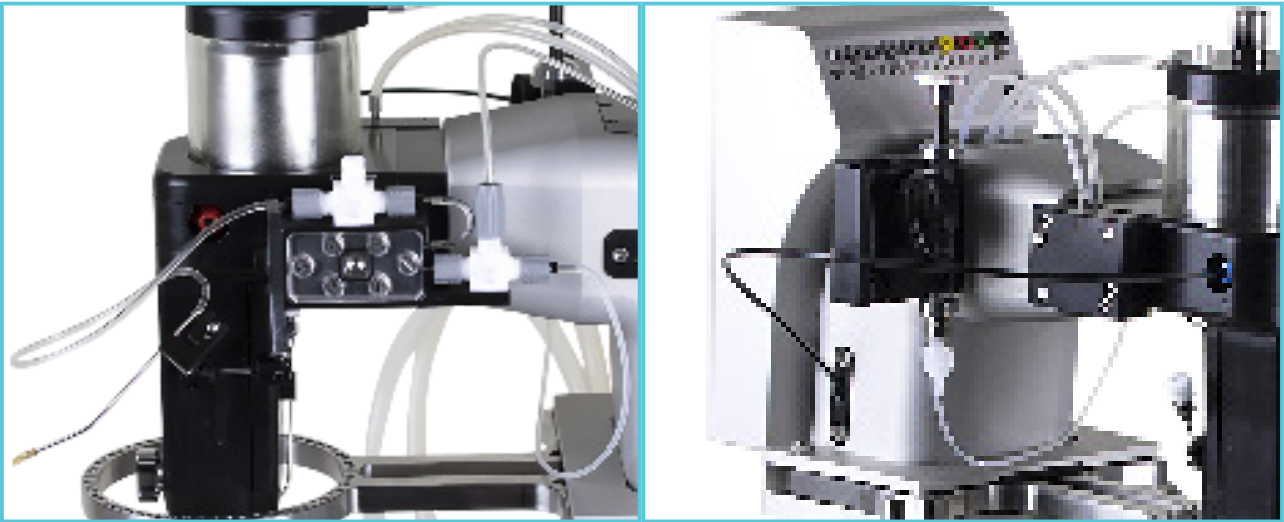


Fig.86 LVP package shown on the MyoHEART system. The LVP housing is attached to the right side and the syringe is placed in the syringe holder on the left side of the MyoHEART system.

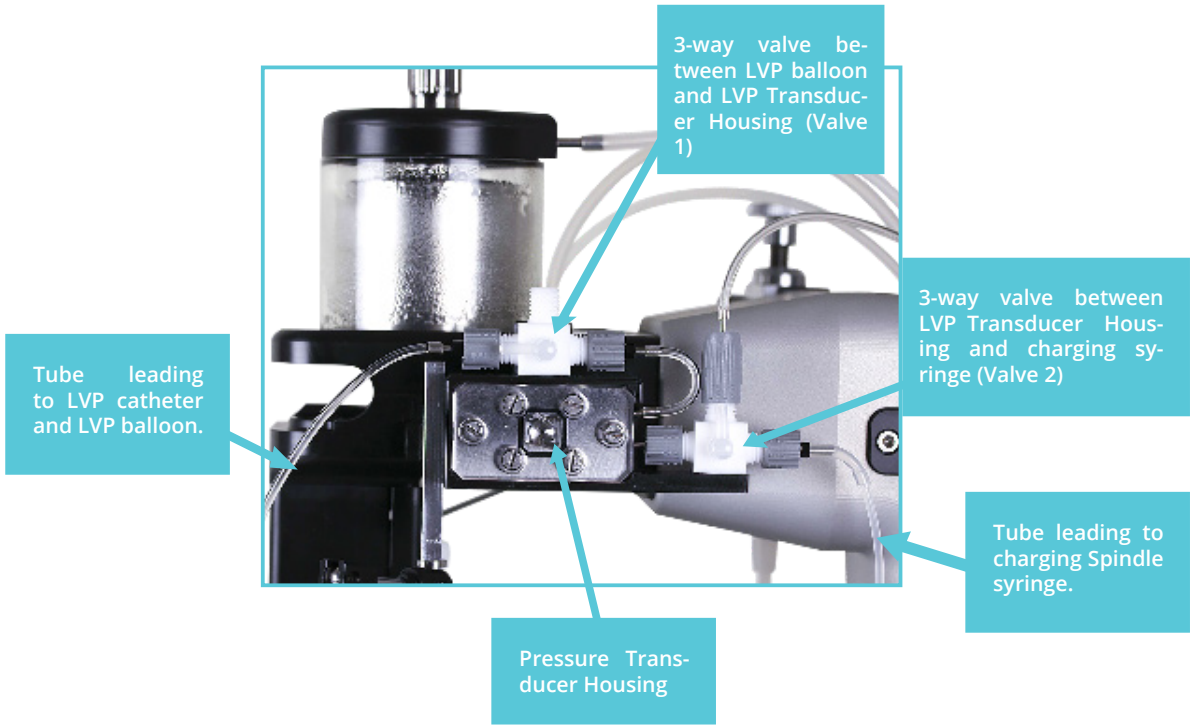


Fig.87.: Overview and description of valves and LVP Housing.

- Make an ethanol and H<sub>2</sub>O 1:1 mixture (5-10ml) using 96% ethanol and distilled water. Preheat the solution to 37°C.
- Fill the spindle syringe with the pre-heated ethanol - H<sub>2</sub>O mixture.
- Remove air bubbles from the syringe before connecting to the tubing leading to the LVP housing.

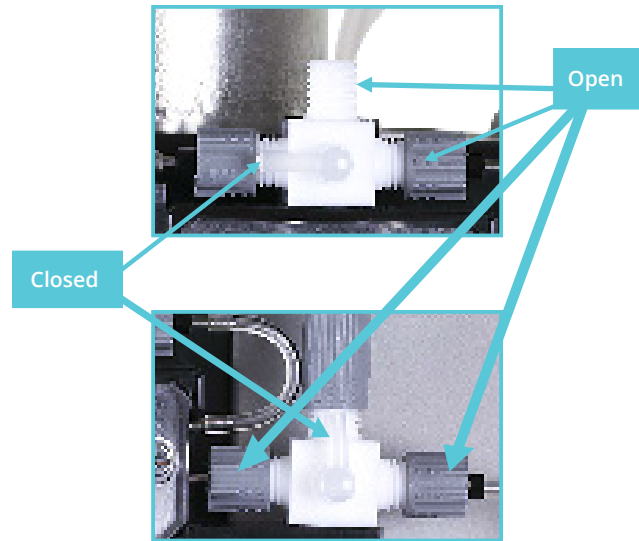


Fig.88.: The LVP valves 1 and 2. The close and open positions of the valves.

- Open 3-way valve 1 and close valve 2 towards the LVP housing as shown in fig.89.A.
- Fill the tube using the spindle syringe until the ethanol mixture can be seen in the short tubing pointing upwards.

- Open valve 2 towards the LVP housing and close valve 1 towards the catheter as shown in fig.89.B.
- Fill the LVP housing with the ethanol - H<sub>2</sub>O mixture until the ethanol mixture is visible on the 3-way valve 2 outlet pointing upwards.

- Open valve 1 towards the catheter as shown in fig.89.C.

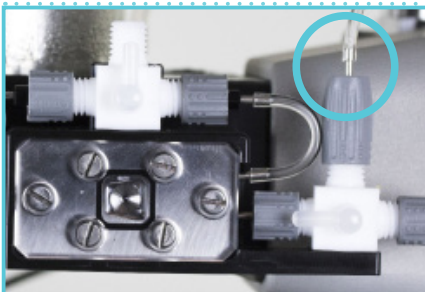


Fig.89.A.

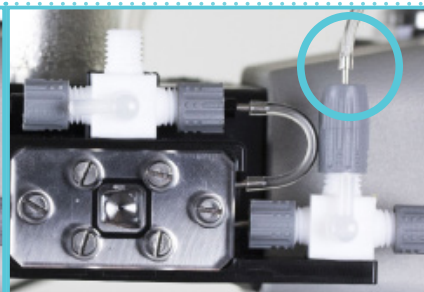


Fig.89.B.

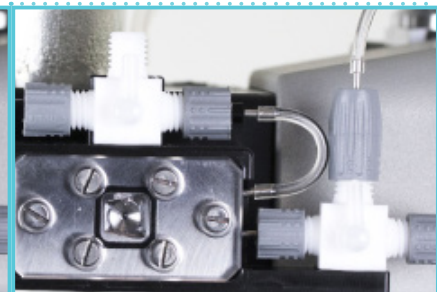
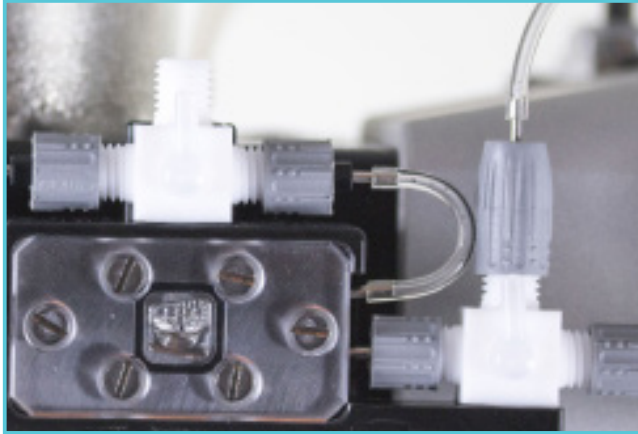
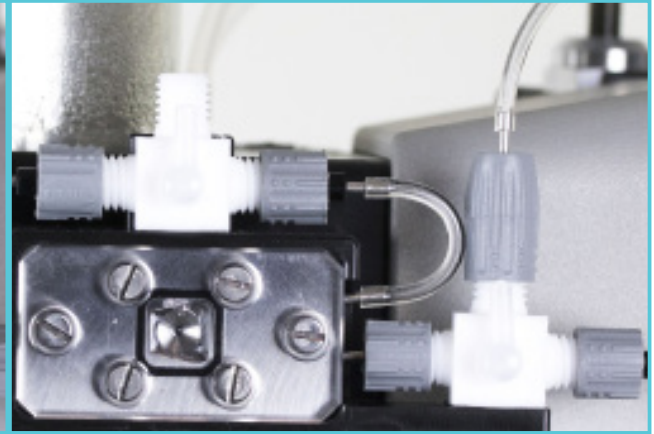


Fig.89.C.



*Fig.90.A.: Make sure that all air is removed from the transducer housing by filling it slowly. Here air can easily be seen.*

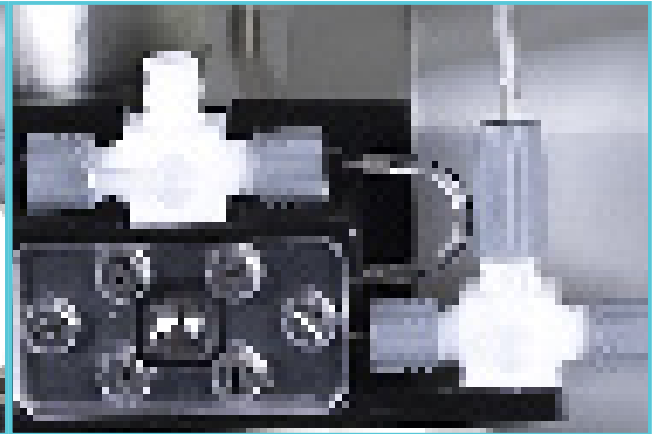


*Fig.90.B.: All air is nearly removed from the LVP housing.*



*Fig.90.C.: All air is removed and no air bubbles visible.*

- Make sure no air bubbles are visible in the tubing and the LVP housing (fig. 90.C.).



*Fig.90.D.*

- Close valve 1 when ethanol mixture has been dripping 20-30 drops from the catheter (fig. 90.D.).





Fig. 91.A.

- Attach the right size balloon to the LVP catheter.



Fig. 91.B.

- Open Valve 1 again and fill the balloon with ethanol mixture (fig. 91.B.).

- Fill the balloon until the LVP pressure is approx. 100mmHg (The LVP pressure can be followed directly on the Main menu of MyoHEART).

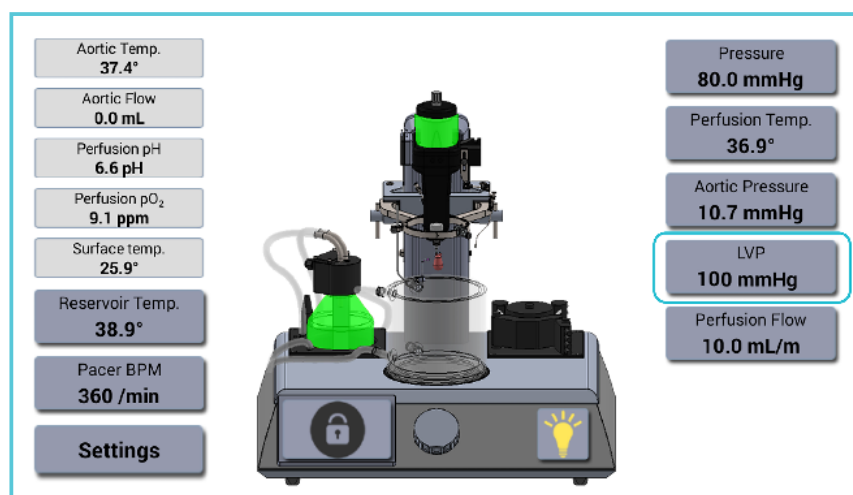


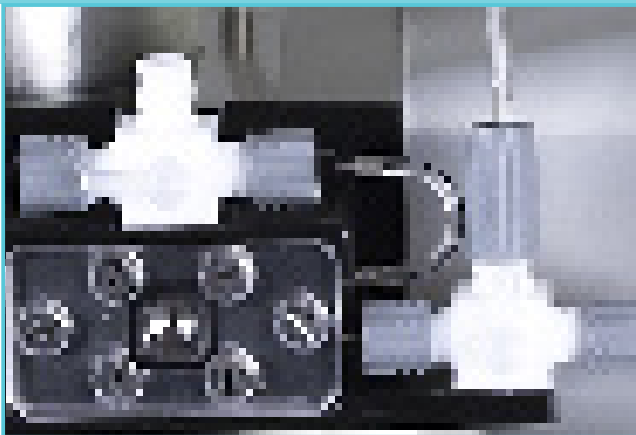
Fig.92.: The actual pressure in the LVP latex balloon can be seen on the Main Menu in the LVP menu.

- Close valve 1 towards the catheter as shown below.
- Use fingers to force all the ethanol mixture and air bubbles out of the balloon.

- Open valve 1 again and fill the balloon with the ethanol mixture using the spindle syringe until a pressure of max 100mmHg is obtained.



**WARNING:** Make sure that valve 1 is closed towards the LVP housing before forcing the liquid and air bubbles out of the balloon otherwise the transducer will be broken and needs to be replaced. (Never exceed 250mmHg that will destroy the pressure transducer).



*Fig.93.A.:*



*Fig.93.B.:*

- If air bubbles are still visible in the balloon. Close valve 1 and use fingers to force all the ethanol mixture and air bubbles out of the balloon.
- Repeat this until no visible air bubbles can be seen in the LVP balloon.

**NOTE:** It is extremely important that the pressure transducer inside the LVP housing is never exposed to more than 250mmHg.

- Secure the balloon to the catheter with a suture, when all air bubbles are removed from the LVP housing and tubing. Place the balloon on the LVP catheter at the same height as the mounted heart and close valve 2 towards the spindle syringe to zero the pressure inside the balloon (see fig. 93.A.).

- Close valve 2 towards the LVP housing as shown in fig.93.B..

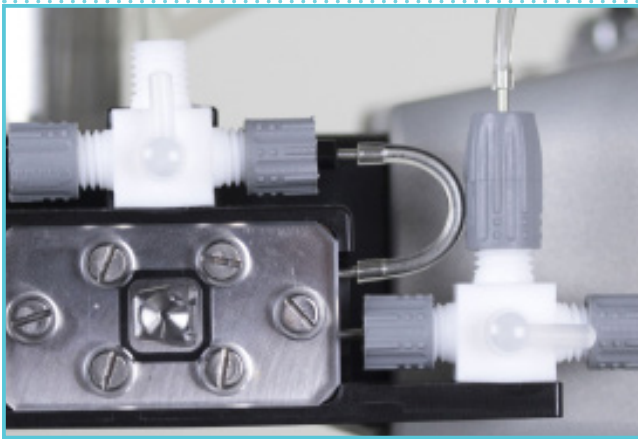


Fig.93.A.

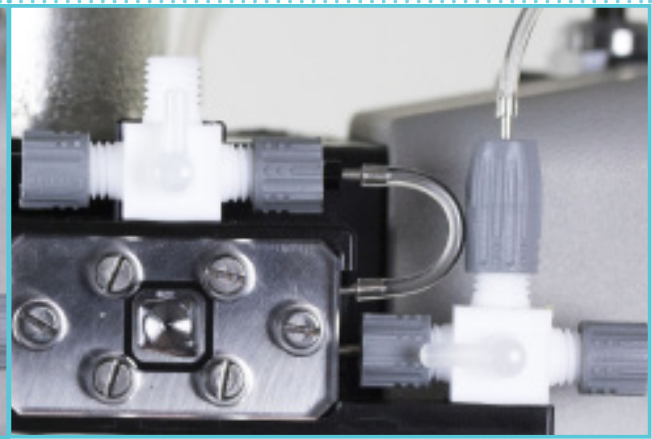


Fig.93.B.

- Go into the MyoHEART main menu and press the LVP menu.

- Zero the LVP pressure as shown below.

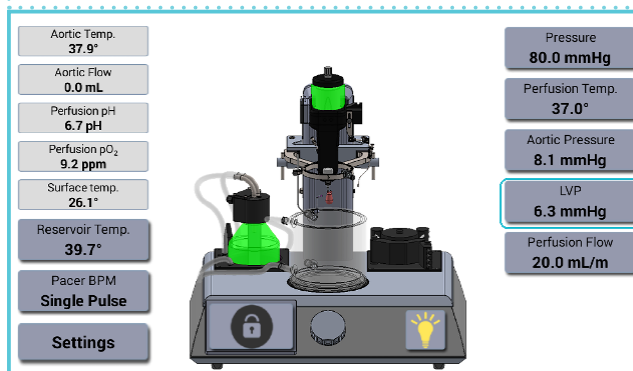
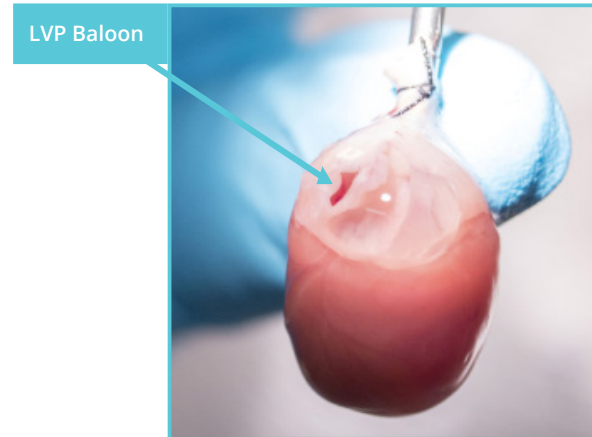


Fig.94.A.: Zero the LVP pressure.



Fig.94.B.: Zero the LVP pressure.

- Open valve 2 towards the spindle syringe and deflate the balloon attached to the steel LVP catheter.
- Close valve 2 towards the LVP housing.
- Remove left atrial appendage to provide a clear field of view.



*Fig.95.: The deflated balloon has to be inserted into the left ventricle.*

- Introduce the deflated balloon into the left ventricle via the mitral valve.
- Make sure that the cannula/balloon has the right direction before entered into the left ventricle.
- Be careful while inserting and securing the balloon as it is very easy to damage the heart.
- Inflate the balloon until the pressure is approx. 0-5mmHg when the balloon is in placed in the Left ventricle.
- Close valve 2 to get the right pressure readings (IMPORTANT).



*Fig.96.: The LVP balloon inserted into the left ventricle.*

**NOTE:** Close valve 2 towards the spindle syringe before the correct LVP pressure will be shown.

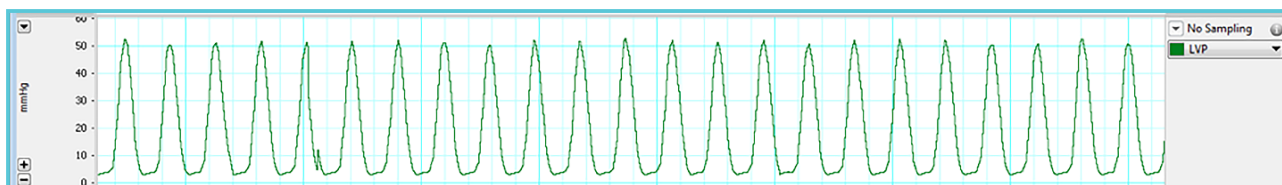


Fig.97.: LVP pressure trace in Labchart.

NOTE: An excessively high balloon volume should be avoided since it may cause tissue compression and subendocardial ischemia which will lead to an unstable preparation with an increased propensity to arrhythmias.

## ECG MEASUREMENTS AND HEART RATE (BPM)

If the ECG /Pacer Package has been added to the system as an add-on, then connect the ECG/ Pacer Unit to the MyoHEART Tower as shown in fig.98.A. and fig.98.B.



Fig.98.A.: ECG/Pacer Package. ECG/Pacer Amplifier Unit and ECG electrode kit.

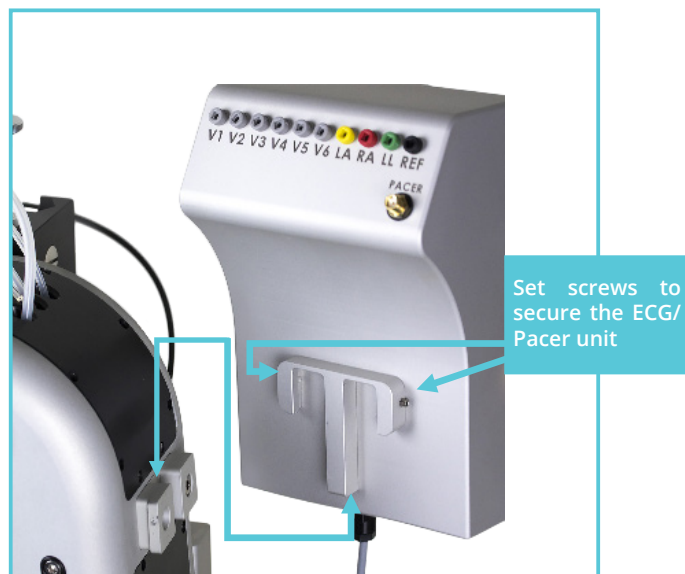


Fig.98.B. The ECG/Pacer Amplifier Unit can be attached/detached from the MyoHEART system. In case repair is needed detach the Amplifier Unit and send it to DMT.

- Connect the ECG-Pacer box to the connection plug on the right hand side of the MyoHEART Tower as shown in fig.99.A. and fig.99.B..

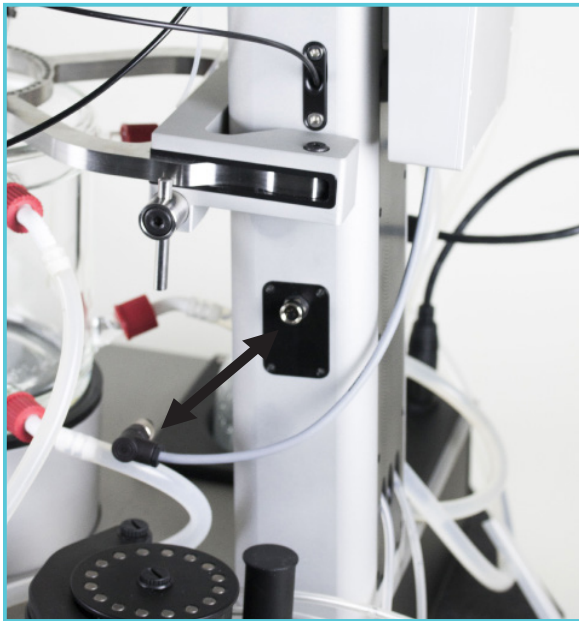


Fig.99.A.: Connecting the ECG/PACER unit to the MyoHEART system.

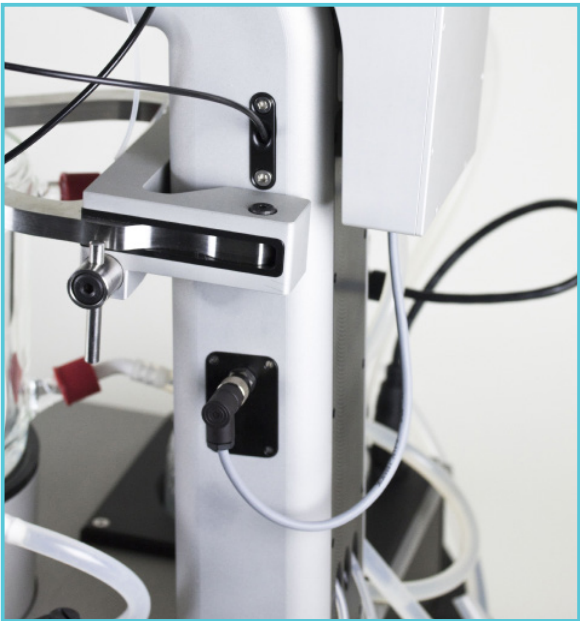


Fig.99.B.: ECG/PACER connected correctly.

ECG Settings

Export Channels

Change license

Change workflow

Configure Actions

Configure pH

Configure O2

Device Name

Name

MyoHEART

Change

Pacer Settings

☒ Pacer Voltage Output

☐ Pacer Current Output

Rheobase Step

0.10

Change

Temp. Differences

Perfusion temp. diff. (°)

0.00

Change

Reservoir temp. diff.(°)

2.00

Change

Software Ver. 1.0.0

Search

Aortic Mean Flow

5.0 secs.

Aortic Mean Pressure

5.0 secs.

BPM ECG Channel

ECG Lead 3

Back

Fig.100.: ECG setting menu. This menu is used for setting the amplifier and enable the ECG signals.

In the Settings Menu and ECG Settings submenu the ECG signal amplification can be set. The default is 600x and can be changed by pressing the number to 100, 200, 400, 600, 800 and 1200x if necessary.

The ECG channels can be disabled and enabled by pressing the icon.

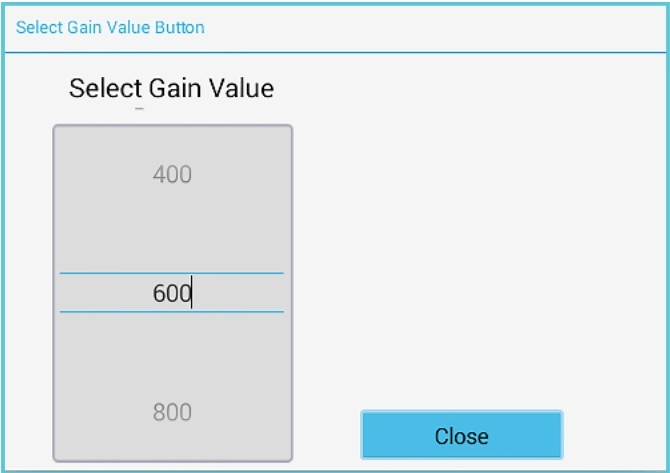


Fig.101.: ECG Amplifier settings. The ECG signal can be amplified 100, 200, 400, 600, 800, 1000 and 1200 times by changing the gain.

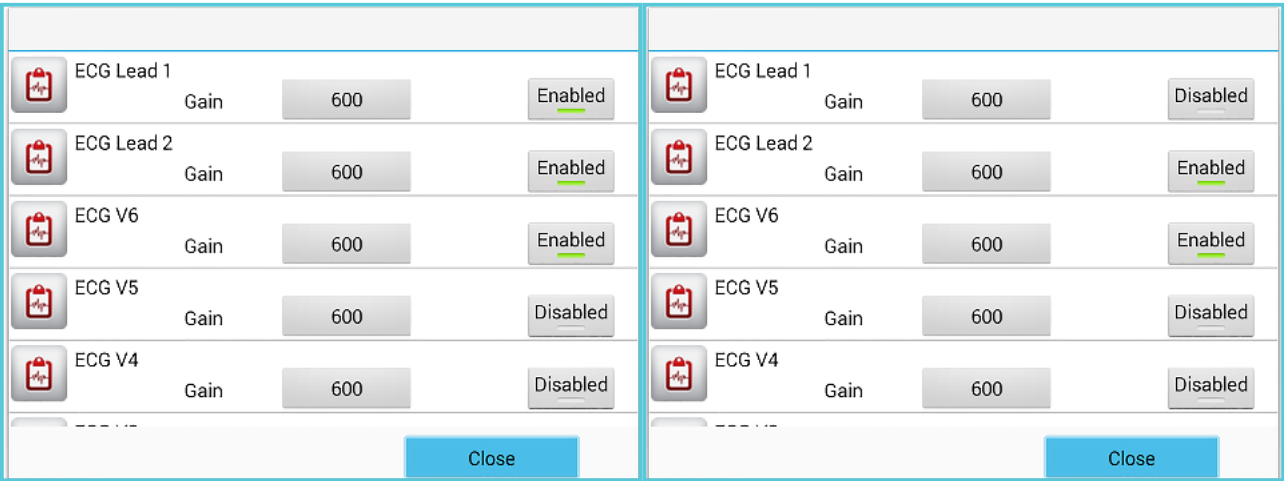


Fig.102.: ECG setting menu. This menu is used for setting the amplifier and enable the ECG signals.

To obtain a good ECG signal the three ECG electrodes LA (left-arm), RA (right-arm) and LL (left-leg) has to be connected to the ECG-box.



Fig.113.: Connectors on the ECG/Pacer Amplifier Unit.

The ECG-electrode plug-color should match the color on the ECG-box. The ECG electrodes has to be placed 1-2mm from the mounted heart while it is submerged in the buffer reservoir. The LA electrode (yellow), the RA electrode (red) and the LL electrode (green) should be positioned to the heart as shown in the picture below. The REF electrode (black) should be place 2-5mm below the heart making sure that the REF electrode has a center position.

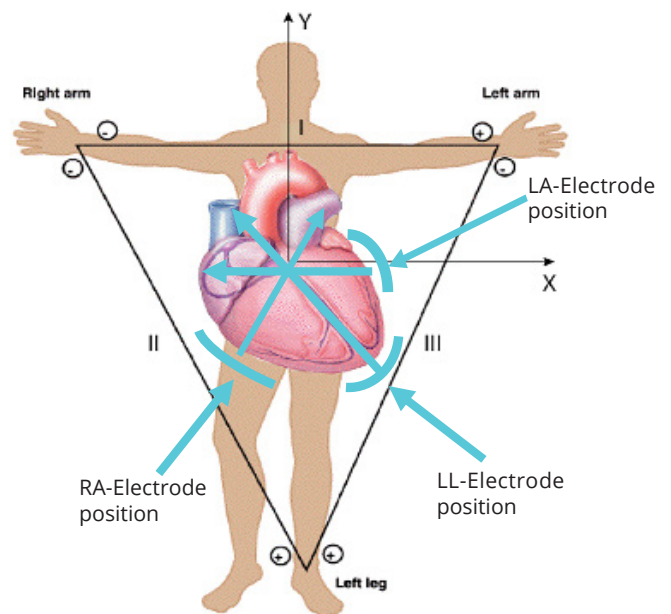


Fig.104.: Wilson ECG recordings demands placement of the electrodes similar to what is shown here.



Adjust the LA, LL and RA electrode and look at the ECG trace in Labchart (use Swipe mode in LabChart). The ECG electrode holders is completely flexible and very tiny movements of the electrodes can have a dramatically effect of the ECG traces. The ECG signal is based on the

Wilson principles (reference) and therefore all three ECG electrodes are needed to get good ECG traces. The three ECG leads from the Wilson coupling is shown as Lead 1, 2 and 3 in Labchart screen view shown below.



Fig. 105.: ECG recording trace in Labchart.

ECG and reference electrodes are placed on a mounted heart according to the Wilson-coupling as shown in fig. 106.

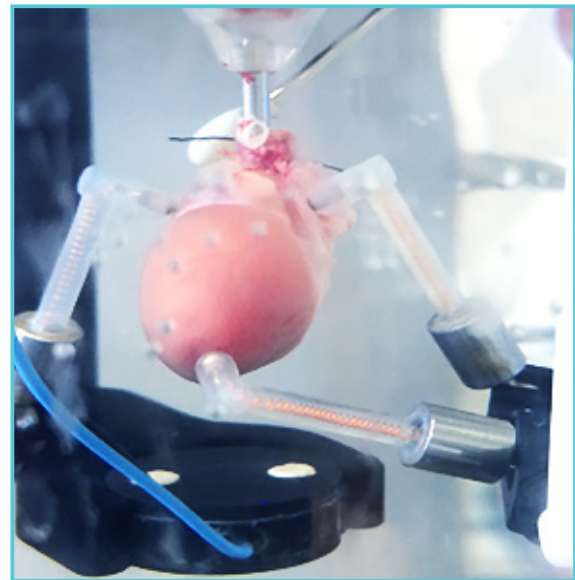


Fig. 106.

## MAINTENANCE OF THE ECG ELECTRODES

It is highly recommended that the ECG and reference electrodes after each use is submerged into chlorine for 1-2 hours or overnight.

NOTE: ONLY submerge the part of the ECG electrode in contact with the heart marked with a blue circle in fig.107.



*Fig.107.: ECG electrode. The AgCl contact electrode should be cleaned on a regular basis with a sandpaper (grain 1000 or more) and the part marked with a blue circle should be submerged into chlorine after use.*

If the AgCl part of the ECG electrode and reference electrode is turning a bit gray/black, then use a piece of sandpaper (Grain 1000 or more) to

remove the debris followed by the submerging them into Chlorine.

HEART BEATS PER MINUTES (BPM)

- Select the ECG Lead channel (ECG Channel 1, 2 or 3) with an optimal ECG to measure the actual BPM shown on the trace.
- Go into the Settings menu and press the BPM ECG Channel menu and select the ECG Lead channel with the optimal ECG signal.

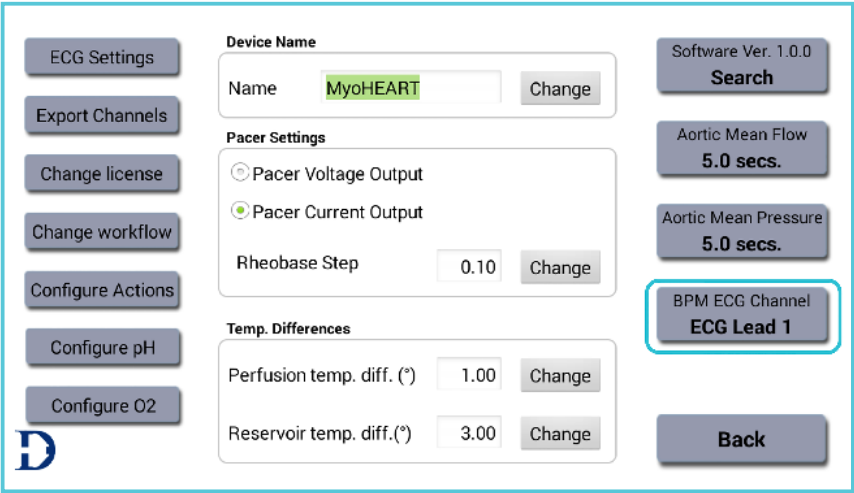
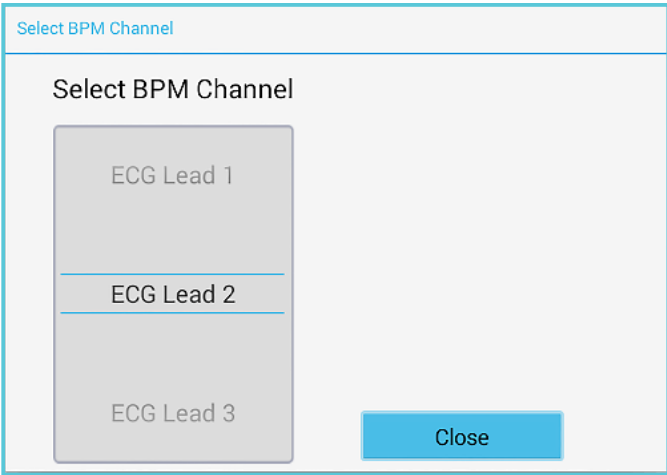


Fig. 108.: BPM ECG Channel menu. This menu is used for defining which channel to choose for BPM recordings.



The BPM Channel in Labchart will now show the exact same trace as the chosen ECG Lead channel. In Labchart right click with the mouse at the right hand side of the BPM trace and select Cyclic Measurement (see below), and in the Preset menu select e.g. the ECG-Rat.

Make sure that every ECG peak is measured

by the algorithm, otherwise change the S.D. (standard deviation) setting.

In the example below the S.D. has to be changed from 3.25 to 1.75 before the algorithm measure every ECG and marked as a beat (see below). Change the Decimal places to 0. Click OK. After 2-5 seconds the BPM value is shown in the trace.

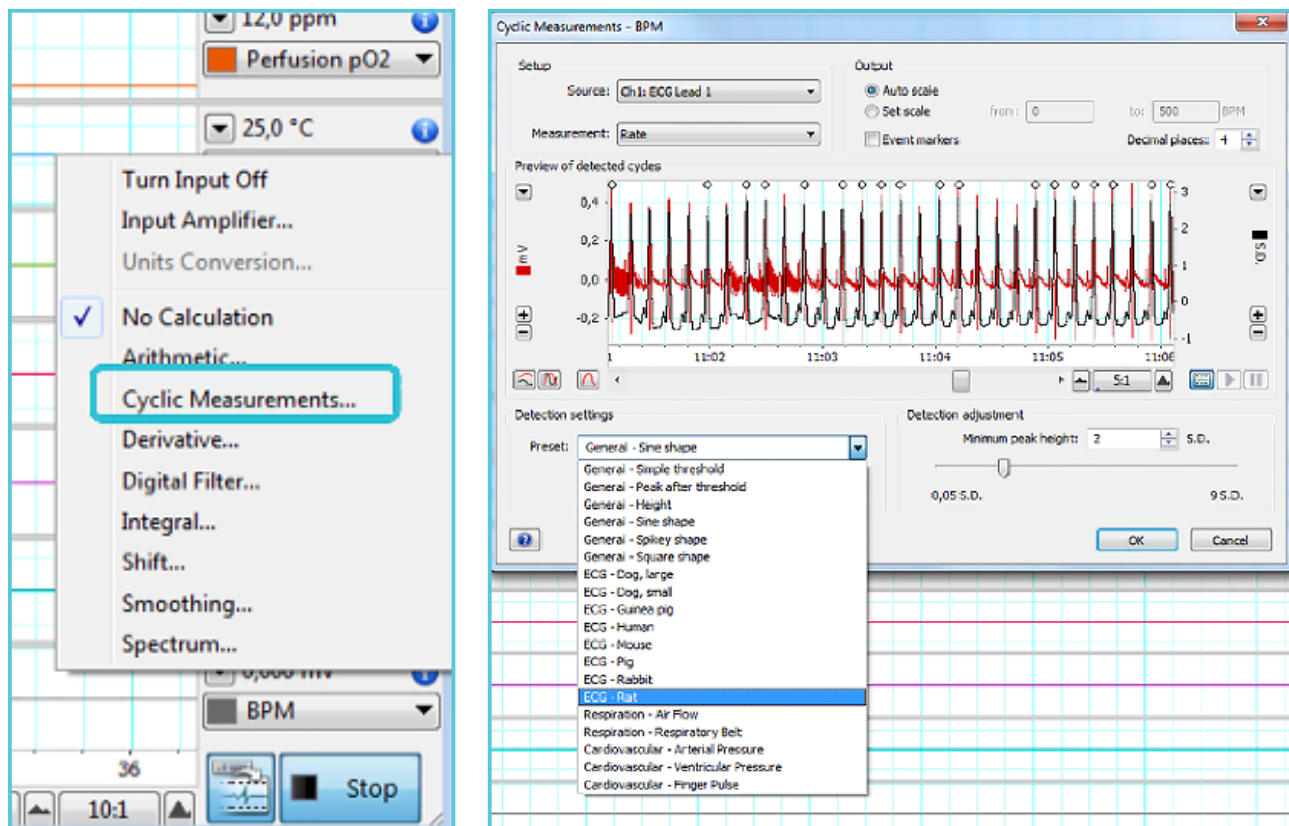


Fig.109.: Setting up the BPM recordings in Labchart.

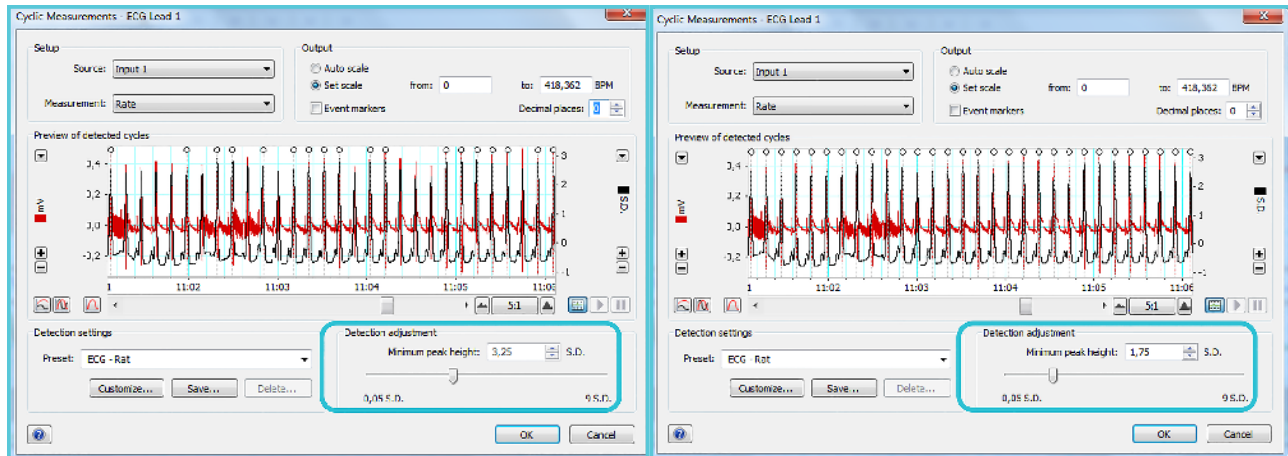


Fig. 110.: Change the Detection adjustment values until every ECG is detected as seen on these screen shots.

## MyoHEART PACER MODULE

Stimulation/Pacing the heart:

To contract at its spontaneous rate, the isolated heart undergoes a small progressive time dependent decline in heart rate. Furthermore, spontaneous heart rate in a perfused heart preparation is usually significantly below the physiological heart rate. For rat hearts (which have an in vivo rate of 350-400 beats/minute), heart rates of 250-320 beats/minute, can be expected. To obtain a similar heart rate of the isolated heart as in-vivo the use of a stimulator to pace the heart to a set value is needed.

The MyoHEART system has a pacer/stimulator build into the ECG/Pacer Amplifier Unit (#100317).



Fig. 111.A.: ECG/Pacer Amplifier Unit and a pacer electrode with holder.



Fig. 111.B.: Pacer electrode.

The Pacer module are found in the Main Menu as shown in fig.112.

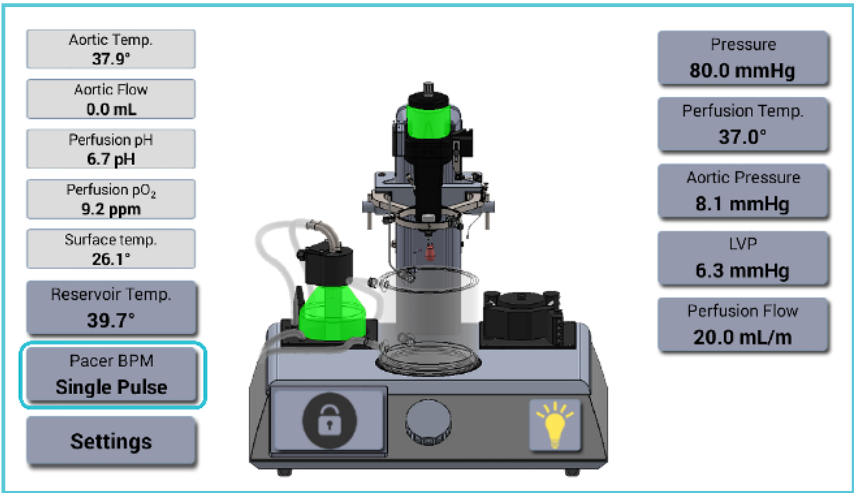


Fig.112.: The Pacer BPM menu of MyoHEART.

Press the Pacer BPM menu to enter the Pacer Module.

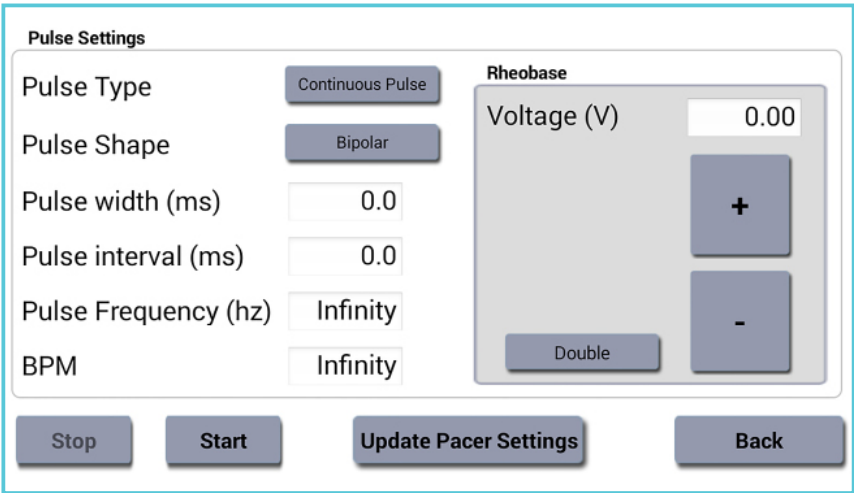
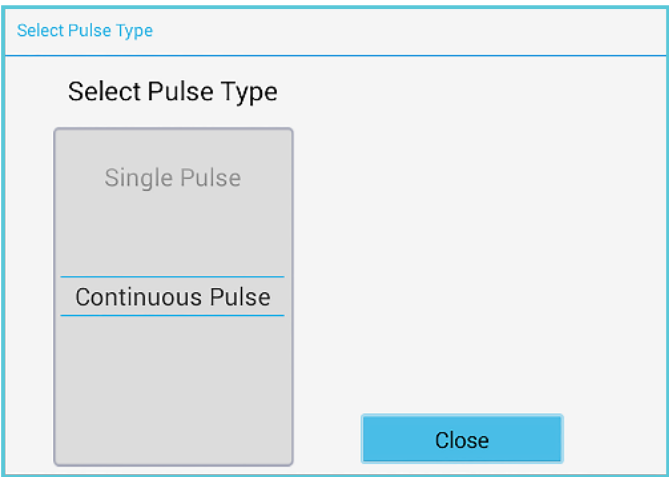


Fig.113.: Pacer module of MyoHEART.

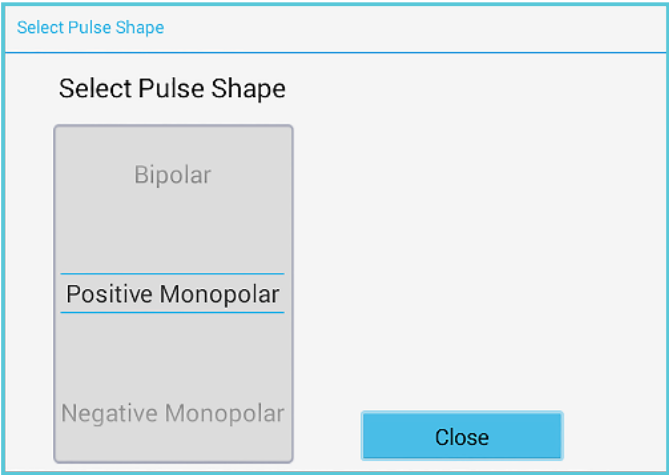
In the Pacer menu the following parameters can be defined.

**Pulse Type:** Continuous Pulse, Single Pulse.



*The Pacer BPM menu of MyoHEART.*

**Pulse Shape:** Positive Monopolar, Negative Monopolar and Bipolar



*The Pacer BPM menu of MyoHEART.*

**Pulse width:** Duration of the given pulse in milliseconds.

**Pulse interval:** Time in milliseconds between two pulses.

**Pulse Frequency:** Enter the frequency in Hz, e.g. 5Hz means 5 pulses in 1 second (This will be dependent on the pulse width). When a frequency is selected, MyoHEART will calculate the **Pulse interval** keeping the

**Pulse Width** constant. Furthermore, MyoHEART will calculate the BPM (pulses per minute).

example is shown in fig.114.A., B. and C.

**BPM:** Enter the beats per minute equivalent to pulses per minute. MyoHEART will calculate the Pulse Frequency and Pulse interval keeping the Pulse width constant (see above example).

To transfer the new Pacer Setting values to the stimulator inside the MyoHEART system press the **Update Pacer Settings**.

Pulse Settings

Pulse Type

Single Pulse

Pulse Shape

Bipolar

Pulse width (ms)

5

Pulse interval (ms)

160

Pulse Frequency (hz)

6.2

BPM

375

Rheobase

Voltage (V)

0.00

+

-

Double

Stop

Start

Update Pacer Settings

Back

Pulse Settings

Pulse Type

Single Pulse

Pulse Shape

Bipolar

Pulse width (ms)

5

Pulse interval (ms)

166.7

Pulse Frequency (hz)

6

BPM

360

Rheobase

Voltage (V)

0.00

+

-

Double

Stop

Start

Update Pacer Settings

Back

Pulse Settings

Pulse Type

Single Pulse

Pulse Shape

Bipolar

Pulse width (ms)

5

Pulse interval (ms)

171.4

Pulse Frequency (hz)

5.8

BPM

350

Rheobase

Voltage (V)

0.00

+

-

Double

Stop

Start

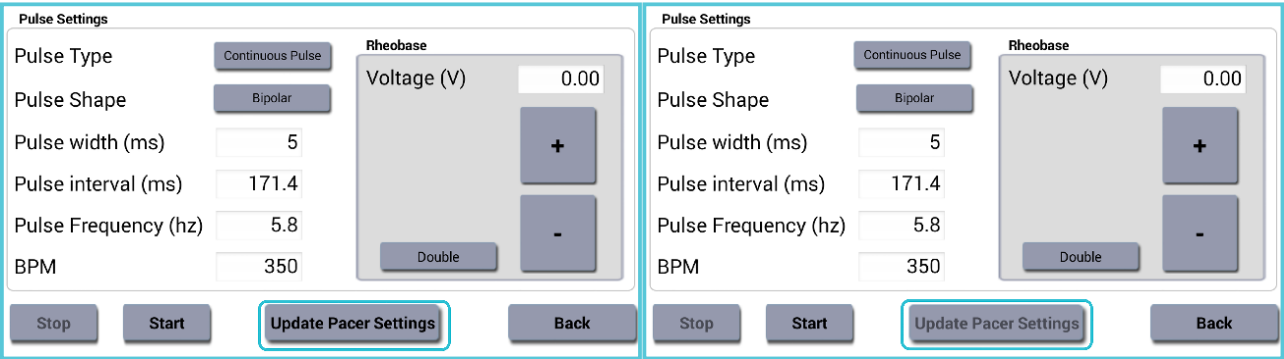
Update Pacer Settings

Back

Fig. 114.A. ,B. and C. An example of how the Pacer is programmed to 350 BPM.



When the new Pacer Settings have been uploaded the ‘Update Pacer Settings’ icon is scaled out to indicate that the entered values have been uploaded (fig.115.A. and 115.B.) to the internal stimulator.



## Pacer Settings menu

This menu is used to define if the pacer should pace in current or voltage stimulator mode. The level of increase in either volt or amps are defined here. Shown in fig.116.

The Rheobase Step is the change in Volt (mV) or Amperes (mA) when the '+' or '-' is pressed in the Rheobase sub menu of the Pacer BMP menu (see fig.117.).

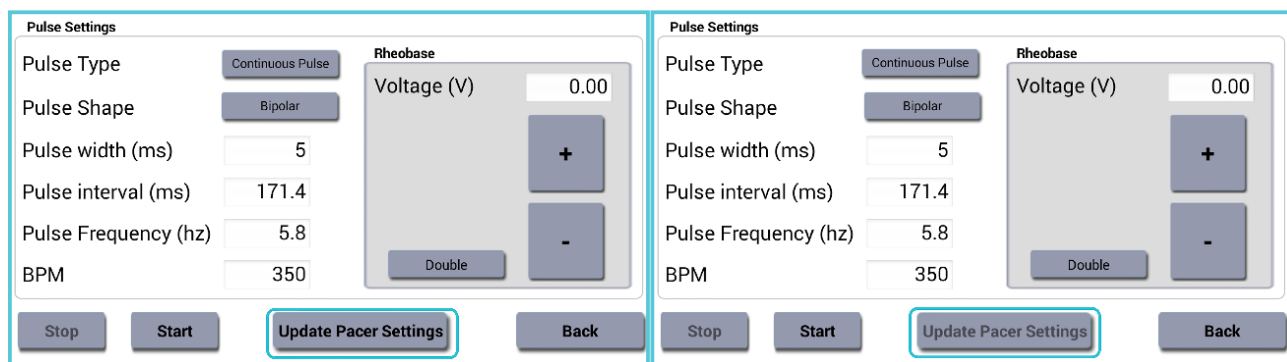


Fig. 117.: Finding the Rheobase: Start at 0 V or 0 A and stepwise increase the voltage or current until the pacer takes over the heart rate.

### To identify the Rheobase for the mounted heart:

- Place the pacer electrode on the atria, never on the ventricle.
- Make sure that you can follow the heart's natural BPM (see page 79-81).
- Select a setting in the Pacer menu that will give a different BPM to be able to monitor when the Rheobase is reached.
- Start pressing the + icon in the Pacer BPM

menu (see fig.117.). When the change in BPM can be monitored at the BPM trace in Labchart, the Rheobase has been identified and the pacer has taken over the heart rate.

- Press Double to double the volt/amp of the identified Rheobase value, to be sure that the pacer will have the control during the whole experiment.

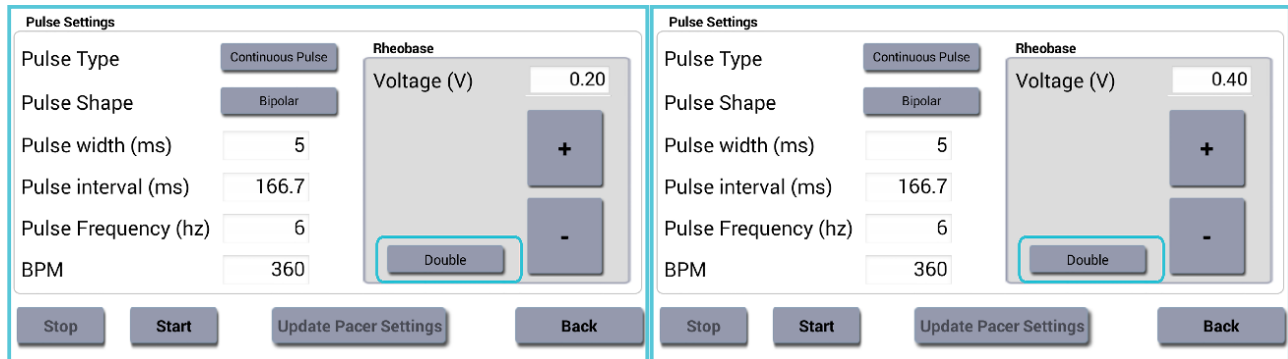


Fig.118.: Pacer menu in MyoHEART.

## pH AND $pO_2$ MODULE OF MYOHEART

If the MyoHEART system were not delivered with the pH and/or the  $pO_2$  package, then the system has to be send back to the DMT for built-in of the modules. Before returning the system please contact your DMT sales person or contact

support@dmr.dk.

If the pH and/or  $pO_2$  package already are built into the MyoHEART system, then the fiber optic cables coming out of the MyoHEART Tower can be seen as shown in fig.119.



Fig.119.: The  $pO_2$  and pH sensor fiber optic cables in MyoHEART.

The fiber optic cables are going into the pH and pO<sub>2</sub> sensors attached at a Luer lock placed in the pH and pO<sub>2</sub> sensor adaptor as shown in fig.120.

The pH/O<sub>2</sub> adapter can be pulled out of the Tower by hand.

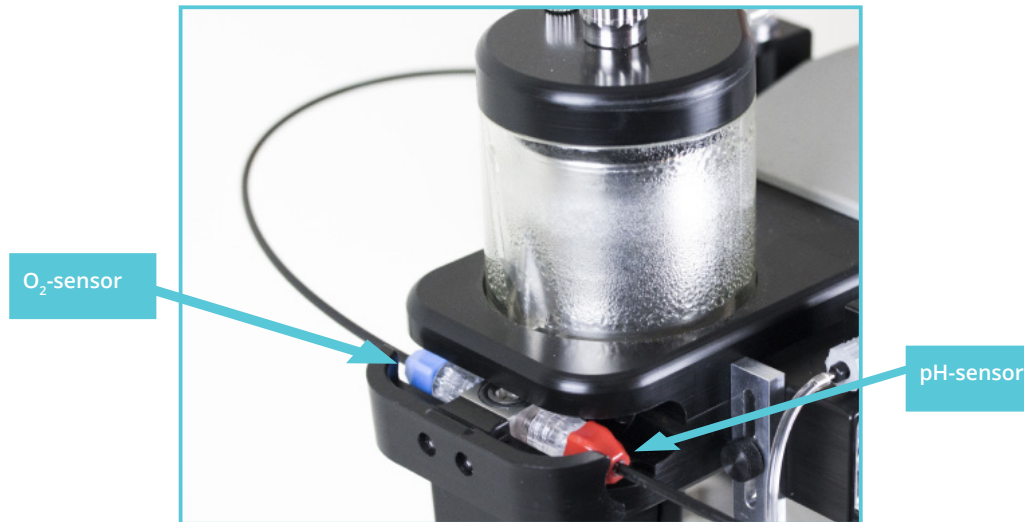


Fig.120.: The pO<sub>2</sub> and pH sensor fiber optics in MyoHEART.

The pH and pO<sub>2</sub> sensors are fixed onto the red and blue Luer lock, respectively.

If the MyoHEART system is delivered with the pH and/or the pO<sub>2</sub> system the Luer Lock Sensors have not been installed in the pH/pO<sub>2</sub> sensor

housing. Please take the appropriate sensor and place it as shown in fig.122. and fig.123.

To replace the sensors with new ones, release the optical fiber by loosening the Luer lock screw and then replace the Luer Lock sensors with a new pO<sub>2</sub> or pH Luer lock sensor as shown in fig.121.



Fig.121.

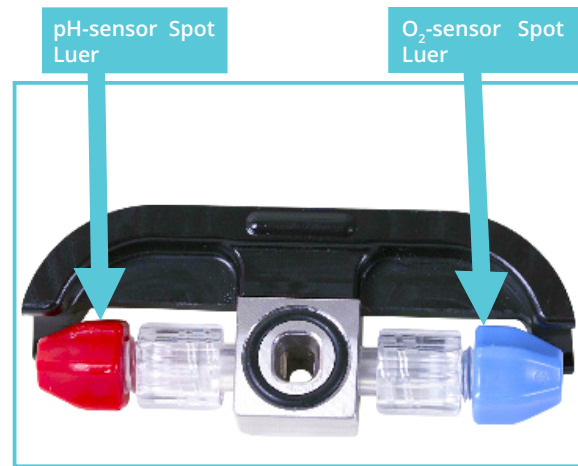
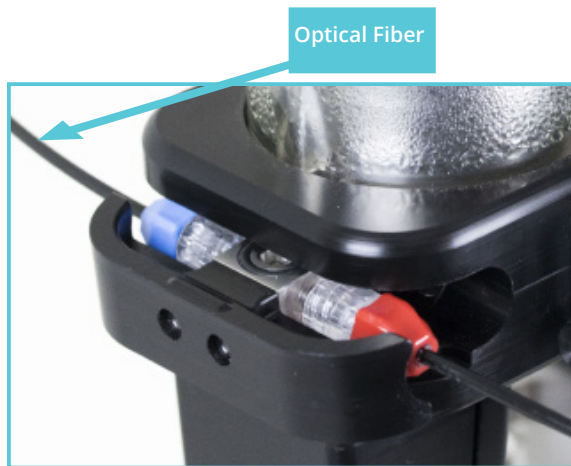


Fig. 122.: The  $pO_2$  and pH sensor fiber optics in MyoHEART.

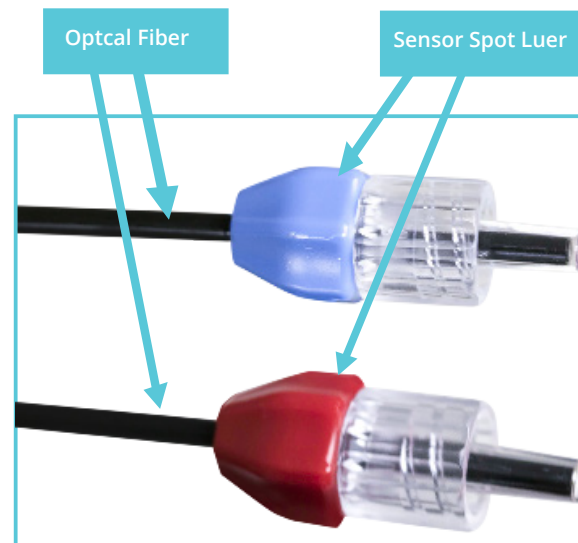
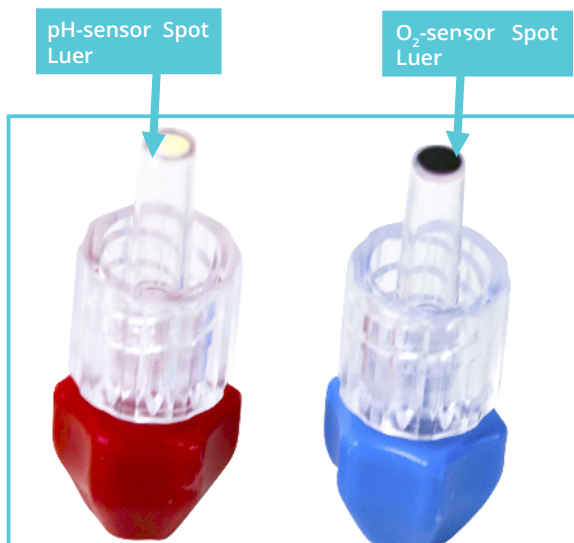


Fig. 123.: The  $pO_2$  and pH sensor fiber optic cables in MyoHEART.

In Labchart pH and pO<sub>2</sub> are shown and the pO<sub>2</sub> is shown as ppm (parts per million equals mg/l).

NOTE: It is extremely important that every time a pH or pO<sub>2</sub> sensor is replaced that the pH and pO<sub>2</sub> sensors are configured to the given batch of sensors.

CONFIGURATION OF THE pH AND O<sub>2</sub> SENSORS

Every time a new pH and pO<sub>2</sub> sensors is inserted in the sensor housing the sensors need to be configured to be able to show the right values.

Enter the Setting menu and select either the Configure pH or pO<sub>2</sub>.

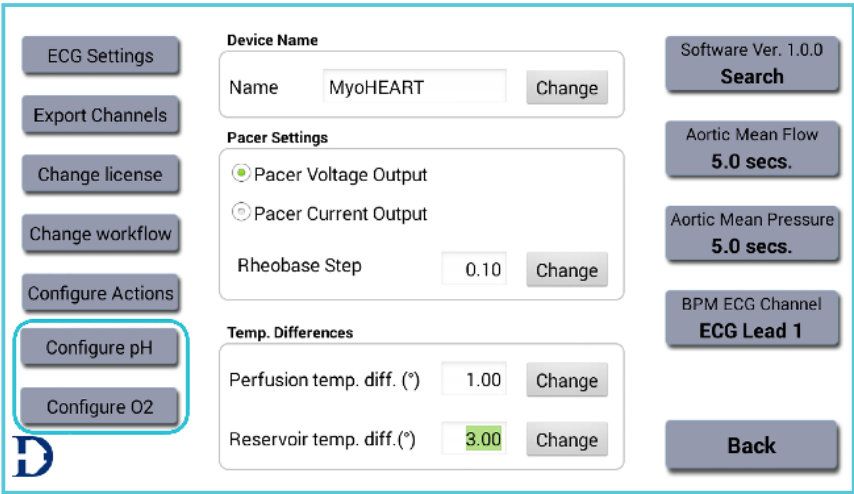


Fig.124.: Configure the pO<sub>2</sub> and pH sensors.

Enter the calibration values from the data sheet delivered with the sensor in the Configure pH menu.

Configure pH Module

pH Sensor Setup

Imin58.00

dpH0.52

Imax21.00

Temperature39

pH07.00

pH Offset3.9

Cancel

Save

Fig.125.: Configure pH menu.

The different values to be entered can be found on the datasheet following the pH sensor batch.

An example of the data sheet is shown in fig.126.

Final Inspection Protocol

Type of sensor

Single use flow through cell with integrated pH sensor

Ordering code

FTC-SU-HP8-US

Article number

200001611

Batch number

FTC-SU-HP8-1545-01

Production Date

11 Nov 2015

Do not use after

11 Nov 2017

Reference devices

SOEM-Prot-0146

Dear customer,

Data are specific for the test instrumentation used in our laboratory. Your instrument in combination with the sensors might show different signal amplitude and phase angles.

Data

Data were obtained with 40 mM PBS, ionic strength = 140 mM

	Actual value	Valid range	QC-passed?
Imin	56.22	45.00 - 60.00	ok
Imax	22,04	15.00 - 40.00	ok
pH0	6.79	6.00 - 8.00	ok
dpH	0.49	0.30 - 1.00	ok
Temperature	37	35 - 38	ok

Fig.126.



In Labchart pH and pO<sub>2</sub> are shown and the pO<sub>2</sub> is shown as ppm (parts per million equals mg/l).

Configure Oxygen Module

O2 Sensor Setup

Cal 0 Phase61.05

Cal 0 Temp.21.0

Cal 2nd Phase27.21

Cal 2nd Temp.21.0

Cancel

Save

Fig.127.: Configure pO<sub>2</sub> menu.

The different values to be entered can be found on the datasheet following the pO<sub>2</sub> sensor batch. An example of the data sheet is shown in fig.128.

where the values to enter is marked with a blue box.

Data

Atmospheric pressure: 980 hPa

	Phase signal	Valide range	Temperature	Valid range	Amplitude	QC-passed?
	[°]	[°]	[C°]	[C°]	[µV]	(ok / failed)
cal 0	60.36	58.00 - 62.00	20.0	18.0 - 22.0	28608.7	OK
0% air sat						
cal 2nd	27.69	25.00 - 29.00	20.0	18.0 - 22.0	12154.4	OK
100 % air sat						

Response time [t90]: < 60 s

Valid range: < 60 s

Please type in these values into the software for "manual calibration"

Fig.128.

THE O<sub>2</sub> LEVEL IN THE PERFUSION BUFFER SHOWN IN PERCENT

The get the O<sub>2</sub> level as a percentage of the maximum O<sub>2</sub> level in a given perfusion buffer, one should make a vigorous O<sub>2</sub> or Carbogen bubbling of the perfusion buffer for 5 minutes. Then start perfusion the MyoHEART system and start the Labchart recording of the O<sub>2</sub> level in ppm. Let the trace run for at least 10 minutes or until it is not increasing anymore. This level is 100% O<sub>2</sub> level in the perfusion buffer. Then start a vigorous N<sub>2</sub>/CO<sub>2</sub> bubbling of the perfusion buffer. Now the pO<sub>2</sub> trace in Labchart

should drop. Continue until the O<sub>2</sub> level has reached a plateau. This level is the 0% O<sub>2</sub> level in the perfusion buffer. Do a 2-point calibration in Labchart using the 0% O<sub>2</sub> and 100% values. This will make it possible to have a Go into Labchart and do a 2-point calibration using the 100% and 0% values of the O<sub>2</sub> trace. Now the trace is shown as percentage of the maximum O<sub>2</sub> level in the given perfusion buffer. trace of the O<sub>2</sub> in percent of the maximum O<sub>2</sub> level in the given perfusion buffer.



# CHAPTER 4: Data Acquisition in MyoHEART

In MyoHEART all parameters are converted in to digital data and piped directly into the computer through the ethernet cable connection. On the computer the installed Labchart Pro software

will record and save all trace data selected in the **Export Channels** menu in MyoHEART. Go into the **Settings** menu and select Export Channels as shown below.

## EXPORT CHANNELS

In MyoHEART the user can select the parameters that should be recorded and saved for data analysis in Labchart. The Export Channel sub

menu is located in the Settings menu (fig. 129). In this menu the channels/parameters to be recorded is defined.

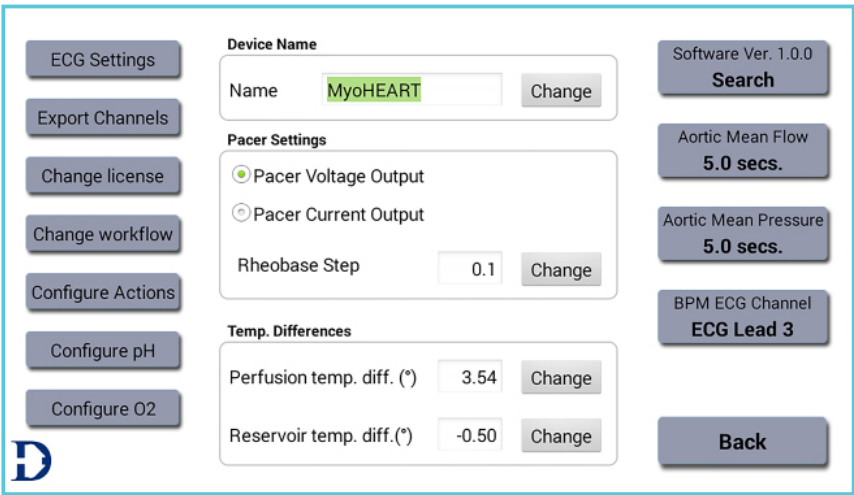


Fig.129.: Export Channel menu.

Pressing the Export Channel menu, the window shown in fig.130 will appear.

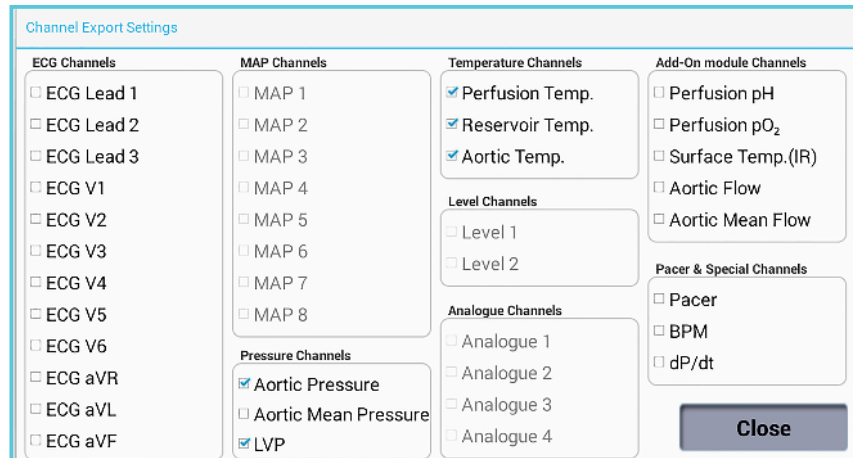


Fig.130.: Export Channel menu.

List of all parameters in the MyoHEART system. The gray-scaled parameters cannot be selected.

- Select the parameters of interest to be recorded in Labchart.
- Restart Labchart after selection.

The Export Channels is divided into the following categories

- ECG Channels
- MAP Channels
- Pressure Channels
- Temperature Channels
- Level Channels
- Analogue Channels
- Add-on module Channels
- Pacer & BPM Channels.

### ECG channels

The ECG recording in MyoHEART is based on

the Wilson coupling and therefore always select ECG Lead 1, 2 and 3 to get a proper ECG trace in one of the three lead traces (See description in Appendix B).

The other additional ECG channels are reserved for electrodes mounted on a 270° circular holder lowered into the buffer reservoir, to record unipolar Wilson leads V 1 to V 6 from their simulated electrode positions. These ECGs closely resemble a body surface ECG and reflect global changes in activation and repolarization of the isolated heart. The aVL, aVR, aVF is augmented limb leads calculated based on the other ECG recordings as described in Appendix B.

### MAP Channels.

The MAP electrodes and module will be introduced later in 2016.

Pressure Channels

**Aortic Pressure** - This channel/parameter is the actual pressure measured just above the mounted heart (see fig.131.A.).

**Aortic Mean Pressure** - This channel uses values from the Aortic pressure channel and calculate

the Aortic Mean Pressure across a given time period defined by the user. This time period, is defined by entering the Settings Menu and pressing the Aortic Mean Pressure Menu. Select the time period of seconds the mean pressure values should measure across (see fig. 131.B.). In the example below the Aortic Mean Pressure is calculated over 25.0 seconds.

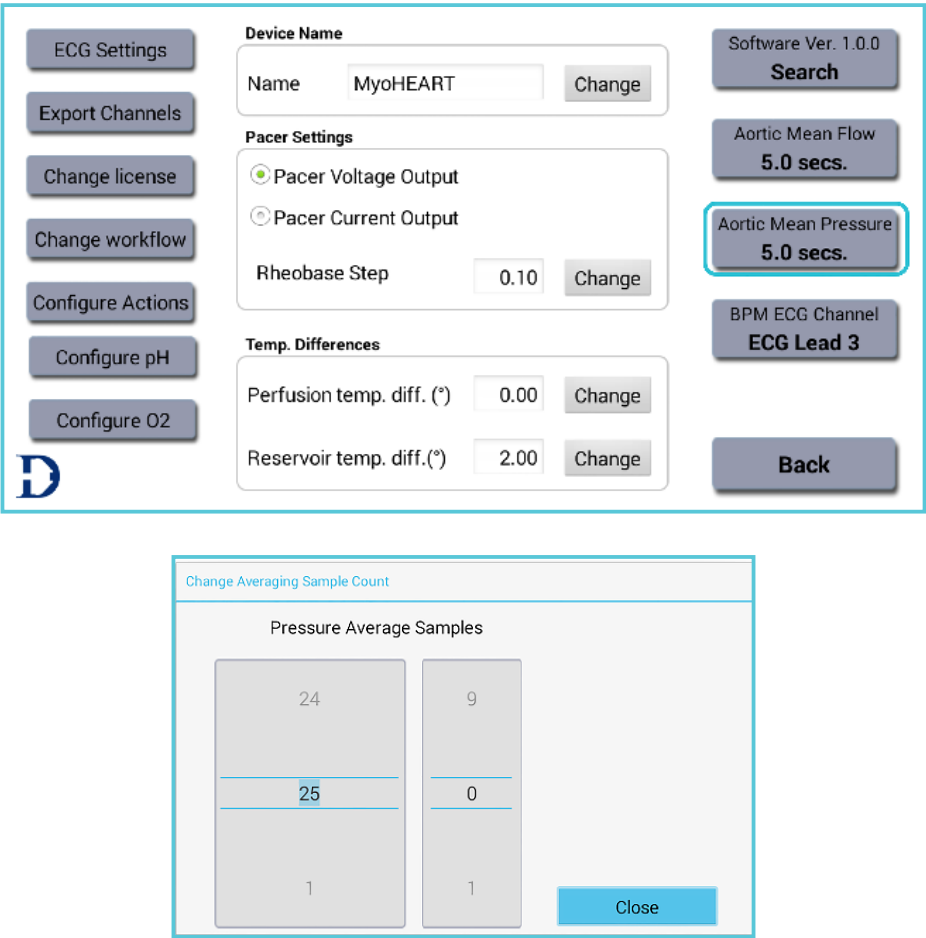


Fig. 131.B.: Aortic Mean Pressure.

**LVP (Left Ventricle Pressure)** – The Left Ventricle Pressure is measured by placing the appropriate size balloon in the left ventricle of the mounted

heart as described in Chapter 3. The LVP is measured in mmHg.

## TEMPERATURE CHANNELS

### **Perfusion Temp.**

This channel/parameter is the actual temperature of the perfusion buffer in the Perfusion Buffer Heating unit (see fig.20. and 21.).

### **Reservoir Temp.**

This channel/parameter is the actual temperature of the water in the heater bottle (see fig.31. and 32.).

### **Aortic Temp.**

This channel/parameter is the actual temperature

of the perfusion buffer just before it enters the mounted heart (see fig.26.).

### **Level Channels**

Channels reserved for future features and product releases.

### **Analogue Channels**

Channels reserved for future features and product releases.

---

## Add-on module Channels

**Perfusion O<sub>2</sub>** – This Channel can be selected if the O<sub>2</sub>- module has been added to the MyoHEART system. The O<sub>2</sub> trace will be shown in ppm equal to mg O<sub>2</sub>/liter in Labchart

**Perfusion pH** - This Channel can be selected if the pH-module have been added to the MyoHEART system. The pH meter has a working range between pH 6-9.

**Surface Temp. (IR)** – This is the temperature measured with the IR-temperature probe connected to the left hand side of the Tower (see picture below). It is important to keep a 90° angle to the surface to measure the correct temperature. Place the IR-temp sensor in the IR-temp holder preventing it from moving during measurement.

**Aortic Flow** – This channel/parameter can be selected if a flowmeter has been added to the MyoHEART system. The build-in flowmeter is positioned just above the Aortic Inlet (working range 0.5ml/min to 50ml/min) and flow shown is the raw signal from the flowmeter.

**Aortic Mean Flow** – This channel uses the values from the Aortic Flow channel and mean the values across a given time defined by the user. Define this time period by going into the Settings Menu and pressing the Aortic Mean Flow menu and select the period of seconds the Flow values should be taken the mean of (see figures below).

In the example below the Aortic Mean Flow is calculated over 23.0 seconds.

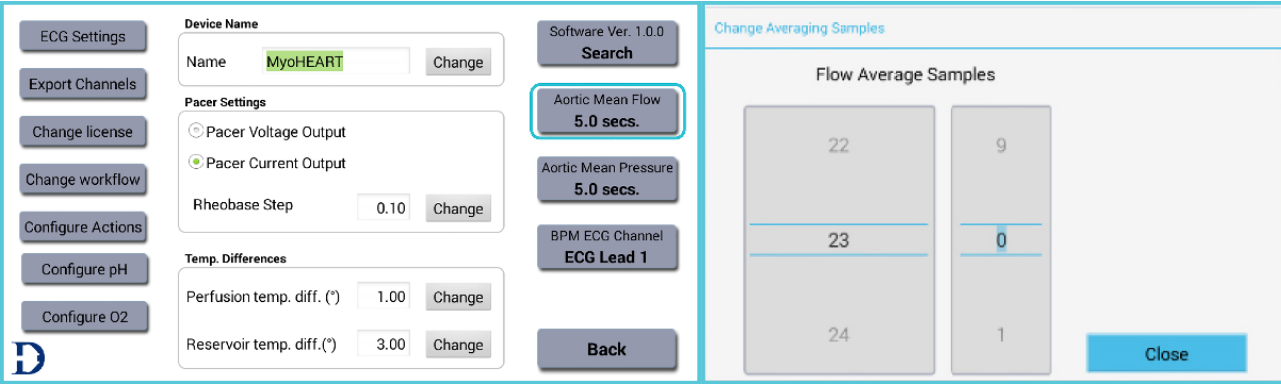


Fig.132.: Aortic Mean Flow.

## TEMPERATURE CHANNELS

### Pacer & BPM Channels

#### Pacer

This channel/parameter will show the actual voltage/ampere the pacer delivers at the given time in the trace.

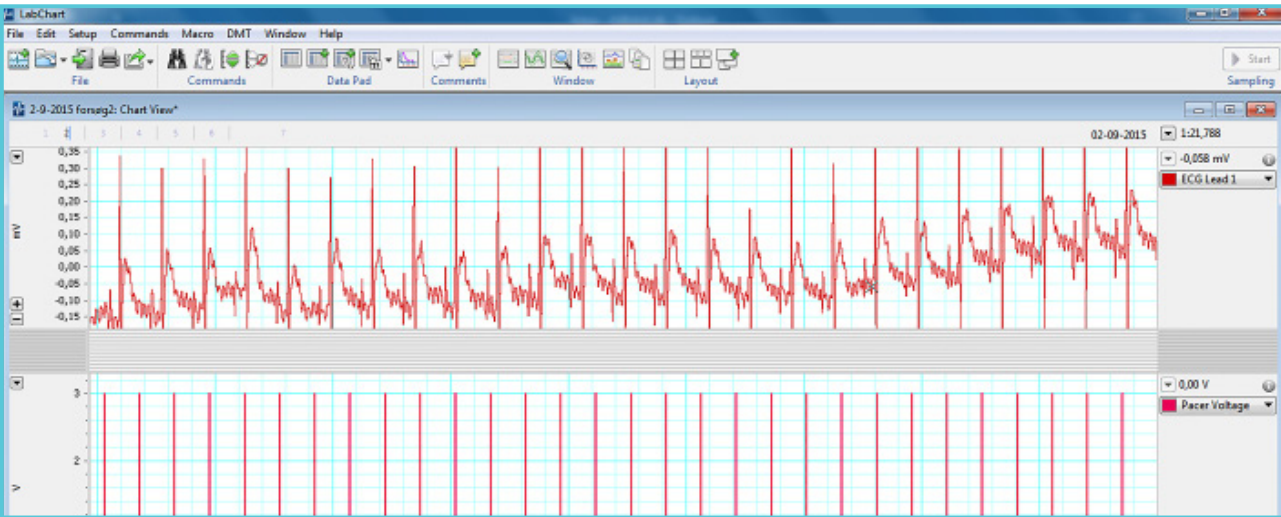


Fig.133.: Trace of the Pacer stimulus.

**BPM**

This channel/parameter shows the number heart beats per minute. (see page 79-81).

**dP/dt (max) (OPTIONAL)**

The dP/dt is a measure for the Left Ventricle contractility calculated from the LVP trace. By selecting the dP/dt the LVP trace will be shown in the three channels in Labchart as the following three parameter names

Max dP/dt (evaluation of systole function of LV)

Min dP/dt (evaluation of diastolic function of LV)

**Avg dP/dt**

Before Labchart shows the right values for the three parameters go into Labchart and right click on the right hand side of Labchart of the given trace.

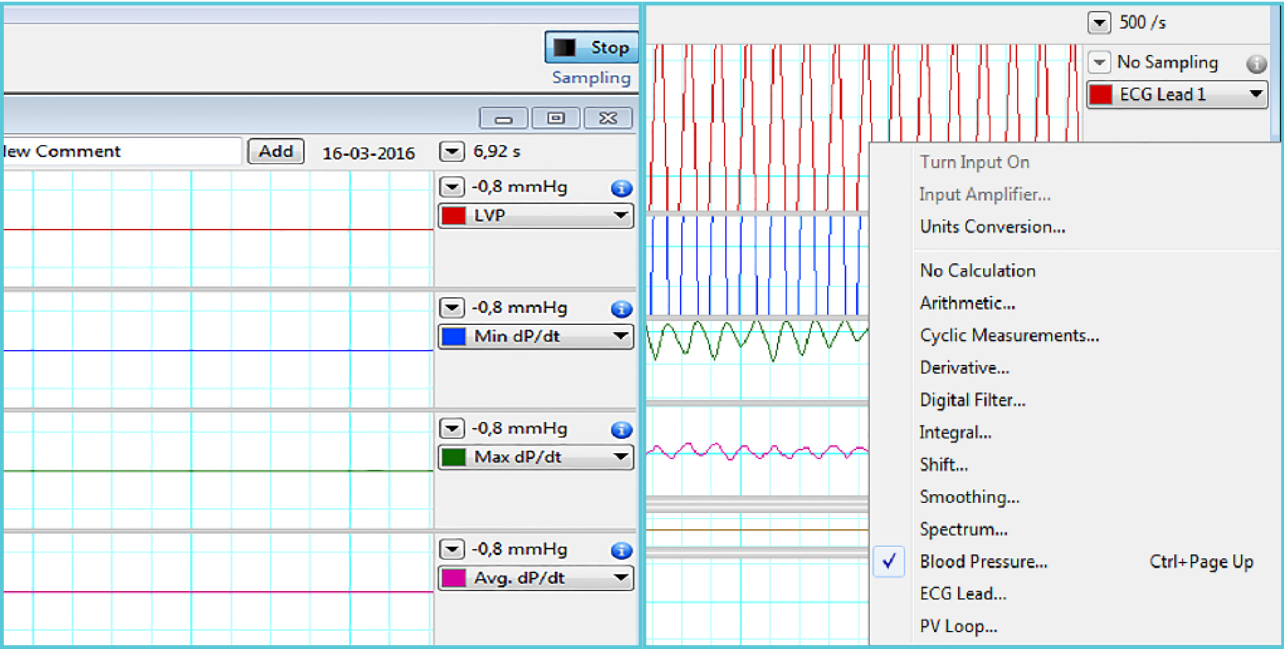


Fig.134.: Right Click in the right hand side to select the Blood Pressure menu in Labchart.

Select the Blood Pressure menu as shown in fig.134. The Blood Pressure menu shown in

fig.135.-137. will turn up and here select the Max dP/dt for the Max dP/dt trace.

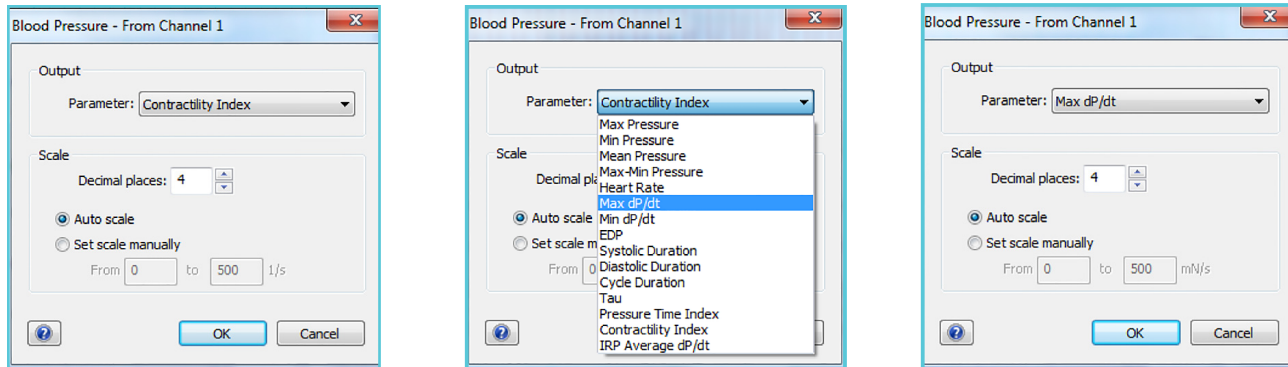


Fig. 135.: Blood Pressure menu in Labchart. Select the Max dP/dt in the Contractility dropdown menu for the Max dP/dt trace.

The Min dP/dt and the Avetage dP/dt is select in the same way for the corresponding trace names in Labchart as shown below.

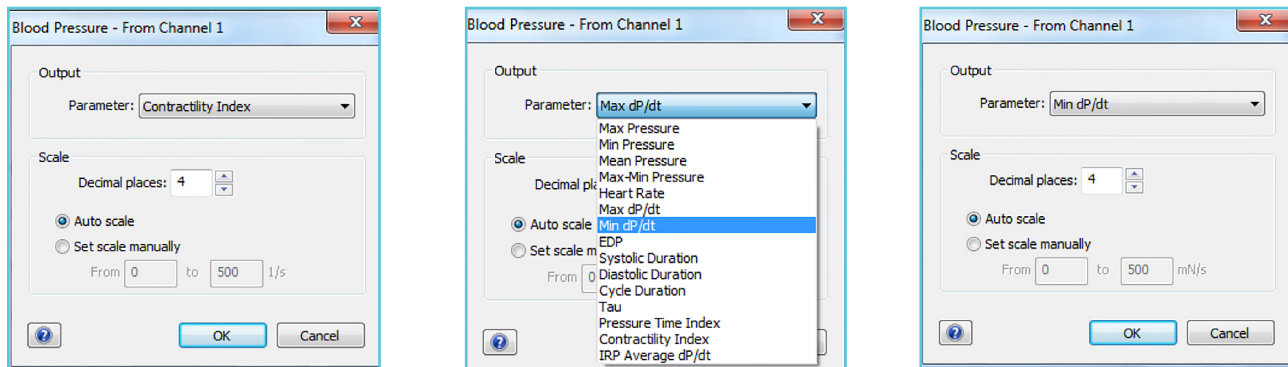


Fig. 136.: Blood Pressure menu in Labchart. Select the Min dP/dt in the Contractility dropdown menu for the Min dP/dt trace.

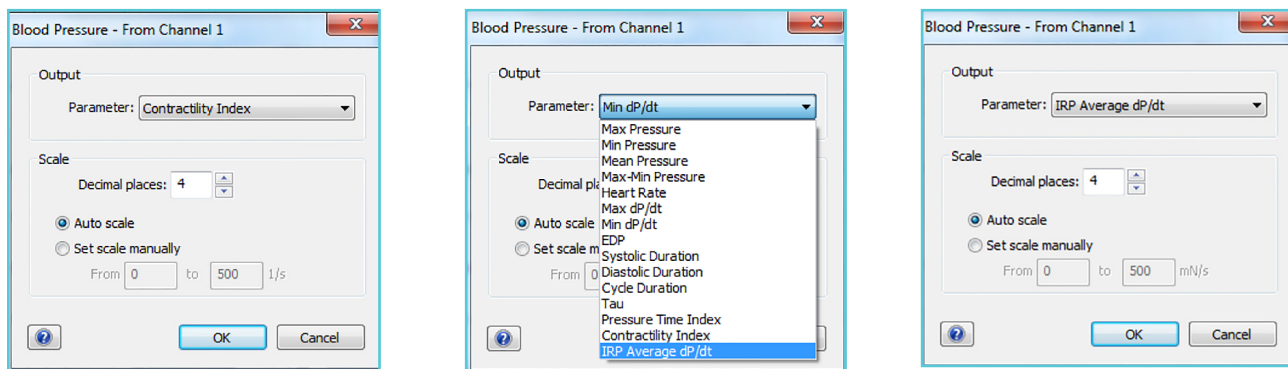


Fig. 137.: Blood Pressure menu in Labchart. Select the Avg dP/dt in the Contractility dropdown menu for the Avg dP/dt trace.

# CHAPTER 5: CHANGE MyoHEART LICENSE AND UPDATE OF THE MYOHEART SOFTWARE

## 5.1 CHANGE MYOHEART LICENSE

There are several add-on modules to the MyoHEART basic system and depending on the modules added, the license has to be changed in order to get the functionality of the Add-on modules available.

To change the license:

- Press the 'Change License' menu in the Settings menu

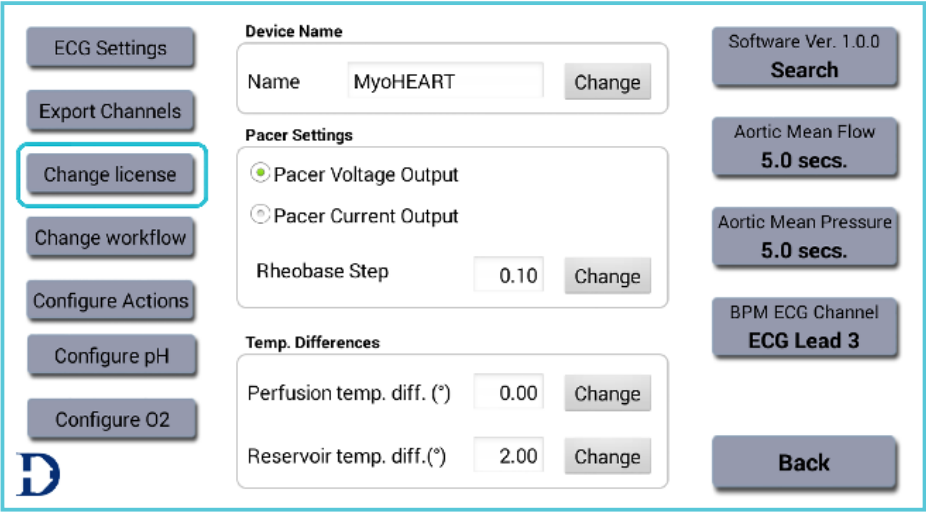


Fig. 138.: Change MyoHEART license menu.



Update MyoHEART License

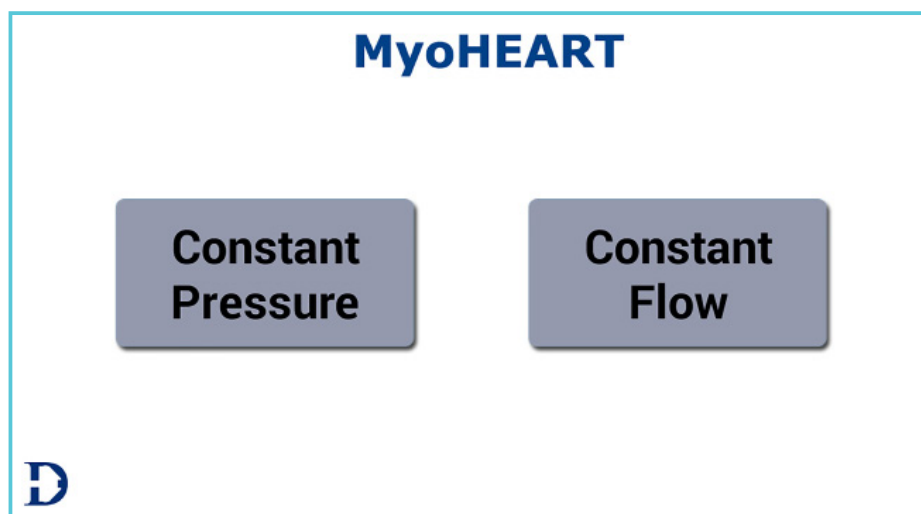
Customer  
dmt user

License  
67D8019224B5-25F60E7464F5-4373C07FEDD2-3007D9518639

Cancel Save

*Fig. 139.: Change MyoHEART license menu.*

- Enter the new license code you have obtained by your DMT sales representative and press save.
- MyoHEART will now restart and return to the Startup screen shown below.



The new add-ons will now be shown and ready to use.

5.2 UPDATING THE MYOHEART SOFTWARE

- The MyoHEART software can search for new updates.
- Press the Software Search menu in the Settings menu

NOTE: Please make sure the MyoHEART system is connected to the internet otherwise the software cannot search for new updates.

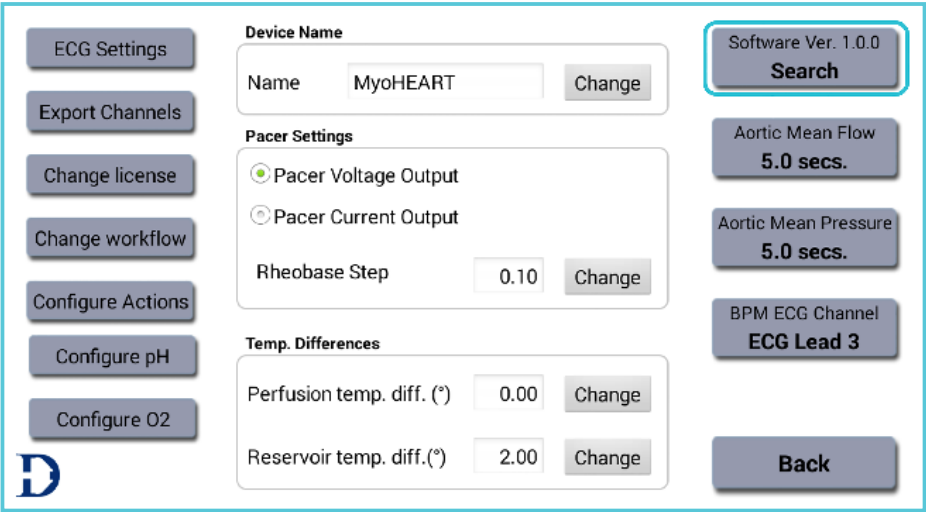


Fig. 140.: MyoHEART software update menu.

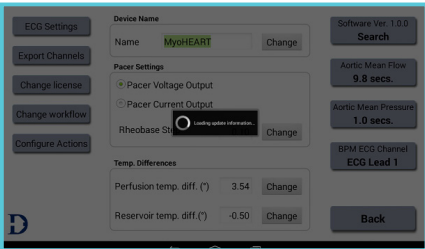


Fig. 141.A.: MyoHEART is searching for new MyoHEART releases.

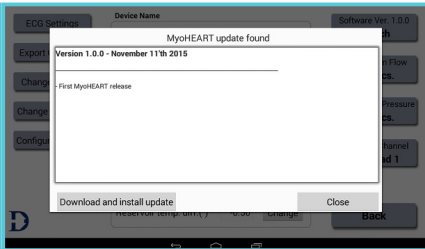


Fig. 141.B.: New software found.

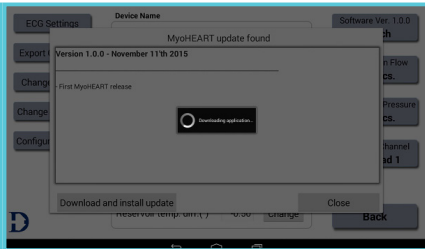


Fig. 14.C.: Downloading and Installing update.

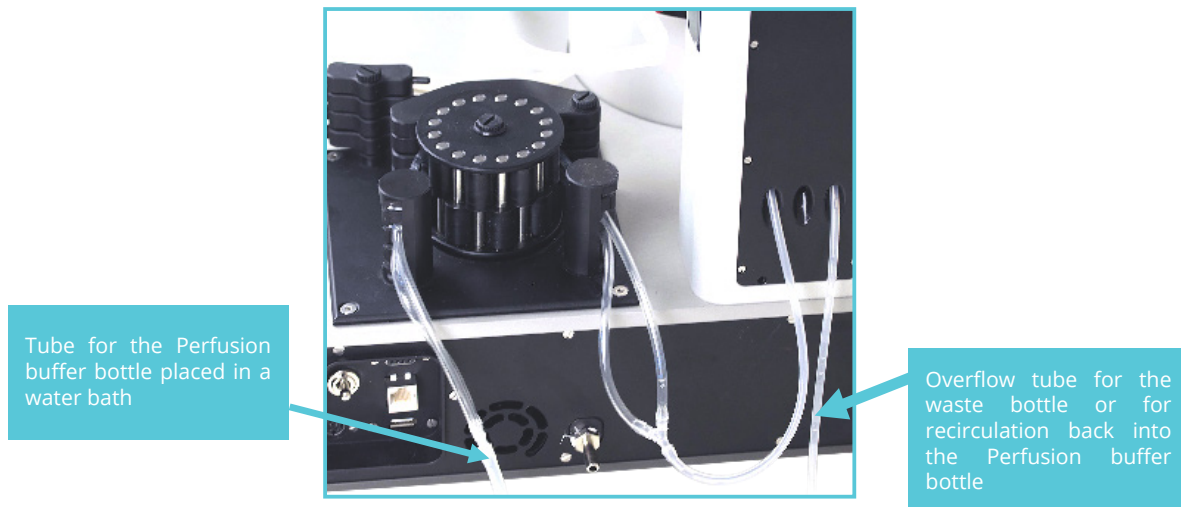
- Press Download and install update

## CHAPTER 6. CLEANING AND MAINTENANCE

Cleaning and maintenance of the MyoHEART system after each use is extremely important to have a fully functional system for years.

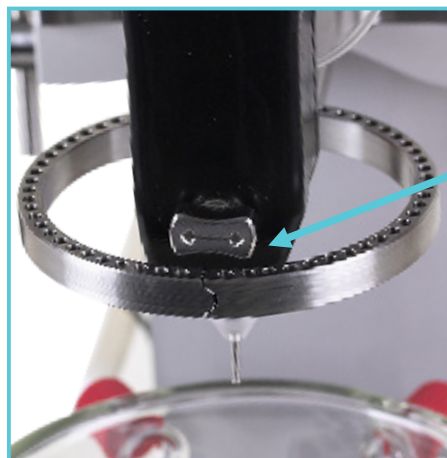
**Remove buffer and clean with distilled water.**

- Place the peristaltic pump tubing normally placed in the Perfusion buffer bottle into an empty bottle.
- Start the peristaltic pump.

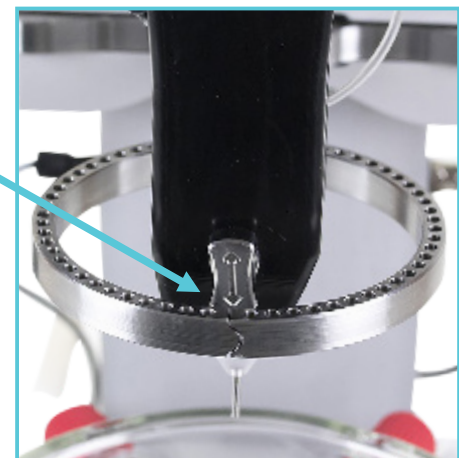


*Fig. 142.: Overview of where to place the tubes for the Perfusion buffer and the Overflow tube.*

- Open the aortic inlet stopcock.



*Fig. 143.A.: Aortic stopcock closed position.*



*Fig. 143.B.: Aortic stopcock open position.*

- Press the Max Speed button in the Flow menu as shown in fig.144. Close the Aortic Inlet stopcock when all buffer has been emptied into the Water Jacketed Buffer Reservoir.
- Press Max Speed in the Flow menu. Now the overflow tubing and the pressure controlling unit will be emptied from buffer.
- Stop the flow when there is no buffer coming out of the overflow tubing.
- Place the peristaltic pump tubing normally placed in the perfusion buffer bottle, in the bottle with distilled water.
- Start the peristaltic pump.

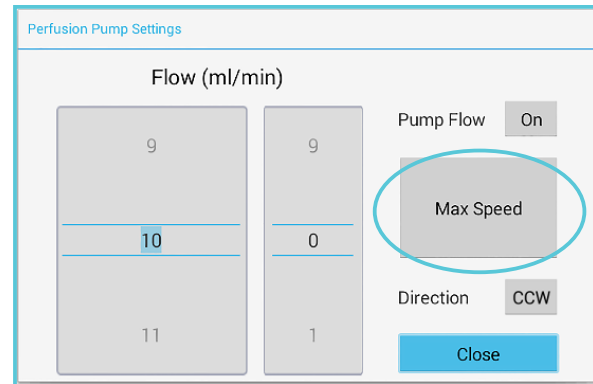


Fig.144.

- Open the aortic inlet stopcock. Press Max Speed flow for 60sec.
- Open valve on top of the Perfusion buffer heating unit (see below) and close the Aortic Stopcock.



Fig. 145A.: The Perfusion Buffer Heating Unit.

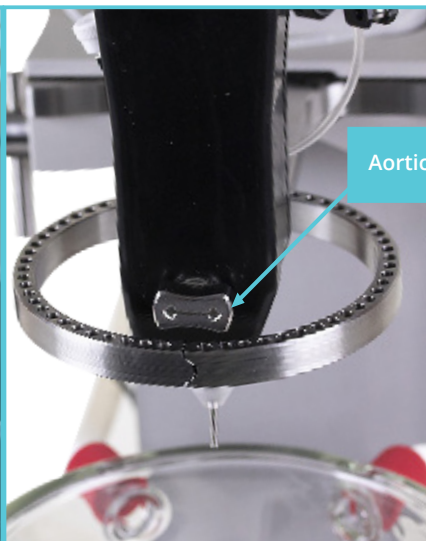


Fig.145.B.: Aortic stopcock closed position.

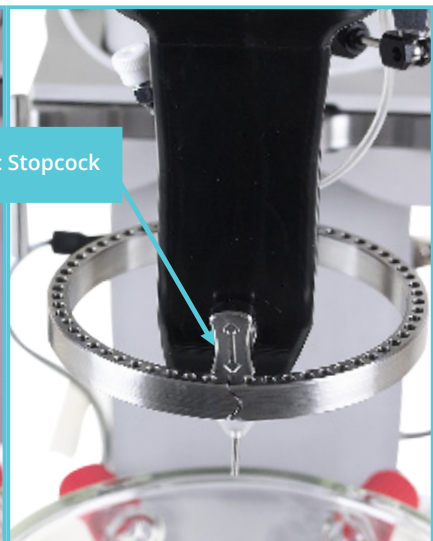


Fig.145.C.: Aortic stopcock open position.

- The Perfusion buffer heating unit will now be filled with distilled water. When it is completely filled open the stopcock again.
- When the Perfusion buffer heating unit is empty from distilled water, close the aortic inlet stopcock.
- Repeat step 7 and 8 two times.
- Place the tubing from the peristaltic pump in an empty bottle.
- Open the aortic inlet stopcock.
- Press the Max button in the Flow menu as shown below. When all distilled water has been emptied into the Water Jacketed Buffer Reservoir then close the Aortic Inlet Stop Cock.
- Press Max in the Flow menu. Now the overflow tubing and the Pressure Controlling unit will be emptied.
- Stop the flow when there is no distilled water coming out of the overflow tubing anymore.
- The MyoHEART internal tubing has now been cleaned.
- Empty the Water-Jacketed Buffer Reservoir by releasing the clamp on the tubing attached to the reservoir shown below and drain all buffer into a waste container.
- Rinse the Water-Jacketed Buffer Reservoir with distilled water.



*Fig. 146.: Filling the Perfusion buffer heating unit with distilled water to the point indicated in figure 146C.*

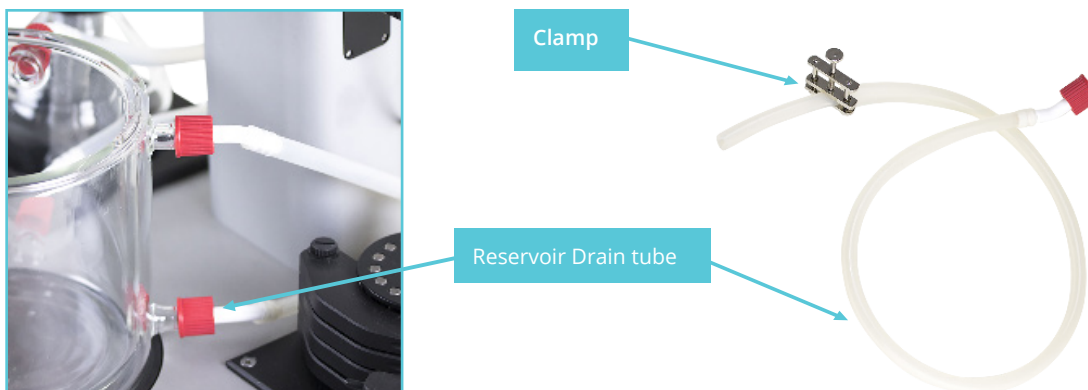


Fig.147.: Reservoir Drain tube.

- Wipe clean with a napkin.
- Empty the Water Jacketed Buffer Reservoir from 'Heating water' coming from the Heating Bottle. An easy way to do this is to place the Heating Rod in an empty container/bottle and turn on the Reservoir pump as shown below. The water in the Water Jacketed Buffer Reservoir will then be pumped out of the reservoir into the empty reservoir/bottle.



**WARNING: DO NOT TURN ON THE HEAT.**

- Stop the pump.
- Close the aortic inlet stopcock.

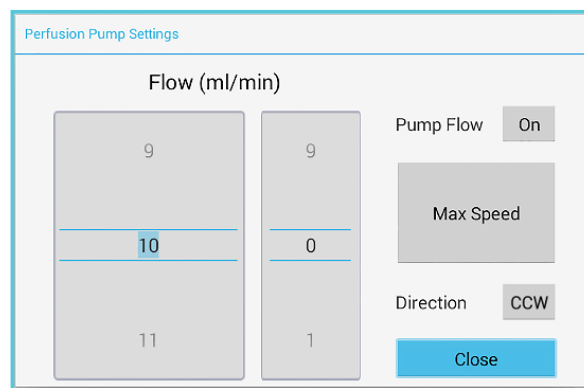


Fig.148.: Stop the peristaltic pump by pressing the ON icon.

- Turn off:
1. Pressure in the Pressure menu (only in the Constant Pressure Mode).
  2. The heating of the Aortic Perfusion buffer heating unit in the Perfusion Temp menu.
  3. The heating and pump of the Heating Rod in the Reservoir Temp menu.

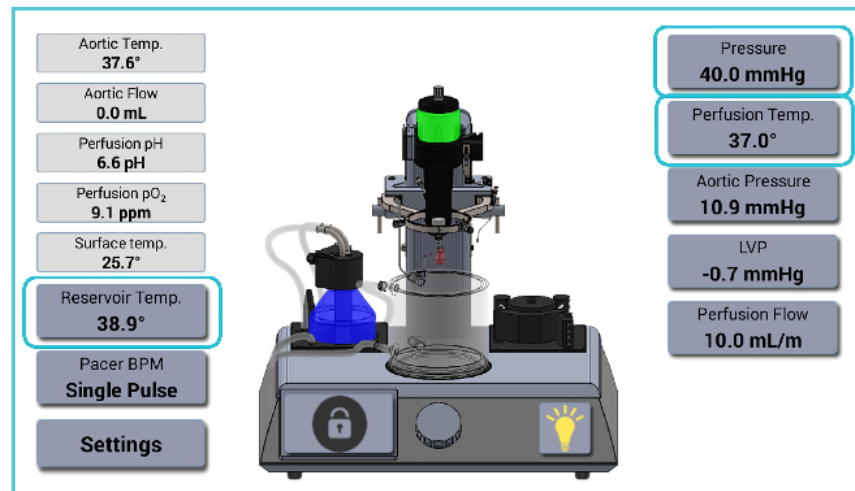


Fig.149.: Constant Pressure Mode. The three menus used to turn off pressure and heating.

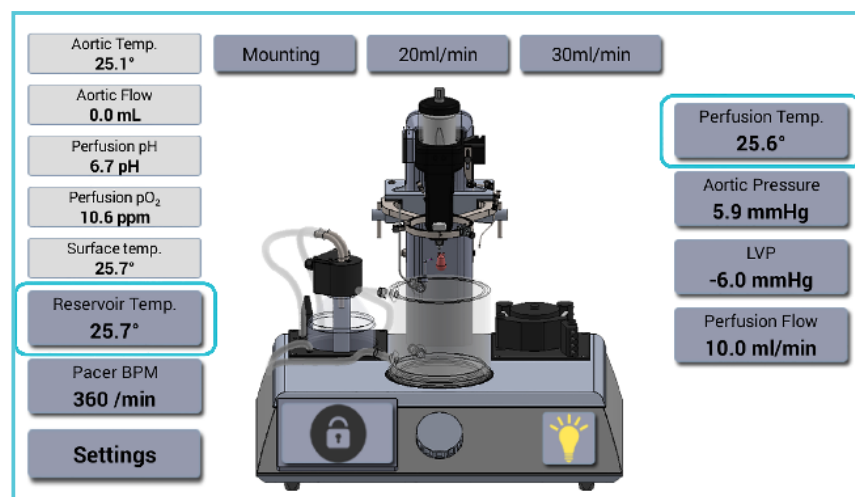
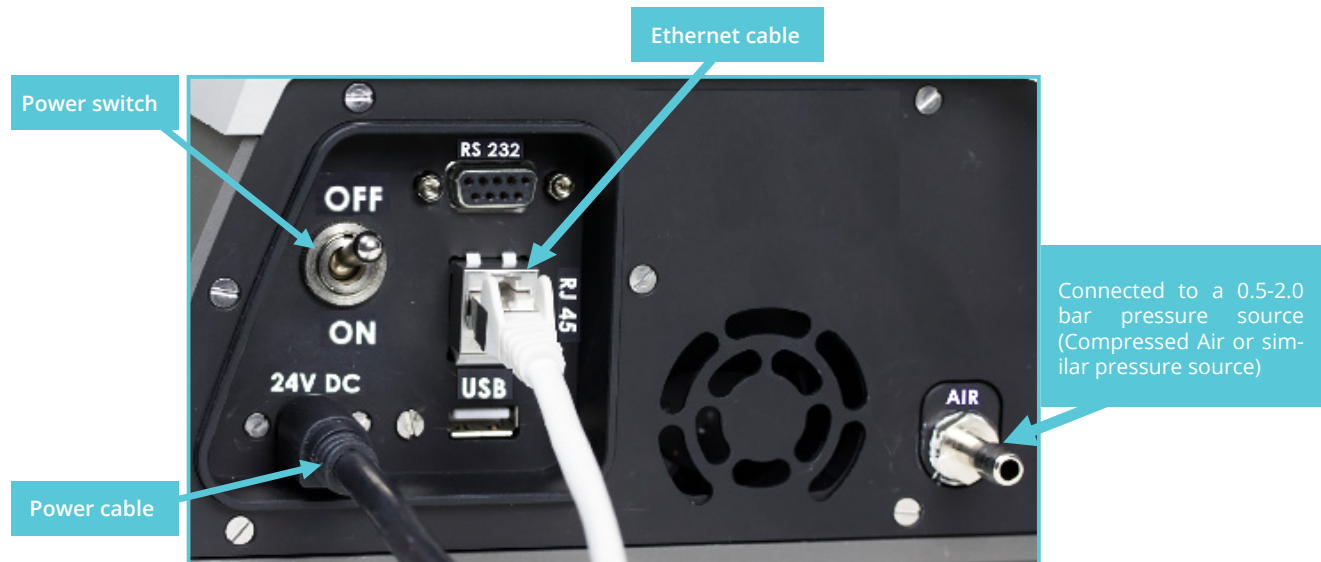


Fig.150.: Constant Flow Mode. The two menus used to turn off the heating.



- Turn off the pressure coming from a gas tank or similar pressure source
- Turn off the power of MyoHEART system using the main power switch.



*Fig.151. Turning OFF the main power switch.*

### Peristaltic pump maintenance:

The MyoHEART system is delivered with six sets of tubing for the peristaltic pump. The Perfusion value precision is highly dependent on whether the peristaltic tubing is new or has been used for a long period. The perfusion flow of the pump can be controlled by collecting the flow for 2-3 minutes running through the MyoHEART system in the Constant Flow mode into an empty container (remember to weight it before filling) and then weigh the container after e.g. 3 min.

flow at a given set flow e.g. 10.0ml/min. If the flow difference between the set flow and actual flow is too high, then replace the peristaltic tubing with a new. The peristaltic tubing set should be replaced on regular basis every week (after 5 days of running 8 hours a day) to make sure that the Perfusion flow is as precise as possible. To get a very precise measurement of the actual flow an Internal Flowmeter for the MyoHEART system would be needed.



## SPECIFICATIONS

### External Power adapter 150W:

#### Input:

Volt 100-240VAC 50/60Hz.

Current max.: 1.8 Amps.

No Load Input Power <0,5W

Energy Efficiency Level V, CEC2008 & EISA 2007

#### Output:

Volt 24VDC.

Current max. 6.25A.

### MyoHEART System data:

Dimensions L\*D\*H in cm: 55 x 46 x 56

Net weight: 30kg.

Heart chamber Dia. \* H in cm: 15 x 13,5 Volume 1.6liter.

Environmental humidity: 20% to 80% RH, none condensing.

Environmental operating temperature: +20 to +30°C.

Environmental storage temperature: +4 to +70°C.

**Flow meter:** Flow sensor measure range 0 to 40ml/min.

Accuracy 10 % of measured value from 1ml/min. to 40ml/min.

**Peristaltic pump:** 0 to 100 rpm.

**pH sensor range:** pH5.5 to pH8.5. Accuracy  $\pm 0,1$ pH.

**pO<sub>2</sub> sensor range:** 0 to 45ppm. Accuracy  $\pm 0,5$  %.

### Heater Bottle for the Water Jacketed Buffer Reservoir:

Built-in.

Temperature range: 20 - 50°C.

Temp. Resolution: 0.1°C.

Temp. Stability:  $\pm 0.3$ °C. (When target temperature attained).

**Perfusion buffer heater:**

Built-in.

Temperature range: 20 - 50°C.

Temp. Resolution: 0.1°C.

Temp. Stability: +/- 0.2°C.

**External IR temperature probe:**  $\pm 0.1^{\circ}\text{C}$  accuracy in the range 30-40°C

**Perfusion pressure settings:** 0mmHg to 250mmHg.

**Perfusion pressure transducer** 0mmHg to 250mmHg.

**LVP pressure transducer:** 0mmHg to 250mmHg.

**Pacer:**

Output selectable between Volt and Current. Bipolar or monopolar.

Volt output range 0 to 15V resolution 0,01V.

Current output range 0 to 15mA resolution 0,01mA.

Stimuli pulse width 0,1 to 1000ms.

Frequency 0,1 to 20Hz.

**ECG:**

Wilson coupling up to 12 lead's Derivations.

Gain range select able from 100 to 1200.

# APPENDIX A

## EXAMPLE OF A MYOHEART LANGENDORFF EXPERIMENT ON GUINEA PIG HEART

**Purpose:**

To investigate compounds effects on isolated perfused guinea pig hearts.

**Animals:**

Female Harlan guinea pigs are used (app. 450 g).

**Reagents:**

Heparin /salt water 1000 ie/ml

Ketamine/xylazine

Krebs-Henseleit solution (Perfusion solution)

Mucasol 3 % for cleaning

**Perfusion buffer:**

For 2000 ml KB stock solution x 20		Final concentration 1 x perfusion solution
2 M KCl	80 ml	4 mM
4 M NaCl	1200 ml	120 mM
1 M CaCl2	100 ml	2,5 mM
1 M MgCl2	24 ml	0,6 mM
1 M NaH2PO4	24 ml	0,6 mM

The 20X stock solution should be filtered to remove small particles.

***Stock solution:***

	Concentration	MW	g/L
NaCl	4 M	58.44	233.76
KCl	2 M	74.55	149.10
MgCl <sub>2</sub> , 6H <sub>2</sub> O	1 M	203.30	203.30
NaH <sub>2</sub> PO <sub>4</sub> , 2H <sub>2</sub> O	1 M	156.01	156.01
CaCl <sub>2</sub>	1 M	147,02	147,02
Glucose, H <sub>2</sub> O	1 M	198.17	198.17
Should be filtered			
NaHCO <sub>3</sub>	1 M	84.01	84.01

***Working solution:***

Add 100 ml 20 X KB stock +50 ml NaHCO<sub>3</sub> + 22 ml Glucose fill to 2000 ml with Milli-Q water.

Bubble the solution for min 20 min with Carbogen (5% CO<sub>2</sub>, 95% O<sub>2</sub>)

4-6 L KB solution is needed for 1 experiment

***Dosing:***

For drug testing the compounds are dissolved in DMSO and diluted in the KB solution for retrograde delivery to the heart.

***Equipment***

Turn on the water bath (37°C), MyoHEART system Reservoir and Perfusion Temp heating and Computer. Select the parameter for recording in the Settings-> Export Channels. Start Labchart.

***Purge the MyoHEART system with KB solution (Perfusion buffer).***

***Operation and mounting of the heart***

The Guinea pig is anaesthetized with intraperitoneal injection of ketamine/xylazine. 1000 i.e./100g of heparin is injected IV into the femoral vein. Respiration is maintained by artificial ventilation through a cannula in the trachea (volume 12 ml/kg, rate 60 strokes/min). Upon thoractomy, a perfusion cannula is inserted in the aorta for retrograde perfusion (perfusion pressure is set to 40 mmHg and 14 ml/min at this point).

***Protocol:***

When the HR is below 300 BPM the experiments is initiated, minimum 15 min after perfusion was initiated and maximum 1 H after.

Baseline recordings: 18 min no pacing + 2 min pacing (LV) (300 BPM (CL=200 ms), find rheo base), measure ERP by applying S2 stimulation at decreasing coupling intervals. Repeat the pacing procedure from RA. Repeat rheo and ERP determinations after 2 and 4 additional minutes to confirm that the recordings are stable.

Drug conc 1: 18 min no pacing + 2 min pacing (LV) (300 BPM (CL=200 ms), find rheo base), measure ERP by applying S2 stimulation at decreasing coupling intervals. Repeat the pacing procedure from RA .

Drug conc 2: 18 min no pacing + 2 min pacing (LV) (300 BPM (CL=200 ms), find rheo base), measure ERP by applying S2 stimulation at decreasing coupling intervals. Repeat the pacing procedure from RA.

Drug conc 3: 18 min no pacing + 2 min pacing (LV) (300 BPM (CL=200 ms), find rheo base), measure ERP by applying S2 stimulation at decreasing coupling intervals. Repeat the pacing procedure from RA.

Washout: 18 min no pacing + 2 min pacing (LV) (300 BPM (CL=200 ms), find rheo base), measure ERP by applying S2 stimulation at decreasing coupling intervals. Repeat the pacing procedure from RA.

***Analysis:***

Flow: The flow is measured as the mean flow of the last 2 min every 2nd minute.

ECG: QT, PR, RR and QTc are recorded.

## APPENDIX B: ECG LEADS IN MYOHEART

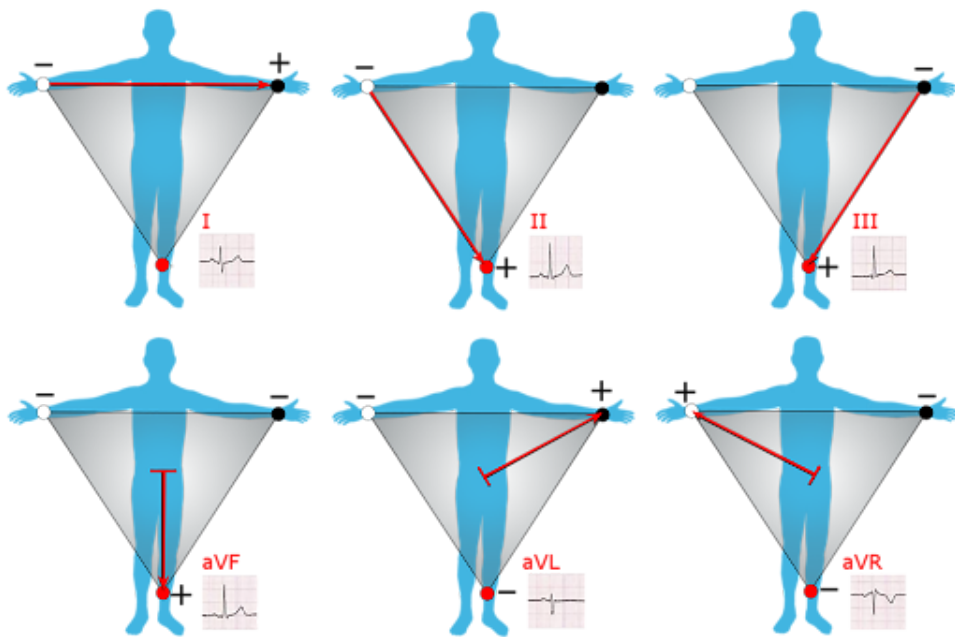
The term “lead” in electrocardiography refers to the 12 different vectors along which the heart’s depolarization is measured and recorded. There are a total of six limb leads and augmented limb leads arranged like spokes of a wheel in the coronal plane (vertical) and six precordial leads that lie on the perpendicular transverse plane (horizontal). In medical settings, the term leads are also sometimes used to refer to the ten electrodes themselves, although this is not technically a correct usage of the term.

Each of these leads represents the electrical potential difference between two points. For each lead, the positive pole is one of the ten electrodes. In bipolar leads, the negative pole is a different one of the electrodes, while in unipolar leads, the negative pole is a composite pole known as Wilson’s central terminal. Wilson’s central terminal VW is produced by averaging the measurements from the electrodes RA, LA, and LL to give an average potential across the body:

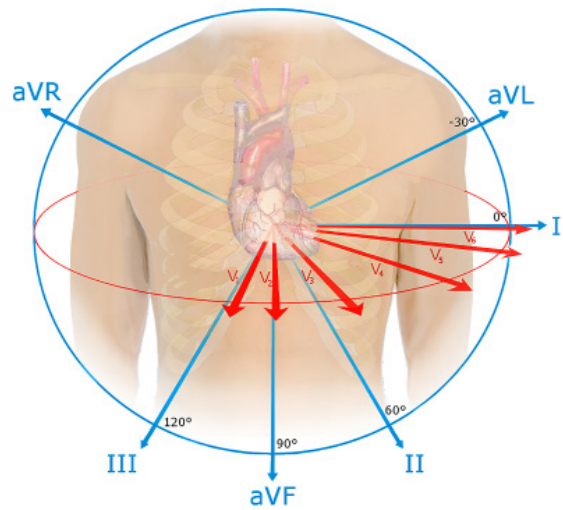
$$V_W = \frac{1}{3}(RA + LA + LL)$$

In a 12-lead ECG, all leads except the limb leads are unipolar (aVR, aVL, aVF, V1, V2, V3, V4, V5, and V6).

LIMB LEADS



The limb leads and augmented limb leads



Leads I, II and III are called the limb leads. The electrodes that form these signals are located on the limbs—one on each arm and one on the left leg. The limb leads form the points of what is known as Einthoven's triangle.

- Lead I is the voltage between the (positive) left arm (LA) electrode and right arm (RA) electrode:

$$I = LA - RA$$

- Lead II is the voltage between the (positive) left leg (LL) electrode and the right arm (RA) electrode:

$$II = LL - RA$$

- Lead III is the voltage between the (positive) left leg (LL) electrode and the left arm (LA) electrode:

$$III = LL - LA$$

## AUGMENTED LIMB LEADS

Leads aVR, aVL, and aVF are the augmented limb leads. They are derived from the same three electrodes as leads I, II, and III, but they use Wilson's central terminal as their negative pole.

- Lead augmented vector right (aVR) has the positive electrode on the right arm. The negative pole is a combination of the left arm electrode and the left leg electrode:

$$aVR = RA - \frac{1}{2}(LA + LL) = \frac{3}{2}(RA - V_W)$$



- Lead augmented vector left (aVL) has the positive electrode on the left arm. The negative pole is a combination of the right arm electrode and the left leg electrode:

$$aVL = LA - \frac{1}{2}(RA + LL) = \frac{3}{2}(LA - V_w)$$

- Lead augmented vector foot (aVF) has the positive electrode on the left leg. The negative pole is a combination of the right arm electrode and the left arm electrode:

$$aVF = LL - \frac{1}{2}(RA + LA) = \frac{3}{2}(LL - V_w)$$

Together with leads I, II, and III, augmented limb leads aVR, aVL, and aVF form the basis of the hexaxial reference system, which is used to calculate the heart's electrical axis in the frontal plane.

## PRECORDIAL LEADS

The precordial leads lie in the transverse (horizontal) plane, perpendicular to the other six leads. The six precordial electrodes act as the positive poles for the six corresponding precordial leads: (V1, V2, V3, V4, V5 and V6). Wilson's central terminal is used as the negative pole.

# APPENDIX C: PERISTALTIC PUMP SAFETY INSTRUCTION

## Safety Instructions

for peristaltic built-in pumps

The article number, serial number, and manufacturing date (month/year) are located on the pump rating plate. In case of further questions, please provide us with all the information on the rating plate.

**Spetec GmbH**  
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Germany  
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Fax: +49 (0) 81 22 / 10 3 67  
Internet: [www.spetec.de](http://www.spetec.de)  
e-Mail: [info@spetec.de](mailto:info@spetec.de)

Version: 09.12.2009  
Version: 1.1

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### 1. SAFETY REGULATIONS AND INSTRUCTIONS

Read these safety instructions carefully before you start working with the device. Observe the following warnings in order to avoid endangering persons or causing faults. These safety instructions are deemed to be part of the device. These safety instructions must be included if the device is sold or passed on to others. These safety instructions may be duplicated and passed on to others in order to provide information on potential dangers and how to avoid them.

- 1.1 Warning Information Danger Levels**  
The following danger levels are used in these operating instructions in order to indicate potentially dangerous situations and important safety regulations:



#### WARNING

The dangerous situation could occur, and could lead to slight injuries if the measures aren't followed. Work with great care.

#### CAUTION

The dangerous situation could occur, and could lead to injuries or material damage if the measures aren't followed.

#### NOTE

A potentially harmful situation could occur and will result in material damage if it is not avoided.

#### 1.2 Qualification of the Personnel

Installing the device, trial operation, and work on the electrical system may only be performed by an electrician. The device may only be transported, unpacked, operated, serviced, and otherwise used by trained and authorized specialist personnel.

#### 1.3 Basic Safety Rules

The safety risks emanating from the device must be re-evaluated after installation into the end user device. Observe the following during work on the device:

- ➔ Don't make any changes, additions, or modifications to the device without prior approval from Spetec.

#### 1.4 Electrical Voltage and Current

Check the electrical equipment of the device on a regular basis.

Repair loose connections and defective cables immediately.



#### WARNING

If the operating voltage is applied, the motor automatically starts up again, e.g. after a power failure. Risk of injury

- ➔ When performing work on the device, turn the mains voltage off and lock it out so it cannot be turned back on.

#### 1.5 Safety and Protection Functions



#### WARNING

Without safety systems, you could e.g. reach into the running device with your hands and injure yourself.

The device is an installation component without function, you as the operator are responsible for sufficiently protecting the device.

#### 1.6 Electromagnetic Radiation

Interference due to electromagnetic radiation, e.g. related to operation via controllers, is possible.

If excessive radiation levels occur once the device is installed, then suitable shielding measures must be implemented before putting the device on the market.

#### NOTE

**Electrical or electromagnetic faults after installation of the device in customer systems.**

Ensure that the entire system meets EMC requirements.

### 1.7 Mechanical Movement

#### CAUTION

##### Rotating device

Body parts which come into contact with the motor drive unit can be injured.

- Protect the device against contact. Before working on the system/machine, wait until all parts have come to a standstill.



#### WARNING Rotating device

Long hair, loose clothing, and jewellery can catch and be pulled into the device. You can be injured.

- Don't wear any loose or dangling clothing or jewellery while working on moving parts.
  - Protect long hair with a cap.
- There is only a slight risk of injury since the device only develops max. 90 N-cm.

### 1.8 Hot Surface



#### CAUTION

##### High temperature of electronic components

Risk of burns

- Provide for sufficient contact protection.

### 1.9 Transport

#### CAUTION

##### Transporting the hose pump

- Only transport the hose pump in the original, anti-static packaging.

### 1.10 Storage

Store the device under dry and weather proof conditions in the original packaging and in a clean environment. Protect the device against environmental influences and dirt until final installation. We recommend storing the device for no more than one year. Observe the storage temperature.

### 1.11 Disposal

For disposal of the device, observe all relevant requirements and regulations which apply in your country.

## 2. PROPER USE

The device is designed solely as an installed device for the conveying of fluids according to the technical data. Any other use or use beyond this scope is deemed to be improper use and is misuse of the device. Customer systems must meet the mechanical, thermal, and service life related loads.

#### Proper use also includes

- using the device in accordance with the allowable ambient temperature,
- operating the device with all safety systems,
- observing the safety information.

#### Improper use

The following uses of the hose pump in particular are prohibited and can be dangerous:

- operating the hose pump in the vicinity of flammable substances or components,
- operating the hose pump in an explosive atmosphere,
- use of the hose pump as a safety technology component or to perform safety-related functions,
- as well as all possible uses which are not listed under proper use.

Ask Spetec for support for all special questions.

## 3. CONNECTION AND COMMISSIONING

### 3.1 Making the Mechanical Connection

#### CAUTION

Risk of cutting and crushing injuries during removal of the hose pump from the packaging

- Ensure that anti-static measures are implemented.
- Lift the device from the packaging carefully, and make sure to avoid impacts.
- Wear safety shoes.

### 3.2 Making the Electrical Connection

The electrical connection is made after the mechanical connection.

### 3.3 Checking the Connections

#### Requirements

- Before you connect the device, ensure that the control voltage matches the motor data.
- Only use cables which are designed for the current load according to the specifications.

### 3.4 Turning the Device On



#### WARNING

##### Hot components

Risk of fire

- Ensure that there are no flammable and combustible materials in the vicinity of the hose pump.
- Check the device for externally visible damage before turning it on.
- Make the electrical connection.

### 3.5 Turning the Device Off

- Disconnect the device from the supply voltage.

## 4. MAINTENANCE, FAULTS, POSSIBLE CAUSES AND RECTIFICATION

Don't perform any repairs on your device. Send the hose pump to Spetec for repair or replacement.



#### WARNING

If the operating voltage is applied, the motor automatically starts up again, e.g. after a power failure.

### 4.1 Technical Safety Inspection

#### Fault/Error Possible Cause Possible Rectification

- |                                                        |  |
|--------------------------------------------------------|--|
| Motor doesn't turn                                     |  |
| - Mechanical jam                                       |  |
| - Faulty controller                                    |  |
| - Faulty connection                                    |  |
| - Defective control board                              |  |
| - Turn off, remove power, and clear the mechanical jam |  |
| - Check the control signal, restore the connection     |  |
| - Ambient temperature too high                         |  |

