dolomite

MITOS P-PUMP RANGE

USER MANUAL

Mitos P-Pump range

Product name	Product picture	Product description
Mitos P-Pump (Part No. 3200016)		The Mitos P-Pump provides pulseless liquid flow with a precise pressure driven pumping mechanism. It operates over a wide pressure range (0-10bar) with excellent response time and accuracy.
Mitos P-Pump Basic (Part No. 3200175)		The Mitos P-Pump Basic provides pulseless liquid flow with a precise pressure driven pumping mechanism. Connecting to a PC via RS232 serial interface allowing data logging and control using free PC software.
Mitos P-Pump Remote (Part No. 3200176)		The Mitos P-Pump Remote provides pulseless liquid flow operating over a wide pressure range (0 - 10bar) with excellent response time and accuracy. The design allows users to connect to Dolomite Remote Chambers or custom chambers with a push-click action.
Mitos P-Pump Remote Basic (Part No. 3200177)		The Mitos P-Pump Remote Basic connects to a PC allowing data logging and control using free PC software. The design allows users to connect to Dolomite Remote Chambers o custom chambers with a push-click action.

All four pumps in the Mitos P-Pump range provide pulseless liquid flow with a precise pressure driven pumping mechanism. The pumps operate over a wide pressure range (0-10bar). **Please note the Basic versions of the pumps will not work without PC control.**

<u>Note:</u> The Mitos P-Pump should not be used for prolonged periods with acetone. After being used with acetone, the chamber lid should be removed to allow the pressure chamber to be ventilated. Acetone must never be stored in the Mitos P-Pump.

For more information on the Mitos P-Pump product range please visit our website http://www.dolomite-microfluidics.com/webshop and download our technical datasheets.

Closed-loop Flow Control for the Mitos P-Pump

Please see separate Mitos P-Pump Flow Control user instructions for details on how to operate using closed-loop flow control.

Closed-loop flow control is an enhancement to the Mitos P-Pump system for improved control of flow rates from 70 nl/min to 5 ml/min. It requires that a Mitos Flow Rate Sensor (Part No. 3200096 – 3200100) is connected in-line between the pump and the microfluidic device. Once the pump detects that a flow rate sensor is connected, the flow control menu options are enabled. A target flow rate can then be set on the P-Pump and the pump pressure is automatically adjusted to meet the target flow rate.

System for Flow Control: Mitos P-Pump (Part No. 3200016) with Mitos Sensor Display (Part No. 3200095) and Mitos Flow Rate Sensor (Part No. 3200096 – 3200100)

The key benefits of closed-loop flow control are:

- Control flow rates instead of pressure making experiments easier to set-up and optimise.
- Improved flow rate precision: even better control over introduction of micro-scale reagent volumes.
- Ideal for droplet generation: higher long-term droplet monodispersity in flow control mode compared with pressure control mode.

Contents

1. Important Information

Overpressure Warning

Do not connect a pressure supply over 11 bar gauge to the Mitos P-Pump range. This may result in failure of the Mitos P-Pump range and injury to the user.

Glass Pressure Chamber Warning

If the glass pressure chamber is scratched or cracked, do not continue to use the Mitos P-Pump. This may result in failure of the Mitos P-Pump and injury to the user. Please contact Dolomite for replacement of the glass vessel.

Maintenance Advice

Maintenance should only be attempted by qualified service personnel. Removal of the back panel may invalidate any warranty. Please contact Dolomite for further information.

General Advice on Use of Pressure Equipment

Care must be taken when the Mitos P-Pump is pressurised to ensure that the unit is not dropped or damaged in any way.

Use of Oxygen and flammable gases

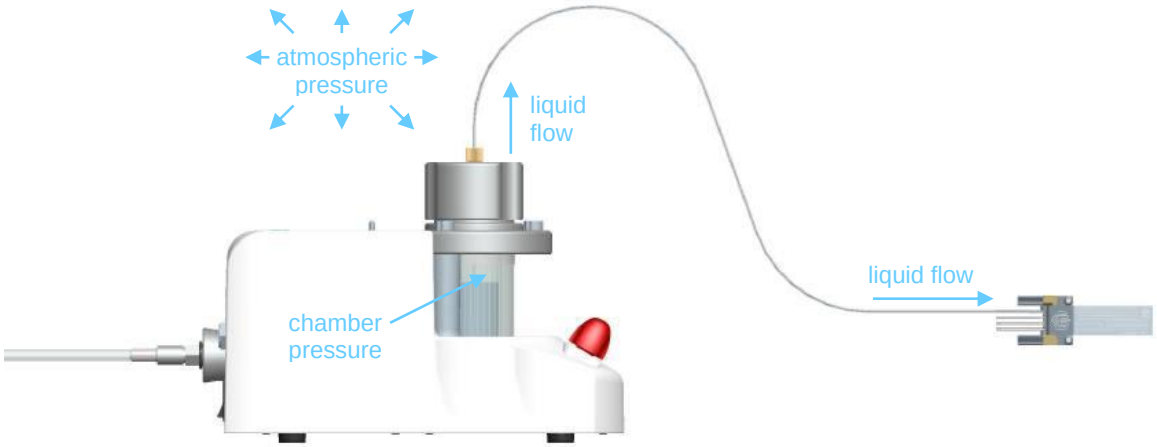
P-Pump should *not* be used with Oxygen or flammable gases

Eye Protection

Safety glasses should be worn at all times when using a Mitos P-Pump. This is due to the use of pressurised equipment and is especially important when hazardous liquids are used.

2. Getting Started

2.1 Introduction



The Mitos P-Pump range delivers fluid by a pressure driven pumping mechanism. The user sets the chamber pressure (gauge pressure), which determines the flow rate of liquid from the chamber. When the user vents the chamber (or when the Mitos P-Pump range is switched off) the pressure inside the chamber returns to atmospheric and flow stops.

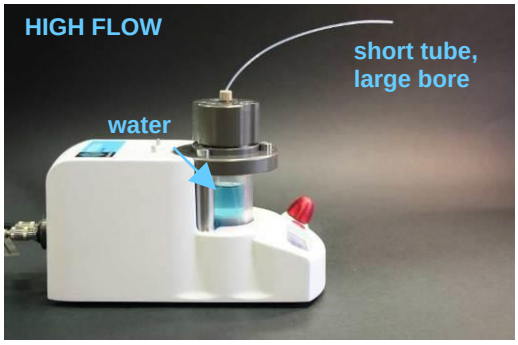
Gauge pressure: The pressure relative to atmospheric pressure (ambient air)

Absolute pressure: The pressure relative to a perfect vacuum

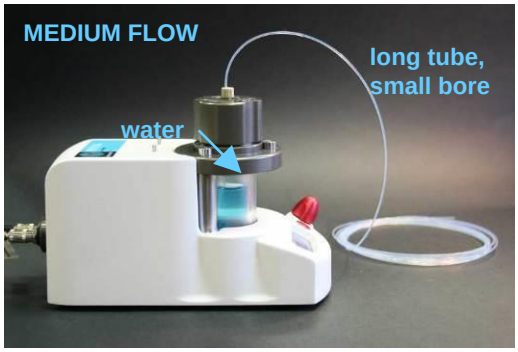
3. Understanding Pressure Driven Flow

The pressure driven flow concept applies to all pumps within the Mitos P-Pump range, whether the pressure chamber is part of the pump module, i.e Mitos P-Pump and Mitos P-Pump Basic or is connected to the pump via a pneumatic connection, i.e Mitos P-Pump Remote and Mitos P-Pump Remote Basic.

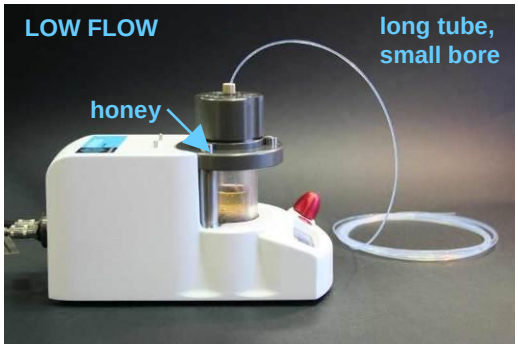
3.1 The Basics



If the Mitos P-Pump range is set to 5bar pressure and water is pumped out through a short section of tube, the water will be pumped out at a high flow rate.



If the short section of tube is replaced with a very long section of tube with a very small internal diameter, the water flow rate will slow down considerably. Microfluidic channels are equivalent to a tube with a very small internal diameter.



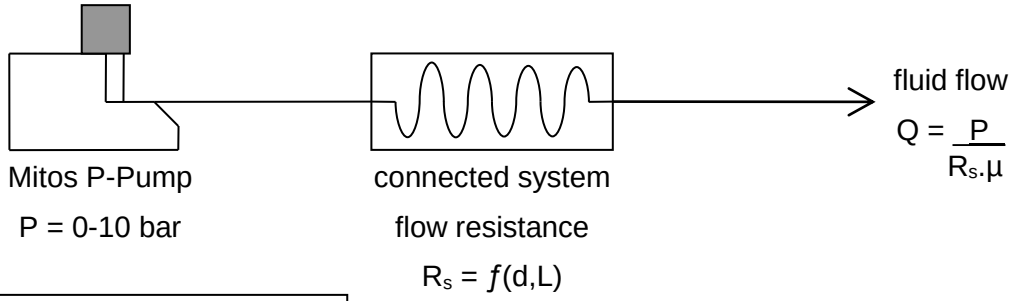
If the water is replaced with honey, then the flow rate will slow down even further (if it flows at all). This is due to the high viscosity of honey.

The following table show the effect of tube length, tube bore and viscosity on flow rate.

Effect of tube length on flow rate		**Effect of tube internal diameter on flow rate**		**Effect of viscosity on flow rate**	
Tube length	**Flow rate**	**Tube ID**	**Flow rate**	**Viscosity**	**Flow Rate**
0.01m	Q	1000µm	Q	1cP water	Q
0.1m	Q / 10	100µm	$Q / 10^{4}$	10cP salt solution	Q /10
1.m	Q / 100	10µm	$Q / 10^{8}$	100cP light machine oil	Q /100
10m	Q / 1000	1µm	$Q / 10^{12}$	1000cP corn syrup	Q /1000
100m	Q / 10000	0.1µm	$Q / 10^{16}$	10000cP thick honey	Q /10000

3.2 General Theory

When using the Mitos P-Pump range, it is important to be aware that the flow rate generated at a chosen pressure is dependent on the flow resistance of the system that you connect to and the viscosity of the fluid. This is illustrated in the diagram below.



Key

P: pressure set by user (bar)

R_s: flow resistance (mm^{-3})

d: tube internal diameter (mm)

L: tube length (mm)

Q: flow rate (µl/min)

µ: viscosity (cP)

Flow rate dependence on flow resistance

The flow resistance of a length of tube (or circular channel) is a function of the internal diameter and length. A long tube with small internal diameter gives a high flow resistance. This can be calculated with the following formula and used to calculate the flow rate in the system when pumping at a selected pressure.

flow resistance of tube or channel

$$R_s = 6.79 \times 10^{-9} . \frac{L}{d^4}$$

Insert into formula →

flow rate generated by a selected pressure

$$Q = \frac{P}{R_s . \mu}$$

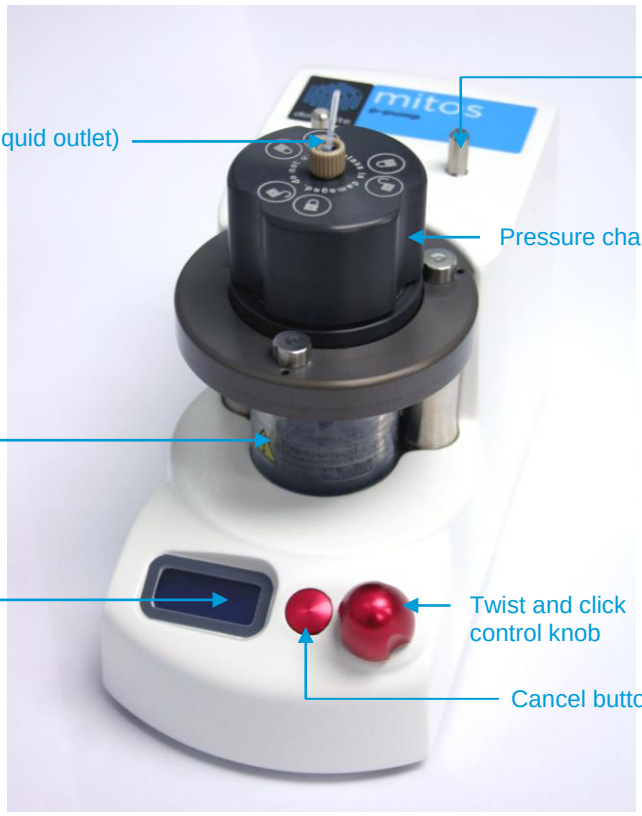
Please note the correct units must be used as defined above

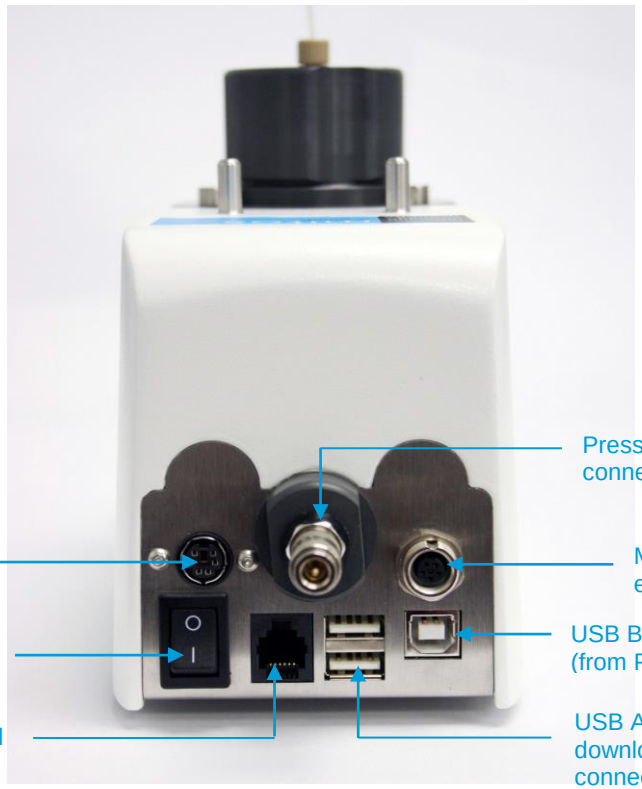
Formulae for flow rate calculation

For more information on using flow resistors with the Mitos P-Pump range please see section 10.

4. Mitos P-Pump (Part No. 3200016)

4.1 Features





The following accessories are supplied with the Mitos P-Pump:

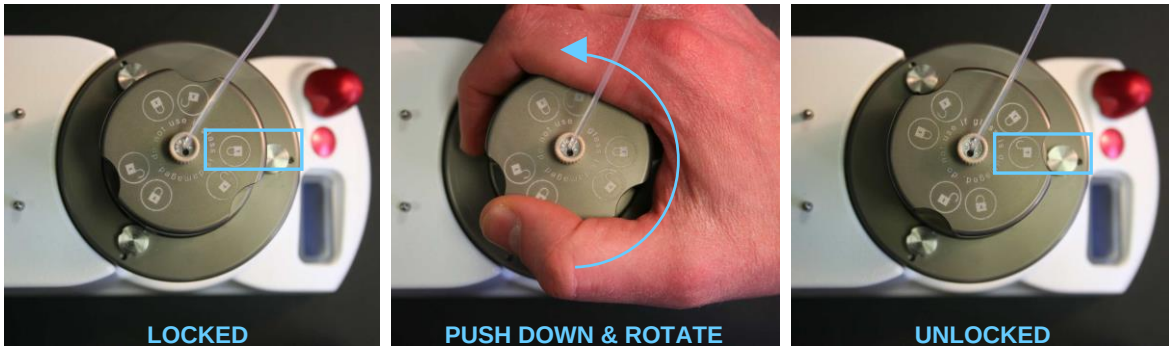
- Pneumatic supply cable
- Tubing FEP 250µm ID, 1/16” OD, 2m length
- Power supply unit
- Mains IEC lead

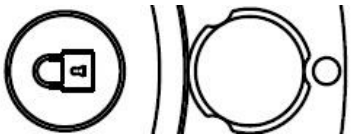
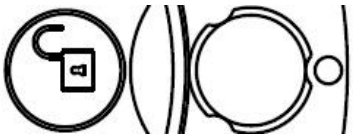
User to supply the following:

- Vessel containing sample liquid
    - Liquids to be pumped must always be placed in a suitable vial within the glass chamber. **Never place any liquid directly in the glass chamber!**
- Compressed air / gas supply

4.2 Fluidic Connection

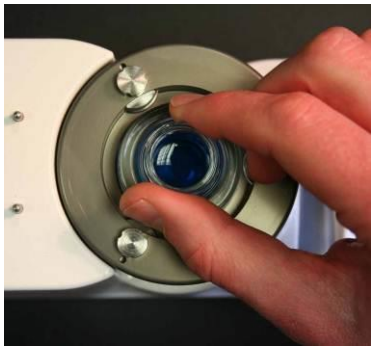
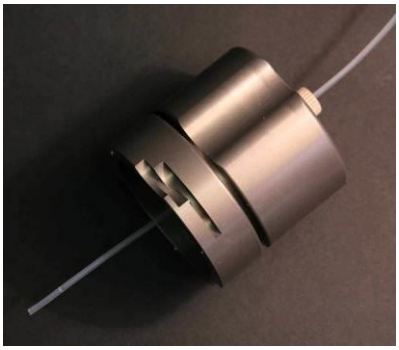
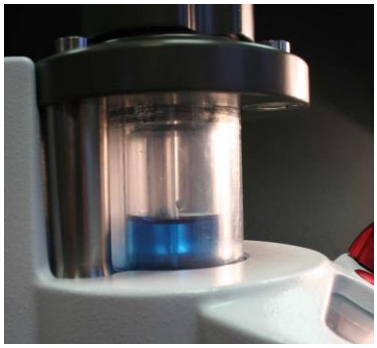
4.2.1 Opening Chamber



Locked symbol aligned	Two stage opening process	Unlocked symbol aligned
	1) push down & rotate anticlockwise 2) pull upwards, slight turn anticlockwise & pull upwards to open	

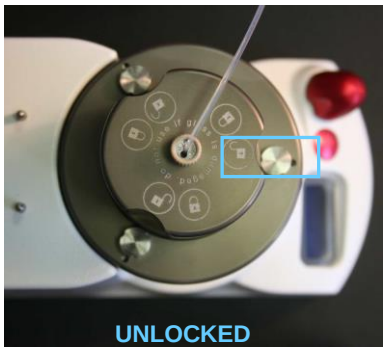
4.2.2 Inserting Fluid Vial

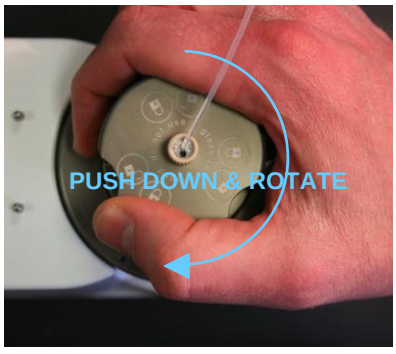
The fluid to be pumped must always be placed inside a small vial and not directly into the chamber!

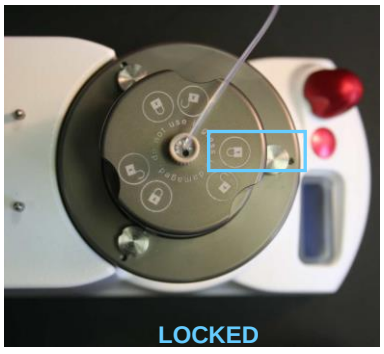




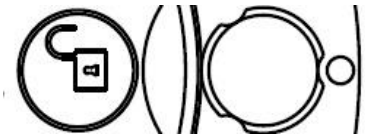
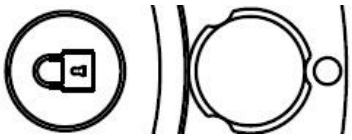
Insert fluid vial	Connect dip tube	Guide dip tube into vial
• place fluid vial (smaller than Ø30 x H88mm) into chamber • use vessel holder for small fluid vials	• insert 1/16” OD tube into chamber lid • leave length of tube protruding and tighten fitting	• as the chamber lid is put in position, ensure that the dip tube is guided into the fluid vial

4.2.3 Closing Chamber

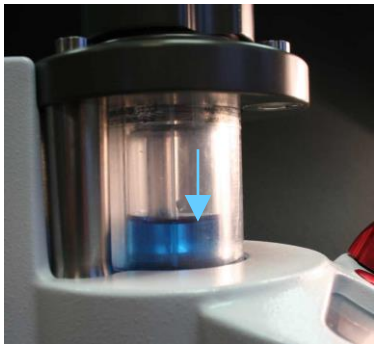


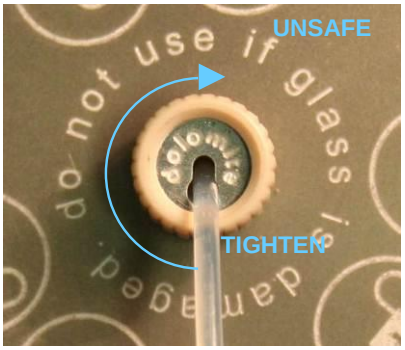


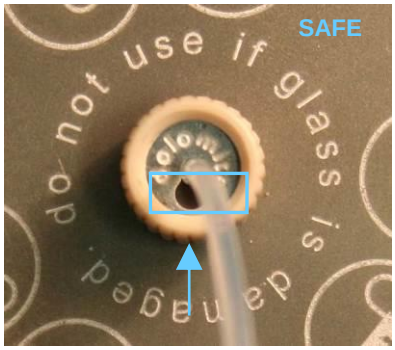


Unlocked symbol aligned	Two stage closing process	Locked symbol aligned
	1) push down, slight turn clockwise and push down 2) rotate clockwise until lid clicks into position	

4.2.4 Adjusting Dip Tube (Part No.3200143)







Adjust dip tube	Dip tube free (unsafe)	Dip tube retained (safe)
• ensure dip tube is below surface of the liquid	• in this state the dip-tube may be ejected at high pressures	• to ensure safety, retain dip tube by inserting into cleat

4.3 Pneumatic Connection

To connect pneumatic supply:	To disconnect pneumatic supply:
• use pneumatic supply cable (included) to link compressed air / gas supply to the Mitos P-Pump	• turn off compressed air / gas supply first • push in sleeve of pressure supply connector to release

4.4 Power Connection

Insert power cable	Press switch to turn on
• only use the power supply unit provided	• 1 indicates ON and 0 indicates OFF

4.5 Mitos Sensor Unit Electrical Connection

To connect to Mitos Sensor Unit:	
• use electrical cable supplied with the Mitos Sensor Unit	• The Mitos Sensor Units can also connect to the Mitos P-Pump range via a fluidic connection for more information please see section 8.

For more information on Dolomite's Mitos Sensor Units please visit our website www.dolomite-microfluidics.com/webshop

5. Mitos P-Pump Basic (Part No. 3200175)

The Mitos P-Pump Basic connects to a PC via RS232 serial interface allowing data logging and control using free PC software or your own applications. **A PC is required to use this pump.**

5.1 Features

The following accessories are supplied with the Mitos P-Pump Basic:

- Pneumatic supply cable
- Tubing FEP 250µm ID, 1/16” OD, 2m length
- Power supply unit
- Mains IEC lead

User to supply the following:

- Suitable Windows ™ PC
- Vessel containing sample liquid
    - Liquids to be pumped must always be placed in a suitable vial within the glass chamber. **Never place any liquid directly in the glass chamber!**
- Compressed air / gas supply

For information regarding fluidic connection to the Mitos P-Pump Basic please see 4.2.

5.2 Pneumatic Connection

To connect pneumatic supply:	To disconnect pneumatic supply:
• use pneumatic supply cable (included) to link compressed air / gas supply to the Mitos P-Pump Basic • either port can be used	• turn off compressed air / gas supply first • push in sleeve of pressure supply connector to release

5.3 Power Connection

Insert power cable	Press button to switch on
• only use the power supply unit provided	• front of the pump press the button to switch ON

5.4 USB to RS232 Connection

Insert RS232 connector
• connect USB to PC

The Mitos P-Pump Basic connects to a PC via RS232 serial interface allowing data logging and control using free PC software. For PCs that do not support an RS232 serial interface, Dolomite offer a USB adapter cable (Part No. 3200197).

5.5 Mitos Sensor Unit Electrical Connection

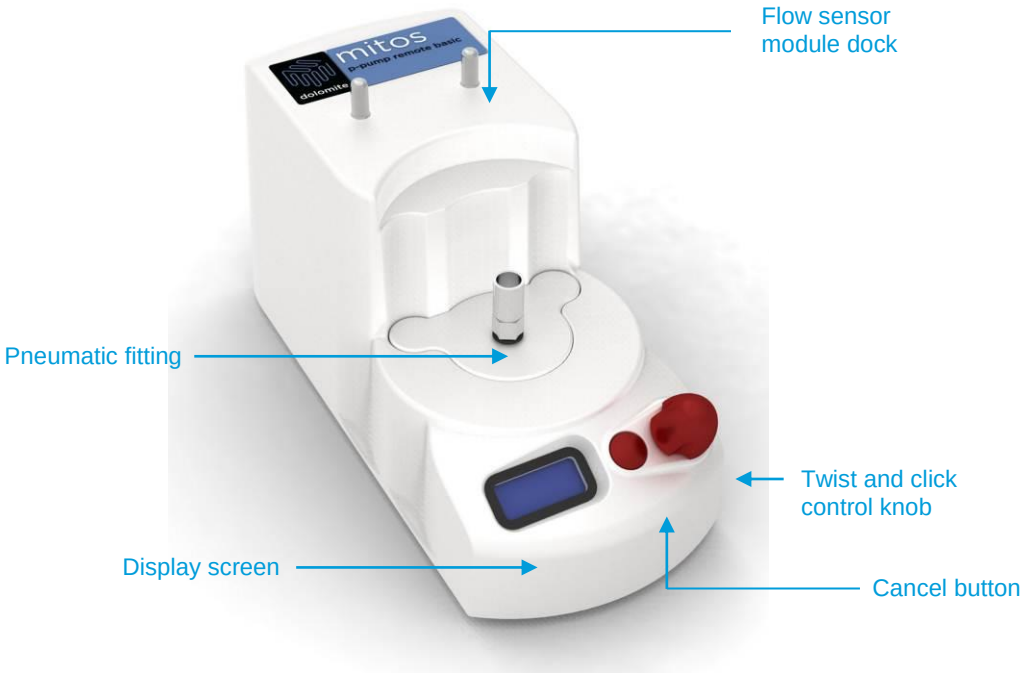
To connect to Mitos Sensor Unit:	
• use electrical cable supplied with the Mitos Sensor Unit	• The Mitos Sensor Units can also connect to the Mitos P-Pump range via a fluidic connection for more information please see section 8.

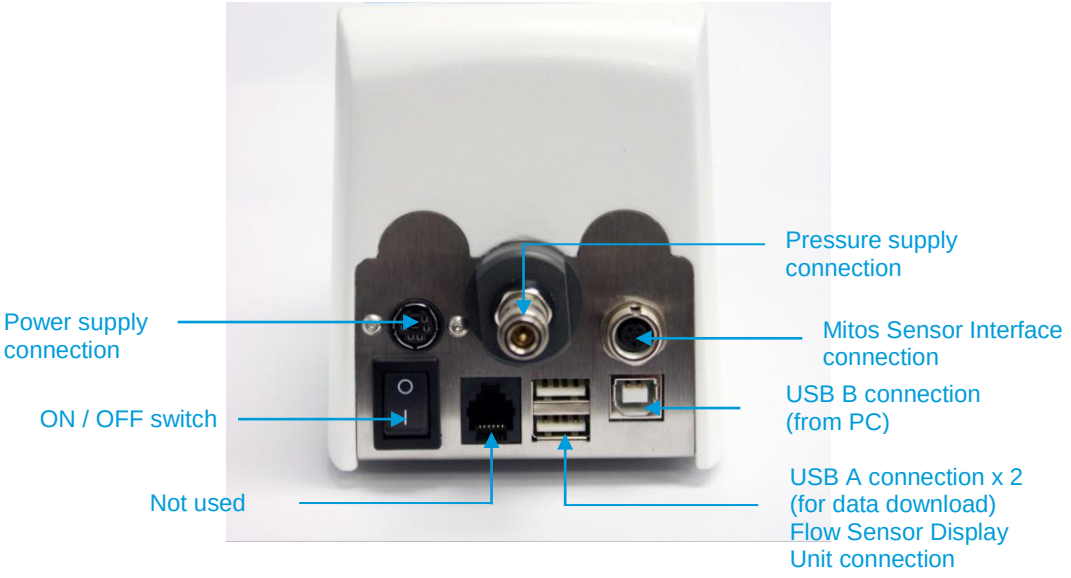
For more information on Dolomite's Mitos Sensor Units please visit our website www.dolomite-microfluidics.com/webshop

6. Mitos P-Pump Remote (Part No. 3200176)

The Mitos P-Pump Remote provides pulseless liquid flow operating over a wide pressure range (0 - 10bar) with excellent response time and accuracy. Pressure driven flow is ideal for microfluidic systems where highly stable flow is required in the nl/min to µl/min range for applications such as droplet formation. The design allows users to connect to Dolomite Remote Chambers with a push-click action.

6.1 Features





The following accessories are supplied with the Mitos P-Pump Remote:

- 2 x Pneumatic supply cable
- Tubing FEP 250µm ID, 1/16” OD, 2m length
- Power supply unit
- Mains IEC lead

User to supply the following:

- Vessel containing sample liquid
    - Liquids to be pumped must always be placed in a suitable vial within the glass chamber. **Never place any liquid directly in the glass chamber!**
- Compressed air / gas supply

6.2 Pneumatic Connection

To connect pneumatic supply:	To disconnect pneumatic supply:
• use pneumatic supply cable (included) to link compressed air / gas supply to the Mitos P-Pump Remote • either port can be used	• turn off compressed air / gas supply first • push in sleeve of pressure supply connector to release

6.3 Power Connection

Insert power cable	Press switch to turn on
• only use the power supply unit provided	• 1 indicates ON and 0 indicates OFF

6.4 Connection to Remote Chamber

The Mitos P-Pump Remote features a pneumatic fitting which allows the connection to Dolomite's Remote Chambers or custom chambers.

As shown below, the Mitos P-Pump Remote is connected to the Mitos P-Pump Remote Chamber 30 (Part No. 3200178), a glass pressure chamber which connects securely to the pump via a pneumatic fitting.

The Mitos P-Pump Remote Chamber 30 can be placed on a hotplate, magnetic stirrer or incubator to benefit applications requiring temperature control.

Connect Mitos P-Pump Remote Chamber 30	
• connect via provided pneumatic tubing (3m length)	• Pneumatic tubing is connected to the pump and chamber via a push-click action enabling quick release both ends and reducing downtime between experiments.

For information regarding fluidic connection to the Mitos P-Pump Remote Chamber 30 please see 4.2.

6.5 Mitos Sensor Unit Electrical Connection

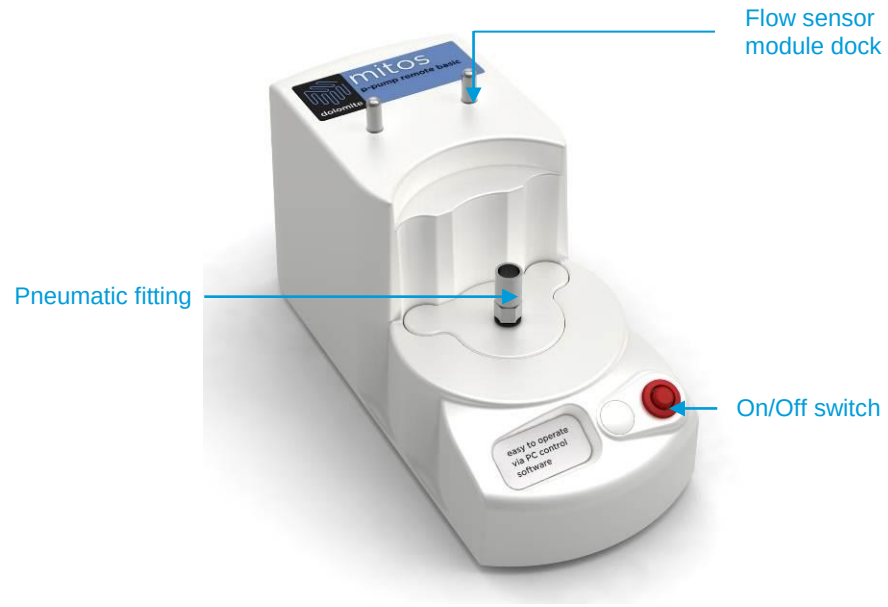
To connect to Mitos Sensor Unit:	
• use electrical cable supplied with the Mitos Sensor Unit	• The Mitos Sensor Units can also connect to the Mitos P-Pump range via a fluidic connection for more information please see section 8.

For more information on Dolomite's Mitos Sensor Units please visit our website www.dolomite-microfluidics.com/webshop

7. Mitos P-Pump Remote Basic (Part No. 3200177)

The Mitos P-Pump Remote Basic connects to a PC via RS232 serial interface allowing data logging and control using free PC software or your own applications. **A PC is required to use this pump.** For PCs that do not support an RS232 serial interface, Dolomite offers a USB adapter (Part No. 3200197). All the other features of the pump are the same as for the Mitos P-Pump Remote (Part No. 3200177) including pulseless pumping performance and easy to use pneumatic fitting.

7.1 Features



The following accessories are supplied with the Mitos P-Pump Remote Basic:

- 2 x Pneumatic supply cable
- Tubing FEP 250µm ID, 1/16” OD, 2m length
- Power supply unit
- Mains IEC lead

User to supply the following:

- Suitable Windows™ PC
- Vessel containing sample liquid
- Compressed air / gas supply

7.2 Pneumatic Connection

To connect pneumatic supply:	To disconnect pneumatic supply:
• use pneumatic supply cable (included) to link compressed air / gas supply to the Mitos P-Pump Remote Basic • either port can be used	• turn off compressed air / gas supply first • push in sleeve of pressure supply connector to release

7.3 Power Connection

Insert power cable	**Press button to switch on**
• only use the power supply unit provided	• Front of the pump press 1 to switch ON

7.4 USB to RS232 Connection

Insert RS232 connector
• connect USB to PC

The Mitos P-Pump Remote Basic connects to a PC via RS232 serial interface allowing data logging and control using free PC software. For PCs that do not support an RS232 serial interface, Dolomite offer a USB adapter cable (Part No. 3200197).

7.5 Connection to Remote Chamber

The Mitos P-Pump Remote Basic features a pneumatic fitting which allows the connection to Dolomite's Remote Chambers or custom chambers.

The Mitos P-Pump Remote Basic can connect to the Mitos P-Pump Remote Chamber 30 (Part No. 3200178), a glass pressure chamber which connects securely to the pump via a pneumatic fitting.

The Mitos P-Pump Remote Chamber 30 can be placed on a hotplate, magnetic stirrer or incubator to benefit applications requiring temperature control.

Connect Mitos P-Pump Remote Chamber 30	
• connect via provided pneumatic tubing (3m length)	• Pneumatic tubing is connected to the pump and chamber via a push-click action enabling quick release both ends and reducing downtime between experiments.

For information regarding fluidic connection to the Mitos P-Pump Remote Chamber 30 please see 5.2.

7.6 Mitos Sensor Unit Electrical Connection

To connect to Mitos Sensor Unit:	
• use electrical cable supplied with the Mitos Sensor Unit	• The Mitos Sensor Units can also connect to the Mitos P-Pump range via a fluidic connection for more information please see section 8.

8. Mitos Sensor Units Connection

The Mitos Sensor Display (Part No. 3200095) and Mitos Flow Rate Sensors (Part No. 3200096-3200100) are compatible with the Mitos P-Pump range for measuring and displaying ultra low liquid rates.

The high precision thermal sensor technology provides total media isolation and extremely low internal volume with no moving parts. All measurement data is fully calibrated for water and temperature compensated by means of an internal microcontroller.

The Mitos Flow Rate Sensor simply attaches to the Mitos Sensor Display with a push-click action. Once connected to a Flow Rate Sensor, the display can be used as a standalone device (see 8.1) or sit on top of a Mitos P-Pump (see 8.2)

By connecting the USB lead of the Sensor Display to a Mitos P-Pump, the display is powered and the Mitos P-Pump records the flow rates which will be stored in a log file within the pump together with the pressure control data (see 8.3).

8.1 Standalone device

Fig. 1 Standalone device

- Mitos Sensor Unit connected to a Mitos P-Pump as a standalone device

8.2 Connection to the top of the Mitos P-Pump

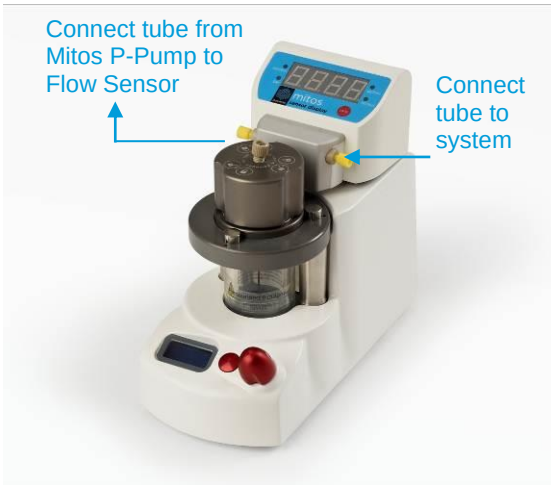


Fig. 2. Connection to top of a Mitos P-Pump	Fig. 2. Connection to top of a Mitos P-Pump
• Connect Mitos Sensor Unit to the pins on the Mitos P-Pump	• Connect tubing from a Mitos P-Pump through Mitos Sensor Unit and connect to your system

8.3 USB Connection

Fig. 3. USB Connection to the Mitos P-Pump

- use USB cable supplied with the Mitos Sensor Unit

8.4 Electrical Connection

To connect to Mitos Sensor Unit:
• use electrical cable supplied with the Mitos Sensor Unit

For more information on Dolomite's Mitos Sensor Units please visit our website www.dolomite-microfluidics.com/webshop

9. Controlling the pumps

The Mitos P-Pump (Part No. 3200016) and Mitos P-Pump Remote (Part No. 3200176) feature an intuitive twist-and-click knob and display for manual user control as described in 9.1. Additionally, PC software is also available enabling the pumps to be controlled from a simple PC application see section 10.

The Mitos P-Pump Basic (Part No. 3200175) and Mitos P-Pump Remote Basic (Part No. 3200177) can **only** be controlled via the PC Software as described in section 11.

Please contact our Technical Support Team support@dolomite-microfluidics.com to receive a link to download the software online.

The pressure pump above features the twist-and-click knob and can be controlled via Manual User Control as well as PC Software.

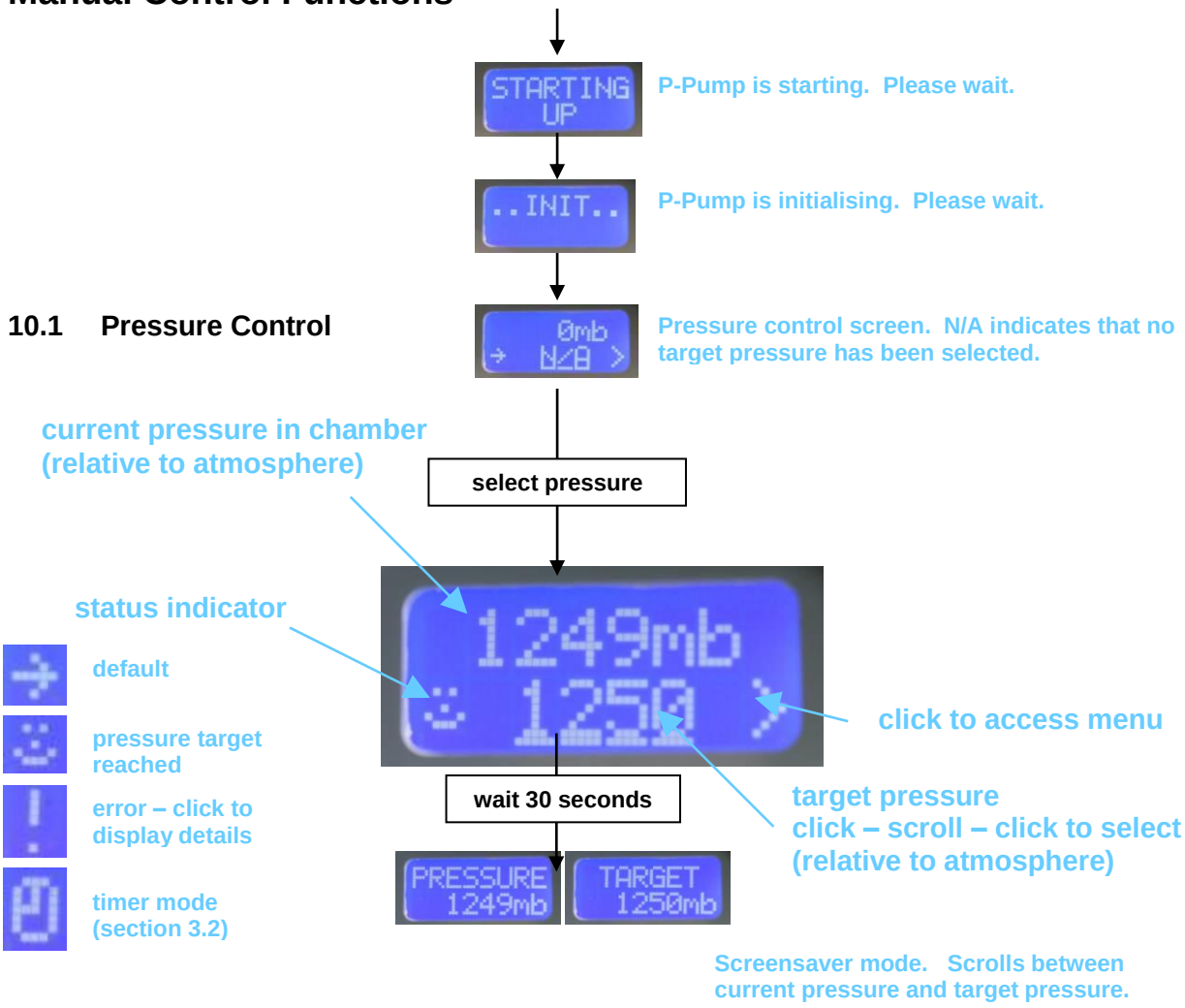
The pressure pump above features the basic design; user control is only via PC Software.

10. Manual User Control

This section only applies to Mitos P-Pump (Part No. 3200016) and Mitos P-Pump Remote (Part No. 3200176)

Manual Control Functions

10.1 Pressure Control



The Mitos P-Pump and Mitos P-Pump Remote can operate with positive and negative supply pressure. Maximum positive supply pressure is 11bar and this value should not be exceeded due to safety reasons. There is no limit on the minimum supply pressure.

The range of the target pressure that can be set on the Mitos P-Pump and Mitos P-Pump Remote depends on the actual supply pressure. For positive supply pressure the target pressure can be set within the range of:

MINIMUM PRESSURE: 20mbars

MAXIMUM PRESSURE: SUPPLY PRESSURE - 250mbars

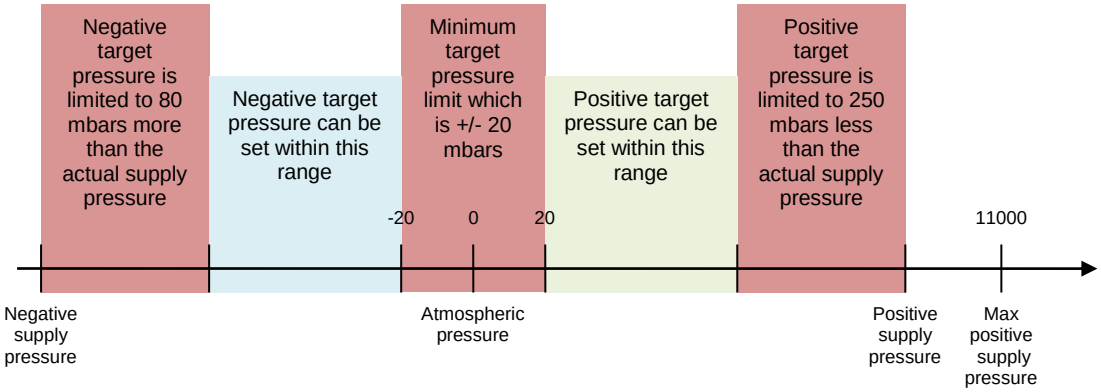
For example, for the supply pressure of 3500mbars it gives the range of 20mbars to 3250mbars.

For negative supply pressure the target pressure can be set within the range of:

MINIMUM PRESSURE: SUPPLY PRESSURE + 80mbars

MAXIMUM PRESSURE: – 20mbars

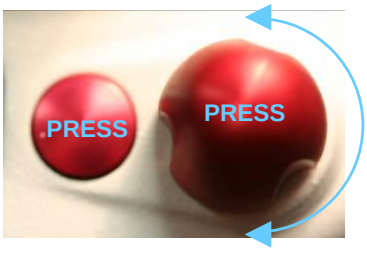
For example, for the supply pressure of -800mbars it gives the range of -720mbars to -20mbars.



10.2 User Controls

Back button

Press to stop pressure control press again to vent chamber (NOTE: chamber will also vent if the P-Pump is switched off)

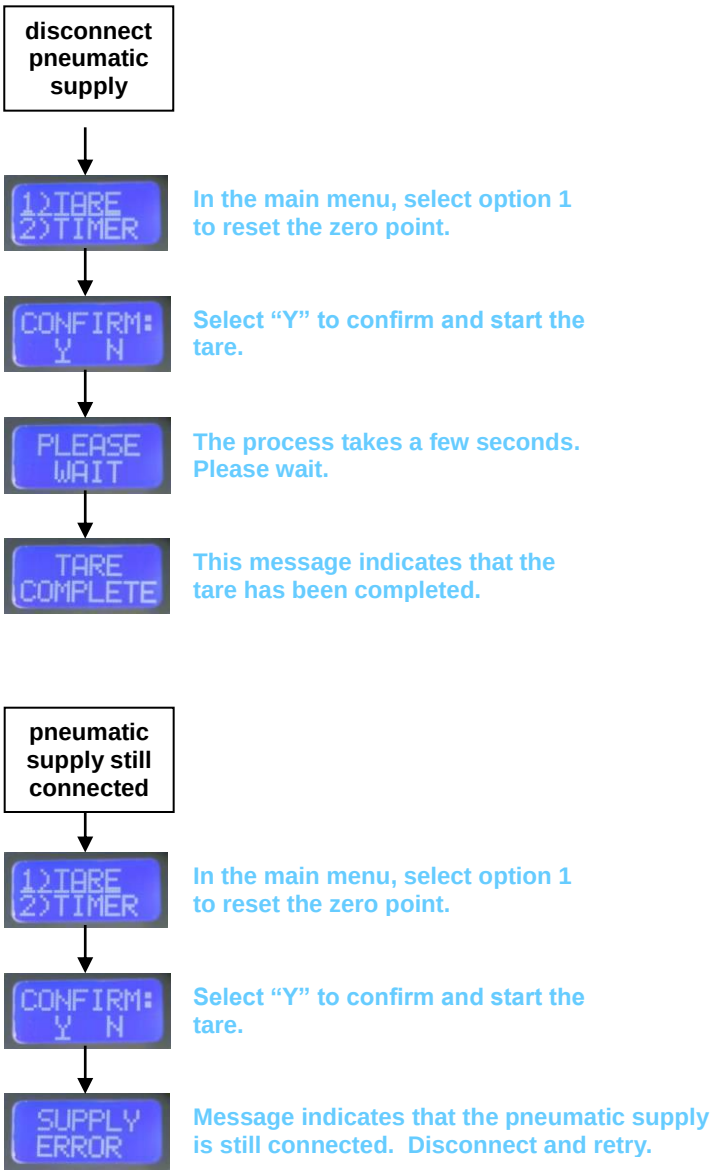


Twist and click knob

Scroll to menu option and press to access

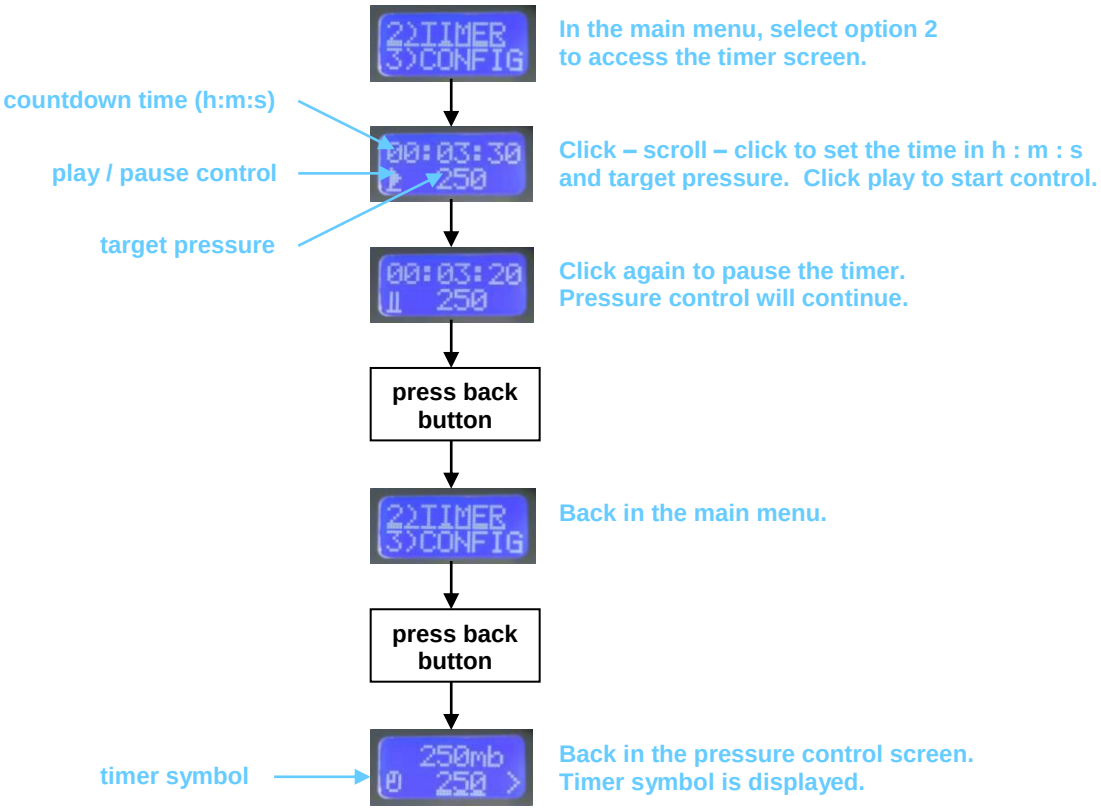
10.3 Menu Option: Tare

The tare option opens the pressure chamber to atmosphere and resets the zero point for the pressure in the chamber. Once this has been set, then the Mitos P-Pump and Mitos P-Pump Remote will maintain an accurate zero point for long periods of time. The Mitos P-Pump and Mitos P-Pump Remote will automatically adjust to changes in atmospheric pressure, so it is not necessary to use the tare function frequently.



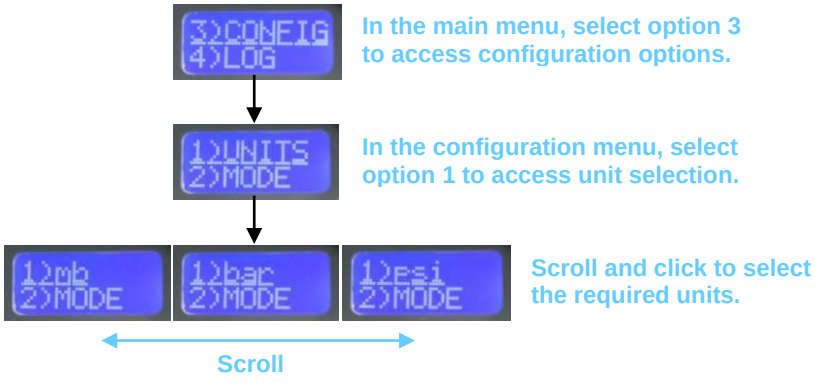
10.4 Menu Option: Timer

The timer option enables the pressure to be controlled at a selected value for a set period of time before venting to atmosphere. The timer can be started after the Mitos P-Pump and Mitos P-Pump Remote is already controlling at a pressure to vent the chamber in a set period of time. Alternatively, the timer can be used to start and end pressure control. This function is particularly useful in stopping the pump before the sample fluid has been used up.



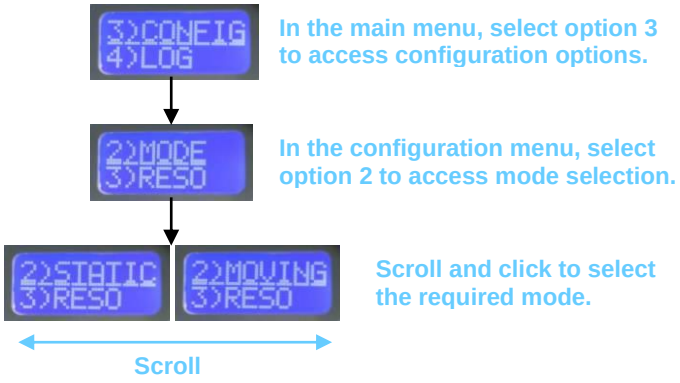
10.5 Menu Option: Configuration - Units

The Mitos P-Pump and Mitos P-Pump Remote can be configured to operate in pressure units of mbar, bar or psi.



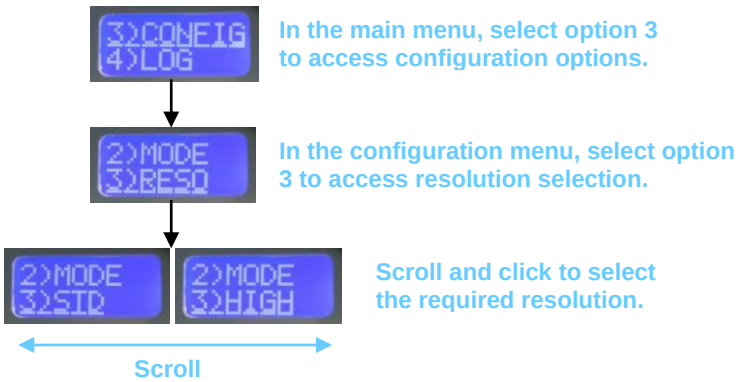
10.6 Menu Option: Configuration - Mode

The Mitos P-Pump and Mitos P-Pump Remote have two main modes of use. The first is static mode where the user selects a target pressure and the pump controls to that pressure. This is used in the majority of situations. The second is moving mode where the user dynamically controls the target using the twist-and-click control knob and the pump follows this moving target. This is particularly useful for precise control of liquid movement on a microfluidic chip or for observing the effect of small pressure changes on a system (e.g. droplet generation).



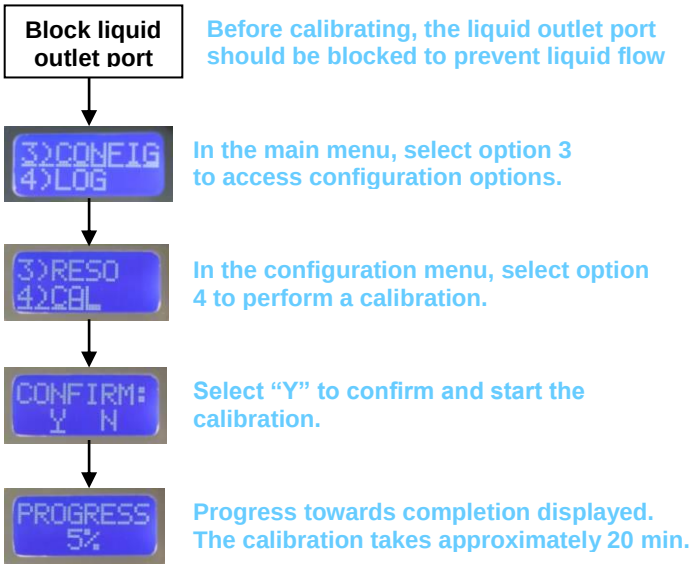
10.7 Menu Option: Configuration - Resolution

There are two resolution settings available. The standard resolution setting allows the target pressure to be set in the smallest possible increment at low pressures, but larger increments at higher pressures. This enables the user to scroll through the pressure range quickly and efficiently. The high resolution setting allows the target pressure to be set in the smallest possible increment across the entire pressure range. This may be required where small pressure changes have a significant effect on a system. However, it will take a long time to scroll through the pressure range.



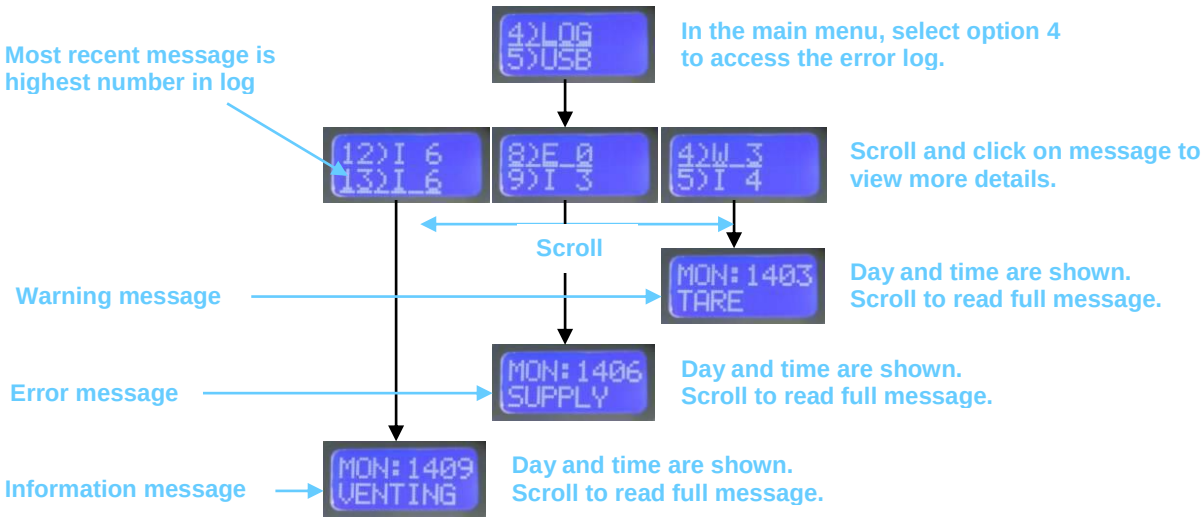
10.8 Menu Option: Configuration - Calibration

The calibration function should be used when the pressure control is more unstable than expected or takes longer than expected to reach the target pressure. Over long periods of time, there may be some degradation in the pressure control and the calibration function will retune the control for optimum performance. The Mitos P-Pump and Mitos P-Pump Remote are factory calibrated to work best with compressed air. If the pumps is to be used with a gas of significantly different density (e.g. Helium) then a calibration is recommended. If the vessel size is changed to operate with the Mitos Remote Chamber 400, a calibration is also required.



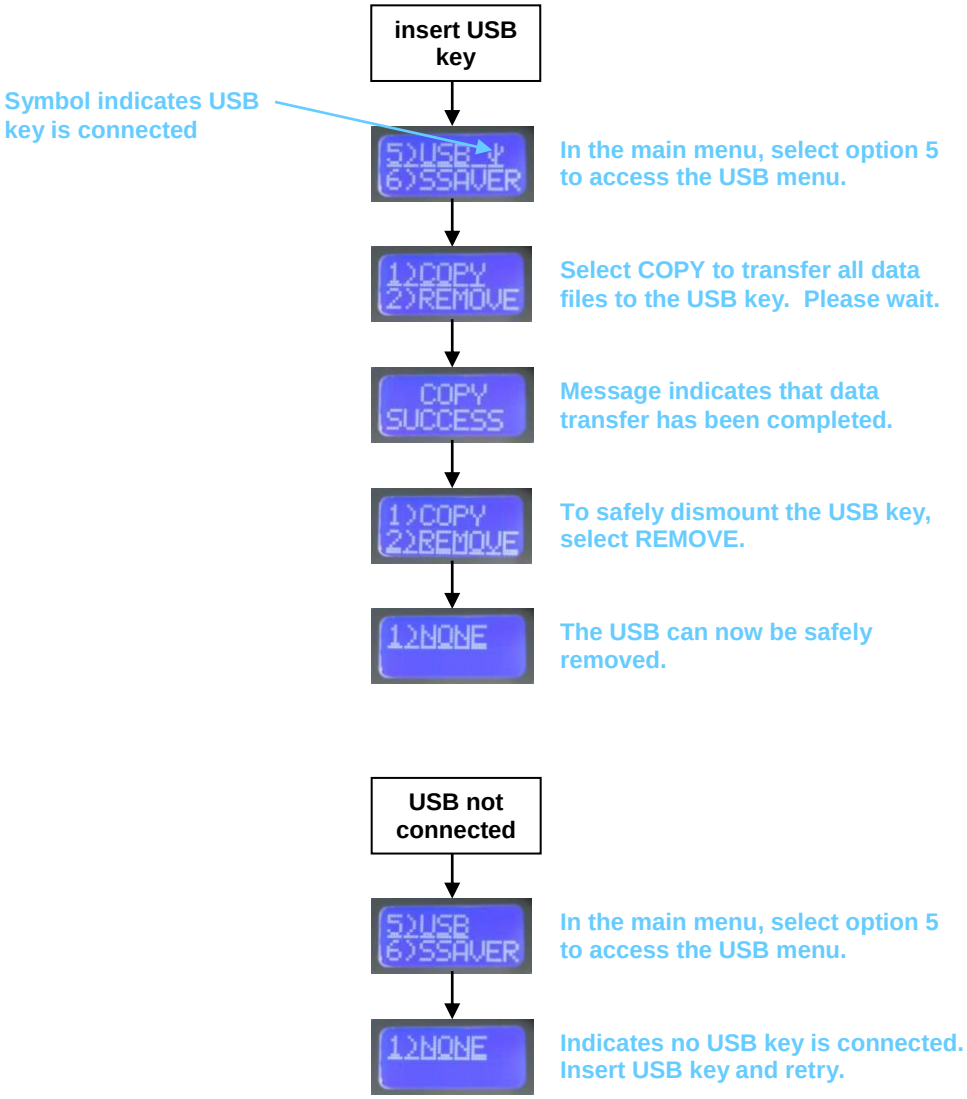
10.9 Menu Option: Error Log

To aid troubleshooting and provide information on issues with the Mitos P-Pump and Mitos P-Pump Remote, there is an error log. In the error log, all the previous messages for this session are recorded. The 3 categories of logged messages are information messages, warning messages and error messages.



10.10 Menu Option: USB Data Export

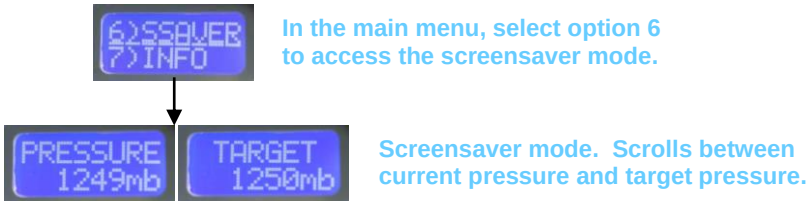
The USB option allows pressure control data to be exported to a PC using a USB key. Each time the Mitos P-Pump and Mitos P-Pump Remote are turned on, a new data file is created. This data file contains information on the atmospheric pressure (mbar abs), supply pressure (mbar abs), chamber pressure (mbar gauge) and target pressure (mbar gauge). If the pump is left running overnight, a new data file is created at 00:00:00. The Mitos P-Pump and Mitos P-Pump Remote store data from the previous 7 days.



The pressure control data files are contained in a folder named “logs”. The file names are in the format “PressurePumpDataLog_Year_Month_Date_Time.csv” and files can be opened with Microsoft Excel.

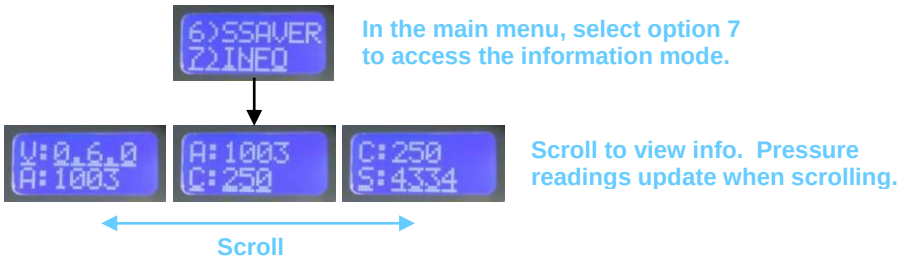
10.11 Menu Option: Screensaver

The screensaver option allows the user to enter the screensaver mode manually.



10.12 Menu Option: Information

This menu option provides information on the software version and the current atmospheric, chamber and supply pressure readings.



11. PC Software User Control

11.1 Detect devices

11.1.1 USB connection

Mitos P-Pump and Mitos P-Pump Remote pumps connect to your PC via a standard USB cable. The pump will be automatically detected by the PC Software as soon as the PC Software has been started on the PC.

Users can also connect/disconnect pumps after the PC Software has been started. In that case the devices still get detected automatically but the detection might take up to 15 seconds.

11.1.2 Connection via a serial cable

Mitos P-Pump Basic and Mitos P-Pump Remote Basic connect to your PC via a serial (RS232) cable or USB to RS232 adapter cable.

1) USB to RS232 cable

If the pump is connected using Dolomite's USB to RS232 Adaptor Cable (Part No. 3200197) all devices will be detected automatically by the PC software and shown in the "P-Pumps" section (see point 9.1.2).

2) Serial converter and serial cables

If the pump is connected via a generic serial converter or to a serial port, the devices will not be detected automatically but have to be added manually following the step-by-step process below:

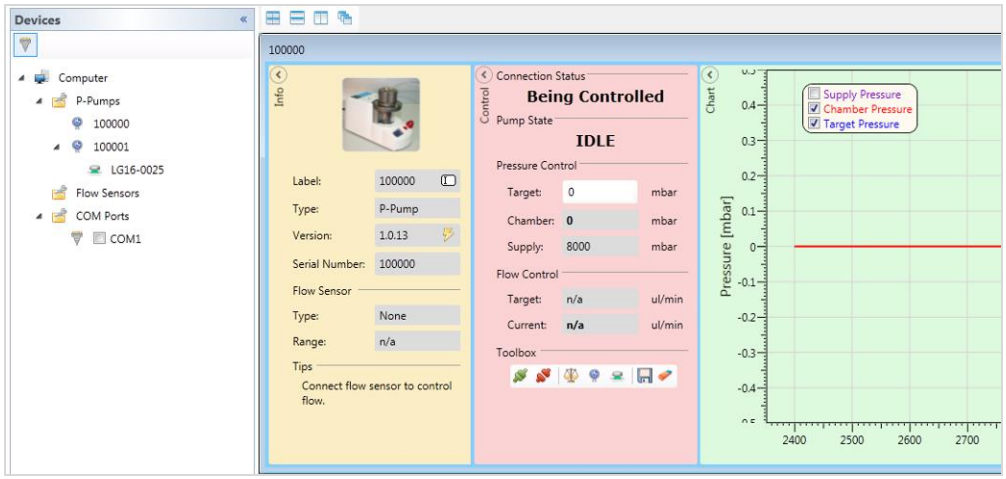
1. Start the PC Software and open the "Devices" section
2. Click on the following icon  (top left corner) to show all COM ports connected to the PC which might take up to 15 seconds
3. Select the COM port that connects the pump to the PC
4. If the serial converter or serial cable you are using offers more than one COM port you might need to select all ports/try the different COM ports to identify the right port that connects the pump to the PC
5. The PC Software will scan the COM port/ports selected which might take a couple of seconds
6. After the scanning has been completed, the COM port which connects the pump to the PC will disappear from the COM ports list and the pump will be shown in the "P-Pumps" section

11.2 Using the PC software

The PC Software offers 3 sections as shown below:

1) Devices

This section allows users to monitor and set the target and chamber pressure of the pump. It is divided into a “P-Pumps” section showing all pumps connected to the PC Software and “Flow Sensors” section showing all Flow Sensors connected to the PC Software.



Toolbox icons

 Start Remote Control

 Stop Remote Control

 Tare Pump and Flow Sensor

 Tare Pump

 Tare Flow Sensor

 Erase chart data

 Save chart data to csv.file

<u>Please note:</u> Some of the above icons might be hidden due to the type of pump you are using and the pump state.

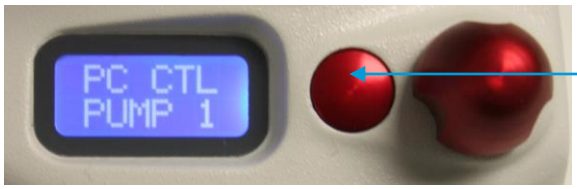
When connecting the Mitos P-Pump or Mitos P-Pump Remote to the PC Software, the Connection Status will automatically change to “Being Controlled” and the pump display will show “PC CTL” as shown below.

This will automatically disable the twist-and-click-knob of the pumps and the pumps can only be controlled via the PC Software.

Change the PC control mode to Pump control mode

To control the pump via the twist-and-click-knob and display and use the PC Software for data log only, select (Stop Remote Control). The Connection Status of the pump will change automatically from “Being Controlled” to “Not Being Controlled”. Remote control can be enabled at any time by selecting (Start Remote Control).

You can also exit the PC control mode via the pump as shown below:



Press button to exit PC mode

Select Y for Yes and press button to confirm exit

Please note: The Mitos P-Pump Basic and Mitos P-Pump Remote Basic do not offer a twist-and-click-knob for advanced control. When connecting these pumps to the PC Software the Connection Status will always be “Being Controlled”. The toolbox icons “Start Remote Control” and “Stop Remote Control” will be hidden.

2) Logs

This section displays all important events such as control commands sent to the pump/pumps, connection/disconnection of a device or device errors.

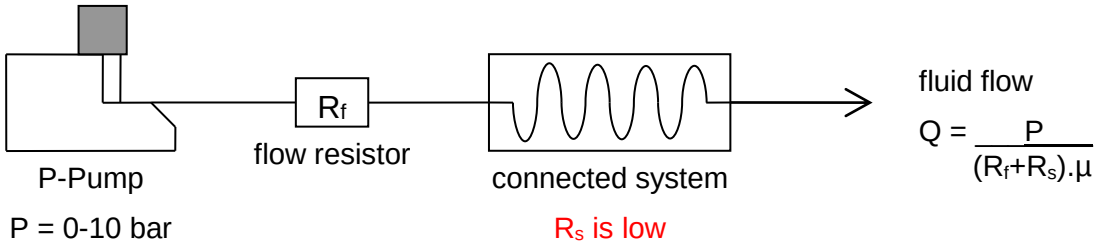
3) Help

This section contains a link to Dolomite’s website and allows users to access and download the Mitos P-Pump datasheet.

12. Using Flow Resistors

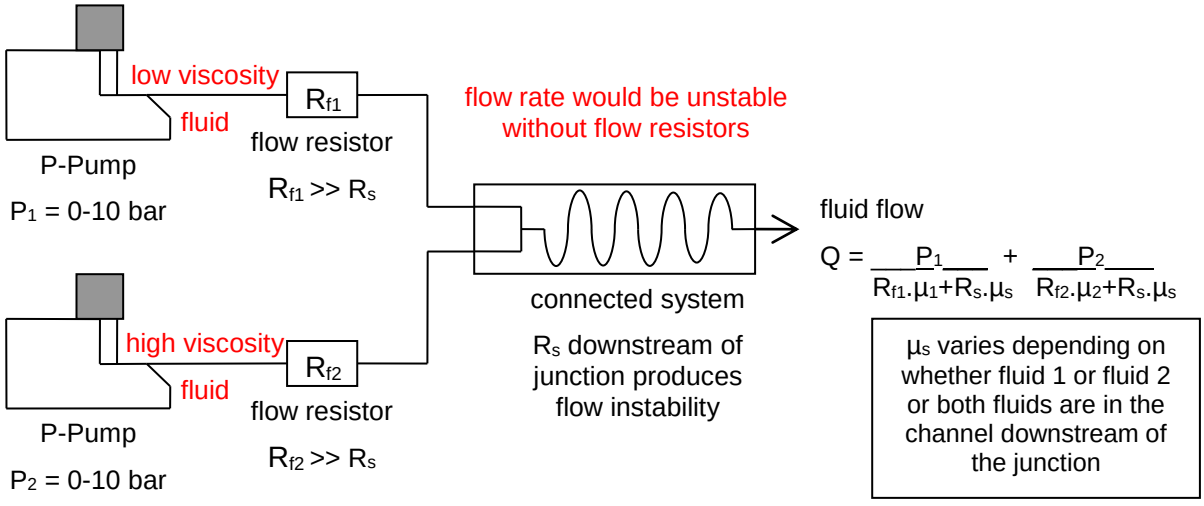
12.1 Flow Resistors

There are three main cases where it is necessary to insert a flow resistor between the Mitos P-Pump range and the connected system. The first case is where the flow resistance of the connected system is low (large diameter, short length of tube or channels). As a result, the user will have limited ability to pump at the low end of the flow rate range. In practice, this means that the user will not be able to access very low flow rates and will not be able to adjust the flow rate in very small steps. The benefit of a flow resistor is that the desired flow rate can be achieved by setting a pressure in the middle of the range. This enables optimal flow rate control and resolution.



Flow resistor required – case 1

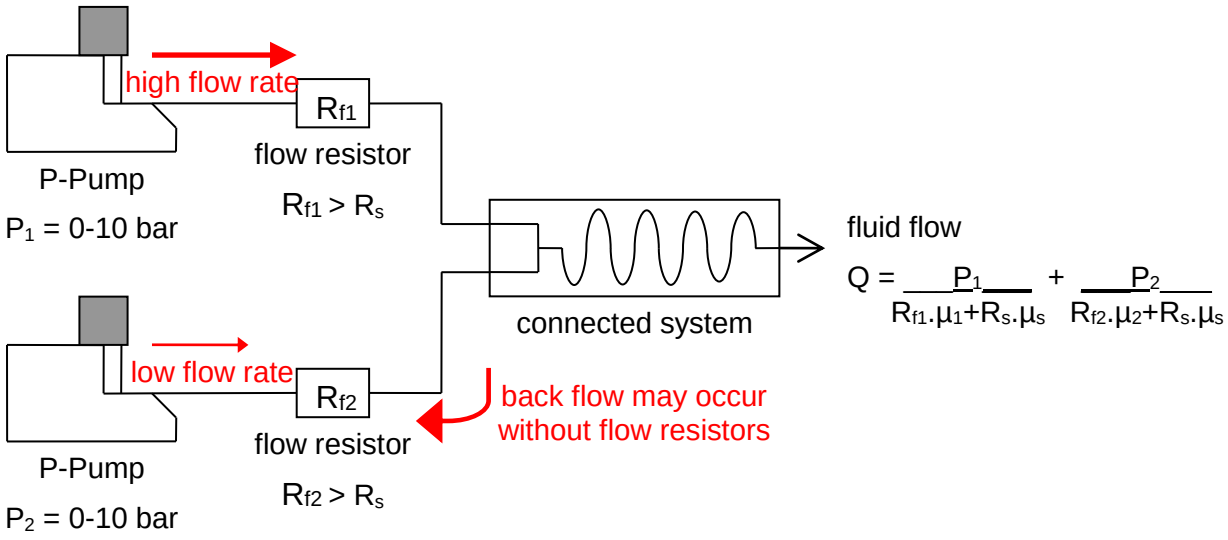
The second case is where 2 or more immiscible fluids of different viscosities are pumped into a junction and there is a length of channel (flow resistance) downstream of the junction. The flow rate will be unstable because the viscosity downstream of the junction (μ_s) alternates between low and high depending on whether fluid 1 or fluid 2 or both fluids are in the channel downstream. However, if correctly sized flow resistors are inserted between the Mitos P-Pump range and the connected system then the flow rate can be stabilised. This is because the flow rate is now determined by the R.μ in the flow resistor (constant) and the R.μ in the connected system (varying). Therefore, for highly stable systems, the flow resistance of the flow resistor (R_{f1}, R_{f2}) should be significantly higher than the flow resistance of the connected system (R_s).



Flow resistor required – case 2

In applications such as droplet generation, where fluid 2 is highly viscous, it may not be possible to insert a large flow resistor on channel 2 since this will limit the flow rate range available to the user. If a flow resistor is used, the maximum pressure of 10bar may generate low flow rates, but greater pressure would be required to access higher flow rates. In this instance, it is recommended that a flow resistor should only be inserted on channel 1. If highly stable flow is critical to the application, it is also recommended that the connected system should be designed to have as low flow resistance as possible. Please contact Dolomite for assistance.

The third case is where 2 or more fluids of similar viscosities are pumped into a junction and a high flow rate ratio is required (10:1 to 100:1). The problem is that there will be a tendency for back flow into the channel with the lower flow rate. This can be resolved by inserting flow resistors between the Mitos P-Pump range and the connected system to make flow through the connected system the path of least resistance. Ideally, the flow resistance of the flow resistor (R_{f1}, R_{f2}) should be higher than the flow resistance of the connected system (R_s).

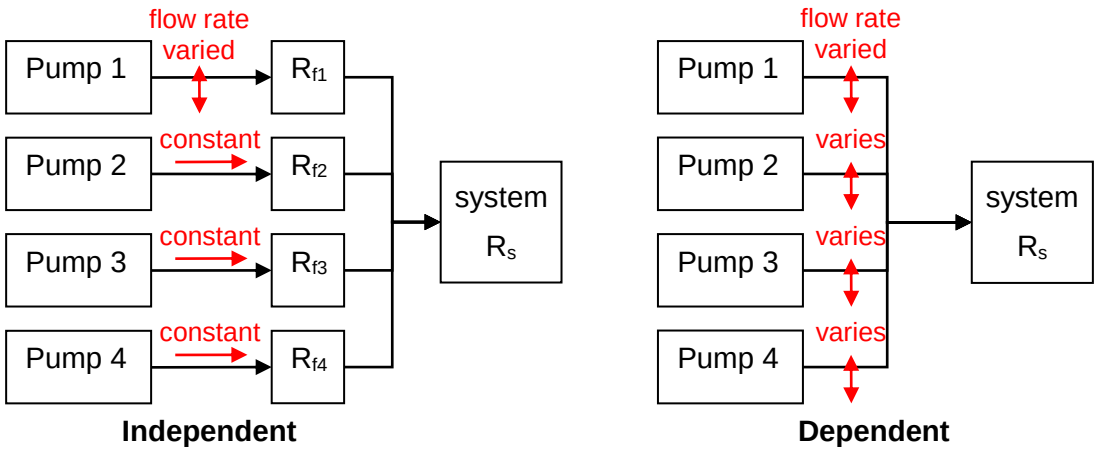


Flow resistor required – case 3

Dolomite also offers a wide range of Mitos P-Pump Flow Resistors (Part No. 3200028 – 3200032) to optimize your microfluidic system, from a minimum flow rate of 0.01µl/min to a maximum flow rate of 1000µl/min. For more information please visit our website http://www.dolomite-microfluidics.com/webshop

12.2 Flow Rate Calibration

If the flow resistor resistance is much higher than the resistance of the connected system, then the resistance of the connected system ($R_s.\mu_s$) can be ignored in determining the flow rate. Therefore, the flow rate from the pump is directly proportional to the pressure. As a result, the Mitos P-Pump range can be calibrated for a specific fluid with the flow resistor before connecting to the system. This is achieved by measuring the flow rate at a selected pressure. Any change in the pressure will then give a predictable change in the flow rate (e.g. if the pressure is increased by 20%, the flow rate will be increased by 20%). In this situation, we can consider the pumps to be independent because they will not be affected by flow rates from other pumps. It should be noted that if the main flow resistance is downstream of the junction, then variations in the pressure of one pump will affect the flow rate from all other pumps. In this situation, the pumps can be described as dependent.



13. Accessories

Dolomite offers a broad range of accessories including flow resistors, vessel holders and starter kits.

Product Name	Product picture	Description	Advantages
Mitos P-Pump Vessel Holder Kit (Part No. 3200017)		Enabling the Mitos P-Pump range to be used with a wide range of standard and non-standard fluid vessels.	• Minimizes sample waste
Flow Resistor F1, F3, F10, F30, F100 (Part No. 3200028 - 3200032)		The Flow Resistors can be used to insert additional flow resistance into a system.	• Prevents flow rate instability
Mitos P-Pump Starter Kit (Part No. 3200033)		Containing a selection of tubing and fittings to enable fluidic connection between a Mitos P-Pump and a microfluidic system.	• To begin test work with the Mitos P-Pump range
Pneumatic Connector Kit (Part No. 3200034)		Containing a selection of fittings and tubing to enable connection of your compressed air or gas supply to a Mitos P-Pump	• Enables fast and reliable connection of compressed air or gas supplies
Mitos P-Pump 3-way Chamber Lid (Part No. 3200044)		The Mitos P-Pump 3-way Chamber Lid can be used to pump 3 liquids simultaneously from a Mitos P-Pump.	• Providing a low cost method of delivering 3 reagents to a microfluidic system

Mitos P-Pump 3-way Vessel Holder Kit (Part No. 3200045)		This Vessel Holder is designed to accommodate 3 micro tubes in a Mitos P-Pump.	• Improves ease of use when using the Mitos P-Pump for 3-channel pumping
Mitos P-Pump Remote Chamber 400 (Part No. 3200043)		The Remote Chamber enables greater input volumes up to 400 ml to be used with a Mitos P-Pump.	• Continuous pumping • Option for heating and magnetic stirring • Easy to view sample liquid levels
Mitos P-Pump Remote Chamber 30 (Part No. 3200178)		The Mitos P-Pump Remote Chamber 30 is a 0 - 10bar lockable glass pressure chamber.	• Sample volumes from 100µl to 30ml • Option for heating and magnetic stirring • Easy to view sample liquid levels
Dip Tube Fitting (Part No. 3200143)		The Dip Tube Fitting allows users to easily connect a dip tube into a fluid vessel on a Mitos P-Pump.	• Featuring an in-built strain relief • Compatible with 1/16 OD tubing and 1/4-28 flat bottom ports
USB to RS232 Adapter Cable (Part No. 3200197)		For PCs that do not support an RS232 serial interface, Dolomite offers a USB to RS232 Adapter Cable.	• Allowing users to connect their Mitos P-Pump Basic or Mitos P-Pump Remote Basic to a PC

13.1 Accessories compatibility

Accessories	Mitos P-Pump	Mitos P-Pump Basic	Mitos P-Pump Remote	Mitos P-Pump Remote Basic
Mitos P-Pump Vessel Holder Kit (Part No. 3200017)	✓	✓	✓*	✓*
Flow Resistor F1, F3, F10, F30, F100 (Part No. 3200028 - 3200032)	✓	✓	✓*	✓*
Mitos P-Pump Starter Kit (Part No. 3200033)	✓	✓	✓*	✓*
Pneumatic Connector Kit (Part No. 3200034)	✓	✓	✓	✓
Mitos P-Pump 3-way Chamber Lid (Part No. 3200044)	✓	✓		
Mitos P-Pump 3-way Vessel Holder Kit (Part No. 3200045)	✓	✓		
Mitos P-Pump Remote Chamber 400 (Part No. 3200043)	✓	✓	✓	✓
Mitos P-Pump Remote Chamber 30 (Part No. 3200178)			✓	✓
Dip Tube Fitting (Part No. 3200143)	✓	✓	✓*	✓*
USB to RS232 Adapter Cable (Part No. 3200197)		✓		✓

✓* Accessories can only be used with the pumps when used with Mitos P-Pump Remote Chamber 30

14. FAQ'S

Why can't I select a target pressure?

Please check you have connected a compressed air / gas supply correctly (see section 4.4).

Why can't I select a target pressure as high as my supply pressure?

To ensure quick response times, the maximum target pressure available is limited to 250 mbar below supply pressure.

Why is the chamber pressure not reaching the target pressure?

If your target is near supply pressure, then the cause may be fluctuation in your compressed air / gas supply. Please select a lower target or increase your supply pressure. If you target is near atmospheric pressure, then the cause may be an incorrect zero point. Please use the tare function (see section 10.4).

Why is the chamber pressure not stabilizing?

If there is significant fluctuation in the supply pressure, then it will be difficult for the chamber pressure to reach a stable value. Also, when very high flow rates are used, the Mitos P-Pump must constantly adjust the flow of air / gas into the chamber and some instability may be unavoidable.

Can I put my liquid directly in the chamber?

No. You must always put the liquid to be pumped into a suitable vial and place this within the glass pressure chamber.

Why is the tare function not working?

Please ensure your compressed air / gas supply has been disconnected. If you have already disconnected your compressed air / gas supply, then air may be trapped in the pneumatic supply connector. Please connect and disconnect the pneumatic supply cable to vent this trapped air.

Why is there pressure in the chamber when I close the chamber lid?

The process of putting the chamber lid on compresses the air in the chamber slightly. This can be avoided by ensuring that the dip tube fitting is not tightened until after the chamber lid has been closed. Alternatively, the chamber can be vented after the chamber lid has been closed by pressing the back button.

Why can't I remove the chamber lid easily?

If the chamber is pressurised, then the lid cannot be removed as the pressure locks the chamber. Please vent the chamber before attempting to remove the lid. If the chamber lid is difficult to turn, then it is recommended to apply a small amount of silicone grease to the o-ring inside the chamber lid. For further advice on opening the chamber, please see section 4.3.1.

Will the flow rate obtained be affected by changes in atmospheric pressure?

No, the Mitos P-Pump range automatically adjusts the absolute pressure in the chamber to maintain a constant gauge pressure (pressure relative to atmospheric pressure).

How do I know what flow rate the fluid is flowing at?

Either a flow sensor is required or the system can be calibrated for a selected fluid, so that a pressure can be translated into a flow rate. Please contact Dolomite for further advice.

Why is there backflow into my Mitos P-Pump?

When pumping 2 or more liquids using a Mitos P-Pump there is the possibility of backflow from one pump at higher pressure to another pump at lower pressure. This can be prevented by taking the following steps:

1) Connect a flow resistor between the Mitos P-Pump range and the chip for each liquid. The flow resistor should be selected so that all liquids are flowing at approximately the same flow rate at a pressure of 1bar. (See flow resistor selection below).
2) Ideally the flow resistance before the junction (where 2 or more liquids meet) should be greater than the flow resistance after the junction.
3) Before connecting to the chip, it is recommended to prime the inlet tubing. This is achieved by flowing liquids through until they reach the edge connector and waiting until air bubbles have also been flushed through. The Linear Connector can then be connected to the chip.
4) Initially, set all Mitos P-Pumps to the same pressure e.g. 1bar. Then, gradually adjust the pressures of the pump channels to obtain the flow required.

How do I avoid gas dissolution in the liquid which is being pumped?

Some liquids can absorb air when put under pressure and then release the air in the form of bubbles when the pressure is reduced. This occasionally causes problems with bubbles appearing after a flow resistor or a constriction. To avoid this issue the following can be done:

- If the system can be set-up with less flow resistance and lower pressure then the level of gas dissolution can be reduced.
- The P-Pump can be fed with pressurised Helium rather than pressurised air. Helium has very low solubility in liquids in comparison to other gasses. Please ensure the P-Pump is used in a fume hood when operating with Helium.
- An immiscible liquid such as light oil can be dispensed onto the surface of the liquid that is being pumped to provide a barrier for gas dissolution.

How do I select the correct flow resistor for my system?

The flow resistor should be selected based on the desired flow rate and the viscosity of the selected liquid using the table below.

Desired flow rate at 1 bar pressure (µl/min)

Dynamic viscosity of selected liquid (cP)	1 Flow rate range 0.01 – 10	3 Flow rate range 0.03 – 30	10 Flow rate range 0.1 – 100	30 Flow rate range 0.3 – 300	100 Flow rate range 1 – 1000
1 e.g. water at 20 ºC	**F1**	**F3**	**F10**	**F30**	**F100**
3 blood at 37 ºC	**F3**	**F10**	**F30**	**F100**	
10 25% wt CaCl sol. at 20 ºC	**F10**	**F30**	**F100**		
30 vegetable oil at 40 ºC	**F30**	**F100**	**Out of range**		
100 light machine oil at 20 ºC	**F100**				

Why are the flow rates unstable in my system?

If you pumping 2 or more fluids into a junction and there is significant flow resistance downstream of the junction, then a flow resistor may be required (see section 10.1). Please contact Dolomite for further advice.

15. Power consumption specification

The maximum power consumption for the P Pump range is 40 Watts (1.67 Amps at 24 Volts).

The Dolomite Centre Ltd.
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W: www.dolomite-centre.com

The Dolomite Centre Limited
Registered office: 27 Jarman Way,
Royston, Hertfordshire, SG8 5HW, UK
Company No. 05640084

CE Declaration of Conformity

In accordance with EN 45014:1998

We — The Dolomite Centre Ltd

of — Unit 1, Anglian Business Park, Orchard Road, Royston, Herts, SG8 5TW, UK

declare that:

Equipment — **Mitos P-Pump**

Model name/Part number — **3200016**

in accordance with the following Directive(s):

73/23/EEC	The Low Voltage Directive and its amending directives
89/336/EEC	The Electromagnetic Compatibility Directive and its amending directives

has been designed and manufactured to the following specifications:

EN 61010-1: 2001	Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements
EN 61326-2-2:2006	Electrical equipment for measurement, control and laboratory use. EMC requirements
EN 61000-4-3:2002	EMC – Immunity
EN 55022:2006	EMC – Radiated current emissions

I hereby declare that the equipment named above has been designed to comply with the relevant sections of the above referenced specifications. The unit complies with all applicable essential requirements of the Directives.

Signed by: .....

Name: Andrew Lovatt

Position: CEO

CE10

Done at The Dolomite Centre Ltd
Unit 1, Anglian Business Park, Orchard Road, Royston, Herts, SG8 5TW,
UK on 8th March 2010

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Company No. 05640084

CE Declaration of Conformity

In accordance with EN 45014:1998

We — The Dolomite Centre Ltd

of — Unit 1, Anglian Business Park, Orchard Road, Royston, Herts, SG8 5TW, UK

declare that:

Equipment — **Mitos P-Pump Basic**

Model name/Part number — **3200175**

in accordance with the following Directive(s):

73/23/EEC	The Low Voltage Directive and its amending directives
89/336/EEC	The Electromagnetic Compatibility Directive and its amending directives

has been designed and manufactured to the following specifications:

EN 61010-1: 2001	Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements
EN 61326-2-2:2006	Electrical equipment for measurement, control and laboratory use. EMC requirements
EN 61000-4-3:2002	EMC – Immunity
EN 55022:2006	EMC – Radiated current emissions

I hereby declare that the equipment named above has been designed to comply with the relevant sections of the above referenced specifications. The unit complies with all applicable essential requirements of the Directives.

Signed by: .....

Name: Andrew Lovatt

Position: CEO

CE11

Done at The Dolomite Centre Ltd
Unit 1, Anglian Business Park, Orchard Road, Royston, Herts, SG8 5TW,
UK on 8th September 2011

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The Dolomite Centre Limited
Registered office: 27 Jarman Way,
Royston, Hertfordshire, SG8 5HW, UK
Company No. 05640084

CE Declaration of Conformity

In accordance with EN 45014:1998

We The Dolomite Centre Ltd

of Unit 1, Anglian Business Park, Orchard Road, Royston, Herts, SG8 5TW, UK

declare that:

Equipment **Mitos P-Pump Remote**

Model name/Part number **3200176**

in accordance with the following Directive(s):

73/23/EEC	The Low Voltage Directive and its amending directives
89/336/EEC	The Electromagnetic Compatibility Directive and its amending directives

has been designed and manufactured to the following specifications:

EN 61010-1: 2001	Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements
EN 61326-2-2:2006	Electrical equipment for measurement, control and laboratory use. EMC requirements
EN 61000-4-3:2002	EMC – Immunity
EN 55022:2006	EMC – Radiated current emissions

I hereby declare that the equipment named above has been designed to comply with the relevant sections of the above referenced specifications. The unit complies with all applicable essential requirements of the Directives.

Signed by: .....

Name: Andrew Lovatt

Position: CEO

CE11

Done at The Dolomite Centre Ltd
Unit 1, Anglian Business Park, Orchard Road, Royston, Herts, SG8 5TW,
UK on 8th September 2011

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Registered office: 27 Jarman Way,
Royston, Hertfordshire, SG8 5HW, UK
Company No. 05640084

CE Declaration of Conformity

In accordance with EN 45014:1998

We — The Dolomite Centre Ltd

of — Unit 1, Anglian Business Park, Orchard Road, Royston, Herts, SG8 5TW, UK

declare that:

Equipment — **Mitos P-Pump Remote Basic**

Model name/Part number — **3200177**

in accordance with the following Directive(s):

73/23/EEC	The Low Voltage Directive and its amending directives
89/336/EEC	The Electromagnetic Compatibility Directive and its amending directives

has been designed and manufactured to the following specifications:

EN 61010-1: 2001	Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements
EN 61326-2-2:2006	Electrical equipment for measurement, control and laboratory use. EMC requirements
EN 61000-4-3:2002	EMC – Immunity
EN 55022:2006	EMC – Radiated current emissions

I hereby declare that the equipment named above has been designed to comply with the relevant sections of the above referenced specifications. The unit complies with all applicable essential requirements of the Directives.

Signed by: .....

Name: Andrew Lovatt

Position: CEO

CE11

Done at The Dolomite Centre Ltd
Unit 1, Anglian Business Park, Orchard Road, Royston, Herts, SG8 5TW,
UK on 8th September 2011

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