Vapourtec R2xx
Pumping Module

User Manual

Original date: 5th June 2009

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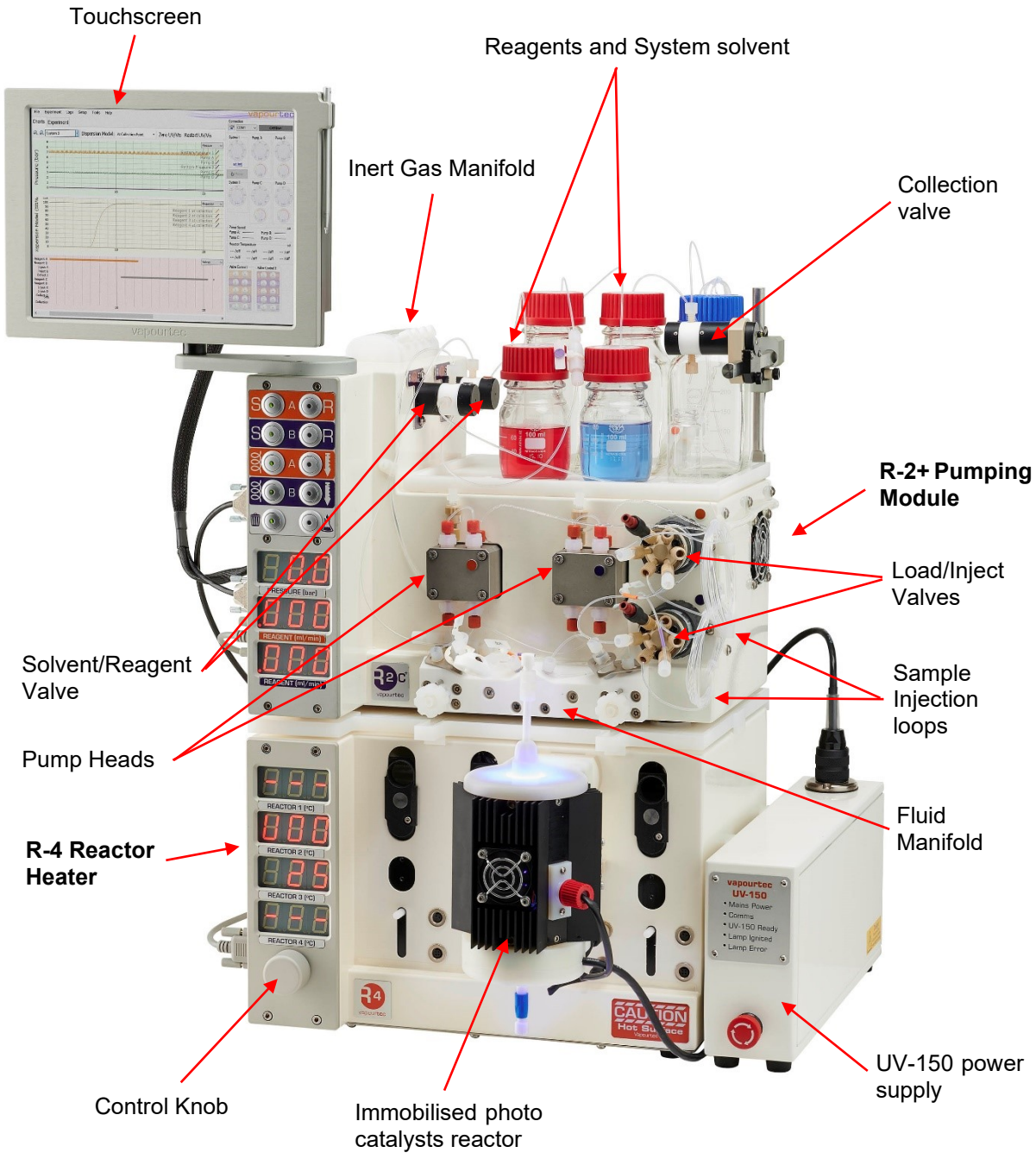
CONTENTS

1 PRODUCT DESCRIPTION

The Vapourtec R2xx is a pumping module for applications in Flow Chemistry, particularly for use with the Vapourtec R-4 Reactor Heater to form a complete flow chemistry system.



The different pumping module variants are shown below.

Where more than 2 pumps are required, a second pump module can be used to expand the system to 4 pumps.

In this case the original module is referred to as the “Primary” and the additional one as the “Secondary”.

Model	Number of pumps	Sample Injection Loops	Strong acid resistance
R2	2	×	×
R2 Plus	2	✓	×
R2 C	2	×	✓
R2 C Plus	2	✓	✓

2 SAFETY INFORMATION

The symbols shown below will be used throughout this manual to draw the reader’s attention to important information.

Attention. Important notes.

Caution. Hot surfaces.

Not permitted.
Misuse may cause damage.

Isolate equipment from mains

Note.

3 INSTALLING THE PUMPING MODULE

Your Vapourtec pumping module can be installed by the User. Contact Vapourtec for the **R-Series Installation Guide**.

Before the pumping module is used this manual should be read.

3.1 Unpacking

Carefully lift the pumping module out of the packaging and place on a firm surface.

3.2 Siting

For safety your pumping module must be sited within a fume cabinet or other suitably vented enclosure. If it is decided to site the pumping module in an open lab then the customer should undertake a thorough risk assessment prior to operation. The R-2xx systems are designed to stand on top of the R-4 Flow Reactor Heater.

Ensure the R-2xx is standing centrally on top of the R-4 Flow Reactor Heater and that both systems are level.

Ensure the drip tray is securely installed on top of the pumping module before placing solvent bottles on top of the module. Damage may result from spillage of liquids into the pumping module or flow reactor heater. If spillage of liquids does occur, isolate the pumping module and the R-4 from the mains.

Provide a firm surface for the pumping module and check that the structure is adequate for supporting its weight or site the pumping module on top of the R-4 Reactor Heater, again, checking that the structure is adequate for supporting the weight of both units.

Leave a minimum distance of 100 mm between the rear of the pumping module or the flow reactor heater and pumping module and any solid objects. The R-4 requires this clearance to ensure adequate air flow through the equipment.

Do not block the air exhausting from the fan on the right-hand side of the pumping module. This is necessary to ensure adequate air flow through the pumping module.

If you need to move your pumping module, caution should be exercised as it weighs 12 kg. To avoid damage, disconnect the pumping module from the R-4 Flow Reactor Heater and the mains power supply. Disconnect all fluid connections between the pumping module and any reactors on the R-4 Flow Reactor Heater. Remove any bottles of solvent, reagent, waste or collected products from the drip tray on top of the pumping module. Carefully lift the pumping module off the R-4 Reactor Heater. Ensure that all the glass heat exchangers are removed from the R-4 Flow Reactor Heater before moving.

3.3 Care of your pumping module

For a standard R2 or R2+ system (non-acid resistant), strong acids such as; hydrochloric acid, hydrobromic acid or fuming nitric acid **MUST NOT** be pumped through the HPLC pumps, or damage will result.

If strong acids are to be used, then either:

a) An **R2C/R2C+** (strong acid compatible) system should be used instead. †

b) Strong acids should be injected into the non-acid resistant system using sample loops and 6 port injection valves such as those available on the R2+ system. (This **does not apply** to fuming nitric acid and sulphuric acid, however). †

† Note that an R2 or R2+ can be upgraded to an R2C or R2C+ acid compatible system, either with an engineer visit or by returning the unit to base. Charges apply.

† Note that the faceplate of the 6 port injection valves is made of **PEEK** (Polyether ether ketone). Check the Acid compatibility before using the sample loops.

When using solutions containing tetrahydrofuran (THF), care must be taken NOT to use PEEK tubing for aspirating the solvent into the pumps. Poor pumping performance will result due to PEEK residue contaminating the pump check valves. Vapourtec supply stainless steel reagent aspiration tubes, these should be used for THF.

When changing solvents with significantly different properties, (e.g. from a polar solvent to a non-polar solvent) it is necessary to first change the solvent to fresh Isopropanol (IPA). If this is not done then pumping performance may be compromised and the “AIR” warning will flash. Refer to solvent miscibility chart in section 10.3.

To maintain optimal pumping performance, it is best practise to keep the pumps clean by periodic pumping of 10 to 20 ml of Isopropanol (IPA) through the pumps at 2 ml/min. If the pumping module is to be left with solvent for a period of time it is advisable to leave the system with IPA.

Contact Vapourtec for the pump maintenance and troubleshooting guide, if needed.

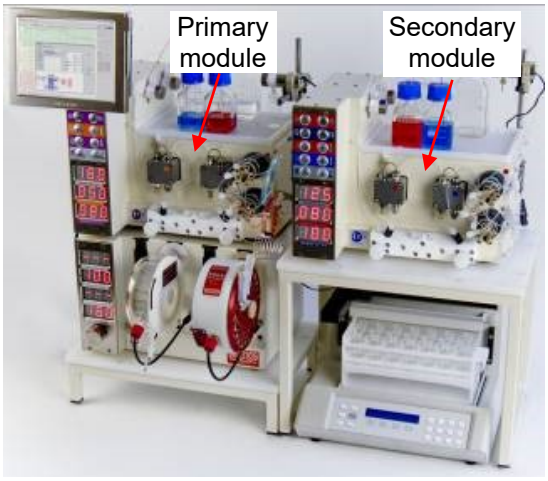
3.4 Connecting the R-2xx to the R-4

1. Plug the RS232 9-pin cable into both the R-2 pumping module (connector marked “R4”) and the R-4 flow reactor heater. This enables the R-4 control knob to be used to control both the R-2 and the R-4.
2. For fluid connections see section 5.2 in this User Manual.

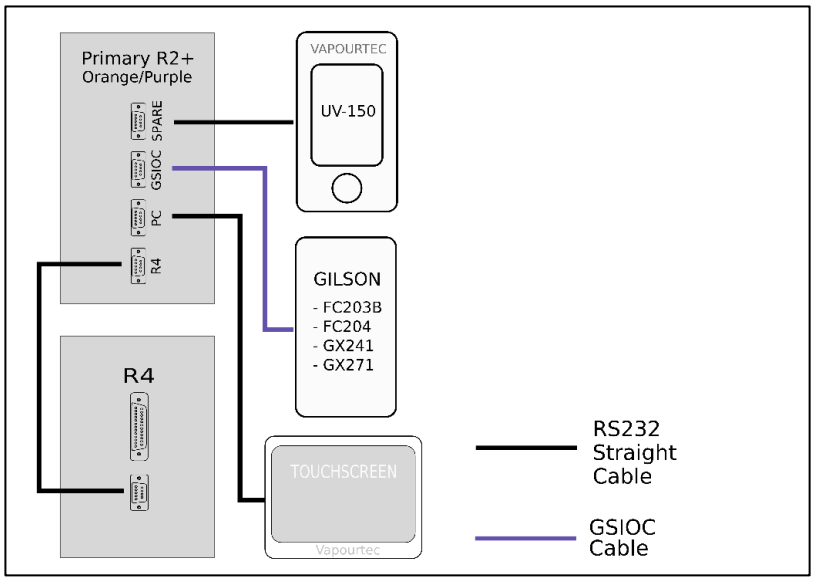
Please ensure that all fluid connections are free from leaks as damage may occur to the R-2 or the R-4 from spillage into the pumping module or the flow reactor.

3.5 Connecting a second pump module

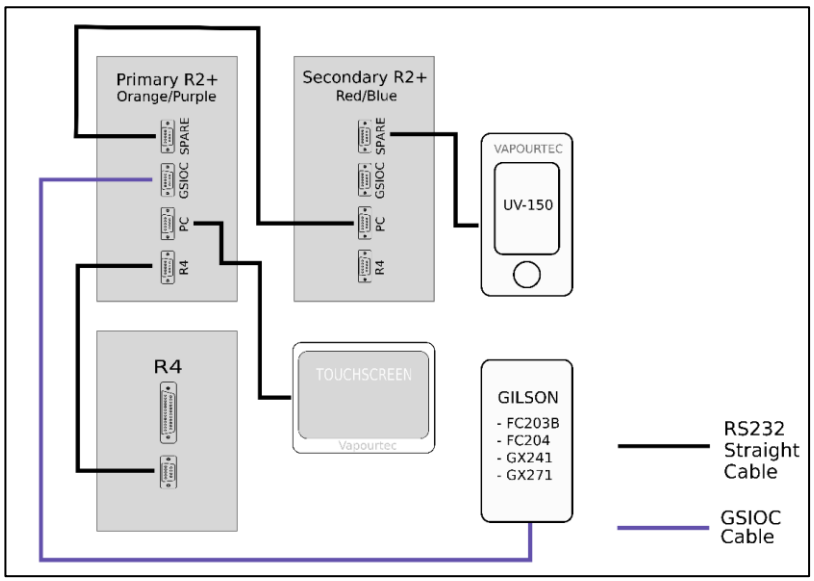
1. A system can be upgraded to 4 pumps with the addition of an R2xx module. A special stand is also available (see right).
2. Plug the extra supplied RS232 9-pin cable into the “spare” socket of the Primary pumping module and the “PC” socket of the Secondary pumping module. This enables the R-4 control knob to be used to control the R-4 and both pumping modules.



Cable connection for 2 pumps system:

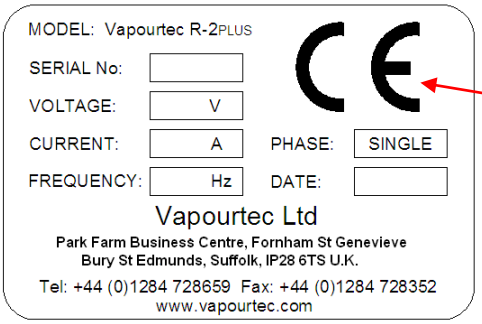


Cable connection for 4 pumps system:



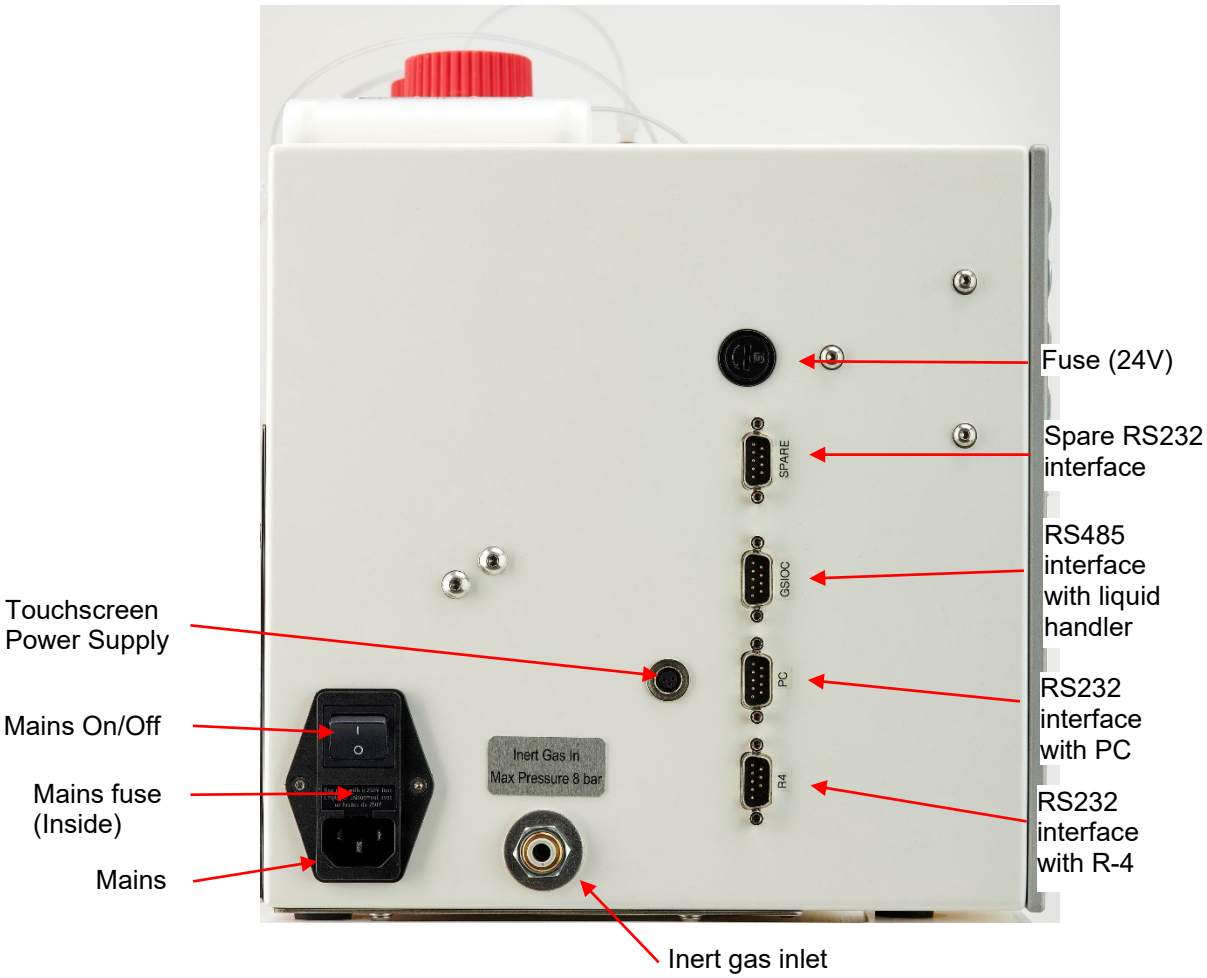
3.6 Electrical connections

Check the rating plate located to the rear of the pumping module to ensure that the electrical supply you intend to connect to the reactor is suitable for your model of pump module.



Rating plate with electrical specifications

The electrical connections should be made in accordance with the picture below. For detailed specifications of the serial and switched I/O connections please see the appropriate section in this manual.



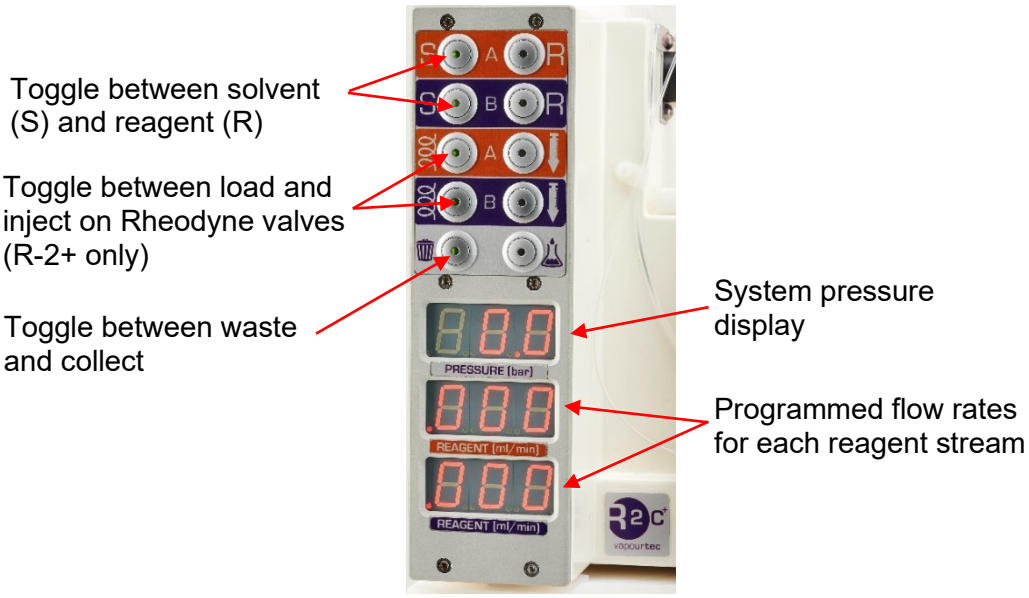
4 THE USER INTERFACE

4.1 Description of the interface

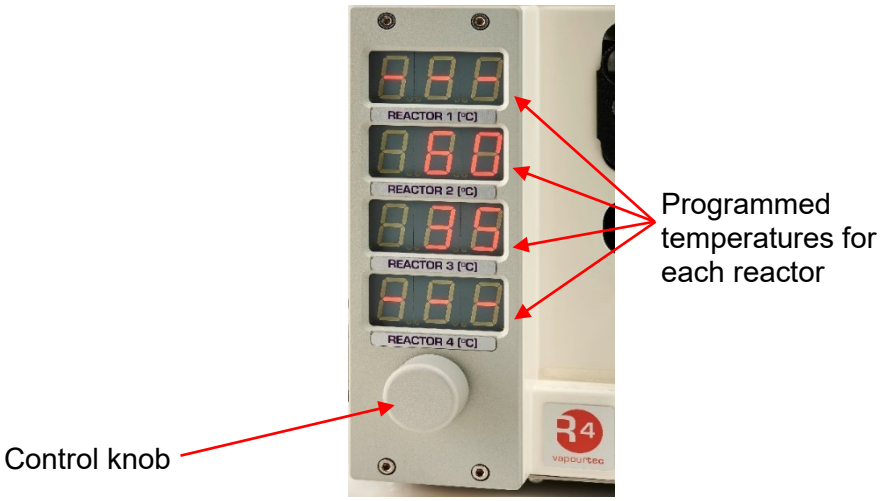
The R-2 module can be controlled in 2 different ways: a) using the press buttons on the front panel and R-4 control knob **OR** b) using R-Series Software (for system with Vapourtec embedded touch panel)

For system without the touch panel and control software, the R-2 can be manually controlled by the press buttons and the R-4 knob. The control knob on the R-4 can be used to switch between three modes: OFF, SET and ON and is also used to set the required temperature for each column on the R-4 reactor heater.

The press buttons on the R-2+ and R-2 are used to toggle between the required fluid supply to the pumps (Solvent or Reagent) and the waste and collection ports after the reactors. The user interface is colour coded to show the flow path for each reagent stream. Please see the photographs below for more details.



R2 Pump Module



R4 Reactor Heater

4.2 Display of data during pumping

During pumping the top display will show the actual pressure (in bar) within the reactor (system pressure). The lower two displays will show the programmed flow-rates (in mL/min) of the two reagent streams.

If R- Series software is purchased, real-time data (Reactor temperatures, pressures, flow rates, valve positions, heater power, etc.) can be logged, displayed and charted.

Refer to R-Series Software user manual for details.

5 OPERATION

5.1 Configuring the pumping module for use with R-4 Reactor Heater

The pumping module can be integrated with your R-4 Reactor Heater. Refer to section 3.5 on the cable connection.

The pumping module is provided with serial data communication using RS232 protocols. With a suitable cable connected to the 9-way serial port, the pumping module can be controlled remotely using the serial command set. Contact Vapourtec for details.

5.2 Fluid connections

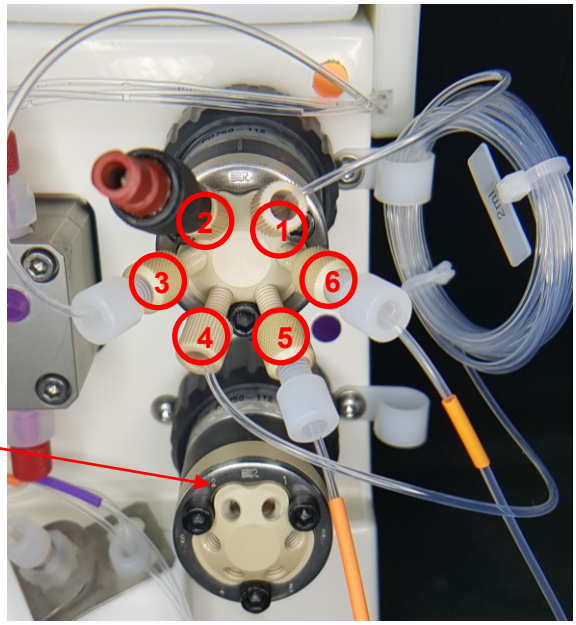
The reagents can be fed directly from the reagent bottles or via the sample loops (for R2+ module only).

For larger scale synthesis, it is more viable to feed the reagents directly from the reagent bottles.

The benefits of using the sample loops (for R2+ module):

- The reagents are precious/scarce: Small scale synthesis to avoid unnecessary reagents wastage. The sample loops are calibrated at specific volume (2ml size supplied as standard, other sizes upon request), thus reagents leftover is minimal.
- Avoid direct contact of reagents with the pump head. For example, loading suspension/slurry into the sample loops could avoid pump blockage. However, reactions involve slurry could be difficult to handle. Please contact Vapourtec for assistance.
- Use of autosampler for automation of multiple reactions. The reagents have to be injected into the sample loops before being loaded into the reactor.

Tubing connection to the sample loop valve (R2+ only):



Port number engraved on the metal ring

Port 1 & 4 = Sample loop

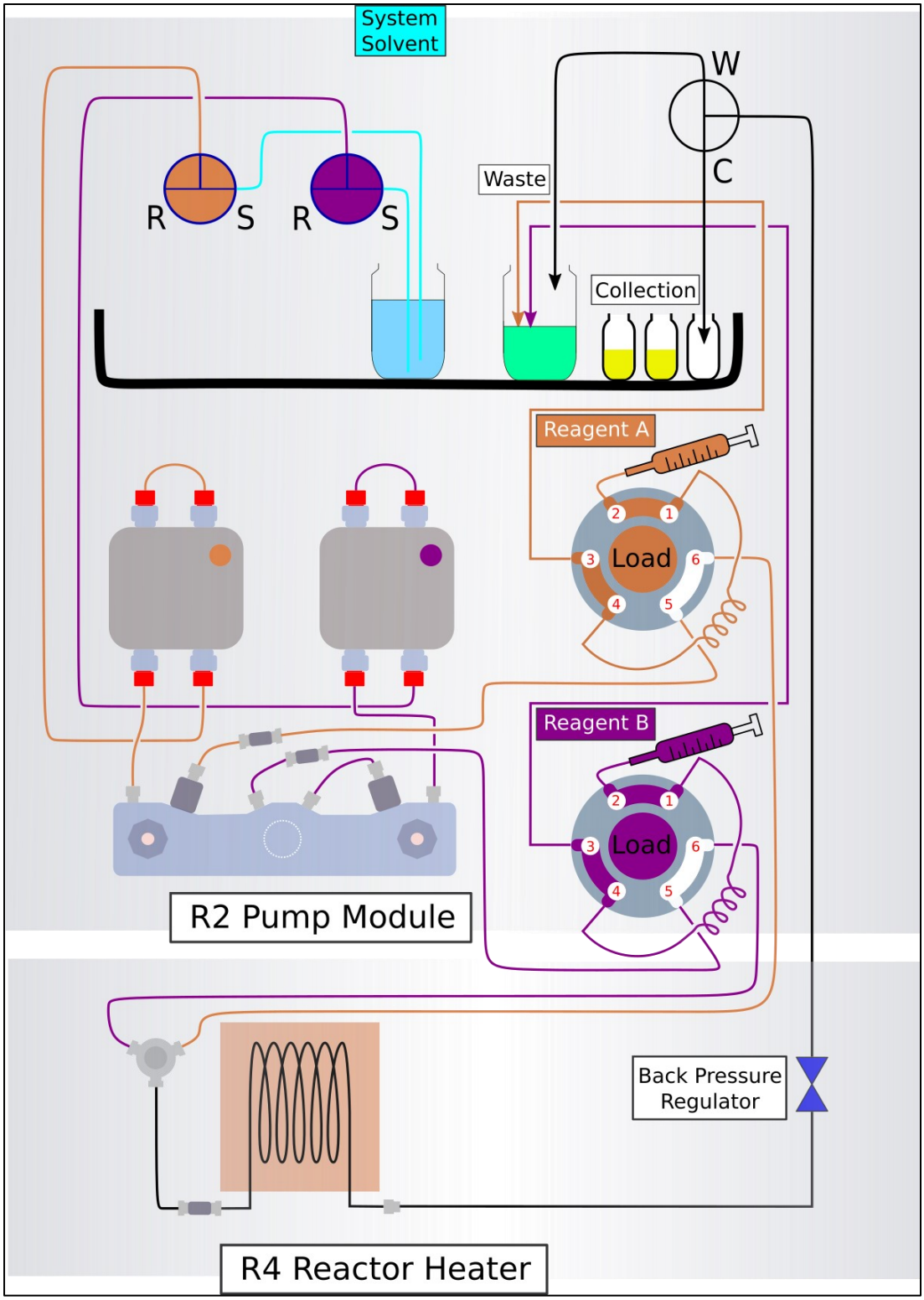
Port 2 = Sample load Injection

Port 3 = Waste

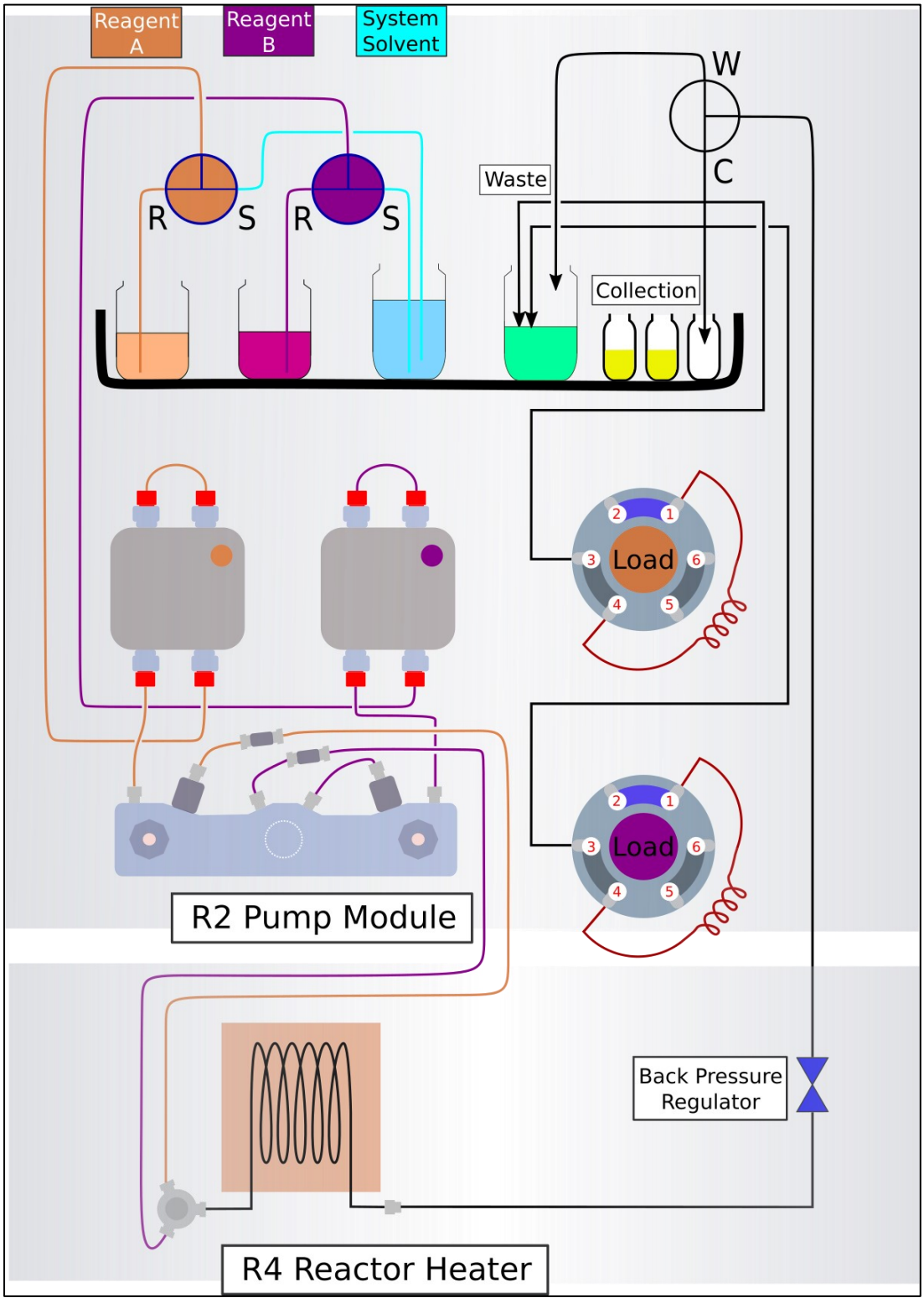
Port 5 = 32cm inlet from the pump

Port 6 = 28cm outlet to the reactor

Fluid connections for small-scale synthesis using injection loops (R2+ only):



Fluid connections for large-scale synthesis:



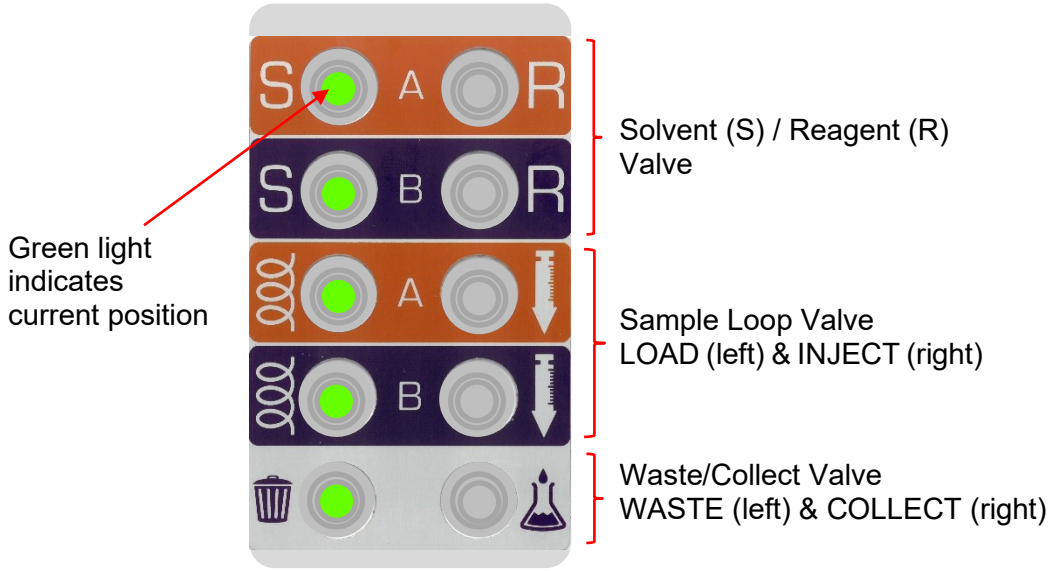
5.3 Front panel press buttons control

The press buttons on the front panel are used to manually control the flow path of the solvent and reagents by switching the position of the:

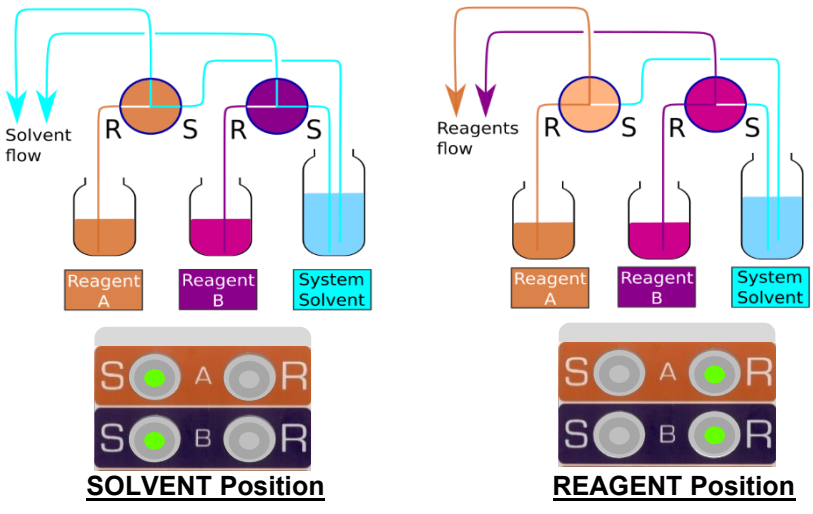
- Solvent/Reagent valves
- Sample loop valves
- Waste/Collect valves

Each row of the button controls an individual valve and switches their position to direct the fluid flow from/to a desired pathway. The current position of the valves is indicated by the green LED light lit on the button. When the R2XX module is power on, the default position for all the valves:

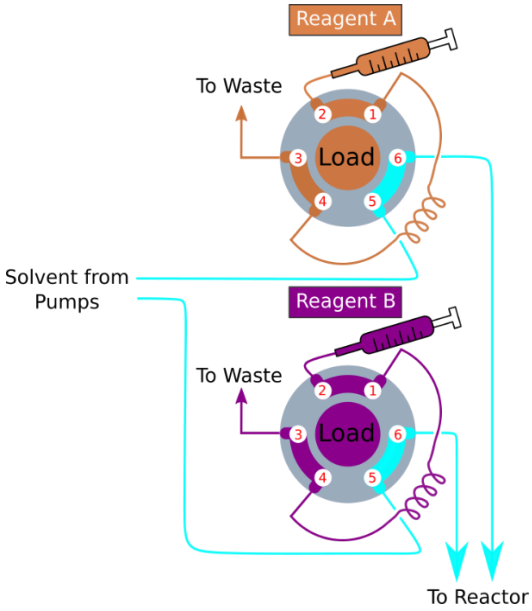
Type of Valve	Default Position
Solvent/reagent valve	SOLVENT
Sample loop valve	LOAD
Waste/collect valve	WASTE

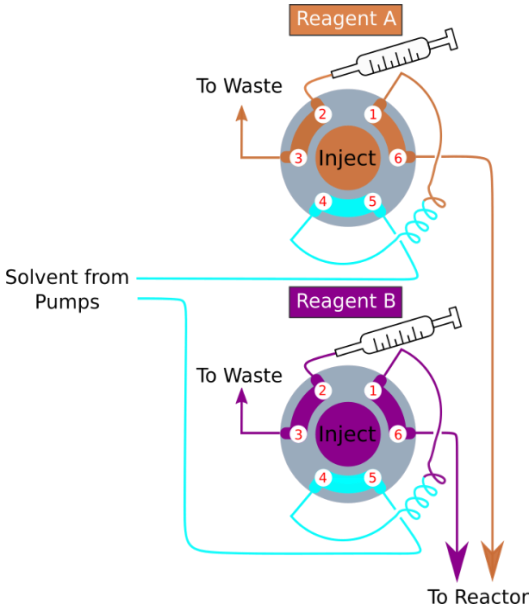


Solvent/Reagent Valve Position and flow path:



Sample Loop Valve Position and flow path:





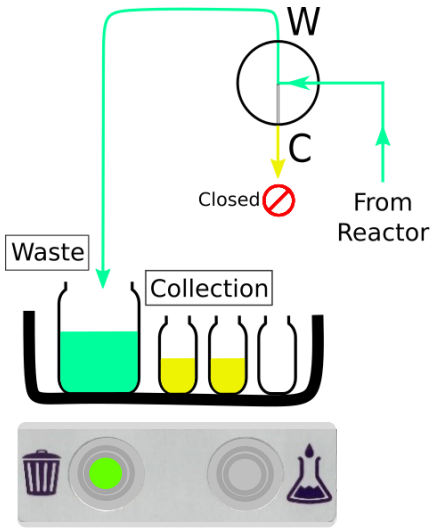
LOAD Position

INJECT Position

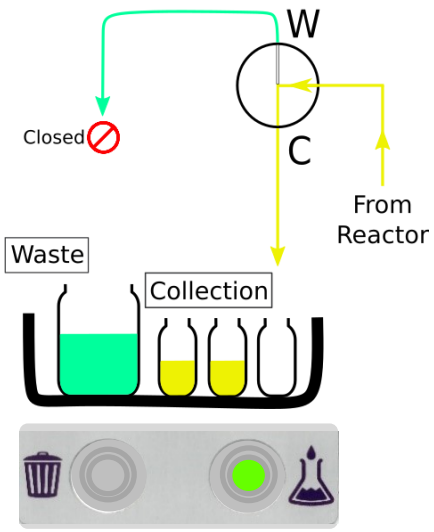
Refer to section 5.2 for the different tubing connection for WITH/WITHOUT using the sample loops.

When sample loops are used, only solvent is passing throught the pump.

Waste/Collect Valve Position and flow path:



WASTE Position



COLLECT Position

5.4 Installing back pressure regulators (BPR)

A back pressure regulator should be fitted to ensure:

a) All gases and vapour remain in the solution.

b) Solvent is not boiling in the reactor. Solvent boiling could result in solid precipitation and block the reactor.

Connect the BPR to the outlet of the reactor. The set pressure of the BPR should be chosen to ensure vapour bubbles do not occur but that reactors are not over-pressurised. Please see the tables below for assistance with the choice of the correct back pressure regulator for your reaction.

Caution. Ensure the BPR is connected to the outlet of the reactor with the arrow pointing in the direction of flow of fluids. If this is not done there is a risk of damage to reactor columns or tubes.

Pressure to prevent vapour bubbles at 150ºC and 250ºC for selected solvents

Solvent	Minimum Pressure to prevent vapourisation			
	150ºC		250ºC	
	Bar	psi	Bar	psi
DMSO	-	-	5.0 bar	75 psi
DMF	-	-	7.8 bar	120 psi
Toluene	2.7 bar	40 psi	16.7 bar	250 psi
Water	4.8 bar	70 psi	✖	✖
THF	8.8 bar	130 psi	✖	✖
Isopropanol	10.2 bar	150 psi	✖	✖
Chloroform	10.2 bar	150 psi	✖	✖
Ethanol	10.2 bar	150 psi	✖	✖
Methanol	12.9 bar	90 psi	✖	✖
Di-chloromethane	21.8 bar	320 psi	✖	✖

✖ = not recommended

Refer Appendix 10.2 (page 48) for extended list of solvent vapour pressure at elevated temperature

Vapourtec recommend running the reaction with a minimum of **3 bar** back pressure. This could be achieved by either using a 6 bar BPR (supplied) or an adjustable type BPR (not included with the R2XX module).

See the following section on the type of BPR available from Vapourtec.

Check the maximum operating pressure for each reactor before running the pump to avoid damage to reactor. Refer to Table 5.4.

Vapourtec provide BPRs with different pre-set pressure rating. The BPRs can be connected in series to achieve the preferred back pressure. E.g., 8 bar + 6 bar BPR in series will generate 14 bar pressure upstream.

Type of BPR available:

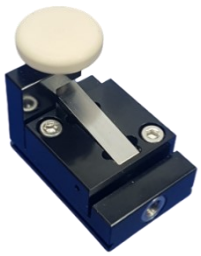
Type of BPR	Description	Acid Resistance
	Passive spring-loaded, 6 bar or 8 bar pre-set at 1ml/min flowrate	YES
	Passive spring-loaded, 250 psi pre-set at 1ml/min flowrate	NO
	Adjustable pressure up to 10 bar. * Not included with R-2 system, contact Vapourtec for quote.	YES
	Active BPR, pressure up to 10 bar. Constant back pressure. * Stand-alone pump, not included with R-2 system, contact Vapourtec for quote.	YES, depend on type of pump tube used. Contact Vapourtec for details.

Table 5.4: Maximum Safe Operating Pressures for Reactors in Vapourtec Flow Chemistry Systems

Tube reactors (all standard pressure systems)	Reactor temperature range				
	-70°C to -20°C	-20°C to 40°C	40°C to 99°C	100°C to 150°C	150°C to 250°C
PFA tube reactors (and PFA supply tubing)	40 bar (580 psi)	40 bar (580 psi)	25 bar (362 psi)	15 bar (217 psi)	Do not use
UV-150 Photochemical reactors	10 bar (145 psi) Min Temp: -40°C	10 bar (145 psi)	10 bar (145 psi) Max Temp: 80°C	Do not use	Do not use
Stainless Steel	42 bar (609 psi)	42 bar (609 psi)	42 bar (609 psi)	42 bar (609 psi)	42 bar (609 psi)
Copper					
Hastelloy®					

Tube reactors (High Pressure, 200 bar systems)	Reactor temperature range				
	-70°C to -20°C	-20°C to 40°C	40°C to 99°C	100°C to 150°C	150°C to 250°C
PFA tube reactors (and PFA supply tubing)	40 bar (580 psi)	40 bar (580 psi)	25 bar (362 psi)	15 bar (217 psi)	Do not use
UV-150 Photochemical reactors	10 bar (145 psi) Min Temp: -40°C	10 bar (145 psi)	10 bar (145 psi) Max Temp: 80°C	Do not use	Do not use
Stainless Steel	200 bar (2900 psi)	200 bar (2900 psi)	200 bar (2900 psi)	200 bar (2900 psi)	200 bar (2900 psi)
Hastelloy®					
Copper	42 bar (609 psi)	42 bar (609 psi)	42 bar (609 psi)	42 bar (609 psi)	42 bar (609 psi)

Table 5.4: Maximum Safe Operating Pressures for Reactors in Vapourtec Flow Chemistry Systems (cont.)

Column reactors (Used on any Vapourtec system)	Reactor temperature range				
	-40°C to -20°C	-20°C to 40°C	40°C to 99°C	100°C to 150°C	150°C to 250°C
6.6 mm Bore Columns	20 bar (290 psi), Silicone O-rings only	40 bar (580 psi)	30 bar (435 psi)	20 bar (290 psi)	Do not use
10 mm Bore Columns	20 bar (290 psi), Silicone O-rings only	30 bar (435 psi)	25 bar (362 psi)	15 bar (217 psi)	Do not use
15 mm Bore Columns	20 bar (290 psi), Silicone O-rings only	20 bar (290 psi)	15 bar (217 psi)	10 bar (145 psi)	Do not use

Chip Reactor (Used on any Vapourtec system)	Reactor temperature range				
	-40°C to -20°C	-20°C to 40°C	40°C to 99°C	100°C to 150°C	150°C to 250°C
All Chip Reactors	20 bar (290 psi)	20 bar (290 psi)	20 bar (290 psi)	20 bar (290 psi)	Do not use

Ion electrochemical reactor (Used on any Vapourtec system)	Reactor temperature range				
	-40°C to -10°C	-10°C to 40°C	40°C to 99°C	100°C to 150°C	150°C to 250°C
	Do not use	5 bar (72.5 psi)	5 bar (72.5 psi)	Do not use	Do not use

Large diameter tubular reactor for rapid mixing (Used on any Vapourtec system)	Reactor temperature range				
	-70°C to Room Temp.	Room Temp. to 40°C	40°C to 99°C	100°C to 150°C	150°C to 250°C
	10 bar (145 psi) Require External Chiller	10 bar (145 psi)	10 bar (145 psi)	10 bar (145 psi)	Do not use

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5.5 Priming the pumps

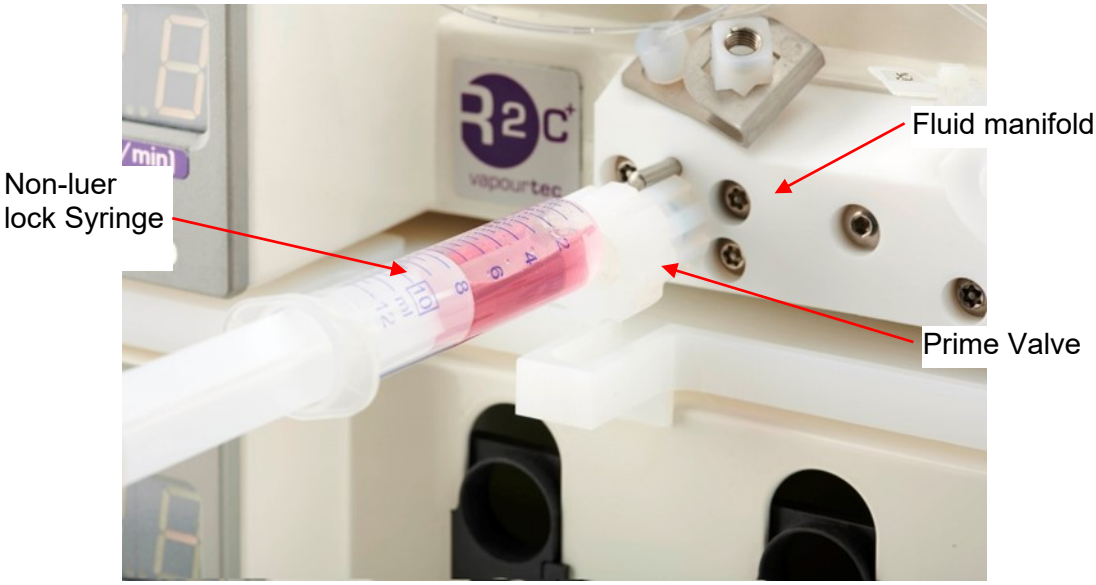
Vapourtec R2XX utilise piston pumps to deliver the fluid. The piston pump uses the similar technology as those used in HPLC systems. It can deliver high pressure, reliable, and can accurately operate across a wide range of flow rates. However, the actual flow rates can differ to expected results in certain circumstances, affecting the accuracy. The causes for this include:

- Transient or static air bubbles, caused by excessive dissolved gas in the reagents or insufficient wetting of the pump working parts
- Transitions between reagents that are not fully miscible (pumping immiscible mixture)
- Obstructions caused by particulates in the fluids

The prime valve is designed to remove the air bubbles present in the aspiration line and pump head.

To prime the pumps, insert a **NON-Luer** lock syringe into the prime valve on the front of the fluid manifold. The pumps can be primed either whilst running or whilst stopped. Turn the prime valve a quarter turn anti-clockwise and draw the syringe back until fluid appears in the syringe. Return the valve to the closed position by tightening the valve in a clockwise direction. Please see photograph below.

Toggle the line between solvent and reagent using the push button (refer to Section 5.3) to ensure both solvent and reagent connections are primed before starting your synthesis.



Do not use luer lock syringe for priming as this will undo the tip of the prime valve and cause leaking.

5.6 Pump head backwash

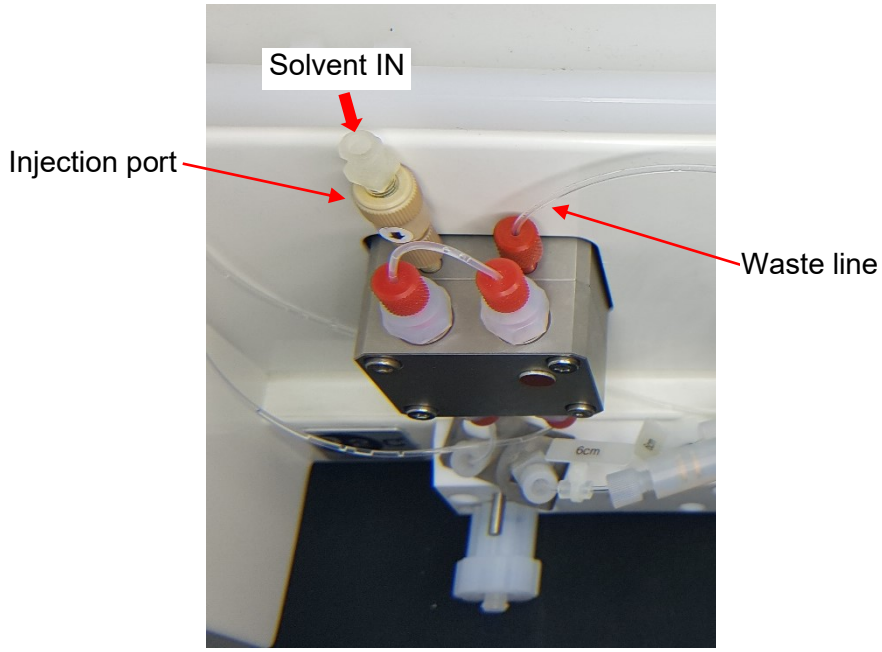
The pump piston is made of high strength, chemical and scratch resistant sapphire. The piston is sealed off by set of high- and low-pressure seals. If chemical residue is left on the piston, precipitation can happen. When the piston is in movement, the solid formed on the surface might scratch and damage the seals, which will cause leakage.

Backwash ensures film of chemicals which may be left on piston is flushed away. Backwash should **always** contain:

- fresh solvent, preferably the same as system solvent
- miscible with what is being pumped (piston pump cannot handle immiscible solution)
- not likely to react with what is being pumped

If strong acid (or any corrosive solution) is used as system solvent, DO NOT backwash the pump head with the system solvent but instead choose a non-corrosive alternative solvent for backwashing.

Use a small volume Non-Luer lock syringe (2ml or 5 ml size), fill with solvent. Inject the solvent via the pump backwash injection port (luer fitting + check valve). Waste solvent will be discharged via the waste line to the waste bottle. See picture below.



Backwash injection port is made of PEEK. **DO NOT** backwash with strong acid or corrosive liquids.

Always use a small size syringe (2ml or 5ml size) in order to generate enough pressure to crack open the injection port. A larger size syringe might fail to push solvent in and could cause spillage or splash.

5.7 Inert gas manifold and needle kit

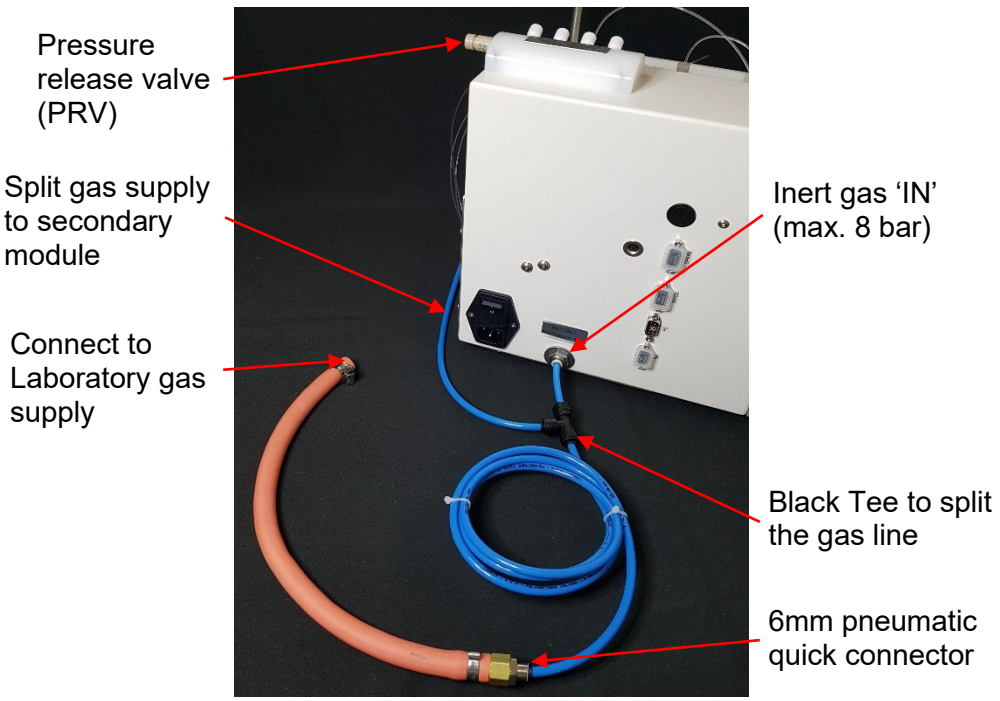
The pump module is supplied with an inert gas system that is capable of supplying 4 channels of continuous flow of inlet gas to the reagents bottles. This is useful for:

- Blanket the moisture/air sensitive solutions (e.g. organometallic solution)
- Ensure there is a positive pressure connected to the headspace above the solutions in a closed bottle

It is advisable to use inert gas to pressurise the bottle for low boiling point solvent, e.g. Dichloromethane (DCM) and Chloroform in order to have a smooth pumping of liquid.

Contact Vapourtec for details on how to handle low boiling point solvent.

The inert gas (typically Nitrogen) is brought into the module at full line pressure (max. 8 bar) and is regulated internally down to 40mbar, then distributed to a manifold situated next to the reagent tray. Up to 4 tubes, with septum piercing needles, can then be taken from the manifold to the nearby reagent bottles, while unused ports on the manifold remain closed.



There are 2 safety protection layers to ensure the bottles are not over pressurised:

- High pressure release on the built-in gas regulator
- Additional pressure relief valve (PRV) on the distribution manifold.

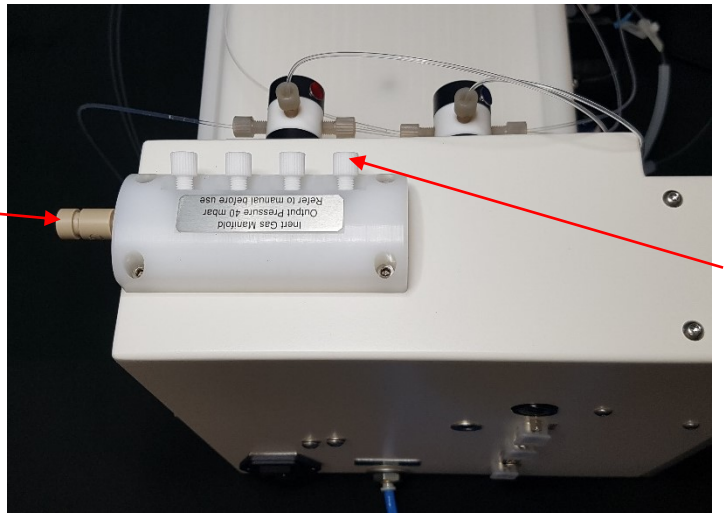
A set of inert gas needle kit is supplied with the system. The needle kit comprising:

- 4x Short Septum Piercing Needles with PFA nuts
- 4x Inert Gas Tubing (0.2mm ID) with PFA nuts and unions
- 1 x Pressure Relief Valve (PRV)

There is restrictor inside the inert gas tubing (black tagged tube). **DO NOT** use these tubes for any purposes other than feeding inert gas.

A safety pressure relief valve (cracking pressure at 0.5bar) is supplied with the R2 module. Fit the PRV on the inert gas manifold as picture below.

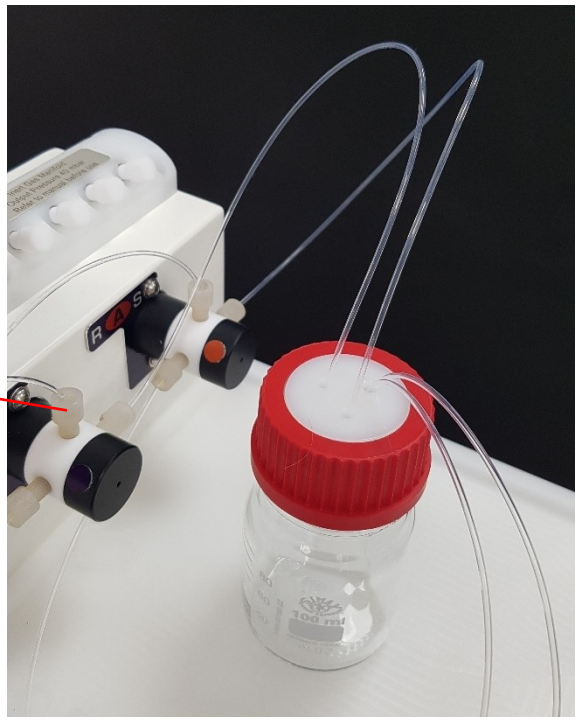
Pressure release valve (PRV)



4 x Inert gas outlet (closed with blanking plug)

5.8 Aspiration line and Organometallic kit

Strong acid resistant PFA tubing with 1.6mm OD, 1mm ID is used as the standard aspiration line on the R2XX module. The aspiration tube fit and hold firmly on the supplied red bottle cap.



The aspiration line uses etched PFA nut that can provide better grip when screwed on to the solvent/reagent valve. The etched nut appears brownish in colour which is a result of the etching process. This is **NOT** a defect.

The organometallic chemistry kit consists of a set of tubes and needles which enable reagents to be aspirated from bottles sealed with septa, while inert gas is supplied into the bottles to replace the volume removed.

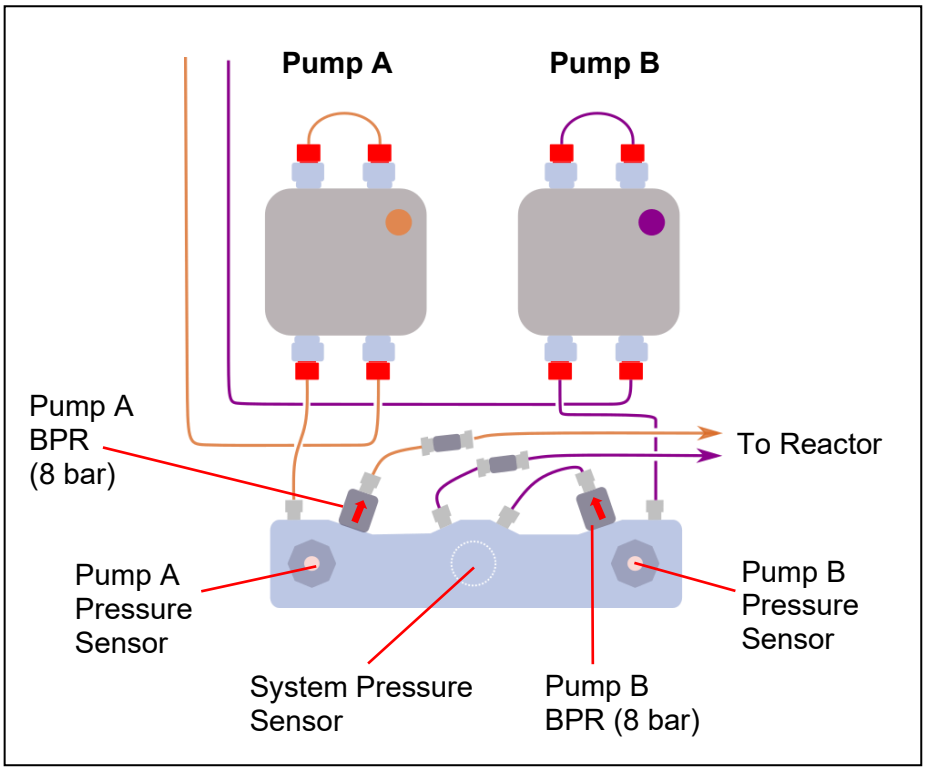
For synthesis that involves air/moisture sensitive reagents, the user should replace the standard aspiration line with the organometallic needle kit.

5.9 System Pressure, Pump Pressure & Pressure Monitoring

There are 3 pressure sensors located inside the fluid manifold to monitor:

- Pump A pressure
- Pump B pressure
- System pressure

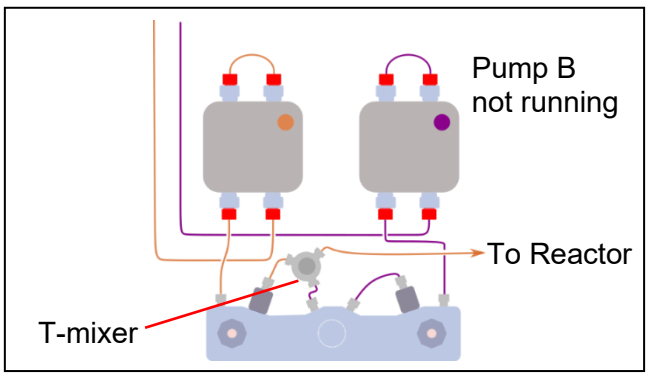
On each flow channel, there is a BPR located after the pump pressure sensor. These BPRs are pre-set at 8 bar pressure to ensure the pumps' pressure is always higher than the system pressure.



The 'System Pressure' is the pressure inside the reactor and it is generated by the BPR fitted at the downstream of the flow path (after the reactor).

ONLY the system pressure is displayed on the front panel. The pumps' pressure reading is only accessible via the R-Series software.

The system pressure is measured on channel B. If only 1 pump is required for the synthesis, **ALWAYS** use pump B OR connect the system pressure sensor using a T-mixer if only channel A is used, see picture below.



5.10 Pump performance monitoring

The R2 module has a pump monitoring system built-in that offers the following facilities:

- It detects any failure to pump correctly across the whole range of flow rates
- It tells the user which pump is not pumping correctly.

The pump monitoring system monitors each of the flow channels separately and returns a flashing 'Air' warning on the front panel display when the pump is not pumping correctly.

When the system is flashing 'Air' the delivery of the pump would not be accurate and the users need to identify and troubleshoot the problem.

The most common root cause for the 'Air' warning are:

a) Gas bubble presents in the flow path

Check that the reagent/solvent bottles are not running dry. Prime the line to remove the gas bubbles.

b) Particle or dirt trapped in the pump check valves

Check the bottles for dirt/dust. Run the pump at maximum flowrate for a few minutes could help to flush out the particles.

c) The pump head is not fully wetted

Backwash the pump head with plenty of solvent.

d) Pumping an immiscible solution

Avoid using immiscible mixture. Flush and backwash the pump head with a 'bridging' solvent (solvent that can mix well with the immiscible mixture). E.g., using anhydrous THF to flush out a water/toluene mixture. Refer to Appendix 10.3 for solvent immiscibility.

Contact Vapourtec if a constant 'Air' warning issue present. DO NOT take apart the pump head or manifold without first consulting with Vapourtec technical support.

The system will flash a 'Lo' warning and stop the pumps when it senses a sudden pressure which indicates a leak in the flow path.

The 'Lo' warning feature will be activated only when the system pressure is above 3 bar.

A flashing 'bAr' warning indicates an overpressure trip.

'Air' warning

'LO' warning

'bAr' warning

5.11 Setting the pumping pressure and speed

Use the display for the Rxx-2, R-2+ and the control knob on the R-4 to switch ALL between three modes; OFF, SET and ON. To achieve this control the following operation is required;

- One push of the control knob changes all displays to read SET.
- Turning the control knob clockwise changes all displays to read ON.
- Turning the control knob counter clockwise changes the displays through SET to read OFF.

The maximum pressure of the R-2 or R-2+ can be set in the range 0 – 50 bar.

The pumping speeds of each pump can be set independently in the range 0 – 10ml/min.

The temperature of each of the 4 reactors can be set independently in the following ranges:

Position	Reactor type	Range
1	Standard PFA tube or column	Ambient to 150°C
	Cooled tube reactor	-70 °C to ambient
	Cooled column	-40 °C to ambient
2	Standard PFA tube or column	Ambient to 150°C
	High temperature tube	Ambient to 250°C
3	Standard PFA tube or column	Ambient to 150°C
	Cooled tube reactor	-70 °C to ambient
	Cooled column	-40 °C to ambient
4	Standard PFA tube or column	Ambient to 150°C
	High temperature tube	Ambient to 250°C
	Cooled tube reactor	-70 °C to ambient
	Cooled column	-40 °C to ambient

Refer to *Vapourtec R-4 Flow Reactor Heater User Manual* for detail operation of the R4 unit.

Caution. If at any time the control knob is pressed once but then no other action is taken the display will revert to actual temperature after 5 seconds.

Caution. Do not place anything other than the glass heat exchangers in the holes in the front of the R-4 as they may be hot.

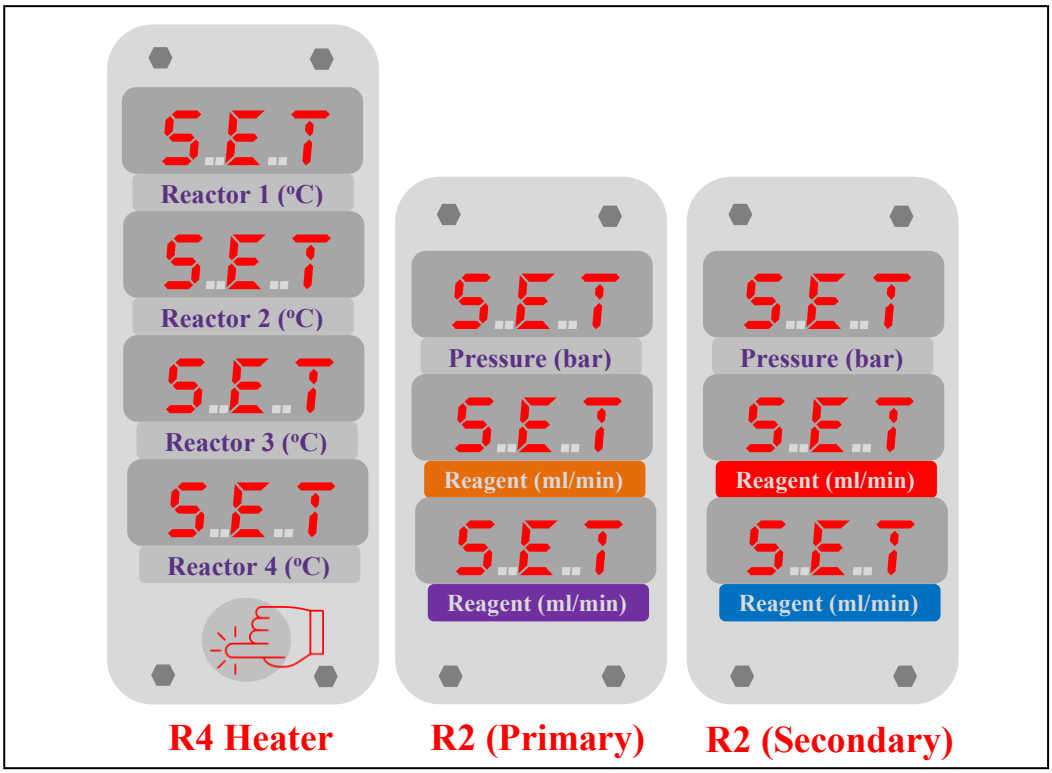
The pump pressure setting is the overpressure safety cut-off limit set to protect the system and reactors. E.g., If the pump pressure is set as 15 bar, the system will trip when the system pressure reaches 15 bar.

When the system trip due to overpressure, the front panel display will flash a ‘bAr’ warning.

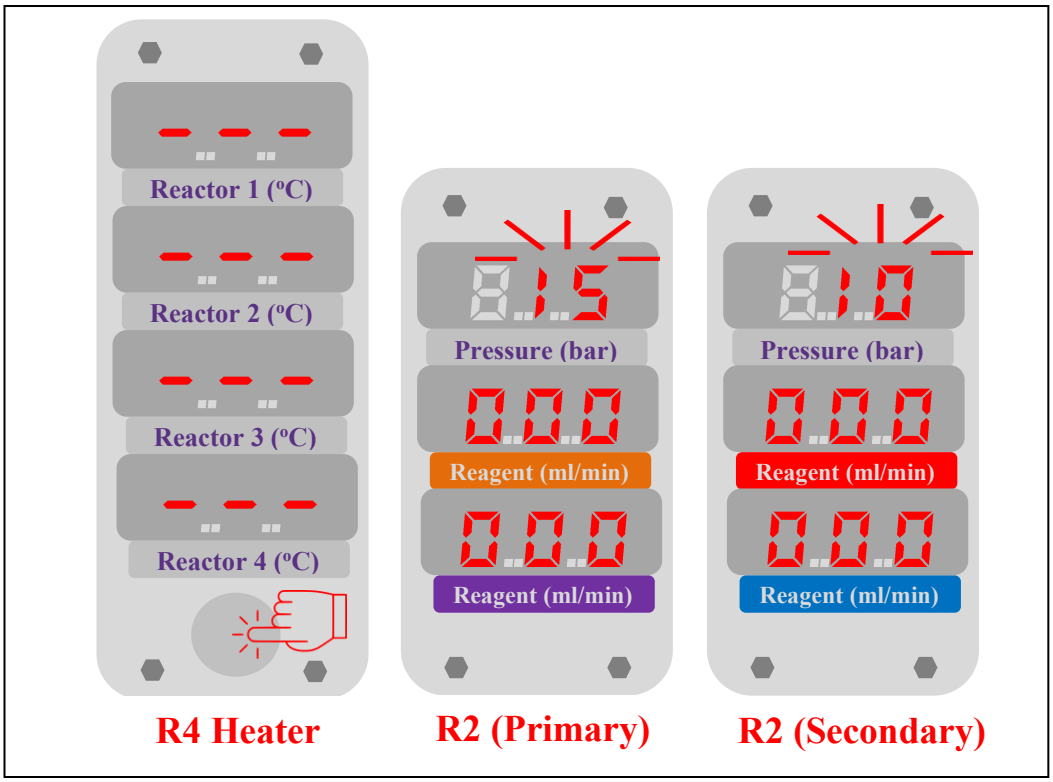
Always refer to the *reactor temperature and pressure range* table (Appendix 10.1, page 46) and ensure the overpressure safety cut-off limit is set correctly to protect the reactor used.

The following illustrates the steps to set the pump pressure (overpressure limit) and speed for a 4 pumps R-Series system:

- Press the R4 control knob, all the modules will switch to SET mode.



- Press the R4 knob **again** while SET is displayed will make all modules enter the SET mode. All segments show the current setpoint stored in the system memory.



- The system overpressure trip setting on **BOTH** R2 will starts blinking. Indicating they are ready to receive a new setpoint.
- Turn the control knob clockwise to increase the setpoint value and counter clockwise to decrease.
- Press the control knob to accept the set value for overpressure trip and move down to next level (pump A flowrate).
- Repeat the same process to input the setpoint for each level.

- If the pumps or heaters are on, then they should remain on throughout the changing of the set point (unless a particular reactor is set to OFF).
- If the pumps or reactor heaters were OFF before the set points were adjusted, then after adjusting the set points the pumps/heaters will revert to OFF state.

  Once the set points have been adjusted the displays will all revert to displaying the actual pressure, pumping speed and temperature.

5.12 Turning the pumps and heaters on and off

To turn the pumps OFF:

1. Press the control knob - all counter displays read SET.
2. Turn the control knob counter clockwise until OFF is displayed and then press the control knob again.
3. Both pumps and all heaters are turned OFF while the displays on the R-4 show actual temperature, the top display on the R-2 or R-2+ shows the actual pressure, and the flowrate shows zero.

Caution. If at any time the control knob is pressed once but then no other action is taken the display will revert to actual temperature after 5 seconds.

Caution. Do not place anything other than the glass heat exchangers in the holes in the front of the R-4 as they may be hot.

To turn the pumps ON:

1. Press the control knob - all counter displays read SET.
2. Turn the control knob clockwise until ON is displayed and then press the control knob again.
3. Both pumps and all heaters are turned ON while
   - The displays on the R-4 show the actual temperature with a moving dot underneath the temperature reading. The moving dot indicating the power is being supplied to the heater.
   - The top display on the R-2 or R-2+ shows the actual pressure.
   - The second and third display on the R-2 or R-2+ shows the set flowrate.

6 INTERFACING THE R-2 FOR AUTOMATION

6.1 Overview of Serial Interface

The R-2 is equipped with two different interface options for communication between upstream processes or serial communication using RS232 protocols.

The RS-232 interface uses a 19200 Baud rate, 8 data bits, 1 stop bit and no parity for data transmission. The lead length connecting the RS-232 devices can be up to 3 m long but should be kept as short as possible to ensure reliable data transfer.

Please contact Vapourtec Ltd for details of the serial command protocol.

6.2 Command Protocol

Control of the R-2 and R-2+ is achievable through software available from Vapourtec Ltd. Please contact Vapourtec Ltd for further information.

7 USER SERVICEABLE PARTS

7.1 User replaceable parts

ALWAYS consult Vapourtec Technical Support prior conducting any of the following procedures.

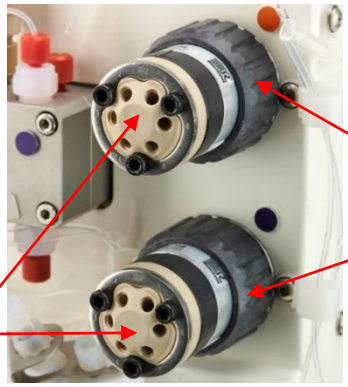
7.1.1 Replacing the fuse

Isolate the equipment from mains before removing ANY covers.

Remove the fuse cover on the side panel (see picture below). There are 2 user replaceable fuse on the module. For description of fuse function and specification see General Specifications in section 0.

7.1.2 Replacing the sample loop (Rheodyne) valve head

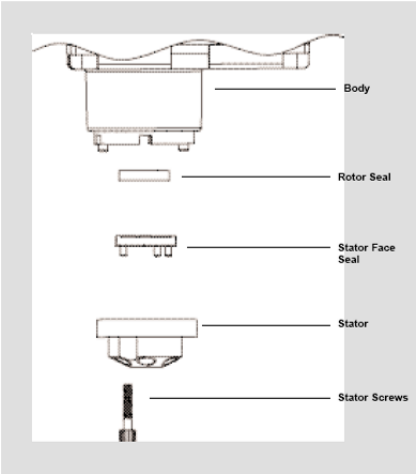
Isolate the equipment from mains before removing ANY covers.



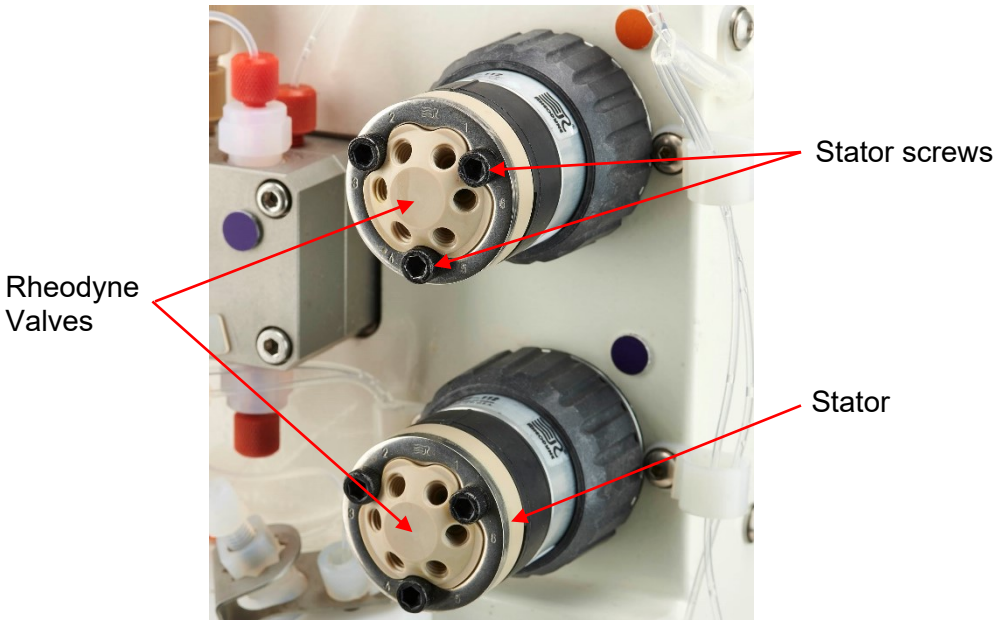
7.1.3 Replacing the Rheodyne rotor seal/stator face seal

Isolate the equipment from mains before removing ANY covers.

1. Using a hex key, remove the stator screws located in the stator.
2. Remove the stator and stator face seal from the valve body.
3. Slip a flathead screwdriver underneath the rotor seal to remove it.
4. Mount the new rotor seal with the grooves facing the stator. The three pins on the shaft assembly fit into the mating holes in the rotor seal only one way.
5. Remove the stator face seal from the stator.
6. Mount the new stator face seal on the stator. The three pins on the seal fit into the mating holes in the stator only one way.
7. Mount the stator and stator face seal on the valve so that the stator locating pins in the body enter the mating holes in the stator.



8. Replace the three stator screws. Tighten each down firmly (no more than 6 in/lbs [0.7 Nm]).



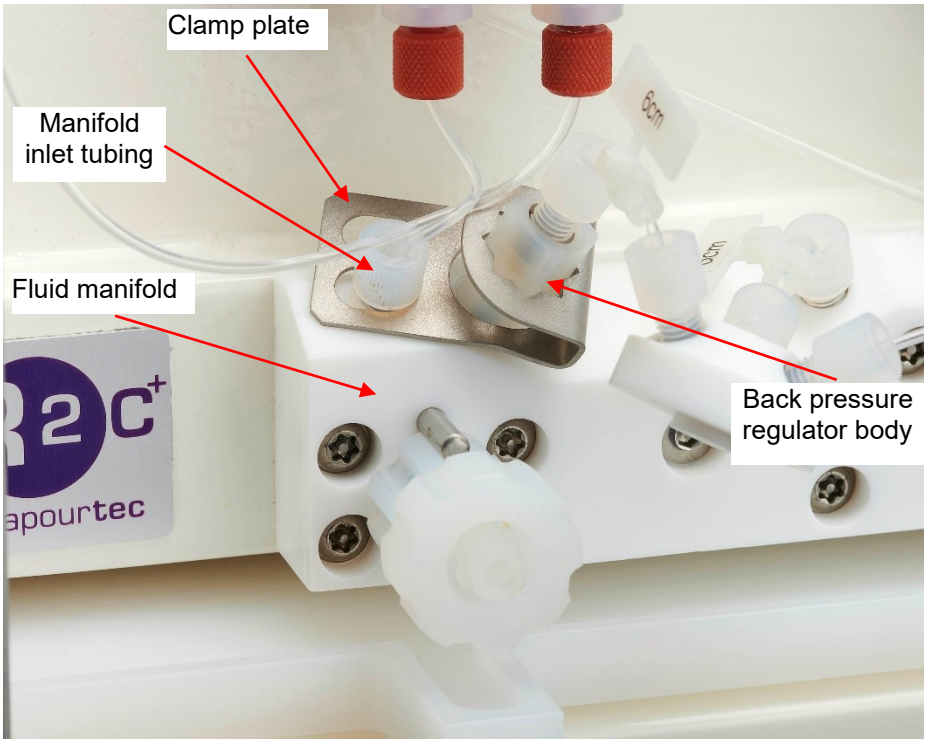
7.1.4 Replacing the pump delivery back pressure regulators

Ensure that the pumps are turned off and there is no pressure left in any of the fluid connections. To reduce the pressure to zero, loosen the connection between the T-junction and any reactors connected to the R-2 fluid connections.

1. Unscrew the manifold inlet tubing to release the metal clamp plate.
2. Remove the metal clamp plate, unscrew the body of the back pressure regulator from the fluid manifold.
3. Remove the old back pressure regulator cartridge carefully from the manifold by pulling it upwards.
4. Replace the back pressure regulator cartridge (8 bar pressure), making sure that the end with the cap is facing downward.
5. Carefully screw back the body of the back pressure regulator to the manifold, taking care not to cross-thread it.
6. Tighten the body into the manifold, install the metal clamp plate and secure it with the manifold inlet tubing.

If the back pressure regulator is cross threaded when replaced in the fluid manifold, this may cause a leak and the need to replace the fluid manifold.

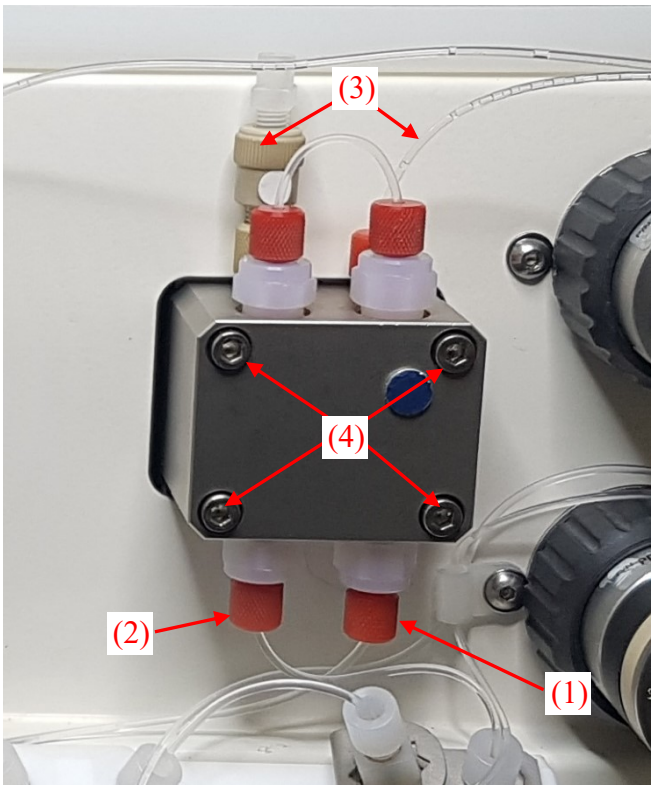
Over-tightening the back pressure regulator body may also have the same effect.



7.1.5 Replacing the pump head

Before removing the pump head from the system, ensure the pump has been flush and backwash with plenty of IPA to decontaminate the pump head.

1. Remove the solvent/reagent tubes from the IPA bottles.
2. Use a syringe to draw out the remaining IPA via the prime valve.
3. Unscrew nut to disconnect 'IN tube' from pump (1).
4. Unscrew fitting from 'OUT' position (2).
5. Unscrew and remove the backwash INLET and OUTLET port (3).
6. Sequentially unscrew the pump screws (4), ONE turn each at a time, to ensure that the pump head comes out straight and the pistons are not broken or damaged.
7. The pump head can now be removed.
8. Line up the new pump head and again, screw the new head in sequentially.
9. Reattach all the pump fittings.



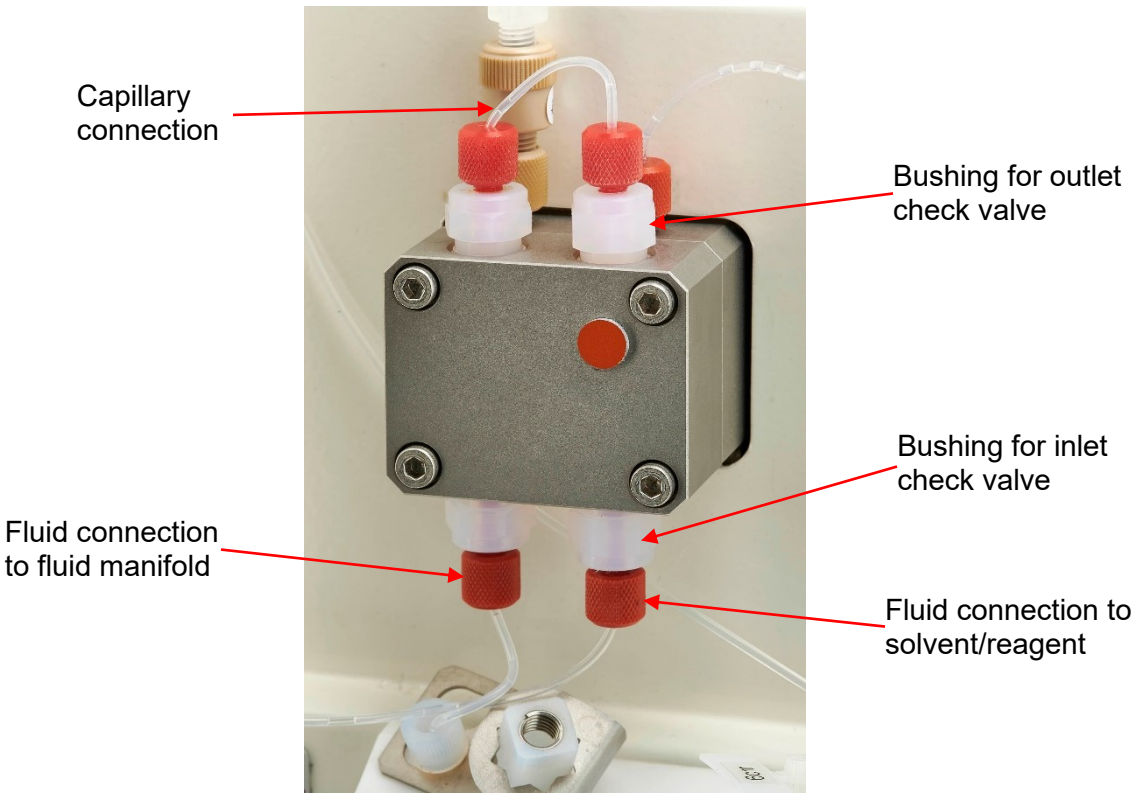
7.1.6 Replacing the pump check valves

The pump check valves are **NOT** consumable item and need not be replaced frequently. The check valves can be cleaned or unblock by flushing with high flow rate of solvent. Contact Vapourtec before any attempts are made to alter/replace the check valves.

IT IS NOT ADVISABLE for the user to tamper with the pump check valves before consulting Vapourtec.

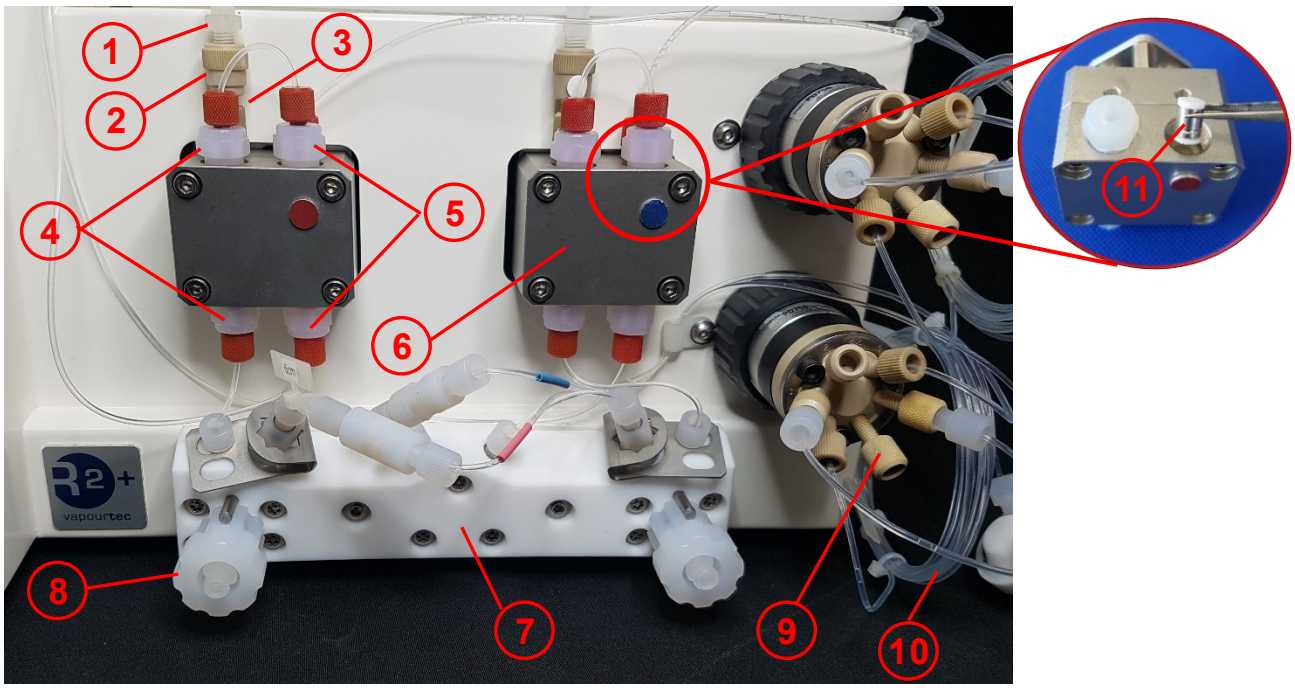
Ensure that the pumps are turned off and there is no pressure left in any of the fluid connections. To reduce the pressure to zero, loosen the connection between the T-junction and any reactors connected to the R-2 fluid connections.

1. Remove the fluid connection between the pump and the solvent/reagent supply and the connection between the pump and the fluid manifold.
2. Remove the bushing on the inlet side (see photograph below). The lower check valve can be removed together with the bushing.
3. Remove the complete capillary connection between the two pump chambers. Loosen the screw fittings alternately, to avoid bending the capillary.
4. Remove the bushing from the outlet side.
5. Remove the upper check valve using pair of tweezers.

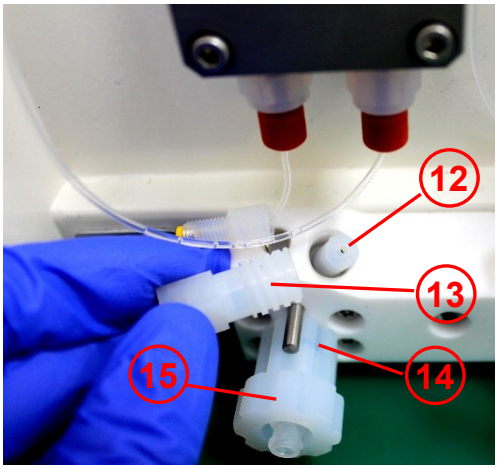


7.2 Spare parts & Accessories listing

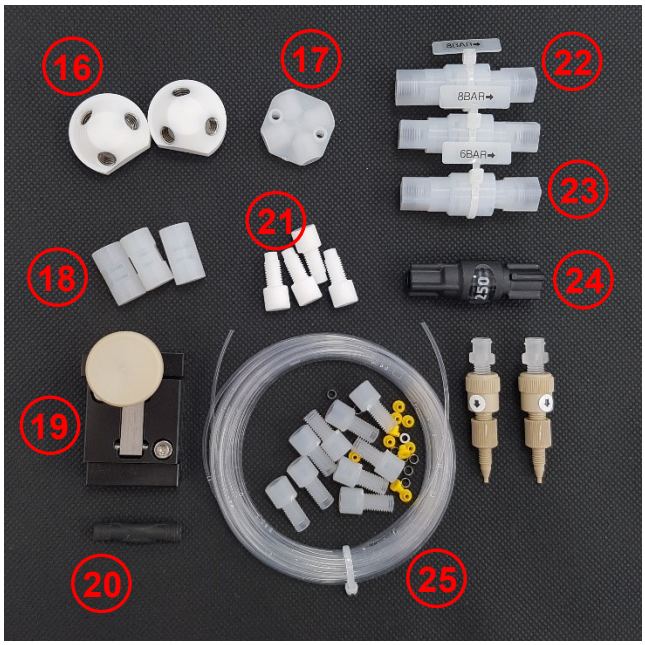
7.2.1 Service Parts



No	Vapourtec Part No.	Description of Spare Parts and Accessories
1	30-3194	F Luer 1/4 - 28.PP
2	30-3288	CV Inlet 3301 pump backwash
3	30-3171	FingerTight I Peek F-120
4	40-1251	Inlet Connector PFA
5	40-1250	Inlet Connector PFA - CV side
6	50-1275	Replacement 10 ml acid resistant pump head
7	50-1179	Fluid Manifold - service
8	50-0254	Prime valve assembly R2/P2 Plus
9	30-3286	Adapt-Extra Long - Peek
10	40-1157	2 ml Sample loops (pair of)
	40-1158	5 ml Sample loops (pair of)
	40-1159	10 ml Sample loops (pair of)
11	50-1168	Acid resistant check valve

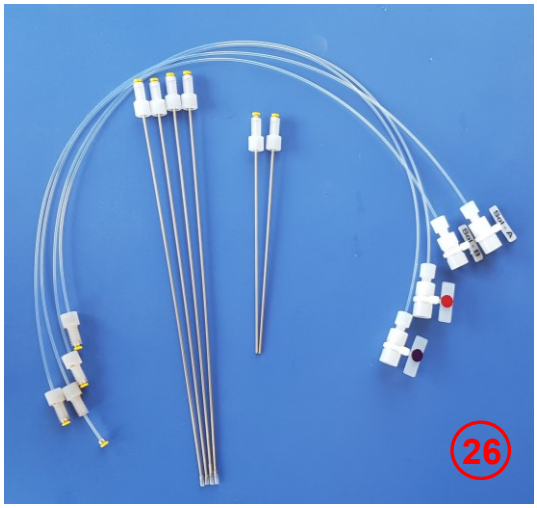


No	Vapourtec Part No.	Description of Spare Parts and Accessories
12	50-1176	Acid resistant back pressure regulator cartridge only
13	40-1254	BPR outer body MALE
14	40-1253	Prime Sleeve Acid
15	40-1252	Prime Valve Acid

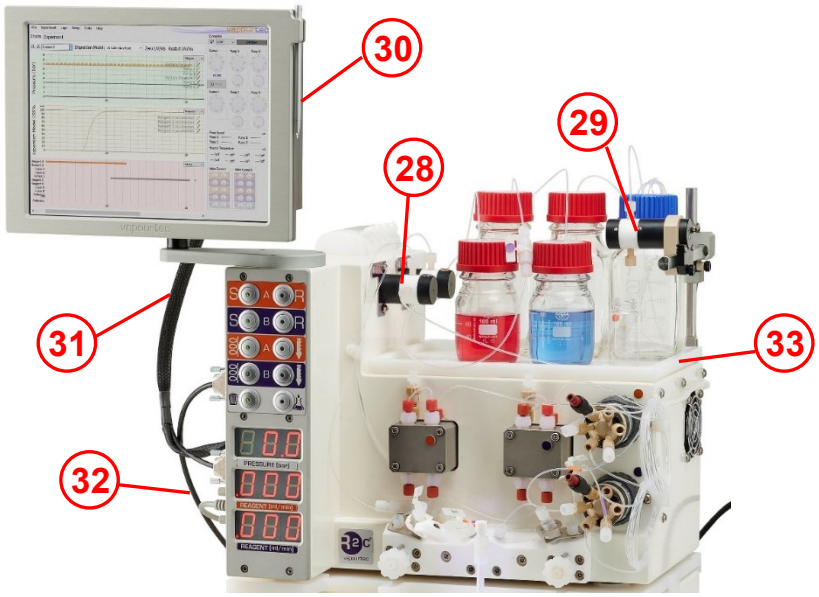


No	Vapourtec Part No.	Description of Spare Parts and Accessories
16	40-1276	Cooled Mixer
17	30-3201	ETFE 4-Way Cross 1mm hole

18	40-1924	Union - PFA
19	50-1315	Adjustable Back Pressure Regulator
20	40-1355	Flexible Element for Adjustable BPR
21	40-1313	PTFE Blanking Plug
22	50-1167	Acid resistant back pressure regulator complete assembly (8 bar)
23	50-1175	Acid resistant back pressure regulator complete assembly (6 bar)
24	40-1153	Standard (non-acid resistant) 250 Psi back pressure regulator (BPR)
25	50-1418	Tubing kit 1/16" 2m supplied with 10 nuts and 10 ferrules



No	Vapourtec Part No.	Description of Spare Parts and Accessories
26	50-1279	R-Series septum piercing kit (organometallic)
27	50-1281	Inert gas manifold needle kit



No	Vapourtec Part No.	Description of Spare Parts and Accessories
28	50-1387	Solvent/Reagent Valve
29	50-1386	Waste/collect valve
30	40-1321	Stylus for touchscreen
31	50-1151	Touch screen cable assy
32	50-1193	Serial cable assy R2 to R4 straight
33	40-1107	Drip tray R2

7.2.2 R-Series Service Kit

50-0270 **R2+ Service Kit**

Part Number	Part Description	Quantity
50-0252	Vapourtec replacement pump seal kit 10ml	2
50-0255	Rheodyne service kit 1mm bore	2
40-1154	Pump Delivery back Pressure Regulator - Pack of 2	1
50-0254	Prime valve assembly R2/P2 Plus	2

50-0272 **R2 Service Kit**

Part Number	Part Description	Quantity
50-0252	Vapourtec replacement pump seal kit 10ml	2
40-1154	Pump Delivery back Pressure Regulator - Pack of 2	1
50-0254	Prime valve assembly R2/P2 Plus	2

50-0271 **R2C+ Service Kit**

Part Number	Part Description	Quantity
50-0252	Vapourtec replacement pump seal kit 10ml	2
50-0255	Rheodyne service kit 1mm bore	2
50-0254	Prime valve assembly R2/P2 Plus	2
50-1176	Acid resistant back pressure regulator cartridge only	2

50-0279 **R2C Service Kit**

Part Number	Part Description	Quantity
50-0252	Vapourtec replacement pump seal kit 10ml	2
50-0254	Prime valve assembly R2/P2 Plus	2
50-1176	Acid resistant back pressure regulator cartridge only	2

7.2.3 R-Series Tubing Kit

50-1102 **Tubing kit - solvent/reagent to pump**
- 2 x 46cm non-flanged etched nut + F100x Finger tight Male Nut
- 2 x 38cm non-flanged, etched nut + open one end
- 2 x 32cm non-flanged, etched nut, non-etched nut
- 2 x 25cm non-flanged, non-etched nut + open one end
- 2 x PFA Union (40-1924)

50-1103 **Tubing kit - pumps to manifold**
- 2 x Pump top loop (0.75mm x 75mm)
- 1 x Pump A to Manifold (0.75mm x 68mm)
- 1 x Pump B to manifold(0.75mm x 102mm)
- 2 x flanged 6cm tubes
- 1 x flanged 92mm pump B to system pressure
- 2 x 85cm backwash tubing
- 2 x 10-32 to 1/4-28 PEEK adaptor (30-3198)
- 2 x CV3301 replacement backwash checkvalve (30-3288)
- 2 x 1/4-28 to female Leur fitting (30-3194)

50-1104 **Tubing kit - manifold to rheodyne**
- 2 x Manifold to Rheodyne (32cm)
- 2 x sample to reactor (32cm)
- 2 x 2ml sample loop (40-1157)
- 2 x Valve to waste 80cm

50-1105 **Tubing Kit - Manifold to Reactors**
- 2 x 75cm flanged tubes
- 2 x 50cm flanged tubes (1 orange 1 purple)
- 2 x 50cm flanged tubes
- 4 x 32cm flanged tubes
- 2 x 6cm flanged tubes

50-1106	**Tubing kit - reactor to waste / collect** 1 x 50cm non-flanged tube 1 x 2.5cm collection tube 1 x 28cm to waste

50-1418	**Tubing kit 1/16" 2m supplied with 10 nuts and 10 ferrules** 1/16" PFA tubing cut to 2m 10 x PFA nuts (40-1266) 10 x PFA ferrules (30-3193)

50-1419	**Tubing kit 1/8" 2m with 10 nuts and 10 ferrules** 1/8" tubing PTFE cut to 2m 10 x 1/8" ETFE ferrules 10 x PFA nut 1/8" (40-1351)

50-1280	**Viscous solvent kit (R-Series)** 4 x 90cm, 2.4mm ID PTFE tube, etched PFA nut, open 1 end 2 x 46cm, 2.4mm ID PTFE tube, etched PFA nut one end, non-etched PFA nut one end 6 x V-PTFE CONNECTOR 12mm Dia X 22mm long (40-1518)

8 TROUBLESHOOTING

The following troubleshooting list is not exhaustive, kindly contact Vapourtec if you experience any issues with the R2XX module.

Problem	Possible Cause	Solution
No display	System not plugged in and turned on Fuse (24V) needs replacing.	Check system is plugged in and turned on. Replace fuse as described in Section 7.1.1 of this user manual.
Pumps not running	Maximum pumping pressure has been exceeded so pumps have tripped.	Check maximum pumping pressure is correct and re-set if required. Turn pumps on using the control knob.
Pumps running but no solvent flow through system	System has run out of solvent Blockage in back pressure regulators. Back pressure regulator installed the wrong way round. Leak at one of the fluid connections.	Check solvent/reagent supply containers Check all back pressure regulators are free from sediment and replace if necessary. Check that the arrow on the back pressure regulator is pointing in the direction of fluid flow. Check all fluid connections are leak-free.
System pressure display flashing 'Air'	Air lock in pumps System has run out of solvent and/or reagent. Mixture of polar and non-polar solvents in the pump Leak in fluid connections Faulty pump check valve	Prime pumps using the Luer ports on the front of the fluid manifold. Top up system solvent and/or reagents and re-start pumps. Prime pumps using the Luer ports on the front of the fluid manifold. When changing between polar and non-polar solvents, IPA should first be pumped through the system before changing the polarity of the solvent system. Check all fluid connections between the solvent/reagent supply containers and the pumps are leak-free. Prime pumps using the Luer ports on the front of the fluid manifold. Replace pump check valves as described in section 7.1.6 of this user manual.

Problem	Possible Cause	Solution
	Faulty pump delivery back pressure regulator	Replace the back pressure regulator in the manifold as described in section 7.1.4 of this user manual.
System pressure display flashing 'Lo'	Low pressure due to a leak in fluid connections.	Check all fluid connections are leak-free. Prime pumps using the Luer ports on the front of the fluid manifold.
	Low pressure due to lack of system solvent/reagent.	Top up system solvent and/or reagents and re-start pumps. Prime pumps using the Luer ports on the front of the fluid manifold.
System pressure display flashing 'bAr'	System pressure has gone over pressure trip.	Check system target pressure is not set too low. Check back pressure regulators are free from blockages and installed the correct way round. Check all tubing is clear of blockages. Re-start the pumps and prime if necessary.
Pump display flashing 'bAr'	Blockage in fluid manifold.	Check all tubing is clear from blockages. Check back pressure regulators are free from blockages.
	Back pressure regulator connected the wrong way round and reactor pressure trip set above 44 Bar.	Check back pressure regulator on the reactor is connected the correct way round and check the reactor pressure trip is set below 44 Bar. Re-start pumps and prime if necessary.
	Blockage in reactor.	Remove reactor from the system and disconnect fluid connections. Connect a syringe to the reactor and check there is a free-flow of fluid through the reactor. Replace reactor cartridge if there is no fluid flow.

9 GENERAL SPECIFICATIONS

R-2, R-2C, R-2+ and R-2C+

Independent Pumps Pressure Range Flow rate/channel	2 0 – 50 Bar 0.001 to 10ml/min
Control interfaces: Serial	RS 232 communication standard x 2 RS485 (GSIOC)
Environmental	Operational ambient temperature range: 15 to 25 ºC Operational humidity: 20 to 70% RH
Size & Weight	Width: 350 mm Height: 270 mm (230 mm R2) Depth: 280 mm Weight: 12 kg
Services	Power; 230V (+/- 10%), 50 Hz, 1A (see rating plate) Or, 110V (+/- 10%), 60 Hz, 2A (see rating plate)
Fuses	IEC socket (230 V external): 1 A, 20 mm, type T IEC socket (110 V external): 2 A, 20 mm, type T Fuse socket (24V): 6.3A, 20mm, type T
Conformity	Conforms to all applicable EEC standards, CE marked.

10 APPENDIX

10.1 Reactor Temperature and Pressure Range

Tube reactors (all standard pressure systems)	Reactor temperature range				
	-70°C to -20°C	-20°C to 40°C	40°C to 99°C	100°C to 150°C	150°C to 250°C
PFA tube reactors (and PFA supply tubing)	40 bar (580 psi)	40 bar (580 psi)	25 bar (362 psi)	15 bar (217 psi)	Do not use
UV-150 Photochemical reactors	10 bar (145 psi) Min Temp: -40°C	10 bar (145 psi)	10 bar (145 psi) Max Temp: 80°C	Do not use	Do not use
Stainless Steel Copper Hastelloy®	42 bar (609 psi)	42 bar (609 psi)	42 bar (609 psi)	42 bar (609 psi)	42 bar (609 psi)

Tube reactors (High Pressure, 200 bar systems)	Reactor temperature range				
	-70°C to -20°C	-20°C to 40°C	40°C to 99°C	100°C to 150°C	150°C to 250°C
PFA tube reactors (and PFA supply tubing)	40 bar (580 psi)	40 bar (580 psi)	25 bar (362 psi)	15 bar (217 psi)	Do not use
UV-150 Photochemical reactors	10 bar (145 psi) Min Temp: -40°C	10 bar (145 psi)	10 bar (145 psi) Max Temp: 80°C	Do not use	Do not use
Stainless Steel Hastelloy®	200 bar (2900 psi)	200 bar (2900 psi)	200 bar (2900 psi)	200 bar (2900 psi)	200 bar (2900 psi)
Copper	42 bar (609 psi)	42 bar (609 psi)	42 bar (609 psi)	42 bar (609 psi)	42 bar (609 psi)

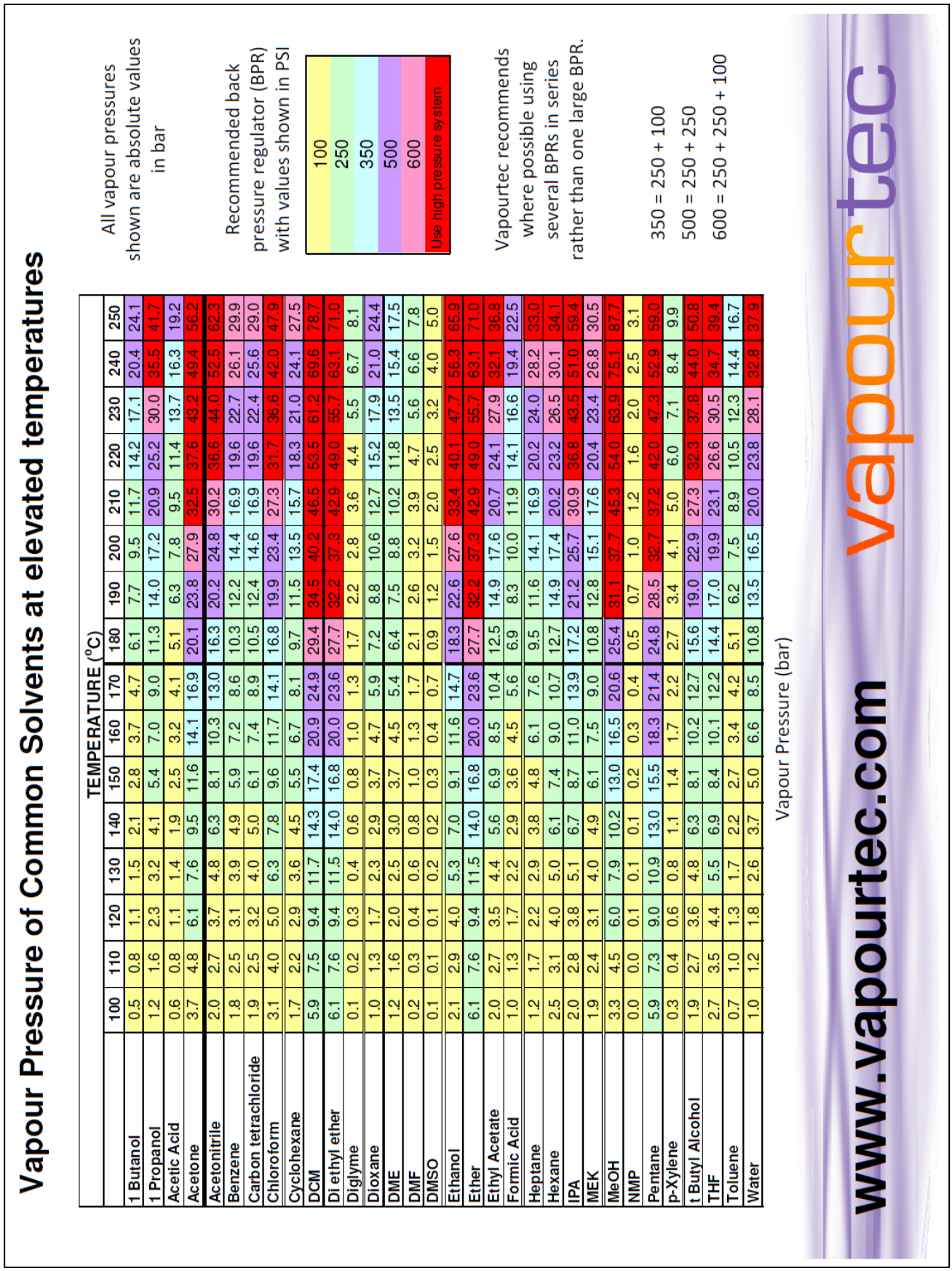
Column reactors (Used on any Vapourtec system)	Reactor temperature range				
	-40°C to -20°C	-20°C to 40°C	40°C to 99°C	100°C to 150°C	150°C to 250°C
6.6 mm Bore Columns	20 bar (290 psi), Silicone O-rings only	40 bar (580 psi)	30 bar (435 psi)	20 bar (290 psi)	Do not use
10 mm Bore Columns	20 bar (290 psi), Silicone O-rings only	30 bar (435 psi)	25 bar (362 psi)	15 bar (217 psi)	Do not use
15 mm Bore Columns	20 bar (290 psi), Silicone O-rings only	20 bar (290 psi)	15 bar (217 psi)	10 bar (145 psi)	Do not use

Chip Reactor (Used on any Vapourtec system)	Reactor temperature range				
	-40°C to -20°C	-20°C to 40°C	40°C to 99°C	100°C to 150°C	150°C to 250°C
All Chip Reactors	20 bar (290 psi)	20 bar (290 psi)	20 bar (290 psi)	20 bar (290 psi)	Do not use

Ion electrochemical reactor (Used on any Vapourtec system)	Reactor temperature range				
	-40°C to -10°C	-10°C to 40°C	40°C to 99°C	100°C to 150°C	150°C to 250°C
	Do not use	5 bar (72.5 psi)	5 bar (72.5 psi)	Do not use	Do not use

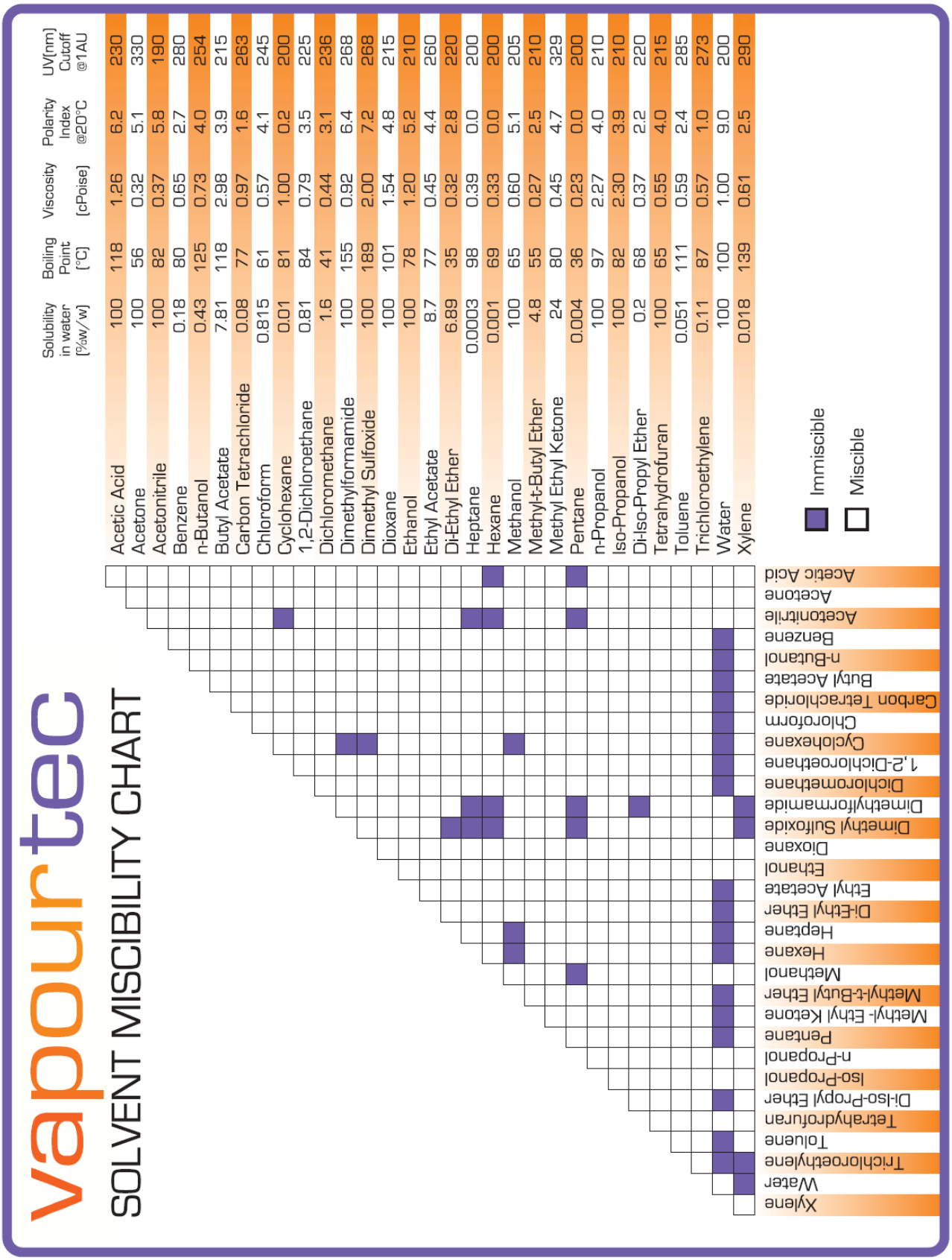
Large diameter tubular reactor for rapid mixing (Used on any Vapourtec system)	Reactor temperature range				
	-70°C to Room Temp.	Room Temp. to 40°C	40°C to 99°C	100°C to 150°C	150°C to 250°C
	10 bar (145 psi) Require External Chiller	10 bar (145 psi)	10 bar (145 psi)	10 bar (145 psi)	Do not use

10.2 Solvent vapour pressure at elevated temperature



	TEMPERATURE (°C)																			
	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250
1 Butanol	0.5	0.8	1.1	1.5	2.1	2.8	3.7	4.7	6.1	7.7	9.5	11.7	14.2	17.1	20.4	24.1
1 Propanol	1.2	1.6	2.3	3.2	4.1	5.4	7.0	9.0	11.3	14.0	17.2	20.9	25.2	30.0	35.5	41.7
Acetic Acid	0.6	0.8	1.1	1.4	1.9	2.5	3.2	4.1	5.1	6.3	7.8	9.5	11.4	13.7	16.3	19.2
Acetone	3.7	4.8	6.1	7.6	9.5	11.6	14.1	16.9	20.1	23.8	27.9	32.5	37.6	43.2	49.4	56.2
Acetonitrile	2.0	2.7	3.7	4.8	6.3	8.1	10.3	13.0	16.3	20.2	24.8	30.2	36.6	44.0	52.5	62.3
Benzene	1.8	2.5	3.1	3.9	4.9	5.9	7.2	8.6	10.3	12.2	14.4	16.9	19.6	22.7	26.1	29.9
Carbon tetrachloride	1.9	2.5	3.2	4.0	5.0	6.1	7.4	8.9	10.5	12.4	14.6	16.9	19.6	22.4	25.6	29.0
Chloroform	3.1	4.0	5.0	6.3	7.8	9.6	11.7	14.1	16.8	19.9	23.4	27.3	31.7	36.6	42.0	47.9
Cyclohexane	1.7	2.2	2.9	3.6	4.5	5.5	6.7	8.1	9.7	11.5	13.5	15.7	18.3	21.0	24.1	27.5
DCM	5.9	7.5	9.4	11.7	14.3	17.4	20.9	24.9	29.4	34.5	40.2	46.5	53.5	61.2	69.6	78.7
Di ethyl ether	6.1	7.6	9.4	11.5	14.0	16.8	20.0	23.6	27.7	32.2	37.3	42.9	49.0	55.7	63.1	71.0
Diglyme	0.1	0.2	0.3	0.4	0.6	0.8	1.0	1.3	1.7	2.2	2.8	3.6	4.4	5.5	6.7	8.1
Dioxane	1.0	1.3	1.7	2.3	2.9	3.7	4.7	5.9	7.2	8.8	10.6	12.7	15.2	17.9	21.0	24.4
DME	1.2	1.6	2.0	2.5	3.0	3.7	4.5	5.4	6.4	7.5	8.8	10.2	11.8	13.5	15.4	17.5
DMF	0.2	0.3	0.4	0.6	0.8	1.0	1.3	1.7	2.1	2.6	3.2	3.9	4.7	5.6	6.6	7.8
DMSO	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.7	0.9	1.2	1.5	2.0	2.5	3.2	4.0	5.0
Ethanol	2.1	2.9	4.0	5.3	7.0	9.1	11.6	14.7	18.3	22.6	27.6	33.4	40.1	47.7	56.3	65.9
Ether	6.1	7.6	9.4	11.5	14.0	16.8	20.0	23.6	27.7	32.2	37.3	42.9	49.0	55.7	63.1	71.0
Ethyl Acetate	2.0	2.7	3.5	4.4	5.6	6.9	8.5	10.4	12.5	14.9	17.6	20.7	24.1	27.9	32.1	36.8
Formic Acid	1.0	1.3	1.7	2.2	2.9	3.6	4.5	5.6	6.9	8.3	10.0	11.9	14.1	16.6	19.4	22.5
Heptane	1.2	1.7	2.2	2.9	3.8	4.8	6.1	7.6	9.5	11.6	14.1	16.9	20.2	24.0	28.2	33.0
Hexane	2.5	3.1	4.0	5.0	6.1	7.4	9.0	10.7	12.7	14.9	17.4	20.2	23.2	26.5	30.1	34.1
IPA	2.0	2.8	3.8	5.1	6.7	8.7	11.0	13.9	17.2	21.2	25.7	30.9	36.8	43.5	51.0	59.4
MEK	1.9	2.4	3.1	4.0	4.9	6.1	7.5	9.0	10.8	12.8	15.1	17.6	20.4	23.4	26.8	30.5
MeOH	3.3	4.5	6.0	7.9	10.2	13.0	16.5	20.6	25.4	31.1	37.7	45.3	54.0	63.9	75.1	87.7
NMP	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.7	1.0	1.2	1.6	2.0	2.5	3.1
Pentane	5.9	7.3	9.0	10.9	13.0	15.5	18.3	21.4	24.8	28.5	32.7	37.2	42.0	47.3	52.9	59.0
p-Xylene	0.3	0.4	0.6	0.8	1.1	1.4	1.7	2.2	2.7	3.4	4.1	5.0	6.0	7.1	8.4	9.9
t Butyl Alcohol	1.9	2.7	3.6	4.8	6.3	8.1	10.2	12.7	15.6	19.0	22.9	27.3	32.3	37.8	44.0	50.8
THF	2.7	3.5	4.4	5.5	6.9	8.4	10.1	12.2	14.4	17.0	19.9	23.1	26.6	30.5	34.7	39.4
Toluene	0.7	1.0	1.3	1.7	2.2	2.7	3.4	4.2	5.1	6.2	7.5	8.9	10.5	12.3	14.4	16.7
Water	1.0	1.2	1.8	2.6	3.7	5.0	6.6	8.5	10.8	13.5	16.5	20.0	23.8	28.1	32.8	37.9

10.3 Solvent Miscibility Chart



11 VAPOURTEC WARRANTY

11.1 Standard limited warranty

The Vapourtec Ltd standard UK warranty follows. The warranty covers parts and labour for a period of 12 months, commencing the date of invoice, for any repairs deemed the result of a defect in materials and/or workmanship by Vapourtec Ltd. This warranty excludes wear and tear of parts considered to be 'consumable'; a list of these parts is given below. Replacement of consumable parts or repairs to equipment that is not covered by this warranty will be chargeable.

Any factory approved changes or extensions to this warranty should be received in writing from Vapourtec Ltd and filed with this warranty statement. If your equipment is eligible for coverage, please review this warranty thoroughly and contact Vapourtec Service Department with any questions you may have. If your equipment is not covered by our standard warranty, or you are seeking optional or additional coverage, see sections below for service plans offered.

Consumable parts and other items not covered by the standard warranty:

- External tubing and tubing connectors
- Pump check valves
- Back pressure regulators

Items COVERED by the limited warranty

- Parts and labour for a period of one (1) year from date of delivery. Any part excluding those in the list above found to defective will be either repaired or replaced at the discretion of Vapourtec Ltd, free of charge by Vapourtec Ltd.
- On site labour if repairs require that Vapourtec Ltd personnel travel to the equipment.

Items NOT COVERED by the limited warranty

- Travel time, travel expenses and mileage expended by Vapourtec Ltd personnel if repairs require on-site labour.
- Transportation of equipment for repair.
- Vapourtec Ltd cannot be held responsible for incidental or consequential damages

The above statement is a final and complete statement of the agreement between the Customer and Vapourtec Ltd. Vapourtec Ltd makes no other warranties expressed or implied, of merchantability, fitness or otherwise, with respect to the goods supplied under this agreement, which extend beyond the description of this limited warranty.

Vapourtec Ltd will have the right to inspect the equipment and determine the repairs or replacements necessary. The customer will be notified within a reasonable time of any damages incurred that are not covered by this warranty prior to initiation of such repairs.

Any customer modification of this equipment or any repairs undertaken without prior written consent of Vapourtec Ltd will render the limited warranty void.

11.2 Service contracts

Vapourtec recognises that by choosing Vapourtec R Series Flow Chemistry equipment you are investing both capital and resources. Our customer support program is designed to help you protect the value of your investment by prolonging the usable life of the equipment and maximising system performance & up-time in your laboratory.

For your convenience we present a range of support contracts to suit your budget and working requirements. Often our contracts provide more cost-effective cover than insurance, with faster response and no risk of refusal of cover in subsequent years.

Service and Breakdown Contract (SBC)

The SBC is a full service breakdown contract that includes preventive maintenance and all parts and labour. It is ideal for heavily trafficked or multi-user instruments in high throughput environments and guarantees peace of mind throughout the year. All service call outs and a scheduled preventive maintenance visit are included. If you do need to call in an engineer, there is no call out fee and all parts and labour are included. This is the best option for the busy laboratory where up time is at a premium.

Includes:

- One preventive maintenance visit per year
- All call-out, travelling time and labour charges *
- All parts needed for PM or Call out visits, inc. full Service Kit but excluding the items in the section below titled exclusions
- Average 48-hour response time
- Attractive discounts for multiple systems on the same site
- Access to Vapourtec on-line technical support
- Free software downloads to keep your copy of R-Series Software updated

Exclusions:

- Glassware
- Reactor and reactor components
- Replacement back pressure regulators
- Replacement pump check valves
- Replacement of sealing components for the injection valves except during the annual PM when these parts are replaced. This applies to the R2+ only

* Please note, clearing of blockages caused by foreign objects or precipitation of compounds will be attended but travelling time and labour charges may be charged at Vapourtec discretion.

Preventative Maintenance Contract (PMC)

Our PMC is a popular option with budget-conscious laboratories that cannot afford the inconvenience of an unscheduled stoppage. It includes a planned maintenance visit and the cost of all parts needed during that visit and labour costs. Call-outs are charged at normal rates.

Includes:

- One preventive maintenance visit per year, including cost of full Service Kit of parts, travelling time and labour
- Average 48-hour response time
- Attractive discounts for multiple systems on the same site
- Access to Vapourtec on-line technical support
- Free software downloads to keep your copy of R-Series Software updated

Discount Schedule for SBC and PMC

If you have more than one Vapourtec system included in your Service Contract you will be eligible for attractive discounts that help stretch your service budget further. The systems are assessed for discount in installation date order, so your newest systems attract the highest level of discount.

1st (oldest) system = List Price

2nd system = 15% discount

3rd system = 20% discount

4th system = 25% discount

5th system = 30% discount

All subsequent systems = 30% discount

On-site Training of your own engineers.

For multiple installations of Vapourtec equipment it may be advisable to have your own engineers or technicians trained to provide first-line service diagnostics and repairs. Please contact Vapourtec if this is of interest.

Annual Training/User support Contracts

Training/User support contracts are offered on a 12-monthly basis, and cover on site and telephone support for users with application enquiries.

These contracts are based on 12 days per annum training/user support for Vapourtec system users. Please contact Vapourtec if this is of interest.

11.3 Sample copy of EC declaration of conformity

EC DECLARATION of CONFORMITY

CE

Product	Vapourtec R-2 Pumping Module
Serial no.	

Manufacturer Vapourtec Ltd
Address Park Farm Business Centre
Fornham St Genevieve
Bury St. Edmunds
Suffolk
IP28 6TS

We hereby declare that the product above complies with the essential health and safety requirements of the following directives:

MACHINERY	**Directive 2006/42/CE** Implemented in the UK by Supply of Machinery (Safety) Regulations 2008 (SI 2008 no. 1597).
Low Voltage Directive (LVD)	**Directive 2006/95/CE** Implemented in the UK by The Electrical Equipment (Safety) Regulations 1994 (SI 1994 no. 3260).
Electromagnetic Compatibility (EMC)	**Directive 2004/108/CE** Implemented in the UK by The Electromagnetic Compatibility Regulations 2006 (SI 2006 no. 3418).
CE marking	**Directive 93/68/EEC** Implemented in the UK by The EMC (Amendment) Regulations (1994 no. 3080).

The product has been designed and manufactured in accordance with European standards:

EN 292-1: 1991	Safety of Machinery: Basic concepts and General Principles
EN 292-2: 1991	Safety of Machinery: Technical principles & Specifications
EN 954-1: 1997	Safety of Machinery: Guards
EN 60204-1: 1997	Safety of Machinery: Electrical equipment for machines. Part 1 General requirements
EN 61010-1: 2001	Safety requirements for electrical equipment for measurement, control and laboratory use

A Technical Construction File is retained at the manufacturer's address.

Signed	
Name	
Position	
Date	

11.4 Vapourtec contact details

Address: Vapourtec Ltd
Park Farm Business Centre
Fornham St Genevieve
Bury St Edmunds
Suffolk
IP28 6TS
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e-mail info@vapourtec.com
Web: www.vapourtec.com