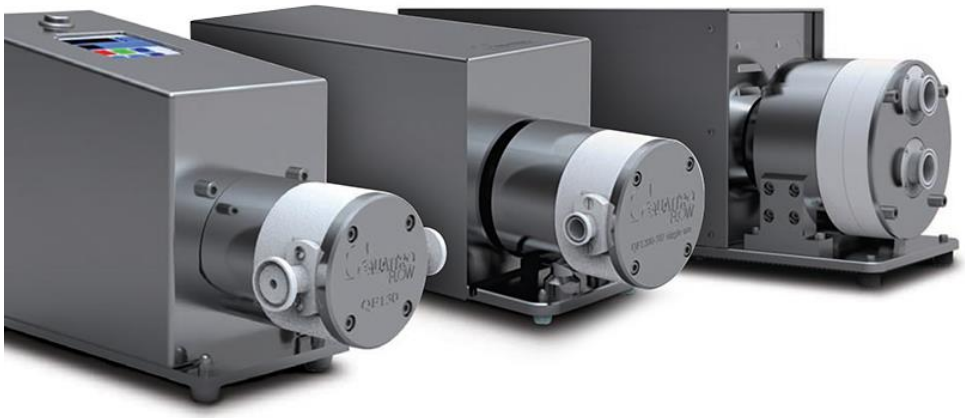
Quattroflow Installation, Operation & Troubleshooting Guide



Version: Rev. 0 (July 2017)

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Revision	Date	Changes/ Comment	Issued by
0	July 2017	First Release	Tim Dudda

1 INTRODUCTION

This installation, operation and troubleshooting guide helps to support the engineering / planning process, installation and use of Quattroflow Diaphragm Pumps.

This document contains basic knowledge how Quattroflow Pumps work and explanations regarding the technical and physical principals. It should help to project the right Quattroflow Pump for each application and it gives important points for consideration for planned systems.
For end users we bring together topics like installation, operation and maintenance. We want to ensure a safe and reliable operation with our pumps. The Troubleshooting section helps with quick recommendations on identification and solving of potential issues.

Please read the official and recent operating manuals and safety instructions carefully which are available for Quattroflow Pumps and accessories. This document doesn't replace the user manual.

In this guide given information are general recommendations which depend on the respective application and process conditions.

2 BASICS

2.1 General description of Quattroflow Pumps & Functioning

Quattroflow™ develops and manufactures single-use and multiple-use Quaternary (Four-Piston) Diaphragm Pumps for critical applications in the biopharmaceutical industry. This technology is CIP/SIP capable and offers disposable solutions that increase flexibility, reduce down-time, eliminate costs of cleaning validation, and risks of cross-contamination. Quattroflow pumps can be found in all areas of biologic manufacturing such as cross-flow filtration systems, chromatography, and centrifuges. Quattroflow ensures safety, efficiency and reliability for handling biologics such as plasma products, therapeutic proteins, monoclonal antibodies, vaccines, and other high value products.

Technical definition:

- Reciprocating positive displacement pumps
- Diaphragm pump (membrane pump)

The Quattroflow displacement pump is based on this principle. The 4-piston (quaternary) diaphragm technology enables a gentle pumping. Each stroke of the four diaphragms is generated by an eccentric shaft, which is connected to the electric motor.
The four segments of the pump diaphragm oscillate back and forth. This alternate movement is created by a connector plate (nutating disc) that is arranged on a ball bearing. The ball bearing sits on an eccentric shaft. The connector plate does not turn.
The inlet and outlet check valves restrict fluid motion to the desired direction from the inlet connection port to the outlet connection port.

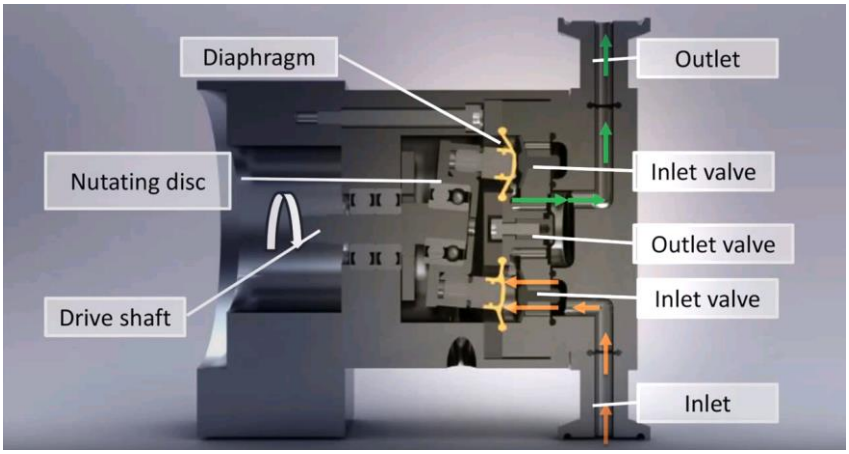


Figure 1 Sectional drawing of the Quattroflow pump head

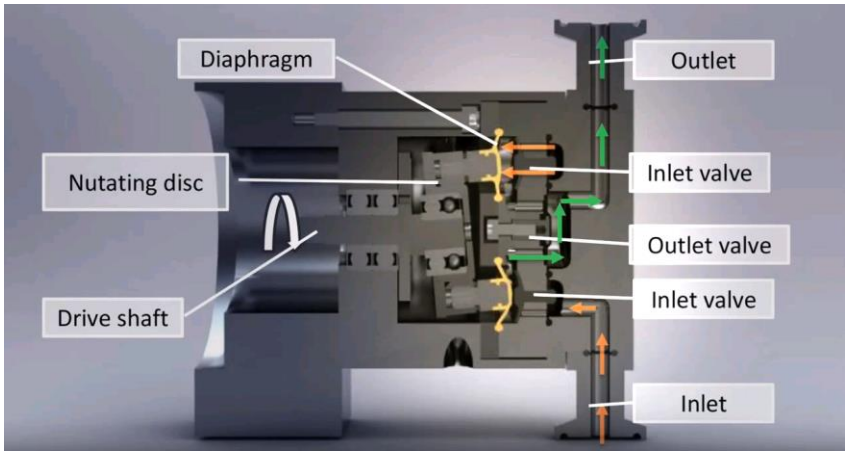


Figure 2 Sectional drawing of the Quattroflow pump head

With each turn of the eccentric shaft creates 4 discharge strokes of liquid. The overlapping of the 4 strokes effectively minimizes the pulsation and enables stable flow conditions.

Quattroflow Pumps have got the following main features:

- Low pulsation
- Safe for dry run
- Self priming
- Linear turndown
- Low heat input

2.2 Volume flow and pressure

In opposite to other pump types like centrifugal pumps, positive displacement pumps have got a defined displacement volume. For that reason Quattroflow Pumps have got a pump curve which is nearly linear over the complete flow range. The pump curve shows the correlation between flow rate and discharge pressure. The pump speed is directly related to the flow rate.

The following factors influence the correlation between pump speed and flow rate:

- Back pressure
- Medium (density and viscosity)
- Eccentric shaft of the Pump (in degree)

Back pressure:
The higher the back pressure in your system the lower is the max. flow rate at same pump speed (see Figure 3).

Medium (density and viscosity):
All shown Quattroflow pump curves are valid for water at room temperature that means a density of approx. 1000 kg/m³ and a dynamic viscosity of approx. 1 mPa*s (= 1 cP).
The higher density and / or the viscosity the lower is the max. flow rate of the pump. Please see also chapter “Medium with high viscosity”.

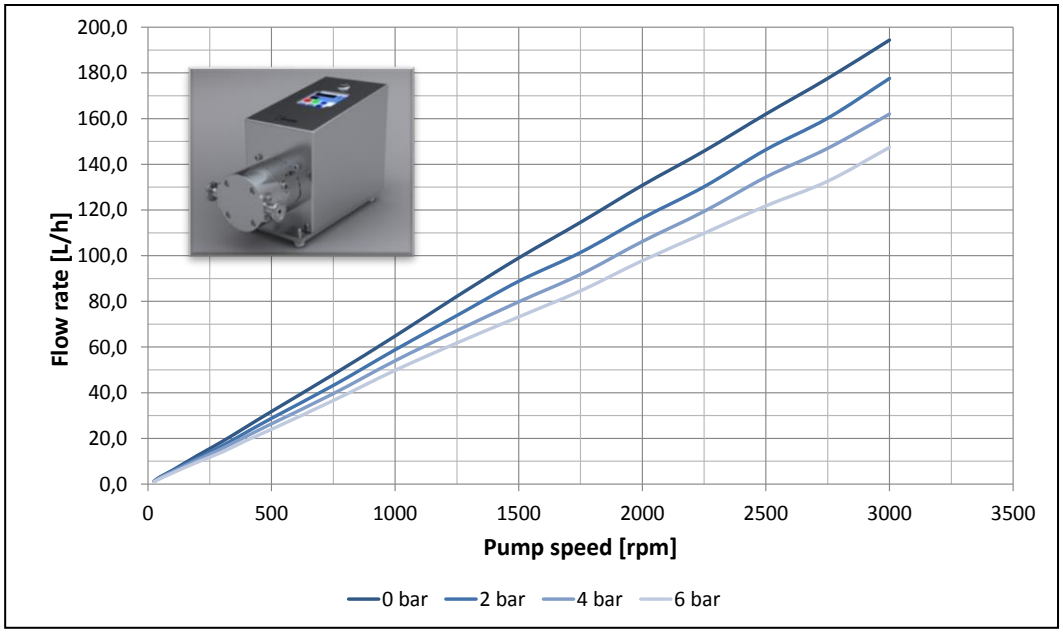


Figure 3 Exemplary pump curve for QF150 pump with 5° eccentric shaft

3 MEDIUM

3.1 Chemical resistance

The table below shows the standard product wetted materials for multiple-use and single-use Quattroflow pump chambers. The second table shows an overview of the chemical resistance against some mediums which are often used with Quattroflow Pumps.

For multiple-use pump chambers made of stainless steel standard stainless steel is 1.4435 (316L). Generally this material has got good characteristics to resist corrosion. Certainly there is a risk of pitting and surface corrosion when the medium comes in contact with chloride-containing mediums like NaCl. On request we could offer other stainless steel alloys with higher corrosion resistance. In this case please contact the Quattroflow Team to get more information and support.

The chemical resistance depends on some factors like mixture, concentration, temperature and standing time. In case that the chemical resistance is unknown we recommend to test our materials with your medium under real conditions. Please consult the factory for support.

Please check the chemical resistance of the product wetted materials against our mediums. If you are not sure about the chemical resistance please contact the Quattroflow Support Team.

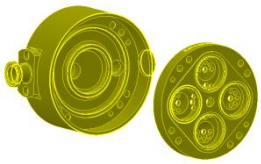
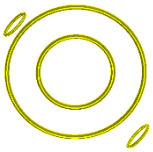
Component	Description	Material	Certification
	**Diaphragm**	**Santoprene**	**USP Cl. VI, FDA 21CFR177, BSE/TSE safe** ***(included)***
	**Ports, valve plate, pump housing**	**Multiple-Use: 1.4435 / 316L**	**3.1 Material certificate Ferrite and surface roughness protocol** ***(optional)***
		Single-Use: PP / PE	**USP Cl. VI, FDA 21CFR177, BSE/TSE safe** ***(included)***
	**In- & outlet valve**	**EPDM**	**USP Cl. VI, FDA 21CFR177, BSE/TSE safe** ***(included)***
	**O-rings**	**EPDM**	**USP Cl. VI, FDA 21CFR177, BSE/TSE safe** ***(included)***

Table 1 Product wetted components of Quattroflow Pumps

Substance	Santoprene	EPDM	1.4435	PP
Isopropanol, Ethanol	Good	Good	Good	Good
NaOH	Good	Good	Good	Good
Mineral Oil	Not recommended	Not recommended	Good	Good (room temperature)
NaCl	Good	Good	Not recommended	Good
Acetic Acid	Good	Not recommended	Good	Good
Phosphoric Acid	Good	Good (max 30%)	Good	Good
Toluol	Good	Not recommended	Good	Not recommended
HCl (max. 20%)	Good	Good	Not recommended	Good
Acetonitrile (diluted)	Good	Fair	Good	Not recommended

Table 2 Chemical resistance of some selected mediums

Please note that this table is for indication only and needs to be verified with the actual medium in the process.

3.2 Solids and suspensions

Solid particles should not have a diameter greater than 0.1mm, as larger solids can prevent valves from proper sealing. This however depends also on the solid concentration and low concentration of larger particles might be acceptable. Even though the pump is not damaged by particulates, care should be taken when pumping abrasive solids. In this case please consult the factory for further support.

3.3 Sticky Mediums

In case sticky mediums are pumped, please make sure that the pump is flushed and cleaned thoroughly immediately after the process to prevent sticking of valves.

3.4 Medium with high viscosity

Generally Quattroflow pumps can handle medium viscosities **up to 1000 mPa*s (cP)**. The higher the viscosity of the medium the lower is the maximum reachable flow rate of the pump (see Table 3 below).
Please make sure that the pump is always operated in the linear range of the performance curve (see Figure 4). If the pump is operated at higher motor speeds outside the linear flow range, damage of diaphragms may occur.

Pump size / eccentric shaft	Max. flow rate @ 500 mPa*s (cP)	Max. flow rate @ 1000 mPa*s (cP)
QF150 / 5°	120 l/h	50 l/h
QF1200 / 5°	700 l/h	500 l/h
QF4400 / QF5050 / 6°	4000 l/h	3500 l/h

Table 3 Max. flow rates at different dynamic viscosities for different Quattroflow Pumps.

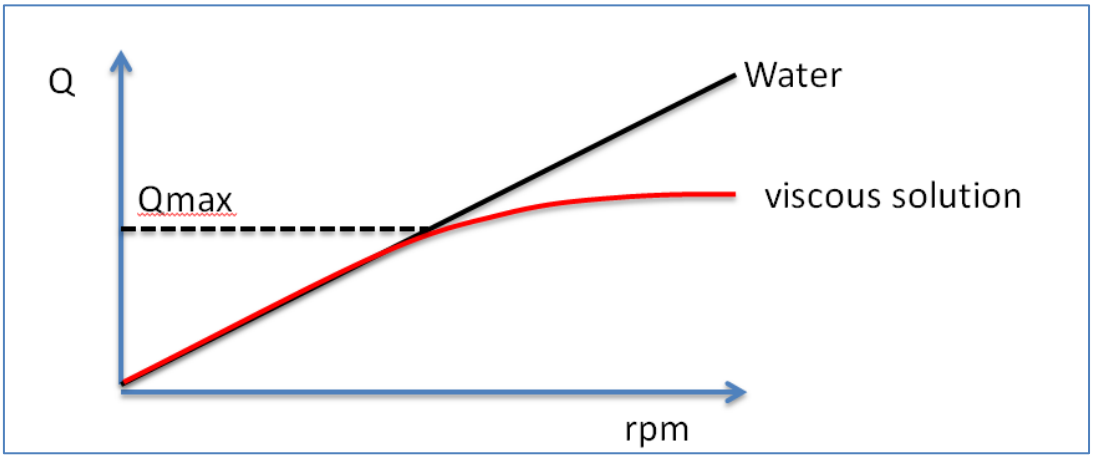


Figure 4: Max. flow rate for viscous media (exemplary)

4 INSTALLATION

1.: Suction line
2.: Protection from High pressure
3.: Outlet line
4.: Flow direction

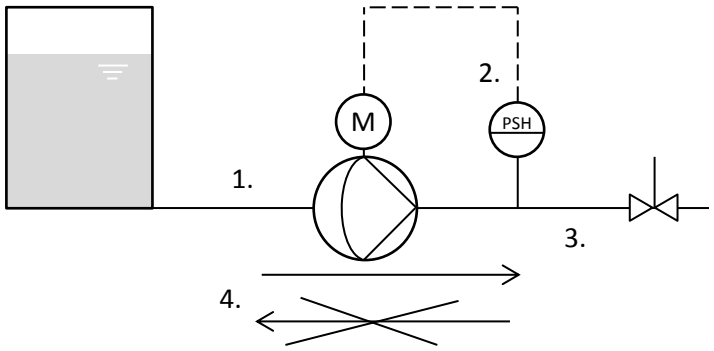


Figure 5 Exemplary set up for a Quattroflow pump.

4.1 Suction line

Make sure that the internal diameter from the suction line is large enough (typically equivalent with the internal diameter form the pump connector). Flow velocities should typically be below 2 m/s. Consider larger diameters for fluids with higher viscosities. Minimize the pressure drop in the suction line that can be caused by e.g. complex valve installations, sensors, etc. Avoid high suction lift.
If hoses were used in the suction line, make sure that they do not collapse due to the negative pressure.

If these points are not considered, cavitation might occur which can result in heavily reduced maximum achievable flow rate, strong pulsation, heavy noise and potentially damage of the pump!

4.2 Outlet line

Please make sure that the outlet line is large enough (typically equivalent with the internal diameter form the pump connector). If the inner diameter of the outlet line is too small, the pump performance is limited.
Make sure that the outlet pipe or hose is safe against high pressure.

4.3 Protection from high pressure

In order to protect the diaphragm from high pressure events (e.g. accidentally closed valves) we strongly recommend installing either a pressure relief valve or a pressure switch in the outlet line that automatically turns of the motor in case the maximum allowed pressure has been reached. Consider the technical specification from the pump for the maximum allowed pressure.

A short too high back pressure can cause damage at the diaphragms. For this reason it is very important to protect the pump from high pressure on the pressure line.

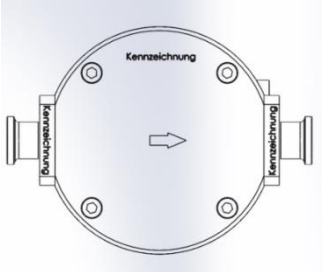
4.4 High inlet pressure

In case of high inlet pressure (e.g. due to high filling level of the feeding vessel) we recommend to install a pressure reducing valve on the discharge side of the pump in case low flow rates need to be achieved. This is necessary, because the fluid path through the pump is open in flow direction.

4.5 Flow directions

Due to the internal check valves inside the pump liquid cannot flow backwards through the pump. Please mind this if the installation needs to be emptied through the pump.
Note: The flow direction is independent from the direction of motor rotation.

4.6 Product connections



Suction and discharge connections of sizes QF150 and QF1200 are mounted opposite at the pump chamber (“inline”). An arrow on the pump chamber shows the flow direction (see figure), so that the suction and pressure side can be clearly identified.

The size QF4400, QF5050 and QF20K have both ports in front of the pump chamber and are marked with "IN" (inlet) and "OUT" (outlet).

Please see the drawings below for Quattroflow pump chamber orientation which are supplied as standard ex works. All QF pump chambers can be rotated in 90° steps to adapt the pump to your process and application. The orientation has no influence on the self-venting behavior.
See also chapter Drainability of Quattroflow Pumps. There you can find further information about the pump chamber orientation for best drainability.

Standard port and pump chamber orientation from factory:

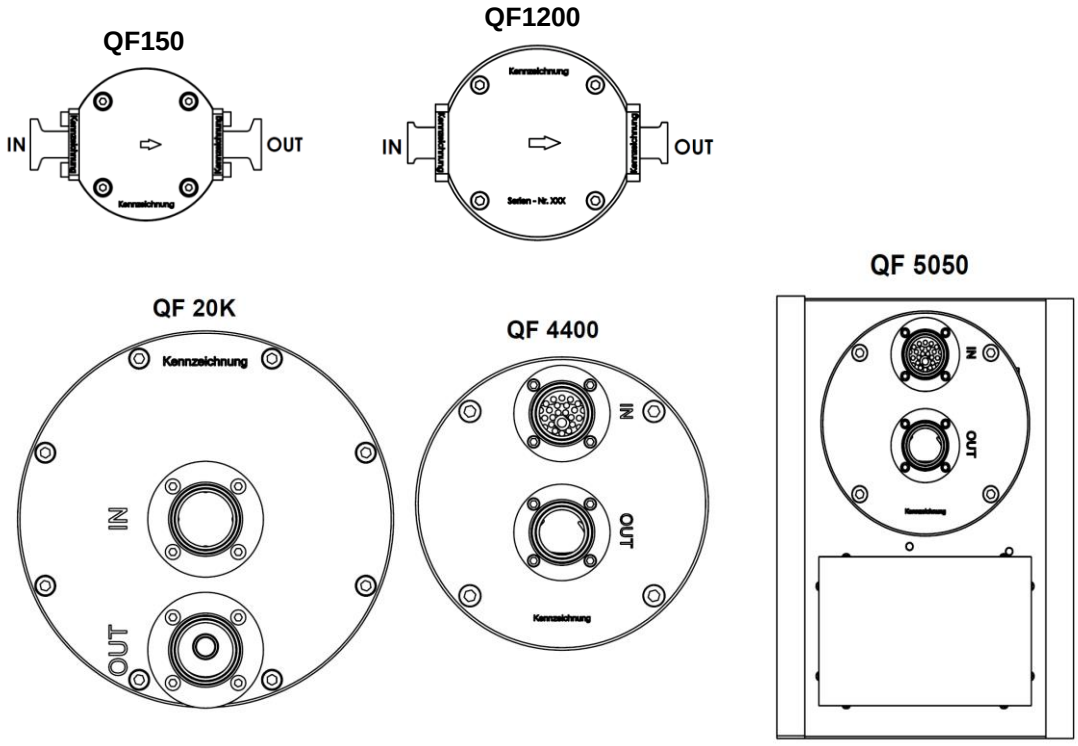


Figure 6 Standard pump chamber orientation for Quattroflow pumps.

In case that the pump chambers should be rotated:
Please mind that the clamp ring needs to be rotated as well to access the clamping ring screw (see installation instructions in the user manual).
If the clamping ring screw is not fixed before operation the pump could be damaged.

5 START-UP OPERATIONS

Before start-up of the pump anyone should acquaint oneself with the explanations of the chapter troubleshooting. Only by this the defect quickly can be realized and eliminated in case of trouble. Problems which cannot be solved or with an unknown reason should be passed on to the manufacturer.

Before using your pump in your process perform a test run to get used to the specific properties of the pump.
During start-up pay attention to the warning and safety instructions in the user manual.

5.1 Mounting the pump

All QF standard pumps are mounted on a stainless steel base plate. If you are using an “OEM” pump version without base plate the pump has to be fixed with the provided mounting.
When installing the pump please consider that around the pump enough space is available for operation and maintenance. Pay attention to the required space needed for assembly and disassembly of the pump chamber.

5.2 Mounting the pump chamber

If you have ordered a complete QF pump the stainless steel pump chamber is built-on ex works.
If you have ordered a Quattroflow Single-Use Pump or just a Single-Use pump chamber, the chamber will be supplied separately. The front crews and the clamping ring screw have to be tightened with the defined torque which is given in the user manual.
Single-Use Pump chambers must be assembled with the respective pressure plate made of stainless steel.

Please check the given torque for front screws and clamping ring screw in the user manual. If the clamping ring screw is not fixed before operation the pump could damaged.
It is not possible to use single-use pump chambers without pressure plate.

5.3 Cleaning before start-up (Multiple-Use, Stainless Steel pump chamber)

All Multiple-Use pump chambers made of stainless steel are not cleaned or sterilized ex works. For this reason prior to the very first use it might make sense to clean and sanitize the pump chamber.

Prior to each use we recommend flushing the pump with a proper fluid (e.g. water or buffer). A commercial caustic cleaner and/or 0.1N to 0.5N NaOH can be applied. The chosen cleaning agent can be recirculated and also stored inside the pump chamber. For flushing out of any cleaning agent do not recirculate! Check with appropriate analytical methods the success of the flushing procedure.

For further cleaning procedures see chapter Cleaning.

5.4 Priming

Quattroflow pumps are self-priming and can run dry (no use of mechanical seals).

Please note that the pump needs to be properly primed in order to achieve a stable flow and low pulsation. A minimum flow rate is required for the priming (complete removal from air inside the pump chamber). The following table indicates the minimum required pump speed for water with <0.5 bar discharge pressure. Please note that these values may depend on the installation. The duration of the vent process at a given min. pump speed is generally from 5 to 10 seconds.

Pump size / eccentric shaft	Min. pump speed for self-venting at free output	Min. flow rate for self-venting at free output
QF150 / 5°	ca. 1000 rpm	ca. 75 l/h
QF1200 / 5° (Standard)	ca. 500 rpm	ca. 300 l/h
QF1200 / 3°	ca. 900 rpm	ca. 300 l/h
QF4400 / QF5050 / 6° (Standard)	ca. 500 rpm	ca. 3.200 l/h
QF4400 / QF5050 / 3°	ca. 700 rpm (ca. 80 sec.)	ca. 2250 l/h (ca. 80 sec.)
QF20K / 7°	ca. 150 rpm	ca. 4.000 l/h

Table 4 Minimum pump speed and flow rate for self-venting at free output (Water @ RT)

The following table shows the suction high for each pump size. Please note that these values may depend on the installation.

Pump size / eccentric shaft	Pump speed	Suction lift (dry)
QF150 / 5°	3000 rpm	2,0 – 3,0 m
QF1200 / 5° (Standard)	1800 rpm	4,0 – 4,5 m
QF1200 / 3°	1800rpm	2,5 – 3,0 m
QF4400 / QF5050 / 6° (Standard)	1200 rpm	4,0 – 4,5 m
QF4400 / QF5050 / 3°	1200 rpm	2,5 – 3,0 m
QF20K / 7°	780 rpm	4,0 – 4,5 m

Table 5 Suction high and respective pump speed (Water @ RT)

6 CLEANING

The following chapter shows the different cleaning processes for Quattroflow pump chambers. Please note that not all three cleaning methods are suitable for all types of pump chambers.

Pump chamber type	CIP	SIP	Autoclave
Multiple-Use pump chamber made of stainless steel Valve plate made of stainless steel	Yes	Yes	Yes
Multiple-Use pump chamber made of stainless steel Valve plate made of PP (Polypropylene) (only for QF4400S / QF5050S)	Yes	No	No
Single-Use pump chamber made of PP (Polypropylene)	No	No	Yes (except QF20K SU)
Single-Use pump chamber made of injection molded PE (Polyethylene) (only for QF1200SU)	No	No	No

6.1 CIP – Cleaning in place

The Quattroflow pump (multiple use) can be used as **active CIP-pump** to pump the CIP medium through the complete skid.
Also it is possible that another **external pump** is used as CIP-pump. Please find some further information for both operating modes below.

Quattroflow Pump as active CIP pump:
Depending on the products in contact with the pump and given requirements the cleaning procedure needs to be adapted accordingly. It is the responsibility of the user to verify the cleaning efficiency. Safety rules and safety measures like protective glasses, gloves and protective clothing have to be followed and used when working with chemicals like sodium hydroxide (NaOH).

As a general rule we recommend to clean the pump according to the following procedure:

1. Pre rinse the pump with pure water, until residual amounts of product have been removed.
2. Cleaning step with 0.5 M NaOH (ca. 50°C) at 80% of the maximum RPM for approximately 30 min. Check before, if surrounding conditions (e.g. pipe diameter, system pressure rating) allow to operate the pump at this speed.
3. Final rinse with pure water, until neutrality has been achieved (e.g. by measuring conductivity or pH of the rinse water).

Temperature for CIP-medium: max. 90 °C (194 °F)
Pressure: max. 4 bar (58 PSI)
The flow rate should not be higher than 80% of the maximum flow rate which is given for the used Quattroflow pump (please see given table below).
Please check the chemical resistance of the product wetted materials against the used CIP mediums.

CIP with external pump:
If you use another external pump for you CIP-process, the passive Quattroflow Pumps will be rinsed freely. Please note the given important information below.

Temperature for CIP-medium: max. 90 °C (194 °F)
Pressure: max. 4 bar (58 PSI)
The flow rate should not be higher than 80% of the maximum flow rate which is given for the used Quattroflow pump (please see given table below).
Please check the chemical resistance of the product wetted materials against the used CIP mediums.

The fluid path through the pump is only open in flow direction, from inlet to outlet connection port. It is not possible to rinse the pump in reversed flow direction, because the check valve will not open.

Pump size	Max. flow rate for CIP QF active or passive mode Max. 80 % Pump speed
QF150	144 l/h
QF1200	960 l/h
QF4400 / QF5050	4000 l/h
QF20K	12800 l/h

Table 6 Max. flow rate for CIP processes. Quattroflow pump as active pump or as passively rinsed.

Pressure drop:
The following tables show the approx. pressure drop which is generated by the rinsed Quattroflow Pump chamber, when using an external CIP-pump.

Pump size: QF150 Pressure sensor: 1/2“	
Flow rate [l/h]	Differential pressure [barg]
47	0,1
70	0,1
91	0,2
114	0,3
135	0,5

Table 7 Pressure drop of QF150 pump chamber at different flow rates. Water @ RT

Pump size: QF1200 Pressure sensor: 3/4“	
Flow rate [l/h]	Differential pressure [barg]
89	< 0,1
170	< 0,1
348	0,1
516	0,3
680	0,5
840	0,6

Table 8 Pressure drop of QF1200 pump chamber at different flow rates. Water @ RT

Pump size: QF4400 / QF5050 Pressure sensor: 2“	
Flow rate [l/h]	Differential pressure [barg]
2000	0,2
2500	0,2
3000	0,2
3500	0,3
3800	0,3
4000	0,3

Table 9 Pressure drop of QF4400 / QF5050 pump chamber at different flow rates. Water @ RT

6.2 SIP - Steaming in place

There are some important points to observe for cleaning the Quattroflow pump with hot steam:

- For steaming in place the **pump chamber has to be installed on the pump drive**
- During the steaming process the **pump must not run**
- During the steaming process the temperature in the pump must **not exceed 130°C (266°F)**
- SIP process should **not longer than 30 min.**
- The cooling down process of the pump chamber should be **against room temperature**
- Depending on the SIP conditions it may be necessary to **shorten the maintenance intervals** for the elastomers significantly*****
- The **tightening torques** of the front bolts of the pump chamber have to be verified after each SIP cycle (please see user manual for given torque values)

In case the listed points above are not observed, there is a high risk for damage the elastomer parts in the pump chamber.

***** Typically it is possible to use the same elastomer parts (diaphragms, valves, O-Rings) for 6 – 8 SIP cycles, if the given points above are observed. This number of maximum SIP cycles depends on further process conditions (e.g. medium, temperature, flow rate, back pressure…).

Condensate removal after SIP process

After SIP-process Quattroflow pumps may contain a non-recoverable volume of condensate which depends on the pump size, pump type and process conditions.
To remove the full amount of condensate out of the pump chamber there is the possibility to mount the pump in vertical position. Please see chapter
Full drainability: Vertical position of the pump (pump chamber downwards) for more information.

Blow down after SIP process

Quattroflow MU Pumps can handle a so called blow down process that is often executed after the SIP cycle. Blow down is used cooling down the system and removing the residual condensate out of the system over steam traps. For this purpose sterilized compressed air is blown in the system. Concurrent the compressed air is used to hold a constant over pressure in the system to avoid a vacuum that is caused by the condensing steam.

- Quattroflow Pumps are not suitable for vacuum on the suction or/and discharge side because it could cause damage at the diaphragms and valves.
- Quattroflow pumps should not run while the blow down and cooling down process.
- Steam and compressed air can only flow in the default direction from inlet to outlet side of the pump

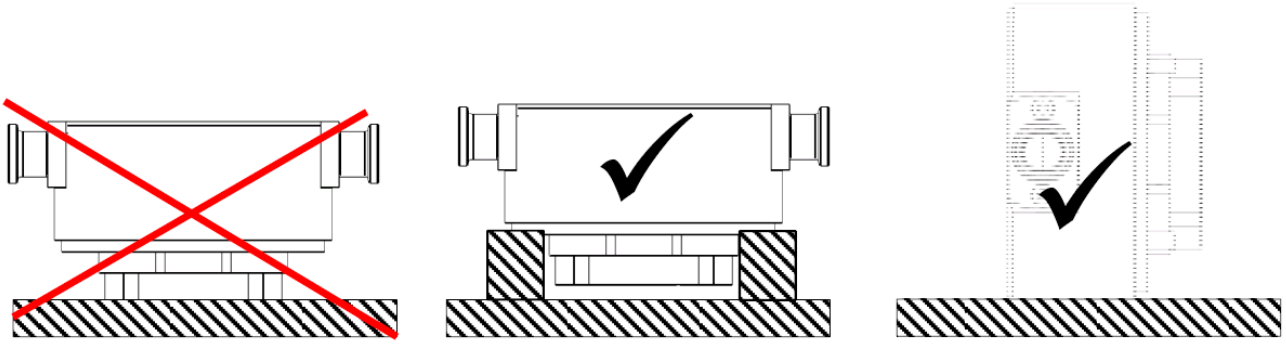
6.3 Autoclave

For autoclaving of the pump chamber we recommend the following steps.

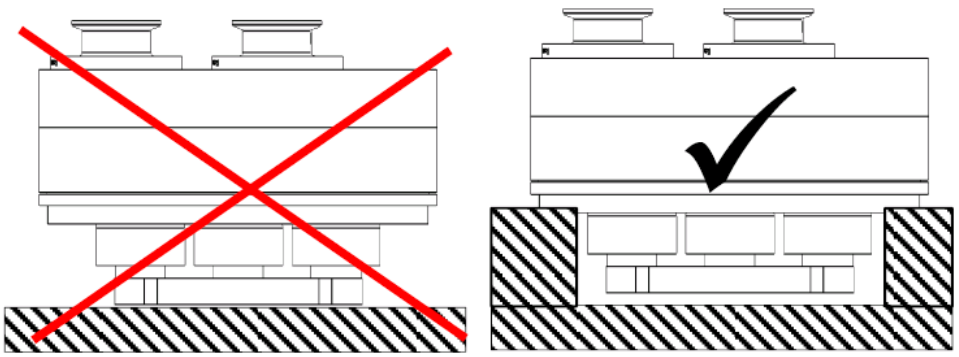
1. CIP of the pump chamber with any suitable process
2. Empty the pump
3. Remove the pump chamber from the pump drive
4. Close in and outlet of the pump e.g. by connecting hoses. Ensure that a free interchange of gas and steam over a sterile barrier (e.g. sterile filter) at in- and outlet is available.
5. Autoclaving of the prepared pump chamber in a vacuum autoclave:
   max. 130°C (266°F)
   max. 30 min.
   Follow instructions of the autoclave manufacturer

Please make sure that the pump chamber is not placed on the clamp ring during the autoclave process. The clamp ring should not be loaded during autoclaving.

QF150, QF1200



QF4400, QF5050 (QF20K SU not autoclavable)



7 DRAINABILITY OF QUATTROFLOW PUMPS

After draining, Quattroflow pumps may contain a non-recoverable volume of liquid which depends on the pump size, pump type and orientation of the pump chamber.
To support maximum product recovery and drainability we give the following information:

7.1 Optimized drainability: orientation of the pump chamber

There is the possibility to rotate the pump chamber in 90° steps for all Quattroflow pump sizes. This rotation is independent of the orientation of the pump drive which stands standardly horizontally on the ground.

The following two tables show the standard orientation of all QF pump sizes and the pump chamber orientation for an optimized drainability.

For the small Quattroflow pump series QF150 and QF1200 we recommend a vertically mounted pump chamber (inlet up, outlet down) for optimized drainability.
The shown standard orientation for QF4400, QF5050 and QF20K pump series is also the recommended orientation for optimized drainability.

In case that the pump chambers should be rotated:
Please mind that the clamp ring needs to be rotated as well to access the clamping ring screw (see installation instructions).
If the clamping ring screw is not fixed before operation the pump could be damaged.

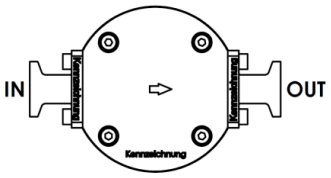
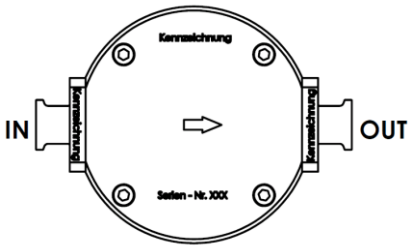
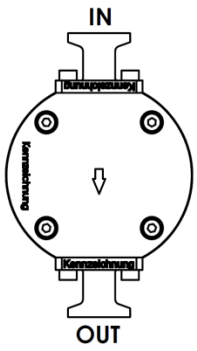
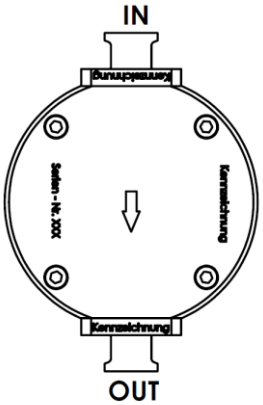
	QF150	QF1200
Standard orientation Pump drive horizontally (standard) pump chamber horizontally mounted		
Optimized drainability * Pump drive horizontally (standard) pump chamber vertically mounted		

Table 10 Standard and optimized orientation of QF pump chambers (QF150, QF1200).

*** Please note that the fluid path (inlet and outlet valves) opens automatically, if there is small over pressure or hydrostatic head on the inlet site of the pump chamber. Please check if an additional valve before the inlet connection port is needed in your system.**

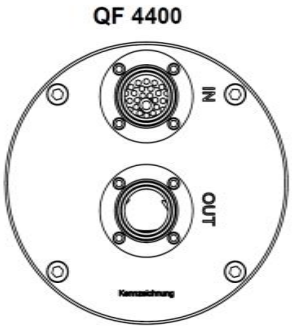
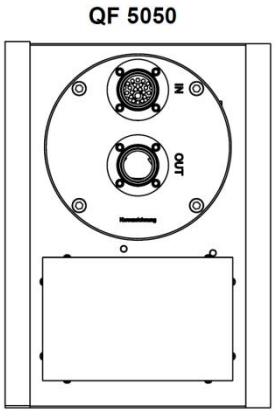
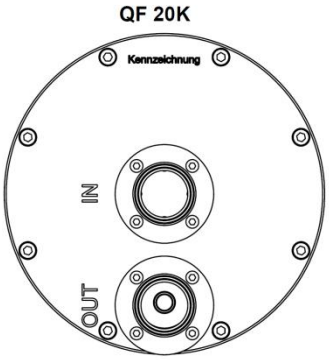
	QF4400	QF5050	QF20K
Standard orientation = Optimized drainability **Pump drive horizontally (standard)** **inlet up, outlet down (standard)**			

Table 11 Standard and optimized orientation of QF pump chambers (QF4400, QF5050, QF20K).

7.2 Full drainability: Vertical position of the pump (pump chamber downwards)

To reach a full drainability of Quattroflow Pump chambers there is the possibly to mount the complete pump drive and pump head in vertically position. There are some figures below which show this orientation exemplary.

For the reason that the pump chamber shows downwards the medium will flow out of the inlet and outlet port caused by the gravitation.

For all pump sizes we recommend installing valves both at the inlet and the outlet site of the pump chamber for draining after the process or cleaning procedure is finished.

For new or existing Quattroflow pump with gear motors, there are some points which have to be considered for horizontal mounting. Please contact the support team to get further information.

	QF150	QF1200
Full drainability Pump drive Vertically, Pump chamber downwards		

Figure 7 QF150 and QF1200 orientation for full drainability.

Please contact the support team to get more information on vertical installation of QF150 and QF1200 pumps.

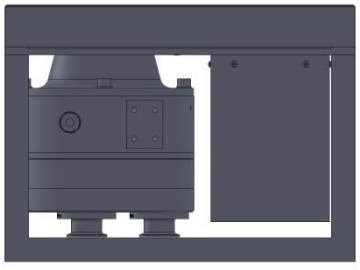
	QF5050
Full drainability Complete pump is rotated, Pump chamber downwards	

Figure 8 QF5050 orientation for full drainability.

There is nothing else to consider mounding the QF5050 pump as shown above. QF5050 pump is designed to operate in all orientations.

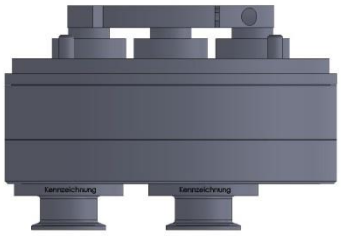
	QF4400	QF20K
Full drainability **Pump drive Vertically, Pump chamber downwards**		

Figure 9 QF4400 and QF20K orientation for full drainability.

Please contact the support team to get more information on vertical installation of QF4400 and QF20K pumps.

8 TROUBLESHOOTING

Quattroflow pumps operate very reliable and error-free, if they will be operated and serviced in accordance with the instruction manual. If there is still a problem the following table should help detecting and fixing the cause by yourself.

Please read also the official and recent operating manuals and safety instructions carefully which are available for Quattroflow Pumps and accessories.

If you would like to contact the manufacturer for support, please keep the serial number of the pump and information about the process parameters available.

Operating troubles										Cause / remedial action
Pump does not start	Pump does not prime	Output is not obtained	Pressure head is not obtained	Output is not consistent	Pump operates noisy / vibrations	Pump is leaky	Motor gets to warm	Too high pulsation	Diaphragm damage	
	X					X				The front screws of the pump chamber / pressure plate are not tightened enough. Fix it with the defined tightened torque.
	X									Check the direction of flow showed by the arrow on the pump, in case of wrong way, turn the pump head.
	X	X		X						Check suction pipeline and TC-seals for tightness.
	X	X	X	X						Check suction head -> increase suction line cross section.
	X	X		X						Check viscosity of liquid pumped.
X										Check power supply and cables.
		X	X	X				X		Avoid air inclusions in the liquid to be pumped.
		X		X						Check pressure head-open valve in discharge line completely, remove obstruction in discharge line.
		X			X			X		The diameters of the pipes in suction or pressure line are too small -> risk for cavitation.
					X					Check the coupling halves. They must be fixed with a lash -> see Quattroflow manual.
					X					Check longitudinal play of coupling rod pins. The spider made of plastic might be worn.
	X	X		X						Check whether foreign bodies in pump.
X							X			Pump stopped by the thermal circuit breaker. Allow the motor to cool down – maybe reduce the power consumption.

Table 12 Troubleshooting Table 1

Continuation of Troubleshooting Table 1:

Operating troubles										Cause / remedial action
Pump does not start	Pump does not prime	Output is not obtained	Pressure head is not obtained	Output is not consistent	Pump operates noisy / vibrations	Pump is leaky	Motor gets to warm	Too high pulsation	Diaphragm damage	
X					X					Bearings are worn or defective and must be replaced.
	X									The valves are dry (e.g. not in use for a long time), deformed or worn. Change valve or wet the pump.
						X				The diaphragm is burst -> replace with respective elastomer service-kit.
	X	X	X			X				O–rings between valve plate and pump housing are defective -> Replace with respective elastomer service-kit.
		X			X					The clamping ring screw got loose -> fix it with the defined torque.
X										Parameters of the control panel are wrong -> check basic settings.
X										Pump may not start in manual mode if configured for remote operation (e.g. external 4-20mA signal); check parameter settings.
						X				Pump after SIP cooled down too fast - slow cooling with room temperature.
									X	Too high vacuum on suction side of the pump.
									X	Diaphragm are not correctly installed on supports -> see QF manual.
								X		Pump chamber is not completely vented -> see chapter Start-up operations.
									X	Check chemical compatibility of elastomers.

Table 13 Troubleshooting Table 2

Subject to change without notice.

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