



Application Note

QF1200SU Q-Control Pump

**PID Pressure Control
combined with PendoTECH® Single-Use Sensor™**



1 Overview

For this test, the Q-Control pump was used in combination with PendoTECH Single-Use Pressure Sensor. A flow sensor can be directly connected with the Q-Control pump as plug-and-play solution. All the required evaluation and control units are integrated in the pump drive and the Q-Control software contains special modes and features for the use with PendoTECH pressure sensors. After a quick basic setup in the Q-Control settings, the sensor is programmed. The sensor is ready to use with the PID pressure control mode. Pressure data can be recorded on an USB-stick.

In this PID control mode the operator can set a specific pressure as a setpoint, and the pump controls the pump speed automatically to reach the pressure setpoint. The actual pressure value measured by the PendoTECH sensor is continuously monitored and evaluated by the PID control software. When the system pressure is increasing, the pump reduces the speed automatically to keep the setpoint constant. When the operator changes the setpoint, the pump increases or decreases the pump speed automatically.

The technical goal for a PID control system is a fast and stable control behavior at same time. Overshooting and fluctuations are to be avoided. Additionally, the PID-control should work over a wide setpoint range. All single-use Quattroflow pumps are qualified for working pressures between 0 to 4 barg discharge pressure, so they are suitable for typical Biotech filtration applications like virus filtration, sterile filtration, depth filtration, etc.

In a real process, complex equipment, special software, and skilled operators are required to setup a good working PID control system. The Q-Control pump provides an easy and fast plug-and-play solution instead.

The Q-Control software supports the user with an automated Autotune function to determine the P, I and D values which are necessary for each PID-control system. For these tests the basic parameters were determined with the Autotune function and they were slightly optimized manually in the Q-Control settings. After a few minutes the system was ready to use.

2 Setup

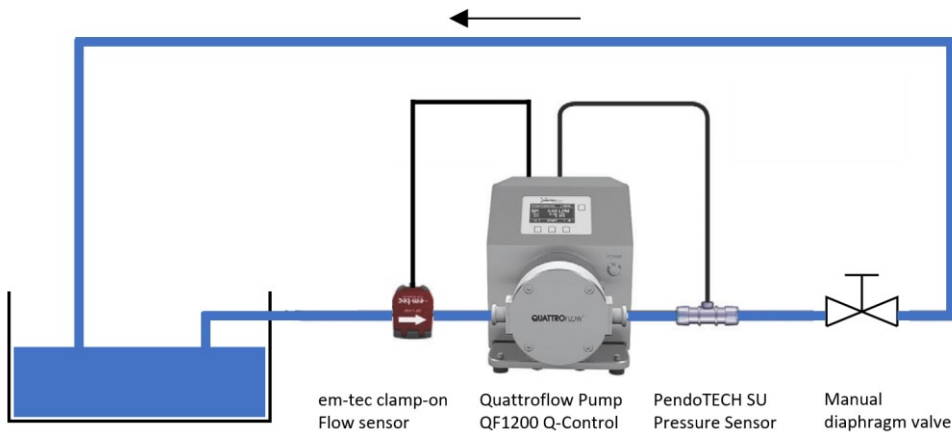


Figure 1 Schematic test setup

| Quattroflow Pump | |
|--|---|
| Pump series | QF1200SU |
| Panel / control system | Q-Control with integrated em-tec and PendoTECH evaluation units |
| Drive / motor | Synchronous Servo-Motor 485W |
| Eccentric shaft | 5° |
| Pressure sensor | |
| Sensor type | PendoTECH® Single-Use Pressure Sensor Operating range from -0.79 to 5.2 bar |
| Sensor ID | PREPS-N-5-050 |
| Size | 3/4" TC to 1/2" HB |
| Evaluation unit | PressureMAT® Sensor Transmitter PT-60 Max. pressure: 4,14 barg (60 psig) |
| Flow sensor | |
| Sensor type | em-tec ultrasonic clamp-on transducer |
| Model and Size | BioProTT Series, BCT 3/8 x 3/32 A |
| Calibration | Max. Flow: 10 l/min Medium: Water Medium Temperature: 23 °C Tubing: 3/8" x 3/32" PVC |
| Flow measurement platform | FlowMCP-a (1 channel) |
| System | |
| Medium | Water |
| Medium temperature | approx. 23 °C |
| Tubing | 3/8" x 3/32" PVC ID: 9,53 mm |
| Q-Control parameterization; only PID pressure control relevant parameters; software version 01.02.00 | |
| Motor ramp | 50 %/s (1200 RPM/s) |
| Max. pump speed | 2400 RPM |
| PID Flow control P-value | 0,10 |
| PID Flow control I-value | 0,03 |
| PID Flow control D-value | 0,00 |
| Analog-input 4 mA (Sensor scaling) | 0,0 bar |
| Analog-input 20 mA (Sensor scaling) | 4,14 bar |

Table 1 Test setup and instruments

3 Test Execution

First the pump and system were fully primed and vented at high pump speed.

The diaphragm valve in the outlet line was throttled to create a back pressure of 4 barg at approx. 500 l/h flow rate. The valve was not adjusted during the complete test.

To show rapidity and stability of the PID control function other influencing factors should be eliminated. For this reason, the Setpoint values for flow rate were transmitted via MODBUS RS485 protocol to the Q-Control system. Since we used this method, a manual and slower adjustment of the setpoint via the control panel was not necessary.

Following pressure setpoints were set to the Q-Control pump:

| Setpoint no. | Setpoint pressure [bar] | Setpoint difference |
|--------------|-------------------------|---------------------|
| 1 | 0,1 | +3,9 |
| 2 | 4,0 | -1,0 |
| 3 | 3,0 | -1,0 |
| 4 | 2,0 | -1,0 |
| 5 | 1,0 | -0,5 |
| 6 | 0,5 | -0,4 |
| 7 | 0,1 | +3,9 |
| 8 | 4,0 | -3,9 |
| 9 | 0,1 | - |

Table 2 Setpoints pressure

Each setpoint was held for approx. 1 minute. Between the setpoint changes, the system and the pump were in a constant PID pressure control mode.

Flow rate as control value was measured with an em-tec ultrasonic clamp-on sensor. This was directly connected to the Q-Control pump which contains an integrated em-tec evaluation unit.

4 Test results

Charts

All data points were logged with a frequency of 1 Hz.

The data points are drawn with interpolated lines.

Red curves illustrate the setpoint for outlet pressure, which were set to the Q-Control panel.

X-axis are showing the relative time of the test duration.

Flow range

At 0,1 barg pressure the flow rate was approx. 70 l/h at ~110 RPM pump speed.

At 4,0 barg pressure the flow rate was around approx. 500 l/h at ~820 1/min pump speed.

The complete test was performed within this flow range.

Because the focus is on pressure control, the flow trends are not shown in detail.

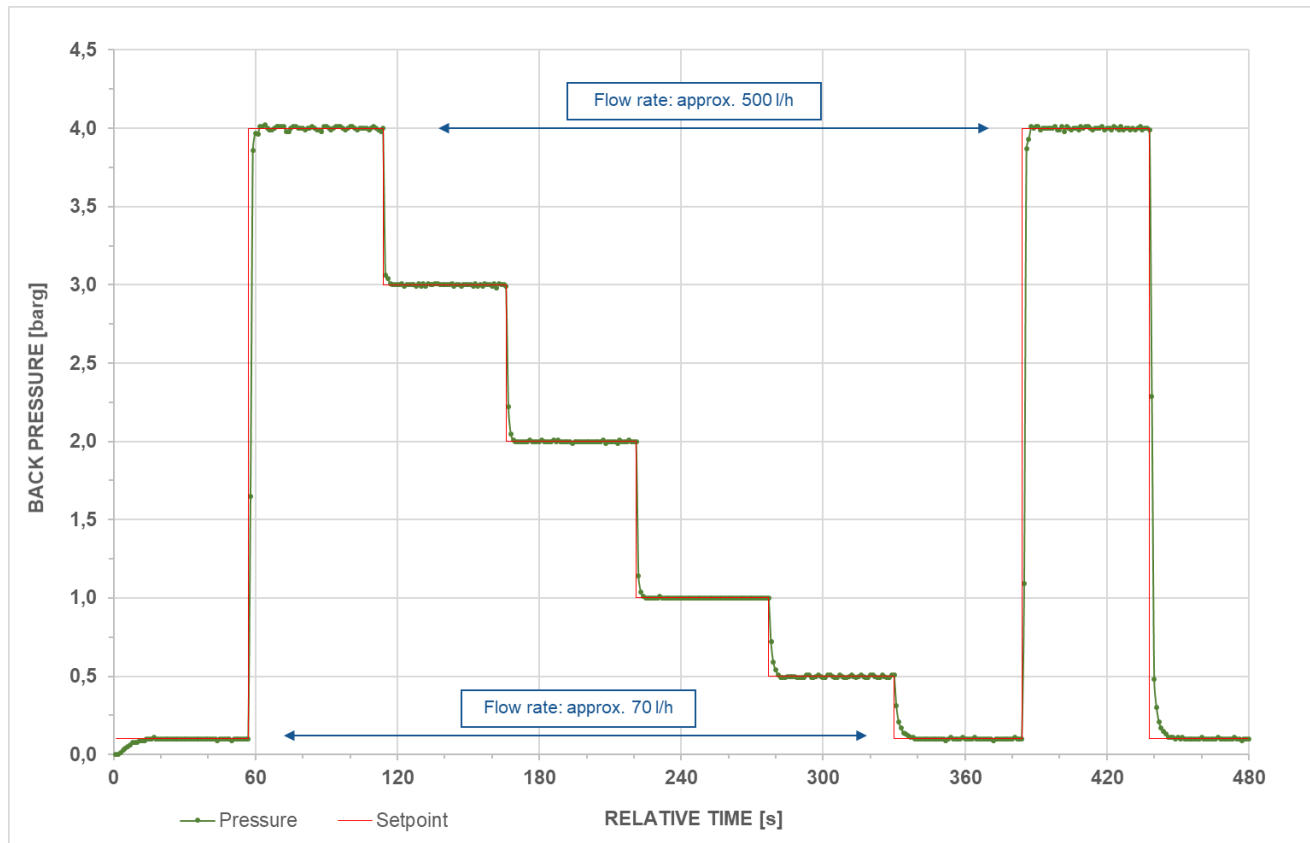


Figure 2 PID pressure control, overview complete test

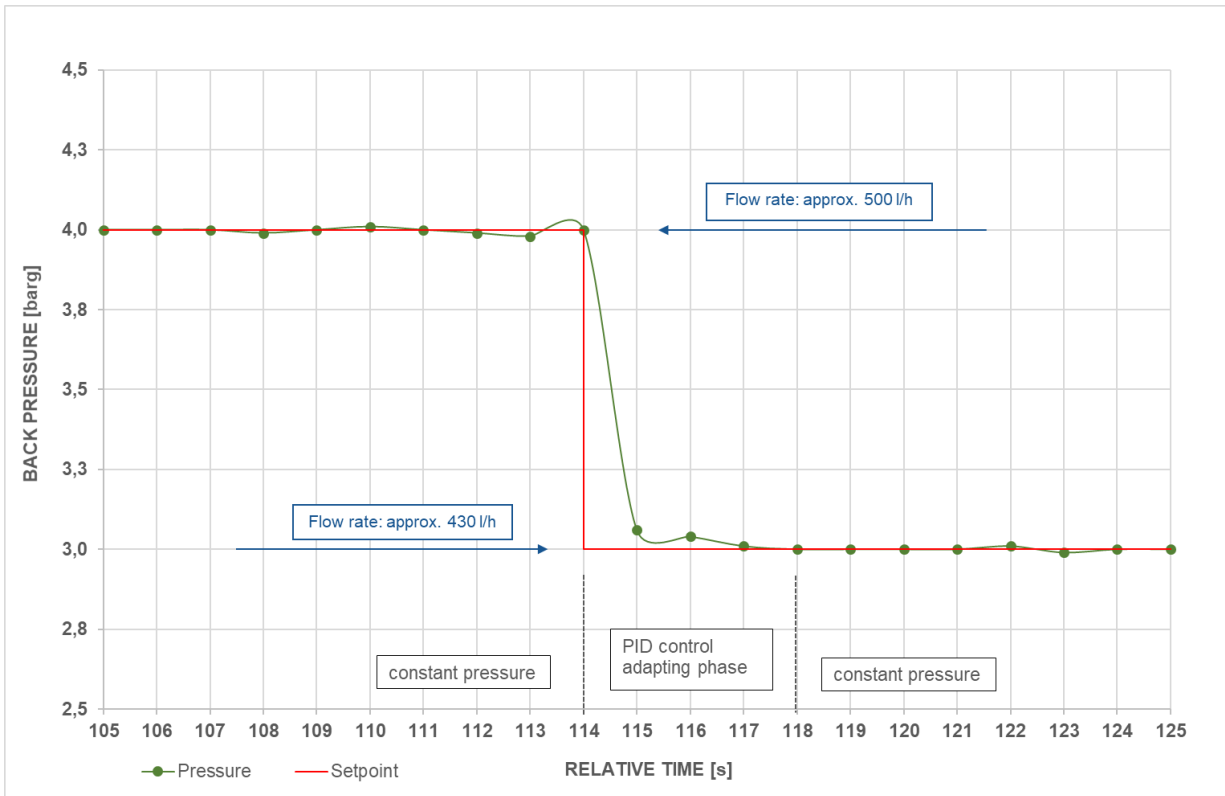


Figure 3 Pressure control, setpoint 4,0 → 3,0 barg

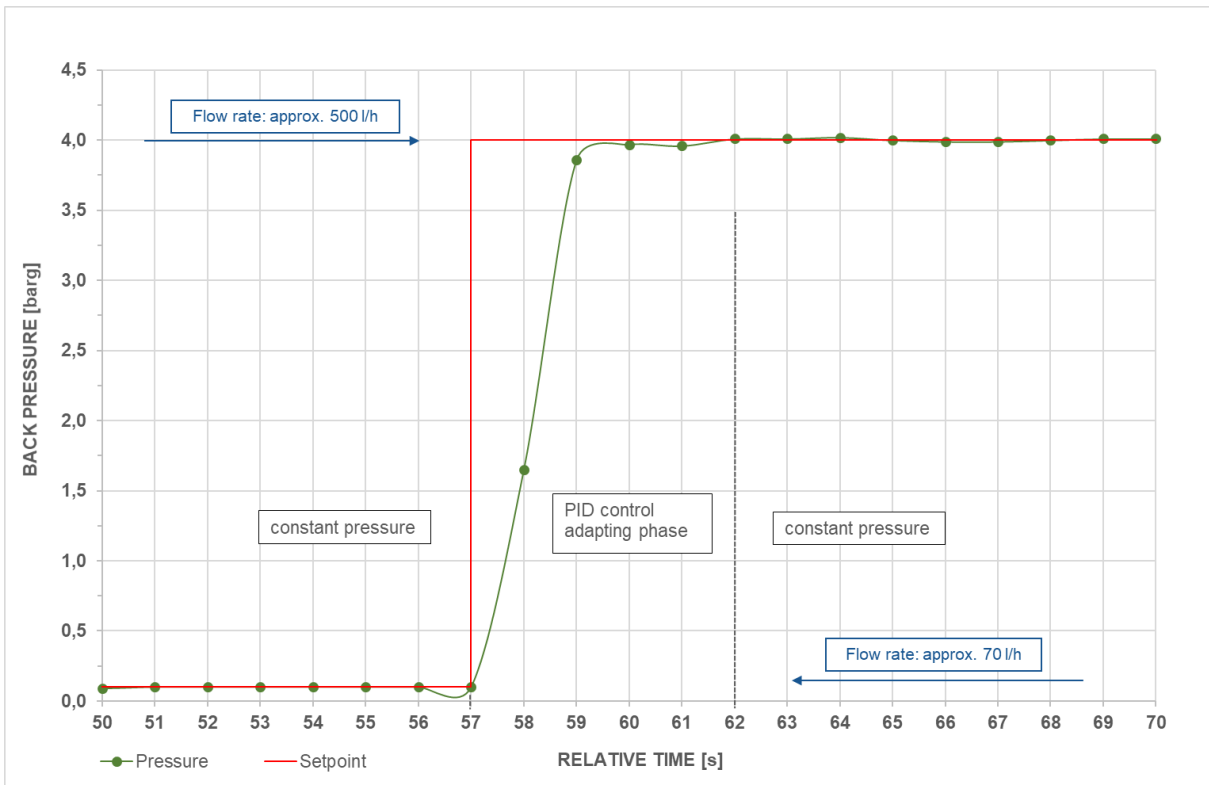


Figure 4 Pressure control, setpoint 0,1 → 4,0 barg

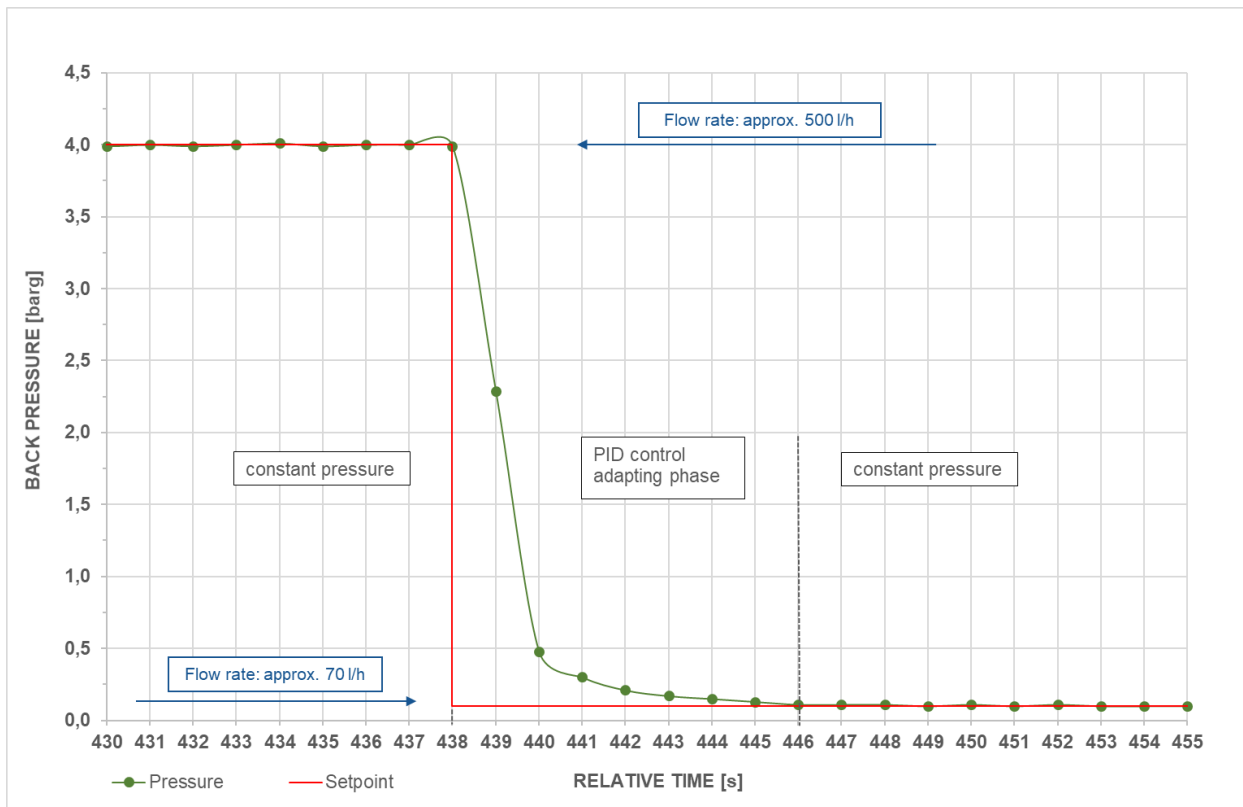


Figure 5 Pressure control, setpoint 4,0 → 0,1 barg

5 Discussion and summary

These tests have shown a very fast and stable PID control system over a wide operation range of pressure setpoints and resulting flow rates.

A setpoint change of 1 barg takes only approx. 4 seconds until the PID control system reaches the stable setpoint. Even the large setpoint steps of $\pm 3,9$ barg take only around 5 seconds in upwards and 8 seconds in downwards direction.

During all tests the PID control was very stable and no overshooting or fluctuating behavior was visible.

This application note is demonstrating that the combination between Q-Control pump and PendoTECH pressure sensor provides an easy and fast solution for a good working PID flow control system.

The information contained in this document was checked for correctness and completeness at the time of publication. The product data may change without prior notice.

Quattroflow® is a brand of PSG Germany GmbH since April 2020.
(formerly ALMATEC Maschinenbau GmbH)



PSG Germany GmbH

Hochstraße 150-152 · D-47228 Duisburg, Germany

Phone: +49 (0) 2065 89205-0 · Fax: +49 (0) 2065 89205-40

www.quattroflow.com · psg-germany@psgdover.com