HOW POSITIONING AND ON-SITE ADJUSTMENT IMPACT THE BIOPROTT™ FLOWSU SYSTEM

1 Introduction

1.1 Starting Point

Pumps and fluid control play a critical role within the majority of bioprocessing applications. In many of these applicatios, these factros are combined by flow meters. Especially for chromatography, where positive displacement pumps are considered the gold standard and where hold-up volume as well as the size of the overall system need to be as small as possible, there is usually a flow sensor located directly next to the pump.

1.2 Background

While placing the sensor right next to the pump is an effective way of decreasing the footprint and the hold-up volume, the majority of flow meters are sensitive in respect to their positioning as they require a developed flow profile for maximum accuracy. Another factor which influences the reading of the flow meters is backpressure, which is caused by L-bows or other equipment in the flow path, i.e. in the outlet section of the sensor as this, too, impacts the flow profile. The reason why a not-fully-developed flow profile and consequently also backpressure impact the products within the BioProTT™ family as much is the fact that it causes the flow to enter and form a transition area within the flow where a laminar flow and a turbulent flow are present at the same time. In concrete terms, this means that the flow along the tube wall is laminar while the flow within the middle section of the tube is a turbulent one. As this causes the flow profiles to continuously shift, it is difficult to measure accurately within these areas.

1.3 Sensor Adjustment

One way of solving — or at least reducing — this effect is to determine the optimal operational flow range and to adjust and calibrate the BioProTT™ FlowSU System for that. The BioProTT™ FlowSU System is an inline ultrasonic flow measurement system consisting of a multi-use evaluation device and a single-use sensor. It is the newest addition to the BioProTT™ portfolio.

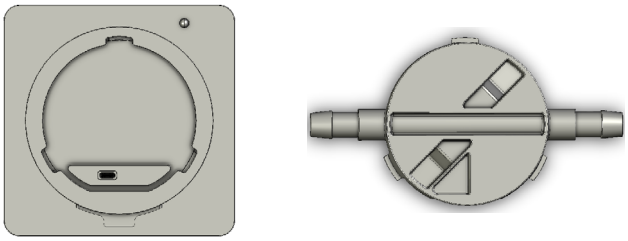

Figure 1: BioProTT™ FlowSU System (left) multi-use part; (right) single-use part

While the single-use sensors are not calibrated individually, the BioProTT™ FlowSU System, i.e. the multi-use part of the flow measurement system, does come with a standard adjustment parameter set. Although these parameters fit a large number of biopharma applications, the final accuracy of the system depends on several influencing factors, most of which cannot be taken into account prior to being integrated into a skid and/or system. Due to this, em-tec offers an on-site adjustment feature where customers can carry out an adjustment tailored to their application and specific setup. As the specific setup is the part that can be imitated least, the following chapters will illustrate the impact that the distance to the pump has on the BioProTT™ FlowSU System and what benefits the on-site adjustment offers.

2 Tests

2.1 General Setup and Method

In order to not distort any of the results, the test setup was designed to imitate the actual conditions within the field of bioprocessing as closely as possible. For the BioProTT™ FlowSU System, a 1/2“ sensor was used in combination with a Quattroflow® 1200 SU HT 5 with a 1/2“ Tri Clamp single-use pump chamber. For a reference flow, a Siemens Magflow was installed into the tubing circuit. The tests were then carried out using water at ambient temperature as medium.

2.2 General Setup 1

For the first tests, the flow sensor was placed after the pump with straight inlet and outlet sections and RPM (=Rounds Per Minute) ranging from 50 to 2000. The distance between pump and flow sensor was 10 cm and 20 cm respectively.

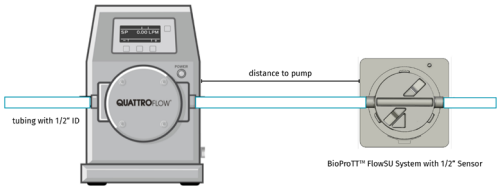

Figure 2: Setup Version 1 with straight in- and outlet section

2.3 General Setup 2

In a second version of the setup, the distance between pump and flow sensor was kept at 10 cm, but an L-bow connector was added after the sensor with a distance of first 5 cm and then 15 cm from the outlet.

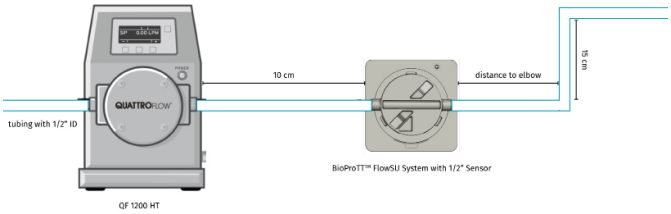

Figure 3: Setup Version 2 with L-bow

2.4 Parameters, Settings, and Procedures

To ensure the best possible accuracy and performance of the BioProTT™ FlowSU System even in a setup where the distance to the pump and elbow are reduced to a minimum — 10 cm and 5 cm respectively — an on-site adjustment was carried out. The on-site adjustment feature is available through the web interface where the system's internal parameters can be adapted to best fit the current installation position of the BioProTT™ FlowSU System.

Here, nine adjustment points were defined:

- 0 ml/min
- 300 ml/min
- 500 ml/min
- 1000 ml/min
- 1500 ml/min
- 2500 ml/min
- 5000 ml/min
- 7500 ml/min
- 10000 ml/min

The adjustment was performed with one single-use sensor. After, i.e. once the adjustment was in place, the tests were carried out again using the same setups as before, once with the same single-use sensor that had been used for the adjustment and once with another single-use sensor, i.e. one that wasn't used during the adjustment.

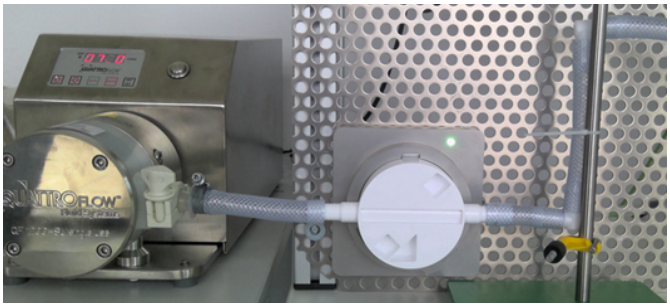

Figure 4: Test setup

For each of the six setups, there were 16 verification points, i.e. specific flow values, targeted for the measurement. The output rate of the BioProTT™ FlowSU System was set to 0.1 Hz, which means a moving average of the past ten seconds; i.e. each transmitted flow value is the average of the individual values of the past ten seconds. The calculation of the tolerances is based on the comparison with the readings of the Siemens Magflow.

3 Results

All measured values are plotted in the diagram below (Figure 5) together with the specified tolerances from the factory (verified under lab conditions) and the chaotic flow range (gray area). The chaotic flow range describes the range between the laminar and the turbulent range.

Looking at the two blue curves shows that, for the most part, the setup after the Quattroflow®, i.e. in regard to L-bow or straight outlet, does not have much of an impact on the performance of the sensor, especially within the chaotic flow range.

What does have a clear impact, however, is the distance between the pump and the sensor, for the closer the sensor is placed to the pump, the less accurate it performs with the standard calibration.

The addition of back pressure further increases inaccuracies (see yellow curves). Nevertheless, even when outside the specification, the BioProTT™ FlowSU sensors perform quite well as their accuracy was consistently better than 4 % at higher flow ranges (~150 l/h) even if the installation position did not meet the general recommendations. On top of that, above the chaotic range, a linear factor can be used to improve the accuracy.

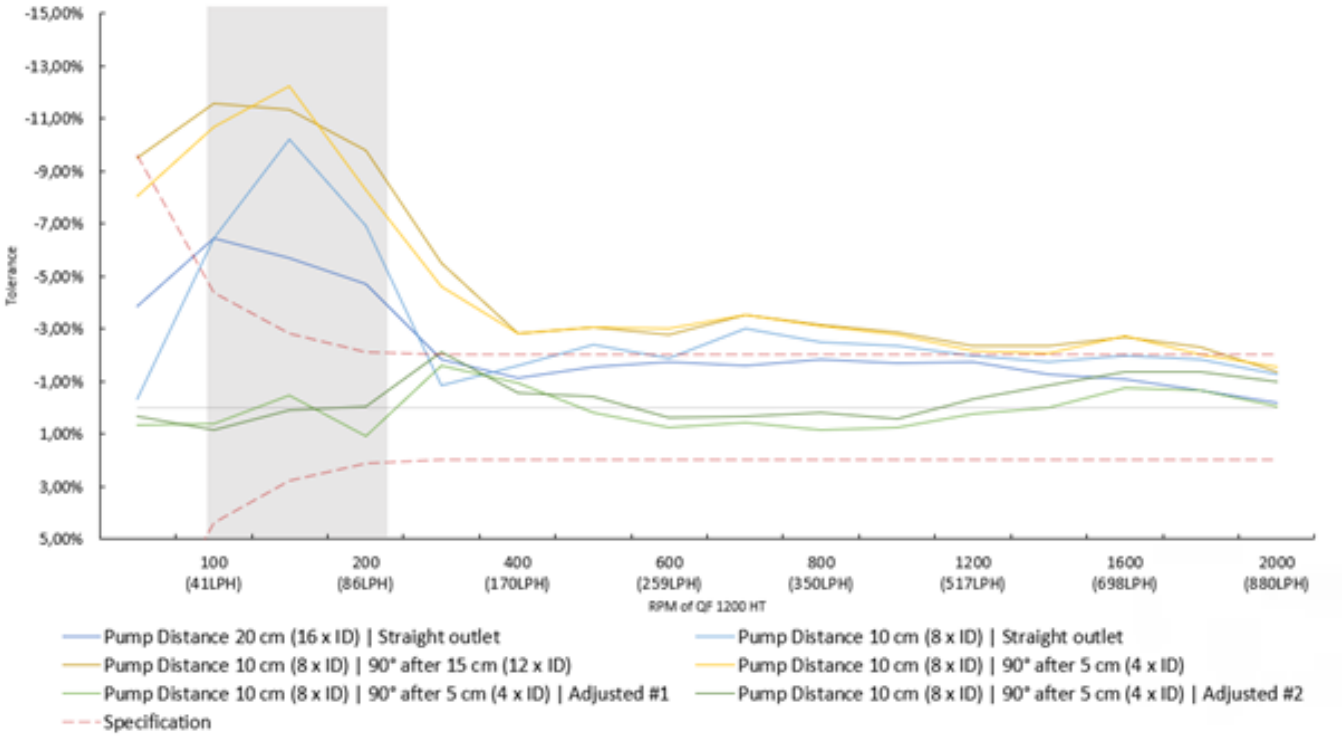

Figure 5: Measurement Results

Furthermore, by using the on-site adjustment for the BioProTT™ FlowSU System, the accuracy can be improved across the complete flow range. Additionally, the determined parameters which can be saved and stored in the multi-use device work for all connected single-use sensors and provide the same level of accuracy as for the one the adjustment and determination of parameters was carried out with.

4 Conclusion

As the initial adjustment and calibration of sensors takes place under lab conditions, i.e. with a specific setup including a straight in- and outlet section and a non-pulsating pump providing a stable and constant flow, and a pump positioning that ensures that there is no disturbance on the flow profile, it can differ quite a bit from the actual conditions found in the field. There, it is inevitable that not all of these parameters and requirements can be observed and met as decreasing the footprint and hold-up volume are major concerns and thus often prioritized.

Consequently, the setup and integration position of the BioProTT™ FlowSU System is not always ideal regarding the flow measurement system‘s performance.

To compensate for that, it is strongly recommended to use the on-site adjustment tool as this helps achieve a highly accurate flow measurement even in complex setups: performing an adjustment based on the actual positioning and setup, and creating application-specific calibration tables, the system is directly adjustable to its actual conditions, paving the way for the highest possible accuracy.

What should be taken into account, however, is the chaotic flow area, which depends on the inner diameter of the tube as well as on the density and temperature of the medium. To do so, the optimal operational flow range should be defined as this significantly impacts the accuracy and overall performance of the flow measurement system.

5 Contact

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