TechNote Issue #1:

How to Optimize the Accuracy in Your Flow Measurement Application?

1 Introduction

The BioProTT™ FlowMeasurement System was developed for the non-invasive measurement of volumetric flows within flexible tubing systems. Moreover, it was designed for environments with strict hygienic requirements and is thus suitable for both industrial and laboratory applications alike. The BioProTT™ FlowMeasurement System is made up of an evaluation device — also referred to as flow meter or transmitter — and one of our compatible sensors.

Figure 1: The BioProTT™ FlowMeasurement System for laboratory (left) and industrial (right) applications

Its function is based on the ultrasonic transit time method, where the volumentric flow rate is determined through the transit time difference between ultrasonic signals that are alternately sent with and against the flow direction. The ultrasonic signal is directly influenced by five parameters:

- medium type
- medium temperature
- tube size
- tube material
- the flow range (Qmin and Qmax)

To ensure the highest possible accuracy, each of our sensors is adjusted and calibrated according to these parameters. In addition, there are also external factors that impact the accuracy. This application note will highlight and explain these factors so that system integrators and operators are able to maintain and optimize the accuracy on site.

2 Setup

2.1 Sensor Positioning

For best results, we recommend that the sensor is clamped onto a straight section of the tube. Any bends or kinks in the tubing can affect the flow profile of the fluid and can therefore lead to displayed flow values that are not necessarily representative of the flow within the whole tubing system. Ideally, the straight inlet section on either side of the tube as well as to valves or other sensors is 15 times the inner diameter (ID) of the tube. For a sensor with the size of 1/4“ x 1/16“, where the first number refers to the inner diameter, an ideal inlet section would be 3 3/4“ or 95.25 mm.

If it is not possible for the inlet section to be straight for the recommended length, try to find the straightest available section of the tube and position the sensor there.

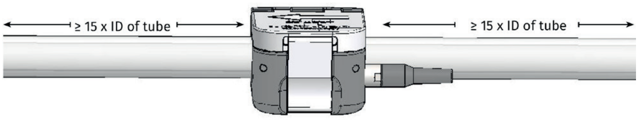

Figure 2: Sensor Positioning

The great majority of setups within the bioprocessing field include pumps and valves which influence the flow. Generally, one can position the sensor on either side of the pump. The advantage for a position before the pump is the lower pressure as the pressure tends to be higher the smaller the distance is to the pump. This also means that there is no need to use a high-pressure tube.

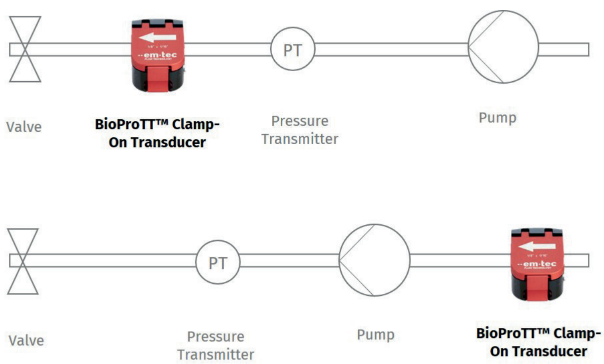

Figure 3: Sensor positioning in relation to the pump

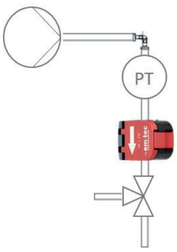

Figure 4:
Setup with elbow

A possible disadvantage of positioning the sensor before the pump would be the fact that suction of the the pump might create negative pressure which could lead the tube to deform slightly, which, in turn, might influcence the measurement.

Consequently, it is essential to ensure that the distance between the sensor and the pump is large enough for the flow profile to be relatively stable. If elbows are necessary for your setup, however, try to ensure that the in- and the outlet of the sensor is straight for the recommended distance of 15 times the ID of the tube and free of any connectors. Regarding the latter, it is best to not connect tubes with different inner diameters even if the section between them is straight as this, too, impacts the flow. If different tube sizes are nevertheless necessary, please go from a greater diameter to a smaller one instead of the other way around.

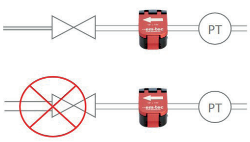

Figure 5: Setup with different tube sizes

Furthermore, the flow path should be aligned to ensure that there is no air in the tube and that the fluid can be completely still once the pump was turned off. Not only is this essential for zeroing, but it also improves the quality of the flow profile, leading to more stable flow values and measurements as a result.

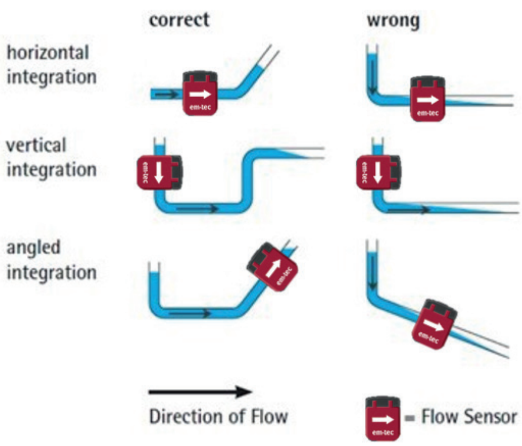

Figure 6: Possible Integrations and Flow Paths

Also ensure that the arrow on the sensor lid aligns with the flow direction. While a measurement is possible if the arrow points in the opposite direction of the flow, the flow values are then displayed as negative if the digital interface is used whereas the analog interface can only give out negative flow values until a current of 1 mA is reached.

2.2 Tubing

When setting up the system, please make sure that the BioProTT™ Clamp-On and the tubing are compatible. The adequate tube size is indicated on the sensor lid. Selecting matching tubes and sensors is important as the acoustic coupling (i.e. signal strength) is directly related to the signal quality.

For ultrasound-based measurement systems such as the BioProTT™ FlowMeasurement System, the acoustic coupling, also referred to as RSS value (=Received Signal Strength), plays a pivotal role within the measurement.

If the tube is too small, there is so-called empty space within the flow channel which can attenuate or even break the ultrasonic signal. If the tube is too big, the sensor lid either does not close at all, which reduces the acoustic coupling, or the tube is crammed into the flow channel and thus deformed, which too, impacts the signal.

Figure 7: Tube is too small

Figure 8: Tube fits

Once the right tube is selected, the sensor can be clamped on. Before inserting the tube, make sure the clamping areas of the sensor and the tube are clean and free of any residue as this might reduce the RSS value and thus the signal quality. To insert the tube in the sensor, apply even pressure and try to not stretch or pull the tube as this could affect the geometry of the tube and/or create cracks in the material, both of which might impact the ultrasonic signal and thus the measurement values.

To fix the tube in its final position, close the lid tightly. The lid is closed correctly if there was an audible "click" from the snapper.

Please note: The tube should fit snugly into the flow channel without being crammed.

2.3 Application Parameters

Another important factor before and during setup are the parameters of your application. Every em-tec sensor is pre-adjusted and calibrated according to customer specifications.

The relevant parameters are:

- medium type
- medium temperature
- tube size
- tube material
- flow range (Qmin and Qmax)

For the best results, please make sure to respect the parameters indicated in the documentation (i.e. the Calibration Information Sheet of the sensor). The reason why these parameters are so important is because — aside from the flow range—they all influence the ultrasonic signal. Not only do different types of fluid have different densities, but these densities are also influenced by the temperature as well as the concentration of salts, sugars, proteins, particles, etc. Moreover, a change in density can then also affect the speed of sound through the media. The same goes for the tube, as different materials have different acoustic properties. Moreover, it takes the ultrasonic signal longer to travel from one side to the other the bigger the wall thickness is, meaning that this too, is a factor that must be taken into account and cannot easily be changed in retrospect. However, in order to guarantee flexibility for our customers, each sensor can store up to seven calibration tables, which means that one sensor can be used for seven different applications with seven different sets of parameters as long as the tube is always the same size. In addition, changes to the type of medium and the medium temperature used can also be compensated by using a customer-specific calibration factor. This factor adjusts the measurement values by a linear factor and can be set directy on the device or on the web interface, depending on the respective flow meter.

For more information about the calibration factor, its use and how to determine it, please ask for our application note "Determining the Calibration Factor" which is available for download on our website or upon request at em-tec-info@psgdover.com.

3 Measurement

There are several steps that should be followed before and during the flow measurement in order to ensure the highest possible accuracy.

3.1 Equilibration of the System

When the BioProTT™ FlowMeasurement System is first set up, and the sensor is first clamped on, its temperature may differe from the temperature of the tubing and the fluid within it. Depending on the environment, the ambient temperature too, may be higher or lower than the system's. While it is possible to carry out flow measurements right away, it is recommended to wait for five to ten minutes before starting the measurement so the BioProTT™ FlowMeasurement System has enough time to equilibrate and adapt.

3.2 Acoustic Coupling

For measurement systems whose function is based on ultrasonic signals, the acoustic coupling rate or the RSS value (Received Signal Strength), plays a pivotal role both for the measurement as such as well as for the accuracy. The RSS value describes the signal strength and thus indicates the quality of the ultrasonic signal. As the measurement relies on the transmitted ultrasonic signal, a sufficient acoustic coupling is a prerequisite of an accurate measurement.

The RSS value is displayed as % and should always exceed 50%. It is influenced by factors such as air bubbles within the tube, which make the value drop, or empty space between the sensor's flow channel and the tubing as well as if the tube is not completely filled with liquid.

3.3 Zero Flow Adjustment

One of the key aspects when it comes to optimizing and ensuring the measurement accuracy is the zero flow adjustment. It levels any existing offsets and helps improve the measurement and its accuracy. Consequently, a zero flow adjustment (also referred to as „zeroing“) must be carried out before each new measurement and, ideally, whenever possible without disturbing the running process. Depending on the evaluation device the system can be zeroed via the zero button on the display, via the web interface, or via a current pulse or digital command.

During the zero flow adjustment, it is also essential that

- the tube is completely filled with liquid.
- there are no air bubbles in the tube.
- the RSS value is greater than 50%.
- the liquid does not move, i.e. that there is no changing flow displayed.
- the BioProTT™ FlowMeasurement System is properly set up.

The zeroing time should not exceed 60 seconds. Once the system was zeroed, the flow measurement can be carried out.

4 Maintenance

The BioProTT™ FlowMeasurement System is a very low-maintenance system and does not need any extensive care. The sensors in particular, are designed for long-term use and made to last. To maintain and optimize accuracy, we recommend regular calibrations to be carried out. Ideally, the time between calibrations should not exceed 24 months. For more information regarding the adjustment and calibration, please contact em-tec GmbH.

Additionally, we also advise to regularly clean the device with the detergents recommended in the respective user manual and to perform regular visual checks to ensure that there are no damages to the devices that might impact the flow measurement.

5 Contact

If there are any questions concerning the information in this document, or if you are having trouble at some point during the calibration, please do not hesitate to contact us.

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