Non-Product Contact Process Flow Measurement

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Background

There are two (2) primary methods utilized for flow rate determination. The first method is termed **Direct Rate Measurement**, which involves either "*gravimetric or volumetric*" measurement of the collected flow. The second method is termed **Indirect Rate Measurement**, which involves "*measuring or sensing*" the process flow stream in a tube or pipe and correlating that *measured value* to an actual flow rate based upon a given set of known variables.

Since the late 1980s, there have been more than 20 indirect methods for measuring process flows. Some of these methods include:

- Rotary Vane
- Pilot Tube
- Reciprocating Piston
- Variable Area
- Venturi Tube
- Turbine
- Electro-Magnetic
- Coriolis
- Vortex
- Ultrasonic
- etc.

Of these available methods, only a limited number are actually suitable for flow rate measurement of biopharmaceutical process streams and even far fewer of these are suitable technologies for implementation into single-use process systems. The focus of our presentation will be one of these later technologies, ultrasonic flow measurement or more specifically, transit-time ultrasonic flow measurement.

Objectives

To demonstrate that a non-product contact, compact, clamp-on ultrasonic flow meter can achieve the overall performance accuracy and repeatability required for typical process control applications employed by the biopharmaceutical industry and is a viable alternative to the traditional gravimetric methods utilized for single-use applications.

Measurement Principle

Essentially, the em-tec BioProTT™ flow measurement system utilizes what is termed as a transit-time (TT) ultrasonic method which measures precise flow values in flexible tube and piping systems. The ultrasonic converters (piezoceramics) in the flow sensors transmit high-frequency acoustic signals through and against the flow direction. The time differential between these signals is proportional to the volumetric flow.

The basic principle is illustrated below in Fig. 1.

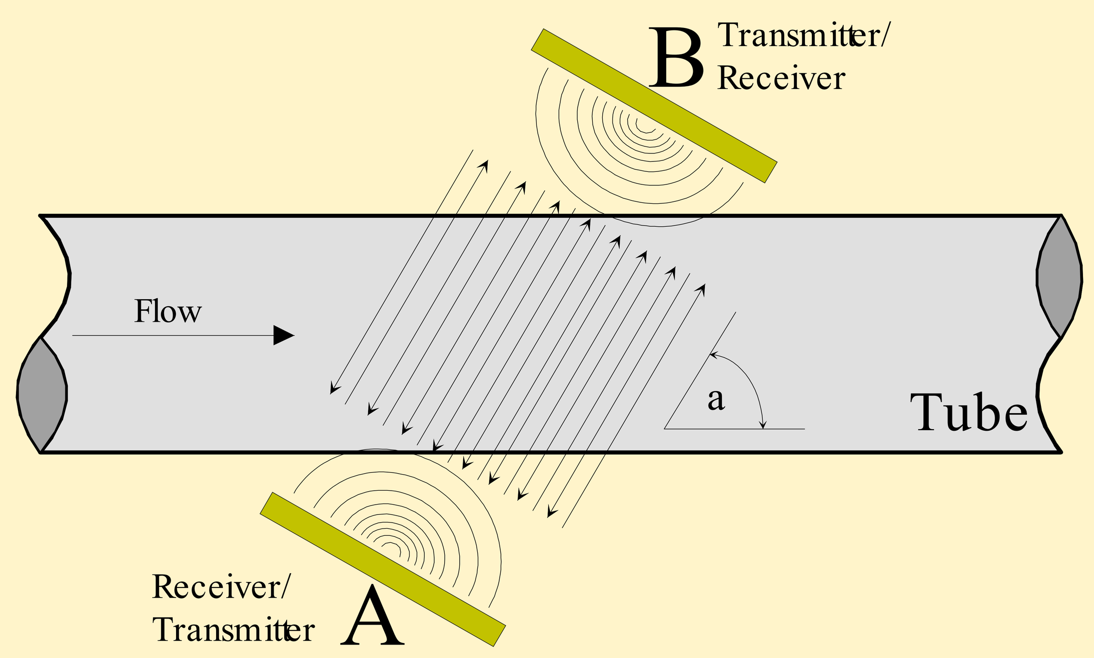

Figure 1: Principle of ultrasonic flow measurement (simplified using only two ceramics)

One piezoceramic (A) is excited by a set of high-frequency vibrations and transmits ultrasonic waves to a second opposing piezoceramic (B) that acts as a receiver. The piezoceramics are arranged at a specific angle α in relation to the flowing medium. The transit time is influenced by the medium. The flow velocity of the medium can be calculated using the measured transit time differential. The flow rate value in liters per minute is calculated using the known cross-sectional area of the tubing being scanned by ultrasonic transmission.

Four ultrasound converters configured in a crosswise arrangement transmit high-frequency sound signals alternately in and against the direction of the flow. The transit time for each impulse is measured; the transit-time difference between the upstream and downstream movement of the impulses is proportional to the volumetric flow.

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Test Configuration

Setup One

An em-tec BCT 3/4" X 3/16" clamp-on style transducer was calibrated for platinum-cured silicone tubing① and setup on the retentate line of an SU TFF System② and configured in-series with a NIST calibrated coriolis flow meter⑤.

Setup Two

An em-tec BCT 3/4" X 3/16" clamp-on style transducer was calibrated for platinum-cured silicone tubing① and setup on the elution line of an SU Isocratic Chromatography System③ and configured in-series with a NIST calibrated coriolis flow meter⑤.

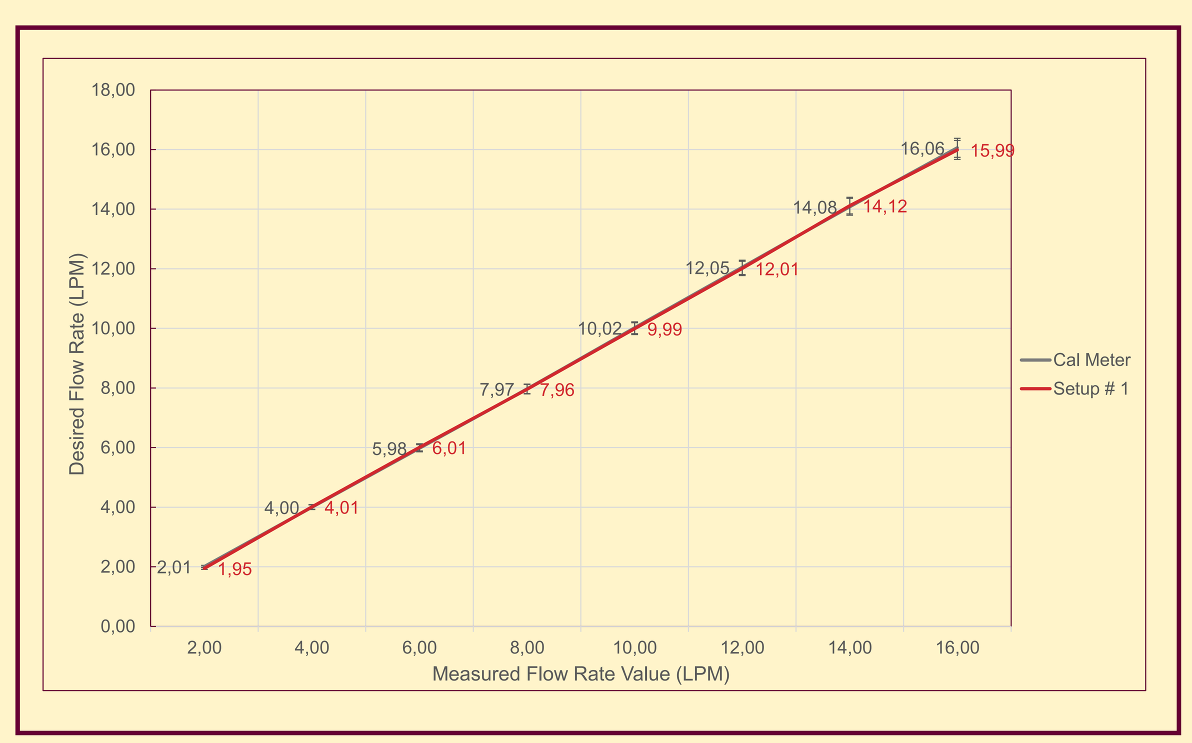
Setup Three

Two em-tec BCT 3/4" X 3/16" clamp-on style transducers were calibrated for platinum-cured silicone tubing①. A transducer was setup on the outlet line of each of the two feed pumps on a SU Gradient Chromatography System④ and configured in-series with a NIST calibrated coriolis flow meter⑤.

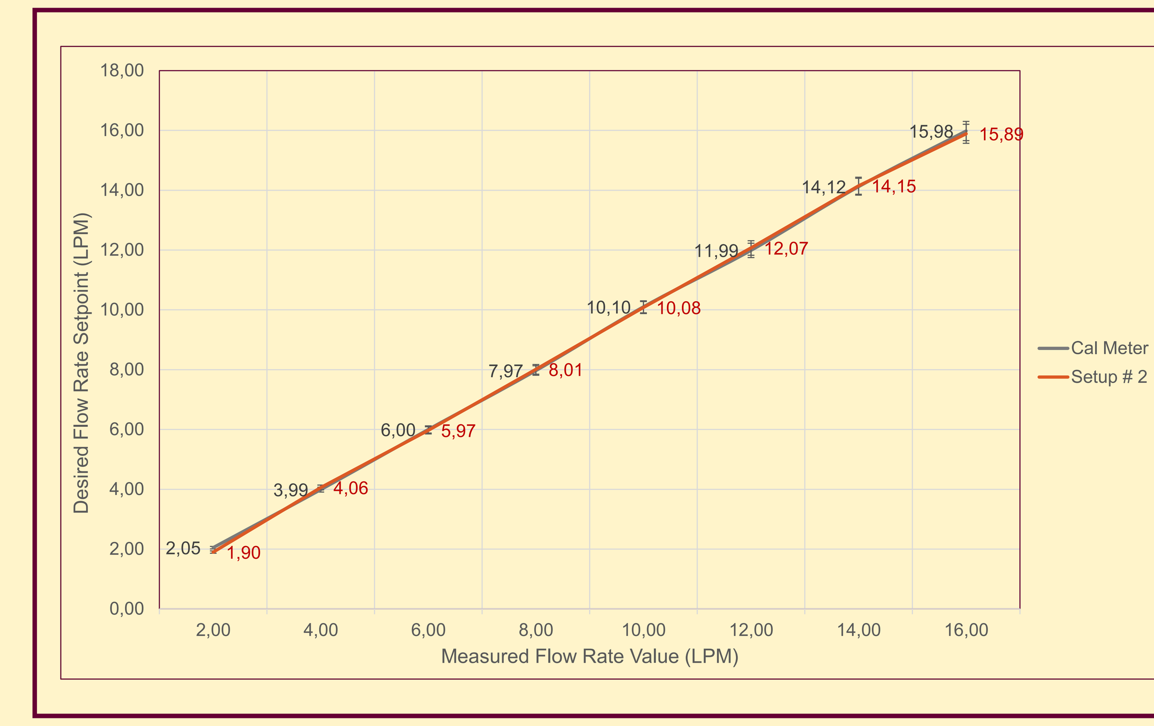
Each test setup was performed using 0.2µm filtered deionized water at 20-22 ºC and allowed to recirculate for NLT 15 min. at an average flow rate of 8-10 lpm for equilibration purposes.

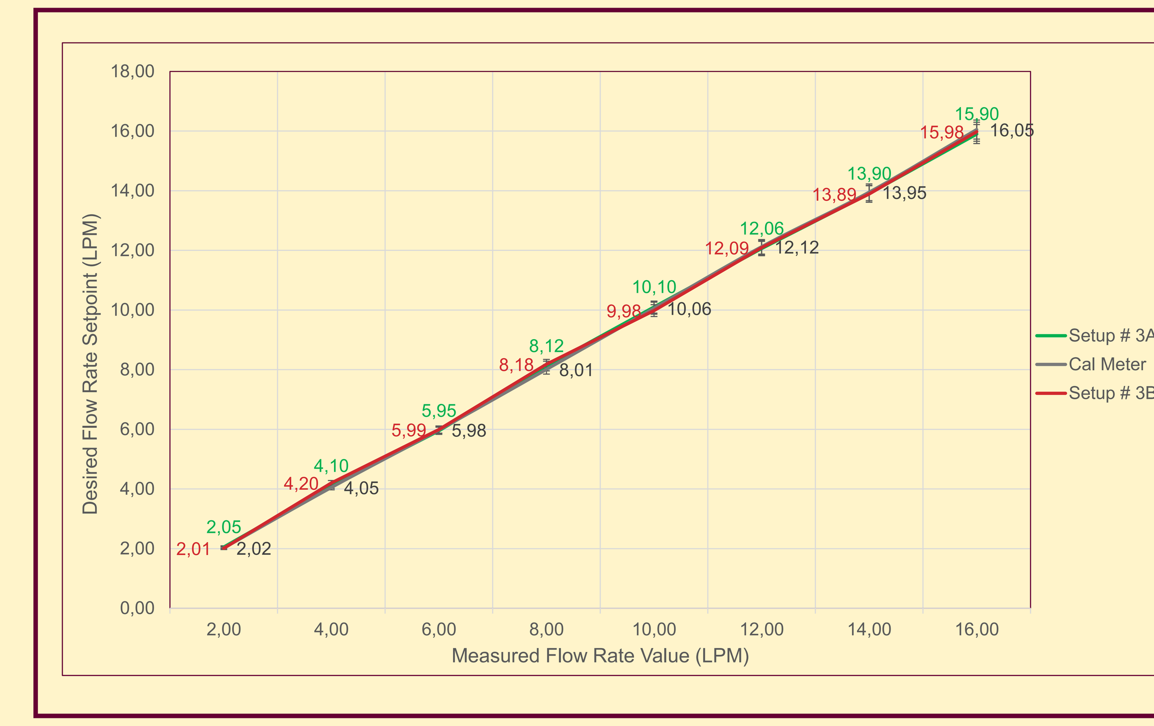
Results

BCT 3/4" x 3/16" Flow Rate Accuracy Test Data⑥



Results Cont.





⑥ **PLEASE NOTE:** Each datum point illustrated on the above-referenced charts represents the average value of three consecutive flow rate measurement values collected during the test phase of this study.

Conclusion

The test data from this study clearly illustrates that with proper material calibration and unit setup, flow rate measurement accuracies of less than +/- 2% of reading can be achieved.

Participants

- C. Van Patten, Tech. Services – ALPHABIO, Inc.
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- V. Pantess, Eng. Consultant – Greenfield Consulting, LLC

References

1. Tubing Material - ASTR750-A65 (supplied by FlowSmart) and LSR60 (supplied by BlueStar Silicones)
2. SU TFF System – ABS0475-SYS-001 (supplied by AlphaBio)
3. SU Isocratic Chromatography System – ABS0474-SYS-001 (supplied by AlphaBio)
4. SU Gradient Chromatography System – ABS0474-SYS-201 (supplied by AlphaBio)
5. Reference Flow Meter – 80F15AFTSACAABAAA (supplied by Endress+Hauser)