STUDY

Investigating Variation in Flow from Peristaltic Pumps

With peristaltic pumps, several flow paths can be operated simultaneously. However, many parameters influence the actual flow rate in each channel. Accurate determination of the individual flow rate in the individual channels is crucial for reproducible results.

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1 Example of a peristaltic pump

Source: ggw - stock.adobe.com

Peristaltic pumps find wide application in modern labs, they are considered inexpensive, easy to use and maintain and, most important of all, are extremely reliable and flexible. The range of application is huge, from simple transfer of a liquid from one container to another in HPLC and Ion chromatographs, to more complex usage as dispensing tools for reagents in flow chemistry. Despite all known limitations related to inferior performance in presence of high back pressure, peristaltic pumps can be considered the 'go to' choice for lab pumps. One of the most interesting and useful features of many peristaltic pumps, is their ability to accommodate two or more cartridges at the same time, thus allowing several flow paths to be operated simultaneously. The flow rate of each single path is defined by the diameter of the tubing and of fluid back pressure, as the rotation speed of the pump head will be equal for all mounted cartridges. As simple as this may sound, it is unfortunately not true. In reality, many more parameters including the inner diameter and age of the tubing, tube tension in the cartridge, dissolved gases, and air bubbles, all can have considerable influence on the actual flow rate in each channel of the peristaltic pump. This study investigates the flow rate obtained from a dual cartridge peristaltic pump equipped with two brand-new lengths of Tygon tubing with identical ID (0.76 mm) experiencing the exact same back pressure at the pump outlet. The flow rate was measured using two Testa Analytical Liquid Chromatography Flowmeters (with certified calibration) rated for flow rates up to 5 mL/min, well within the nominal range of the peristaltic pump. The pump head was a high-resolution, low pulsation type with twelve runners to produce nominal flows as low as 0.053 µL/min and up to 5.3 mL/min with the utilized tubing. The focus was not purely to assess the absolute accuracy of the flow, as any pump can be calibrated to deliver a cer-

LAB TIP

Ypu can find more on this topic at www.lab-worldwide.com, search term **peristaltic pump**

There are several videos about the **flowmeter** from Testa under https://www.testa-analytical.com/videos.html

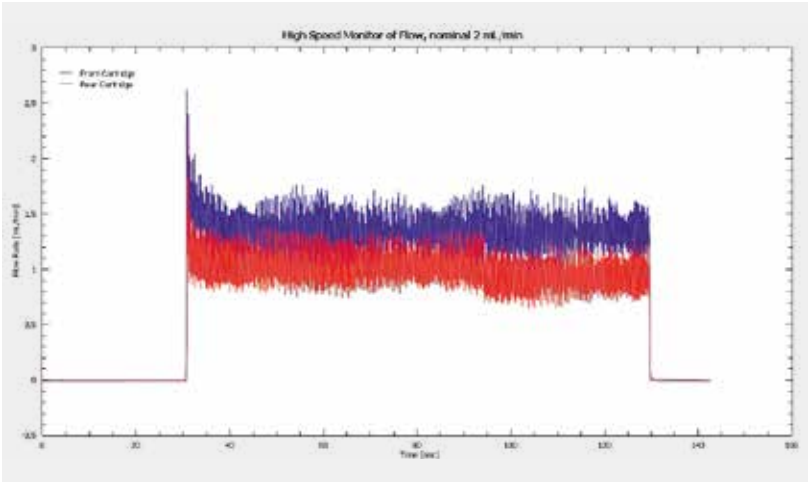
tain flow. In addition, the investigation sought to gain an understanding of individual performances of the peristaltic pump in its two separate path channels and identify differences which might turn to be significant enough to affect the results of an application.

Short Term Flow Fluctuation

Peristaltic pumps, even those equipped with a high number of runners on the wheel (as the one used for these tests), are known to produce a highly fluctuating flow. As a consequence, the first tests were run to determine flow fluctuations produced by the two cartridges installed. For ease of indication, we defined one cartridge to be 'Front Cartridge' and the second 'Rear Cartridge.' We kept this denomination throughout the tests and descriptions in this study. Determination of short-term fluctuation was done by selecting the fastest data acquisition speed (0.078 s). Figure 2 shows data obtained by the two Liquid Chromatography Flowmeters for the two cartridges. The data clearly shows that, although different in terms of flow average, the two peristaltic pump cartridges demonstrated similar flow fluctuations, in the range of 0.5 mL/min. Aside from the difference in absolute flow, both channels seem to operate in a similar fashion.

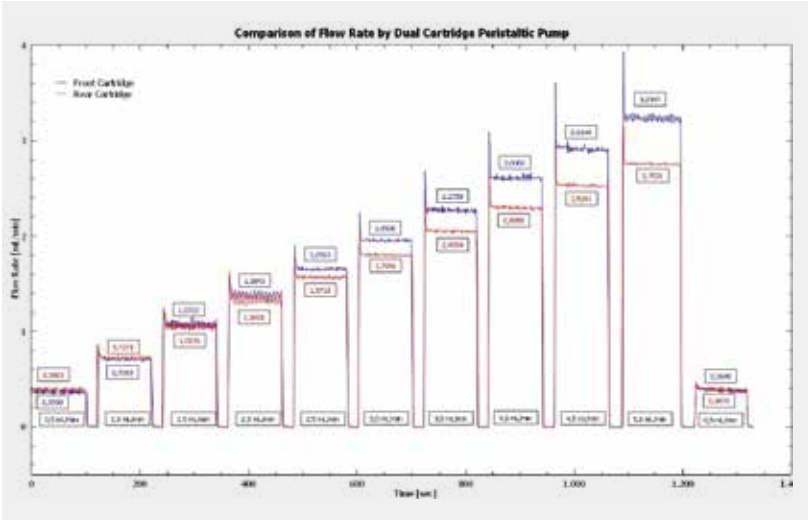
Ramping up the Flow Rate

Once it was determined that short term fluctuations are similar for both cartridges, we then investigated the impact of increasing flow rate. The aim of these tests was to reveal whether the two flow paths operate in a similar fashion across the complete range of flow rates selectable on the peristaltic pump. In doing this, we sought to find out whether the measured discrepancy in average flow rate stayed constant across the range or not. Identical operation across a wide range of nominal flow rates is an important feature when two reagents are to be



Source: Testa Analytical Solutions

2 Data obtained by the two Liquid Chromatography Flowmeters for two cartridges



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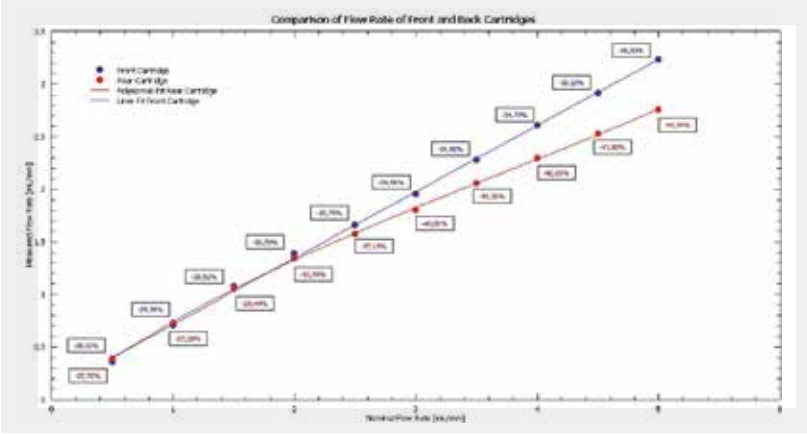
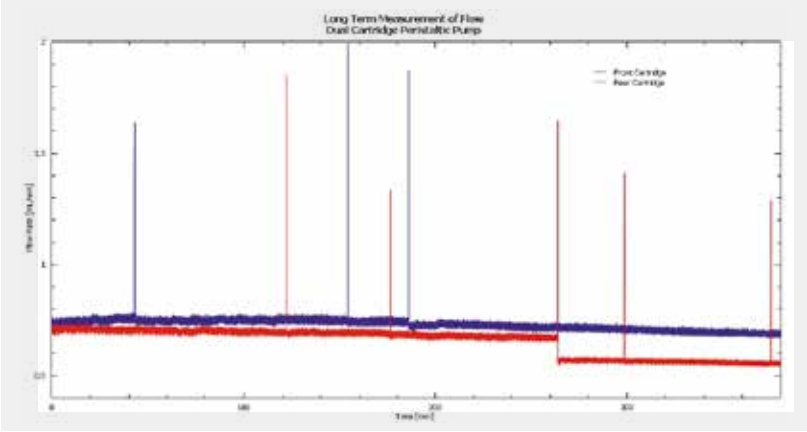
3 Data obtained with the flowmeters for both peristaltic pump cartridges

mixed at equal rates, a common requirement in many flow chemistry applications. The Liquid Chromatography Flowmeter were set for a lower data rate of about 1 Hz or more precisely an integration time of 1.171 s as for this investigation, high frequency pulsation would make evaluation more complicated and also generate a much larger data set which was unnecessary. This test was performed by running the pump at different nominal flowrates in increments of 0.5 mL/min. Between each increment, flow was stopped to make sure conditions were identical for each step of the ramp. Figure 3 shows the monitoring data obtained with the flowmeters for both peristaltic pump cartridges. It is immediately obvious, that the two cartridges perform very differently with regard to flow rate. This difference in effective flow rate is not, what could be expected (i. e., constant), but the difference gets larger at higher flow rates. This is even more evident in Figure 4, where the average effective flow rates are plotted versus the nominal flow rate and percentage error is shown for each step of the ramp. It is apparent from this test that the errors in flow at the front cartridge are almost constant for the complete range of investigation. By comparison, the rear cartridge showed a pronounced deviation from the expected straight-line relationship instead revealing a highly non-linear response with regards to the nominal flow rate.



Source: Testa Analytical Solutions

4 Average effective flow rates versus the nominal flow rate and percentage error



Source: Testa Analytical Solutions

5 Performance of the dual cartridge peristaltic pump on a longer run, over several hours

The Influence of Run Time

One last test we ran was to measure the performance of the dual cartridge peristaltic pump to ascertain how constant flow is on a longer run, over several hours (see figure 5). This investigation revealed a clear negative drift in measured flow rate from both channels of the peristaltic pump. In fact, we found that the effective flow rate practically halved after 10 hours of continuous operation. This long run also shows spikes — an indication of gas or air bubbles being pushed through the system.

Conclusions

The flow rate delivered by two cartridges running on the same peristaltic pump head at the same time is not necessarily identical, even when tubing, back pressure and fluid are identical. Therefore, we have shown that accurate determination of the individual flow in the 2-channel peristaltic pump under investigation is paramount for obtaining reproducible and expected results. In addition, the data shows that time is a parameter of major importance when the absolute value of the flow rate is important to your application (e. g., a multi pump flow chemistry reaction). The Liquid Chromatography Flowmeter has been proven to be an essential tool for optimization of those applications where peristaltic pumps are involved. ■

LAB INFO

How to calibrate HPLC pumps?

To maintain consistent accuracy of results, each and every HPLC pump needs calibration of the flow rate it delivers on a regular base. The traditional method of calibrating HPLC pump flow rate relies upon a gravimetric method in which the total weight of solvent delivered in a given time is determined and transformed into flow rate by taking into account the density of the solvent.

This gravimetric method, although accurate, has some operational challenges. Though the weight of delivered solvent can be determined accurately using modern scales, this weight data must be precisely synchronized with a time measurement which can be challenging. Transforming this data into flow rate (volume/time) requires accurate values of solvent density at the precise temperature the HPLC pump is operating at.

However, even when reliable solutions are found for all the above, this method is still relatively time consuming to determine flow rate repeatably and accurately. As such, the gravimetric calibration of an HPLC pump flow rate can typically take an excess of 30 minutes.