

# Microfluidics and the Essential Role of High Performance Syringe Pumps

High quality syringe pump instruments must deliver accurate fluid volumes, precision flow rates, and optimal functionality

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## Overview

As the complexity of experimental systems and multiplexing platforms continues to grow, so has the need to address the logistics of time, throughput, and costs. Born in the early 1990's, the field of microfluidics emerged to face these needs while offering innovative solutions to previously intractable problems. A simple yet fitting analogy is that of the electronics field. Early devices required excess space, time, and were resource intensive, however, as the power of technology grew, the devices became smaller, faster, and more efficient – and in essence more capable to tackle new and challenging tasks.

With increased performance comes the need for increased precision and reliability. Modern microfluidic devices utilize state-of-the-art fabrication methods and high-performance fluid delivery systems. Moreover, advanced microfluidic devices require high quality syringe pumps designed with precision engineering, robust performance, and versatility to suit the most demanding applications.

## Overview of syringe pumps in microfluidics

Significant improvements in experimental precision has been one of the main strengths of the evolving microfluidics field. With fabrication methods lifted from the semiconductor industry and other sources, device configurations and applications are nearly limitless owing to precision machining and tight manufacturing tolerances. The range of materials, fabrication methods, and fluid delivery sources has made microfluidic devices broadly applicable to the life sciences, biomedical research, and the biotechnology industry and other areas.

Apart from design and fabrication, the most important component of a microfluidic device is the fluid delivery system. Advancements in syringe pump design have been a main driver of microfluidic pump capabilities. As such, precision syringe pumps are now the most common fluid delivery instruments used in modern microfluidic research and applications. Key metrics of syringe pump performance include: capability to support a broad range of volumes, consistency to maintain varying or constant flow rates, and versatility to allow a range of functions such as fluid mixing, oscillation, and push-pull operation among others.

## Metrics of syringe pump quality and performance

The ability to adjust the working range of the instrument by interchanging syringes of different diameters is a valuable feature of high quality syringe pumps. Small syringes enable better control of flow rates but obviously have an upper limit on volume. Larger syringes can accommodate higher volume applications, albeit at the expense of decreased flow rate control. Regardless, versatility, accuracy, and precision of volume control are vitally important aspects of instrument function. High quality instruments should have the capability to deliver a broad range of fluid volume with high precision.

High quality pumps permit accurate monitoring of flow rate. True flow rates of microfluidic systems must take into account the settling time and the stability of the fluid flow. When a syringe piston begins to push (or pull) a fluid through a system, there is a lag in time as the fluid and components of the system adjust according to the elasticity of the materials. It is important to select pumps with optimal performance and consistency in order to accurately measure flow rate -- lack of control and certainty in flow rates are a major culprit in failed experimentation.

Stability of the flow rate is another major consideration for syringe pump performance. Dictated largely by the minimal movement of the syringe pumps, oscillations in the flow rate can arise from instrument performance and suboptimal step movements of the piston motor(s). For this reason, it is important to know the step movement parameters and select pumps with minimal effects of movement on a given microfluidic system.

Depending on the complexity of the system or the need for versatility, optional syringe pump features should include programmable step-rate functionality and dual rate, push-pull, and oscillatory flow rate capabilities. In the end, it is the balance between responsiveness, stability, and the requirements of the system which will dictate the right syringe pump. In this respect, the quality and performance metrics of the pumps will greatly impact the odds of success.

## Microfluidic syringe pump applications

Modern applications of microfluidic devices permeate many fields of research. Cell biological applications include ultrahigh throughput screening of single cells to measure effects of small molecules or drugs. For these investigations, delivery of isolated cells to anchor points within microfluidic channels is accomplished by various methods, such as liquid droplet encapsulation, which require volumes on the nanoliter scale. Once formed, anchored cells undergo perfusion with culture medium, drug formulations, and wash out solution, all which require accurate and precise nanoliter scale fluid delivery. A high-quality instrument is absolutely required to provide the necessary accuracy and precision of nanoliter

fluid delivery. In addition, multiplexed fluid exchange requires an instrument capable of proficient channel switching and features such as versatile syringe rack configurations and parallel dosing functionality.

Other microfluidic applications include systems to monitor the optimal biochemical conditions for enzyme catalysis and substrate binding activities. Biomedical uses include lab-on-a-chip applications such as glucose monitoring or toxicity analyses in research subjects. Regardless of the field of application, syringe pumps are vital components of microfluidic systems and the quality and performance of the instrument is paramount to success.

This article was written by LabX in conjunction with Chemyx.

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