

# Re-defining the concept of a metering pump

**When is a metering pump not a metering pump? When recent technical developments have given it additional capabilities that do not fit into the traditional remit, says Donelle Capriotti, Business Development Director at Wanner Engineering, who suggests that a new definition is required.**

Many types of pumps and systems exist for controlled liquid flow, from closed-loop centrifugal pump systems to positive displacement rotary pumps. The technology demanded in precision chemical injection, however, has long been the reciprocating metering pump. Although metering pump systems are distinguished for their accuracy, linearity and repeatability, traditional metering pumps suffer from operational drawbacks. Inaccuracies in pumping, lost motion, and potential leakage are common during stroke adjustment, and the intermittent, pulsating flow of metering pumps can place strain on the system. A brand of pumps featuring electronic flow control and a multiple-diaphragm design could overcome these encumbrances – even potentially redefining what a metering pump is.

Metering pumps have benefited from advancements in technology in the many years since their

predecessor, the lubricator, first made its appearance on steamships. Packed piston and plunger pumps are capable of a wide range of flows and pressures, but contact of the piston or plunger with the pumped medium requires compatibility of the materials of construction and fluid, which can result in costly replacement and maintenance. Environmental and safety issues involving leakage have also contributed to the decline in popularity of this design, especially when compared to the sealless advantages of the diaphragm metering pump.

## Sealless pumps for accurate dosing

Wanner Engineering Inc manufactured its first Hydra-Cell sealless pumps in the early 1970s, focusing on agricultural applications and the burgeoning car wash market. When analysing the market data it compiled about the use of its pumps, Wanner

Engineering was intrigued to learn that many Hydra-Cell pumps were operating successfully in applications demanding accurate dosing. In many cases, Hydra-Cell was replacing traditional hydraulically balanced, diaphragm metering pumps. Like metering pumps, Hydra-Cell pumps feature hydraulically balanced diaphragms, but also offer electronic flow control, and most models have multiple diaphragms (see Figure 1).

In traditional hydraulically balanced diaphragm pumps, the diaphragm is balanced between two fluids, the process liquid and the actuating medium. This balanced design allows for higher discharge pressure and higher flow rates than are available with the mechanically actuated diaphragm design.

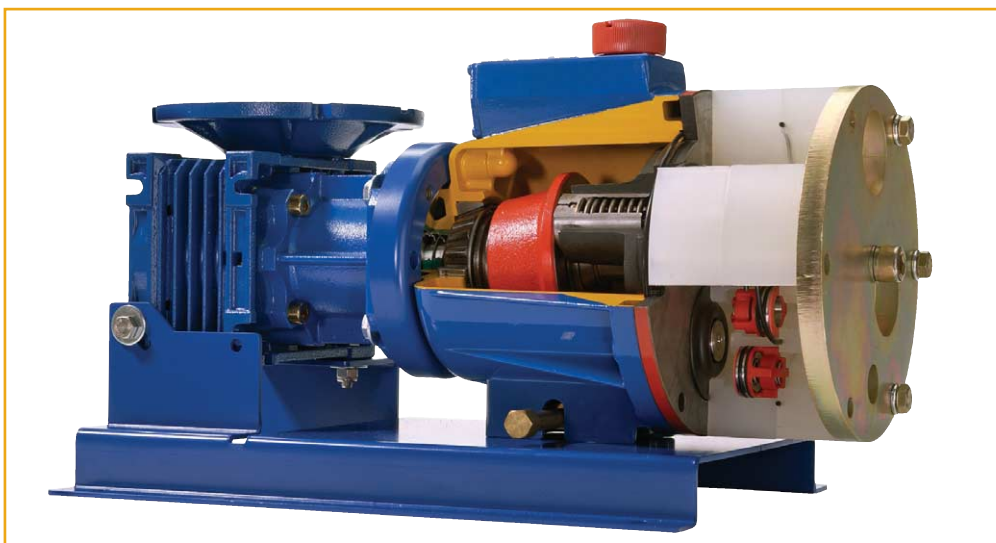
These hydraulically balanced diaphragm metering pumps share several inherent features:

- Primary flow adjustment through change in stroke length via manual control
- Single diaphragm per liquid end
- Pulsating, intermittent flow
- Limited flow and pressure range per plunger, diaphragm and liquid end combination
- Dramatic footprint increases in proportion to flow and pressure capabilities.

## The definition of a metering pump

Over the years, many institutions and associations have developed definitions of metering pumps. Some are industry-specific, such as the American Petroleum Institute's

Figure 1. With a sealless, hydraulically balanced diaphragm design, Hydra-Cell pumps are similar to traditional metering pumps; but also offer electronic flow control and a multiple-diaphragm design.



(API) Standard 675 for controlled-volume, positive displacement pumps. Others have a broader scope, such as that being prepared by the members of the Hydraulic Institute. Regardless of their origination, if these specifications do not react to design and technological improvements, then pumps capable of achieving the same level of precision metering performance with unique design characteristics that differ from, and in many cases improve upon, these specifications may be excluded from consideration. The results of technological advances are most evident in the manner in which flow is adjusted with a hydraulically actuated metering pump. A metering pump's capacity is a function of the diameter of the plunger, the effective length of the stroke and the rate or speed of stroking. Since the diameter of the plunger must remain constant in any given pump, varying the stroke length and pump speed are the only ways to adjust flow. Many years ago,

manual stroke adjusters were added as a feature to metering pumps. Initially, these adjusters could not be used while the pump was operating. Design improvements would later allow for altering stroke length during process.

There are two main classifications for stroke length adjustment. The first, usually referred to as amplitude modulation, varies the radius of eccentricity of the plunger drive mechanism. In basic terms, a slider crank allows the stroke length to be altered by changing the length of a pivot arm, similar to the movement of a pendulum. This is attached to the piston, the stroke length of which corresponds to the size of the arc of the pendulum.

The other classification, referred to as lost motion, can be further subdivided into mechanical and hydraulic lost motion. In mechanical lost motion design, the motor turns a worm shaft, which



rotates an eccentric gear. A cam rotates with the gear and actuates the plunger through a cam follower. As the plunger moves forward on the discharge stroke, it displaces the fluid behind the diaphragm, which in turn displaces the medium being pumped. A spring then retracts the plunger to its original position. Limiting the rearward travel of the plunger changes the stroke length and the resulting flow rate. Hydraulic lost motion involves a change in the effective, as opposed to the actual, stroke length. In this design, the plunger reciprocates the entire

Figure 2. Typically less expensive than electronic actuators, variable frequency drive (VFD) motors and controllers provide full stroke length, thus improving accuracy, eliminating lost motion, and eliminating a potential leak path in metering and dosing applications.

length of the stroke, but a portion of the actuation fluid is deflected through a bypass valve.

## Technological development

As automation gained in popularity, pneumatic and electronic actuators were attached to the stroke adjustment mechanism for both amplitude modulated and lost motion metering pumps. Although they provide a level of convenience, the slow rate of change (typically 1 second/1% of stroke length) results in pumping inaccuracies during the adjustments.

Recently, the use of variable speed drive motors (VFD) to change stroke speed rather than length has grown (see Figure 2). AC and DC drives can respond more quickly, with approximate speeds

of 0 to maximum RPM in 0.5 and 1.3 seconds, respectively. Faster flow correction results in greater long-term accuracy. VFD motors are often less expensive than the electronic actuator alternative. Improvements to reliability, repeatability and linearity performance are other benefits of the AC drives. Many of these drives are available with turn down ratios of 1000:1, which are as good or better than those that can be achieved using the electronic actuator in conjunction with the manual stroke adjuster.

Since full stroke length is considered optimum for metering pump performance, changing speed as opposed to stroke length to alter flow has gained acceptance, lessening the importance of a manual stroke adjustment mechanism. Hydra-Cell Metering Solutions pumps, for example, address flow changes using only VFD motors and controllers, always at full stroke length.

Common among most metering pump designs is the single diaphragm configuration, responsible for the non-linear flow accepted as a 'necessary evil' of metering systems. Hydra-Cell Metering Solutions pumps have as many as five diaphragms per liquid end, each with a corresponding set of valves and pistons. The virtually 'pulse-free' flow characteristics of these multi-diaphragm pumps eliminate many issues long considered inevitable by reducing acceleration losses and pipe strain. This can remove the need for dampeners in the system and expand application opportunities to those requiring linear flow.

To illustrate the effects of pulsation, Wanner Engineering conducted a test of a Hydra-Cell Metering Solutions multi-diaphragm pump and a typical, single hydraulically balanced diaphragm metering pump operating under identical flow and pressure conditions to record the pressure traces (see Figure 3).

Traditional metering pumps can minimise pulsations with dampeners and by multiplexing together several pumps, sequencing the diaphragm

strokes. These options, however, add significant costs, size and maintenance to the system. With such metering pumps, the sizes of the plunger, diaphragm and liquid end increase to correspond to increased flow and pressure demands. Conversely, a pump designed like the Hydra-Cell pump can offer major advantages because the wet end can remain constant and the gearing, by employing different gearboxes with different ratios, is the only difference covering a wide range of flows and pressures. Changes in process requirements can be addressed with the change of a gearbox alone. This reduces acquisition, maintenance and downtime costs for the pump.

These size increases, which also include the drive cases for many manufacturers, may result in massive footprints at higher flows and pressures. A smaller Hydra-Cell pump is capable of producing the same capacity ratings as large multiplex systems, while still meeting API 675 performance standards for steady-state accuracy, linearity and repeatability (See Figure 4).

VFD motors in lieu of manual and electronic stroke adjusters to increase response time and accuracy. Multiple diaphragms per liquid end that virtually eliminate pulsations. Interchangeable gearboxes that broaden the performance envelope. These changes may provide solutions to user problems, but they also exclude Hydra-Cell pumps from the strict definition of 'metering pumps' or 'controlled volume, positive displacement pumps'. Just as the technology behind the traditional metering pump redefined applications once dominated by lubricators, packed piston, and plunger pumps, will new technology change our definition of a metering pump?

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Figure 3. Operating under the same conditions at the same flow and pressure, the multiple-diaphragm designed Hydra-Cell pump provides a smoother performance than a that of the traditional, single-diaphragm metering pump.

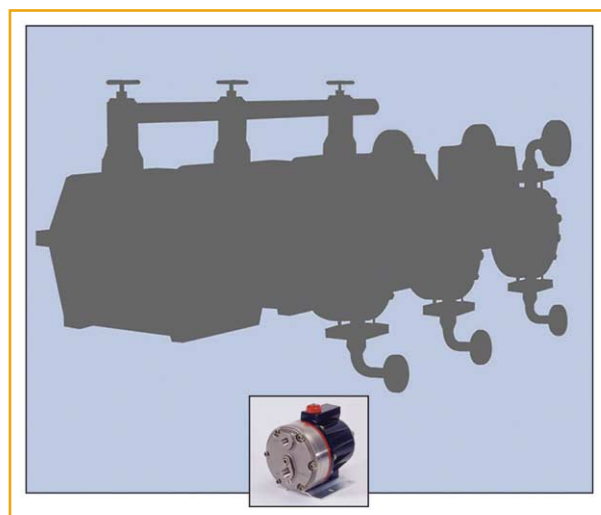
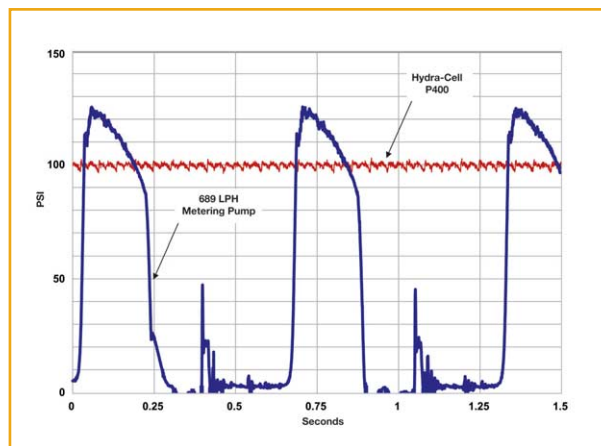


Figure 4. A traditional triplex metering pump arrangement, outlined in the background from a photograph taken atACHEMA 2006, is shown to scale with a Hydra-Cell pump (less motor) in the foreground. Both are hydraulically balanced diaphragm pumps that can meet API 675 standards for steady-state accuracy, linearity and repeatability, yet both are capable of producing 1500 lph at 80 bar.