WATER & WASTES DIGEST

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Valveless Methanol Metering for Effluent Denitrification

The release of high nitrogen concentrations of wastewater effluent into bays and watersheds is of great environmental concern as it can have a devastating effect on water ecosystems. Nitrogen is an end-product of the bacterial degradation of ammonia, which is present in high levels in untreated wastewater.

In its various forms, nitrogen can deplete dissolved oxygen in receiving waters, stimulate aquatic plant growth, and exhibit toxicity toward marine life, as well as present a public health hazard. Wastewater effluents containing nitrogen can cause eutrophication, the excessive growth of plant and algae blooms in lakes, streams and rivers that deprive oxygen and sunlight from marine life. Nitrate is a primary contaminant in drinking water and can cause a human health condition called Methemoglobinemia, in which the oxygen carrying property of hemoglobin is altered.

There is little controversy that the levels of nitrogen created during the wastewater treatment process must be significantly reduced before being discharged into the environment. The challenge, however, is to apply a method to not only reduce the nitrogen present in the effluent, but if possible, do so at an economical cost.

Through a process known as "denitrification", water treatment facilities convert the excess nitrate into nitrogen gas which is then vented into the atmosphere, thus eliminating its ability to cause algal bloom in watersheds and block oxygen and sunlight from reaching marine life below the surface. There are several processes that are commonly used to accomplish this, most of which utilize pre-treatment basins, aeration tanks and blowers. However, for nearly 200 wastewater treatment plants in the US, the answer is a process which involves the addition of methanol into the effluent accelerating the activity of anaerobic bacteria that break down harmful nitrate.

Methanol is a volatile, light, colorless, flammable and biodegradable liquid readily available from suppliers. It's also estimated that methanol denitrification costs are about 1/8 of the cost associated with other methods used.

In most cases, methanol is added into the effluent stream using a metering pump. The type of pump used can vary but needs to meet certain application requirements. Two key areas include chemical compatibility of wetted parts and electrical ratings for the area where the pump is

being installed. Methanol is an alcohol that is considered an organic polar solvent. Therefore, all wetted parts need have a degree of chemical resistance. Methanol is also both volatile and flammable, and therefore the metering pump used will need to meet approvals for use in hazardous locations.

Diaphragm pumps have been traditionally used for metering methanol for wastewater treatment applications. However, there is an alternative metering technology that has only one moving part in the fluid path thereby eliminating internal check valves present in diaphragm as well as other reciprocation pump designs. The technology is called "CeramPump®", and relies on only one moving part, a rotating and reciprocation ceramic piston to accomplish both the pumping and valving functions. This technology is extremely precise and works particularly well in low flow volume wastewater treatment operations typical of colleges, hospitals, and small rural communities, to name just a few. The use of sapphire-hard, dimensionally stable ceramic internal components allows for the precision manufacturing of internal components with extremely tight clearances. This, as well as the elimination of multiple check valves provides a metering pump that can self-prime down to the microliter range, and never lose prime due to air bound or check valves that don't seal well enough to prevent backflow at very low flow rates.

For metering methanol in the denitrification process, the CeramPump® is driven by a 1/3 HP hazardous-duty motor rated for Class I, Group C,D; Class II, Group E,F,G. The photo below is an installation in a non-heated outdoor enclosure at a community college wastewater treatment plant.

Photo 1

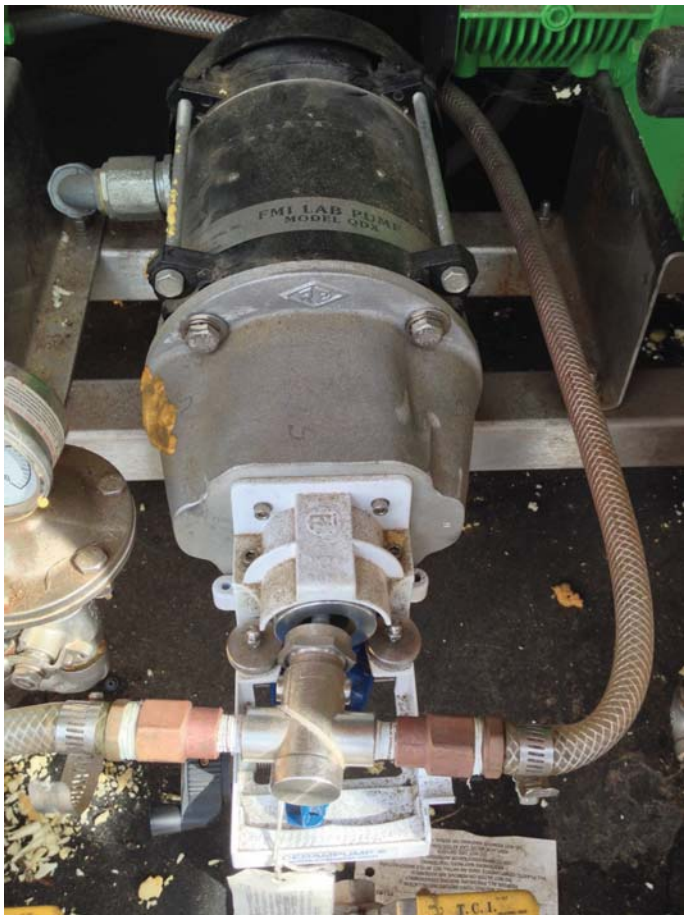

Photo 2

CeramPump® Basics

The CeramPump® is a low volume piston pump, which uses one moving part to accomplish both the pumping and valving functions thereby eliminate check valves which are present in all other reciprocating (syringe, diaphragm, bellows, piston) designs. The CeramPump® uses a unique rotating and reciprocating ceramic piston, moving within a precision mated ceramic liner to accurately pump fluid in one direction without allowing any backflow. The reciprocation action of the piston acts very similar to a standard piston pump. As the piston moves back, it draws fluid into the pump chamber. As it moves forward, fluid is pushed out of the pump.

However, what is truly unique is that in addition to reciprocating, the piston also simultaneously and continuously rotates in one direction. The piston is designed with a flat cut into the end closest to the inlet and outlet port *(See figure 1).* As the piston rotates, the flat is alternately aligned with the inlet and outlet port, essentially functioning as a valve. At no time is the inlet and outlet ports interconnected, and therefore the need for check valves is eliminated. One complete synchronous rotation and reciprocation is required for each suction and discharge cycle as shown in figure 1.

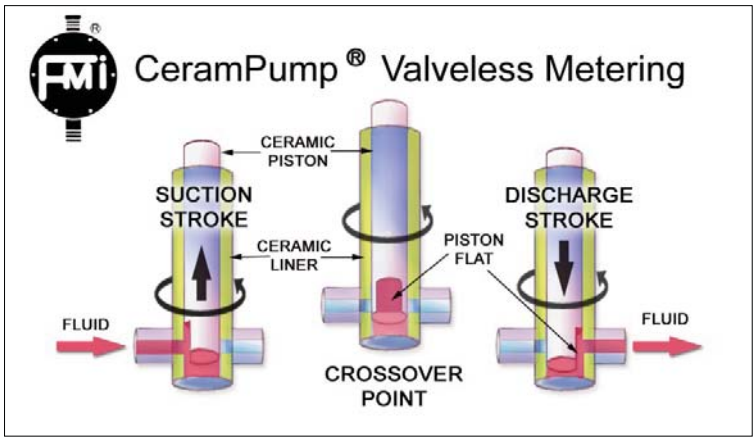

Figure 1

Easy Adjustment of Flow Rate & Dispense Volume

The piston displacement (or volume pumped per stroke) is variable and controlled by the angle of the pump head to the drive. When the pump angle is zero, the pump head is in straight alignment with the drive, the flow is zero. In this situation, there is no reciprocation and the piston is only rotating. As the angle of the pump head increases above zero in either direction with respect to the drive, the piston reciprocates, and fluid is moved through the pump *(See figure 2)*. The greater the angle, the greater the displacement (piston stroke) per cycle. Adjustment is infinite between zero and 100% and a flow rate indicator provides for accurate and simple linear calibration. The pump is designed so that at any angle and flow rate, the piston always bottoms for maximum bubble clearance. This is especially important at very small dispenses and flow rates, as the presence of even a minute bubble will significantly affect accuracy.

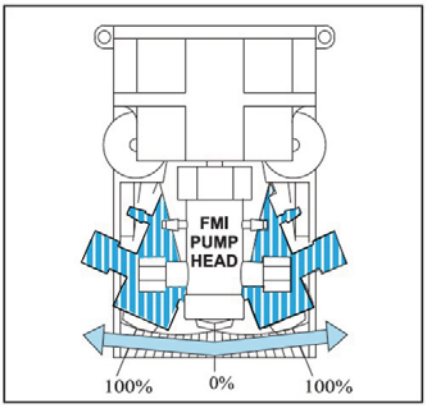

Figure 2

CeramPump® Features Summary:

One Moving Part Valveless Design
The valveless feature of the CeramPump® design is its most significant feature. There are typically four check valves present in diaphragm, bellows, and traditional piston pumps. Even during normal operation, these will wear over time and not seal properly allowing backflow. When this occurs, accuracy will begin to drift, and minimally the pumps will need periodic recalibration. Eventually, the check valves need to be serviced.

Ceramic Internals
The CeramPump® uses sapphire-hard ceramics for both the piston and mated liner. These components are dimensionally stable, in that they will not change shape or dimension over time. They are also wear resistant and chemically inert. As a result, the volume of the pumping chamber remains stable for millions of dispenses eliminating the need for recalibration.

Accuracy & Precision
Consistency in dispensing can be measured by monitoring both the accuracy and precision of the dispenses. Accuracy is a comparison of the average value of the dispense volume compared to the desired or target value. Precision is the range or degree of variation from dispense to dispense. FMI's CeramPump® will maintain a precision of 0.5% or better. (*See figure 3)*

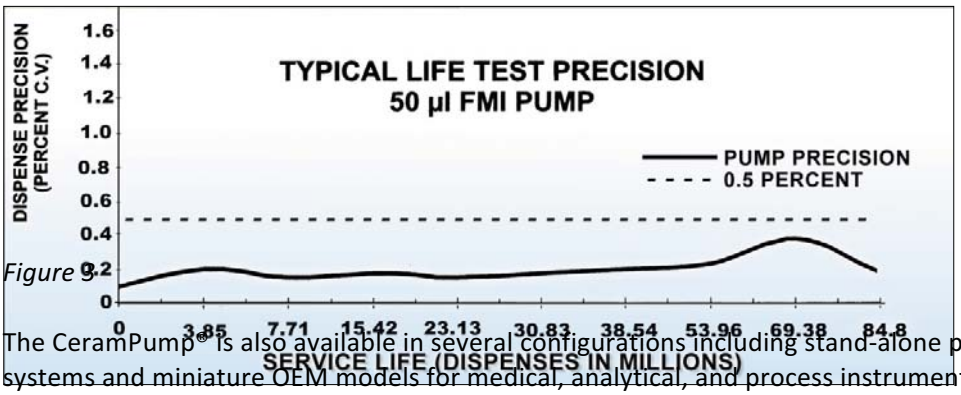

Figure 3

The CeramPump® is also available in several configurations including stand-alone production dispensing systems and miniature OEM models for medical, analytical, and process instrumentation.

Examples of the versatility of FMI's Valveless CeramPump® chemical metering applications:

- Micro-fluidic handling of blood samples & reagents for medical diagnostic instrumentation.

- Sampling air & water for environmental analyzers
- Metering concentrated water treatment chemicals for municipal drinking water disinfection.
- Metering liquid fertilizers and pesticides for ultra-low volume agricultural spraying.
- Addition of nutrients, flavors & colors for food and dairy processing
- On-site blending of performance additives for diesel and home heating oil.
- Dispensing of electrolytes for manufacturing button cell batteries.
- Injecting hydrazine into boiler feed lines for corrosion resistance
- Dispensing of UV curable adhesives, 2-part epoxies, solvents and lubricants used for assembly of disposable medical components.
- Metering and injection of acids and solvents used in hydrometallurgy mining to extract uranium and other ores.
- Chemical feed in a broad array of CPI industries including the manufacture of paints, pigments, plastics, specialty papers, adhesives, foundry & metal stamping products, electronics & semiconductor components.
- Dispensing micro-volumes of a conductive fluid (ferrofluid) for the manufacture of audio speakers, headphones, and ear buds.

About Fluid Metering, Inc.

Located on Long Island about 30 from New York City, Fluid Metering, Inc. patented the first rotating and reciprocating valveless pump and has been providing fluid control solutions for medical, analytical, chemical process, and industrial applications for over 50 years. In each of these markets FMI pumps can be found from the laboratory to the production floor, incorporated into OEM equipment and instrumentation, as well as process control and field installations.

About the Author

Herb Werner has been the Marketing Manager for Fluid Metering, Inc. for 19 years with over 35 years fluid control experience in chemical process, water treatment, medical & analytical instrumentation, pharmaceutical, and semiconductor industries. He has a B.S in Environmental Biology and is an active member of ISA, AWWA, & WEF societies.

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