BIO·CHEM
BECAUSE SUPPORT MATTERS

How BioChem Built a Pump to Last Longer than the Instruments in which it is Installed

Customers expect premium products backed by premium service. They also need to control cost. Most component suppliers address demands from the market for improved cost by designing products with diminished performance.

Why should customers have to sacrifice value? Why can't they get more than they pay for?

BioChem Fluidics, a New Jersey based veteran manufacturer of high-purity specialty valve products, was ready to design a piston pump. Not just a typical piston pump. Something truly unique. A piston pump that met or exceeded every functional specification of typical piston pumps, but one which they would prove will continue to deliver premium performance for 10 million dispenses at 100% duty cycle, which is easily twice as long as other leading suppliers claim similar pumps will perform.

The BioChem Maestro Piston Pump, delivers more value than traditional piston pumps in its class.

A piston pump is used in a fluidic system when the dispense accuracy of a diaphragm pump or a peristaltic pump is not sufficient. BioChem has optimized and validated a piston pump product line that will deliver the longest life and best accuracy of any other pump in its category. This report is a summary of the testing that confirms these claims.

Life/Endurance Improvement

Historically, the failure mode for most piston pumps on the market is usually the seal. When used with clean fluids, 3 million to 5 million cycles might be possible. With aggressive or precipitating fluids, the life expectancy of a piston pump has been even less, and generally a flushed seal chamber is utilized to maintain the piston in a "wet" environment.

BioChem set out to design and validate a piston pump that will provide 10 million cycles with clean fluids and 5 million cycles with aggressive or precipitating fluids. BioChem set out to do this with improvements in design and tolerances of all the components of the piston pump (such as the seal, body, step motor and piston).

Scope of Piston Pump Testing

- **Pump Sizes Tested**: 50, 100, 250, 500, 1000, 2500 and 5000ul
- **Pump Materials**:
    - Head: PMMA or PEEK
    - Piston: Ceramic or PEEK
    - Seal: UHMWPE (standard or with flushed chamber)
- **Pump Configurations:**

    - Maestro (PMMA head and ceramic piston)
    - Maestro PEEK (PEEK head and PEEK piston)
    - Maestro Flushed Seal (acrylic head, ceramic piston with flush chamber)
- **Quantity Tested Per Size**: 5 pumps per size, 10 pumps for 500ul
    - Maestro, with DI water, 5 pumps per size, 10 pumps for 500ul
    - Maestro PEEK, with DI water, 5 pumps per size, 10 pumps for 500ul
    - Maestro Flushed Seal, with DI water, 5 pumps per size, 10 pumps for 500ul
    - Maestro PEEK, with 10% Acetic Acid, 10 pumps for 500ul
    - Maestro Flushed Seal, with 10% Sodium Hydroxide, 10 pumps for 500ul
- **Accuracy Goal**: within 0.5% of selected dispense volume
- **Precision Goal**: < 0.2% Cv
- **Pressure Decay**: ≤ 2% at 30PSI for 60s
- **Life Cycle Test Goals**: 10 million full aspiration/dispense cycles for DI water; 5 million for aggressive fluids
- **Test Fluids**: Water, Sodium Hydroxide, Acetic Acid

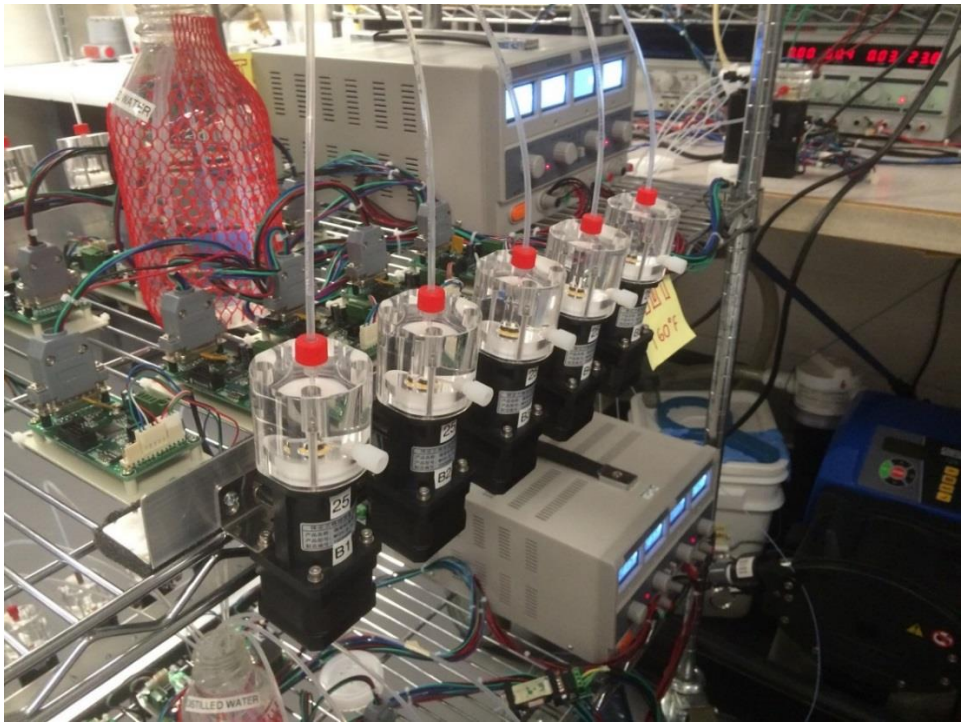


Figure 1 Example Test Fixture

Test Protocol

- Pumps were placed into our proprietary endurance test system where they were cycled at the maximum operating speed (one full aspirate and dispense per second).
- Each pump was tested for accuracy, precision and seal integrity upon initiation and at each subsequent million cycles. All pumps utilizing DI water were cycled until each reached 10M cycles. The 50ul, 500ul, and 5000ul pumps were tested at each million cycles until 10M cycles. The other sized pumps were tested at each million cycles until 6M cycles, then continued to be cycled from 6M to 10M and final data collected at 10M cycles. All pumps utilizing other solutions were tested until 6M cycles.
- Seal integrity was confirmed by performing a leak-down test where the pump head is pressurized to 30PSI for 1 minute and pressure decay was recorded. A pressure decay of 0.6PSI was considered to be a passing test.
- Dispense volume accuracy and precision were measured by a precision scale and the known mass of the test fluid. Accuracy error of 0.5% or less and Cv of 0.2% or less was considered to be acceptable.

Test Results –DI Water (See Appendix A to review actual test data)

- Maestro pumps passed the leak-decay tests and met the accuracy and precision goals up to 10M cycles between 10% and 100% of total dispense volume. Maestro pumps continue to meet the accuracy goals of less than 0.5% down to as low as 2% of dispense volume, while Cv increased to less than 0.5% as low as 2% of dispense volume.
- Maestro Flushed Seal pumps passed the leak-decay tests and met the accuracy and precision goals up to 10M cycles between 10% and 100% of total dispense volume. Maestro Flushed Seal pumps continue to meet the accuracy goals of less than 0.5% down to as low as 2% of dispense volume, while Cv increased to less than 0.5% as low as 2% of dispense.
- Maestro PEEK pumps passed the leak-decay tests and met the precision goals up to 10M cycles between 10% and 100% of total dispense volume, while the accuracy of these pumps were found to be within 0.8% between 10% and 100% of dispense volumes. Maestro PEEK pumps continue to meet the accuracy within 0.8% down to as low as 1% of dispense volume, while Cv increased to less than 0.9% as low as 2% of dispense volume. These slight differences are expected and directly related to the ability to control extremely tight tolerances on the PEEK piston as compared to ceramic.

Test Results –10% NaOH (See Appendix B to review actual test data)

- At 5M cycles Maestro Flushed Seal test pumps passed the leak-decay tests and met the accuracy and precision goals between 10% and 100% of total dispense volume. We expect the same behavior of these pumps below 10% dispense volume as we have experienced with DI water.

Test Results –10% Acetic Acid (See Appendix C to review actual test data)

- At 3M cycles Maestro PEEK test pumps have currently passed the leak-decay tests and met the accuracy and precision goals between 10% and 100% of total dispense volume. We expect the

same behavior of these pumps below 10% dispense volume as we have experienced with DI water.

Figure 2 Test Pumps

Test Conclusions

BioChem embarked on a journey to develop a superior, cost effective pump for the scientific instrument market. We accomplished this with extreme attention to design detail, ensuring component stack up was minimized in this complex assembly; we did this thru careful choices of materials to maximize performance, life, and compatibility with aggressive fluids; we accomplished this by ensuring we can

hold the tightest of tolerances with our vertically integrated machining and manufacturing capability; and we accomplished this with our relentless desire to learn and to be the best, by ensuring what we dreamt up could withstand the harsh environments and expectations of life in scientific instrumentation. During this journey we successfully tested over 150 pumps of various sizes, design, and material construct, to validate performance expectations in all configurations. We validated design inputs and performance with key customers. As the test summary states above, BioChem performed thorough and aggressive validation testing beyond what typical suppliers publish. This is because BioChem is not a component supplier. We are a solution supplier. BioChem deliberately tested units with 10% NaOH and 10% Acetic Acid solutions to simulate abusive conditions seen in the market today, to ensure that the Maestro will exceed the current expectations of the market. While others may have performed similar testing, BioChem is the only supplier to publish proof of validation testing under such difficult conditions.

Employing components designed with such exacting attention-to-detail provides confidence. Considering further that the piston pump is the most critical component to fluidic system accuracy and reliable performance, it is safe to say that BioChem's focus and dedication to delivering the highest performing pump on the market will have its customers beaming about the quality of their instruments.

The Maestro is the best pump on the market.

Comparison of Maestro and 2 Common Competitive Pumps		Maestro	Competitor A	Competitor B
Pump Head	Acrylic	•	•	•
	PEEK	•	•	•
	Ultem®	•	•	
Piston	Zirconia Ceramic	•	•	•
	PEEK	✓		
Seal Ring	UHWM-PE	•	•	•
	Viton O-ring	•	•	
Lead Screw Pitch	20	•	•	•
	30	✓		
	40	•	•	
Pump Life	10 Million Cycles with Distilled Water	✓		
	5 Million Cycles with NaOH or Similar	✓		

It is also easy to implement into existing instruments. BioChem has considered the "drop-in-replacement" concerns that most OEMs have when replacing critical components. No custom or special software is needed to drive the standard stepper motor of the Maestro.

With a competitive price, low cost to implement, and longer life, the ROI is clear.

Summary

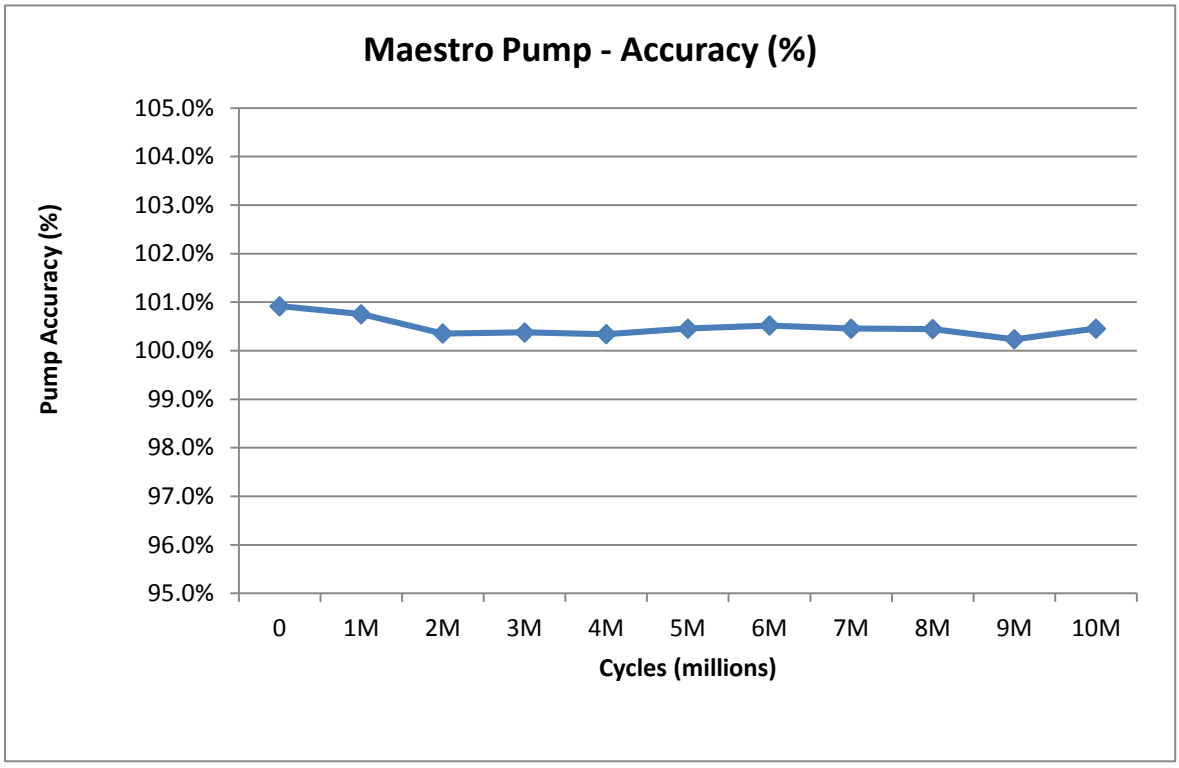
BioChem, a company traditionally known for supplying valves, has designed a new piston pump. The Maestro Piston Pump lasts for up to 10 million cycles at 100% duty cycle while maintaining ≥ 99.5% dispense accuracy and precision of < 0.2% Cv. It is a drop-in-replacement for other pumps in its category.

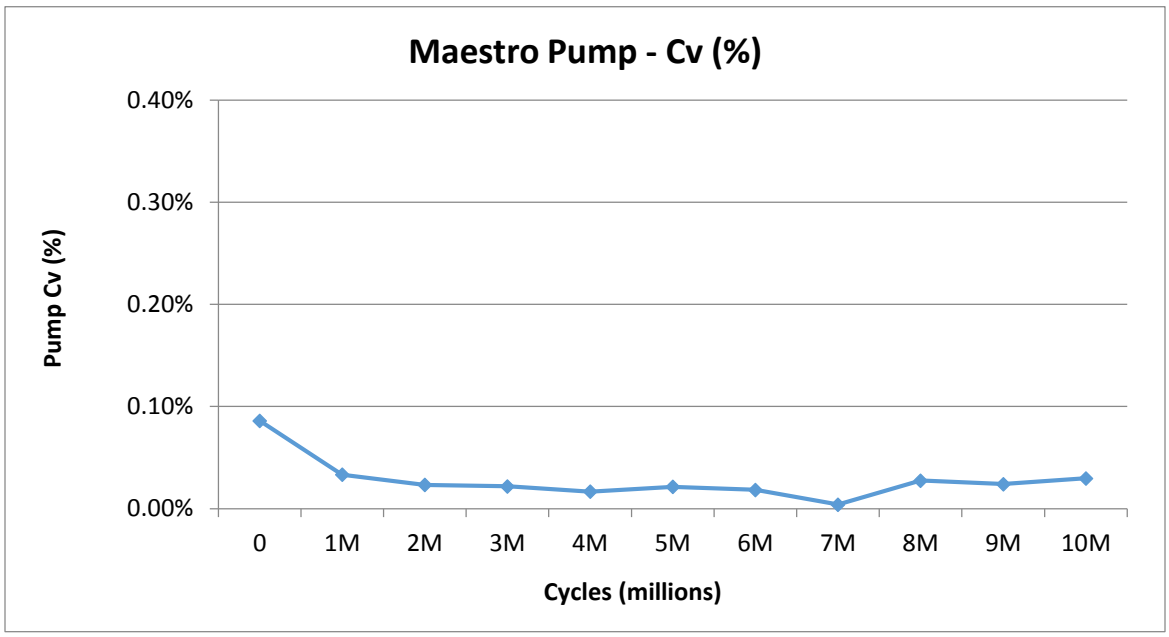
Maestro sets a new standard for functional excellence, provides greater value and is capable of outlasting the serviceable life of many of the instruments in which it is installed.

If you need to precisely move 500nL to 5000µL of liquids, the Maestro Piston Pump from BioChem is the only pump to employ. Don't miss out on your chance to evaluate this exciting new product.

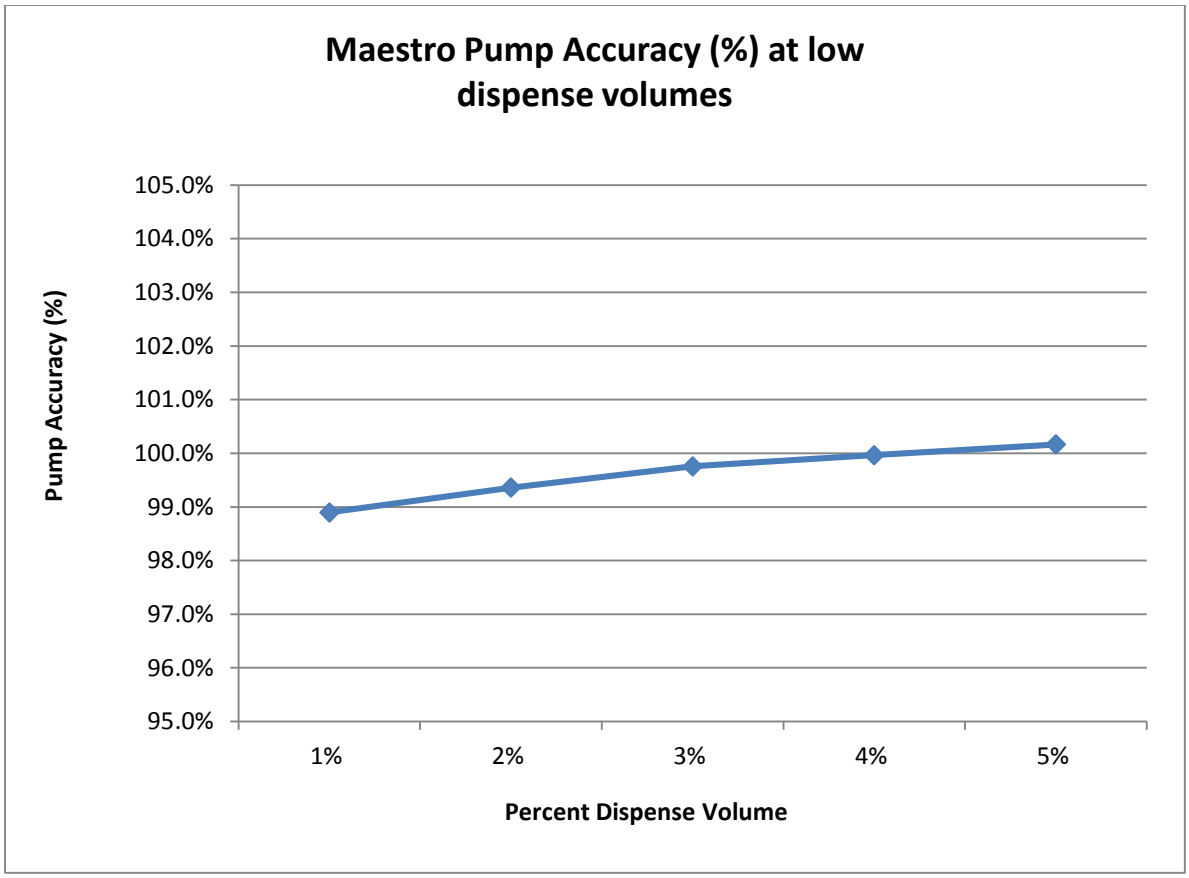
Figure 3 Maestro Piston Pump

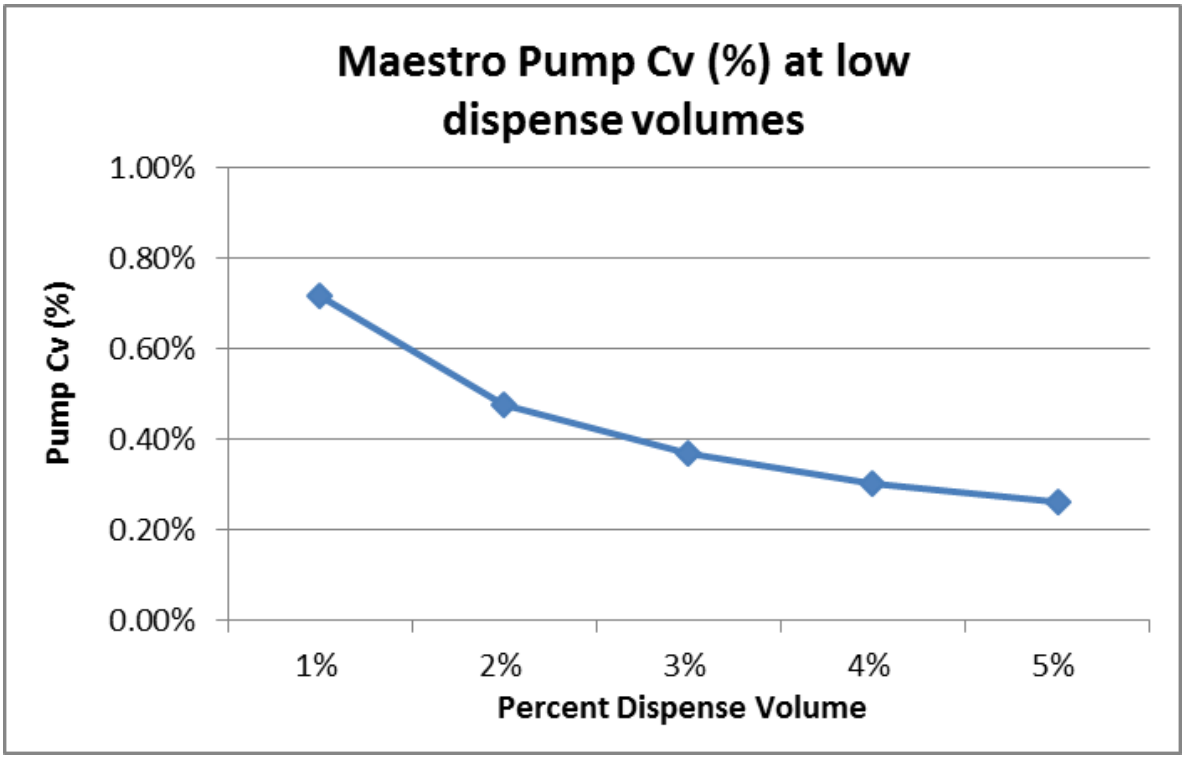
Appendix A

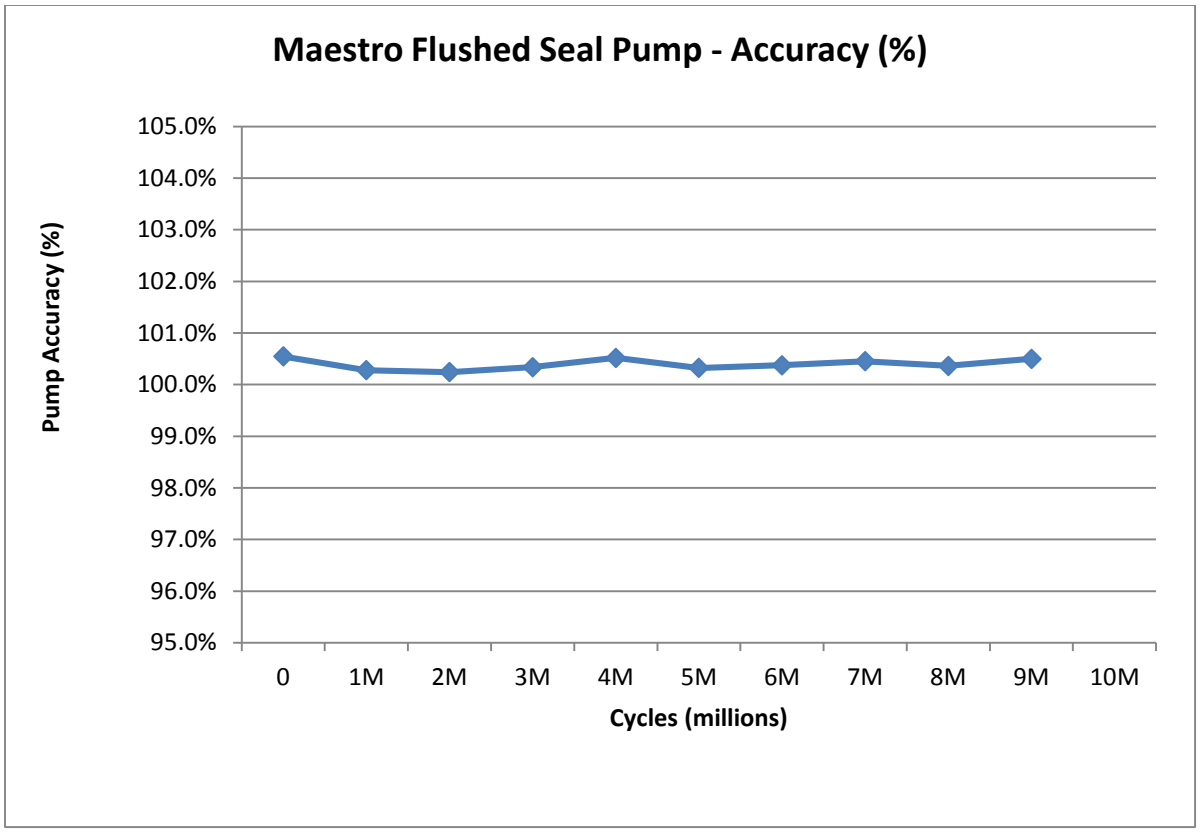


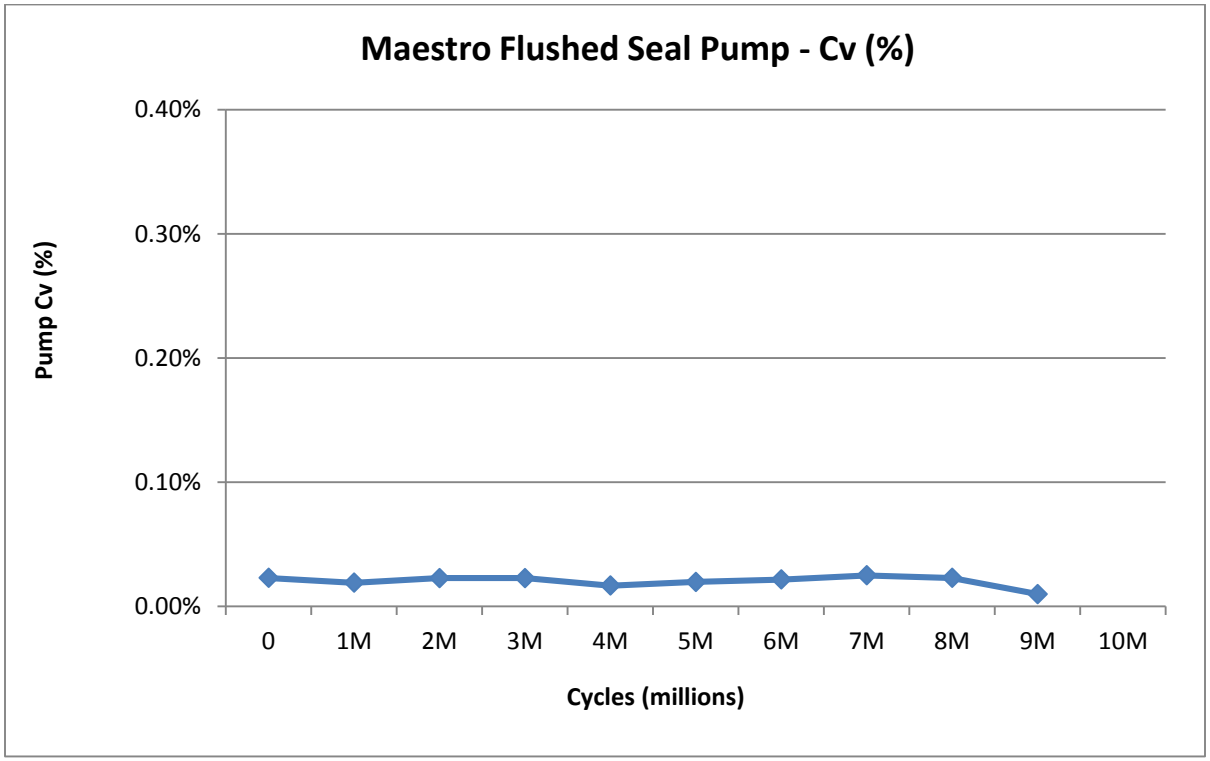


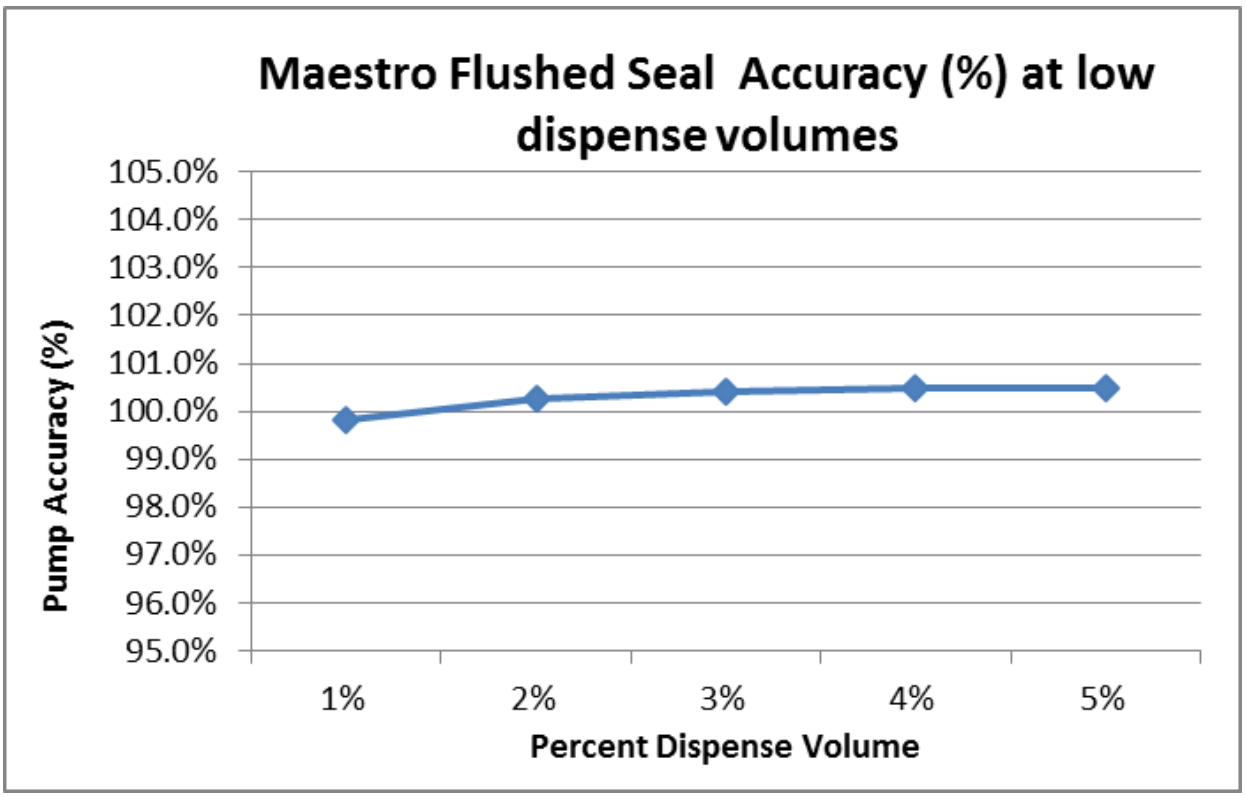
Note accuracy and precision measurements for these pumps at baseline and 1M cycle time-points were performed on a 4 digit scale; all subsequent measurements were made on a 5 digit precision scale, which is the cause for the shift in accuracy.

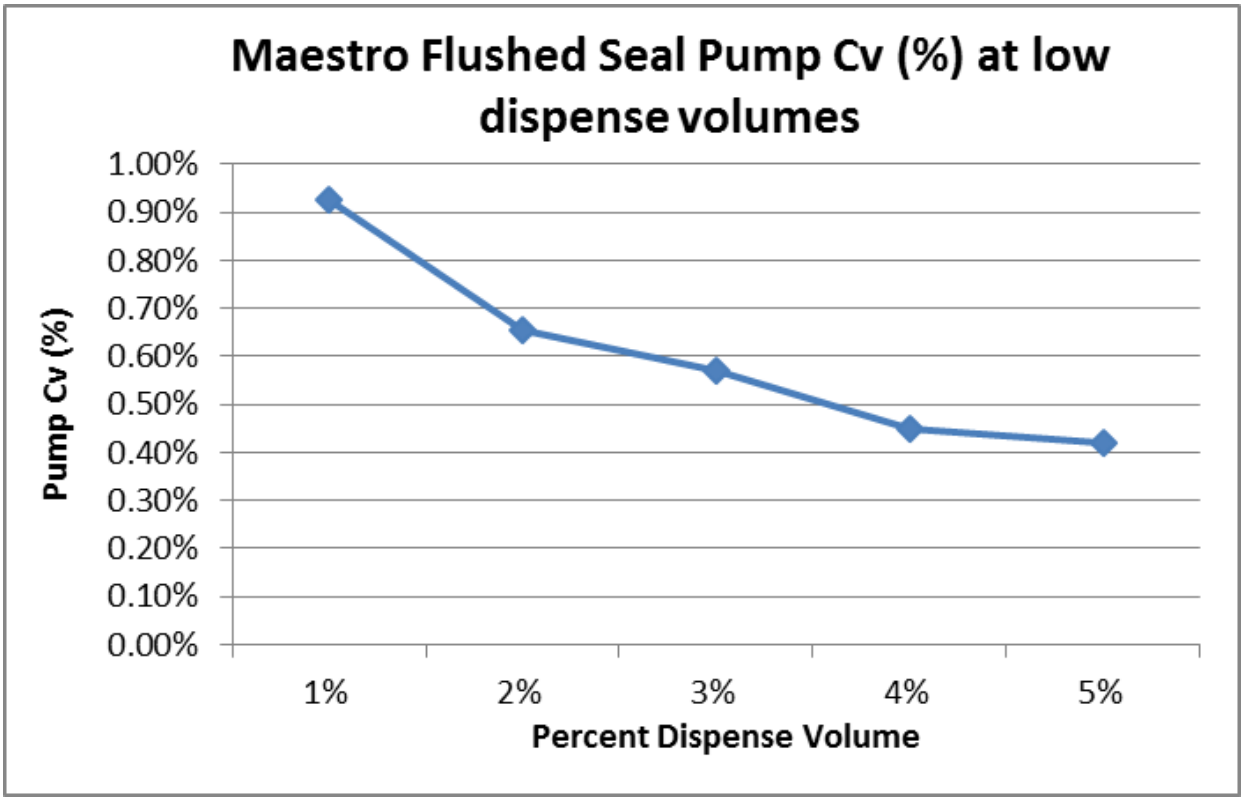

Maestro Pump Accuracy (%) at low dispense volumes
Pump Accuracy (%)
105.0%
104.0%
103.0%
102.0%
101.0%
100.0%
99.0%
98.0%
97.0%
96.0%
95.0%
1%
2%
3%
4%
5%
Percent Dispense Volume

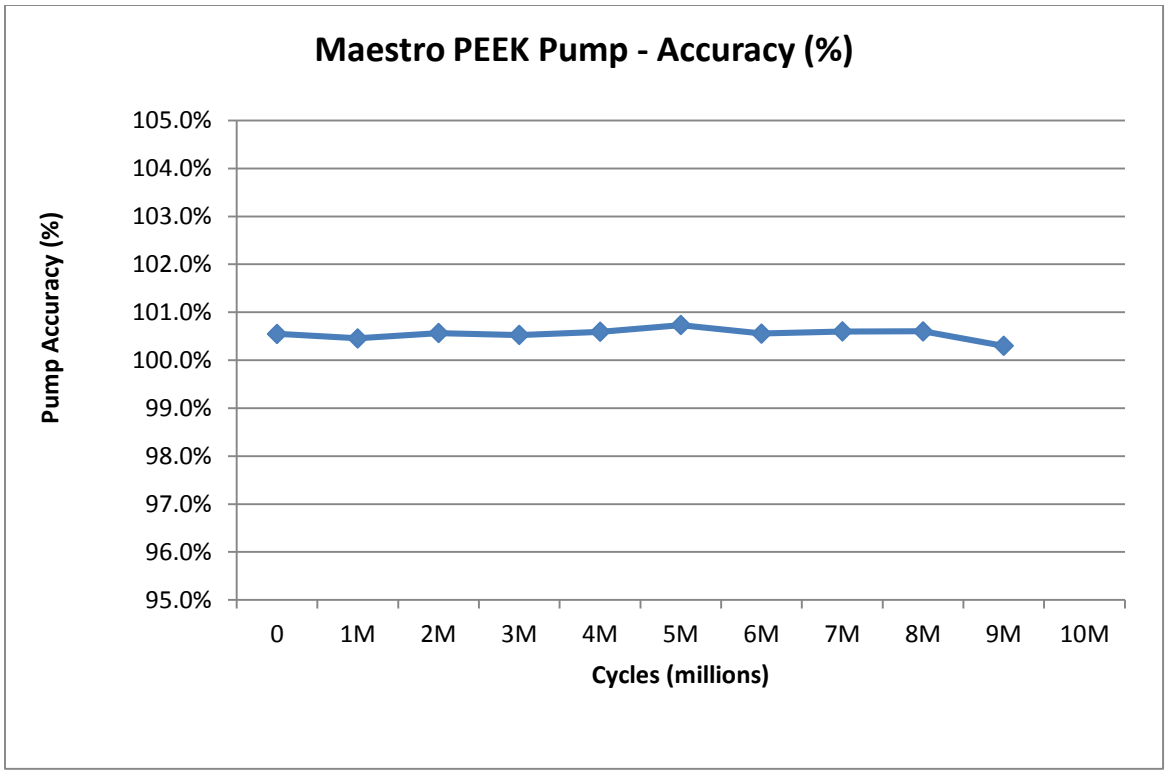

Maestro Pump Cv (%) at low dispense volumes
Pump Cv (%)
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
1%
2%
3%
4%
5%
Percent Dispense Volume

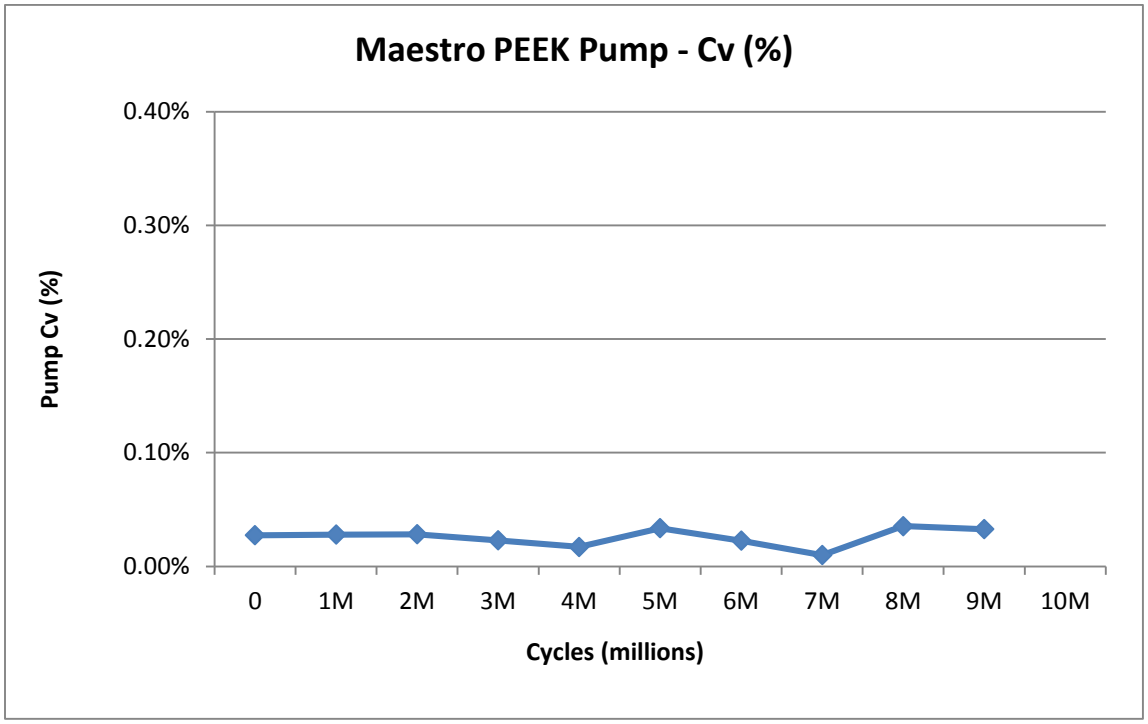

Maestro Flushed Seal Pump - Accuracy (%)
Pump Accuracy (%)
105.0%
104.0%
103.0%
102.0%
101.0%
100.0%
99.0%
98.0%
97.0%
96.0%
95.0%
0
1M
2M
3M
4M
5M
6M
7M
8M
9M
10M
Cycles (millions)

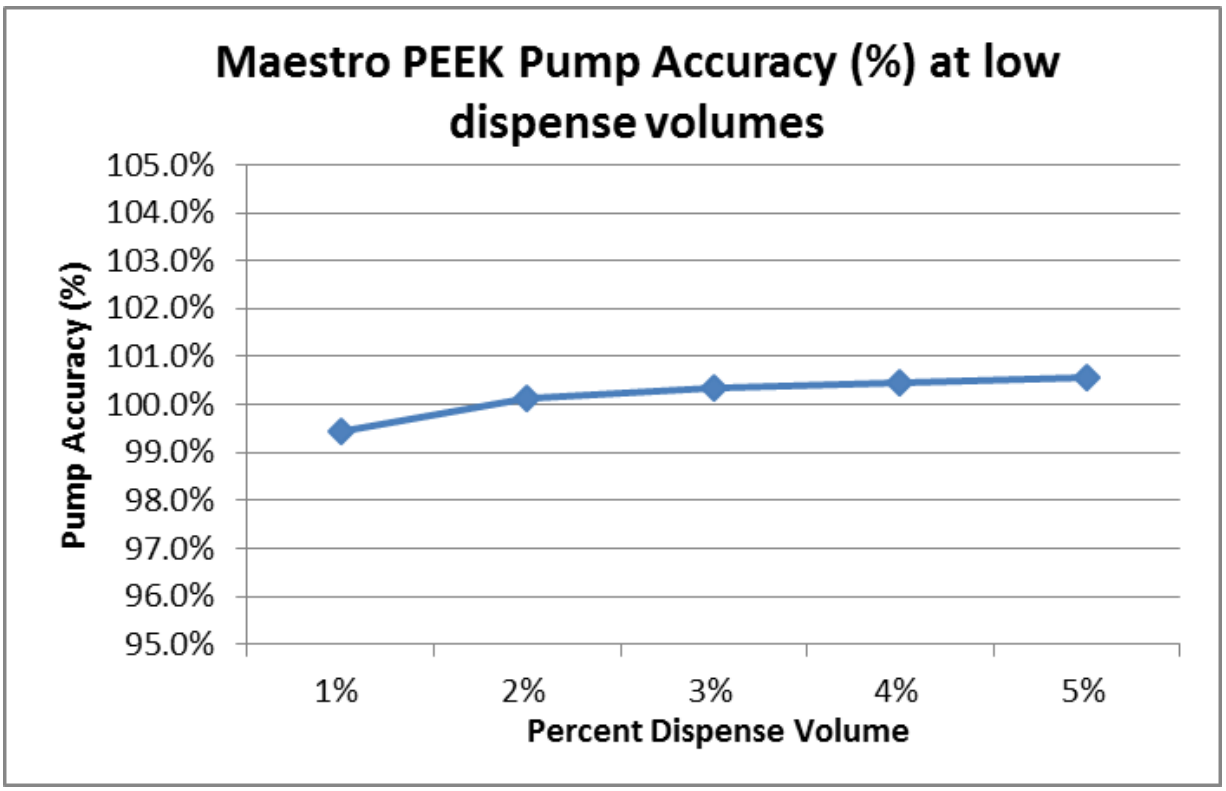

Maestro Flushed Seal Pump - Cv (%)
Pump Cv (%)
0.40%
0.30%
0.20%
0.10%
0.00%
0
1M
2M
3M
4M
5M
6M
7M
8M
9M
10M
Cycles (millions)

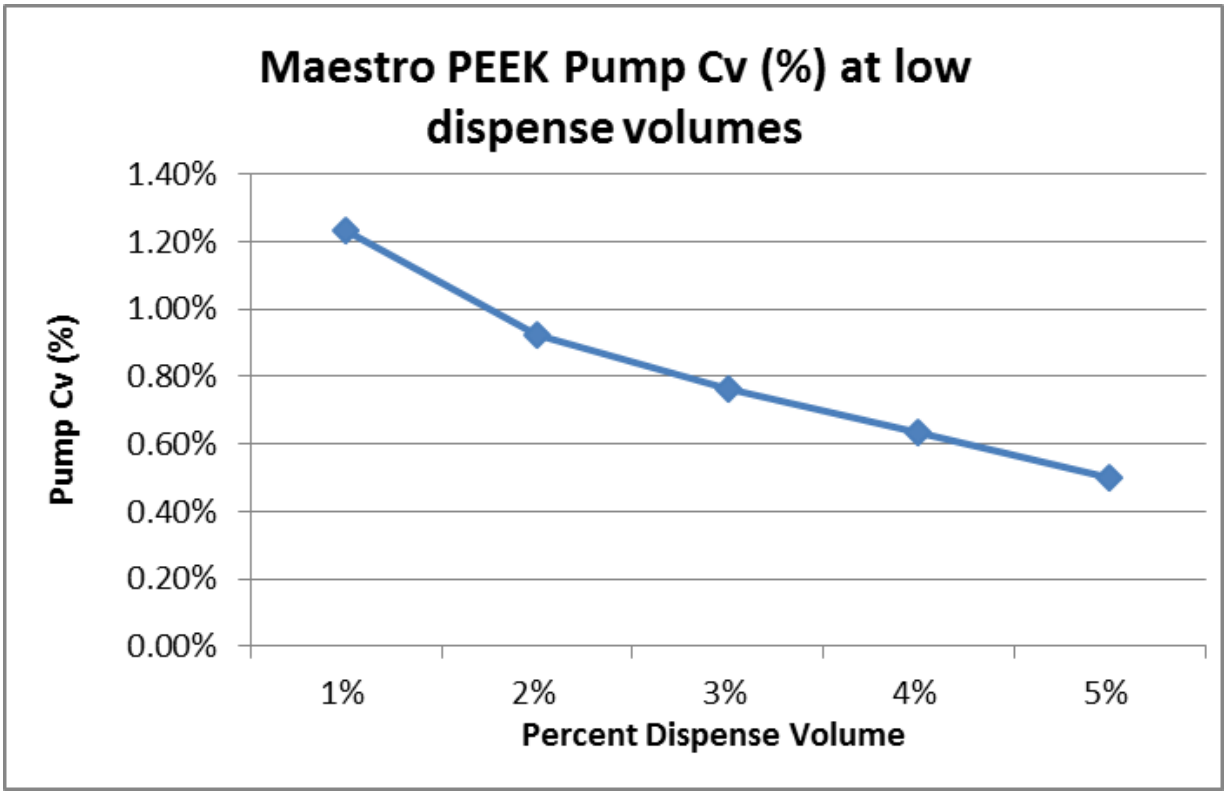

Maestro Flushed Seal Accuracy (%) at low dispense volumes
105.0%
104.0%
103.0%
102.0%
101.0%
100.0%
99.0%
98.0%
97.0%
96.0%
95.0%
Pump Accuracy (%)
1%
2%
3%
4%
5%
Percent Dispense Volume


Maestro Flushed Seal Pump Cv (%) at low dispense volumes
1.00%
0.90%
0.80%
0.70%
0.60%
0.50%
0.40%
0.30%
0.20%
0.10%
0.00%
Pump Cv (%)
1%
2%
3%
4%
5%
Percent Dispense Volume

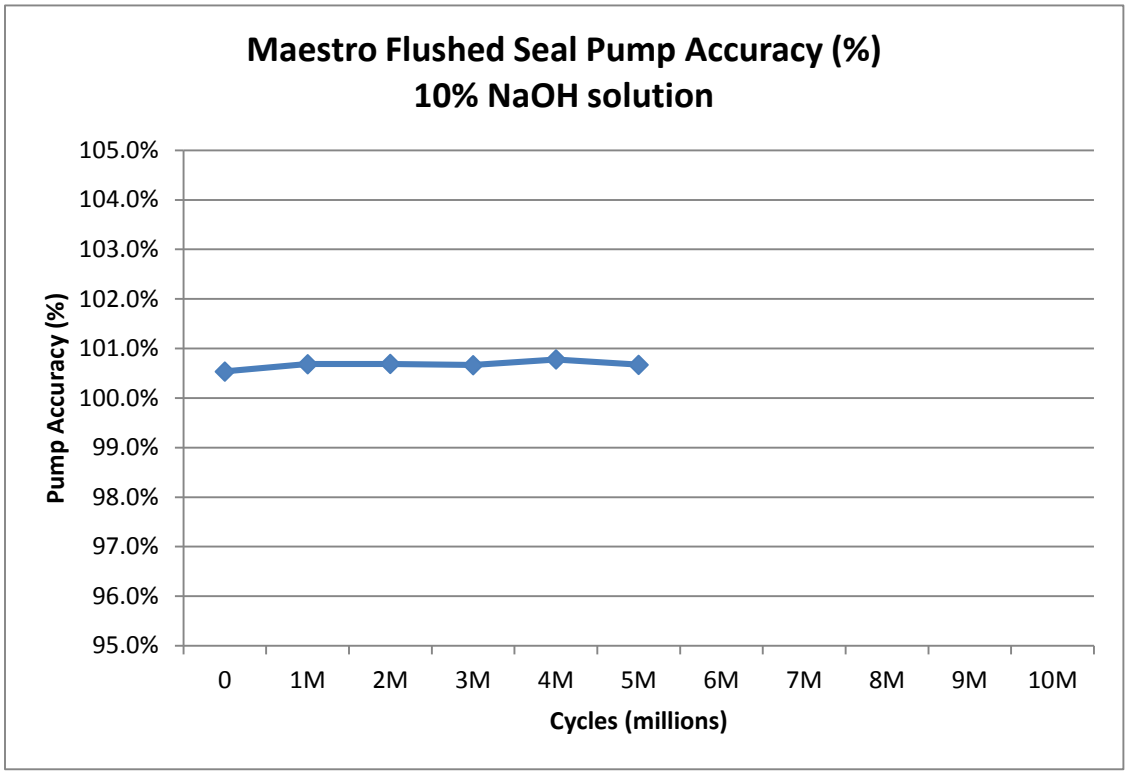

Maestro PEEK Pump - Accuracy (%)
Pump Accuracy (%)
105.0%
104.0%
103.0%
102.0%
101.0%
100.0%
99.0%
98.0%
97.0%
96.0%
95.0%
0
1M
2M
3M
4M
5M
6M
7M
8M
9M
10M
Cycles (millions)

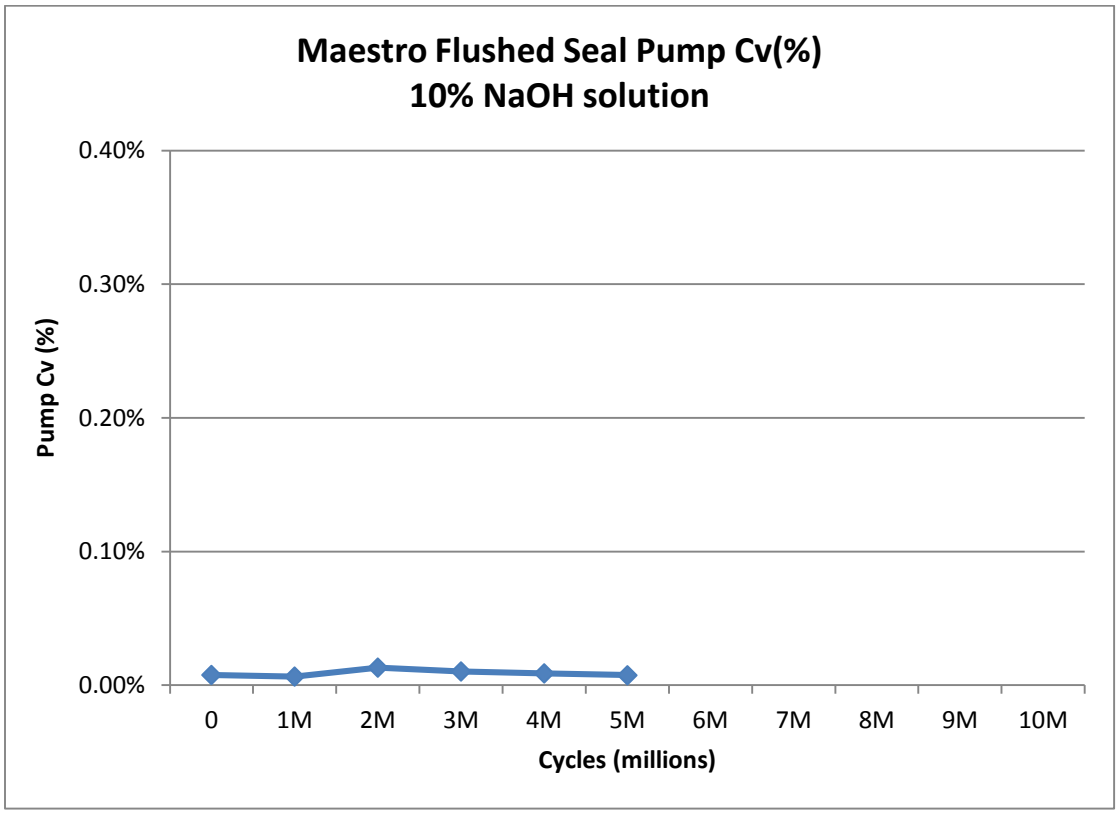

Maestro PEEK Pump - Cv (%)
Pump Cv (%)
0.40%
0.30%
0.20%
0.10%
0.00%
0
1M
2M
3M
4M
5M
6M
7M
8M
9M
10M
Cycles (millions)


Maestro PEEK Pump Accuracy (%) at low dispense volumes
105.0%
104.0%
103.0%
102.0%
101.0%
100.0%
99.0%
98.0%
97.0%
96.0%
95.0%
Pump Accuracy (%)
1%
2%
3%
4%
5%
Percent Dispense Volume

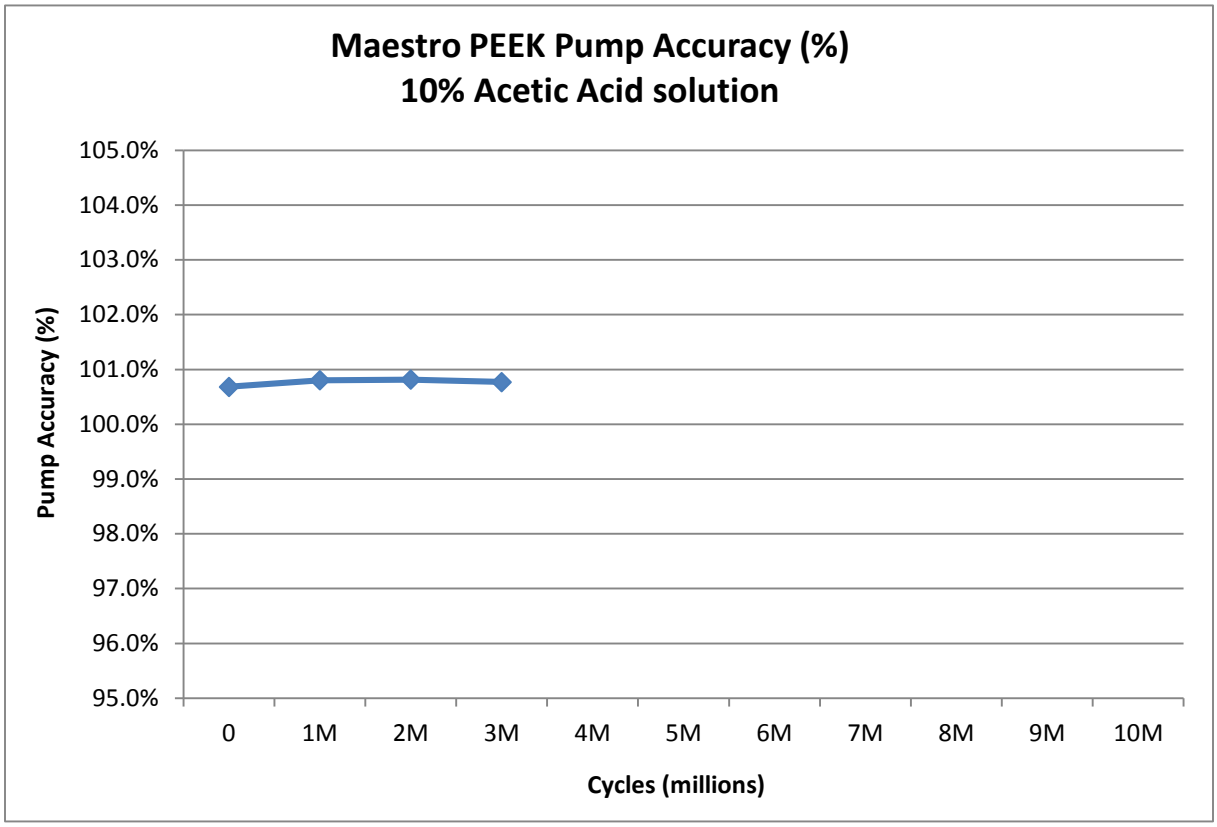

Maestro PEEK Pump Cv (%) at low dispense volumes
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Pump Cv (%)
1%
2%
3%
4%
5%
Percent Dispense Volume

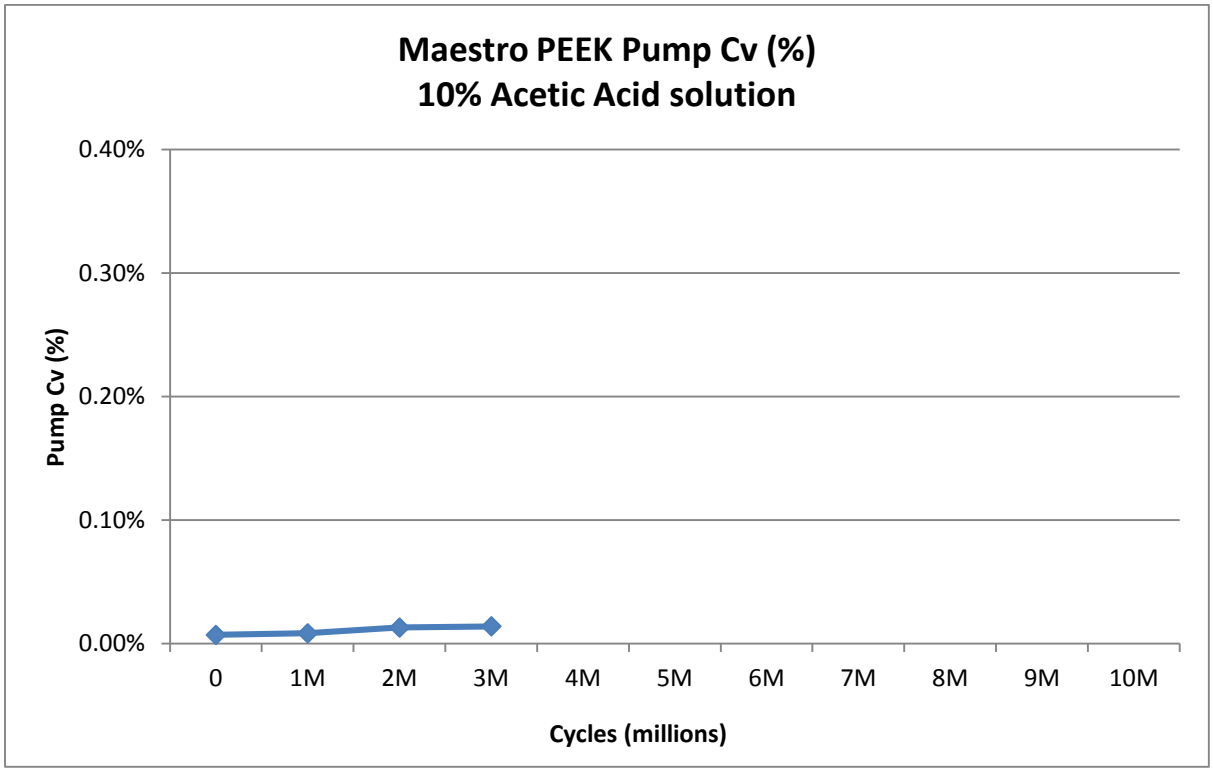
Appendix B


Maestro Flushed Seal Pump Accuracy (%)
10% NaOH solution
105.0%
104.0%
103.0%
102.0%
101.0%
100.0%
99.0%
98.0%
97.0%
96.0%
95.0%
Pump Accuracy (%)
0
1M
2M
3M
4M
5M
6M
7M
8M
9M
10M
Cycles (millions)


Maestro Flushed Seal Pump Cv(%)
10% NaOH solution
0.40%
0.30%
0.20%
0.10%
0.00%
Pump Cv (%)
0
1M
2M
3M
4M
5M
6M
7M
8M
9M
10M
Cycles (millions)

Appendix C


Maestro PEEK Pump Accuracy (%)
10% Acetic Acid solution
105.0%
104.0%
103.0%
102.0%
101.0%
100.0%
99.0%
98.0%
97.0%
96.0%
95.0%
Pump Accuracy (%)
0
1M
2M
3M
4M
5M
6M
7M
8M
9M
10M
Cycles (millions)


Maestro PEEK Pump Cv (%)
10% Acetic Acid solution
0.40%
0.30%
0.20%
0.10%
0.00%
Pump Cv (%)
0
1M
2M
3M
4M
5M
6M
7M
8M
9M
10M
Cycles (millions)