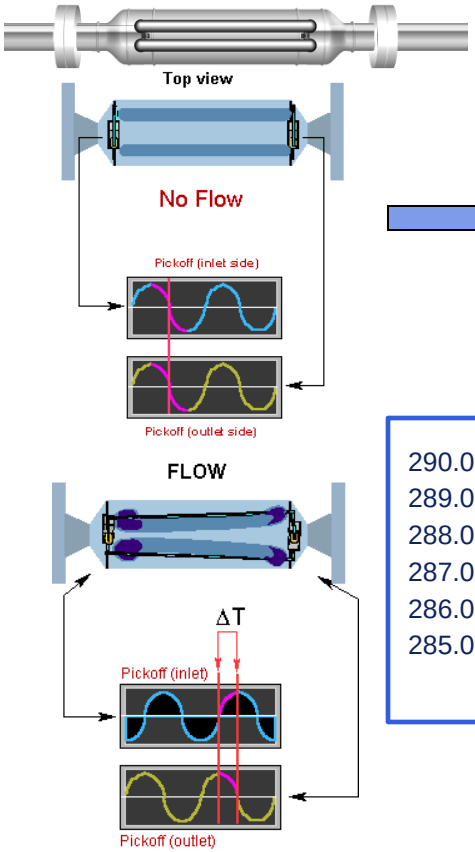
Title: Challenges in Characterizing Flowmeter Dynamic Response

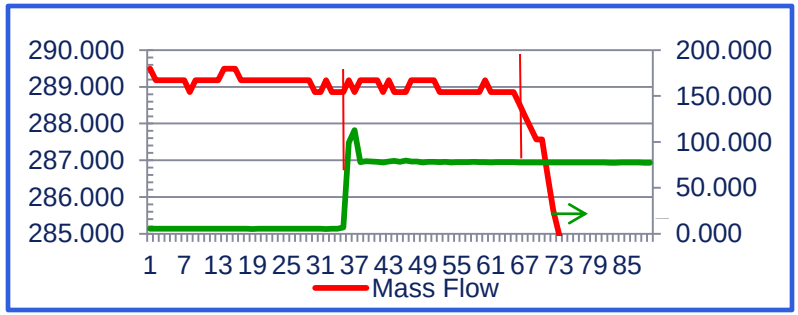
Chuck Gray, Micro Motion

Coriolis Mass Flow Metering

Mass Flow is directly proportional to Delta T (Pickoff Signal Phase Shift)



In this Presentation I will Discuss Industrial Applications for High Speed Flow Metering



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Chuck Gray

Application & Test Engineer - Micro Motion Inc

- Micro Motion Technology
  - Product support
  - EMC
  - Flow Measurement Test
  - “High End” Customer Support
  - 23 Years Experience
- Retired Naval Flight Officer
  - Patrol Aviation & Naval Air Test
- BSEE – University of Colorado
  - Electrical Power & Control Systems

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High Speed Applications

Pipeline Provers

High Speed Filling

Numerous Other Specialized Applications

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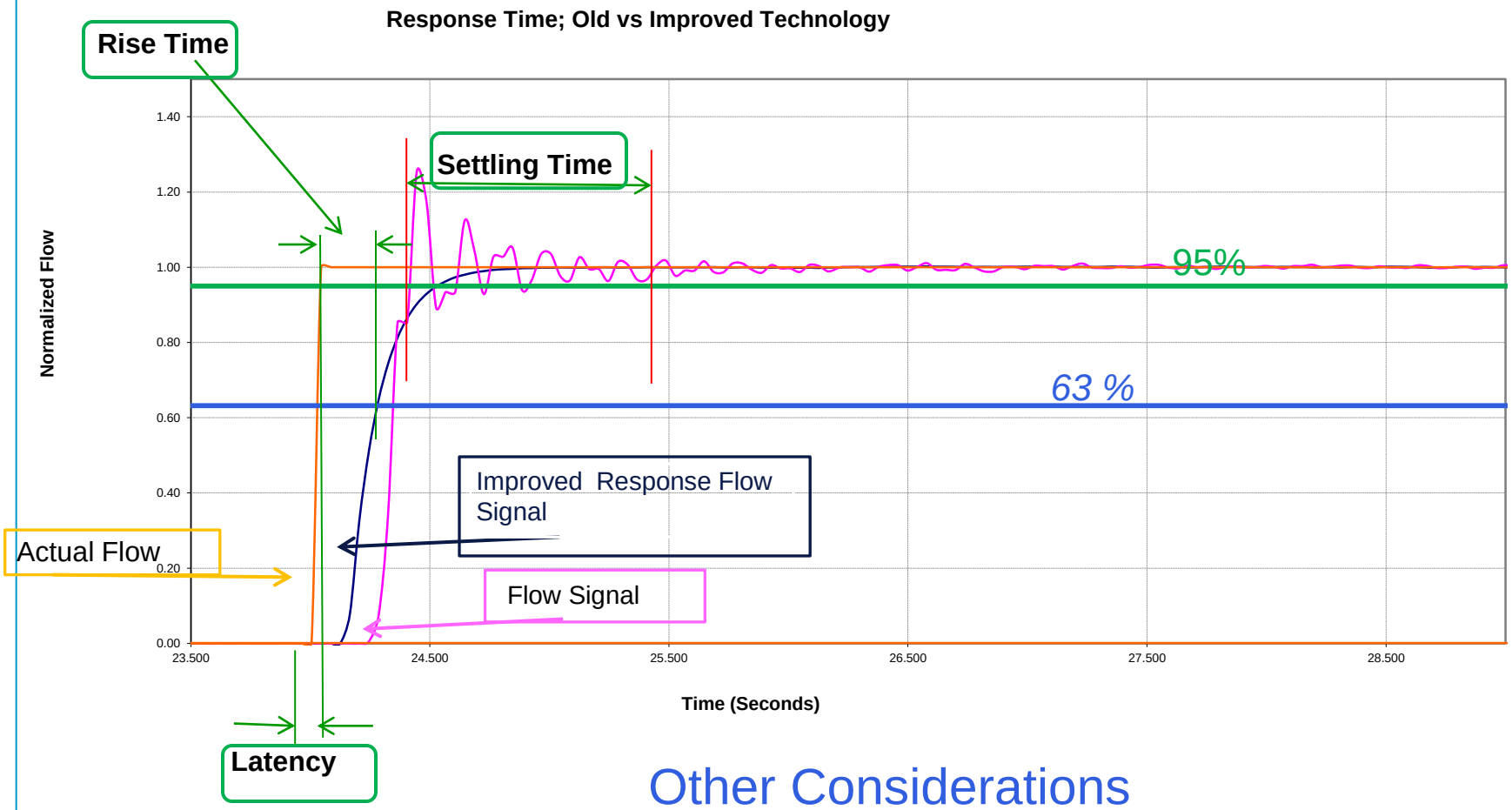
Response to Flow Change

- Response Time is the Time between a Physical Change & a Corresponding Change in an Output Signal
- Coriolis meters exhibit a two-part response curve for changes in measured flow
  - a fixed processing delay - Latency
    - a function of the system architecture
  - second part of the response curve approximates an RC delay - Damping
    - Typically adjustable by the user
    - Rise Time
    - Settling Time

Definitions



Other Considerations

Update Rate
Reference Conditions

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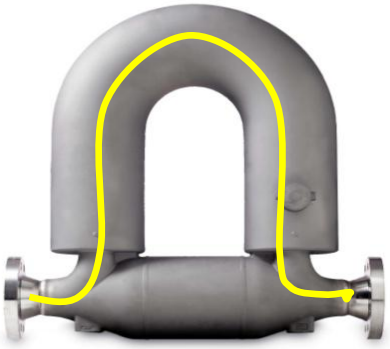
Coriolis Meter Geometry

These are dual tube meters

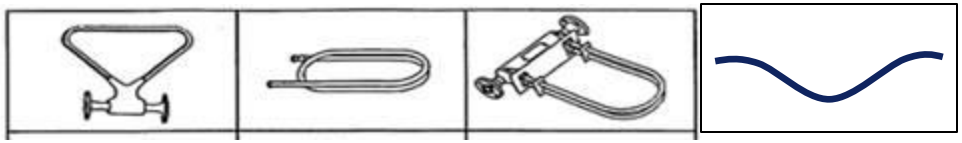
MMI CMF100 1”



MMI CMF400 4”

E&H F83 1”

Straight Tube Meter



Common Coriolis Geometries

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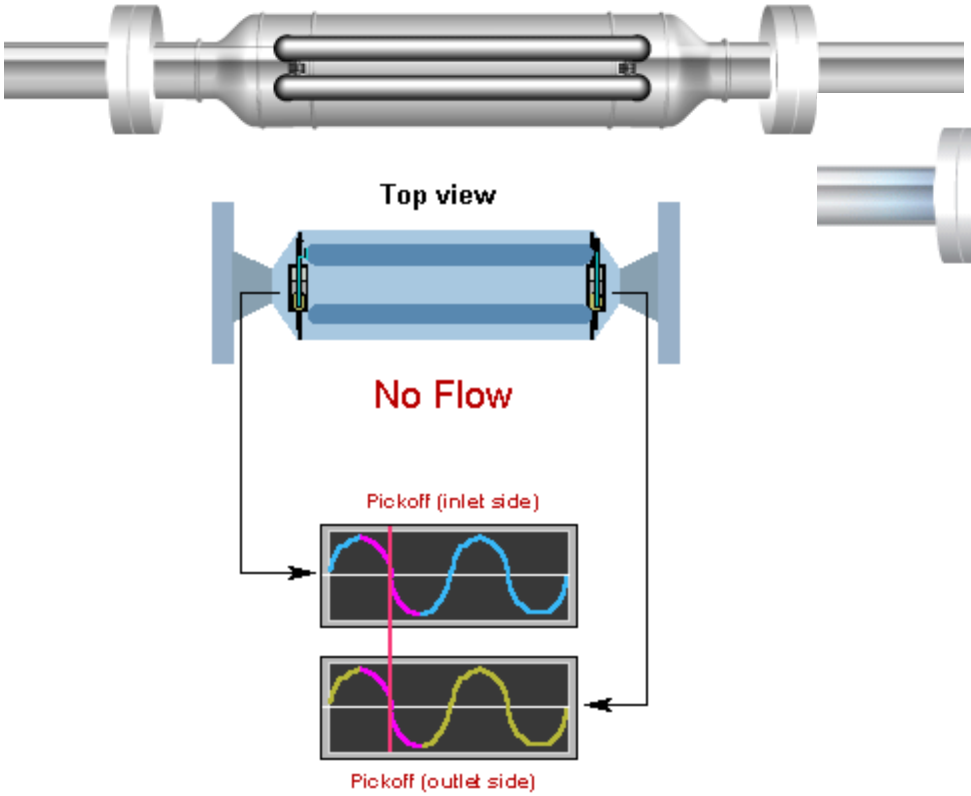
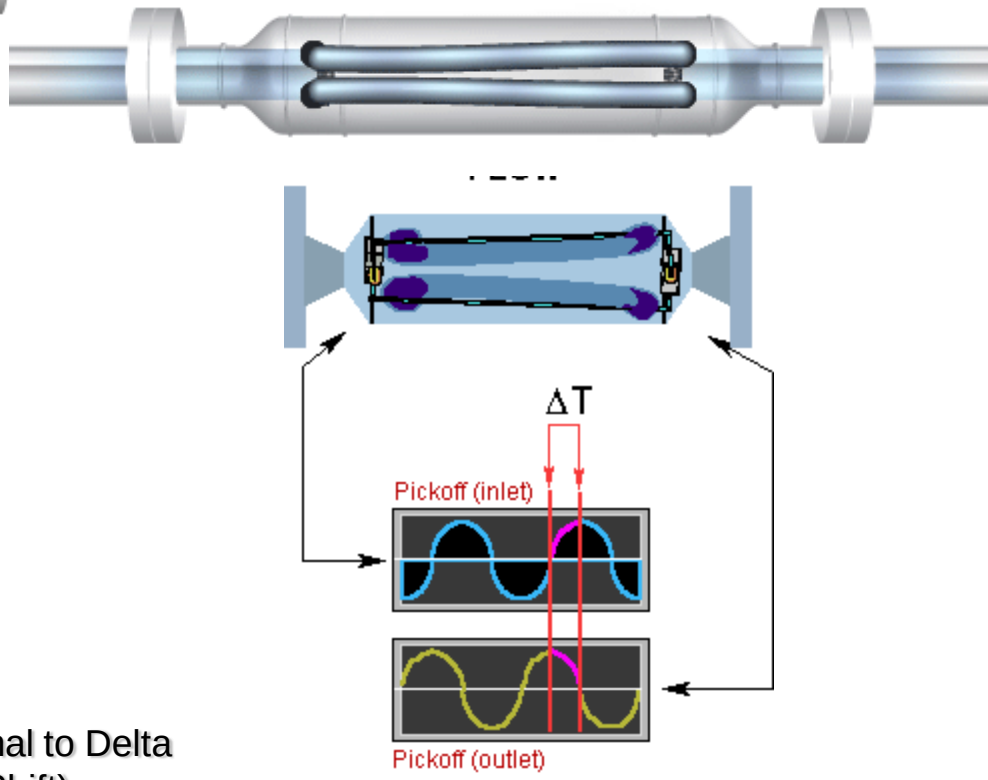
Theory of Operations – Mass Flow





Mass Flow is directly proportional to Delta T (Pickoff Signal Phase Shift)

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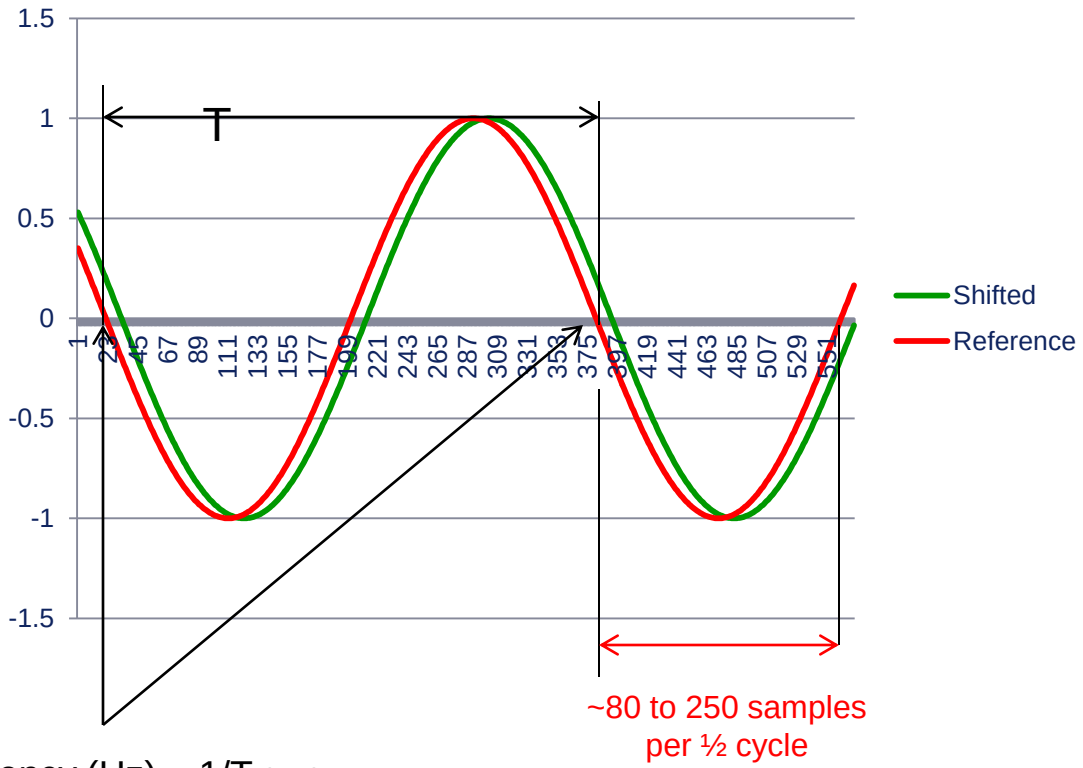
MMI DSP – No Lost Flow data

In Analog Transmitters Flow is Computed every ½ cycle (only)



Frequency (Hz) = 1/T (sec)
2π radians

MMI DSP Transmitters Convert the Pickoff Signal at a 48 Khz Rate

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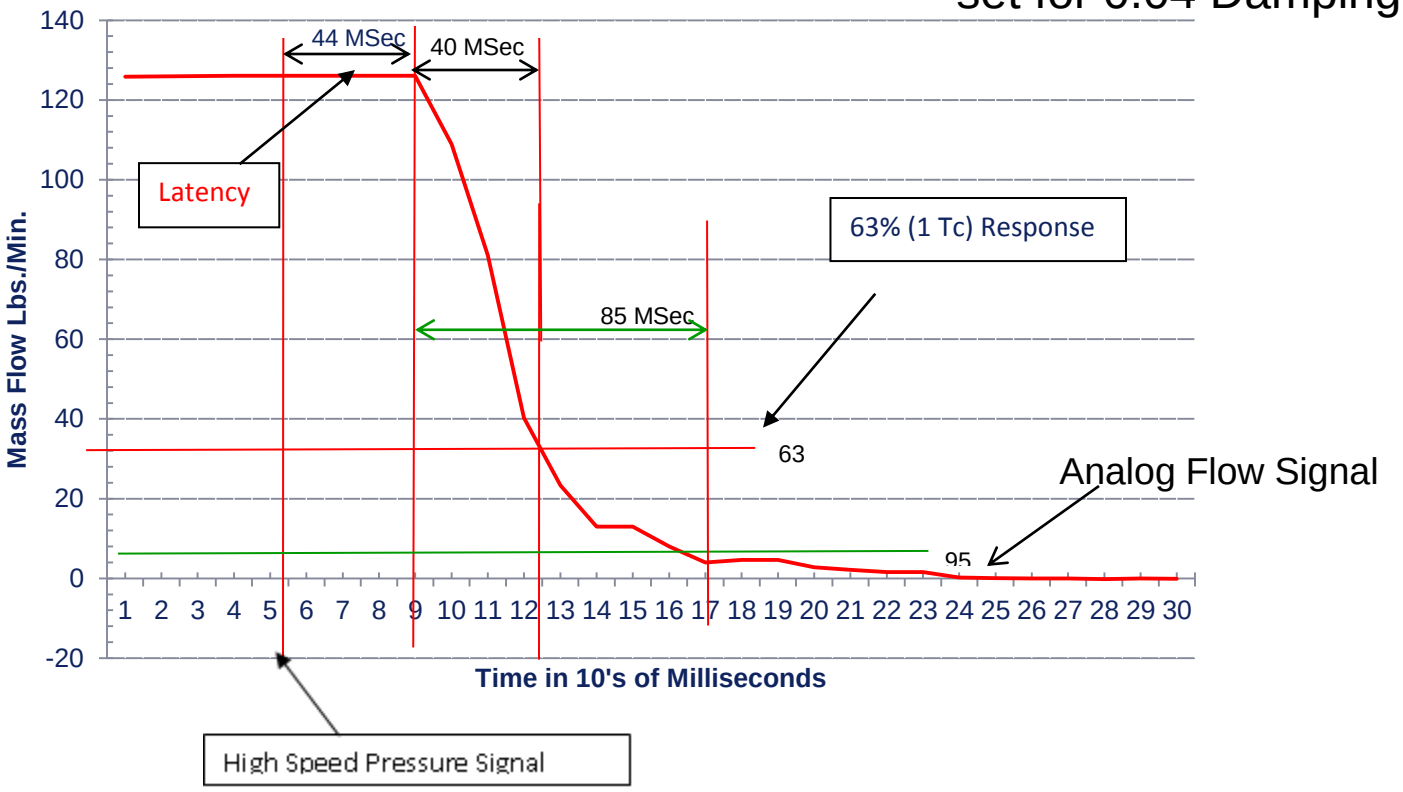
Measured Meter Response to Valve Closure

An Older, Production Meter
set for 0.04 Damping



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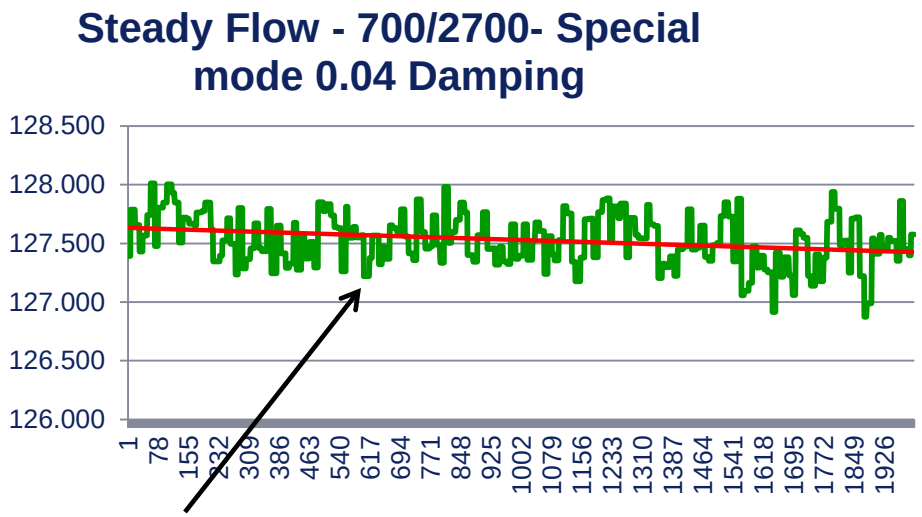
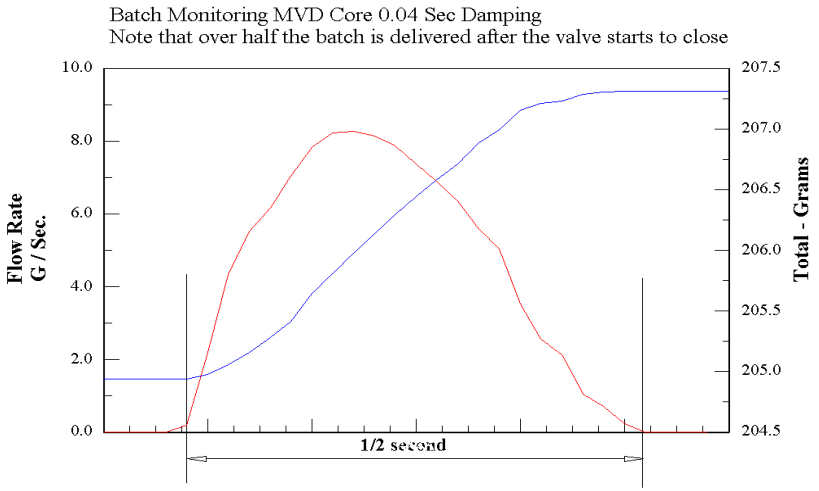
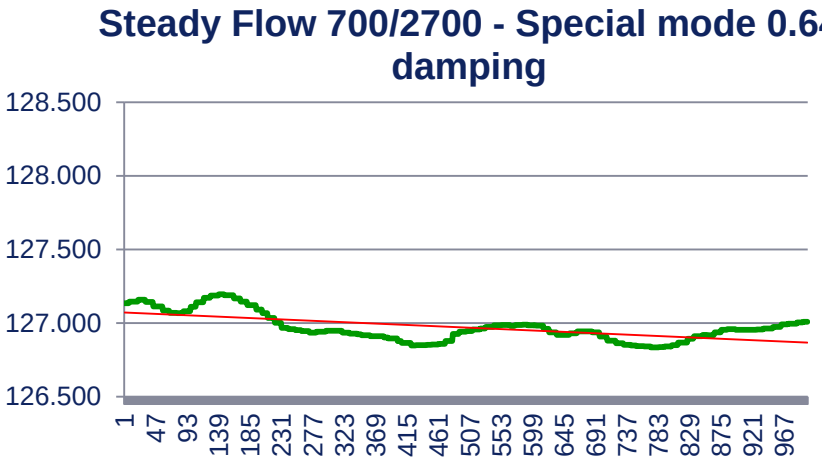
Use Appropriate Flow Damping (filtering)





This Flow Signal Would be Severely Aliased with a Slow Sampling Control System



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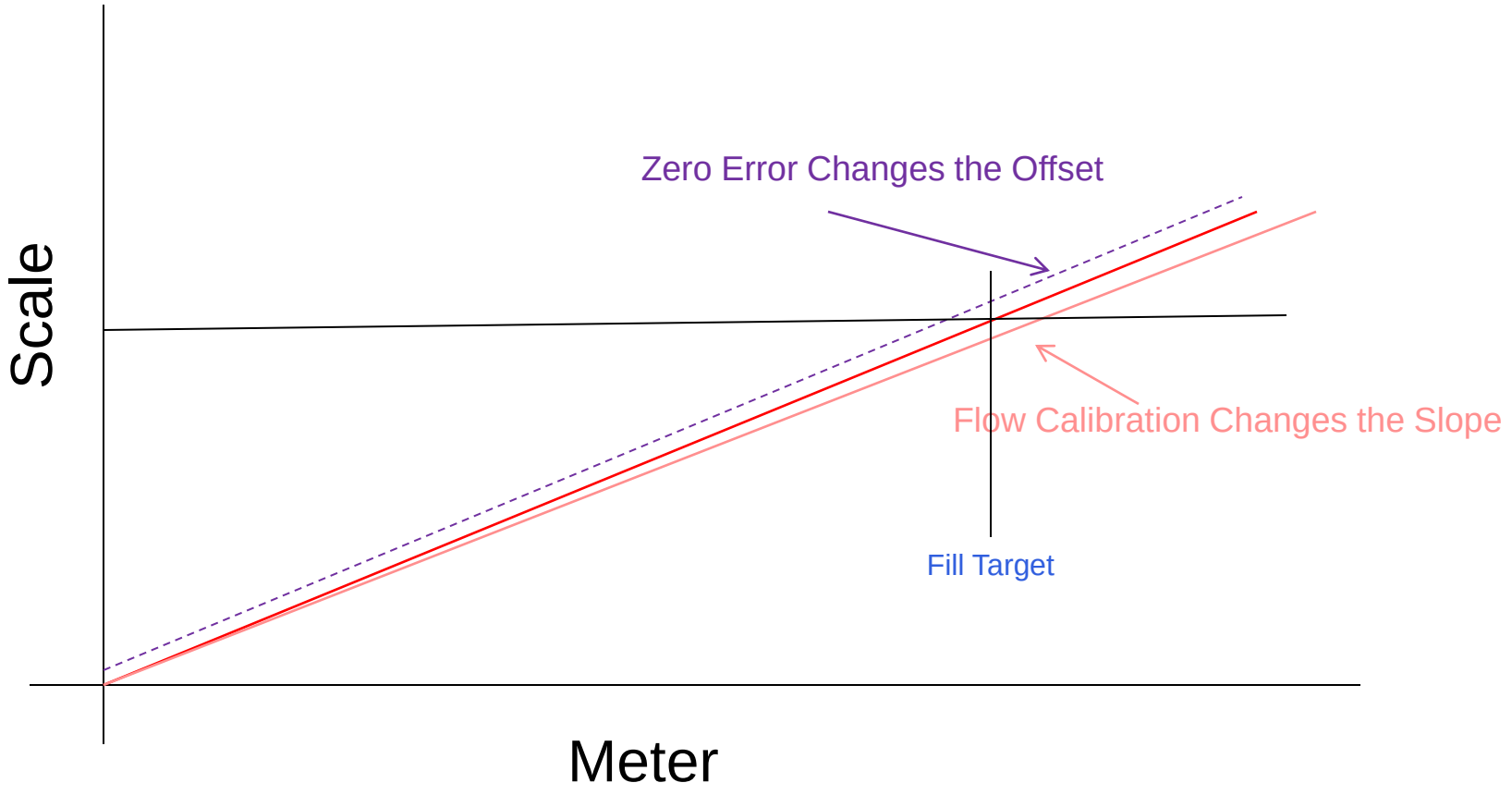
Meter Zero & Calibration



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Micro Motion MVD Technology

- Multi- Stage DSP
  - “immediate “ conversion to digital data for stability
  - Versatile
    - Very fast response with moderate filtering
  - OR
    - Slower response with extensive filtering




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Why are Response Characteristics Important?

Matching the Meter to the Application

- Pipelines
  - Small Volume Provers
- Chemical Plants & Refineries
  - Fast Control Loops
- Special Applications
  - Automotive RDT&E
- Food & Beverage
  - Filling
    - Short Fills
    - Dosing
    - Specialty

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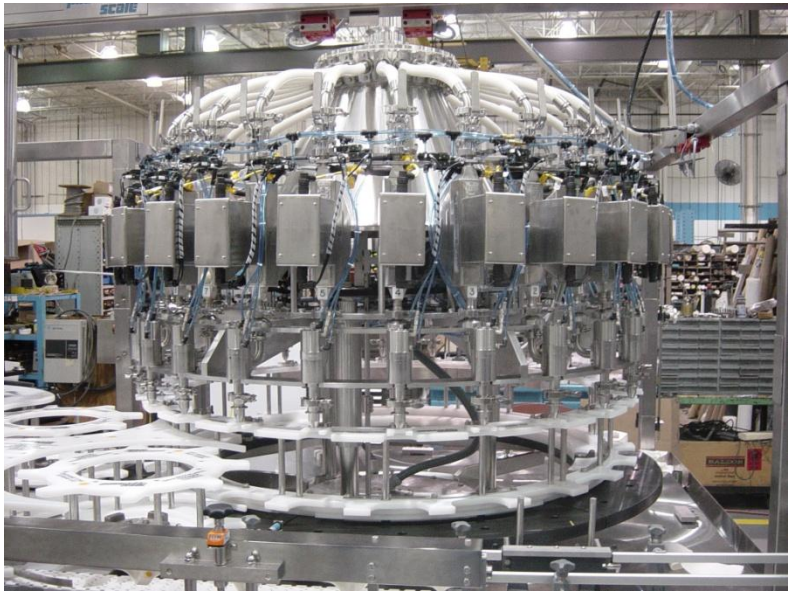
Filling Machines

Bag in Box



Rotary – PSA w/1500F

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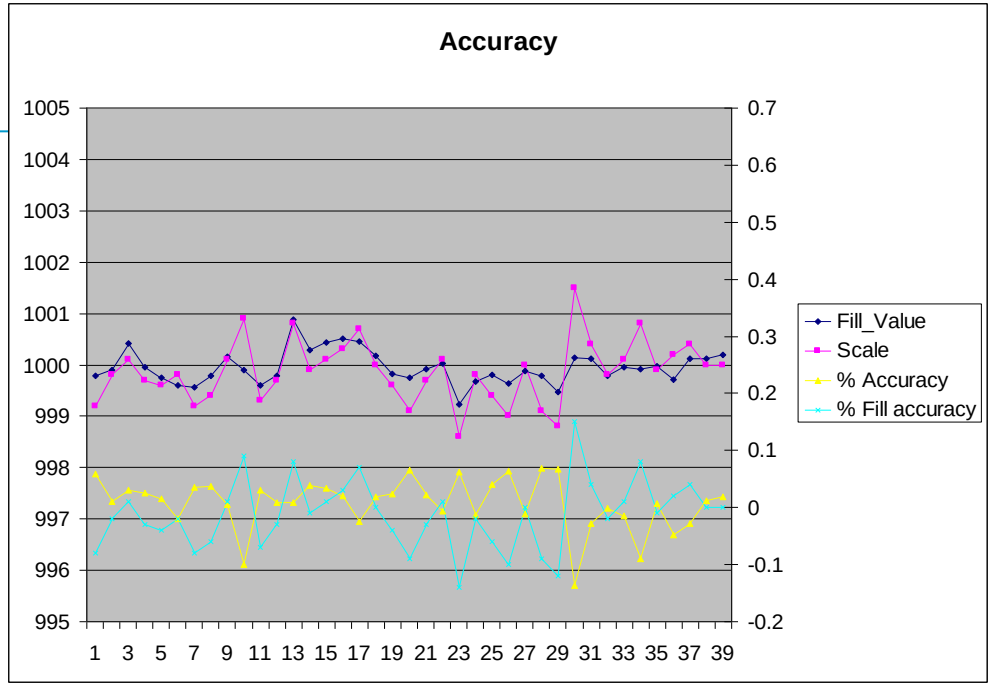
H 50 Performance on Aerated Detergent



Sample from Pressure Tap

Fill = 1000 Grams; Fill Time ~ 3.78 Sec Flow ~ 264 G/Sec.

Heavily Aerated Liquid Laundry Detergent at the product feed supply to Filling Pressure Tank.

H 050 Sensor with Precision Filling Valve

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FMT Performance – Better Std Dev!

Meter	Rate G/Sec.	Fill Target Grams	Fill Time Sec.	Average Fill Grams	Fill Standard Deviation*
.5”	250	1250	4.87	1249.94	0.06%
.5”	125	250	1.99	250.37	0.15%
.5”	62.5	47	0.74	47.02	0.18%
.15”	100	50	0.52	50.02	0.12%
.15”	50	37.5	0.69	37.55	0.18%
.15”	10	5	0.49	5.01	0.33%

* Fill Standard Deviation was calculated using 30 points. Test data demonstrates performance of the complete fill system.

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Filler OEM: Results with Micro Motion Coriolis

- Higher Efficiency and Reliability – 10,000 cases per shift vs. 8,000 with older, less reliable filling technology
- Greater Accuracy = Less Giveaway: Product savings alone can pay for a machine in 2 to 5 years.
- Faster changeover/cleaning = More flexibility and shorter runs. Less inventory and greater uptime!
- Additional measurables provide new features such as density & temperature tracking for quality control.

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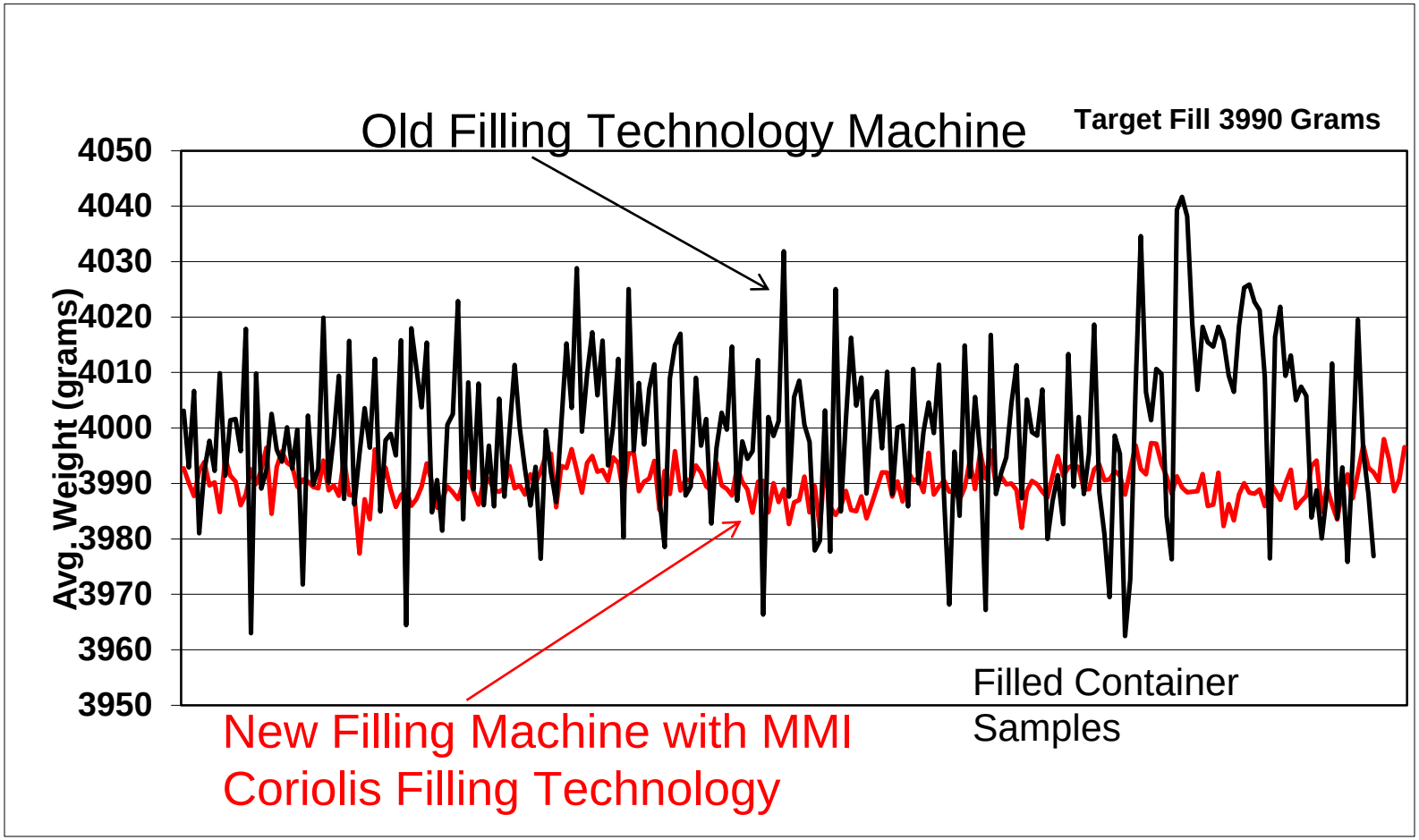

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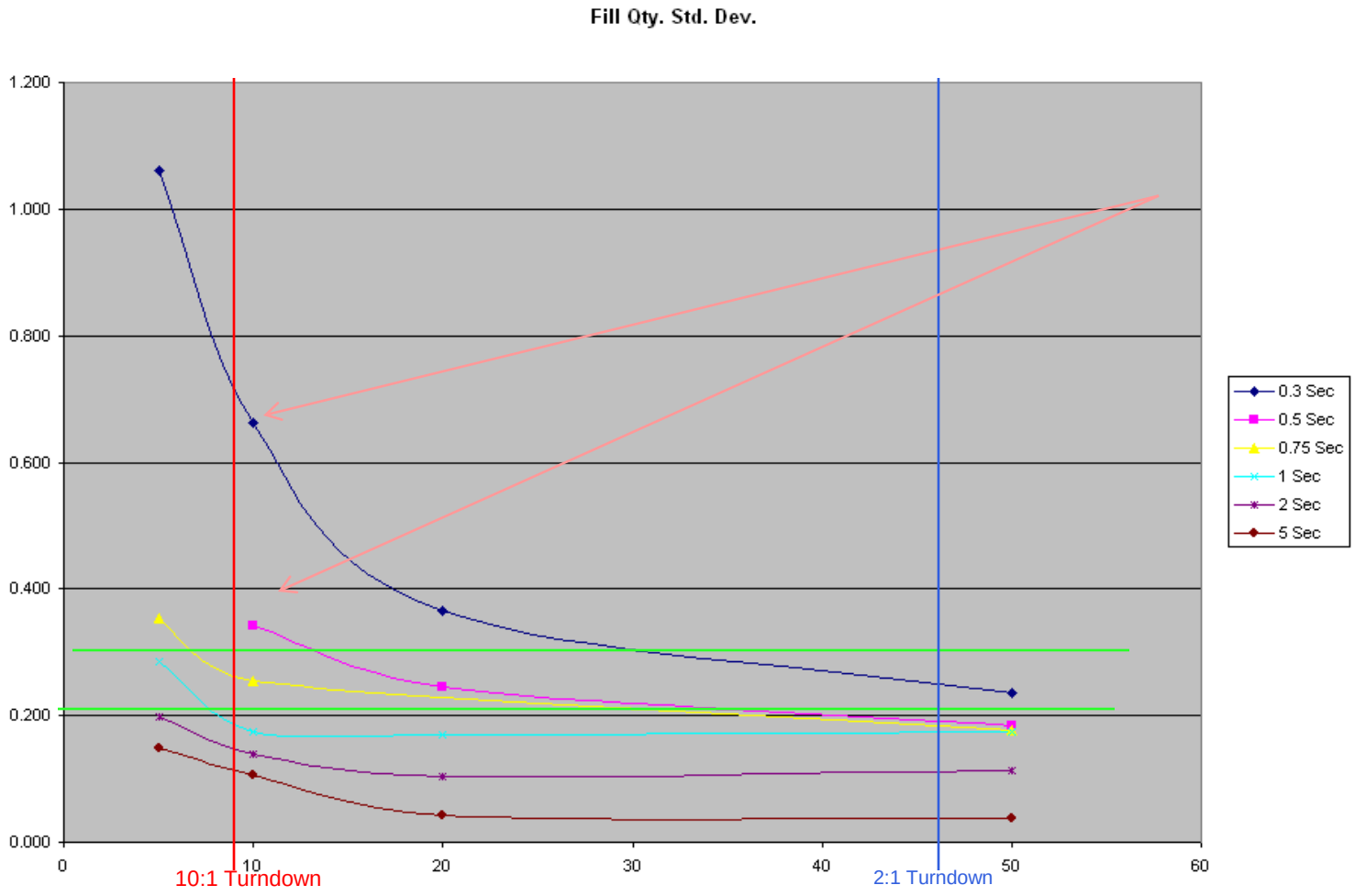
Flow Meter Fill Standard Deviation vs Flow Rate – Several Fill Times



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Pipeline Proving

- Volumetric Flow Meter References
  - Useful when Flow Can't be Interupted
- Large Volume – "Ball" Provers
  - Long Run Times
    - Measurement Phase Difference Generally not Problematic
- Small Volume – "Piston" Provers
  - Short Run Times
    - Measurement Phase Difference may Cause Significant Error
    - Well Documented by others.
      - Takashi Shimada, et all (National Metrology Institute of Japan)
      - Micro Motion Proving Manual, (Cathy Apple)

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Daniel Ball Prover

The ball is launched & recovered here

The time is measured as the ball traverses the pipe between two detectors

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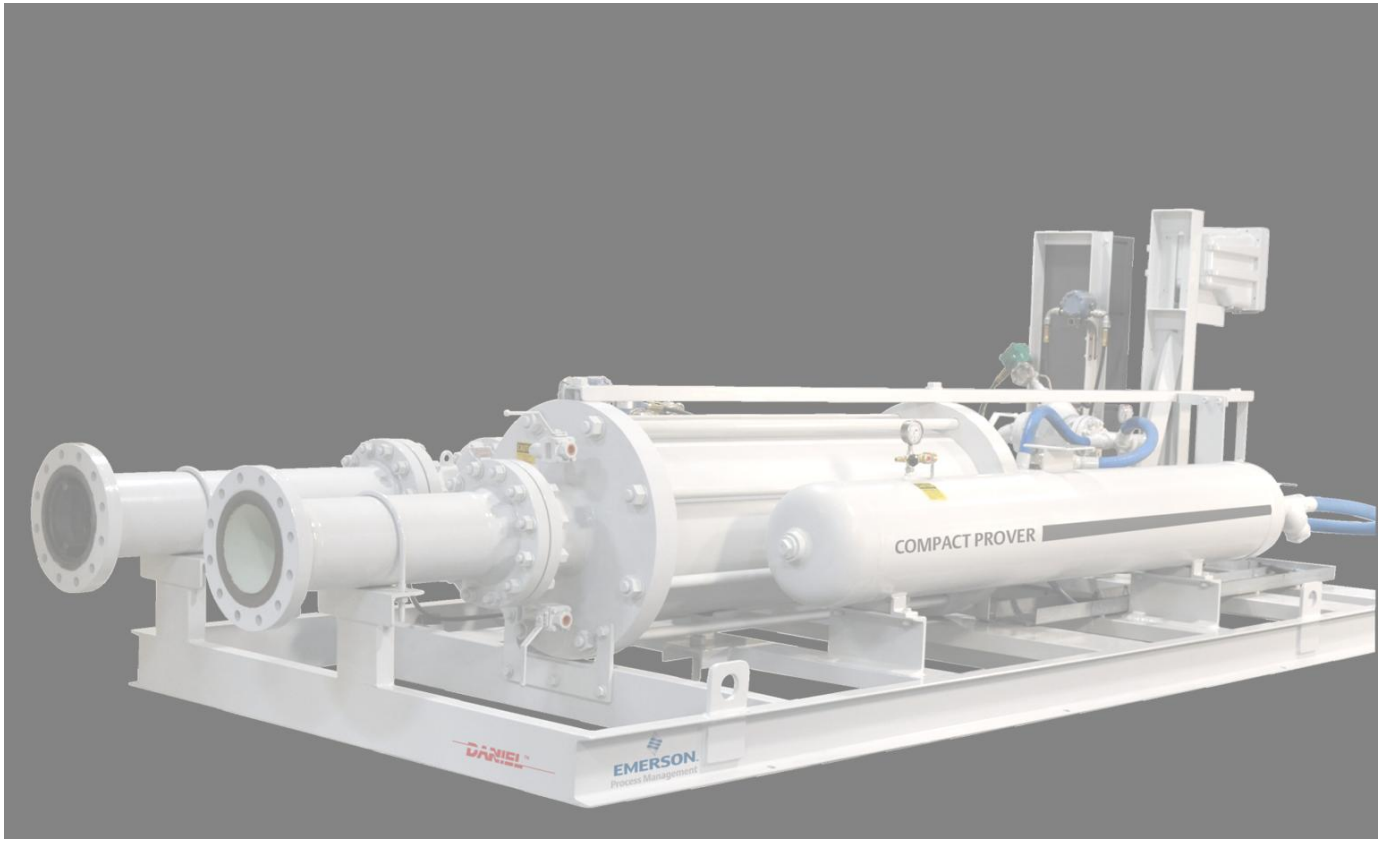
Daniels Compact Prover



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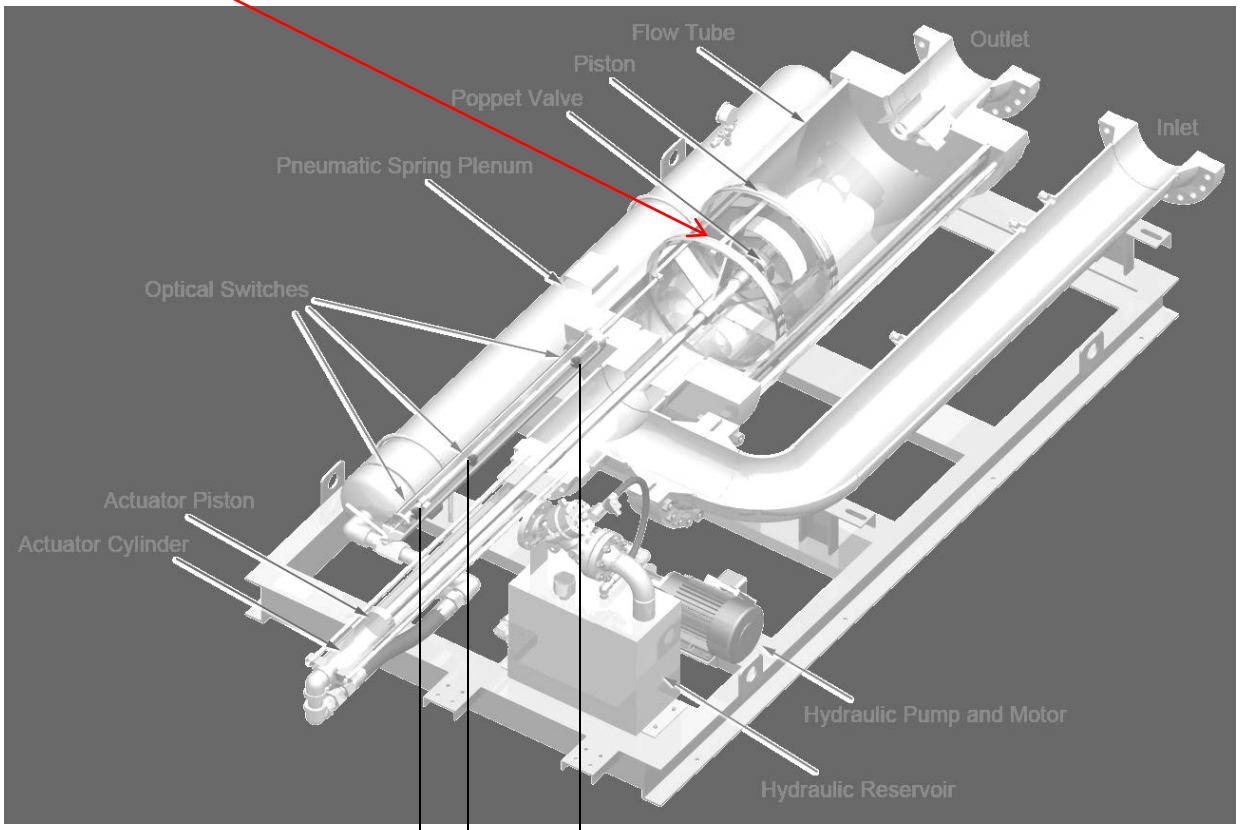
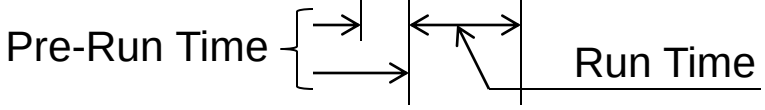
Daniel Small Volume Prover

Valve Actuation Cause flow rate change

Outlet



Inlet



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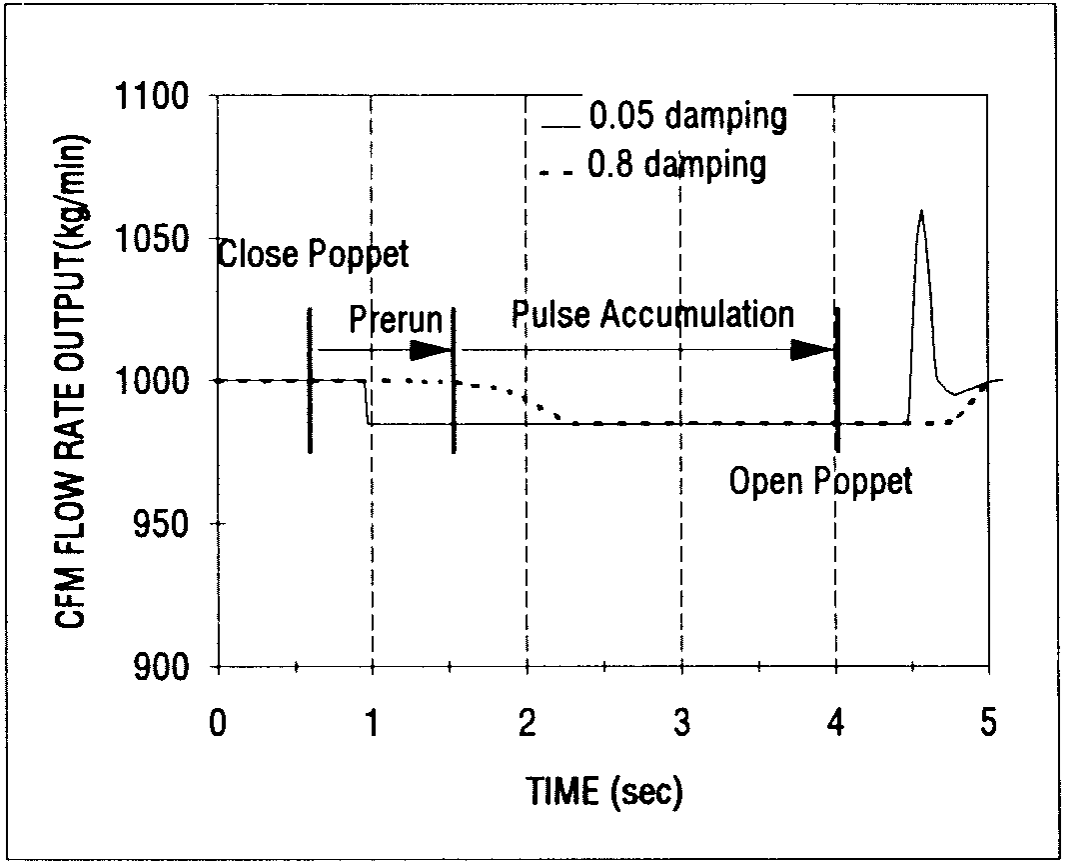
Flow Change with Prover "Launch"



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Proving Manual

Analog RFT 9739 Data

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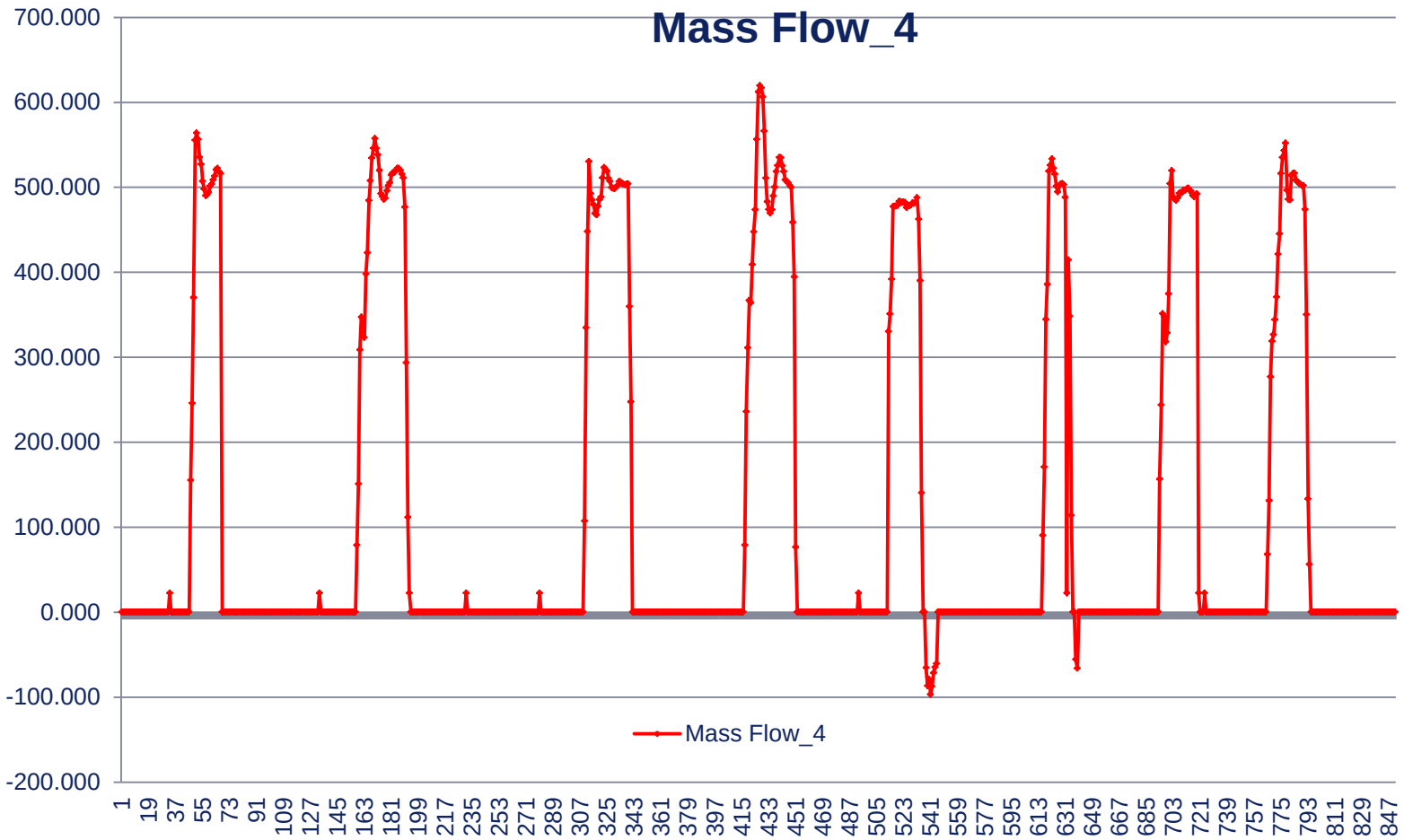
Erratic Product Delivery



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THANK YOU !