A method for reducing errors in wet gas measurement with Coriolis meters

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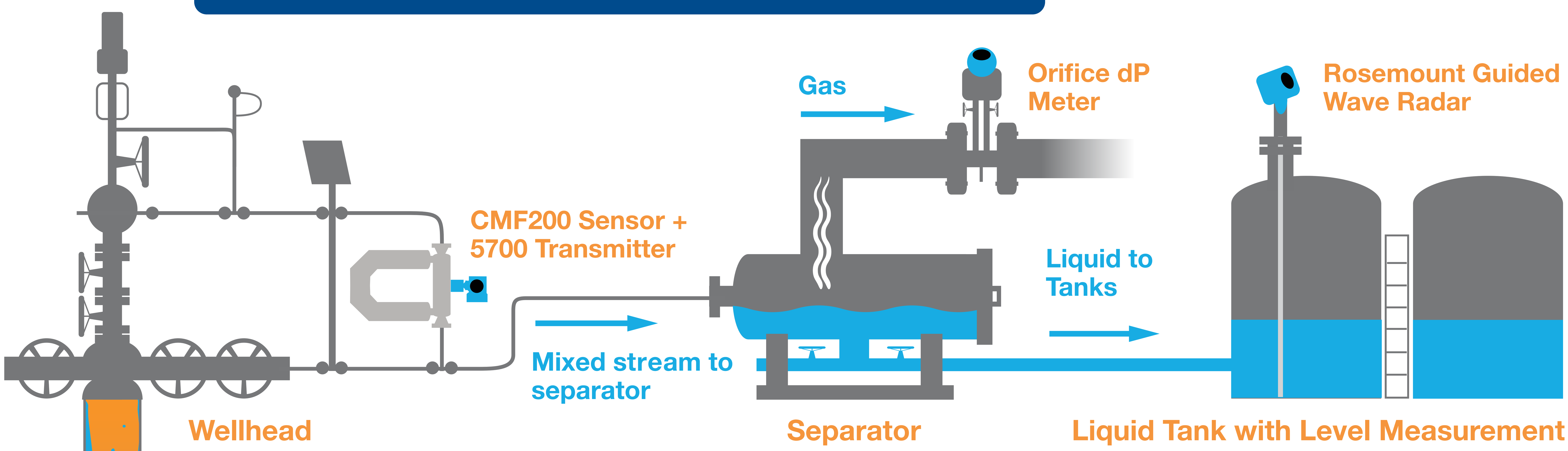
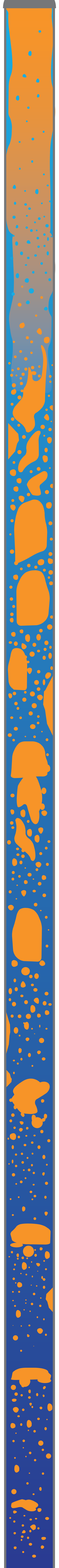
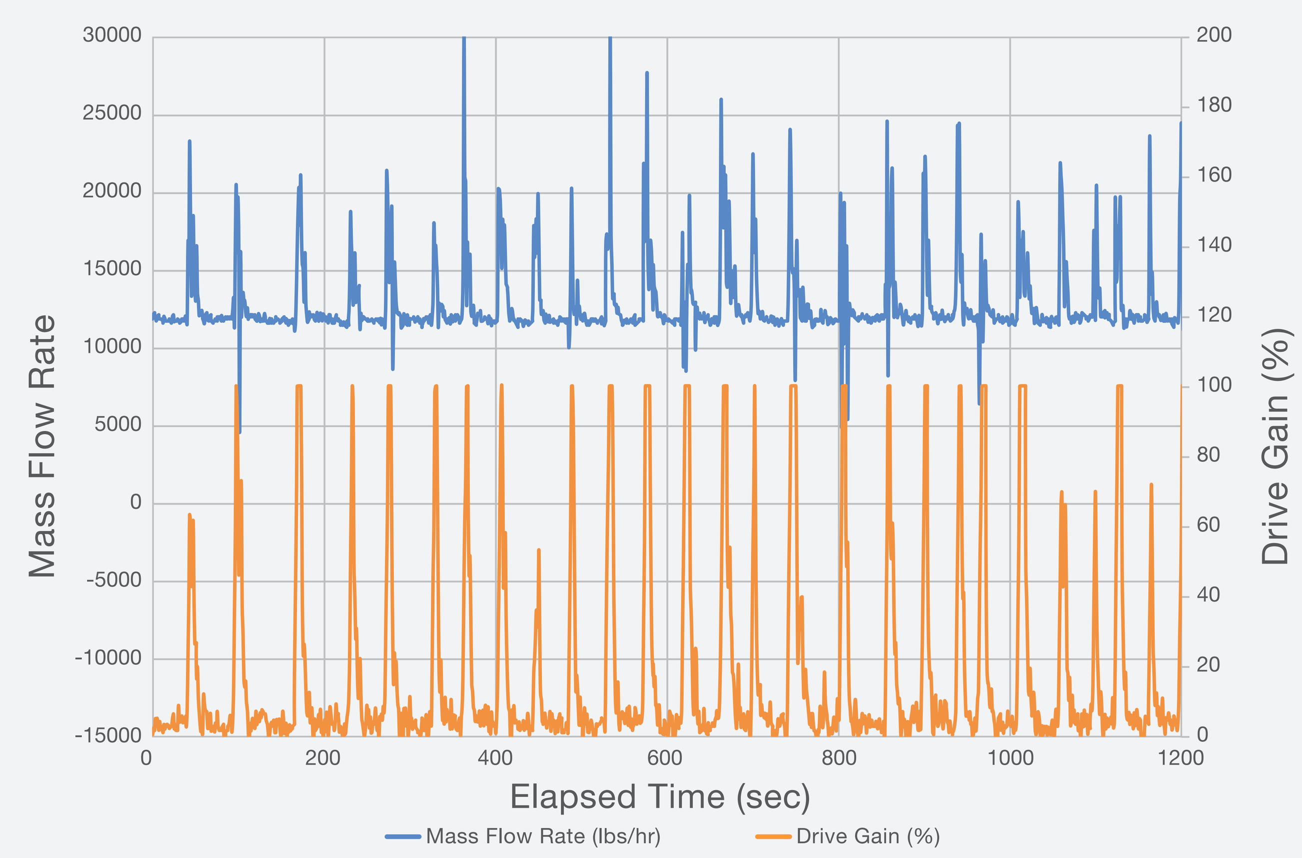


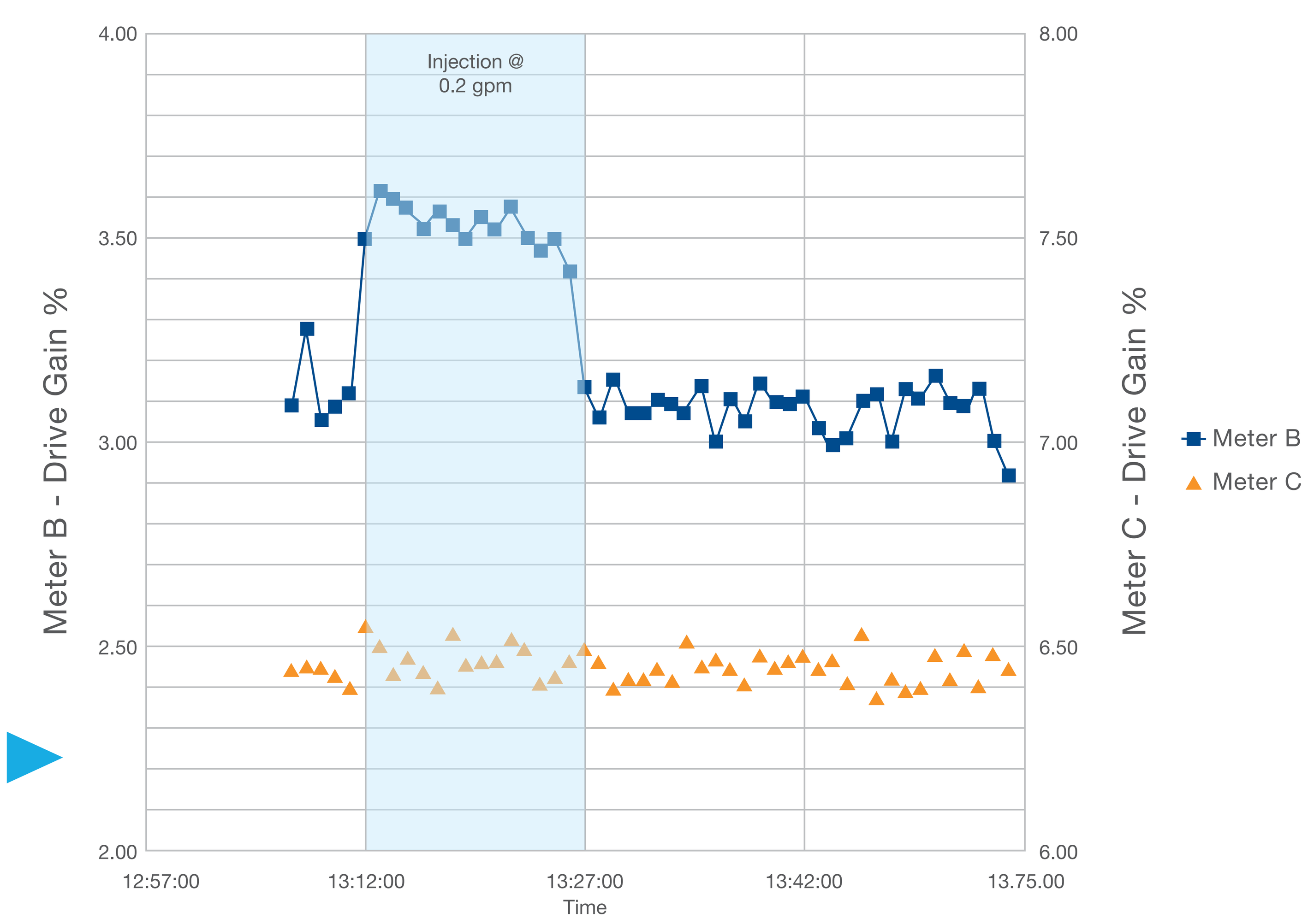


Mass Flow Rate and Drive Gain from Annulus Field Test



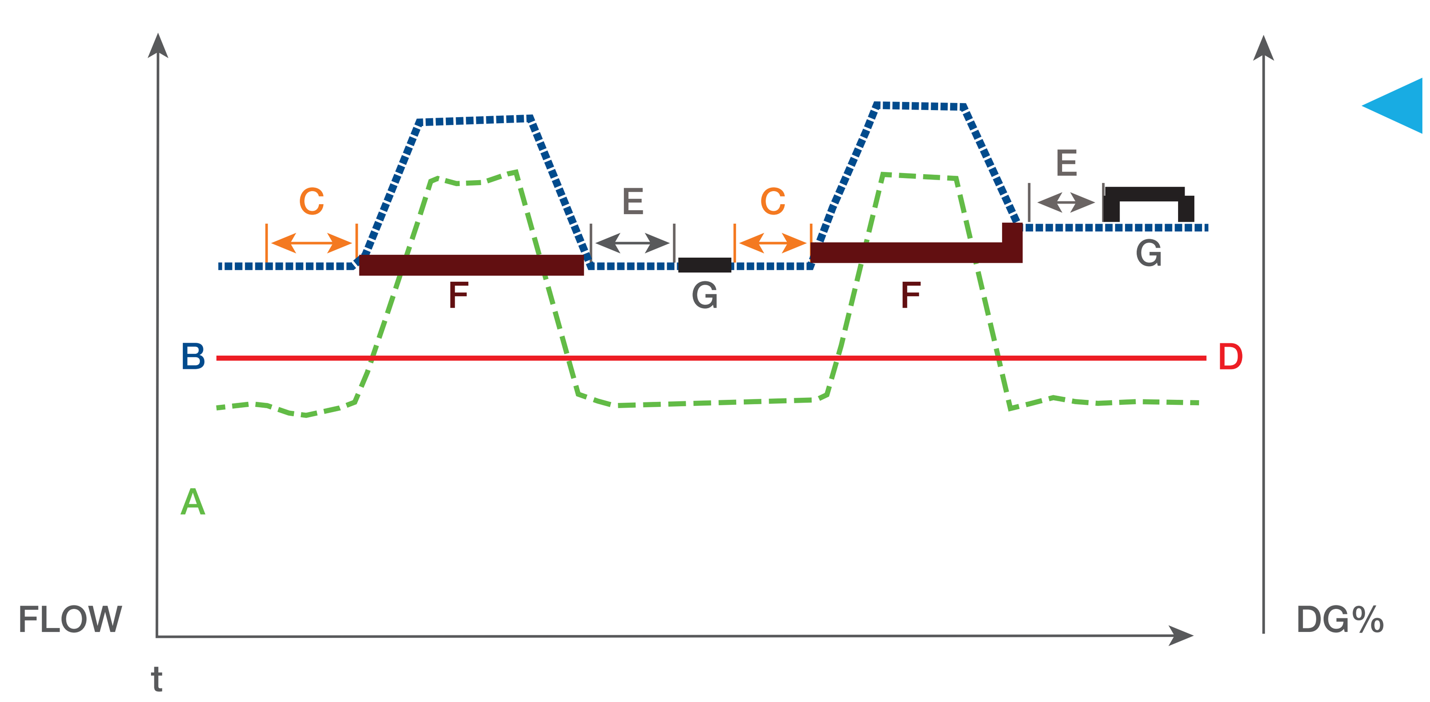
Natural liquid slugging creates pulses in the mass flow, as liquid passes through the meter. Coriolis meters are able to measure gas mass flow rate with accuracy of ±0.25% of rate in dry gasses, but are subject to errors in two phase conditions that vary with process conditions such as phase fraction, velocity and pressure.

Drive Gain Results for Meter B at 100 acfm and 0.2 gpm



Testing at Southwest Research Institute and Pipeline Research Council testing shows some coriolis meter designs are able to detect liquids at as low as 0.013% by volume using drive gain. Drive gain is the amount of energy used to keep the tubes inside the sensor vibrating at target amplitude. Two phase conditions cause damping and more power is sent to maintain vibration amplitude.

Advanced Phase Measurement Remediation Algorithm

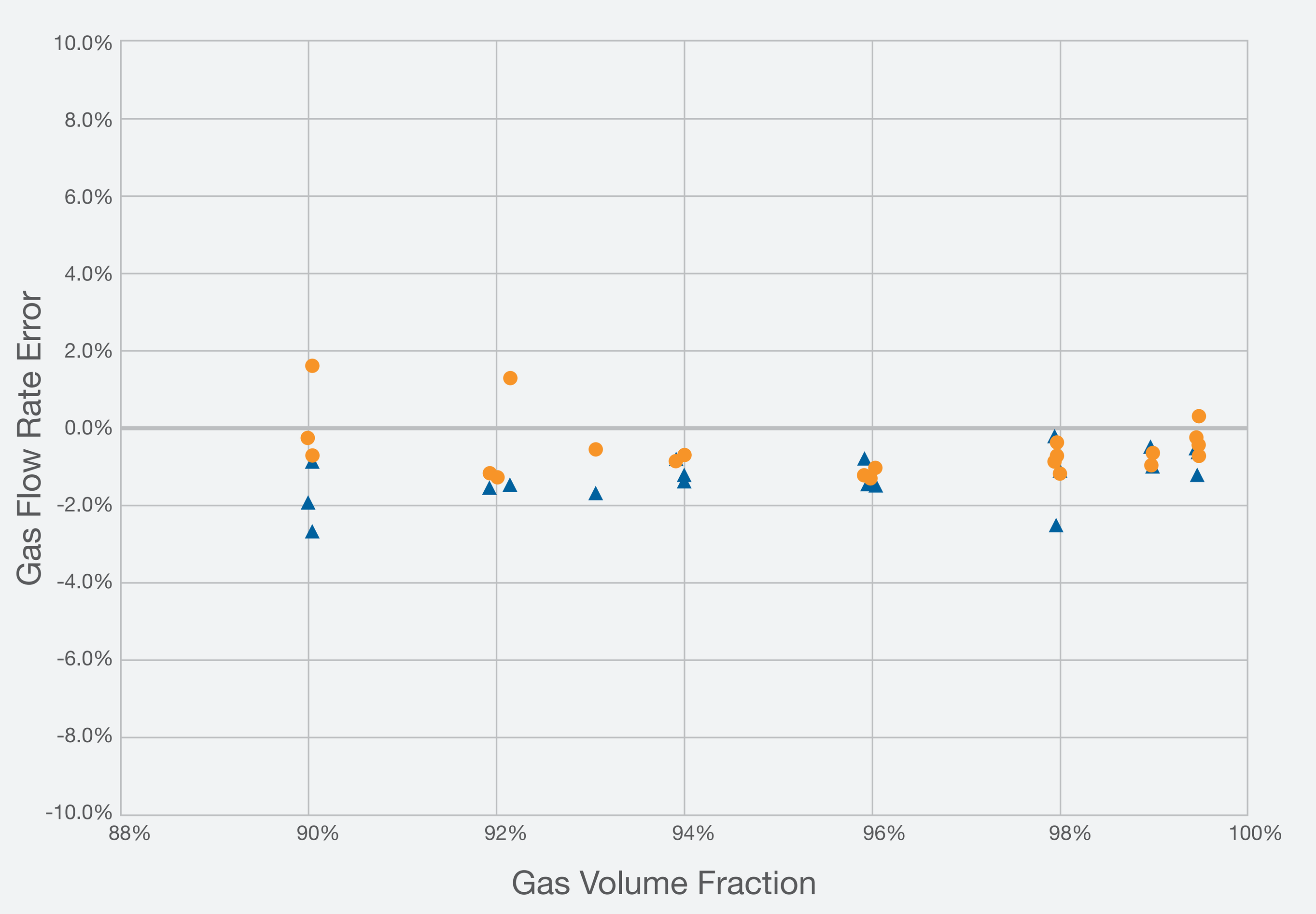


If the two-phase periods are easily identified, then an algorithm can be set in motion to remediate the mass flow output, ignoring the periodic liquid and providing a much better indication of the mass flow rate of the gas phase.

In this chart (left), the letters represent:

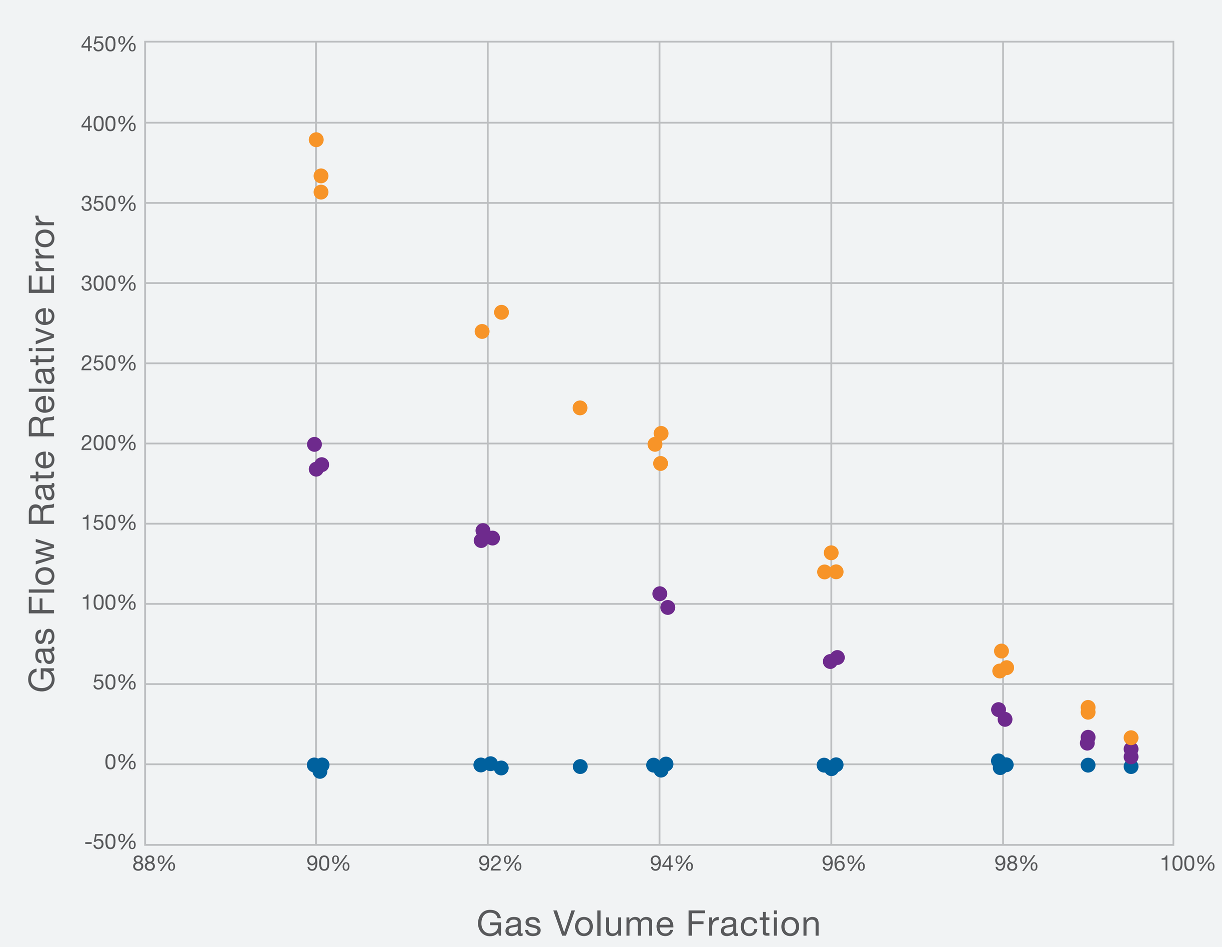
- A Drive Gain
- B Bulk Mass Flow Rate
- C Pre-Mist averaging of flow rate
- D Drive Gain Threshold
- E Post-Mist Delay
- F Held Mass Flow Rate
- G Post-Mist Adjustment

Advanced Phase Measurement Remediation Algorithm



Results from testing at the 4-inch wet gas flow loop at CEESI agree with field test. The algorithm is able to output dry gas mass flow rate, with error in the 1.5-2% range, as measured against a separator in the case of filed tests, and gas injection measurement in the lab.

Coriolis Mixed-Phase Mass Flow Output vs Gas Reference



With the algorithm, errors in dry gas measurement are greatly reduced and are largely insensitive to pressure. Future work will focus on increasing the accuracy and robustness of the algorithm.

REFERENCES: J. Hemp and j. Kutin. 2006. Theory of errors in Coriolis flowmeter readings due to compressibility of the fluid being metered. Flow Measurement and Instrumentation. 17:359-369 [2] J.A. Weinstein. 2008. The motion of bubbles and particles in oscillating liquids with applications to multiphase flow in Coriolis meters. University of Colorado at Boulder Dissertation. Proquest: AAT 3315790. [3] A. HAWLEY AND J. THORSON. 2015. Turbine and Coriolis Meter Diagnostics with Entrained Liquids. Pipeline Research Council International. PR-015-14603-R02