Guidelines for Troubleshooting and Operation of Provers with Micro Motion ELITE® Coriolis Flow Meters

Micro Motion® ELITE® flow meters are high-precision Coriolis flow meters that are often used in the oil and gas industry in conjunction with volume provers. These guidelines are designed to aid in troubleshooting and operation of provers that are in use together with Micro Motion Coriolis meters. Proving results may vary if unstable process conditions exist during proving.

Proving Methods and Proving Data Evaluation

The *American Petroleum Industry (API) Manual of Petroleum Measurement Standards (MPMS) Chapter 4.8, Second Edition, Operation of Proving Systems, Annex A, Evaluating Meter Proving Data* explains the relationship between the number of proving runs, the observed repeatability, and the random uncertainty of the resulting meter factor. One important principal is that a lower meter factor uncertainty will always result as more runs are collected and averaged.

Prover Size and Selection for Fixed-Volume Provers (Does Not Apply to Master Meter Provers)

Important Note: The prover size should never result in a pass time of less than 0.5 seconds or a pre-run time of less than 0.25 seconds.

Increasing the Base Prover Volume (BPV) will result in passing repeatability requirements with fewer prover passes. Increasing the number of passes will allow for passing repeatability requirements with a smaller prover. A decision may be made either to size the prover with a smaller BPV (lower capital investment) with a longer overall proving time, or with a larger BPV with reduced runs (less long-term wear and tear) and shorter overall prove time.

Prover Conditions

It is important to prove at conditions that are as similar as possible to the expected operating conditions. There are many conditions and factors that can influence the success of proving systems.

- Prover equipment and all supporting reference measurement devices must be well-maintained and verified to ensure measurement traceability, reproducibility, and repeatability (API MPMS Ch. 4 and Ch. 21.2, paragraph 2.11).

- Stability of flow rate, density, temperature, and pressure is critical during proving. System design, prover settings, and maintenance can all impact flow rate stability during proving.

- The liquid inside the piping connecting the meter to the prover should remain stable.

  o Minimize piping between the meter and prover.

  o Avoid dead-end branches between meter and prover that may act as a volume "spring" with compressible fluids.
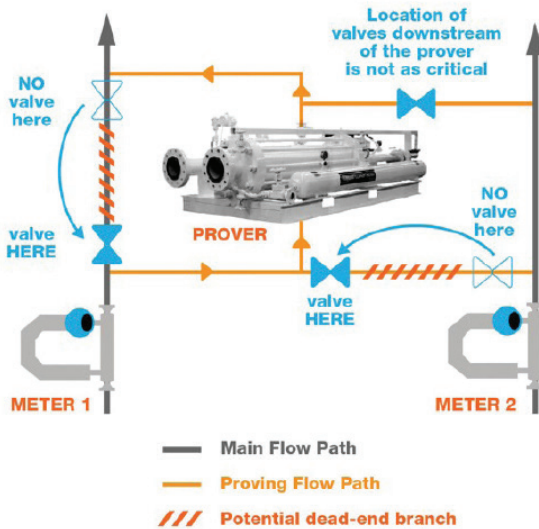
ELITE® Coriolis Flow Meters

Proving loops with a shared prover

To avoid dead-end paths upstream of the prover when proving Meter 1, locate divert valves for Meter 1 proving loop as shown.

- **Main Flow Path**
- **Proving Flow Path**
- **Potential dead-end branch**

- Sufficient back pressure must be maintained on both the prover and the meter to avoid vapor breakout and to maintain a stable flow rate during displacer launch and travel. Minimum recommended back pressure is shown by Equation 4 (from API MPMS Ch. 5.6).

Equation 1: $\rho b \geq 2\,\Delta\rho + 1.25\,\rho_e$

Where: ρb = Minimum back pressure (psig)

$\Delta\rho$ = Pressure drop across meter at max. flow rate

ρ_e = Equilibrium vapor pressure at operating temperature (psia)

- Accurate prover density measurement is crucial when mass proving with a volumetric prover. The following tolerances are advised when using a pycnometer (API MPMS Ch. 14.6).

  o Max. temperature difference = 0.2 °F

  o Max. pressure difference = 1 psi

  o Density Meter Factor (DMF) repeatability should be 0.05% or better between consecutive pycnometer tests

- Flow pulsation from PD pumps, including lack of back-pressure regulation, may influence repeatability and additional passes may be needed to meet random uncertainty requirements.

- Enabling compensation for the effect of pressure on the meter (consult the Transmitter Configuration and Use Manual) can improve repeatability in applications where line pressure varies by more than 30 psig during proving runs.

Meter Operation

When using smaller provers, it is important to ensure that the meter is configured for optimum filtering and speed of response.

1. Select the fastest speed of response available:

   o 5700 transmitter: select "Low Filtering" response mode

   o 2700 transmitter: select "Special" for Update Rate and either "Special" or "Low Filtering" for Calculation Speed

2. Set flow damping to a value between 0.0 and 0.08 seconds.

3. Set density damping to 0.16 seconds.

4. Proving Wizard software is available from Emerson to aid in preparing Micro Motion Coriolis meters for proving

When the meter factor remains stable between proving events, this indicates that the meter zero setting value is good. A change in the meter factor may or may not be related to the meter zero, so it is important to always perform a Zero Verification Test (consult Transmitter Configuration and Use manual) before making any zero adjustments. Only adjust the meter zero if advised to by the Zero Verification Test. If a meter zero is adjusted, reprove the meter.

Coriolis flow meters do not have a fixed K-factor (number of pulses output per unit of flow). The number of pulses output per unit of flow (e.g. pulses per barrel) from a Coriolis meter is an adjustable parameter that can be set to any desired value. However, the frequency of pulses during the highest flow rate must not exceed the pulse input capacity of the prover pulse counting device.

API MPMS Chapter 5.6 Measurement of Liquid Hydrocarbons by Coriolis Meters defines a pulse scaling factor (PSF) as the number of pulses output by a Coriolis meter per unit of flow. In this way, a Coriolis meter PSF is like a mechanical meter's K-factor, but adjustable.

Micro Motion transmitters typically provide a frequency output of up to 10,000 Hz (10,000 pulses per second). Many field device pulse input specifications have a similar maximum pulse input rate of 10,000 Hz. However, some field devices have a maximum pulse input rate that is less than 10,000 Hz. The PSF of the Coriolis flowmeter can be adjusted to stay within the constraints of any field device that is counting the pulses from the meter per the equations shown here:

Max. PSF = (10,000 X 3600) / Max. Rate

Where:

Max. PSF	= maximum PSF in pulses per unit mass or volume to prevent exceeding 10,000 Hz
10,000	= maximum frequency output in Hz
3600	= conversion factor for seconds from hours
Max. Rate	= maximum flow rate in barrels or lbs per hour

The equation above can be rearranged to determine the output frequency at a given flow rate.

Freq = (Max. Rate / 3600) x PSF

Where:

Freq	= frequency output in Hz
Max. Rate	= maximum flow rate in barrels or lbs per hour
3600	= conversion factor for seconds from hours
PSF	= pulse scaling factor in pulses per unit mass or volume

Master Meter Proving

Micro Motion Coriolis meters can be used as master meters per API MPMS Ch. 4.5 for proving with the following advantages:

- A Coriolis master meter can be used to prove in either volume and/or mass units.

- Pass duration can be lengthened to improve repeatability.

- Maintaining stable process conditions is much easier with no effects due to a displacer launch.

- Low maintenance and high reliability, with no seals or moving parts.

Need More Information?

Emerson has extensive field experience in mass and volume proving of our Micro Motion Coriolis meters. Contact us at 1-800-522-6277 or visit our website at www.MicroMotion.com

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