

# Guidelines for the Selection and Operation of Small Volume Provers (SVP) with Micro Motion High Capacity ELITE CMF Coriolis Flow Meters

Micro Motion ELITE® High Capacity (CMFHC) flow meters were introduced in 2007, increasing the flow capacity of high precision Coriolis flow meter technology for the oil and gas industry. To aid in optimizing the operation of measuring systems that include both small volume proving devices and Micro Motion CMFHC ELITE flow meters, Emerson has developed the following set of guidelines. These guidelines are designed to aid in selecting a prover volume that is capable of achieving consistent proving repeatability, while providing the flexibility to minimize prover sizes and/or the number of prover displacer passes. The guidelines include best practices based on years of successful proving experience with Coriolis meters that will help to achieve long-term meter factor reproducibility and stability. However, results may vary if unstable process conditions exist during proving.

It should be noted that the majority of these recommendations are for the sole purpose of ensuring a high probability of consistently meeting proving repeatability requirements. If repeatability requirements are already consistently being met, there is no need to change the process or the prover size.

## Prover Sizing and Selection

For best repeatability results, the recommended minimum prover displaced volume should be no less than the volume that would result in a 0.5 second pass time and a minimum run time of 2.0 seconds (the run time being the sum total of all passes that are averaged for each run). The following equation can be used to calculate the precise prover volume that will achieve 2.0 seconds of run time.

$$\text{Volume (gallons)} = 0.0233 \times \text{max. flow rate (BPH)} \div \text{number of passes per run}$$

The volume should never be less than what would result in a pass time of 0.5 seconds, as defined in the following equation.

$$\text{Volume (gallons)} = 0.0058 \times \text{max. flow rate (BPH)}$$

Table 1 provides examples of rough estimates of prover displaced volumes that will achieve these goals based on:

- Maximum proving flow rate in the installation
- The selected number of passes per run
- 10 runs per proving ( $\pm 0.027\%$  uncertainty)

Once determined, the minimum displaced volume can be used to select the prover size by comparing against the displaced volumes of various sizes published by prover manufacturers. Under certain conditions, the recommendation noted is to use an alternative-type prover because the minimum displaced volume is uncommon or is not commercially available in small volume provers.

Max. Flow Rate (BPH)	Passes per Run	
	1-2	3 or More
	Recommended Minimum Prover Displaced Volume (assuming 10 runs and 0.12% repeatability tolerance)	
3200	75 gal.	25 gal.
3900	90 gal.	30 gal.
4500	105 gal.	35 gal.
5100	120 gal.	40 gal.
6000	140 gal.	47 gal.
8100	190 gal.*	63 gal.
9500	225 gal.*	75 gal.
11600	270 gal.*	90 gal.
	*Exceeds standard SVP sizes. Alternative prover technology recommended	

Table 1. Minimum Prover Displaced Volumes

### Example:

A prover that is to prove flow rates up to 5100 BPH:

- A 40-gallon displaced volume with 3 passes per run
- A 120-gallon displaced volume with 1 pass per run

## Prover Operation

The number of runs for each prove may vary. As the number of runs increases, larger deviation in the repeatability between runs is allowed (e.g., 5 runs require 0.05% maximum deviation, 10 runs require 0.12% maximum deviation). The maximum repeatability tolerance allowed for different numbers of runs can be found in API MPMS Ch.4.8 Operation of Proving Systems. The tolerances allowed by Ch. 4.8 will always result in a final meter factor uncertainty of  $\pm 0.027\%$  or less.

When proving Coriolis meters, it is recommended that you begin by collecting 5 runs and then perform additional runs if needed until the API repeatability/uncertainty requirements are met. If a fixed number of runs must be selected in advance, it is recommended to plan to collect at least 10 runs when proving Coriolis meters when using a small volume prover and 5 runs when using a pipe prover. Both methods are valid according to API MPMS Ch. 4.8.

Combining multiple passes per run (API MPMS Ch.12.2.3) will also reduce the minimum prover displaced volume required for consistent results as shown in Table 1. It is recommended to combine at least three passes per run when using a small volume prover with a Coriolis meter. A single round trip run is sufficient when using a pipe prover.

Some small volume provers allow for selection of the detector switches in order to set the ratio between the pre-run and active-run flight times. Typically, the setting which will achieve the longest active-run time (i.e., time during which pulses are counted) is the setting that will meet the API repeatability requirements with the fewest number of runs when proving a Coriolis meter.

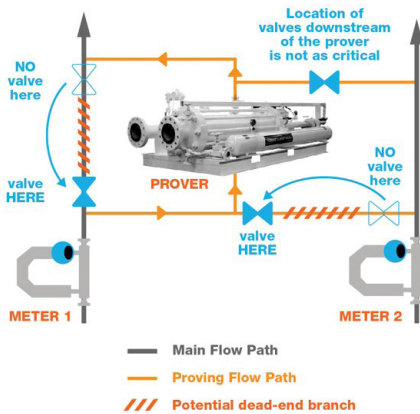
## Prover Conditions

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.

- 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.
  - Minimize piping length between the meter and prover.
  - Avoid dead-end branches between the meter and prover that may be a volume “spring” with compressible fluids.

### 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.



- 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).
- 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 1 (API MPMS Ch. 5.6).

$$\text{Equation 1: } P_b \geq 2\Delta\rho + 1.25\rho_e$$

Where:  $P_b$  = Minimum back pressure (psig)

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

$\rho_e$  = Equilibrium vapor pressure at operating temperature (psia)

- Accurate prover density measurement is crucial when mass proving with a volume prover. The following tolerances are advised when using a pycnometer (API MPMS Ch. 14.6).
  - Max. temperature difference = 0.2 °F
  - Max. pressure difference = 1 psi
  - Density Meter Factor (DMF) repeatability should be 0.05% or better between consecutive pycnometer test

- Flow pulsation from PD pumps may influence repeatability and additional passes may be needed to meet repeatability.
- 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 Sizing and Selection

The maximum flow velocity inside the meter should remain below 60 ft/sec [18 m/sec] during proving to avoid excessive turbulence. Consult meter sizing results for the velocity inside the meter.

Minimum Recommended Flow Rates (0.8 Specific Gravity Fluid)		
CMFHC2	CMFHC3	CMFHC4
850 BPH (4000 lb/min)	1700 BPH (8000 lb/min)	2600 BPH (12,000 lb/min)

## Meter Operation

Micro Motion Coriolis meters allow the pulse output (k-factor) to be scaled to produce more pulses per prover pass. However, the frequency of pulses during the highest flow rate must not exceed the pulse input capacity of the prover pulse counting device. Micro Motion document MC-001949 provides guidance on setting k-factor.

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:
  - 5700 transmitter: select “Low Filtering” response mode
  - 2700 transmitter: select “Special” response mode for both “Update Rate” and “Calculation Speed”
2. Set flow damping to 0.08 seconds.
3. Set density damping to 0.16 seconds.
  - Micro Motion provides Proving Wizard software to aid in configuring the meter for proving applications.

Before adjusting the zero, always perform a Zero Verification Test (consult Transmitter Configuration and Use manual). Only adjust the meter zero if advised to by the Zero Verification Test. If a meter zero is adjusted, a new proving meter factor must be obtained.

## 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 with no seals or moving parts.