Troubleshooting Custody Transfer Meter Factor Shifts

Introduction

Micro Motion Elite Series Coriolis flow meters are applied to liquid hydrocarbon measurement service and proven on a regular basis. The proving interval is determined based on financial exposure, contract, company measurement manual requirement, and/or regulation. Meter proving results in determining a meter factor (MF) which is applied to the indicated meter volume or mass to make a meter agree with a meter prover. Monitoring MF performance from proof to proof under similar operating conditions gives an indication of measurement system quality. This document will discuss using MF changes to troubleshoot measurement systems including a Coriolis flow meter.

MF reproductibility

MF reproducibility is the ability of a measurement system to generate similar MF results over time. Operating conditions should be similar from proof to proof (see API MPMS Ch. 4.8). MF reproducibility limits can vary by application. A common practice is to allow +/- 0.25% of reproducibility variation. MF control charts can be used to track MF performance. API MPMS Ch. 13.2 provides guidance for MF control charting.

Resulting mass MF reproducibility will vary with density MF (DMF) reproducibility in applications where inferred mass proving is implemented and it is important to track both MF reproducibility values (mass and density).

Coriolis transmitter configuration

Coriolis transmitter configuration errors can lead to incorrect MFs. Configuration changes between proofs can influence MF reproducibility. **Transmitter configuration including calibration constants, multiplying factors, and pulse output setup should be verified at the very beginning of any MF troubleshooting exercise.** Smart Meter Verification (if applicable) should be run and pass.

Meter zero

A MF result close to unity (1.0000) is an indication that the meter zero is correct and has not changed. Changes to meter zero are discouraged for meters that are proven regularly because any changes will but a bias in the MF and impact reproducibility. Meter zero simply adds or subtracts from the indicated volume or mass.

Volume calculation

Coriolis mass flow meters directly measure mass flow rate and density. Volume is calculated by dividing mass flow rate by density (Equation 1.). It is important to keep this principle in mind when troubleshooting volumetric meter factors. Abnormal process conditions that impact density like entrained gas in liquid can impact a volumetric MF.

Equation 1.:

$QV = Qm / \rho$

- Where:
  - Qv = Calculated indicated volume rate
  - Qm = Measured mass flow rate
  - ρ = Measured flowing density

MF direction

MFs can be greater or less than unity which is an indication of whether a meter is reading lower or higher than a prover. A MF is the amount of correction applied to a meter reading to match the prover mass or volume during a proof. The MF change direction can be used to eliminate potential measurement system issues.

MF > 1.0000

A MF greater than unity is an indication that the meter volume is underreading a prover. This may be caused by a high meter density which can be due to process buildup on meter tubes.

Paraffin is a common cause of process buildup in crude oil applications. Paraffin can result when the oil temperature is lower than the cloud point (wax appearance temperature).

Comparing the meters temperature corrected API Gravity to a hydrometer is one method of checking for process buildup. A meter corrected API Gravity will read lower than a hydrometer in the event of process buildup on the meter tubes.

Uncompensated pressure effects on a Coriolis meter can lead to large positive MF values. Pressure effects are greater on larger meters and API MPMS Ch. 5.6 requires pressure compensation for effects greater than 0.05%.

Some pipeline measurement systems include thermal bypass loops to prevent over pressure events during shut-in intervals. Incorrectly installed components can create meter bypasses which will lead to high meter factors.

Poor system wiring and/or connections to a portable prover flow computer can lead to “missing” pulses. This is a less common but a possible cause of high MFs.

MF < 1.0000

A MF less than unity is an indication that the meter volume is overreading a prover. This may be caused by a low density reading due to entrained gas.

Ensure that there is sufficient back pressure at the meter outlet. API MPMS Ch. 5.6 provides guidance on a minimum back pressure value (Equation 2).

Equation 2.:

$P_b = 2\Delta P + 1.25P_e$

- Where:
  - P_b = minimum backpressure required (psig)
  - ΔP = pressure drop across the meter at the max rate
  - P_e = equilibrium vapor pressure of the fluid at operating temperature (psia)

Upstream pump or valve cavitation can produce gas entrainment in the flowing liquid and should be eliminated.

Prover bypasses can lead to low MFs. A double block and bleed valve used to divert the meter flow stream into a prover should be checked for a complete seal.

Some pipeline measurement systems include thermal bypass loops to prevent over pressure events during shut-in intervals. Incorrectly installed components can create prover bypasses which will lead to low meter factors.

Bi-directional ball provers have a four-way valve on the prover inlet used to reverse flow direction. Four-way valves have a minimum sealing pressure to seal completely. Operating a prover below the minimum sealing pressure can lead to low meter factors. Four-way valves must be calibrated properly to ensure a complete seal. Inconsistent meter pulse counts between ball travel directions is an indication that the four-way valve is not sealing properly.

MF linearity

Micro Motion Elite Series Coriolis mass flow meters are extremely linear devices. MF deviation is low over a wide operating range. Incorrect meter zero can lead to wide MF variations with a change in operating flow rate. Measurement error created by an incorrect meter zero is a larger percentage of reading at lower flow rates which requires a larger MF. Resetting zero to the factory value can correct “linearity” issues.

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