Micro Motion Coriolis Oil & Gas Metering Recommended Practices for Upstream Allocation

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This document describes the best practices for selecting a Micro Motion flowmeter, which consists of a sensor and transmitter, and setting up the meter for use. The intent is to establish the best choice when considering the performance level requirements and cost of the meter. While Micro Motion offers an array of sensors and transmitters to meet various application requirements, this document considers only those that are typically used for Oil & Gas metering: ELITE®, F-Series, and R-Series sensors, and Series 1000, 2000, and 3000 transmitters. For information about other Micro Motion products, contact your local sales representative.

Sizing and Selection

Properly sizing a Coriolis meter consists of choosing a meter size that optimizes the trade-off between measurement error at minimum flow rate and pressure loss and/or gas velocity at maximum flow rate. At a constant flow rate, pressure, and temperature, the pressure drop and gas velocity are higher through a smaller diameter meter and may give a higher (mass) accuracy measurement and turndown ratio. Likewise, pressure drop and gas velocity are lower when a larger diameter meter is chosen; however, the potential measurement error at a similar low flow rate may increase, and the turndown ratio may decrease. In some gas measurement applications the sensor size could be one or more pipe sizes smaller than the upstream or downstream piping, requiring pipe reducers and expanders. Excessive lengths of small diameter pipe or abrupt flow diameter reductions such as tees, short radius elbows, etc., can adversely affect pressure drop. In cases where a reduction is required, the use of long or gradual transition swedges is suggested.

Pressure Drop vs. Accuracy

The minimum flow rate (min Q) is defined by the lowest flow rate at which the meter error will not exceed the uncertainty specified by the Operator. Use the Micro Motion Sizing Tool to find the best fit for the application.

Volatile hydrocarbon (live oil) sizing considerations. It is important to minimize pressure drop on live liquid hydrocarbons as any drop in pressure can cause gas to liberate from the oil resulting in measurement error.

Measurement errors can typically be avoided by:

- Ensuring the separation system has enough retention time, pressure drop, and applied temperature as required to remove the free gas
- Limiting the pressure drop across the meter upstream of the level valve to 0.75 to 3 psid or less

All of the specifics guiding these two priorities are dependent on the EVP (equilibrium vapor pressure) of the oil to the process operating pressure/temperature and time in residence of the live oil.

Instantaneous Rate vs daily Production Rates. Coriolis flow meters should be sized for the instantaneous rate at the meter rather than the production rate of the well for each fluid (water, oil or gas).

Note: The information that follows is complex. Contact your local Emerson Flow expert for additional guidance.

Micro Motion®

EMERSON™ Process Management

The instantaneous rate across the meter can be determined by carefully completing the following steps:

- First, by determining the daily production rates for:
  - Oil
  - Water
  - Total liquid (should be equal to Oil + water)
  - Total gas
- Second, by production method (natural lift, pump jack, ESP, gas lift, plunger lift, etc.)
- Third, by gas vs. liquid centric well characteristics (actual, not predicted GOR, GLR)
- Fourth, C1 through C5 constituent component stream of the live Oil
- Fifth, Process operating conditions of the separator &/ or treater to the sales system:
  - Pressure, Temperature
  - Level control system including the valve type, size, trim, etc.
  - Downstream pressure of gathering system or sales/ storage tanks

Material of Construction

All stainless steel Micro Motion meters can be rated to at least 1450 PSI; nickel alloy C22 meters can be rated to at least 2160 PSI. For other pressure requirements, check with the Micro Motion Factory. Pay attention to material compatibility. For most natural gas applications, 316L stainless steel is sufficient; however, consider carefully if corrosive components are present. Use nickel alloy C22 as warranted; consult Micro Motion regarding corrosives concerns.

Communication Requirements

In applications where a flow computer is used, the choice of RTU/ Flow computer may determine which Micro Motion products are selected. If the RTU has the capability of processing the mass flow rate directly from the MODBUS registers from the sensor core processer, then only Direct Connect is required. If the above is not applicable then a Micro Motion transmitter is required.

Verification Requirements

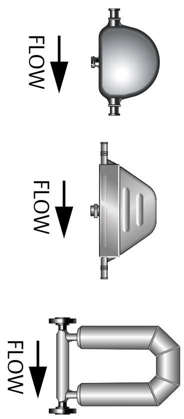
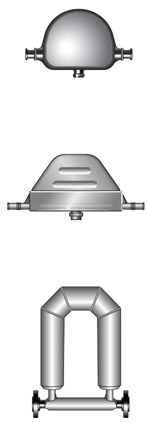
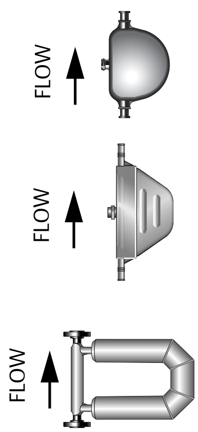
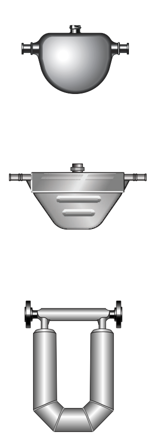
If meter performance verification is required and it can be performed from either the MODBUS registers or traditional I/O via the RTU/ Flow computer, then only Direct Connect is required.

Additionally, if Micro Motion Smart Meter Verification (SMV) is desired, then the meter must be purchased with a model 800 enhanced core processer.

Installation

Orientation

In general, sensor orientation does not affect measurement performance; however, when possible, meters should be oriented according to the preferred orientations shown in the table below, which are based on the shape of the meters and their flow tubes. If it is not possible to use the preferred orientation, use the alternate orientation.

Type	Preferred Orientation	Alternate Orientation
Gases		MINIMAL LIQUID PRESENCE (ALL MODEL TYPES) 
Liquids		

Thermowell Port

Provides for use of a flow temperature reference in the verification of the temperature measurement made by the sensor. The thermowell should be installed upstream of the sensor.

Bypass

May be considered to provide an alternate path for process during meter maintenance and inspection procedures. Consideration should be given prevent inadvertent bypassing of the meter. Use double block and bleed valves to identify bypass leaks caused by a leaking block valve seat.

Isolation Block Valves

Allow the sensor to be removed from the process conditions. Isolation valves should be located in close proximity to the meter to facilitate accurate zeroing. If incorporated with a pressure blow down port, the isolation block valve integrity can be verified by monitoring the pressure after blow-down.

Pressure and Blow-down Port

This port can provide for the monitoring of process pressure if required. If correcting for flow pressure effect, the process connection should be located directly upstream of the sensor.

Sensor Models

ELITE Series

The ELITE models CMF, CMFS, or CMFHC are the highest performance sensor, with the best sensor-based flow and density accuracy and turndown, and widest selection of sensor sizes.

Fiscal Metering Custody Transfer. API Chapter 5 of stabilized (weathered) products, such as pipeline and LACT.

Net Oil. The density measurement is used to determine the percent of water and oil in a single flow stream (i.e., two-phase separator). Because of their superior density measurement accuracy, ELITE meters should be used when water cuts are above 85% and the gravity is lower than 40 API.

F-Series

The F-series sensor is a high performance sensor for accurate flow and density measurement, as well as wide turndown capability.

Production and/or Allocation. Measurement where high accuracy, turndown, or performance verification is required.

Net Oil. F-series sensors can be used when water cuts are below 85% and the gravity is higher than 40 API.

R-Series

The R-Series is the Micro Motion general purpose sensor.

Allocation. Used for measurements where mechanical or differential pressure meter accuracy and turndown performance are inadequate. Coriolis meters deliver accuracy and turndown benefits plus low maintenance and diagnostics.

Transmitter Models

All Micro Motion sensors with integral core processors are capable of direct MODBUS communication. In applications where only direct MODBUS communication is desired, a transmitter may not be required. If this option is chosen, then a model 500 Micro Motion barrier is recommended. If the above is not applicable then a Micro Motion transmitter is required.

All Micro Motion transmitters have the same basic performance specifications. Selection criteria should be based on features required by the application. Transmitters are required for any flow meter which is proven in order to produce a pulse output.

Transmitter	NOC	Weights & Measures	API	Analog/Pulse/ HART	Modbus	Multi-variable
3000	X	X	X	X	X	X
2500/2700		X	X	X	X	X
Direct Connect			X		X	X
1500/1700				X	X	

Series 3000

The Series 3000 transmitter/controller has the largest feature set.

Net Oil . The series 3000 is used when Net Oil calculations are required. For field mounting, use model 3700. For panel mounting, use model 3500.

Series 2000

The Series 2000 transmitters measure multiple variables simultaneously, and they have additional output and digital communication options.

Best Fit. High performance multivariable transmitter. The model 2500 is a DIN rail mount transmitter. The model 2700 is a field mount transmitter with the following features:

- Two-inch pipe mount or integral mount
- Integral backlit configurable display
- Hazardous area approval options

Series 1000

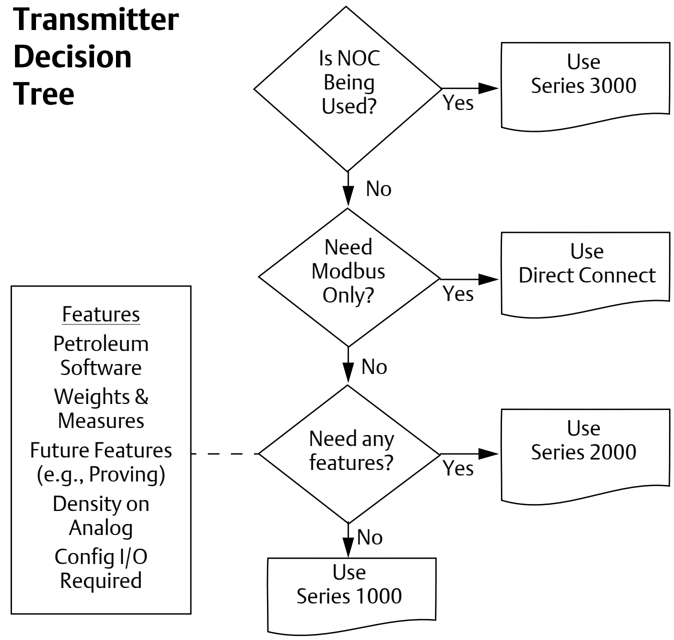
The Series 1000 transmitters output flow only via analog or frequency, and they also have digital communication options.

Best Fit. *Alternative to 2000 Series if only flow output is required.* Used with R-Series meter applications. The model 1500 is a DIN rail mount transmitter. The model 1700 is a field mount transmitter with the following features:

- Two-inch pipe mount or integral mount
- Integral backlit configurable display
- Hazardous area approval options

To determine the optimal transmitter selection, refer to the Transmitter Decision Tree, below.

Transmitter Decision Tree



Setup

Base Configuration

Sensors data is in the core. Flow Calibration Factor and Density K factors from the sensor tag are stored in the Core processor. They should always be verified upon start up or after repair.

Mass and volume flow cutoff. Mass and Volume Flow Cutoff specify the lowest Mass and/or Volume flow rate that will be reported as measured flow. All flow rates below this cutoff will be reported as zero flow.

The appropriate cutoff value must be determined by the end-user as the 'Live Zero' can be influenced by sensor installation, orientation, sudden process temperature changes, and presence of entrained gas in a liquid stream or presence of liquid in a gas stream.

Suggested cutoff values range from 0.2% to 0.5% of the maximum flow rate expected through the sensor but may be higher depending on the influences described above.

Note: Low Flow Cutoff values higher than 0.5% of the maximum flow rate may indicate a process or installation issue that should be investigated

For gas measurement, many users choose to set low flow cut off based on minimum acceptable accuracy:

Mass or Volume Flow Cut off = Published Sensor Zero Stability / Minimum Acceptable Accuracy

At $\text{Pressure}_{\text{Base}}$ of 14.73 PSIG, $\text{Temperature}_{\text{Base}}$ = 60 °F, with SG = 0.6, then Gas Density is 45.92 lb/MCF.

Example:

A model CMF300 has a stated zero stability of 15 lb/hr. If the customer-specified minimum acceptable accuracy is 1%, the mass flow cutoff would be:

15 lb per hour/ 0.01 = 1,500 lb/hr.

Note: for gas applications, Density Cut Off should be set to 0.0.

Special units. Special Unit are sometimes desired and required to interface with different RTUs. A Tab in ProLink software is used to convert base units to desired unit. For example SCF to MSCF (Thousand Cubic Feet) or lb to Mlb (Thousand pounds).

Frequency output. For liquid applications, frequency output provides maximum resolution by setting 10,000 Hz equal to the maximum flow rate. For gas applications, frequency output for gas measurement should be set for maximum resolution related to mass flow. For example, with gas density of 45.92 lb/MCF and a maximum flow rate of 1MMSFD:

- 1,000 MSCF X 45.92 lb/MSCF = 45,920 lb
- Frequency Output should be set to 10,000 Hz = 45,920 lb
  - 10,000 pulses/sec X 86,400 sec / 45,920 lb = which is 18,815 pulses/lb
  - 18,815 becomes the K Factor in the RTU

Pressure compensation. Pressure compensation may be used in MMI transmitter or RTU but should not be used in both. The calibration pressure is found on the sensor calibration certificate. Pressure compensation is based on operating pressure minus calibration pressure.

Meter Verification and Flow Performance Testing

The frequency is at the discretion of the operator. Field Meter Verification of Micro Motion metering system consists of monitoring and evaluating operating conditions and diagnostic indicators to identify possible change in the system performance, as well as the cause. By evaluating the Meter diagnostics the operator can determine if the meter needs to be re-zeroed, if a flow performance test (in-situ or laboratory) needs to be initiated, or if the scheduled maintenance frequency needs to be modified.

Field Meter Verification. The field verification of the Micro Motion meter involves evaluating and monitoring, metering conditions and meter diagnostics to identify changes in meter performance and their causes. The evaluation of these diagnostics will determine the need to re-zero the Coriolis meter, perform a flow performance test (in-situ or laboratory), or adjust periodic maintenance.

- **Meter/Transmitter Verification -** The meter transmitter verification should coincide with the meter zero check. It should include the following procedures:
  1. Verify the sensor calibration and configuration parameters of the transmitter.
  2. Use ProLink software to verify and record all transmitter diagnostics.
- **Micro Motion Smart Meter Verification -** When equipped with this feature, sensor and transmitter diagnostics can be scheduled at some interval or run on demand.
- **Temperature Verification -** The Micro Motion transmitter monitors a temperature element bonded to its flow tubes that corrects for Young's modulus of the flow tubes. Using a temperature reference placed in an upstream thermowell or temporarily placed tightly against the upstream flow splitter/inlet and insulated, verify the temperature indicated by the sensor to be within ±1 ° F of the reference temperature.
- **Meter Zero Verification -** It is recommended by AGA that at minimum, the meter zero be checked at flowing pressure and temperature within 1 to 4 weeks of installation and quarterly during the first year of its field service. The frequency of subsequent zero verifications should be guided by the record of meter zero data, operating conditions, and by operator policy. The meter zero verification should include the following procedures:
  - Create zero flow condition by blocking meter upstream and downstream. Verify meter zero is within the factory specifications for type and size of meter under evaluation. Zero verification cannot be performed correctly without thermal stability. Especially for gas service, be aware that thermal gradients or temperature changes can cause flow within the piping even though the system is blocked in.
  - Perform zero check using Prolink software. Alternatively Prolink can be used to log the live zero value for a minimum of three minutes. Saved data should be averaged and compared to the zero stability specification. If within the specification, record the as-found zero and then return to service.
  - If the zero is not within the specification, record the as-found zero, then rezero, record new zero, and compare to factory specification. If meter zero is within specification, record the as-left meter zero value and return the meter to service.

If meter zero is out of specification check the following:
- Verify isolation valves are not leaking and check for other potential leak sources. If leaks are present, zero verification cannot be performed correctly. Correct issues, re-zero the meter, and record the new zero value.
- Evaluate indicated density, if it is higher than expected by more than 20% for the gas at the blocked-in conditions the sensor may be contaminated and/or have a coating on the flow tubes (e.g., condensates, glycol, amines, water, oil, dirt, etc.) and should be cleaned. A low density reading can also be caused by erosion or corrosion. In this case the sensor will need to be evaluated by Micro Motion.
- Incorrect Mounting can result in an offset or drifting zero, as out-of-square components may cause a bias in the meter zero through change in the dynamic balance of the meter's flow tubes.
- To confirm, check the sensor drive gain to insure it is low and stable. If the meter zero has a history of drifting or instability, then one side of the meter should be unbolted completely to relieve any potential stress that my be present. While unbolted, inspect the mating flange set for shifting, pulling apart, or a misalignment. If mounting stress is found, correct the issues and retest the zero.

Prolink Datalog Instructions

Key diagnostics list

- Process Variables: Density, Mass Flow Rate, Mass Total Temperature, Volume Rate, Volume Total
- Diagnostics: Drive Gain, Input Voltage, Left Pickoff Voltage, Live Zero, Right Pickoff Voltage

Flow performance testing

If flow performance testing is required:

- For liquid, prove according to industry best practices.
- For gas:
  - Remove from service and send to the manufacturer or third party lab.
  - Perform in-situ flow testing via field proving with gas master meters in accordance with industry best practices and/or regulatory requirements.

A field flow performance test verifies meter performance at field operating conditions. Operating conditions can affect the accuracy and repeatability of a meter. When performance testing in the field, use caution to insure the items below are evaluated to minimize their impact on meter performance.

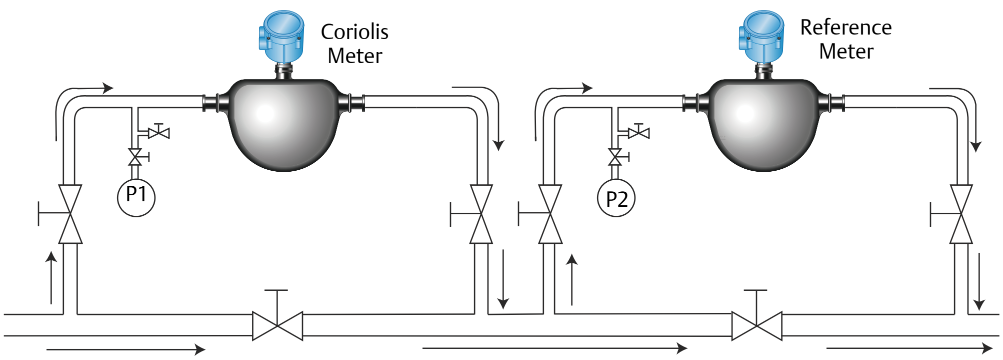
- Mechanical stress on the meter
- Flow variations
- Extreme variations in fluid pressure and temperature
- Ambient temperature changes
- Fluid phase and composition

If field flow performance testing is desired, the metering system piping should be designed to incorporate the attachment of a reference meter.

Example Configuration for Field Performance Testing

When utilizing a reference meter for field performance testing, a reference meter (master meter) should be used. It should be calibrated in a laboratory traceable to a recognized national or international measurement standard. In any case, the reference meter should have a measurement uncertainty less than the field meter being tested.

Note: When a Meter Under Test (MUT) is tested against a field reference, the MUT should not be adjusted if the performance is found to be within the uncertainty of the field reference.



Example configuration for Field Performance Testing

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