Application Manual
MMI-20030076, Rev AD
September 2020

Micro Motion™ Advanced Phase Measurement

Application Manual

MICRO MOTION™

EMERSON™

Safety messages

Safety messages are provided throughout this manual to protect personnel and equipment. Read each safety message carefully before proceeding to the next step.

Safety and approval information

This Micro Motion product complies with all applicable European directives when properly installed in accordance with the instructions in this manual. Refer to the EU declaration of conformity for directives that apply to this product. The following are available: the EU declaration of conformity, with all applicable European directives, and the complete ATEX Installation Drawings and Instructions. In addition the IECEx installation instructions for installations outside of the European Union and the CSA installation instructions for installations in North America are available on the internet at www.emerson.com or through your local Micro Motion support center.

Information affixed to equipment that complies with the Pressure Equipment Directive, can be found on the internet at www.emerson.com or through your local Micro Motion support center.

For hazardous installations in Europe, refer to standard EN 60079-14 if national standards do not apply.

Other information

Full product specifications can be found in the product data sheet. Troubleshooting information can be found in the configuration manual. Product data sheets and manuals are available from the Micro Motion web site at www.emerson.com.

Return policy

Follow Micro Motion procedures when returning equipment. These procedures ensure legal compliance with government transportation agencies and help provide a safe working environment for Micro Motion employees. Micro Motion will not accept your returned equipment if you fail to follow Micro Motion procedures.

Return procedures and forms are available on our web support site at www.emerson.com, or by phoning the Micro Motion Customer Service department.

Emerson Flow customer service

Email:

- Worldwide: flow.support@emerson.com
- Asia-Pacific: APflow.support@emerson.com

Telephone:

North and South America		Europe and Middle East		Asia Pacific	
United States	800-522-6277	U.K. and Ireland	0870 240 1978	Australia	800 158 727
Canada	+1 303-527-5200	The Netherlands	+31 (0) 70 413 6666	New Zealand	099 128 804
Mexico	+52 55 5809 5300	France	+33 (0) 800 917 901	India	800 440 1468
Argentina	+54 11 4809 2700	Germany	0800 182 5347	Pakistan	888 550 2682
Brazil	+55 15 3413 8000	Italy	+39 8008 77334	China	+86 21 2892 9000
Chile	+56 2 2928 4800	Central & Eastern	+41 (0) 41 7686 111	Japan	+81 3 5769 6803
Peru	+51 15190130	Russia/CIS	+7 495 995 9559	South Korea	+82 2 3438 4600
		Egypt	0800 000 0015	Singapore	+65 6 777 8211
		Oman	800 70101	Thailand	001 800 441 6426
		Qatar	431 0044	Malaysia	800 814 008
		Kuwait	663 299 01		
		South Africa	800 991 390		
		Saudi Arabia	800 844 9564		
		UAE	800 0444 0684		

Contents

1 Before you begin

1.1 About this application manual

This application manual explains how to configure and use the Advanced Phase Measurement licensed software option on select Model 5700 transmitters. It also contains limited, supplemental installation and configuration information specifically related to the Advanced Phase Measurement software. Refer to the sensor and transmitter installation manuals and the transmitter configuration and use manual for complete information.

Important
This manual assumes that:

- The transmitter has been installed correctly and completely according to the instructions in the transmitter installation manual
- Users understand basic transmitter and sensor installation, configuration, and maintenance concepts and procedures

1.2 Related documentation

You can find all product documentation on the product documentation DVD shipped with the product or at www.emerson.com.

See any of the following documents for more information:

- Model 5700 installation manual
  - *Micro Motion 5700 Transmitters with Configurable Inputs and Outputs: Installation Manual*
  - *Micro Motion 5700 with Ethernet Transmitters: Installation Manual*
  - *Micro Motion 5700 Transmitters for FOUNDATION™ Fieldbus: Installation Manual*
  - *Micro Motion 5700 Transmitters with Intrinsically Safe Outputs: Installation Manual*
  - *Micro Motion 5700 Transmitters for PROFIBUS-PA: Installation Manual*
- Model 5700 configuration and use manual
  - *Micro Motion 5700 Transmitters with Configurable Inputs and Outputs: Configuration and Use Manual*
  - *Micro Motion 5700 with Ethernet Transmitters: Configuration and Use Manual*
  - *Micro Motion 5700 Transmitters for FOUNDATION™ Fieldbus: Configuration and Use Manual*
  - *Micro Motion 5700 Transmitters with Intrinsically Safe Outputs: Configuration and Use Manual*
  - *Micro Motion 5700 Transmitters for PROFIBUS-PA: Configuration and Use Manual*
- *Micro Motion Enhanced Density Application Manual*
- *Micro Motion Modbus Map*

- *Micro Motion ProLink III with ProcessViz Software User Manual*
- *Micro Motion Ethernet PROFINET Siemens Integration Guide*
- Sensor installation manual

1.3 About the software

Micro Motion Advanced Phase Measurement software improves long-term flow reporting and measurement performance in processes with intermittent periods of two-phase flow, including liquids with entrained gas or gas with entrained liquid. And if it is combined with the Net Oil or Concentration Measurement software options, the software can also report liquid concentration, Net Oil, and/or Gas Void Fraction (GVF) during the same two-phase conditions.

There are three measurement options for the Advanced Phase Measurement software: Net Oil, Liquid with Gas, and Gas with Liquid.

Note
Each option is licensed separately in the transmitter. Field upgrades are permitted.

Table 1-1: Net oil options (choose one)

License option (ordering code)	Description	Availability
MA - Manual Advanced Phase Measurement configuration	Suitable for a mixture of oil and water under predictable flow conditions. Includes manual drive gain threshold only. See Manual Drive Gain Threshold. This option is the Model 5700 upgrade for Production Volume Reconciliation (PVR).	• Not available on a transmitter with intrinsically safe or non-intrinsically safe FOUNDATION™ Fieldbus H1 outputs • Not available on a transmitter with intrinsically safe outputs • Do not combine with APM liquid with gas (option PL) - basic remediation for gas is included.
MW - Net Oil Computer (NOC) software - multiple wells	Ideal for test separators shared by multiple wells. The transmitter stores a total of three well tests in memory. The transmitter can be set up for testing up to 48 independently-configured wells; however, only the most recent three tests that have been completed remain in storage at a time. Suitable for mixtures of oil and water, with remediation for gas.	• Do not combine with APM liquid with gas (option PL) - already included. • Only available on a transmitter with configurable outputs

Table 1-1: Net oil options (choose one) *(continued)*

License option (ordering code)	Description	Availability
PO - Net Oil	Suitable for mixtures of oil and water. Add PL option to remediate for gas.	Can be combined with APM license code PL. PL is recommended since most net oil applications contain gas.

Table 1-2: Liquid with gas

License option (ordering code)	Description	Availability
PL - Advanced Phase Measurement Liquid with Gas	Suitable for any liquid with entrained gas.	• Can be combined with APM license code PO. • Can be combined with license code concentration measurement (CM).

Table 1-3: Gas with liquid

License option (ordering code)	Description	Availability
PG - Advanced Phase Measurement Gas with Liquid	Suitable for any gas that may contain entrained liquids (mist).	Cannot be activated with any other license code.

1.4 APM software requirements

Ensure that your installation meets the requirements in this section.

Transmitter

Advanced Phase Measurement software is available only on the Model 5700 transmitter, either integrally mounted, in a 9-wire remote configuration, or in combination with any 800 Enhanced Core Processor.

Not available with:

- Weights & Measures -NTEP (option NT)
- Safety certification of 4-20 mA outputs per IEC 61508 (option SI)

Sensor

Advanced Phase Measurement software is compatible with any sensor that is supported by the Model 5700 transmitter except for the T-Series and R-Series sensors due to limited performance with two-phase fluids. The software is not compatible with the 700 Standard Core processor.

Installation and wiring

- Follow the installation and wiring instructions in the sensor and transmitter installation manuals.

- Identify and follow any application-specific installation needs as identified in this manual for your application type.
- For the entrained gas/mist/empty-full-empty best installation practices, refer to Best practices for two-phase measurement performance.
- If you plan to use the net oil measurement option with an external water cut monitor:
  - For the 5700 configurable transmitter, Channel D on the transmitter must be enabled, and must be configured as a mA Input, wired to the water cut monitor, and configured appropriately. HART integration is supported on Channel A by polling.
  - For the 5700 Ethernet transmitter, an external host system is required to accept the water cut monitor input and feed it to the transmitter.
  - For the 5700 intrinsically safe transmitter, HART integration is supported on Channel A by polling.

Note
Water cut cannot be input into the 5700 transmitter with FOUNDATION fieldbus output if the software revision of the transmitter is 1.*x*.

Configuration and operation

The Advanced Phase Measurement software can be configured using the interface option already being used to configure the transmitter:

- Transmitter display
- ProLink III v4.2 or later
- Field communicator (Model 5700 configurable and Model 5700 fieldbus transmitters only).
- A fieldbus host (Model 5700 fieldbus transmitter only)
- A web browser (Model 5700 Ethernet transmitter only)

Because much of the Advanced Phase Measurement software process data is not assignable to an output (for example, contract totals), use one of the following external host systems, depending upon the transmitter output type:

- For the Model 5700 configurable transmitter, a Modbus/RS-485 connection to Channel E, that must be enabled and wired to a Modbus host to collect and process data.
- For the Model 5700 Ethernet transmitter, an Ethernet/IP connection to the transmitter, and an appropriate host program to collect the Advanced Phase Measurement software process data.
- For the Model 5700 FOUNDATION fieldbus transmitter, a fieldbus H1 connection to the transmitter and a fieldbus host that reads Advanced Phase Measurement software process data.
- For the Model 5700 intrinsically safe transmitter, HART integration by polling.

1.5 Terms and definitions

The Advanced Phase Measurement software application and this manual use the terms defined here.

Contract hour	Contract totals are recorded and then reset at the beginning of the contract hour.
Contract period	The 24-hour period that monitors how much fluid the well has delivered. Contract totals are reset at the beginning of each contract period.
Contract total	Up to four user-specified totals that are used to measure production.
Corrected density	The density of the process fluid at reference temperature.
Corrected volume	The volume of the process fluid at reference temperature.
Correction	The process of calculating the value of a process variable at reference temperature, starting from the value of the process variable at line temperature (the measured value or observed value).
Density-based water cut	The water cut value calculated by Advanced Phase Measurement software using the measured line density referenced to a density/water cut curve based on user-entered dry oil and water densities at reference temperature.
Density determination	The procedure for obtaining the density of dry oil and water at reference temperature—both are required for use with the Net Oil software option.
Drive gain threshold	Maximum drive gain value expected for single-phase fluid under typical operating conditions. Above the threshold value, the measurement will be remediated in accordance with the configured Advanced Phase Measurement software settings. See Automatic Drive Gain Threshold determination or Manual Drive Gain Threshold for more information.
Entrained, entrainment	The presence of small amounts of gas in a liquid stream, or liquid in a gas stream.
External water cut	A water cut value measured by an external device and supplied to the Advanced Phase Measurement software via the mA Input or any compatible digital protocol; such as HART, EtherNet/IP, etc.
Gas void fraction	The ratio of gas volume to total mixture volume at line conditions. Also called *Gas Volume Fraction*.
Meter factor for shrinkage	A meter factor, established by proving, that acts as a multiplier to shrinkage-factored (SF) variables. Not commonly used.
Mixture	The process fluid before separation - for example, a combination of a two-phase system; two liquids (oil and water), or a three-phase system (gas, oil, and water).

Multiwell	An installation where well tests can be performed on up to 48 wells. A manifold system is used to ensure that the output from a single well is routed through the test separator and the NOC system.
Net	A measurement of a single component of the process fluid - for example, oil only, water only.
Period averaged output (PAO)	Rolling averages, with adjustable averaging period, that help identify trends in noisy data. Available PAOs are: mass flow rate, density, volume flow rate, net oil flow rate and water cut at line and reference conditions, gas void fraction, and temperature. The Average Reporting Interval is used to adjust the averaging period.
Post-mist adjustment delay	Period of stable gas flow conditions after a liquid entrainment event. After this delay, the average flow rate during Post-Mist Adjustment Delay is averaged with the Pre-Mist Averaging Period and the flow rate is adjusted a maximum of +/-10% of reading until any difference has been appropriately corrected in the totalizers. Default = 15 seconds.
Pre-mist averaging period	Period of stable gas flow conditions prior to a liquid entrainment event. Averaging period is user configurable with units = *n* seconds. The average flow rate during this period will be reported until the entrained liquid event has passed. Default = 15 seconds.
Remediated	An adjustment applied to a measured process variable by the Advanced Phase Measurement algorithm to correct for errors associated with two-phase fluid conditions.
Shrinkage	The change in liquid volume between the measurement point and a stock tank due to lighter hydrocarbons.
Shrinkage factor	User input multiplier used to account for shrinkage between measurement point and stock tank. Only affects shrinkage-factored (SF) variables. You can estimate your shrinkage factor by dividing the temperature-corrected metered density by the temperature-corrected oil sales density.
Uncorrected density	The density of the process fluid at line temperature and pressure.
Uncorrected volume	The volume of the process fluid at line temperature and pressure.
Unremediated	Measured variables that are not adjusted by the Advanced Phase Measurement algorithm. In two-phase conditions, these process variables represent the whole mixture, or bulk fluid (e.g. water, oil, and gas).
Water cut	The volume fraction of water in the liquid mixture, in %.

2 Measurement options and configuration

2.1 Liquid with gas

This measurement option improves flow measurement in liquid processes with intermittent entrained gas, or with known-density liquids under continuous entrained gas conditions.

Note
The liquid with gas measurement option can also be combined with the net oil measurement option or concentration measurement. See the *Micro Motion Enhanced Density Application Manual* to configure concentration measurement.

Liquid with gas measurement process

The presence of entrained gas (or bubbles) can cause significant errors when measuring the volume flow of liquid through a Coriolis meter. Because bubbles displace some of the liquid in a flow stream, the measured volume of the mixture may differ from the actual amount of liquid that emerges from the pipe downstream.

So how can you tell when a liquid contains gas? When bubbles are present in a liquid stream, Coriolis meters will report an increase in drive gain coinciding with a decrease in both fluid density(1) and mass flow rate(2) due to the lower amount of mass contained in the liquid-gas mixture. Therefore, in order to measure only the liquid portion of the stream, the volume of the bubbles must be ignored or subtracted from the mixture total. The APM software performs exactly this function, using drive gain as the diagnostic indication that bubbles or entrained gas is present in the liquid flow stream, and then substituting a liquid-only density in place of the live measurement until the gaseous event has subsided. When the gassy portion has passed, indicated by an associated drop in drive gain, the software returns to reporting the live measured volume flow rate.

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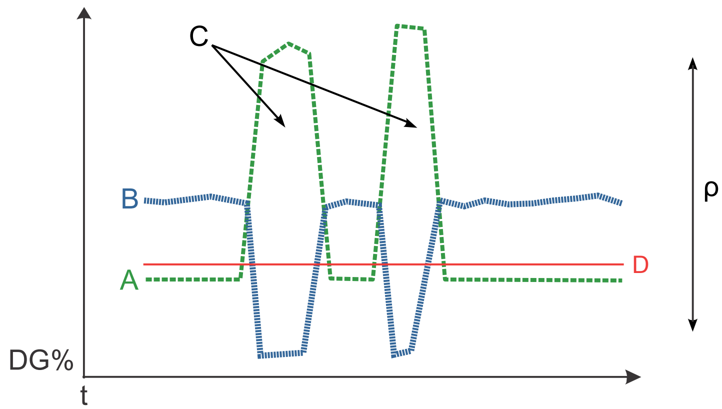
(1) High frequency sensors may erroneously report a higher fluid density when entrained gas is present, and therefore are not recommended for use on liquids with entrained gas. High frequency sensors include the F300/H300 compact, and all T-Series sensors.

(2) The accuracy and repeatability of the mass flow and density measurements for liquids with entrained gas is dependent on the sensor-fluid decoupling ratio, which is a complex function of fluid velocity, fluid viscosity, fluid density, the difference between the liquid and gas densities, the operating sensor frequency, and the Gas Volume Fraction (GVF) of gas. For best measurement performance, GVF should be kept below 15%.

Figure 2-1: How entrained gas affects drive gain and density measurement



- DG% = drive gain percentage
- t = Time
- ρ = Density

A. *Drive gain indication*
B. *Measured density*
C. *Entrained gas ocurring during these intervals*
D. *Drive gain threshold*

Entrained gas in liquids affects drive gain and density measurement. The green line (A) shows the drive gain indication which is stable under most single-phase conditions. However, if gas is entrained in the liquid, the density reading (B) will drop and the drive gain reading will increase. When the entrained gas bubbles go away, the drive gain will return to its normal indication and the density measurement will reflect the density of the liquid.

The APM software identifies entrained gas in liquid flow by detecting the sharp increases in drive gain and corresponding decreases in density measurement. The software continuously monitors the most recent drive gain data (up to 60 minutes) to determine drive gain threshold. If the measurement exceeds the drive gain threshold, the fluid is deemed to contain entrained gas, and remediation occurs.

2.1.1 Production type options

Continuous Flow

Select this option only when flow rates are expected to be stable under normal operating conditions. The APM software assumes the liquid properties and flow velocity through the pipe is constant, and hence is able to remediate the mass flow values in addition to density and volume values.

Variable Flow (default)

Select this option when flow rates are not stable, for applications such as batching, dump valve control, beam pumps, production separators, or other variable processes.

When variable flow is selected, APM will remediate only density and volume variables.

2.1.2 Drive gain threshold mode

There are two ways to determine when remediation occurs, either Automatic or Manual.

Automatic

The APM software will determine when flow conditions are stable or when multiphase flow is present in order to perform remediation. This mode is not available with a manual Advanced Phase Measurement configuration (option MA). See Manual Drive Gain Threshold.

Manual

At drive gain values above the user-entered threshold, the transmitter will perform the configured remediation option. As soon as the drive gain drops below the manual drive gain threshold value, the transmitter returns to reporting unremediated values. See Manual Drive Gain Threshold.

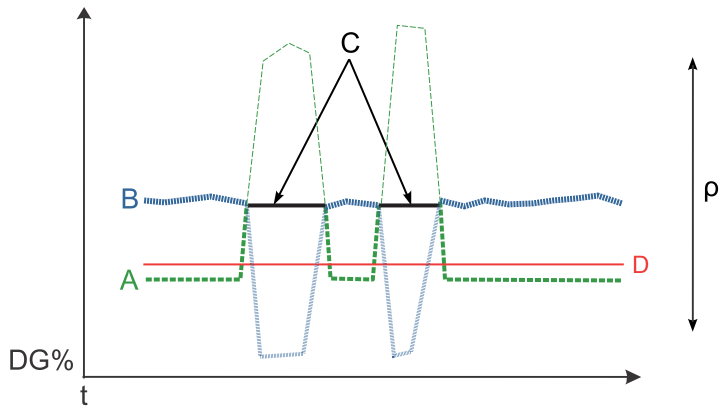
2.1.3 Remediation options (APM Action)

If the drive gain threshold is exceeded, you must select one of the following methods to handle the volume calculation for the period of high drive gain.

Hold Last Value (default)

APM will use a held density value from an earlier point in the process to report density, calculate volume, and calculate any other density-influenced variables during remediation. If this option is chosen, the density from the point just before the entrained gas event is held constant throughout the event.

Figure 2-2: Hold Last Value in operation



- DG% = drive gain percentage
- t = Time
- ρ = Density

A. *Drive gain*
B. *Measured density*
C. *Held density value during entrained gas intervals*
D. *Drive gain threshold*

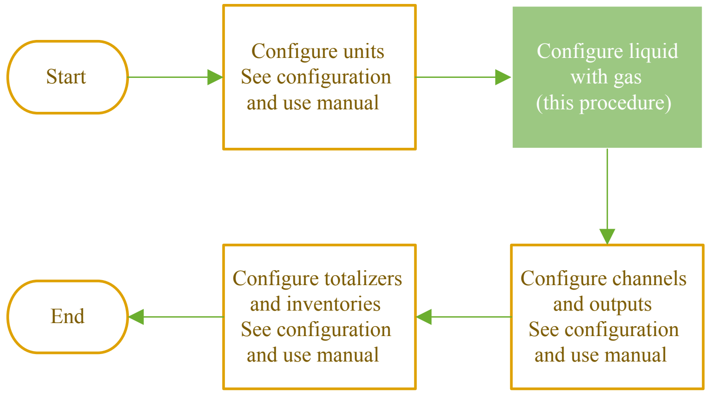
This figure shows how the Hold Last Value feature works in APM. The green line (A) shows the drive gain value and the blue line (B) shows the density reading. If the liquid gets entrained with gas bubbles, the drive gain increases above the drive gain threshold (D). Then the software determines a density value from recent process data that does not have a high drive gain. It then substutes that value for the measured density until the drive gain goes back below the threshold value (D). This substituted density is also referred to as the remediated density.

Density Hold Override

APM will use a user-input density value from an earlier point in the process to report density, calculate volume, and calculate any other density-influenced variables during remediation. This value should reflect the density of the liquid at line conditions.

2.1.4 Configure liquid with gas measurement

Configuring liquid with gas measurement is one part of the following required configuration for APM functionality.



Procedure

1. Set the mass flow cutoff and the volume flow cutoff to a non-zero value. This ensures that totalizing stops when flow is stopped. In most installations, the default value is satisfactory.

Option	Description
Display	**Menu → Configuration → Process Measurement → Flow Variables → Mass Flow Settings**
ProLink III	**Menu → Configuration → Process Measurement → Flow**
Web browser	**Configuration → Process Measurement → Flow Variables**

2. Navigate to one of the following paths based on the tool you are using.

Option	Description
Display	**Menu → Configuration → Process Measurement → Adv Phase Measurement**
ProLink III	**Device Tools → Configuration → Process Measurement → Advanced Phase Measurement**
Field Communicator or enhanced FF host	**Configure → Manual Setup → Advanced Phase Measurement**
Basic FF host (fieldbus transmitters only)	The APM transducer block
Web browser (Ethernet transmitters only)	**Configuration → Process Measurement → Advanced Phase Measurement**

3. Depending on your configuration tool, configure liquid with gas measurement:
   - From the display, navigate to **Single Liquid** and **Save**.
   - From ProLink III, set **Fluid Type** to Liquid with Gas.

4. Verify or make changes to the following settings:

Depending on which tool you are using, the parameter name or order may be different.

Parameter	Description
Production Type	Choose one of the following options: • Continuous flow if the flow in your system is generally constant. Continuous flow assumes a constant flow rate that enables mass flow to also be remediated by subtracting GVF. • Variable flow if the flow in your system frequently starts and stops or fluctuates between high and low flow rates. See Production type options.
Density Hold Override	Density will report this value when in remediation. This value should reflect the density of the liquid at line conditions.
Drive Gain Threshold	• From the display, enable or disable the automatic threshold. Disabling automatic threshold defaults to manual. You must configure a manual threshold value. • From ProLink III, select automatic or manual drive gain threshold. See Drive gain threshold mode.
User Input DG Threshold	For use with manual threshold only, this is the drive gain value above which APM will remediate.
Gas Density @ Line	The density of entrained gas. Default = 0. • Use Default (zero) if the line pressure is less than 250 psi (17.24 bar) absolute. • If the typical line pressure is greater than 250 psi (17.24 bar) absolute, set this parameter to the density of the entrained gas at typical line conditions. This setting will affect the GVF output (and mass flow remediation if **Process Type** is set to Continuous).
Average Reporting Interval If using the display, navigate left to select.	The time period, in minutes, over which process variables will be averaged. The averages are available for retrieval by the host system.
Transmitter Date Not available in the display.	Displays the currently-set date. • From the display, choose **Menu** → **Configuration** → **Time/Date/Tag**. • From ProLink III, choose **Device Tools** → **Configuration** → **Process Measurement** → **Advanced Phase Measurement** in the **Transmitter Date** field.
Transmitter Time	• From the display, set the time zone. • From ProLink III, set the time zone, time zone offset, date, and time.

2.2 Net oil

The Net Oil algorithm calculates the water fraction of the liquid stream so that net oil and net water can be determined. *Net Oil* is the volume of oil, corrected to a reference temperature and/or pressure, that is contained within the gross volume of produced fluid.

Note
The PO measurement option should also be combined with the standalone liquid with gas remediation function that gives it the added capability to mediate against intermittent entrained gas. The MA and MW options are not compatible with PL.

This algorithm requires the following data:

- Flow rate and temperature, that are measured by the meter.
- Density of both dry oil and water from this well at reference conditions. These are determined by the operator and entered during configuration. See Density determination for more information about density determination.
- Current water cut is either:
  - Measured by a water cut monitor and supplied to the Advanced Phase Measurement software via the mA Input or host system[3]
  - Calculated by the Advanced Phase Measurement software from current density data via the density-based net oil calculation (polled via HART). If density-based water cut is chosen, the software uses the following equation to calculate the water cut.

Equation 2-1: Calculation of density-based water cut

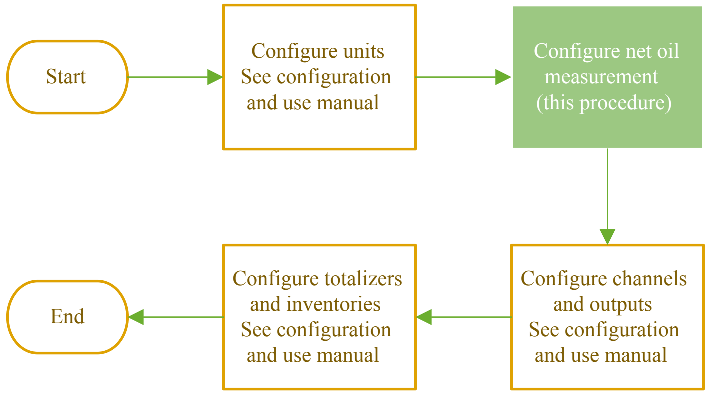
$$WaterCut = \frac{\rho_{mix} - \rho_{oil}}{\rho_{water} - \rho_{oil}}$$

- ρ_{mix} = Density of the oil and water mixture as measured by the sensor
- ρ_{oil} = Density of produced oil calculated from user-supplied value
- ρ_{water} = Density of produced water calculated from user-supplied value

2.2.1 Configure net oil measurement

Configuring net oil measurement is one part of the following required configuration for APM functionality.

(3) Not available for the Model 5700 fieldbus version 1.x.



Prerequisites

If you plan to use a water cut monitor:

- For the 5700 configurable transmitter, Channel D on the transmitter must be enabled, and must be configured as a mA Input, wired to the water cut monitor, and configured appropriately. HART integration is supported on Channel A by polling.
- For the 5700 Ethernet transmitter, an external host system is required to accept the water cut monitor input and feed it to the transmitter.
- For the 5700 intrinsically safe transmitter, HART integration is supported on Channel A by polling.

Note

Water cut cannot be input into the 5700 transmitter with FOUNDATION fieldbus output if the software revision of the transmitter is 1.*x*.

Procedure

1. Set the mass flow cutoff and the volume flow cutoff to a non-zero value. This ensures that totalizing stops when flow is stopped. In most installations, the default value is satisfactory.

Option	Description
Display	**Menu → Configuration → Process Measurement → Flow Variables → Mass Flow Settings**
ProLink III	**Menu → Configuration → Process Measurement → Flow**
Web browser	**Configuration → Process Measurement → Flow Variables**

2. Navigate to one of the following paths based on the tool you are using.

Option	Description
Display	**Menu → Configuration → Process Measurement → Adv Phase Measurement**
ProLink III	**Device Tools → Configuration → Process Measurement → Advanced Phase Measurement**

Option	Description
Field Communicator	**Configure → Manual Setup → Advanced Phase Measurement**
Web browser (Ethernet transmitters only)	**Configuration → Process Measurement → Advanced Phase Measurement**

3. Depending on your configuration tool, configure net oil measurement:
   - From the display, navigate to **Net Oil (NOC)** and **Save**.
   - From ProLink III, set **Fluid Type** to Net Oil (NOC) or Net Oil (NOC) and Liquid with Gas if both are licensed.
4. Verify or make changes to the following settings:

   Depending on which tool you are using, the parameter name or order may be different.

Parameter	Description
Production Type	• Continuous flow if the flow in your system is generally constant. Continuous flow assumes a constant flow rate that enables mass flow to also be remediated by subtracting GVF. • Variable flow if the flow in your system frequently starts and stops or fluctuates between high and low flow rates. See Production type options.
APM Action	If you are using variable flow, when the drive gain threshold is exceeded, you can configure your transmitter to hold the last value, use density oil @ line, or a density hold override, to handle the volume calculation for the period of high drive gain. See Remediation options (APM Action).
Density Hold Override	If the Density Hold Override is used, then density will report this value when in remediation. This value should represent the liquid mixture density at line conditions.
Drive Gain Threshold	• From the display, enable or disable the automatic threshold. Disabling automatic threshold defaults to manual. You must configure a manual threshold value. • From ProLink III, select automatic or manual drive gain threshold. See Drive gain threshold mode.
User Input DG Threshold	For use with manual threshold only, this is the drive gain value above which APM will remediate.
Density Oil @ Line	The NOC algorithm converts the density of dry oil at reference conditions (a user-configured value) to density at line conditions, and calculates volume. This option assumes that all volume during the entrained gas event is dry oil.

Parameter	Description
Gas Density @ Line	The density of entrained gas. Default = 0. • Use Default (zero) if the line pressure is less than 250 psi (17.24 bar) absolute. • If the typical line pressure is greater than 250 psi (17.24 bar) absolute, set this parameter to the density of the entrained gas at typical line conditions. This setting will affect the GVF output (and mass flow remediation if **Process Type** is set to Continuous). This setting is needed only when **Net Oil** is combined with **Liquid with Gas** to more accurately determine GVF at conditions where gases have more mass - such as at high pressure.
Water Density @ Ref	The density of water, corrected to the reference temperature obtained from density determination.
Dry Oil Density @ Ref	The density of dry oil at reference conditions obtained from a density determination.
Reference Temp	The temperature to which net oil and net water measurements will be corrected. The default is 60 °F.
View Production Meas (display only)	The type of net oil data that will be shown on the display. • If you select **Corrected to Standard**, the display shows `Watercut @ Ref`, `Net Oil Flow @ Ref`, etc. • If you select **Uncorrected**, the display shows `Watercut @ Line`, `Net Oil Flow @ Line`, etc. This parameter is applicable only if a net oil process variable is configured as a display variable.
Average Reporting Interval If using the display, navigate left to select.	The time period, in minutes, over which process variables will be averaged. The averages are available for retrieval by the host system.
Transmitter Date and Time Not available in the display.	Displays the currently-set date. • From the display, choose **Menu** → **Configuration** → **Time/Date/Tag**. • From ProLink III, choose **Device Tools** → **Configuration** → **Process Measurement** → **Advanced Phase Measurement** in the **Transmitter Date** field. • From the display, set the time zone. • From ProLink III, set the time zone, time zone offset, date, and time.
Contract Start Time If using the display, navigate left until you can select **Contract Period** to see **Contract Start Hour**.	The time of day at which the contract starts. Enter the time in a 24-hour HH:MM format, where 00:00 = midnight and 18:30 = 6:30 pm.

Parameter	Description
Contract Total [1 - 4] Not available from the display.	Up to four user-specified totals that are used to measure production. See Read contract totals.
Shrinkage Factor-Adjusted Volume Flow Outputs	Enable or disable shrinkage-factored variable calculations.
Shrinkage Factor	A user-input value, multiplied by the measured volume to match the expected volumes after shrinkage.
Meter Factor for Shrinkage	A meter factor, established by proving, that acts as a multiplier to shrinkage-factored (SF) variables. Not commonly used.

2.3 Gas with liquid

This measurement option improves mass flow measurement in gaseous processes with intermittent entrained liquids (mist).

Gas with liquid measurement process

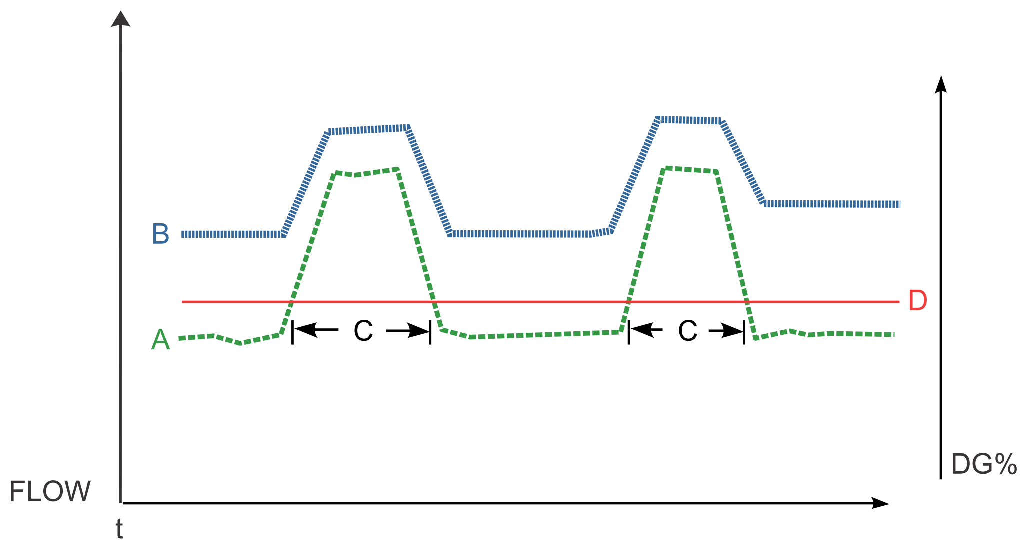
The presence of entrained liquids (or mist) can cause significant errors when measuring the mass flow of gas through a Coriolis meter. Because droplets contribute a relatively large amount of mass to a gas mixture, but do not always move uniformly through the pipe with the gas, even a small amount of condensate can cause measurement discrepancies between what is measured by the meter and what emerges from the pipe downstream.

So how can you tell when a gas contains mist or condensate? When liquids are present in a gas stream, Coriolis meters will report an increase in both drive gain and fluid density(4) in combination with an increase in mass flow rate – due to the higher mass of the combined gas-liquid mixture. Therefore, in order to measure only the gaseous portion of the stream, the mass of the liquids must be ignored or subtracted from the mixture total.(5) The Advanced Phase Measurement software performs exactly this function, using drive gain as the diagnostic indication that mist or entrained liquids are present in the gas flow stream, and then substituting a gas-only flow rate in place of the live measurement until the liquid event has subsided. When the mist event is over, indicated by an associated drop in drive gain, the software returns to reporting the live measured mass flow rate. If the flow rate after the event differs significantly from the rate prior to the event, the software will apply an adjustment to the mass flow output until the totalizers accurately represent the flow rate change that occurred during the mist event.(6)

The following figure shows how the change in density and drive gain are affected by mist.

(4) *Coriolis meters do not measure the density of gases accurately, but the density reading can be combined with drive gain as a useful diagnostic to detect changes in fluid properties.*
(5) *The unmeasured liquids can be (and are often) collected and processed separately downstream if desired.*
(6) *The outputs are adjusted by a maximum of ±10% of live reading.*

Figure 2-3: Effect of transient mist on drive gain and flow measurement



- FLOW = mass flow rate
- DG% = drive gain percentage
- t = Time

A. Drive gain indication
B. Measured mass flow rate
C. Entrained liquid (mist) occurring during these intervals
D. Drive gain threshold

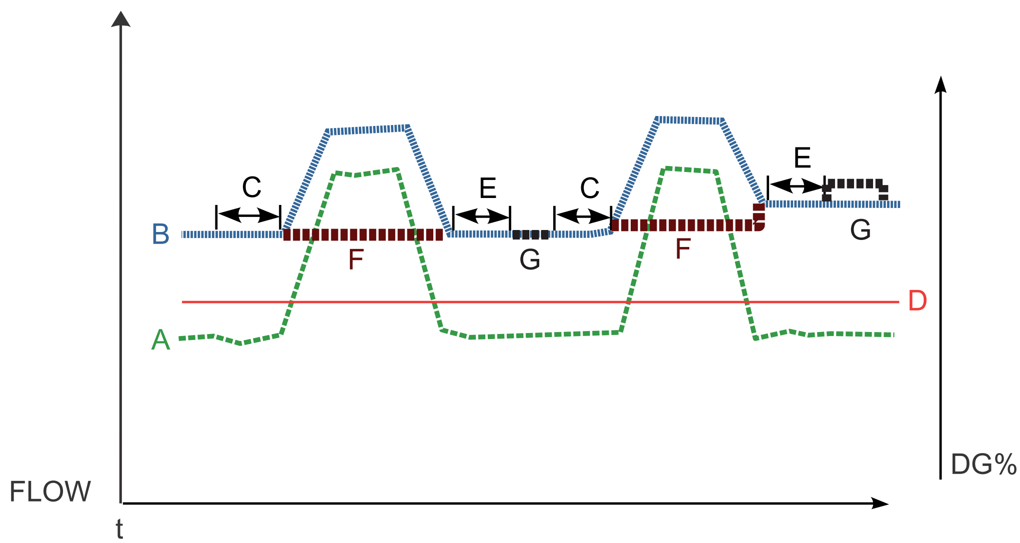
The green line (A) shows the drive gain indication during flow. If mist gets entrained into the gas, the drive gain and the mass flow rate (B) will both increase. The red line (D) shows a drive gain threshold above which mist is entrained in the gas. APM will automatically choose an appropriate drive gain threshold (D) or you can opt to set the threshold manually.

The Advanced Phase Measurement software identifies entrained mist in gas flow by detecting the sharp increases in drive gain and corresponding increases in mass flow measurement. When automatic drive gain threshold is enabled, the software continuously monitors the most recent drive gain data (up to 60 minutes) to determine the drive gain threshold. If the measurement exceeds the drive gain threshold, the fluid is deemed to contain entrained liquid, and remediation occurs.

Gas with liquid remediation

The following figure illustrates Advanced Phase Measurement software processing when mist is detected in the gas stream.

Figure 2-4: Advanced Phase Measurement software: Gas with liquid remediation



- FLOW = mass flow rate
- DG% = drive gain percentage
- t = Time

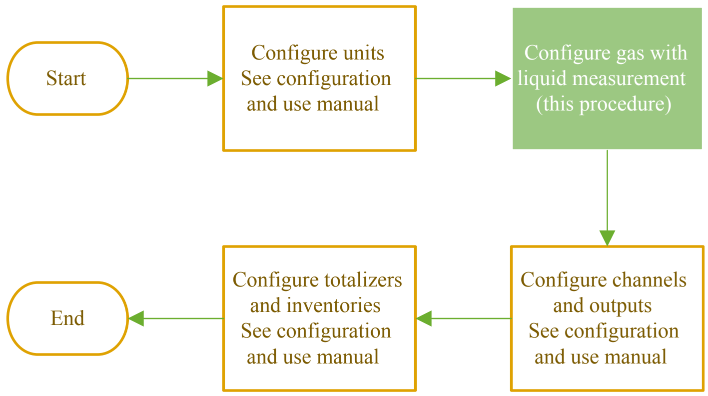
A. *Drive gain indication*
B. *Measured mass flow rate*
C. *Pre-mist averaging period and source of average flow rate during this period*
D. *Drive gain threshold*
E. *Post-mist adjustment delay and source of average flow rate during this period*
F. *Held flow rate during entrained mist intervals*
G. *Post-mist adjustment applied to measured flow rate (if applicable)*

The Advanced Phase Measurement software uses the drive gain and mass flow readings to correct for the presence of entrained mist in gas. The green line (A) shows the drive gain during flow. The blue line (B) shows the measured mass flow reading both with, and without entrained gas. When mist is present, the drive gain will go above the drive gain threshold (D). This threshold value is automatically determined by APM or manually adjustable. When the drive gain exceeds this threshold, APM will look back in time (C) seconds, and determine an average, pre-mist, mass flow rate. It will then substitute mass flow rate (F) until the drive gain goes back below the threshold. Then during time period (E), a post-mist, mass flow rate average is determined. If the post- and pre-mist averages are different, a mass flow adjustment (G) is made to the mass rate after time period (E) until the total mass difference is reconciled.

The first mist event had equal mass flow rates before and after the mist event, so (G) is equal to (F). In the second mist event, the post-mist flow rate was greater than the pre-mist rate, so a (G) was applied that was greater than (F). This held flow rate (F) is also known as the remediated mass flow rate.

2.3.1 Configure gas with liquid measurement

Configuring gas with liquid measurement is one part of the following required configuration for APM functionality.



Procedure

1. Set the mass flow cutoff and the volume flow cutoff to a non-zero value. This ensures that totalizing stops when flow is stopped. In most installations, the default value is satisfactory.

Option	Description
Display	**Menu → Configuration → Process Measurement → Flow Variables → Mass Flow Settings**
ProLink III	**Menu → Configuration → Process Measurement → Flow**
Web browser	**Configuration → Process Measurement → Flow Variables**

2. Navigate to one of the following paths based on the tool you are using.

Option	Description
Display	**Menu → Configuration → Process Measurement → Adv Phase Measurement**
ProLink III	**Device Tools → Configuration → Process Measurement → Advanced Phase Measurement**
Field Communicator or enhanced FF host	**Configure → Manual Setup → Advanced Phase Measurement**
Basic FF host (fieldbus transmitters only)	The APM transducer block

Option	Description
Web browser (Ethernet transmitters only)	**Configuration** → **Process Measurement** → **Advanced Phase Measurement**

3. Depending on your configuration tool, configure net oil measurement:
   - From the display, navigate to **Gas with Liquid** and **Save**.
   - From ProLink III, set **Fluid Type** to Gas with Liquid.
4. Verify or make changes to the following settings:

   Depending on which tool you are using, the parameter name or order may be different.

ProLink III	Description
Drive Gain Threshold	• From the display, enable or disable the automatic threshold. Disabling automatic threshold defaults to manual. You must configure a manual threshold value. • From ProLink III, select automatic or manual drive gain threshold. See Drive gain threshold mode.
User Input DG Threshold	For use with manual threshold only, this is the drive gain value above which APM will remediate.
Pre-Mist Ave Period	Period of stable gas flow conditions prior to a liquid entrainment event. Averaging period is user configurable with units = *n* seconds. The average flow rate during this period will be reported until the entrained liquid event has passed. Default = 15 seconds.
Post-Mist Adj Delay	Period of stable gas flow conditions after a liquid entrainment event. After this delay, the average flow rate during Post-Mist Adjustment Delay is averaged with the Pre-Mist Averaging Period and the flow rate is adjusted a maximum of +/-10% of reading until any difference has been appropriately corrected in the totalizers. Default = 15 seconds.
Average Reporting Interval If using the display, navigate left to select.	The time period, in minutes, over which process variables will be averaged. The averages are available for retrieval by the host system.
Transmitter Date and Time Not available in the display.	Displays the currently-set date. • From the display, choose **Menu** → **Configuration** → **Time/Date/Tag**. • From ProLink III, choose **Device Tools** → **Configuration** → **Process Measurement** → **Advanced Phase Measurement** in the **Transmitter Date** field. • From the display, set the time zone. • From ProLink III, set the time zone, time zone offset, date, and time.

ProLink III	Description
Contract Start Time If using the display, navigate left until you can select **Contract Period** to see **Contract Start Hour**.	The time of day at which the contract starts. Enter the time in a 24-hour HH:MM format, where 00:00 = midnight and 18:30 = 6:30 pm.
Contract Total [1 - 4] Not available from the display.	Up to four user-specified totals that are used to measure production. See Read contract totals.

3 Additional configuration

3.1 Configure viewing and reporting for process variables

When Advanced Phase Measurement software is enabled, additional process variables are available.

Procedure

- To configure a process variable as a display variable, or to report a process variable over an output, see the transmitter configuration and use manual.
- To query a process variable using Modbus, follow standard Modbus programming techniques.

3.1.1 Advanced Phase Measurement specific process variables

The process variables listed here are available only when Advanced Phase Measurement software is enabled.

The following table lists the process variables by measurement option, and provides information on reporting.

Process variable	Advanced Phase Measurement option			Viewing and reporting				
	Liquid with gas	Net Oil	Gas with liquid	Display	Modbus and Ethernet	Fieldbus(1)	mAO1, mAO2, mAO3	FO1, FO2
Gas Void Fraction	✓			✓	✓	✓	✓	
$DensityOil_{@Line}$		✓		✓	✓	✓		
$DensityOil_{@Ref}$		✓		✓	✓	✓		
$NetFlowOil_{@Line}$		✓		✓	✓	✓	✓	✓
$NetFlowOil_{@Ref}$		✓		✓	✓	✓	✓	✓
$NetTotalOil_{@Line}$		✓		✓	✓	✓		
$NetTotalOil_{@Ref}$		✓		✓	✓	✓		
$NetFlowWater_{@Line}$		✓		✓	✓	✓	✓	✓
$NetFlowWater_{@Ref}$		✓		✓	✓	✓	✓	✓
$NetTotalWater_{@Line}$		✓		✓	✓	✓		
$NetTotalWater_{@Ref}$		✓		✓	✓	✓		
$Watercut_{@Line}$		✓		✓	✓	✓	✓	
$Watercut_{@Ref}$		✓		✓	✓	✓	✓	

Process variable	Advanced Phase Measurement option			Viewing and reporting				
	Liquid with gas	Net Oil	Gas with liquid	Display	Modbus and Ethernet	Fieldbus(1)	mAO1, mAO2, mAO3	FO1, FO2
APM contract period								
Today's total	✓	✓	✓		✓	✓		
Yesterday's total	✓	✓	✓		✓	✓		

(1) For fieldbus version 1.x transmitters, you can only publish through the AI Blocks four process variables and two totalizers/inventories.

3.1.2 Default display variables

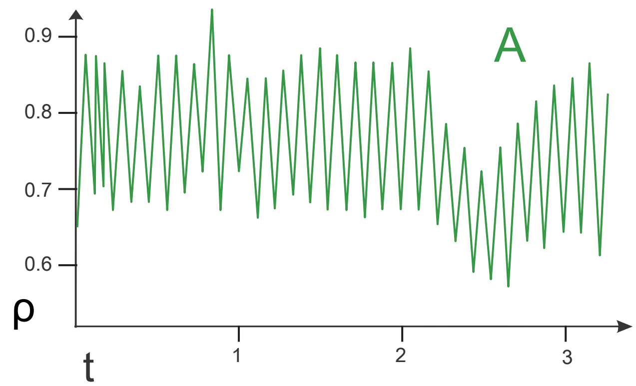
The following table lists the default display variables for Advanced Phase Measurement software. In all cases, the two-line display option is enabled. All of these process variables can be configured as display variables.

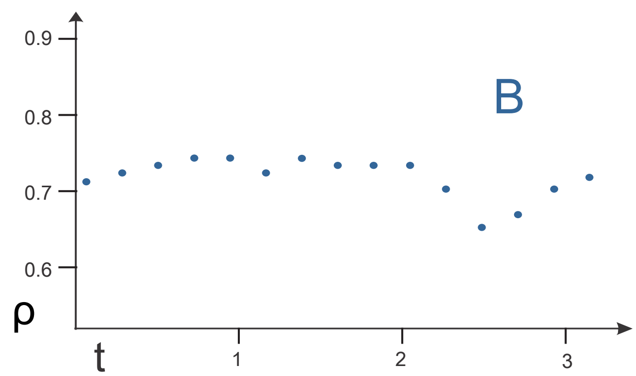
Display variable	Advanced Phase Measurement option		
	Liquid with gas	NOC with gas	Gas with liquid
Two-line display, Variable 1	Volume Flow Rate	Volume Flow Rate	Mass Flow Rate
Two-line display, Variable 2	Volume Total	Water Cut$_{@Line}$	Mass Total
Display Variable 1	Density	Net Oil Flow Rate$_{@Line}$	Temperature
Display Variable 2	Temperature	Net Oil Total$_{@Line}$	Density
Display Variable 3	GVF	Net Water Total$_{@Line}$	Empty
Display Variable 4	Empty	Temperature	Empty
Display Variable 5	Empty	GVF	Empty
Display Variable 6–15	Empty	Empty	Empty

3.1.3 Period averaged output (PAO) configuration

Period averaged outputs provide an easy and reliable way to prevent data collection systems from recording outliers in erratic data. This is included with Advanced Phase Measurement software since two-phase conditions cause more volatile measurement outputs. The period over which the PAOs are averaged can be adjusted using the **Average Reporting Interval** parameter.

Figure 3-1: Example density measurement without averaged outputs and with average outputs





- ρ = Density
- t = Time

A. Density measurement without averaged outputs
B. Density measurement with averaged outputs

3.1.4 Configure PAO

Procedure

Navigate to one of the following paths to set the interval.

Option	Description
Display	**Configuration → Adv Phase Measurement → Reporting Interval**
ProLink III	**Device Tools → Configuration → Process Measurement → Advanced Phase Measurement → Average Reporting Interval**

3.2 Configure APM contract totals into the totalizer history log

The transmitter can be configured to store Advanced Phase Measurement contract totals to the totalizer history log. This allows you to access totals from earlier contract periods. Otherwise, the transmitter maintains data for only the current contract period (today) and the immediately preceding contract period (yesterday).

Procedure

1. Ensure that you have configured the Advanced Phase Measurement contract totals as desired.

Option	Description
Display	**Menu → Configuration → Process Measurement → Adv Phase Measurement → Contract Period**
ProLink III	**Device Tools → Contract Period Totals**

2. Navigate to the **Totalizer Log**.

Option	Description
Display	**Menu → Configuration → Totalizer Log**
ProLink III	**Device Tools → Configuration → Totalizer Log**
Field Communicator	Not available

3. Set **Log Total 1**, **Log Total 2**, **Log Total 3**, and/or **Log Total 4** to the desired Advanced Phase Measurement contract total.

   You can configure the totalizer history log to include both Advanced Phase Measurement and standard totals.(7)

Related information

Read contract totals

3.2.1 History log variables

The following variables are added to the history log when APM is enabled. The output type is not equal to zero.

Liquid with gas

- Gas Void Fraction
- Unremediated Density

(7) *For fieldbus version 1.x transmitters, any two of the publishable totalizers and inventories can be used, but only two at a time.*

- Unremediated Mass Flow
- External Temperature
- Velocity

Net oil with gas and NOC multiple wells

- Net Flow Oil @ Ref
- Watercut @ Ref
- Density of Oil @ line
- Unremediated Density
- Unremediated Mass Flow

Gas with liquid

- Unremediated Mass Flow
- GSV Volume Flow
- TMR Time
- Liquid mass flow estimate
- Extended drive gain

Net oil without gas

- Net Flow Oil @ Ref
- Watercut @ Ref

3.3 Configure events

When Advanced Phase Measurement software is enabled, additional process variables are available to use in event configuration.

Procedure

See the transmitter configuration manual for instructions on configuring events.

4 Transmitter operation

4.1 Read process variables

Advanced Phase Measurement process variables can be configured as display variables or assigned to outputs. See the transmitter configuration manual for information on using the display to read process variables. You can also use the host system for your Modbus, fieldbus, or Ethernet/IP network to read the variables.

4.2 Read contract totals

You can read contract totals for the current 24-hour contract period and for the previous 24-hour contract period. Depending on the configuration of the totalizer log, you may be able to read contract totals for earlier periods.

The contract totals are derived from existing inventories. However, they are reset automatically at the beginning of each contract period. Therefore, the values shown will probably not match the values shown for the inventories.

Important
You can reset inventories manually, and you can stop and start inventories manually. However, if you do this, data for the current contract period will not reflect the entire 24-hour period. Data for earlier contract periods is not affected.

- The contract totals for the current contract period are stored in the **Today's Total [1-4]** parameters.
- The contract totals for the previous contract period are stored in the **Yesterday's Total [1-4]** parameters.
- The contract totals from earlier contract periods can be read in the totalizer log.

Related information

Configure APM contract totals into the totalizer history log

5 APM alerts

This section provides information on the status alerts associated with the APM application. For information on all other Model 5700 alerts, see the appropriate Micro Motion Model 5700 configuration and use manual.

Alert	Cause
A138 APM Remediation	Remediation is active.
Watercut limited to 0%	Watercut has exceeded the upper limit. Check base oil density.
Watercut limited to 100%	Watercut has exceeded the lower limit. Check base water density.
Watercut Unavailable	Watercut unavailable due to high gas. Consider using external watercut meter.

- All alerts are configurable
- All alert severities default to `Out of Specification`
- No alerts are affected by fault timeout

A Application parameters and data

This section includes only Modbus registers that are specific to or redefined for the Advanced Phase Measurement software configuration. To use Modbus to configure other parameters, see the *Micro Motion Modbus Map*.

Typically, Advanced Phase Measurement configuration is performed using either ProLink III or the display. This information is provided for completeness.

A.1 Advanced Phase Measurement Modbus configuration parameters

Parameter	APM option			Modbus		
	Liquid with gas	Net Oil with gas	Gas with liquid	Address	Data type	Integer codes / Unit (Range)
Average Reporting Interval	✓	✓	✓	3900	U16	minutes (1–1440)
Contract Start Time	✓	✓	✓	3966	U16	hours (0–23)
Contract Total [1-4]	✓	✓	✓	3967-3970	U16	• 4 = Inventory 1 • 7 = Inventory 2 • 18 = Inventory 3 • 64 = Inventory 4 • 25 = Inventory 5 • 28 = Inventory 6 • 31 = Inventory 7
Density Corrective Action		✓		4450	U16	• 0 = Hold Last Value • 1 = Density Oil @ Line
Drive Gain Threshold Override	✓	✓	✓	3971	U16	• 0 = manual • 1 = auto
Drive Gain Threshold Override Value	✓	✓	✓	3998-3999		
Dry Oil Density @ Ref		✓		1959	Float	g/cm^3 (0.2–1.5)
Gas Density(1)	✓	✓	✓	3935	Float	Configured unit

Parameter	APM option			Modbus		
	Liquid with gas	Net Oil with gas	Gas with liquid	Address	Data type	Integer codes / Unit (Range)
Output Type	✓	✓	✓	3940	U16	• 0 = No remediation • 1 = Liquid with gas, continuous flow • 2 = NOC with gas, continuous flow • 3 = Liquid with gas, variable flow • 4 = NOC with gas, variable flow • 5 = Gas with liquid • 6 = NOC only
Post-Mist Averaging Period			✓	620	U16	seconds (2–128)
Pre-Mist Averaging Period			✓	619	U16	seconds (2–128)
Reference Temperature		✓		319	Float	Configured unit
Water Density @ Ref		✓		1831	Float	g/cm³ (0.5–1.5)

(1) At line conditions

A.2 Advanced Phase Measurement default totalizer and inventory values

Totalizer/Inventory	Liquid with Gas	Gas with Liquid	Net Oil
1	Mass Flow (Remediated)	Mass Flow (Remediated)	Mass Flow (Remediated)
2	Volume Flow (Remediated)	Volume Flow (Remediated)	Volume Flow
3	Temperature Corrected Volume	Temperature Corrected Volume	Net Oil @ Ref
4	Gas Standard Volume	Gas Standard Volume	Net Oil @ Line
5	Standard Volume	Standard Volume	Net Water @ Ref
6	Net Mass	Net Mass	Net Water @ Line

Totalizer/Inventory	Liquid with Gas	Gas with Liquid	Net Oil
7	Net Volume	Net Volume	Net Volume

A.3 Advanced Phase Measurement Modbus process variables

Process variable[1]	Advanced Phase Measurement option			Modbus		
	Liquid with gas	Net Oil with gas	Gas with liquid	Address	Data type	Unit
Gas Void Fraction	✓			3907	Float	%
Density Oil @ Line		✓		345	Float	SGU
Density Oil @ Line		✓		347	Float	°API
Density Oil @ 60F		✓		1665	Float	°API
Net Oil Flow @ Line		✓		1553	Float	Configured unit
Net Oil Flow @ Ref		✓		1547	Float	Configured unit
Net Oil Inventory @ Line[2]		✓		1665	Float	Automatically derived from configured unit
Net Oil Inventory @ Line[3]		✓		4240	Double	Automatically derived from configured unit
Net Oil Total @ Ref[2]		✓		1661	Float	Automatically derived from configured unit
Net Oil Total @ Ref[4]		✓		4236	Double	Automatically derived from configured unit
Net Water Flow @ Line		✓		1561	Float	Configured unit
Net Water Flow @ Ref		✓		1549	Float	Configured unit
Net Water Total @ Line[2]		✓		1667	Float	Automatically derived from configured unit
Net Water Total @ Line[5]		✓		4248	Double	Automatically derived from configured unit
Net Water Total @ Ref		✓		1663	Float	Automatically derived from configured unit

Process variable[1]	Advanced Phase Measurement option			Modbus		
	Liquid with gas	Net Oil with gas	Gas with liquid	Address	Data type	Unit
Net Water Total @ Ref[6]		✓		4244	Double	Automatically derived from configured unit
Watercut @ Line		✓		1555	Float	%
Watercut @ Ref		✓		1557	Float	%
Total Mist Time[7]			✓	989	U32	Seconds
APM Liquid with Gas remediation status			✓	433, Bit #12	U16	• 0 = Inactive • 1 = Active

(1) For fieldbus version 1.x transmitters, you can only publish through the AI Blocks four process variables and two totalizers/inventories.
(2) Legacy NOC register
(3) Inventory 4 (only if you are using the default configuration)
(4) Inventory 3 (only if you are using the default configuration)
(5) Inventory 6 (only if you are using the default configuration)
(6) Inventory 5 (only if you are using the default configuration)
(7) Automatically set to 0 on a power cycle

A.4 Period Averaged Options current period data

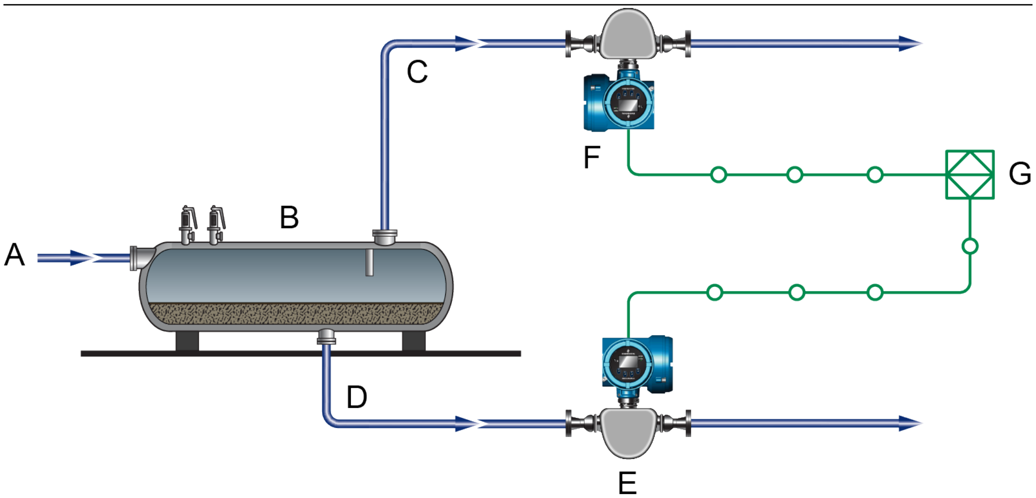
Process variable[1]	Advanced Phase Measurement option			Modbus		
	Liquid with gas	Net Oil with gas	Gas with liquid	Address	Data type	Unit
PAO Mass Flow	✓	✓	✓	3949	Float	Configured unit
PAO Density	✓	✓	✓	3951	Float	Configured unit
PAO Volume Flow	✓	✓	✓	3953	Float	Configured unit
PAO Net Oil Flow @ Line		✓		3955	Float	Configured unit
PAO Net Oil Flow @ Ref		✓		3957	Float	Configured unit
PAO Watercut @ Line		✓		3959	Float	Configured unit
PAO Gas Void Fraction	✓			3961	Float	Configured unit
PAO Temperature	✓	✓	✓	3963	Float	Configured unit
Unremediated Mass Flow	✓	✓	✓	3943	Float	Automatically derived from configured uni

Process variable[(1)]	Advanced Phase Measurement option			Modbus		
	Liquid with gas	Net Oil with gas	Gas with liquid	Address	Data type	Unit
Unremediated Density	✓	✓	✓	3945	Float	Automatically derived from configured uni
Unremediated Volume Flow	✓	✓	✓	3947	Float	Automatically derived from configured uni

(1) For fieldbus version 1.x transmitters, you can only publish through the AI Blocks four process variables and two totalizers/inventories.

B Typical oil and gas applications and other information

B.1 Advanced Phase Measurement with a two-phase separator

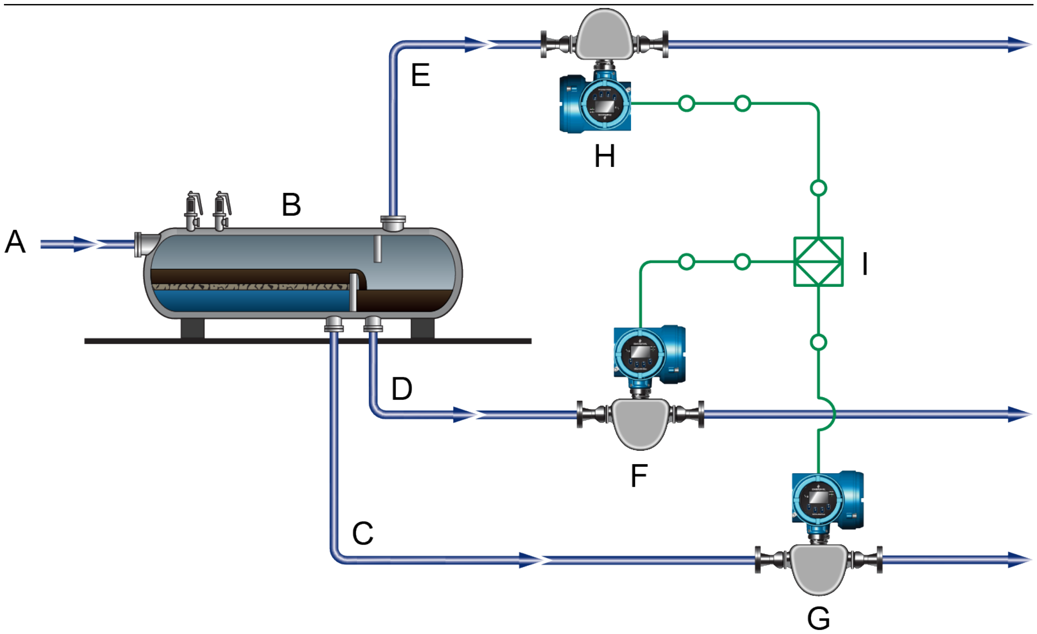


A. *From wellhead*
B. *Separator*
C. *Gas leg*
D. *Oil/water leg*
E. *Coriolis sensor and transmitter with Advanced Phase Measurement (NOC with gas)*
F. *Coriolis sensor and transmitter with Advanced Phase Measurement (Gas with liquid)*
G. *Modbus host (flow computer)*

Related information

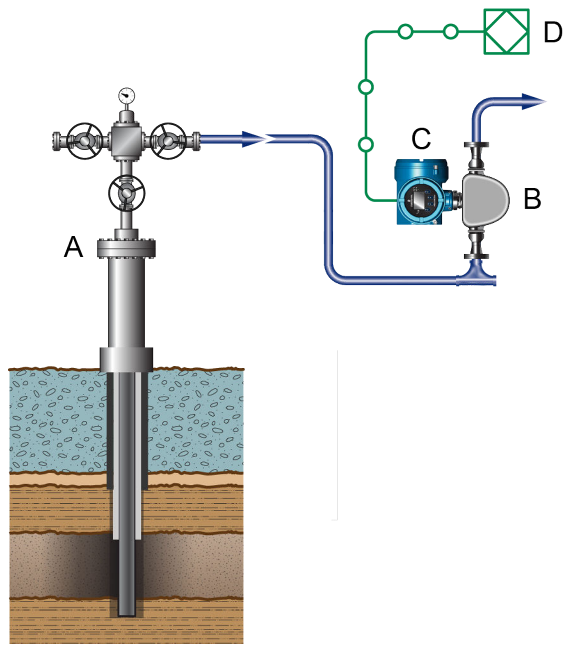
Best practices for two-phase measurement performance

B.2 Advanced Phase Measurement with a three-phase separator



A. *From wellhead*
B. *Separator*
C. *Water leg*
D. *Oil leg*
E. *Gas leg*
F. *Coriolis sensor and transmitter with Advanced Phase Measurement (NOC with gas, variable flow)*
G. *Coriolis sensor and transmitter with Advanced Phase Measurement (Liquid with gas, variable flow)*
H. *Coriolis sensor and transmitter with Advanced Phase Measurement (Gas with liquid)*
I. *Modbus host (flow computer)*

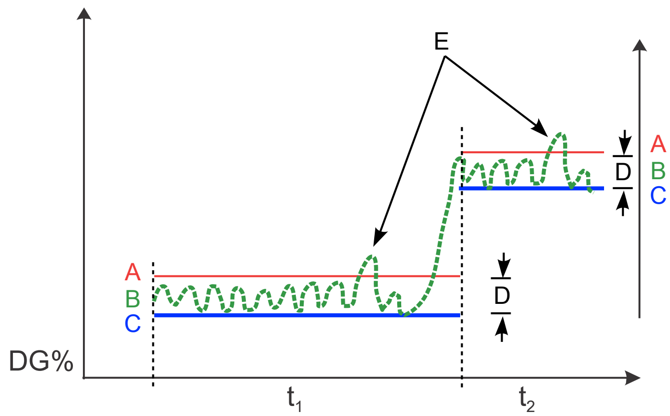
B.3 Advanced Phase Measurement at the wellhead



A. Wellhead
B. Coriolis sensor
C. Transmitter with Advanced Phase Measurement (NOC with gas)
D. Modbus host (flow computer)

B.4 Automatic Drive Gain Threshold determination

An essential function of the Advanced Phase Measurement software is to monitor drive gain, and then use drive gain data to define and adjust the Drive Gain Threshold, which ultimately determines when and how measurement remediation is needed.



- DG% = Drive Gain Percentage
- t_1 = Drive Gain Threshold interval 1
- t_2 = Drive Gain Threshold interval 2

A. *Drive Gain Threshold (measurement will be remediated if drive gain exceeds this threshold)*
B. *Drive gain indication*
C. *Minimum drive gain detected at the beginning of each drive gain threshold interval.*
D. *Drive Gain Threshold Addition. This value is added to the minimum drive gain (C) to establish a small buffer so the software only remediates values that exceed the typical drive gain fluctuations for each unique process.*
E. *Advanced Phase Measurement software remediates density during these intervals.*

This figure illustrates how the software determines the Drive Gain Threshold (A) under live conditions if automatic drive gain threshold is configured. The green dotted line shows the Coriolis sensor's live drive gain indication (B) over time (t). The software continuously analyzes the live drive gain using the most recent data (duration set by the Drive Gain Threshold Interval) to determine the lowest drive gain that is typical for the process.(8)The live drive gain indication for most applications fluctuates a bit under normal operating conditions, typically within a small range that is not attributable to two-phase flow or other process upsets. To avoid remediating during this typical process noise, a small Drive Gain Threshold Addition (D) is added to the lowest sample point (C). The newly established Drive Gain Threshold (A) represents the sampled minimum drive gain plus the drive gain threshold addition. During the remainder of the threshold Interval, if the indicated drive gain (B) exceeds the established Drive Gain Threshold (A), the transmitter will appropriately remediate the measured flow rate and/or the fluid density.(9) After the threshold interval is over, the process starts again.

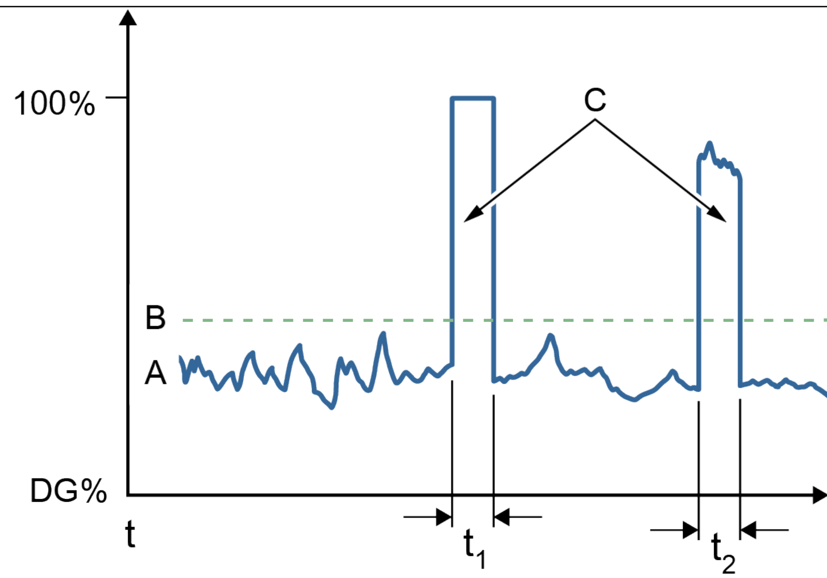
(8) *The factory default for Drive Gain Threshold Interval is 60 minutes, which is suitable for most continuous processes, but it may be shortened or lengthened as required for each application. Contact customer support for assistance.*

B.5 Manual Drive Gain Threshold

When using the manual drive gain threshold option, select a value above the typical variation in the drive gain under normal flowing conditions. Remediation will occur when the drive gain exceeds this threshold limit. If the threshold is set too high, it is possible that some gas entrainment may occur without exceeding the established threshold, and hence no remediation will occur. Alternatively, if the threshold is too low, the process may be remediated even under normal flowing conditions.

If you are using ProLink III, view variations and maximum values during normal operation by using trends or data logs on the drive gain data. If your process is batched or cyclical, you should observe and/or record several cycles to establish normal drive gain levels.

If data collection is not available, view the drive gain on the 5700 display by configuring the display variables. For more information, see the Model 5700 configuration and use manual.



- DG% = Drive Gain Percentage
- t = Time

A. Drive gain indication
B. Drive gain threshold
C. Remediation occurring during these intervals

(9) *The measurement variables remediated by APM are configurable per license type and software and output configuration.*

C Best practices for two-phase measurement performance

Related information

Advanced Phase Measurement with a two-phase separator

C.1 Entrained gas performance

Measurement accuracy for liquids with entrained gas is a complex function of GVF, viscosity, velocity, sensor geometry, drive frequency, and orientation. The best measurement performance will always be achieved if fluid can be measured in single-phase. Add a free-gas knockout upstream if possible. The following guidelines apply regardless if APM options are licensed or not. When gas entrainment is inevitable, APM will improve the measurement performance.

Common sources for unintentional gas entrainment

- Long drops from fill point to liquid level in tanks
- Agitators and mixers
- Leaks in seals or pumps
- Pumping out of nearly empty tanks
- Pressure loss (flashing) for volatile liquids
- Pumping through nearly empty piping

Ways to minimize flow errors

- Use ELITE® (low frequency) sensors whenever possible. F-Series and H-Series sensors are also acceptable, but less accurate.
- Do not use T-Series sensors or Models F300/H300 compact because they have a high operating frequency.
- Orient the meter properly:

Table C-1: Preferred sensor orientation for liquids with entrained gas

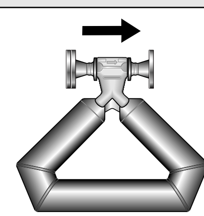
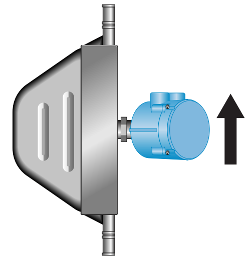
Process	Preferred orientation
Delta-shaped sensors (CMF010, CMF025, CMF050, CMF100)	

Table C-1: Preferred sensor orientation for liquids with entrained gas *(continued)*

Process	Preferred orientation
Any F-Series or CMFS sensor, and CMF200 or larger (flow should go up)	

- Ensure sensor is filled as quickly as possible, and stays full during measurement:
  - For horizontal pipes, maintain a minimum flow velocity of 1 m/s to purge air from an empty pipe and keep it full.
  - For vertical pipes, flow upward and maintain minimum velocity of 1 m/s to prevent solids from settling out of the fluid.
- Add back pressure, or increase line pressure, to minimize size of bubbles in flow stream.
- Size the meter appropriately to operate normally as close to the sensor nominal flow rate as is practical. Higher velocity leads to better performance, as long as pressure drop does not cause liquids flash.
- Ensure fluid is well mixed. If needed, you can install a blind “T” and/or static mixer just upstream of the sensor to evenly distribute bubbles through both sensor tubes. If using a blind “T”, install it in the same plane as the sensor tubes.
- If re-zeroing in the field is necessary, zeroing must be done on a pure liquid without bubbles in order to avoid error. If this cannot be done, use the factory zero.
- Minimize damping on outputs to minimize processing delay from electronics.
- Do not stop the totalizer immediately after batch; allow the totalizer to stabilize for approximately 1 second.
- Set Flow Cutoff as high as is practical to avoid totalizing at no flow condition if bubbles remain in the sensor.

C.2 Entrained liquid (mist) performance

Measurement accuracy for gases with entrained liquids (mist) is mostly related to the amount of mass contained in liquid droplets compared to an equivalent volume of gas containing the same mass. It is important to choose the correct sensor. Otherwise, sensor geometry, drive frequency, and orientation can cause errors that reduce performance. The best measurement performance will always be achieved if fluid can be measured in single-phase. Add a liquid trap upstream if possible. The following guidelines apply regardless if APM options are licensed or not. When liquid entrainment is inevitable, APM will improve the measurement performance.

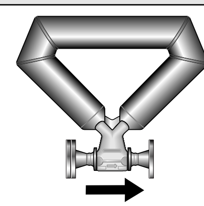
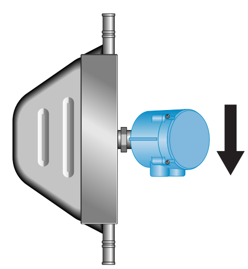
Common sources for unintentional liquid entrainment

- Temperature loss (condensation)
- Pressure increase
- Poorly managed level control in separators or GLCCs
- Malfunctioning or over-filled liquid traps

Ways to minimize measurement errors

- Use ELITE® (low frequency) sensors whenever possible. F-Series and H-Series sensors are also acceptable, but less accurate.
- Size the meter appropriately for gas flow. Avoid high turndowns where sensor sensitivity may be reduced.
- Do not use T-Series sensors or compact Models F300/H300 because they have a high operating frequency.
- Use the enhanced core processor (Model 800) or : they perform best in applications with entrained liquid.
- Orient the meter properly:

Table C-2: Preferred sensor orientation when there could be entrained liquid

Process	Preferred orientation
Delta-shaped sensors (CMF010, CMF025, CMF050, CMF100)	
Any F-Series or CMFS sensor, and CMF200 or larger (flow should go down)	

- Ensure sensor is dried (blown-out) as quickly as possible, and stays dry during measurement.
- Avoid temperature losses; insulation is highly recommended if condensate is caused by cooling temperatures.
- Avoid pressure increases in the system; Ensure that pressure regulators are functioning properly.
- If entrained liquid is unavoidable, try to ensure that the process is well mixed.

- Avoid elbows, valves, or other components that may introduce a flow profile affecting one tube (for example, a swirling motion entering the flow tubes)
- If re-zeroing in the field is necessary, zeroing must be done on a pure gas without liquid in order to avoid error. If this cannot be done, use the factory zero.
- Minimize damping on outputs to minimize processing delay from electronics.
- Do not stop the totalizer immediately after batch; allow the totalizer to stabilize for approximately 1 second.
- Set Flow Cutoff as high as is practical to avoid totalizing at no flow condition if droplets remain in the sensor.

C.3 Density determination

If you are using either the PVR application or the Net Oil application, you must know the density of water from the well, corrected to reference temperature, and the density of dry oil from the well, corrected to reference temperature.

Important
Micro Motion recommends working with a laboratory to obtain the most accurate values. The accuracy of the data depends upon the accuracy of these two density values.

C.3.1 Density determination using a three-phase separator

To configure net oil measurement, you must know the density of dry oil at reference temperature, and the density of produced water at reference temperature. If you have a three-phase separator, you can use density data and the Oil & Water Density Calculator to obtain these values.

Note
Even after separation, oil typically contains some amount of interstitial water. The water cut may be as high as 1% to 3%. For purposes of this application, this is considered dry oil.

Prerequisites

You must have a three-phase separator in the process. You can use a mobile three-phase test separator.

You must have a sensor and transmitter installed on the oil leg, and a sensor and transmitter installed on the water leg or determine the water density separately by manual sampling.

You must have the Oil & Water Density Calculator. This is a spreadsheet tool developed by Micro Motion. You can obtain a copy from your Micro Motion representative or by visiting https://www.emersonflowsolutions.com/oildensityref.

Important
The accuracy of net oil data depends on the accuracy of the density data. Never use an unstable density value, or any density value that has an elevated drive gain.

Procedure

1. Wait until separation has occurred.

2. At the transmitter on the oil leg, do one of the following options:
   - Read and record the density value and the temperature value
   - If logging the live variable data, monitor the live density at line conditions, or the corrected density at 60 °F (15.6 °C) (modbus register 1655)
3. At the transmitter on the water leg, read and record the density value and the temperature value. Alternatively, enter the density of the water obtained by another method, such as sampling.
4. Use the Oil & Water Density Calculator to calculate the density of dry oil at reference temperature and the density of produced water at reference temperature. You can obtain a copy from your Micro Motion representative or by visiting https://www.emersonflowsolutions.com/oildensityref.

   Tip
   Unless the oil is light hot condensate, the oil will almost always contain some interstitial water. This is generally acceptable for allocation measurements. However, if further accuracy is desired, you can determine the water cut and use it in the calculation. To determine or estimate the water cut, take a shakeout sample from one of the following:
   - The current flow/dump cycle, at the time of minimum density
   - Similar oils produced from the same reservoir
   - The tank or tanks that the separator flows into

   Enter this water cut into the Oil & Water Density Calculator to calculate the density of dry oil at reference temperature.

C.3.2 Density determination using a petroleum laboratory

To configure APM for net oil measurement, you must know the density of oil at reference temperature, and the density of produced water at reference temperature. You can obtain these values from a petroleum laboratory.

Note
Even after separation, oil typically contains some amount of interstitial water. The water cut may be as high as 1% to 3%.

Important
If you are using a three-phase separator, you can collect the oil sample and the water sample separately, after separation, or you can collect one sample before separation and have the laboratory perform the separation.

If you are using a two-phase separator, you should collect one sample before separation and have the laboratory perform the separation.

Prerequisites

Sample collection must meet these requirements:

- You must be able to collect a sample that is representative of your process.

- The sample must be collected by a qualified person, using industry-accepted safety standards.
- You must know the minimum required sample size. This varies depending on the water cut and the volume of the sample cylinder. Consult the petroleum laboratory for specific values.
- If the sample contains oil, you must be able to collect and maintain the sample at line pressure, so that the oil will not lose pressure and outgas. This will change the laboratory-measured density.
- If you collect the water sample separately, you must be able to protect it from contamination and evaporation.

You must know the reference temperature that you plan to use.

The petroleum laboratory must be able to meet these requirements:

- The laboratory density meter must be able to keep the oil sample pressurized at line pressure during the density measurement.
- The sample cylinder must be a constant-pressure type, and must be properly rated for the oil–water composition and for sample pressure.
- The laboratory report must include the oil density, water density, and the reference temperature.

Procedure

1. Communicate the handling and measurement requirements and the reference temperature to the petroleum laboratory.
2. If you are collecting one sample that contains both oil and water, identify the point in the line where the sample will be taken.

   Recommendations:

   - Collect the sample at a point where the fluid is well mixed.
   - The line pressure at the sample point should be close to the line pressure at the sensor.
   - The line temperature at the sample point should be close to the line temperature at the sensor.

3. If you are using a three-phase separator and collecting the oil and water samples separately:
   a) Identify the points where the samples will be taken.

      Recommendations:

      - The sample point for oil must be on the oil leg, as close to the sensor as possible.
      - The line pressure at the oil sample point should be similar to the line pressure at the sensor.
      - The sample point for water must be on the water leg, as close to the sensor as possible.

- The line temperature at the water sample point should be similar to the line temperature at the sensor.

b) Wait until separation has occurred.

4. Collect the sample or samples, meeting all requirements for pressure and protection from contamination or evaporation.
5. Mark and tag the sample or samples with the well name or number, time and date, sample type, line pressure, and line temperature.
6. Transport the samples to the laboratory safely, as soon as is practical.

Postrequisites

If the laboratory measurements were not corrected to your reference temperature, use the Oil & Water Density Calculator to calculate density at reference temperature. This is a spreadsheet tool developed by Micro Motion. You can obtain a copy by visiting https://www.emersonflowsolutions.com/oildensityref or from your Micro Motion representative.

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