Supplement
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Micro Motion™ Multiphase Applications

Production Volume Reconciliation (PVR) | Transient Bubble Remediation (TBR) | Transient Mist Remediation (TMR)

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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. 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

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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
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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
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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 the Production Volume Reconciliation application (PVR), the Transient Bubble Remediation application (TBR), and the Transient Mist Remediation application (TMR), using ProLink III.

These three applications are available for Micro Motion MVD™ Coriolis meters in an MVD Direct Connect installation.

PVR, TMR, and TBR are also available for Micro Motion Model 1500, Model 1700, Model 2500, and Model 2700 transmitters.

This application manual does not provide information on installation of any sensors or transmitters, or on general configuration. This information can be found in the applicable sensor installation manual, transmitter installation manual, or transmitter configuration manual.

Related information

Additional documentation from Micro Motion

1.2 ProLink III requirements

To use this manual, you must have ProLink III Professional v4.0 or later, and you must be able to connect from ProLink III to the transmitter or core processor.

1.3 Ordering options

For 800 core processor direct connect installations, PVR, TBR, and TMR are available as Engineering To Order (ETO) applications. PVR and TMR are available individually or in combination with Smart Meter Verification.

PVR, TMR, and TBR features are now available in the standard product when ordered on 1500, 1700, and 2500 Transmitter Models. The ETO is not required on the 800 core processor when used with a transmitter.

To order one of these applications, an ETO must be purchased for the core processor (see Table 1-1). This ETO enables use of the application in an MVD™ Direct Connect installation.

Table 1-1: Core processor ETOs for PVR, TBR, and TMR

Application	Direct connect core processor	ETO number		Process fluid	Desired measurement
		Individual application	Application with Smart Meter Verification (SMV)		
PVR	Enhanced	22166	22701	Mixture of oil and water	Net oil (dry oil at reference conditions) and net water flow
TBR	Enhanced	13386	25699	Liquid with gas	Liquid flow rate and totals
	Standard	12806	Not available.	Liquid with gas	Liquid flow rate and totals
TMR	Enhanced	18922	22706	Gas with entrained liquid (mist)	Gas flow rate and totals

Restriction
Only one ETO can be installed in the transmitter or core processor at a time.

1.4 Additional documentation from Micro Motion

Table 1-2: Additional documentation for PVR, TBR, and TMR installations

Document	Use
Micro Motion® MVD™ Direct Connect Meters: Installation Manual	Installation and wiring for the MVD Direct Connect flowmeter
Sensor installation manual for your sensor	Installation and wiring for the sensor
Configuration manual for your transmitter	Configuration, operation, maintenance, and troubleshooting for features that are not related to PVR, TBR, or TMR
ProLink III User Manual	Installation and use of ProLink III
Modbus Interface Tool	Programming the Modbus host

1.5 Terms and definitions

The terms used to describe Multiphase applications vary widely. This manual, and the PVR, TBR, and TMR applications, use the terms defined here.

Terms used in PVR, TBR, and TMR	
at Reference	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)
At Line	The density of the process fluid at line temperature
At Reference density	The density of the process fluid at reference temperature (60 °F) that is equivalent to its density at line temperature
At Line volume	The volume of the process fluid at line temperature
At Reference volume	The volume of the process fluid at reference temperature (60 °F) that is equivalent to its volume at line temperature
Mixture	The process fluid before separation, such as a combination of oil and water, or gas, oil, and water
Water cut	The volume fraction of water in the liquid mixture, in %
Entrained, entrainment	The presence of small amounts of gas in a liquid stream, or liquid in a gas stream
Remediation	An adjustment applied to a process variable during periods of entrained gas or mist when a substitute density value has been used for volume calculation (PVR and TBR) or the flow rate has been increased or decreased to compensate for unmeasured flow (TMR).
Shrinkage	The change in liquid volume between the measurement point and a stock tank due to lighter hydrocarbons evaporating. This is caused by the stock tank being at a lower pressure, further below the bubble point of the oil. The shrinkage factor is a user-input factor, based on a PVT (pressure-volume-temperature) test of the oil.
Shrinkage Meter Factor	Used just like the normal Meter Factor, when proving the meter against liquid measurement at stock tank conditions.

These terms can be combined in several ways to describe different process variables. The following table provides several examples, but is not a complete list of possibilities.

Table 1-3: Examples of process variable names

Process variable name	Description
Volume Total (unremediated)	The total, by volume, of the mixture (oil/water/gas combination), as measured
Volume Total (remediated)	The total, by volume, of the oil/water minus the volume attributable to gas

Table 1-3: Examples of process variable names *(continued)*

Process variable name	Description
Oil Total at Line	The total amount of oil measured since the last totalizer reset, at line temperature, with no adjustment for temperature variation
Water Cut at Reference	The percentage of water in the oil, as if the measurement had been taken at 60 °F

1.6 PVR, TBR, and TMR applications

PVR, TBR, and TMR are applications designed to provide more accurate process data in the presence of multiple phases. For example, if bubbles are present in the process fluid, or the process fluid is flashing, the volume measurements are often incorrect.

Production Volume Reconciliation (PVR)

- Provides oil and water volumes through density-based calculations for both line and reference conditions
- Detects bubble entrainment or flashing in the sensor, and can correct volumes accordingly
- Best for undersized three-phase separators that frequently have intermittent gas or water contamination in the oil leg
- Offers a simple, low-cost solution for net oil and net water measurement for two-phase separators

Transient Bubble Remediation (TBR)

- Used with single-component liquid streams that may experience intermittent low levels of gas entrainment, that is, gas carryunder
- Enables accurate measurement of a single fluid during periods of entrained gas by providing a substitute density value based on the immediately preceding process density (standard configuration)
- Tracks total time of aerated flow to assist in diagnosing process issues that may cause aeration

Transient Mist Remediation (TMR)

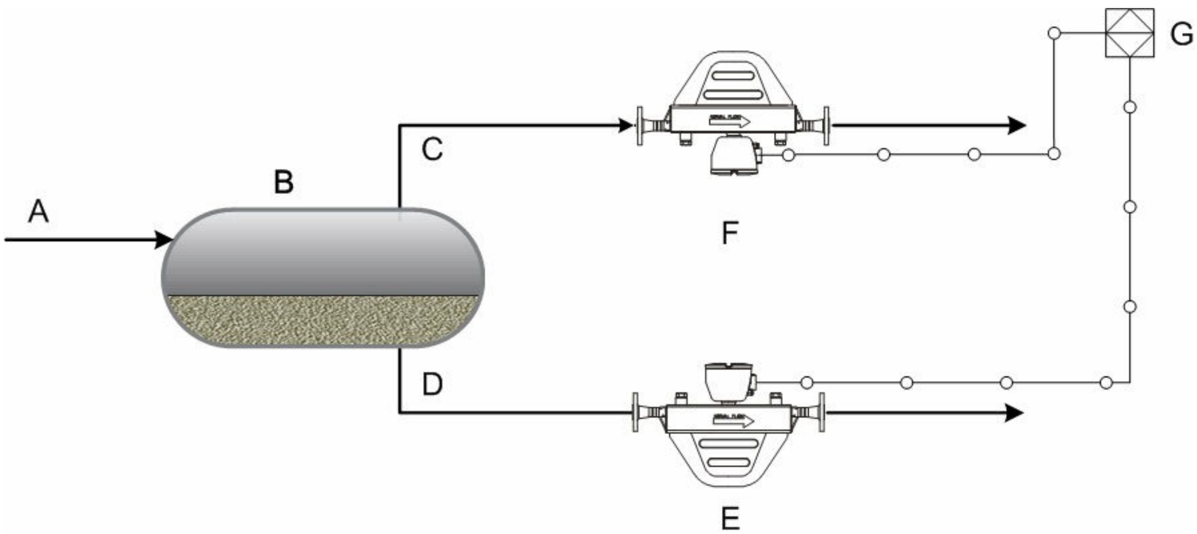
- Used with gas streams that may experience intermittent low levels of liquid entrainment, i.e., liquid carry-over
- Allows gas measurement to continue during periods of entrained liquid (mist) by providing a substitute flow rate value based on the immediately preceding process flow rate
- Returns to reporting the measured flow rate when the mist interval is over, increased or decreased by a maximum of 10%, until flow totals are appropriately adjusted for the unmeasured flow
- Provides an indication of the amount of time that liquid was present in the stream — identifying process improvements to reduce gas stream contamination

1.6.1 Illustrations of PVR, TBR, and TMR installations

PVR, TBR, and TMR can be used with two-phase separators and three-phase separators.

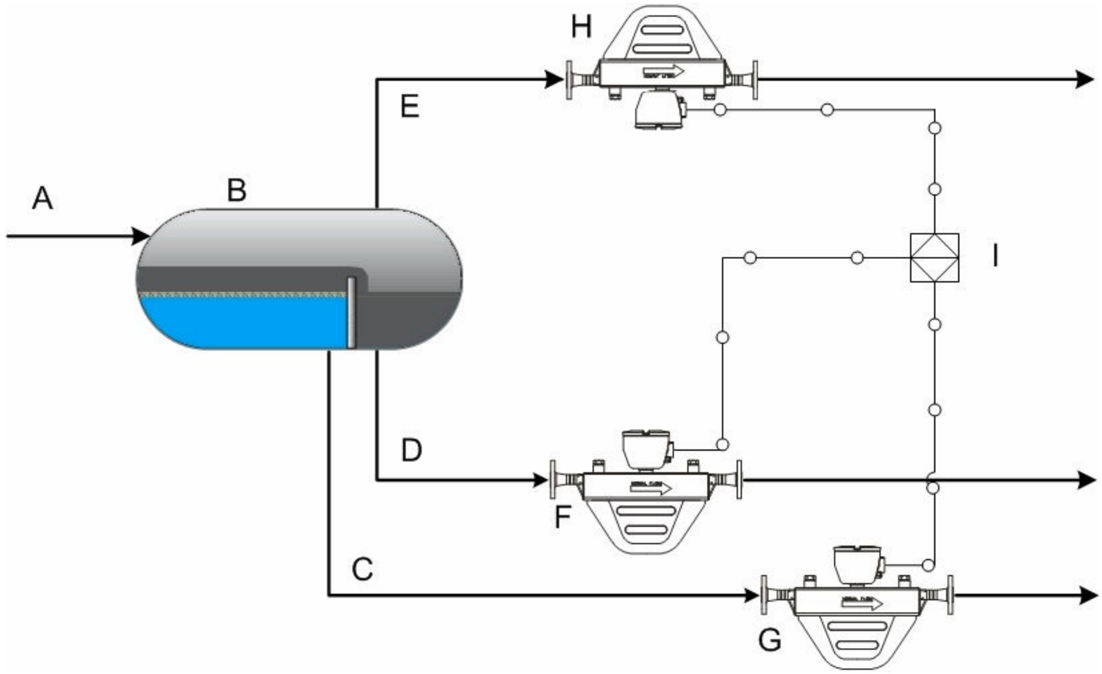
Note
These illustrations do not show all possible combinations.

Figure 1-1: PVR, TBR, or TMR with two-phase separator



A. *From wellhead*
B. *Separator*
C. *Gas leg*
D. *Oil/water leg*
E. *Coriolis sensor with PVR or TBR*
F. *Coriolis sensor with TMR*
G. *Modbus host (flow computer)*

Figure 1-2: PVR, TBR, or TMR with three-phase separator



A. *From wellhead*
B. *Separator*
C. *Water leg*
D. *Oil leg*
E. *Gas leg*
F. *Coriolis sensor with PVR or TBR*
G. *Coriolis sensor with PVR (optional, used in applications where oil measurement is needed in the water leg to detect a malfunctioning separator)*
H. *Coriolis sensor with TMR*
I. *Modbus host (flow computer)*

2 Production Volume Reconciliation (PVR)

2.1 Understanding the PVR application

PVR is used in oil and gas separation applications to compensate for gas and/or water contamination in the oil leg of a three-phase separator. It is also used to quantify the oil and water volumes in the liquid leg of a two-phase separator.

PVR uses the meter's drive gain to indicate if there is entrained gas or transient bubbles in the liquid stream, and adjust the measurement accordingly. Under normal circumstances, i.e., no entrained gas or bubbles, the application uses the Net Oil Computer (NOC) algorithm to calculate and quantify the volumes of oil and water in the liquid stream.

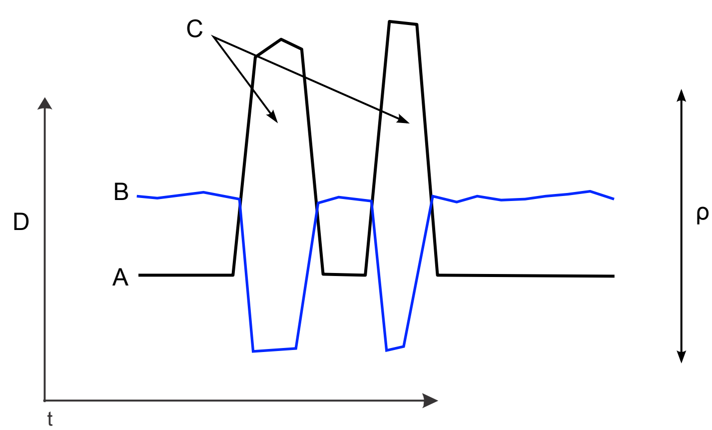
Net Oil Computer (NOC)

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

Compensating for gas in the liquid

Entrained gas, or bubbles in the process fluid, has a negative effect on liquid volume measurement accuracy. The Coriolis sensor calculates volume based on direct density and mass measurements. When a bubble is present, mixture density is reduced, causing the reported volume to be higher than the actual liquid volume. The presence of bubbles is reflected in the drive gain. The following figure shows how the change in drive gain affects density measurement.

Figure 2-1: Effect of transient bubbles on drive gain and density measurement



A. Density
B. Drive gain (actual)
C. Transient bubble condition
D. Drive gain (%)

A *transient bubble condition* is defined in terms of the sensor's drive gain: If the drive gain exceeds the configured threshold for more than a specified interval, the selected PVR action is performed. The transient bubble interval persists until drive gain is below the configured threshold for the specified interval.

PVR volume calculation during bubble events

If the drive gain threshold is exceeded, the volume calculation for the period of high drive gain can be handled in one of three ways.

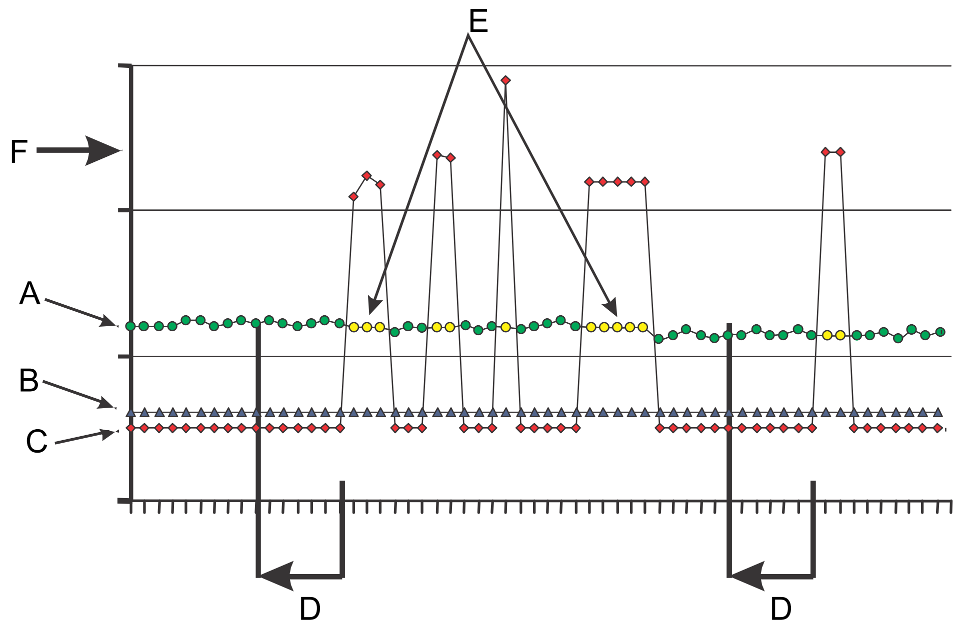
Option	Description
Hold Last Value	Use an average density value from an earlier point in the process to calculate volume. If this option is chosen, the water cut from the point just before the bubble event is effectively held constant throughout the bubble event.
Use Input Density of Dry Oil Converted to Line Conditions	Convert the density of dry oil at reference temperature (a user-configured value) to density at line temperature, and calculate volume. This option assumes that all volume during the bubble event is dry oil.
Alert Only	Post an alert.

Processing for Hold Last Value

This option directs the application to retrieve measured density data from an earlier point in the process. The earlier point is identified by the configured **PVR Lookback Period**. The density values around this point are averaged, and this average is then used in oil calculations.

The following figure shows the substitution of average density data during the transient bubble interval.

Figure 2-2: Hold Last Value in operation



A. Density
*B. **PVR Drive Gain Threshold***
C. Drive gain (actual)
*D. **PVR Lookback Period***
E. Averaged density values
F. Drive gain (%)

Note

If the point defined by **PVR Lookback Period** happens to fall into a previous transient bubble interval, the application automatically extends the lookback interval as required so that the average is calculated from measured density data rather than substituted density values. In the illustration, the first average is applied to several transient bubble events.

2.2 Density determination

To configure Production Volume Reconciliation (PVR), you must know the density of dry oil at reference temperature, and the density of produced water at reference temperature.

Related information

Density determination using the data log from ProLink III
Density determination using a petroleum laboratory

2.2.1 Density determination using the data log from ProLink III

To configure Production Volume Reconciliation (PVR), you must know the density of dry oil at reference temperature, and the density of produced water at reference temperature. You can use log data from ProLink III, with 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.

This procedure assumes the following:

- The highest density value in the logged data represents produced water.
- The lowest density value in the logged data represents dry oil.

Prerequisites

You must be able to connect to the transmitter or core processor with ProLink III.

You must know how to use the data logging feature in ProLink III.

You must be able to run data logging for the necessary time period, which may be a few minutes or a few hours, depending on your separator.

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.

Procedure

1. Connect to the core processor or transmitter with ProLink III.
   - For two-phase separators, connect to the core processor or transmitter on the oil/water leg. See Figure 1-1.
   - For three-phase separators, connect to the core processor or transmitter on the oil leg. See Figure 1-2.
2. Set up data logging to record the following process variables, with a logging interval of 1 second:
   - Mass flow rate
   - Volume flow rate
   - Density
   - Temperature

- Drive gain

3. Collect data.
    a) Open the level control valve on the separator, and allow the separator to drop to the lowest safe level, or until gas is first drawn into the liquid leg.
    b) Close the level control valve and allow the level to rise to the maximum safe level.

       This will increase the residence time for the liquid in the separator, and may allow the water to settle to the bottom and the oil to rise to the top.
    c) Open the level control valve partially, so that the level drops slowly.
    d) Start data logging.
    e) Allow the separator to drop to the lowest safe level, or until gas is first drawn into the liquid leg.
    f) Stop data logging.
    g) Return the separator to automatic level control.
4. Obtain maximum and minimum density data from the log.

   Shortly after the control valve is opened or the dump phase begins, you should see the temperature stabilizing and the density rising to a maximum value and stabilizing. This may represent produced water. Just before the lowest safe level, or before the point where gas is drawn into the liquid leg, you should see the density falling to a minimum value and stabilizing. This may represent dry oil.
    a) Record the maximum density and the corresponding temperature.
    b) Record the minimum density and the corresponding temperature.

Important
Never use an unstable density value, or any density value that has an elevated drive gain.

5. 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.

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.

2.2.2 Density determination using a petroleum laboratory

To configure Production Volume Reconciliation (PVR), you must know the density of dry oil at reference temperature, and the density of produced water at reference temperature. You can obtain this 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%. For purposes of this application, this is considered dry oil.

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

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 oil density measurement units should be in g/cm^3 at reference temperature and/or °API at reference temperature. The water density measurement should be in g/cm^3 at reference temperature. PVR requires a reference temperature of 60 °F. Be sure to specify this to the petroleum laboratory, as some countries use other reference temperatures.
- The laboratory report must include the oil density, water density, and the reference temperature.

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.

You must be able to collect and maintain the oil sample at line pressure, so that the oil will not lose pressure and outgas.

If you collect the water sample separately, you must be able to protect it from contamination and evaporation.

Procedure

1. Communicate the handling and measurement requirements 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 upstream from the separator, at a point where the fluid is well mixed. Fluid in the oil/water leg exiting the separator may not be well mixed.
- The process fluid at the sample point should be representative of the process fluid flowing through the sensor on the oil/water leg.
- The line pressure at the sample point should be close to the line pressure at the sensor.
- Collect the sample from the bottom of the pipe to minimize the amount of gas in the sample.

3. If you are using a three-phase separator and collecting the oil and water samples separately, 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. See Figure 1-2.
   - 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. See Figure 1-2.

   Note
   If you have a Micro Motion sensor on the water leg, you may be able to use the data logging procedure described in Density determination using the data log from ProLink III to determine the water density.

4. If you are using a three-phase separator and collecting the oil and water samples separately, wait until separation has occurred.
5. Collect the sample or samples, meeting all requirements for pressure and protection from contamination or evaporation.
6. Mark and tag the sample or samples with the well name or number, time and date, sample type, and line pressure.
7. 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 from your Micro Motion representative.

2.3 Configure Production Volume Reconciliation (PVR) using ProLink III

PVR is used with three-phase separators to remove gas and/or water contamination from oil measurement on the oil leg, and to quantify the net oil and net water in the liquid leg of a two-phase separator.

Prerequisites

You must know the density of dry oil from this well, at reference temperature and reference pressure.

You must know the density of water at reference temperature.

Procedure

1. Choose **Device Tools** → **Configuration** → **Process Measurement** → **Production Volume Reconciliation (PVR)**.
2. Enable the PVR application.
3. Set **Reference Temperature** to the temperature to be used to calculate standard density.

   In most cases, this is the reference temperature used during density determination.
4. Enter the density of dry oil from this well at the configured reference temperature.
5. Enter the density of produced water at the configured reference temperature.
6. Set **PVR Drive Gain Threshold** to the value of drive gain, in percent, that indicates the presence of bubbles in the process fluid.

   At drive gain values above this threshold, the transmitter will implement the configured PVR action.
7. Set **PVR Drive Gain Threshold High** to the value of drive gain, in percent, that indicates a significant amount of gas in the process fluid.

   At drive gain values above this threshold, the transmitter will post an alert.
8. Set **PVR Action** to the action that the transmitter will perform when PVR remediation is active.

Option	Description
Hold Last Value	The transmitter will calculate volume using a substitute density value. The substitute value is an average of the data around a recent point in the process.
Use Input Density of Dry Oil Converted to Line Conditions	The transmitter will calculate volume using the configured value for oil density, converted to line temperature.
Alert Only	The transmitter will post an alert.

As soon as the drive gain drops below **PVR Drive Gain Threshold**, the transmitter returns to reporting standard density.

9. If you set **PVR Action** to Hold Last Value, set **PVR Lookback Period** to the number of seconds the transmitter will go back in process history to retrieve and average process data.
10. Enable or disable **PVR Timeout** as desired.

Option	Description
Enabled	If PVR actions are applied for the number of seconds specified in PVR Timeout Value, the transmitter performs the configured TBR Timeout Action.
Disabled	PVR actions continue until the drive gain drops below **PVR Drive Gain Threshold**.

11. If you enabled **PVR Timeout**:
    a) Set **PVR Timeout Value** to the number of seconds that the transmitter will perform the PVR action before implementing **PVR Timeout Action**.
    b) Set **PVR Timeout Action** to the action that the transmitter will perform if the PVR timeout is reached.

Option	Description
Alert	The transmitter posts an alert, and continues PVR actions.
Normal Measurement	The transmitter returns to normal measurement, and does not post an alert.

Note
For the location of parameters not exclusive to the PVR software, refer to the transmitter configuration and use manual.

3 Transient Bubble Remediation (TBR)

3.1 Understanding the TBR application

Transient Bubble Remediation (TBR) is indicated for use with liquid streams that may experience intermittent low levels of gas entrainment, i.e., gas carry-under. In the standard configuration, TBR enables accurate oil measurement during periods of entrained gas by providing a substitute density value based on the immediately preceding process density.

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 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.(2) TBR 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.

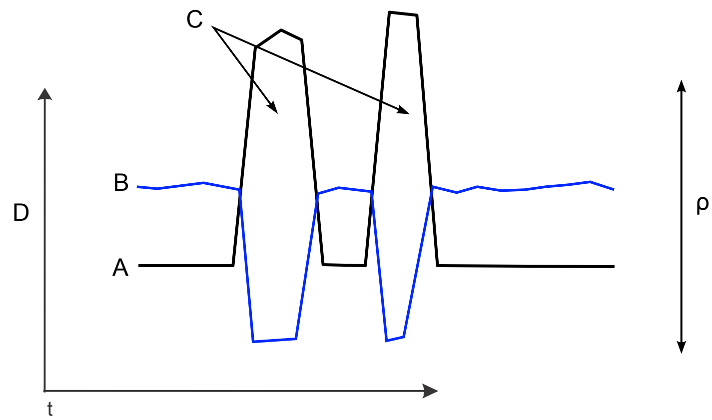
Compensating for gas in the liquid

Entrained gas, or bubbles in the process fluid, has a negative effect on measurement accuracy, because entrained gas causes abrupt increases in drive gain, and the density measurement of the mixture is temporarily low. The following figure shows how the change in drive gain affects density measurement.

(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 F300, H300, and all T-Series sensors.*

(2) *The unmeasured gases can be (and are often) collected and processed separately downstream if desired (using a separator for example).*

Figure 3-1: Effect of transient bubbles on drive gain and density measurement



A. *Drive gain (actual)*
B. *Density*
C. *Transient bubble condition*
D. *Drive gain (%)*

A *transient bubble condition* is defined in terms of the sensor's drive gain: If the drive gain exceeds the configured threshold, the selected TBR action is performed. The transient bubble interval persists until drive gain is below the configured threshold.

TBR actions

The TBR application can perform either of the following actions if transient bubbles are detected:

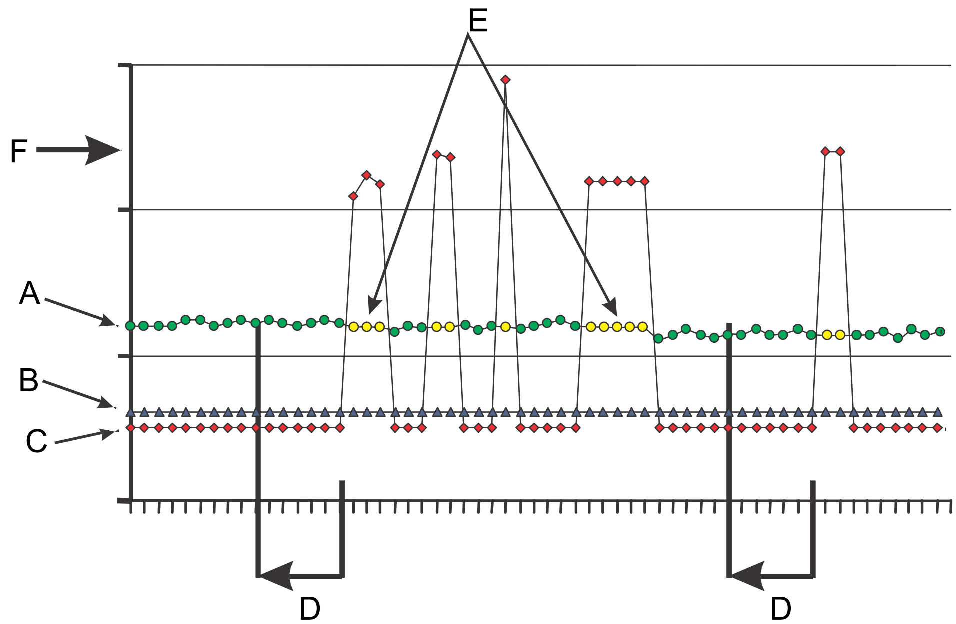
Alert Only	Post an alert
Hold Last Value	Report an average value from an earlier point in the process

Processing for Hold Last Value

This option directs the application to retrieve measured density data from an earlier point in the process. The earlier point is identified by the configured **TBR Lookback Period**. The density values around this point are averaged, and this average is then used in net oil calculations.

The following figure shows the substitution of average density data during the transient bubble interval.

Figure 3-2: Hold Last Value in operation



A. *Density*
B. ***TBR Drive Gain Threshold***
C. *Drive gain (actual)*
D. ***TBR Lookback Period***
E. *Averaged density values*
F. *Drive gain (%)*

Note

If the point defined by **TBR Lookback Period** happens to fall into a previous transient bubble interval, the application automatically extends the lookback interval as required so that the average is calculated from measured density data rather than substituted density values.

3.2 Configure Transient Bubble Remediation (TBR) using ProLink III

TBR is used with liquid streams that may experience intermittent low levels of gas entrainment. TBR allows the system to detect transient bubble conditions, and to take either of two actions in response.

Procedure

1. Choose **Device Tools** → **Configuration** → **Process Measurement** → **Transient Bubble Remediation (TBR)**.
2. Set **TBR Drive Gain Threshold** to the value of drive gain, in percent, that indicates the presence of bubbles in the process fluid.

At drive gain values above this threshold, the transmitter will implement the configured TBR actions.

3. Set **TBR Action** to the action that the transmitter will perform when TBR is active.

Option	Description
Hold Last Value	The transmitter will calculate volume using a substitute density value. The substitute value is an average of the data around a recent point in the process.
Alert Only	The transmitter will post an alert.

4. If you set **TBR Action** to Hold Last Value, set **Lookback Period** to the number of seconds the transmitter will go back in process history to retrieve and average process data.
5. Enable or disable **TBR Timeout** as desired.

Option	Description
Enabled	If TBR is active for the number of seconds specified in **TBR Timeout Value**, the transmitter performs the configured **TBR Timeout Action**.
Disabled	TBR actions continue until the drive gain drops below **TBR Drive Gain Threshold**.

6. If you enabled **TBR Timeout**:
   a) Set **TBR Timeout Value** to the number of seconds that the transmitter will perform TBR before implementing **TBR Timeout Action**.
   b) Set **TBR Timeout Action** to the action that the transmitter will perform if the TBR timeout is reached.

Option	Description
Alert	The transmitter returns to normal measurement and an alert is posted..
Normal Measurement	The transmitter returns to normal measurement, and does not post an alert.

Note
For the location of parameters not exclusive to the TBR software, refer to the transmitter configuration and use manual.

4 Transient Mist Remediation (TMR)

4.1 Understanding the TMR application

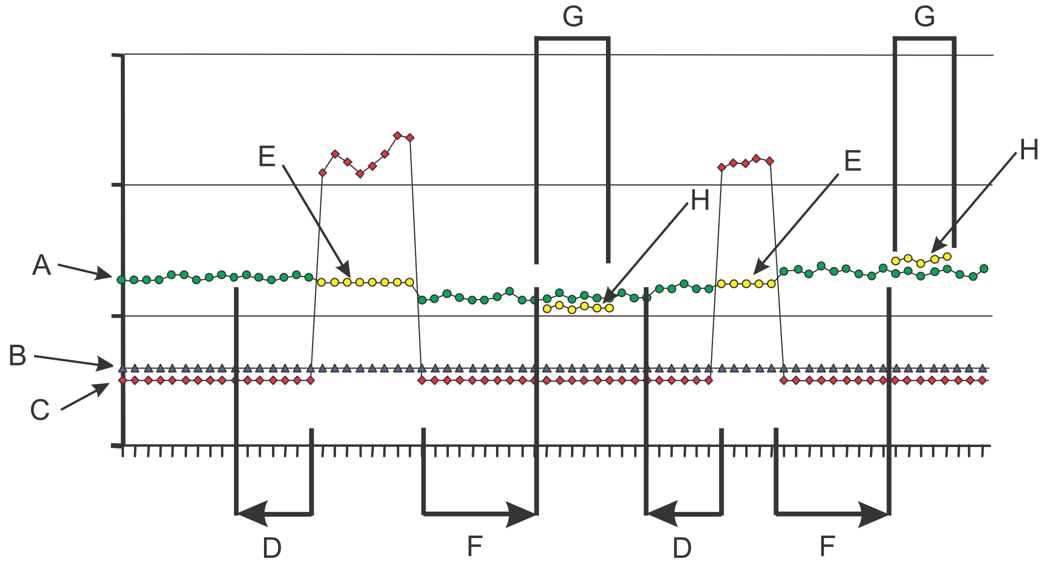
TMR is designed for use with gas streams that may experience intermittent low levels of liquid entrainment, i.e., liquid carry-over.

Entrained liquid, or mist in the process fluid, has a negative effect on measurement accuracy, because entrained liquid causes abrupt increases in drive gain, and the density measurement is temporarily low. TMR allows gas measurement to continue during periods of entrained liquid (mist) by providing a substitute flow rate value based on the immediately preceding process flow rate. When the mist interval is over, TMR returns to reporting the measured flow rate, increased or decreased by a maximum of 10%, until flow totals are appropriately adjusted for the unmeasured flow.

A *transient mist condition* is defined in terms of the sensor's drive gain: If the drive gain exceeds the configured threshold, the transmitter automatically performs transient mist remediation. The transient mist interval persists until drive gain is below the configured threshold.

The following figure illustrates TMR processing.

Figure 4-1: TMR in operation



A. *Flow rate*
B. ***TMR Drive Gain Threshold***
C. *Drive gain (actual)*
D. ***Pre-Mist Averaging Period** and source of M1*
E. *Averaged flow rate values*
F. ***Post-Mist Adjustment Delay** and source of M2*
G. *Adjustment period*
H. *Adjusted flow rate values*

When TMR is detected, the transmitter substitutes an average flow rate value, M1, for the measured flow rate, for the entire transient mist interval. The substitute flow rate is calculated from the actual flow rate data for the previous *n* seconds, where *n* is determined by the setting of **Pre-Mist Averaging Period**.

When the transient mist interval is over, the transmitter waits for the number of seconds specified by **Post-Mist Adjustment Delay**. During that period, the transmitter calculates a second average flow rate, M2. M1 and M2 are then averaged, producing an approximate value for the actual flow rate during the transient mist interval. The measured flow rate is then increased or decreased by a maximum of 10% until the flow total has been compensated for all of the unmeasured flow.

4.2 Configure Transient Mist Remediation (TMR) using ProLink III

TMR is designed for use with gas streams that may experience intermittent low levels of liquid entrainment.

Procedure

1. Choose **Device Tools** → **Configuration** → **Process Measurement** → **Transient Mist Remediation (TMR)**.
2. Enable the TMR application.
3. Set **TMR Drive Gain Threshold** to the value of drive gain, in percent, that indicates the presence of mist in the process fluid.

   At drive gain values above this threshold, the transmitter will initiate TMR.

4. Set **Pre-Mist Averaging Period** to the number of seconds over which flow rate will be averaged to produce a substitute flow rate.

   When mist is detected, the transmitter retrieves the most recent flow rate data for the specified number of seconds, averages the data, and reports the result rather than the measured flow rate.

5. Set **Post-Mist Adjustment Delay** to the number of seconds that the transmitter will wait, after mist is detected, before beginning TMR adjustment.

   During TMR adjustment, the transmitter increases or decreases the measured flow rate by a maximum of 10%. The TMR adjustment continues until the flow total has been completely compensated for the unmeasured flow.

   Note
   For the location of parameters not exclusive to the TMR software, refer to the transmitter configuration and use manual.

5 Display variables

5.1 Display variables available with PVR, TBR, and TMR

When PVR, TBR, or TMR is implemented on your transmitter, additional application-specific process variables are available to configure as display variables.

The following table lists the process variables that are available for configuration as display variables. For instructions on configuring display variables, see the configuration manual for your transmitter.

Table 5-1: Process variables available as display variables

Process variable	Application		
	PVR	TBR	TMR
Oil Total At Line	✓		
Water Total At Line	✓		
Water Cut At Line	✓		
Accumulated TBR Time	✓	✓	
Mass Flow (unremediated)	✓	✓	✓
Mass Total (unremediated)	✓	✓	✓
Mass Inventory (unremediated)	✓	✓	✓
Mass Flow (remediated)			✓
Mass Total (remediated)			✓
Mass Inventory (remediated)			✓
Meastured Oil Density At Reference (Fixed API Units)	✓		
Meastured Oil Density At Reference (Fixed SGU Units)	✓		
Oil Flow Rate At Line	✓		
Oil Flow Rate At Reference	✓		
Oil Total At Reference	✓		
Unremediated Density At Line	✓	✓	
Unremediated Volume Flow At Line	✓	✓	
Unremediated Volune Total At Line	✓	✓	
Volume Flow (remediated)	✓	✓	✓
Volume Total (remediated)	✓	✓	✓
Volume Inventory (remediated)	✓	✓	✓

Table 5-1: Process variables available as display variables *(continued)*

Process variable	Application		
	PVR	TBR	TMR
Water Cut At Reference	✓		
Water Flow Rate At Line	✓		
Water Flow Rate At Reference	✓		
Water Total At Reference	✓		

A Application parameters and data

To use Modbus to configure other parameters, see the *Micro Motion Modbus Interface Tool*.

This information is provided for completeness.

A.1 PVR parameters and data

Table A-1: PVR configuration parameters

Parameter	Description	Modbus location and data type
Application Status	Enabled/disabled	Coil 75, coil 246 (write to both coils) • 0=Disabled • 1=Enabled
Density of Dry Oil at Reference Temperature	Density of dry oil from this well, in g/cm^3, at 60 °F	1959–1960, Float
Density of Water at Reference Temperature	Density of produced water from this well, in g/cm^3, at 60 °F	1831–1832, Float
PVR Drive Gain Threshold	The drive gain, in %, that triggers the configured PVR remediation action	617–618, Float
PVR Drive Gain Threshold High	The drive gain, in %, that represents a significant amount of gas in the liquid stream. The transmitter sets a flag.	343–344, Float
PVR Action	The remediation action to be implemented	ETO ≤ v3.95: 624 Bit 0, U16 • 0=Calculate volume from a substitute density value, derived from averaged density values from an earlier point in the process • 1=Alert only
		ETO > v3.95: 4450, U16 • 0=Calculate volume from a substitute density value, derived from averaged density values from an earlier point in the process • 1=Alert only • 2=Calculate volume using the configured value for oil density, converted to line temperature
PVR Lookback Period	The number of seconds to go back to determine a substitute density value	620, U16

Table A-1: PVR configuration parameters *(continued)*

Parameter	Description	Modbus location and data type
PVR Timeout	Enable or disable a timeout on the PVR remediation action	624 Bit 6, U16 • 0=Disabled • 1=Enabled
PVR Timeout Value	The number of seconds that PVR remediation will be performed before timing out	619, U16
PVR Timeout Action	The action to be performed if PVR remediation times out	624 Bit 1, U16 • 0=Normal Measurement • 1-Alert
Enable Shrinkage Factor Adjusted Volume Flow Outputs	Enables a set of variables that are adjusted for user-defined oil shrinkage	Coil 376
Shrinkage Factor	User-defined oil shrinkage value, using a no-flow computer.	1689-1960, Float
Shrinkage Meter Factor	User-defiined oil shrinkage value using the meter/transmitter. Users can restrict the meter factor to the shrinkage factor level for easier record keeping.	3992-3993, Float
Sales Density	Enables comparison of produced density to sales density to determine the shrinkage factor.	4465-4466, Float

Table A-2: PVR application status

Modbus location and data type	Value	Description
52–55, 8–byte ASCII	DENSHI	The calculated uncorrected water cut is greater than 100%. Water cut is reported as 100%.
	DENSLO	The calculated uncorrected water cut is less than 0%. Water cut is reported as 0%.
	GVF_HI	The GVF is high; drive gain is higher than PVR Drive Gain Threshold High.
	GVF_LO	The GVF is low; drive gain is between PVR Drive Gain Threshold and PVR Drive Gain Threshold High.
	(eight space characters)	No condition is active.

Table A-3: PVR process variables

Process variable	Value		Modbus location and data type
	No entrained gas detected	Entrained gas detected	
Water Cut At Line	Calculated water cut at line conditions	Core Processor ETO < v4.13: 0	1555–1556, Float
		Core Processor ETO ≥ v4.13: • PVR Action=0 or 1: Calculated water cut at line conditions • PVR Action=2: 0	
Water Cut At Reference[(1)]	Calculated water cut at 60 °F	Core Processor ETO < v4.13: 0	1557–1558, Float
		Core Processor ETO ≥ v4.13: • PVR Action=0 or 1: Calculated water cut at 60 °F • PVR Action=2: 0	
Water Flow Rate At Line[(1)]	Net volume flow rate of the water at line conditions	Core Processor ETO < v4.13: 0	1561–1562, Float
		Core Processor ETO ≥ v4.13: • PVR Action=0 or 1: Net volume flow rate at line conditions • PVR Action=2: 0	
Water Total At Reference[(1)]	Net volume flow rate of the water at 60 °F	0	1549–1550, Float
Water Total At Line	Net volume total of the water at line conditions, incrementing	Core Processor ETO < v4.13: Net volume total of the water at line conditions held at previous value; total does not increment	1667–1668, Float
		Core Processor ETO ≥ v4.13: • PVR Action=0 or 1: Net volume flow rate at line conditions, incrementing • PVR Action=2: Net volume total of the water at line conditions held at previous value; total does not increment	

Table A-3: PVR process variables *(continued)*

Process variable	Value		Modbus location and data type
	No entrained gas detected	Entrained gas detected	
Water Total At Reference (1)	Net volume total of the water at 60 °F, incrementing	Core Processor ETO < v4.13: Net volume total of the water at 60 °F held at previous value; total does not increment Core Processor ETO ≥ v4.13: • PVR Action=0 or 1: Net volume flow rate at 60 °F, incrementing • PVR Action=2: Net volume total of the water at 60 °F held at previous value; total does not increment	1663–1664, Float
Oil Density At Line (Fixed SGU Units) (1)	Density of the oil at 60 °F (user-specified), converted to line conditions using line temperature and API Even Table Correction for "A Tables" (Temp $_{@Line}$, DensityOil $_{@60F}$), then reported in SGU units	Density of the oil at 60 °F (user-specified), converted to line conditions using line temperature and API Even Table Correction for "A Tables" (Temp $_{@Line}$, DensityOil $_{@60F}$), then reported in SGU units	345–346, Float
Oil Density At Line (Fixed API Units) (1)	Density of the oil at 60 °F (user-specified), converted to line conditions using line temperature and API Even Table Correction for "A Tables" (Temp $_{@Line}$, DensityOil $_{@60F}$), reported in °API	Density of the oil at 60 °F (user-specified), converted to line conditions using line temperature and API Even Table Correction for "A Tables" (Temp $_{@Line}$, DensityOil $_{@60F}$), reported in °API	347–348, Float
Oil Flow Rate At Line (1)	Volume flow rate of oil at line conditions	Volume flow rate of oil at line conditions	1553–1554, Float
Oil Flow Rate At Reference (1)	Volume flow rate of oil at 60 °F	Volume flow rate of oil at 60 °F	1547–1548, Float
Oil Total Rate At Line	Net volume total of the oil at line conditions	Net volume total of the oil at line conditions	1665–1666, Float
Oil Total At Reference (1)	Net volume total of the oil at 60 °F	Net volume total of the oil at 60 °F	1661–1662, Float
Density	Density of the oil and water mixture, at line conditions	Core Processor ETO < v4.13: Remediated density of the mixture at line conditions, with the configured TBR action applied	249–250, Float

Table A-3: PVR process variables *(continued)*

Process variable	Value		Modbus location and data type
	No entrained gas detected	Entrained gas detected	
		Core Processor ETO ≥ v4.13: • PVR Action=0 or 1: Remediated density of the mixture at line conditions, with the configured TBR action applied • PVR Action=2: User-specified density of oil at 60 °F, converted to line conditions	
Mass Flow Rate	Mass flow rate of the liquid mixture, unremediated for PVR	Mass flow rate of the liquid mixture, unremediated for PVR	247–248, Float
Mass Total	Mass total of the liquid mixture, unremediated for PVR	Mass total of the liquid mixture, unremediated for PVR	259–260, Float
Mass Inventory	Mass inventory of the mixture, unremediated for PVR	Mass inventory of the mixture, unremediated for PVR	263–264, Float
Volume Flow Rate	Volume flow rate of the mixture, remediated for PVR	Volume flow rate of the mixture, remediated for PVR	253–254, Float
Volume Total	Total volume of the mixture at line conditions, remediated	Total volume of the mixture at line conditions, remediated	261–262, Float
Volume Inventory	Volume inventory of the mixture, remediated for PVR	Volume inventory of the mixture, remediated for PVR	265–266, Float
Unremediated Volume Flow Rate At Line(1)	Volume flow rate of the mixture at line conditions, with TBR correction (unremediated)	Volume flow rate of the mixture at line conditions, with TBR correction (unremediated).	2265–2266, Float
Volume Total At Line(1)	Total volume of the mixture at line conditions, without TBR correction (unremediated)	Total volume of the mixture at line conditions, without TBR correction (unremediated)	349-350, Float
Accumulated TBR Time (2)	Total number of seconds that TBR correction has been active, since the last master reset	Total number of seconds that TBR correction has been active, since the last master reset	2267–2268, INT32
Shrinkage Factor Oil Flow Rate At Line(3)	Volume flow of oil at line conditions, adjusted by shrinkage factor and shrinkage meter factor	Volume flow of oil at line conditions, adjusted by shrinkage factor and shrinkage meter factor	1733–1734, Float

Table A-3: PVR process variables *(continued)*

Process variable	Value		Modbus location and data type
	No entrained gas detected	Entrained gas detected	
Shrinkage Factor Oil Flow Rate At Reference(3)	Volume flow of oil at reference conditions, adjusted by shrinkage factor and shrinkage meter factor	Volume flow of oil at reference conditions, adjusted by shrinkage factor and shrinkage meter factor	1735–1736, Float
Shrinkage Factor Volume Flow Rate At Reference(3)	Volume flow of the mix at reference conditions	Volume flow of the mix at reference conditions	1737–1738, Float
Shrinkage Factor Oil Total at Line (3)	Volume Total of the mix at line conditions	Volume Total of the mix at line conditions	4616–4617, Float
Shrinkage Factor Oil Total at Reference (3)	Oil Total of the mix at reference conditions	Oil Total of the mix at reference conditions	4618–4619, Float
Shrinkage Factor Volume Total At Reference (3)	Volume Total of the mix at reference conditions	Volume Total of the mix at reference conditions	4796–4797, Float
Measured Oil Density At Reference (Fixed SGU Units)(3)	Density of the mixture at 60 °F, assuming the mixture is all oil. reported in SGU Units		1655–1666, Float
Measured Oil Density At Reference (Fixed API Units) (3)	Density of the mixture at 60 °F, assuming the mixture is all oil. reported in °API.		4465–4466, Float
Unremediated Density(4)	Density of the mixture at line conditions (unremediated for PVR)		1539–1540, Float

(1) Not available when connected to a transmitter.
(2) Requires the enhanced core processor v4.11 or later with ETO 22166 or ETO 22701.
(3) Requires the enhanced core processor v4.31 or later with ETO 22166 or ETO 22701.
(4) Requires the enhanced core processor v4.40 or later with ETO 22166 or ETO 22701. If for direct connect, use ETO 13386 or the standard 800 v4.42 or greater if connected to a Model 2700 Transmitter.

A.2 TBR parameters and data

Table A-4: TBR configuration parameters

Parameter	Description	Modbus location and data type
Drive Gain Threshold	The drive gain, in %, that triggers TBR	617–618, Float
TBR Action	The remediation action to be implemented	624, U16 • Bit #0: Initial Action — 0=Hold Last Value — 1=Alert Only • Bit #2: Drive Gain Averaging — 0=1 second — 1=4 seconds • Bit #3: Apply to Mass Flow (affects volume flow) — 0=Yes — 1=No • Bit #4: Apply to Density (affects volume flow) — 0=Yes — 1=No • Bit #5: Timeout Alert Type — 0=Two-Phase Flow — 1=Density Out of Range
TBR Lookback Period	The time period (seconds) that the application goes back in time to determine the substitute density to use in calculations	620, U16
TBR Timeout	Enable or disable a timeout on the TBR remediation action	624 Bit #6, U16 • 0=Disabled • 1=Enabled
TBR Timeout Value	The number of seconds that TBR remediation will be performed before timing out	619, U16
TBR Timeout Action	The action to be performed if TBR remediation times out	624 Bit #1, U16 • 0=Normal Measurement • 1=Alert

Table A-5: TBR application status parameters

Application status	Description	Modbus location and data type
TBR Active	Indicates whether TBR is active or inactive	433 Bit #10, U16
TBR Total Time	The duration of the TBR interval, in seconds	989, U32

Table A-6: TBR process variables

Process variable	Description	Modbus location and data type
Mixture Mass Flow Rate (unremediated)	Mass flow rate of the mixture, unremediated	247–248, Float
Mixture Mass Total (unremediated)	Mass total of the mixture, unremediated	259–260, Float
Mixture Mass Inventory (unremediated)	Mass inventory of the mixture, unremediated	263–264, Float
Mixture Uncorrected Volume Flow Rate (remediated)	Volume flow rate of the mixture, remediated	253–254, Float
Mixture Uncorrected Volume Total (remediated)	Total volume of the mixture at line conditions, remediated	261–262, Float
Mixture Uncorrected Volume Inventory (remediated)	Volume inventory of the mixture at line conditions, remediated	265–266, Float
Unremediated Density(1)	Volume inventory of the mixture at line conditions, remediated	1539-1540, Float

(1) *Requires the enhanced core processor v4.40 or later with ETO 13386 for direct connect, or the standard 800 v4.42 or greater if connected to a Model 2700 Transmitter.*

A.3 TMR parameters and data

Table A-7: TMR configuration parameters

Parameter	Description	Modbus location and data type
Application Status	Enabled/disabled	Coil 75 (Core processor version less than v4.40) Coil 473 (Core processor version 4.40 or greater.) • 0=Disabled • 1=Enabled
Drive Gain Threshold	The drive gain, in %, that triggers TMR	617–618, Float
Pre–Mist Averaging Period	The time period (seconds) that the application goes back in time to determine the density to use in TMR remediation	619, U16
Post–Mist Adjustment Delay	The time period (seconds) that the transmitter waits before beginning density adjustment	620, U16
TMR Action	The remediation action to be implemented	624, U16 • Bit #5: Timeout Alert Type — 0=Two–Phase Flow — 1=Density Out of Range

Table A-8: TMR application status parameters

Application status	Description	Modbus location and data type
TMR Active	Indicates whether TMR is active or inactive	433 Bit #12, U16

Table A-8: TMR application status parameters *(continued)*

Application status	Description	Modbus location and data type
TMR Total Time	The duration of the TMR interval, in seconds	989, U32

Table A-9: TMR process variables

Process variable	Description	Modbus location and data type
Mass Flow Rate (remediated)	Mass flow rate of the process fluid, remediated	973–974, Float
Mass Total (remediated)	Mass total of the process fluid, remediated	975–976, Float
Mass Inventory (remediated)	Mass inventory of the process fluid, remediated	977–978, Float
Mass Flow Rate (unremediated)	Mass flow rate of the process fluid, unremediated	247–248, Float
Mass Total (unremediated)	Mass total of the process fluid, unremediated	259–260, Float
Mass Inventory (unremediated)	Mass inventory of the process fluid, unremediated	263–264, Float
Uncorrected Liquid Volume Flow Rate (remediated) (1)	Volume flow rate of the process fluid, remediated	253–254, Float
Uncorrected Liquid Volume Total (remediated) (1)	Total volume of the process fluid at line conditions, remediated	261–262, Float
Uncorrected Liquid Volume Inventory (remediated) (1)	Volume inventory of the process fluid at line conditions, remediated	265–266, Float
Corrected GSV Flow Rate (remediated) (2)	Corrected GSV flow rate of the process fluid, remediated	455–456, Float
Corrected GSV Total (remediated) (2)	Corrected GSV total of the process fluid, remediated	457–458, Float
Corrected GSV Inventory (remediated) (2)	Corrected GSV inventory of the process fluid, remediated	459–460, Float

(1) *Applicable if Volume Flow Type = Liquid.*
(2) *Applicable if Volume Flow Type = Gas Standard Volume. GSV is available with TMR for transmitters v6.62 and later.*

B Best practices for two-phase measurement performance

B.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.
- Use the enhanced core processor (Model 800) either as direct connect or with the 1000-2000 Transmitter family: they perform best in applications with entrained gas.
- Orient the meter properly:

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

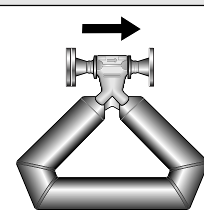
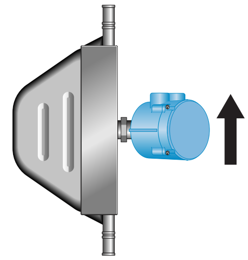
Process	Preferred orientation
Delta-shaped sensors (CMF010, CMF025, CMF050, CMF100)	

Table B-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.

B.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.

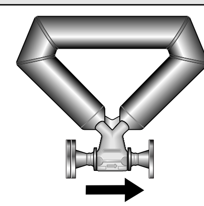
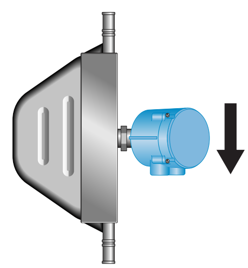
Common sources for unintentional liquid entrainment

- 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 the 1000-2000 transmitter family: they perform best in applications with entrained liquid.
- Use the enhanced core processor (Model 800) either as direct connect or with the 1000-2000 transmitter family: they perform best in applications with entrained liquid.
- Orient the meter properly:

Table B-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.

B.3 Density determination

If you are using either the PVR application or the , 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 PVR data depends upon the accuracy of these two density values.

B.3.1 Density determination using a petroleum laboratory

To configure PVR 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 oil and water density measurement units must be entered into the PVR software in g/cm^3 at reference temperature (always 60 °F with an enhanced core processor direct connect or with the 1000-2000 transmitter family).
- 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.

B.3.2 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 know the reference temperature that you plan to use (always 60 °F (15.6 °C) with an enhanced core processor direct connect or with the 1000-2000 transmitter family).

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.

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