Multiwell Supplement
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Micro Motion Model 5700 Transmitter Net Oil Calculations

Multiwell Supplement

MICRO MOTION

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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.

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.	0870 240 1978	Australia	800 158 727
Canada	+1 303-527-5200	The Netherlands	+31 (0) 704 136 666	New Zealand	099 128 804
Mexico	+41 (0) 41 7686 111	France	0800 917 901	India	800 440 1468
Argentina	+54 11 4837 7000	Germany	0800 182 5347	Pakistan	888 550 2682
Brazil	+55 15 3413 8000	Italy	8008 77334	China	+86 21 2892 9000
		Central & Eastern	+41 (0) 41 7686 111	Japan	+81 3 5769 6803
		Russia/CIS	+7 495 981 9811	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 manual

This manual explains how to understand, plan, configure, and use the Net Oil Calculations (NOC) application on a Model 5700 transmitter.

The information in this document assumes that users understand all corporate, local government, and national government safety standards and requirements that guard against injuries and death.

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:

- *Micro Motion Advanced Phase Measurement Application Manual*
- *Micro Motion Model 5700 Transmitters with Configurable Outputs: Configuration and Use Manual*
- *Micro Motion Model 5700 Transmitters with Configurable Outputs: Installation Manual*
- *Modbus Interface Tool*
- *Micro Motion ProLink III User Manual*
- Sensor installation manual

1.3 Overview of Model 5700 NOC tasks

Step	**Task**	Model 5700 NOC (multiwell) supplement (this manual)	Model 5700 installation manual	Model 5700 configuration and use manual
1	Install the Model 5700		✓	
2	Set up digital commmunications			✓
3	Start up the system	✓		
3	Configure security and language			✓
4	Configure system data			✓
5	Configure inputs			✓
6	Configure digital communications			✓
7	Configure the NOC application	✓		
8	Configure outputs	✓		✓
9	Configure NOC status alert severity	✓		✓
10	Perform optional configuration			✓
11	Run an NOC well test	✓		

Step	Task	Model 5700 NOC (multiwell) supplement (this manual)	Model 5700 installation manual	Model 5700 configuration and use manual
12	Perform NOC continuous measurement	✓		
13	Perform calibrations and meter verification			✓
14	Troubleshoot alerts	✓		✓

2 Planning

2.1 NOC overview

NOC is a software option that customers can purchase for the Model 5700 transmitter.

The NOC application can provide real-time measurements of water cut when paired with a Micro Motion sensor installed on either of the following options:

- The oil or water leg of a two-phase separator
- The oil leg of a three-phase separator

Alternatively, the NOC application can receive water cut data from an external water cut monitor. When the water cut value is known, net oil volume flow and net water volume flow can be calculated.

Net oil volume flow and net water volume flow can also be calculated by the Advanced Phase Measurement software from current density data.

All volume rates and totals are at line conditions, uncorrected, unless stated otherwise.

2.2 NOC terminology

Term	Definition
Actual	The flow rate as measured at the time of viewing.
Average	The flow-weighted average, calculated from the beginning of the applicable time period.
Back flow	Uncorrected volume flow that is moving backward through the sensor.
Density or density @ line	The density of the mixture, with no corrections applied.
Gross or gross @ ref	The sum of the oil volume and the water volume, as measured by the NOC application.
Net oil or net oil @ ref	Oil that is measured by volume, corrected to reference temperature, with the oil shrinkage factor applied.
Net water or net water @ ref	Water that is corrected to reference temperature, with the water shrinkage factor applied.
PV	Process Variable
Total	The rolling total, calculated from the beginning of the applicable time period.
Uncorrected gross or gross @ line	The raw volume flow measurement from the oil or oil and water leg.
Uncorrected oil or net oil @ line	Oil moving through the oil or oil and water leg that is measured by volume, with no corrections applied. Temperature correction and shrinkage factors are not applied.
Uncorrected water cut or water cut @ line	The percentage of water in a production stream that is at operating conditions.
Uncorrected water or net water @ line	Water moving through the oil or oil and water leg, measured by volume, with no corrections applied. Temperature correction and shrinkage factors are not applied.

Term	Definition
Water cut or water cut @ ref	The percentage of water in a production stream, corrected to reference temperature, with the water shrinkage factor applied.

2.3 NOC system components

The Model 5700 NOC system requires:

- One Model 5700 transmitter with the NOC software option
- One Micro Motion sensor installed on the oil and water, or oil leg
- (Optional) A water cut monitor on the oil and water, or oil leg

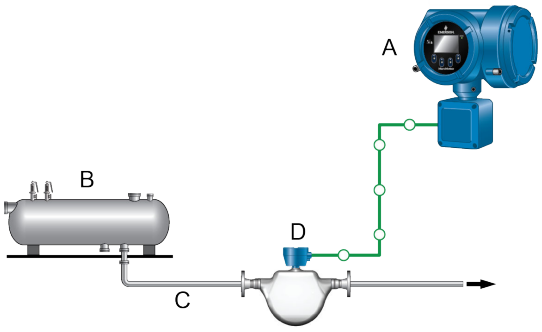
2.4 Installation architecture

You can install the Model 5700 NOC system with a two-phase separator, or a three-phase separator.

Note
The following examples do not illustrate all possible combinations.

NOC system with a two-phase separator

With a two-phase separator, the NOC system uses density-based water cut data.

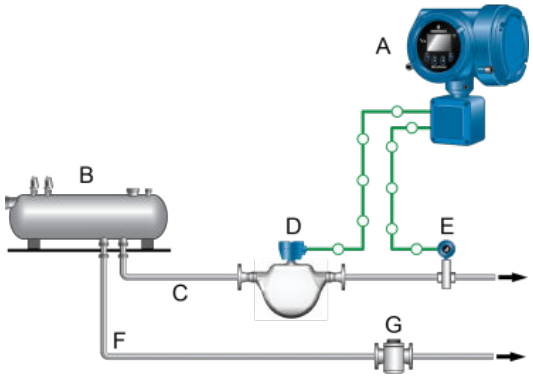


A. Model 5700 transmitter
B. Separator
C. Oil/water leg
D. Sensor

NOC system with a three-phase separator

With a three-phase separator:

- A meter is installed on the water leg, but the Model 5700 transmitter does not monitor or record flow data from this source.
- A water cut monitor is installed on the oil leg. The NOC system can be configured to use either density-based water cut data, or data from the water cut monitor.



A. Model 5700 transmitter
B. Separator
C. Oil leg
D. Sensor
E. (Optional) Water cut monitor
F. Water leg
G. Flowmeter for water

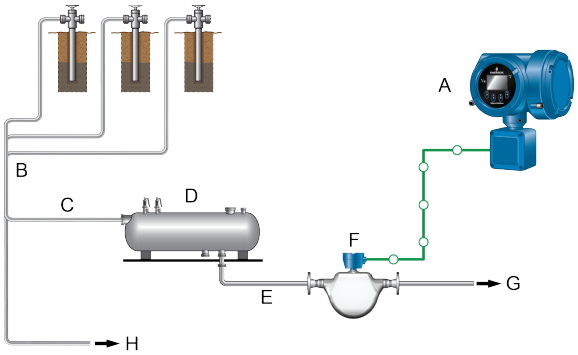
2.5 Operation modes

The NOC system operates in either well test mode or continuous mode.

You can change modes after initial configuration. However, changing modes affects current measurement and data collection.

Well test mode

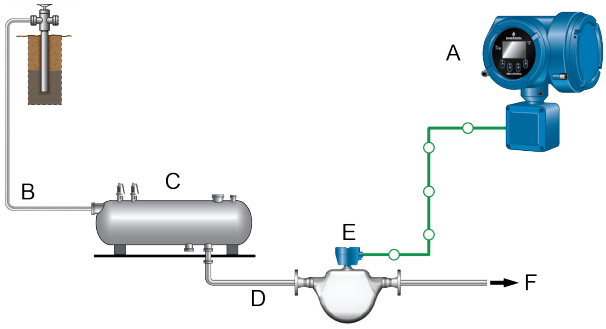
Well tests can be performed on up to 48 wells. A manifold system is used to ensure that output from a single well is routed through the test separator and the NOC system. The system can save data for a total of three well tests. If more than three tests are run, older tests are overwritten as required.



A. Model 5700 transmitter
B. Manifold
C. One well to test separator
D. Separator
E. Liquid leg
F. Sensor
G. To production separator
H. Other wells to production separator

Continuous mode

One well is measured continuously. The NOC system supplies current flow data, plus running averages and totals.



A. Model 5700 transmitter
B. From a single well
C. Separator
D. Liquid leg
E. Sensor
F. To production separator

2.6 Required well data

The following information is required for each well tested or measured by the NOC system:

- Density of dry oil from this well at reference temperature and reference pressure. To ensure the most accurate net oil data, the density should be based on live oil rather than dead oil. “Live oil” refers to crude oil at line pressure.
- Density of the water from this well, at reference temperature and reference pressure.

If you do not know the density values, do any of the following tasks:

- Take samples of produced oil and produced water, perform laboratory analysis, and enter the results into the well configuration.
- Perform an in-line density determination for oil, water, or both. During in-line density determination, the appropriate process fluid (water or live oil) is routed through the sensor, density values are averaged over a user-specified time period, and these values are converted to reference temperature. The water cut calculation uses these average values for D_O and D_W.
- Enter approximate values at initial configuration, begin measurement, and recalculate NOC data at a later time when well-specific density values are known.

2.7 Water cut determination

There are two options for determining water cut, density-based and water cut monitoring.

Density-based

The NOC application derives the water cut by applying the following equation:

$$Water\ cut = \frac{D_{Mix} - D_O}{D_W - D_O}$$

$\mathbf{D_{Mix}}$	Density of the oil, water, and gas mixture
$\mathbf{D_O}$	Density of produced oil (user-supplied value)
$\mathbf{D_W}$	Density of produced water (user-supplied value)

Water cut monitoring (external water cut)

A water cut monitor is used to measure the process stream directly. The Model 5700 transmitter retrieves the water cut data via a HART connection. A HART connection between the primary mA output on the NOC platform and the water cut monitor is required.

The Model 5700 can also use external water cut using an mA Input.

2.8 NOC features and options

This section describes several features and options of the NOC application.

2.8.1 Temperature correction

Temperature correction refers to the conversion of data collected at the observed process temperature to the equivalent values at reference temperature. The NOC application automatically applies temperature correction to NOC data, using the temperature data from the RTD built into the sensor.

2.8.2 Shrinkage factors

Shrinkage is a reduction in mass and volume of crude oil due to the vaporization and evaporation of the volatile components in the oil. By estimating the shrinkage during oil storage or transport, you can estimate sellable oil based on upstream volume measurement.

Note
The contraction of the volume due to cooling is not a mass loss. It is the thermal contraction of the oil accounted for by "temperature correction" via the Volume Correction Factors in API Ch 11.1.

The NOC application includes one shrinkage factor for oil. The net oil flow rate measured by the NOC application is automatically multiplied by the corresponding shrinkage factor and output on a separate PV. By default, the shrinkage factors are set to 1.0, resulting in no compensation for shrinkage.

Use your standard methods to determine the appropriate shrinkage factors, taking into consideration the location of the sensor in your process.

2.8.3 Liquid with gas

This measurement option improves flow measurement in liquid processes with intermittent entrained gas.

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

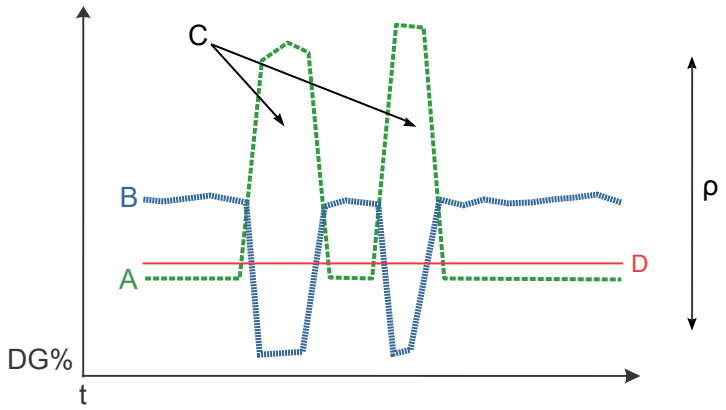
The presence of entrained gas (or bubbles) can cause significant errors when measuring the volume flow of liquid through a Coriolis meter. Because bubbles displace some of the liquid in a flow stream, the measured volume of the mixture may differ from the actual amount of liquid that emerges from the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

(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%.*

The Advanced Phase Measurement software with NOC 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.

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 Advanced Phase Measurement software with NOC 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.

The drive gain threshold can also be entered manually. For details about drive gain thresholds, see B-4 or B-5.

Production type options

Continuous Flow

Select this option only when flow rates are expected to be stable under normal operating conditions. The Advanced Phase Measurement software with NOC 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, or other variable processes. When variable flow is selected, APM will remediate only density and volume variables.

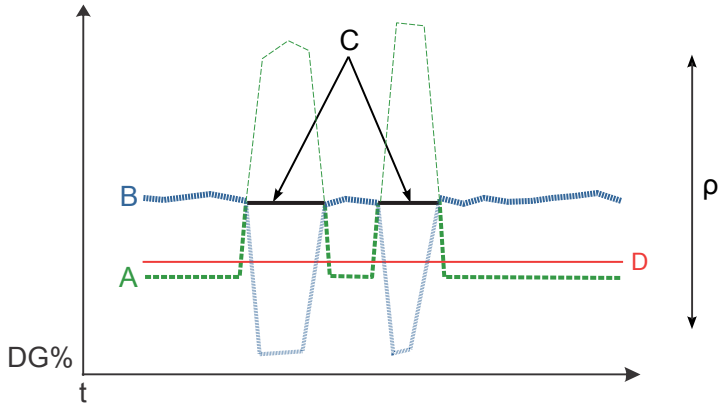
Remediation options (APM Action)

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.

2.9 Configuration checklist

This section contains questions that you should answer before beginning basic configuration of the Net Oil Computer Software and the NOC system.

Note
These questions are specific to implementing the NOC system and do not address basic system configuration (for example, configuring the clock, passwords, events, communications, etc.).

- Will this system be used to test multiple wells or to perform continuous measurement of a single well?
- If it will be used for well testing, what wells will be tested? in what order?
- Will you use density-based water cut data or a water cut monitor? If you are using a water cut monitor, what is its range?
- For all wells that will be measured:
  - What is the oil density at reference temperature? If not known, will you perform a density determination?
  - What is the water density at reference temperature? If not known, will you perform a density determination?
  - (For Well Test mode only) What is each well's purge time?
- Will you use HART communications for water cut data? If yes:
  - What are the HART tags of the external devices?
  - Is the primary mA Output wired to support HART communications with the external devices?
- If you will configure shrinkage factors, what values will you use?

3 Configure the NOC application

This section explains how to configure the NOC application and perform density determination procedures.

CAUTION

- Failure to perform configuration tasks in the proper sequence could result in an incomplete configuration. For the sequence, see Overview of Model 5700 NOC tasks.
- Do not change configuration during data collection. Changes made to the NOC configuration will affect NOC measurement. Changes made to other configuration parameters may affect NOC measurement.
- To ensure accurate NOC data, follow the instructions in Manage other activity during a well test or Manage other activity during continuous mode measurement to change configuration.

3.1 Basic configuration procedure

Use the following general steps to configure the NOC application.

Prerequisites

- You must have a valid NOC license on your transmitter.
  Go to **Menu** > **Service Tools** > **License Manager**.
- Make sure that API Referral is disabled.
  Go to **Menu** > **Configuration** > **Process Measurement** > **API Referral**.

Procedure

1. Go to **Menu** > **Configuration** > **Process Measurement** > **Adv Phase Measurement** > **Application Setup** > **Net Oil (NOC)** and save.
2. Go to **Menu** > **Configuration** > **Process Measurement** > **Well Perf Measurement**.
3. Set **Mode of Operation** to Continuous or Well Test.

Option	Description
Continuous	One well, separator, or pipeline is monitored continuously.
Well Test	A well test is performed on any of the wells on a manifold, up to 48 wells. Each well is configured independently and well test data is stored separately.

4. Set **Reference Temperature** to the reference temperature to be used by the NOC application.
5. If you are using continuous mode, go to **Well Data-Densities** and set the well parameters for the well being measured.
6. If you are using well test mode, go to **Well Data-Densities** and perform the following steps:
   a) Specify the well to configure.
   b) Assign a name to the well.
   c) Set the well parameters for the well being measured.

   See Well parameters.

7. Go to **Menu > Configuration > Process Measurement > Well Perf Measurement > External Inputs** to enable or disable use of a water cut monitor. If **Water Cut Monitor** is enabled, additional setup is required.

   See Set up a water cut monitor.

8. Go to **Menu > Configuration > Process Measurement > Well Perf Measurement > Compensations** to set the parameters.

Option	Description
APM Remediation	See Remediation options (APM Action).
Shrinkage Factors	See Shrinkage factors To disable shrinkage factors, set them to 1.0.
Contract Reset	If enabled, the NOC totals are reset when the contract time has ended. See the *Micro Motion Advanced Phase Measurement Application Manual*.

9. Optional: Configure mA Outputs, Discrete Outputs, or Frequency Outputs to report NOC data.

   For these procedures, see the *Micro Motion Model 5700 Transmitters with Configurable Outputs: Configuration and Use Manual*.

   - Assign the required process variable to the output. Available NOC process variables are listed in NOC process variable (PV) to output assignments.
   - Configure other output parameters as required.

10. Optional: Configure the severity level of the NOC status alerts.

    - For these procedures, see the *Micro Motion Model 5700 Transmitters with Configurable Outputs: Configuration and Use Manual*.
    - For a list of NOC status alerts, see Alerts.

11. Optional: Configure the process variables.

    For the procedures, see the *Micro Motion Model 5700 Transmitters with Configurable Outputs: Configuration and Use Manual*.

3.1.1 Well parameters

Parameter	Default	Description
Well Name	Well *xx* (where *xx* is the well number) For example, Well 05	A name that identifies this well. A name can contain a maximum of 16 characters, including spaces.
Oil Density @ Ref	0.8000 g/cm³ (800.000 kg/m³)	The oil density from this well at reference temperature. This parameter is required only if density-based water cut is used.
Water Density @ Ref	1.0000 g/cm³ (1,000.000 kg/m³)	The water density from this well at reference temperature. This parameter is required only if density-based water cut is used.

Parameter	Default	Description
Purge time	0 sec	(Well Test mode only) The measurement delay period after a well test has been started. Purge time allows the separator to displace any contents from the previous test.
Drive Deviation Limit	8%	The maximum acceptable Drive Gain during a water or oil density determination. If the drive gain is greater than the limit, the density determination may need to be rerun.
Oil Duration Ave	30 sec	The sample time, in seconds, for an oil density determination procedure.
Water Duration Ave	30 sec	The sample time, in seconds, for a water density determination procedure.
Mass Hold Value	0.0 g/cm³ (0 kg/m³)	Held mass flow value used during remediation.
Density Hold Value	0.0 g/cm³ (0 kg/m³)	Held density value used during remediation.
Vol Flow Hold Value	0.0 l/s	Held volume flow value used during remediation.
Current DG Threshold	30%	Above the threshold value, the measurement will be remediated in accordance with the configured Advanced Phase Measurement software settings.

3.1.2 NOC process variable (PV) to output assignments

NOC PV	Assignable outputs		
	DOs	mAs	FOs
APM event(1)	✓		
Average back flow rate		✓	
Average gross rate		✓	
Average net oil flow rate		✓	
Average net water cut		✓	
Average net water rate		✓	
Average uncorrected gross rate		✓	
Average uncorrected oil rate		✓	
Average uncorrected water cut		✓	
Average uncorrected water rate		✓	
Back flow rate		✓	✓
External water cut		✓	
Gross volume rate		✓	✓
Net oil flow rate		✓	✓
Net water cut		✓	
Net water flow rate		✓	✓
Uncorrected oil volume rate		✓	✓

NOC PV	Assignable outputs		
	DOs	mAs	FOs
Uncorrected water cut		✓	
Uncorrected water volume rate		✓	✓

(1) ON = Remediation active; OFF = Remediation inactive

3.2 Set up a water cut monitor

Use this procedure to configure a water cut monitor.

Procedure

1. Ensure that the water cut monitor is correctly installed, tested, and configured to report water cut data in %.
2. Enable the water cut monitor as an external input if you have not already done so.
   See Basic configuration procedure, Step 7.
3. Optional: To specify a value for an external water cut limit, go to **Menu > Configuration > Process Measurement > Well Perf Measurement > External Inputs**.
   When the measured water cut exceeds this value, an alert is posted.
   - Set this parameter to the highest value in your water cut monitor's range.
   - Disable this alert by setting the value to 100%.
4. Set up a HART polling connection between the Model 5700 device and the water cut monitor.
   a) Ensure that the primary mA Output has been wired to support HART protocol, and that the mAO has a HART connection to the water cut monitor.
      You can also use the mA Input.
   b) Go to **Menu > Configuration > Process Measurement > Well Perf Measurement > External Inputs > Temperature > External Temperature**.
   c) Select **Polling Variable 1** or **Polling Variable 2**.
   d) Set **Polling Control** to **Poll as Primary** or **Poll as Secondary**.
   e) Go to **Menu > Configuration > Inputs/Outputs > Channel A > HART Settings > Poll External Device**.
   f) Specify the device to be polled in **Watercut @ Line**.
5. Verify that water cut data is being received by viewing the current water cut value in either well test mode or continuous mode. Ensure that the displayed value matches the value sent by the water cut monitor.

3.3 Set up Transient Bubble Remediation

Procedure

1. Go to **Menu > Configuration > Process Measurement > Well Performance Meas > Compensations**.
2. Set **Remediation Action** to 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.
3. Optional: Configure a Discrete Output to report APM status.

   See Basic configuration procedure.

3.4 Density determination

If you are performing a density determination for oil and for water, it is more convenient to perform density determination for water first.

At any point during the procedures in this section, you can discard the data and stop the density determination process by selecting **Cancel** or by navigating left to return to other functions.

3.4.1 Density determination for water

There are two density determination methods for water: in-line and manual. This section provides instructions for both methods.

The in-line method requires enough water in the separator to supply a stable flowing density for the density determination period.

If there is not enough water, use the manual method.

Perform in-line density determination for water

Procedure

1. Stop all well tests currently running.
2. Make sure that water is flowing through the sensor.

   You might need to close the outlet valve and the inlet valve from the separator and wait for the phases to settle, then open the outlet valve.
3. Go to **Menu > Service Tools > Verification & Calibration > Density Determination > Water Density > Measure and Save**.
4. You are prompted to select a well.
   The current values for water density, water temperature, volume total, flow rate, drive deviation, pressure (if enabled), and water duration are displayed.

   Note
   The **Drive Deviation** and **Water Duration** values are read-only. To change them, reconfigure the well data. See Basic configuration procedure.
5. Monitor the density and temperature values, watching for the density and temperature readings to stabilize.

6. Optional: Highlight **Volume Total Reset** and navigate to the right to reset the volume total to 0. Select **Continue** to confirm resetting the volume total.

   This enables you to monitor the amount of fluid that remains in the separator, if the separator liquid volume is known.

7. When the density and temperature readings have stabilized, select **Start**.
   The NOC application will average the density and temperature of the process fluid for the duration set by the **Water Duration** value for the well. When a water density determination (DD) is running, the averaging screen shows the DD progress indicating percentage complete, drive gain, density, volume, and temperature. After 100%, the screen will show one of the following screens:

Deviation Limit Exceeded	The deviation was exceeded. This screen displays the maximum drive deviation during the averaging process and the current drive deviation limit. If the **Deviation Limit Exceeded** screen displays, you might need to stabilize the process fluid or increase the **Drive Deviation** value.
Averaging Complete Save	The density and temperature averaging is complete.

8. When the averaging process is complete, you can can save or discard the data (cancel).

   A save will replace the stored value with the new value.

Manual density determination for water

Procedure

1. Stop all well tests currently running.
2. Fill the separator with production fluid from the well that will be tested, and let the phases settle.
3. Take a water sample from the bottom of the water layer or from the water trap.
4. Cover the sample container and allow the sample to cool to near-ambient temperature.
5. Measure the density and temperature of the sample using a hygrometer and a thermometer.
6. Go to **Menu** > **Service Tools** > **Verification & Calibration** > **Density Determination**
7. In well test mode, select the appropriate well.
8. From the last density determination timestamp screen, navigate right, then select **Water Density** > **Manually Enter**.
9. Enter the density of the water sample in the units shown on the **Entry** screen.
10. Enter the temperature of the water sample in the units shown on the screen.
11. Select **Calculate at Ref**, then navigate right.
    The NOC application converts the observed water density to water density at reference temperature. The stored value for water density at reference temperature displays, as well as the date and time at which this value was stored.
12. You can can save or discard the data (cancel).

    A save will replace the stored value with the new value.

3.4.2 Perform in-line density determination for oil

Procedure

1. Stop all well tests currently running.
2. Ensure that oil is flowing through the sensor.
   You might need to drain water from the separator.
3. Go to **Menu** > **Service Tools** > **Verification & Calibration** > **Density Determination**
4. In well test mode, select the appropriate well.
5. After the last density determination timestamp screen, select **Oil Density**.
   The current values for oil density, oil temperature, pressure (if enabled), water cut (if enabled), volume total, flow rate, drive deviation, and oil duration are displayed.

   Note
   The **Drive Deviation** and **Oil Duration** values are read-only. To change them, reconfigure the well data. See Basic configuration procedure.

6. Monitor the density and temperature values, watching for the density and temperature readings to stabilize.
7. Optional: Highlight **Volume Total Reset** and navigate to the right. If you reset this total when the separator first started to flow, i.e. when you were doing the water density determination, you can monitor the amount of fluid to reset the volume total to 0. Select **Continue** to confirm resetting the volume total.This enables you to monitor the amount of fluid that remains in the separator, if the separator volume is known.
8. When the density and temperature readings have stabilized, highlight **Start** and navigate to the right.
   The NOC application will now average the density and temperature of the process fluid for the specified oil averaging duration. If the drive gain exceeds the limit, then the **Oil Deviation Limit Exceeded** screen displays. From this screen, you have the option to continue the save process or discard the data and restart the density determination process.

   Note
   If the **Oil Deviation Limit Exceeded** displays, you might need to stabilize your process fluid or increase the **Drive Deviation** value.

9. If you are using the density-based water cut, take a sample of the fluid in the pipe during this averaging period, then measure the sample water cut. You can use any standard procedure, such as centrifuge, distillation, Karl-Fischer, etc., to measure the water cut. Measure in % volume.

   If you are using a water cut monitor, this sampling procedure is optional. You can use either the water cut data measured by the monitor or water cut data from the sample.

   Important
   The accuracy of the water cut value directly affects the accuracy of the NOC data. Use a representative sample and measure carefully. Some medium and light oil samples may have negligible entrained water.

10. When the averaging process is complete, you can can save or discard the data (cancel). Select **Continue** to confirm resetting the volume total.

    A save will replace the stored value with the new value.

11. Is water cut monitor enabled or disabled?

Option	Description
If enabled	Water cut data from the averaging period displays. a. Select **Continue**. The reference density of dry oil from the density determination will be computed and displayed along with the current values. b. Select **Save** to replace the stored value with the new value. If you are using a water cut monitor and you saved the average water cut and the reference density of oil, the density determination procedure is complete. However, you can still enter a manual water cut value and apply it as described in the following steps.
If disabled	Enter the water cut manually, select **OK** and go to Step 12

12. Select **Enter Watercut**.
    The date and time of the current density determination procedure displays.
13. Enter the water cut you measured in Step 9, then select **Hold to Save**.
14. Highlight **Calculate at Ref** and navigate to the right.
    The NOC application uses this water cut data to convert the observed oil density to dry oil density at reference temperature. The stored value for oil density at reference temperature displays, as well as the date and time at which this value was stored.
15. You can save or discard the data (cancel).

4 Perform a well test

This section explains how to use the NOC application to run a well test.

A well test must be started and stopped manually or through a Modbus command.

Well tests are identified by the well name and by the start date and time. You can save up to three well tests. If you run additional well tests, each new well test will overwrite the oldest well test.

4.1 Run a well test

Prerequisites

Ensure that the NOC application is set for well test mode, and that all necessary data for the well has been configured.

Procedure

1. Go to **Menu** > **Operations** > **Well Performance Meas** > **Well Test Mode**.
2. Select **Start Well Test**.
3. Navigate to the well you want tested.
4. Highlight **Start Well Test** and navigate right to begin the test.

   During the well test you can:

   - Select **Actual** to see current test data.
   - Select **View Production Meas** to view more detailed data on the current test.

   The well test screen displays, showing the test start time and the elapsed time.
5. Select **Stop Test** to end the well test.
   The final well test values are automatically written to memory.
6. To run another test, return to Step 2.

4.2 View well test data

You can view well test data at several points from the display.

You can also read well test data through the Modbus interface, or report actual and average process variables by assigning them to an mA Output or Frequency Output.

Procedure

Choose one of the following options:

Option	Description
To access basic data for the current well test	If running, select **Actual** or **View Production Meas**.
To access more detailed data for either the current test or a stored test	• To view stored tests, choose **Operations** > **Well Performance Meas** > **Well Test Mode**

Option	Description
	• To view archives, choose **View Well Tests** from the **View Well Tests** screen.

4.2.1 Well test mode display values

Process variable	Definition
Actual density	The current density of the production fluid.
Actual gross rate	The current flow rate of the production fluid (all process fluid through the NOC sensor).
Actual net oil rate	The current net oil flow rate.
Actual temperature	The current temperature of the production fluid.
Actual water cut	The current water cut used in net oil calculations that may be either density-based or from the water cut monitor, depending on the water cut configuration.
Average density	The average density, calculated from the beginning of the well test.
Average gross rate	The average flow rate of the production fluid (all process fluid through the NOC sensor).
Average gross rate	The average flow rate of production fluid, calculated from the beginning of the well test. This rate: • May or may not include TMR carry-over data, depending on the TMR configuration • Does not include gas data
Average net oil rate	The average net oil flow rate, calculated from the beginning of the well test.
Average net oil rate	The average net oil flow rate, calculated from the beginning of the test. The current net oil flow rate may or may not include oil carry-over, depending on TMR configuration.
Average temperature	The average temperature, calculated from the beginning of the well test.
Average water cut	The average water cut value, calculated from the beginning of the well test.
Average water cut	The average water cut value, calculated from the beginning of the well test.
Gross total	Total production fluid, by volume, calculated from the beginning of the well test.
Net oil total	The total net oil, by volume, calculated from the beginning of the well test.
Remediation	The hours and minutes that remediation has been active
Test started	The date and time that the well test was started.
Test time elapsed	The hours and minutes that the well test has been running.
Water cut overrange	(Water cut monitor only) The hours and minutes that the water cut has been above the configured **External Water Cut Limit**.

4.2.2 Well test mode: production data

For the current test, running average, minimum, maximum, and total values for each process variable are calculated from the beginning of the test. When the well test stops, the final values are stored with the test data.

Process variable	Actual	Avg	Min	Min time/ date	Max	Max time/ date	Total
Net oil	✓	✓	✓	✓	✓	✓	✓
Water cut	✓	✓	✓	✓	✓	✓	
Gross flow	✓	✓	✓	✓	✓	✓	
Net water	✓	✓	✓	✓	✓	✓	
Drive gain	✓	✓			✓	✓	
Density	✓	✓	✓	✓	✓	✓	
Temperature	✓	✓	✓	✓	✓	✓	
Back flow	✓				✓	✓	✓
Mass flow	✓	✓	✓	✓	✓	✓	✓
Uncorrected oil flow	✓	✓	✓	✓	✓	✓	✓
Uncorrected water flow	✓	✓	✓	✓	✓	✓	✓
Uncorrected water cut	✓	✓	✓	✓	✓	✓	
Uncorrected gross	✓	✓	✓	✓	✓	✓	✓
Time test started	*Timestamp*						
Time test elapsed	*Hours and minutes*						
Time of TBR	*Hours and minutes*						
Time of water cut overrange	*Hours and minutes*						

4.3 Well test time periods

For the current test, running average, minimum, maximum, and total values for each process variable are calculated from the beginning of the test. When the well test is stopped, the final values will be stored with the test data.

4.4 Manage other activity during a well test

Certain actions, such as reconfiguring well data, will cause discontinuities in the well test data and will interfere with data collection. If you need to change system configuration or perform a maintenance procedure, perform this procedure before doing so.

Procedure

1. Stop the well test.
2. Make the required configuration changes or perform the required procedures.
3. Start a new well test.

5 Perform continuous measurement

5.1 About continuous mode measurement

In continuous mode, measurement begins as soon as the system is up and running, or as soon as the system is configured for continuous mode measurement.

You cannot start and stop continuous mode measurement. However, you can:

- Pause and resume measurement
- View current data
- Reset the start time for summary variables
- Write archive records that summarize well production from the beginning of the continuous mode time period up to the point the record is written
- View archive records

5.2 View continuous mode measurement data

Use this procedure to view continuous mode measurement data from the Model 5700 display. As an alternative, you can read continuous mode measurement data from the Modbus interface, or report actual and average process variables (PVs) by assigning them to an mA Output or Frequency Output.

Procedure

Choose one of the following options:

Option	Description
To access basic data for the current well test	**Menu > Operations > Well Performance Meas > Continuous > Quick View**
To access more detailed data for either the current test or a stored test	**Menu > Operations > Well Performance Meas > Continuous > View Production Measures**

5.2.1 Continuous mode: quick view

Process variable	Definition
Average/total since	Timestamp for the beginning of continuous mode measurement or the last Reset All.
Average gross rate	Average flow rate of production fluid, calculated from the beginning of the continuous mode measurement or from the last reset.
Average net oil rate	Average net oil flow rate, calculated from the beginning of continuous mode measurement or from the last reset.
Average water cut	Average water cut value, calculated from the beginning of the continuous mode measurement or from the last reset.
Gross total	Total production fluid, by volume, calculated from the beginning of the continuous mode measurement or from the last reset.

Process variable	Definition
Net oil total	Total net oil, by volume, calculated from the beginning of the continuous mode measurement or from the last reset.
Remediation	Hours and minutes that remediation has been active.
Test time elapsed	Hous and minutes since this continuous mode measurement period was started.
Total paused time	Hours and minutes that measurement has been paused.
Water cut overrange	(Water cut monitor only) Hours and minutes that the water cut has been above the configured **External Water Cut Limit**.

5.2.2 Continuous mode: production data

Process variable	Actual	Avg	Min	Min time/ date	Max	Max time/ date	Total	Reset time/ date	Inv
Net oil	✓	✓	✓	✓	✓	✓	✓	✓	✓
Water cut	✓	✓	✓	✓	✓	✓		✓	
Gross flow	✓	✓	✓	✓	✓	✓	✓	✓	✓
Net water	✓	✓	✓	✓	✓	✓	✓	✓	✓
Drive gain	✓	✓			✓	✓		✓	
Density	✓	✓	✓	✓	✓	✓		✓	
Temperature	✓	✓	✓	✓	✓	✓			
Back flow	✓				✓	✓	✓	✓	✓
Mass flow	✓	✓	✓	✓	✓	✓	✓	✓	✓
Uncorrected oil flow	✓	✓	✓	✓	✓	✓	✓	✓	✓
Uncorrected water flow	✓	✓	✓	✓	✓	✓	✓	✓	✓
Uncorrected water cut	✓	✓	✓	✓	✓	✓		✓	
Uncorrected gross	✓	✓	✓	✓	✓	✓	✓	✓	✓

5.3 Pause and resume continuous mode measurement

While measurement is paused, no data is collected, displayed, or stored. Average, minimum, maximum, total, and inventory values are not updated.

You can pause and resume measurement as often as you like.

Procedure

Go to **Menu** > **Operations** > **Well Performance Meas** > **Continuous Mode** > **Pause/Resume**.

5.4 Access view data from continuous measurement screen

Procedure

From the **Continuous Mode** screen, select **View Production Meas** or **Quick View**.

5.5 Access configuration screens from continuous measurement

To prevent data discontinuities, use this procedure to access configuration screens from the continuous measurement screens.

At any point from the continuous measurement screens, you can access the configuration and maintenance menus. The system will not prevent configuration changes, calibrations, or other procedures during continuous measurement. However, many actions can cause discontinuities in the data, and many procedures will interfere with data collection.

Procedure

1. Pause measurement.
2. If required, save an archive record.
3. Make the required configuration changes or perform the required procedures.
4. Reset all process variables (PVs).
5. Resume measurement.

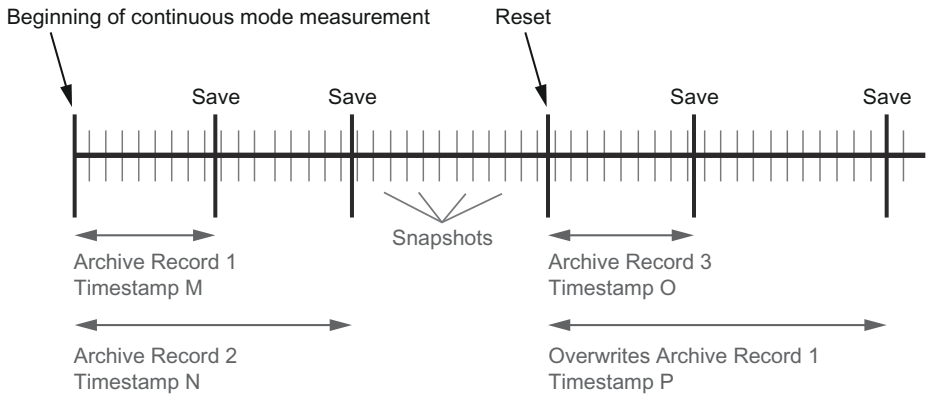
5.6 Continuous mode time periods

You can view, reset, save, and archive continuous mode time periods.

Running average, minimum, maximum, and total values are calculated from the beginning of continuous mode measurement.

The following figure explains the relationship between Save, Reset, snapshots, and archive records.

Figure 5-1: Continuous mode timeline and time periods



5.6.1 Reset continuous mode time periods

Procedure

Choose one of the following options:

Option	Description
Set a new start time for one PV	a. Go to **Menu** > **Operations** > **Well Performance Meas** > **Continuous Mode** > **View Production Meas**. b. Select the PV. c. Press **Reset**. d. Navigate right, then select **Yes** on the reset confirmation screen. Not all PVs can be reset individually. If **Reset** does not display, the system does not allow an individual reset for that PV.
Set a new start time for all PVs	a. Go to **Menu** > **Operations** > **Well Performance Meas** > **Continuous Mode** > **Reset**. b. Follow the prompts.

5.6.2 Archive records

At any time during continuous mode measurement, you can save the current values of the summary variables to an archive record. The archive record is then available for viewing.

Archive records:

- Are identified by a timestamp
- Can be saved for up to three archives

5.6.3 View archive records

Procedure

1. Go to **Menu** > **Operations** > **Well Performance Meas** > **Continuous** > **View Archive**.
2. Specify the archive record you want to view.
3. Select the specific PV you want to view.

5.6.4 Save to an archive record

Use this procedure to save the current values of the summary variables to an archive record.

Procedure

1. Go to **Menu** > **Operations** > **Well Performance Meas** > **Continuous Mode**.
2. Select **SAVE**.

5.7 Manage other activity during continuous mode measurement

Certain actions, such as reconfiguring well data, will cause discontinuities in the data and will interfere with data collection. If you need to change system configuration or perform a maintenance procedure, perform this procedure before doing so.

Procedure

1. Go to **Menu** > **Operations** > **Well Performance Meas** > **Continuous Mode**.
2. Pause measurement.
3. Optional: Save an archive record.
4. Make the required configuration changes or perform the required procedures.
5. Reset all process variables.
6. Resume measurement.

6 Change modes

Changing from well test mode to continuous mode, or from continuous mode to well test mode, affects current measurement and data collection. To change modes, follow the instructions in this section.

6.1 Change to continuous mode

Use this procedure to change from well test mode to continuous mode.

If a well test is running, it will be stopped automatically when the mode is changed.

Procedure

1. Record all required well test data to an external system.
   Well test data will be unavailable from the display while the system is in continuous mode.
2. Go to **Menu** > **Configuration** > **Process Measurement** > **Well Perf Measurement**.
3. Change **Mode of Operation** to **Continuous Mode**.

6.2 Change to well test mode

Use this procedure to change from continuous mode to well test mode.

Procedure

1. If required, save an archive record.
   See Save to an archive record.
2. Record all required well test data to an external system.
   Continuous mode data will be unavailable from the display while the system is in well test mode.
3. Go to **Menu** > **Configuration** > **Process Measurement** > **Well Perf Measurement**.
4. Change **Mode of Operation** to **Well Test Mode**.

7 NOC alerts

This section provides information on the status alerts associated with the NOC application. For information on all other Model 5700 alerts, see the *Micro Motion Model 5700 Transmitters with Configurable Outputs: Configuration and Use Manual*.

Alert	Cause
A136	NOC Power Off
A137	Measurements Paused
A138	APM Remediation
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 alerts default to Info
- No alerts are affected by fault timeout

A Differences between Series 3000 and Model 5700 NOC Modbus registers

Register	Name	Series 3000	Model 5700
1657	Gross Volume Total	Total	Inventory
1659	Mass Total	Total	Inventory
1661	Net Oil Volume Total	Total	Inventory
1663	Net Water Volume Total	Total	Inventory
1665	Uncorrected Oil Volume Total	Total	Inventory
1667	Back Flow Volume Total	Total	Inventory
1669	Back Flow Volume Total	Total	Inventory
1671	Uncorrected Gross Volume Total	Total	Inventory
1673	Gas Volume Total	Total	Inventory
2327	Gross Volume Inventory	Inventory	Total
2329	NOC Mass Inventory	Inventory	Total
2331	Net Oil Volume Inventory	Inventory	Total
2333	Net Water Volume Inventory	Inventory	Total
2335	Uncorrected Oil Volume Inventory	Inventory	Total
2337	Uncorrected Water Volume Inventory	Inventory	Total
2339	Back Flow Volume Inventory (uncorrected)	Inventory	Total
2341	Uncorrected Gross Volume Inventory	Inventory	Total
2343	Gas Volume Inventory (Gas Meter)	Inventory	Total

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