Unico Net Oil Computer Addendum

TRICOR
Coriolis Mass Flow Meter

Manual-Version
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Manual-Revision: 001
Unico Software Number: 806675.000

SW-Version
This Manual is valid for:
Main SW: V25U2 and higher
Display SW: V24U1 and higher

1 General Information

This document is an addendum to the TRICOR Coriolis Mass Flow Meter documentation. In this document, the functionality of the Unico Net Oil Computer (NOC) is explained and defined.

1.1 Measuring Principle TCM

As has been established in the TRICOR Coriolis Mass Flow Meter documentation, there are two parallel flow tubes inside the TCM flow meter. The two tubes vibrate at their resonant frequency in opposite directions. Any mass flow passing through the tubes will delay the vibration at the incoming side (flow towards the central axis), and accelerate the vibration at the outgoing side (away from the central axis). This causes a small time delay between the two ends of the tube. This time delay is measured and used to calculate the mass flow through the tubes.

By measuring the resonant frequency of the tubes the mass of the medium and—given a constant volume inside the tubes—the specific gravity of the medium can be calculated. As both of these effects are temperature dependent, the temperature is measured via a precise sensor for correcting the temperature effects of flow and density measurement.

As a consequence a Coriolis mass flow meter directly measures three properties of the fluid passing through it:
- Mass flow
- Density
- Temperature

Knowing the mass flow and the density, the volume flow can be calculated.

With the addition of the Unico net oil computer (NOC) functionality, the measured density can be used to determine the proportion of oil and water in the fluid passing through the meter. To do this, the densities of both the oil and water must be known. Suppose, for example, the density of water in the fluid is 1.0 g/cm^3 and the density of oil in the fluid is 0.8 g/cm^3. If the density of the fluid is measured to be 0.9 g/cm^3, then we know that it is composed of half water and half oil. As the density of the oil approaches that of water, the inaccuracy of the Unico NOC will increase because any inaccuracy of the density measurement becomes magnified. This is illustrated in the following graph of Oil Cut Accuracy vs. Oil Density.

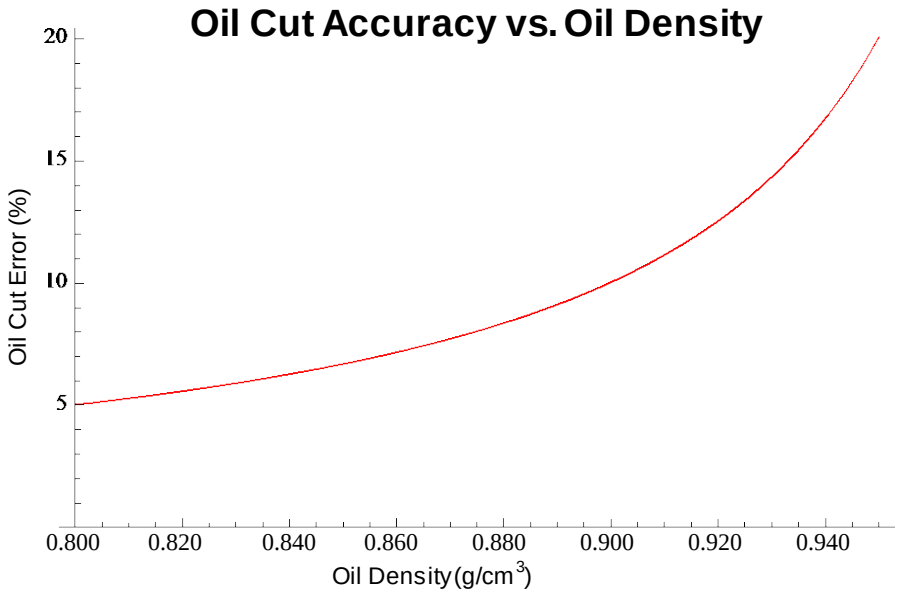


Fig. 1: Plot of the percent error in the oil cut vs. the density of oil, based on the ± 0.001 g/cm^3 accuracy of the meter's density measurement. This graph assumes a 10% oil cut with water density equal to 1.0 g/cm^3 and no free gas present. As the difference between the oil and water density decreases the error increases.

Another property that affects the accuracy of the Unico NOC is the oil cut (percentage of the oil) in the fluid. The smaller the oil cut, the greater the resultant error as shown in the following graph.

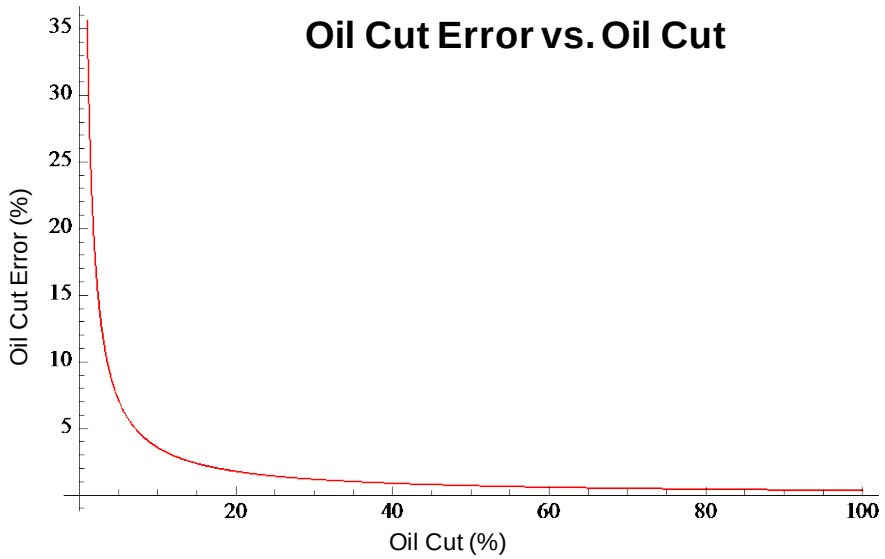


Fig. 2: Plot of the percent error in the oil cut vs. the actual oil cut, based on the ± 0.001 g/cm^3 accuracy of the meter's density measurement. This graph assumes oil density equals 0.823 g/cm^3, water density equals 1.105 g/cm^3 and there is no free gas present.

As oil is brought from the formation up to the surface and the pressure on the fluid decreases, it is normal for gas to come out of solution. This free gas should be removed from the fluid before sending it through the Coriolis meter. Normally, this task is performed by a gas separator. As the amount of free gas in the fluid increases, so does the oil cut error as demonstrated in the graph that follows.

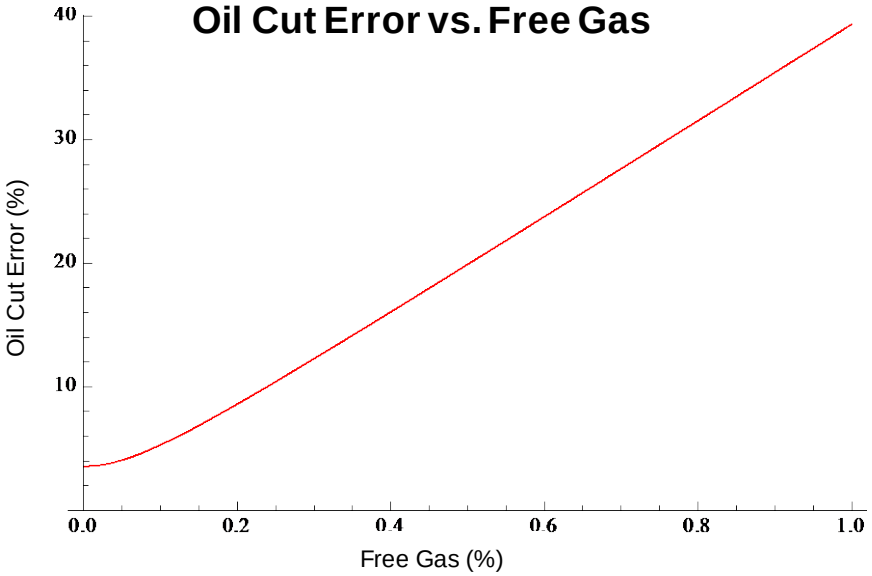


Fig. 3: Plot of the percent error in the oil cut vs. the percent of the fluid volume occupied by free gas (0 – 1% free gas). This graph assumes a 10 % oil cut with oil density equal to 0.823 g/cm^3 and water density equal to 1.105 g/cm^3.

In addition to the oil and water cuts (percentages), the Unico NOC also calculates:

- Fluid, oil and water flow rates at the ambient temperature and pressure
- Daily totals for fluid, oil and water at the ambient temperature and pressure
- Fluid, oil and water flow rates at the reference temperature (60 °F) and pressure
- Daily totals for fluid, oil and water at the reference temperature (60 °F) and pressure

1.2 Meter Mode

The meter can be configured to measure fluids in terms of either mass or volume. For measuring in terms of mass, set the "meter mode" parameter to "MASS MODE." To measure the volume of natural gas passing through the meter, set the "meter mode" parameter to "REF. VOLUME." In this mode the volume of gas will be calculated at the reference temperature and pressure. To measure the oil content in a fluid containing both water and oil, set the "meter mode" parameter to "NET OIL." This addendum assumes that either the "REF. VOLUME" or the "NET OIL" modes are being used*.

Value	Total units	Flow rate units
MASS MODE	Mass	mass/time
AMB. VOLUME	Volume	volume/time
REF. VOLUME*	volume at 60 °F	volume/time at 60 °F and 1 atm
NET OIL*	volume at ambient as well as at 60 °F	volume/time at ambient as well as at 60 °F and 1 atm

1.3 Data Update Time Periods

In the Unico NOC, there are three time period categories that the data parameters can be divided into, that is, three different time periods over which the parameter's value applies.

Tube Vibration Cycle
The data associated with the shortest time period are calculated each tube vibration cycle, roughly once every 7 milliseconds. These data are subject to filtering by the "flow filter" time constant (see the TRICOR Coriolis Mass Flow Meter document). Each of these parameters has the phrase "updated very tube vibration cycle" in the parameter definition.

Data Update Period
The next shortest time period is determined by the value of the "data update period" setup parameter. This time period is typically set somewhere between 10 seconds and several minutes by the user.

Gauge Data
The longest time period, referred to as a gauge event, is determined by the user's activation of the "gauge data request" parameter, typically once per day. These parameters have the word "gauge" in their name.

1.4 Multiphase Flow Compensation

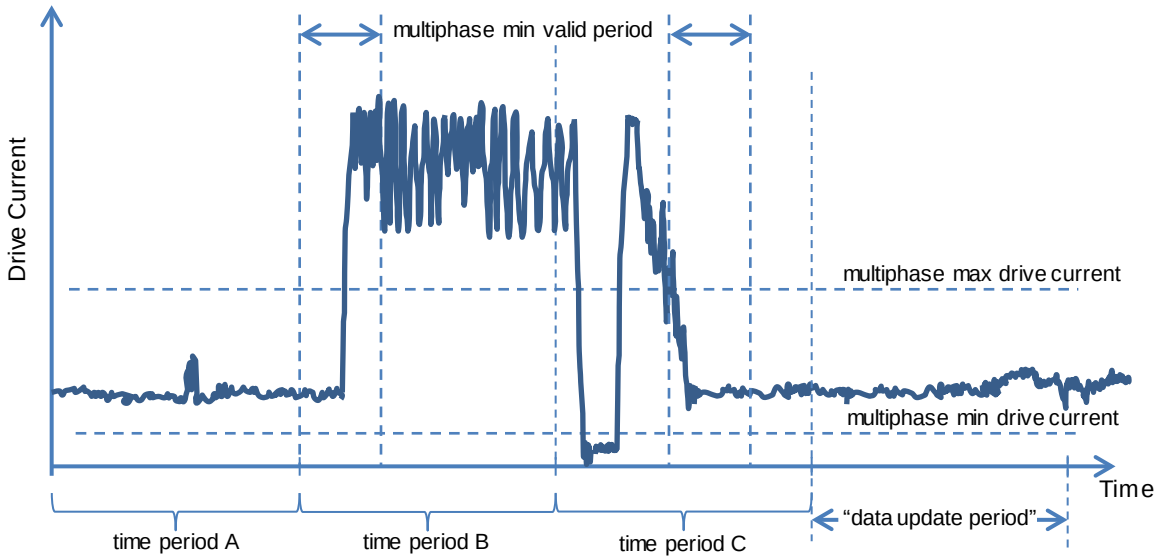
Measuring fluids that contain free gas (or measuring gas that contains entrained fluid) can sometimes result in periods where the amount of the contaminant is enough to spoil the data. For example, gas bubbles present in vibrating tubes that otherwise contain oil and water dissipate the energy of vibration. Generally, the greater the number of gas bubbles in the meter the greater the drive current required to keep the tubes vibrating. Also, when the amount of the contaminant (the gas in liquid, or the liquid in gas) becomes excessive, the drive current required to keep the tubes vibrating may exceed the capability of the meter whereupon the drive current may go to zero.

It is possible to filter out the periods containing bad data by judicious use of these parameters:

- Multiphase comp. mode
- Multiphase max drive current
- Multiphase min drive current
- Data update period
- Multiphase min valid period

The multiphase compensation feature functions whether the meter mode has been set to “NET OIL” or “REF. VOLUME.” Either way, the “multiphase comp. mode” parameter must be set to “COMP. ON.” Choose values for “multiphase max drive current” and “multiphase min drive current” such that when the drive current is outside of the limits established by the values of these parameters, it indicates that the meter is not properly measuring the flow. The values chosen for the “data update period” and “multiphase min valid period” parameters are more subjective. An examination of the characteristics of the drive current while the well fluid is traveling through the meter may reveal clues as to how best to set these time period parameters.

When the multiphase compensation feature is functioning, there are two slightly different cases in which good data is used to supplant bad data in the Unico NOC, (1) within a single “data update period,” and (2) from a valid “data update period” to an invalid one. In the first case, a valid mean density value (or, in the case of gas measurement, a valid mean flow rate) calculated from data collected during a single “data update period” that satisfies the “multiphase min valid period” constraint, is used to replace bad data within the same time period. In the second case, all the data collected from one “data update period” are discarded because there were not enough valid data within that time period to satisfy the “multiphase min valid period” constraint.



For example, in the graph above, the time axis is divided into four time periods equal to the value of the “data update period” parameter. The value for the “data update period” was chosen to nicely fit the example data. During time period A, the drive current does not go beyond the constraints of the chosen min and max drive current settings, so time period A is considered by the meter to be 100% valid. During time period B however, the drive current does not remain within the limits set by the min and max drive current settings for a time period exceeding the “multiphase min valid period” setup, so the mean density from time period A is used when calculating flow data in time period B. In time period C, the drive current is within the min and max drive current settings for a period greater than that described by the “multiphase min valid data” parameter, so the mean density (or, in the case of gas measurement, a

valid mean flow rate) calculated from the valid portions of time period C is used throughout the entirety of time period C.

1.5 Daily Gauge

The daily totals are referred to as “gauged” values. On the meter itself, the gauged values must be triggered manually by writing to the “gauge data request” parameter. This is referred to as a gauge event. The accumulators that get latched into the gauge parameters are:

- Fluid volume accumulator
- Oil volume accumulator
- Water volume accumulator
- Fluid volume accumulator ref
- Oil volume accumulator ref
- Water volume accumulator ref

The gauge parameters are:

- Gauged fluid volume
- Gauged oil volume
- Gauged water volume
- Gauged fluid volume ref
- Gauged oil volume ref
- Gauged water volume ref

Note: if a Unico Dual Phase Flow (DPF™) gateway box is used to communicate with the meter, the gauge values can be automatically calculated once every 24 hours or can be triggered manually with either a pushbutton input or by enabling a setup parameter in the gateway.

1.6 Simulator

The simulator is useful when testing communications with another device. Fluid flow can be simulated in the meter so that when flow and accumulator values are read serially, the meter sends back realistic data rather than zeroes. When the “simulation mode” is set to “ENABLE,” and the “meter mode” parameter is set to either “REF. VOLUME” mode or “NET OIL” mode, then the meter reads the fluid temperature, fluid density, fluid flow rate and drive current from the simulation setups rather than from the meter’s hardware. The simulation setups are:

- Simulation mode
- Simulation fluid temperature
- Simulation fluid flow rate
- Simulation fluid density
- Simulation drive current
- Simulation fluid pressure

1.7 Unico NOC Setup

A few setup parameters are necessary for the Unico NOC to determine the oil and water cuts (percentages) in the fluid. First, if the “meter mode” is not already set to “NET OIL” contact either Unico or AW Lake for the proper activation code, then enter the values for the water density and oil density reference temperature setups. This can be done on the meter display or by using the TRICOR Configurator application program for Windows.

On the meter display, the sequence of screens to reach the reference temperature and density setups is SETUP / PARAMETER / METER MODE / NET OIL. In the section entitled “METER MODE menu”, the TRICOR Coriolis Mass Flow Meter Manual, to which this Addendum belongs, explains how to progress to the “meter mode” parameter.

The following submenus are available:

OIL DENSITY REF.:
"Oil density ref." is the setup parameter for oil density when it is measured at atmospheric pressure and 60 °F.

WATER DENSITY REF.:
"Water density ref." is the setup parameter for water density when it is measured at atmospheric pressure and 60 °F.

DATA UPDATE PERIOD:
The "data update period" setup determines the length of time between updates of the Unico NOC readouts.

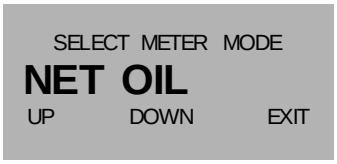
Select "meter mode" on the parameter menu

Possible "meter mode" selections are:

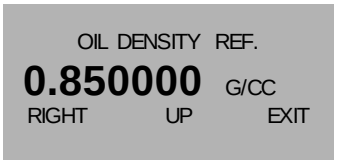
MASS METER
AMB. VOLUME
REF. VOLUME
NET OIL

This addendum assumes that either the "REF. VOLUME" or "NET OIL" selections are used. The Net Oil mode must be activated—normally done at the factory—for the meter to accept the "NET OIL" selection.

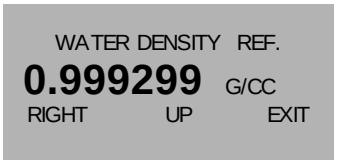
If the meter mode has been set to "NET OIL", pressing "P" will display the "NET OIL" selection. The display shows



Press "P" again to get to the "oil density ref." parameter.



Use the keys "RIGHT" and "UP" to select the desired value and confirm with "P" or skip with "EXIT". If "P" is pressed, the value for the "water density ref." parameter can be entered.



Use the keys "RIGHT" and "UP" to select the desired value and confirm with "P" or skip with "EXIT". If "P" is pressed, the value for the "data update period" parameter can be entered.

Use the keys “RIGHT” and “UP” to select the desired value and confirm with “P” or skip with “EXIT”.

1.8 Natural Gas Metering

When the Coriolis meter is to be used to measure the flow of natural gas, the “meter mode” parameter should be set to “REF. VOLUME.” This mode will convert the mass flow rates and totals to volume flow rates and totals at standard conditions, that is, at the reference temperature and pressure (60 °F and 1 atmosphere).

On the meter keypad, the display sequence to reach the reference volume setups is SETUP / PARAMETER / METER MODE / REF. VOLUME. In the section entitled “METER MODE menu”, the TRICOR Coriolis Mass Flow Meter Manual, to which this Addendum belongs, explains how to progress to the “meter mode” menu.

The following submenus are available:

FLUID DENSITY REF.:
“Fluid density ref.” is the setup parameter for the fluid (gas) density at standard conditions.

DATA UPDATE PERIOD:
The “data update period” setup determines the length of time between updates of the UNICO NOC readouts.

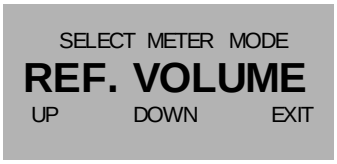
MULTIPHASE COMPENSATION MODE:
Setup for turning the multiphase compensation on and off.

Select “meter mode” on the parameter menu

Possible “meter mode” selections are:

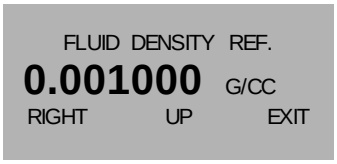
MASS METER
AMB. VOLUME
REF. VOLUME
NET OIL

Set the meter mode to the “REF. VOLUME” mode. Use the keys “RIGHT” and “UP” to select “REF. VOLUME” and confirm with “P”.



Note that if the meter mode is changed, various warnings will be displayed, such as, “WARNING: CHANGING METER MODE WILL RESET ALL DIMENSIONS AND COUNTS!!!!”

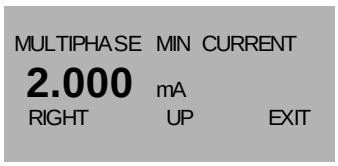
Next the fluid density reference parameter can be changed. It is necessary for the entered value to be accurate. Send a gas sample to a lab for analysis to get an accurate value for the “fluid density ref.” parameter.



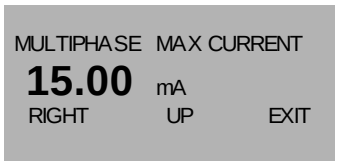
Use the keys “RIGHT” and “UP” to select the desired value and confirm with “P” or skip with “EXIT”. If “P” is pressed, the “data update period” parameter can be set.

Use the keys “RIGHT” and “UP” to select the desired value and confirm with “P” or skip with “EXIT”. If “P” is pressed, the multiphase compensation mode parameter can be set.

Use the keys “UP” and “DOWN” to select the desired value and confirm with “P” or skip with “EXIT”. If the multiphase compensation is set to “Comp. On,” and “P” is pressed, the “multiphase min current” parameter can be set.



Use the keys “RIGHT” and “UP” to select the desired value and confirm with “P” or skip with “EXIT”. If “P” is pressed, the “multiphase max current” parameter can be set.



Use the keys “RIGHT” and “UP” to select the desired value and confirm with “P” or skip with “EXIT”. If “P” is pressed, the “min valid data period” parameter can be set.

Use the keys “RIGHT” and “UP” to select the desired value and confirm with “P” or skip with “EXIT”.
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2 Meter Parameters

2.1 Modbus RTU Serial Connection

The values of the UNICO NOC parameters in the Coriolis meter are available on the meter's serial port using Modbus RTU. Most of the values sent in 32 bit binary floating point IEEE 754 format. A few other items are passed in 16 bit integer format.

Here is a list of the Modbus RTU functions that are supported by the meter. They are color-coded to the spreadsheet that follows and correlate which functions to use with each variable type.

Supported Modbus RTU Functions	
READ_COIL_STATUS	1
READ_INPUT_STATUS	2
READ_HOLDING_REGISTER	3
READ_INPUT_REGISTER	4
FORCE_SINGLE_COIL	5
PRESET_SINGLE_REGISTER	6
FORCE_MULTIPLE_COILS	15
PRESET_MULTIPLE_REGISTERS	16

Here are a couple examples of Modbus RTU messages going to and from the meter.

Example 1: Read holding register function reading the value of the "oil densityref." parameter in the meter:

01 03 23 28 00 02 4F 87

01 = slave ID
03 = function code
23 28 = 9000 decimal = low address
00 02 = number of 16 bit registers
4F 87 = CRC

Example 1 response from the meter indicating a successful read:

01 03 04 3F 5A 5E 35 2E 43

01 = slave ID
03 = function code
04 = byte count
3F 5A 5E 35 = value of the requested registers
2E 43 = CRC

Example 2: Write to one floating point parameter in the meter "oil densityref." using the preset multiple registers function:

01 10 23 28 00 02 04 3F 5A 5E 35 A9 50

01 = slave ID
10 = function code (0x10 = 16 decimal)
23 28 = 9000 decimal = low address
00 02 = number of 16 bit registers
04 = byte count
3F 5A 5E 35 = floating point value to write
A9 50 = CRC

Example 2 response from the meter indicating a successful write:

01 10 23 28 00 02 CA 44

01 = slave ID
10 = function code (0x10 = 16 decimal)
23 28 = 9000 decimal = low address
00 02 = number of 16 bit registers
CA 44 = CRC

2.2 Meter Parameter List

The definitions of these parameters follow in the next section.

DISCRETE COILS (2XXXX read/write bit addresses) (read fn 0x01, write fn 0x05)				
Variable name	**Register type**	**Low address**	**High address**	**Variable type**
Gauge data request	Discrete coil	8000	-	00/FF (Integer)
INPUT REGISTERS (3XXXX read-only register addresses) (read fn 0x04)				
Variable name	**Register type**	**Low address**	**High address**	**Variable type**
Fault word	Input register	8000	-	Integer
Fluid mass flow rate	Input register	9000	9001	Floating point
Volume flow rate	Input register	9002	9003	Floating point
Fluid density	Input register	9004	9005	Floating point
Fluid temperature	Input register	9006	9007	Floating point
Fluid pressure	Input register	9008	9009	Floating point
Drive current	Input register	9020	9021	Floating point
Sensor A amplitude	Input register	9022	9023	Floating point
Sensor B amplitude	Input register	9024	9025	Floating point
Tube frequency	Input register	9026	9027	Floating point

Oil density	Input register	9042	9043	Floating point
Water density	Input register	9044	9045	Floating point
Fluid volume flow rate	Input register	9060	9061	Floating point
Fluid volume flow rate ref	Input register	9062	9063	Floating point
Fluid volume accumulator	Input register	9064	9065	Floating point
Fluid volume accumulator ref	Input register	9066	9067	Floating point
Oil volume flow rate	Input register	9068	9069	Floating point
Oil volume flow rate ref	Input register	9070	9071	Floating point
Oil volume accumulator	Input register	9072	9073	Floating point
Oil volume accumulator ref	Input register	9074	9075	Floating point
Oil cut	Input register	9076	9077	Floating point
Oil cut ref	Input register	9078	9079	Floating point
Water volume flow rate	Input register	9080	9081	Floating point
Water volume flow rate ref	Input register	9082	9083	Floating point
Water volume accumulator	Input register	9084	9085	Floating point
Water volume accumulator ref	Input register	9086	9087	Floating point
Water cut	Input register	9088	9089	Floating point
Water cut ref	Input register	9090	9091	Floating point
Data valid period	Input register	9122	9123	Floating point
Max volume flow rate	Input register	9124	9125	Floating point
Min volume flow rate	Input register	9126	9127	Floating point
Max fluid density	Input register	9128	9129	Floating point
Min fluid density	Input register	9130	9131	Floating point
Max drive current	Input register	9132	9133	Floating point
Min drive current	Input register	9134	9135	Floating point
Mean fluid density	Input register	9136	9137	Floating point
Mean valid fluid density	Input register	9138	9139	Floating point
Gauged fluid volume	Input register	9160	9161	Floating point
Gauged fluid volume ref	Input register	9162	9163	Floating point
Gauged oil volume	Input register	9164	9165	Floating point
Gauged oil volume ref	Input register	9166	9167	Floating point
Gauged water volume	Input register	9168	9169	Floating point
Gauged water volume ref	Input register	9170	9171	Floating point
Raw fluid volume flow rate ref	Input register	9260	9261	Floating point
Raw oil volume flow rate	Input register	9262	9263	Floating point
Raw oil cut	Input register	9264	9265	Floating point

Raw water volume flow rate	Input register	9266	9267	Floating point
Raw water cut	Input register	9268	9269	Floating point
HOLDING REGISTERS (4XXXX read-write register addresses) (read fn 0x03, write fn 0x10)				
Variable name	**Register type**	**Low address**	**High address**	**Variable type**
Meter mode	Holding register	8000	-	Integer
Multiphase compensation mode	Holding register	8001	-	Integer
Simulation mode	Holding register	8002	-	Integer
Oil density ref	Holding register	9000	9001	Floating point
Water density ref	Holding register	9002	9003	Floating point
Gas density ref	Holding register	9004	9005	Floating point
Multiphase min drive current	Holding register	9020	9021	Floating point
Multiphase max drive current	Holding register	9022	9023	Floating point
Multiphase min valid period	Holding register	9024	9025	Floating point
Data update period	Holding register	9040	9041	Floating point
Simulation fluid temperature	Holding register	9086	9087	Floating point
Simulation fluid flow rate	Holding register	9088	9089	Floating point
Simulation fluid density	Holding register	9090	9091	Floating point
Simulation drive current	Holding register	9092	9093	Floating point
Simulation fluid pressure	Holding register	9094	9095	Floating point

2.3 Meter Parameter Descriptions

The parameters in the list from the previous section are defined in this section.

Meter mode
This setup parameter partly determines the units in which fluid flow is measured in the meter. When “MASS MODE” is selected measurements are in mass units, while for the volume and net oil modes measurements are in volume units.

When the “meter mode” parameter is set to “MASS MODE” the meter’s total and flow rate displays are in units of mass and mass per unit time. When the “meter mode” parameter is set to “AMB. VOLUME” the total and flow rate displays are in units of volume and volume per unit time at the ambient temperature and pressure. When the “meter mode” parameter is set to “REF. VOLUME” the total and flow rate displays are in units of volume and volume per unit time, corrected to the reference temperature of 60 °F and atmospheric pressure. When the “meter mode” parameter is set to “NET OIL,” the meter’s net oil computer is enabled and there are total and flow rate displays for oil and water at the ambient temperature and pressure as well as for the oil and water cuts.

Register Type: Holding register
Variable Type: Integer
Low Address: 8000
High Address: none
Default: MASS MODE (0)

Oil density ref.

This is the entered density of the oil produced by the well, measured at atmospheric pressure and a temperature of 60 °F. This setup is used when the “meter mode” parameter is set to “NET OIL.”

Register Type: Holding register
Variable Type: Floating point
Low Address: 9000
High Address: 9001
Units: selected density units
Min: 0.700 g/cm^3
Max: 1.10 g/cm^3
Default: 0.850 g/cm^3

Water density ref.

This is the entered density of the water produced by the well, measured at atmospheric pressure and a temperature of 60 °F. This setup is used when the “meter mode” parameter is set to “NET OIL.”

Register Type: Holding register
Variable Type: Floating point
Low Address: 9002
High Address: 9003
Units: selected density units
Min: 0.999043053 g/cm^3
Max: 1.30 g/cm^3
Default: 0.999043053 g/cm^3

Gas density ref.

This is the entered density of the gas produced by the well, measured at atmospheric pressure and a temperature of 60 °F. This setup is used when the “meter mode” parameter is set to “REF. VOLUME.”

Register Type: Holding register
Variable Type: Floating point
Low Address: 9004
High Address: 9005
Units: selected density units
Min: 0.000500 g/cm^3
Max: 0.005000 g/cm^3
Default: 0.001000 g/cm^3

Data update period
When the "meter mode" parameter is set to "NET OIL" the "data update period" parameter sets the time interval during which the oil, water and fluid data is accumulated and averaged before updating the volume accumulator and flow rate values. When the multiphase compensation mode parameter is set to "COMP. ON" this time interval is partitioned into a period where the meter's density data is considered valid and another where it is considered invalid for purposes of computing the oil and water cut. The mean density during the valid period is used during the entire time interval for purposes of computing the net oil and water accumulated during that period.

When the "meter mode" parameter is set to "REF. VOLUME" the "data update period" parameter sets the time interval during which flow data is accumulated and averaged before updating the reference volume accumulator and flow rate display values. When the multiphase compensation mode parameter is set to "COMP. ON" this time interval is partitioned into a period where the meter's flow data is considered valid and another where it is considered invalid. The mean flow rate during the valid period is used during the entire time interval for purposes of computing the accumulated net reference volume for the time interval.

Register Type:	Holding register
Variable Type:	Floating point
Low Address:	9040
High Address:	9041
Units:	sec
Min:	data min valid time
Max:	3,600.0 sec
Default:	60.0 sec

Multiphase comp. mode
When the "meter mode" parameter is set to "NET OIL" and the "multiphase comp. mode" (multiphase compensation mode) parameter is set to "COMP. ON" then when, because of the presence of free gas in the liquid stream, the meter drive current is greater than the value of the "multiphase max drive current" setup or is less than the value of the "multiphase min drive current" setup, then the meter's density data is not considered valid for purposes of computing the net oil and water. When the drive current is less than the "multiphase min drive current" setup then the flow rate data is also considered invalid.

When the "meter mode" parameter is set to "REF. VOLUME" and the multiphase compensation mode parameter is set to "COMP. ON" then when, because of the presence of entrained liquid in the gas stream, the drive current is greater than the value of the "multiphase max drive current" setup or is less than the value of the "multiphase min drive current" setup then the meter's flow rate data is not considered valid.

Register Type:	Holding register
Variable Type:	Integer
Low Address:	8001
High Address:	none
Selection List:	COMP. OFF (0), COMP. ON (1)
Default:	COMP. OFF (0)

Multiphase min drive current
When the "meter mode" parameter is set to "NET OIL" and the multiphase compensation mode parameter is set to "COMP. ON" and the drive current is less than the value of the "multiphase min drive current" setup then the meter's density measurement is not considered valid for purposes of computing the oil and water cut and its flow rate measurement is not considered valid for purposes of incrementing the net fluid accumulator.

When the “meter mode” parameter is set to “REF. VOLUME” and the multiphase compensation mode parameter is set to “COMP. ON” and the drive current is less than the value of the “multiphase min drive current” setup then the meter’s flow rate data is not considered valid.

Register Type: Holding register
Variable Type: Floating point
Low Address: 9020
High Address: 9021
Units: mA
Min: 0.0 mA
Max: multiphase max drive current
Default: 2.0 mA

Multiphase max drive current

When the “meter mode” parameter is set to “NET OIL” and the multiphase compensation mode parameter is set to “COMP. ON” and the drive current exceeds the value of the “multiphase max drive current” setup, then the meter’s density measurement is not considered valid for purposes of computing the oil and water cut.

When the “meter mode” parameter is set to “REF. VOLUME” and the multiphase compensation mode parameter is set to “COMP. ON” and the drive current exceeds the value of the “multiphase max drive current” setup, then the meter’s flow rate data is not considered valid.

Register Type: Holding register
Variable Type: Floating point
Low Address: 9022
High Address: 9023
Units: mA
Min: multiphase min drive current
Max: NONE
Default: 15.0 mA

Multiphase min valid period

When the “meter mode” parameter is set to “NET OIL” and the multiphase compensation mode parameter is set to “COMP. ON” and the time interval during which the drive current is within the limits set by the multiphase min and max drive current setups is less than the “multiphase min valid period” parameter, then the flow rate and density data from the previous update time interval is used for purposes of incrementing the net oil, water and fluid volume accumulators.

When the “meter mode” parameter is set to “REF. VOLUME” and the multiphase compensation mode parameter is set to “COMP. ON” and the time interval during which the drive current is within the limits set by the multiphase min and max drive current setups is less than the “multiphase min valid period” parameter, then the flow rate data from the previous update time interval is used for purposes of incrementing the reference volume accumulator.

Register Type: Holding register
Variable Type: Floating point
Low Address: 9024
High Address: 9025
Units: sec
Min: 1.0 sec
Max: net oil update time
Default: 10.0 sec

Simulation mode
When the “simulation mode” is set to “ENABLE,” and the “meter mode” parameter is set to either “REF. VOLUME” mode or “NET OIL” mode, then the meter reads the fluid temperature, fluid density, fluid flow rate and drive current from the simulation setups described below rather than from the meter’s hardware. This is useful for testing communications to the meter from another device. The simulation mode should be disabled when fluid is flowing through the meter. The “simulation mode” parameter is automatically set to “DISABLE” when power is cycled on the meter.
Register Type: Holding register
Variable Type: Integer
Low Address: 8002
High Address: none
Selection List: DISABLE (0), ENABLE (1)
Default: DISABLE (0)

Simulation fluid temperature
The “simulation fluid temperature” parameter determines the fluid temperature when the simulation mode is enabled.
Register Type: Holding register
Variable Type: Floating point
Low Address: 9086
High Address: 9087
Units: selected temperature units

Simulation fluid flow rate
This item determines the fluid flow rate when the “simulation mode” parameter is set to “ENABLE.” If the “meter mode” parameter is set to “REF. VOLUME” then the units are mass per time, while if the “meter mode” parameter is set to “NET OIL” then the units are volume per time.
Register Type: Holding register
Variable Type: Floating point
Low Address: 9088
High Address: 9089
Units: selected mass flow rate units or volume flow rate units

Simulation fluid density
This item determines the fluid density when the “simulation mode” parameter is set to “ENABLE.”
Register Type: Holding register
Variable Type: Floating point
Low Address: 9090
High Address: 9091
Units: selected density units

Simulation drive current
This item determines the drive current when the “simulation mode” parameter is set to “ENABLE.”
Register Type: Holding register
Variable Type: Floating point
Low Address: 9092
High Address: 9093
Units: mA

Simulation fluid pressure
The “simulation fluid pressure” parameter determines the fluid pressure when the simulation mode is enabled.
Register Type: Holding register
Variable Type: Floating point
Low Address: 9094
High Address: 9095
Units: selected pressure units

Gauge data request
When the “meter mode” parameter is set to “NET OIL” and the “gauge data request” setup is momentarily set to “ENABLE” (FF), the meter will save the net oil, water and fluid accumulators to the gauged total parameters and will reset the accumulators to zero. The meter will then disable (00) the “gauge data request” parameter.

When the “meter mode” parameter is set to “REF. VOLUME” and the “gauge data request” setup is momentarily set to “ENABLE” (FF), the meter will save the net reference volume accumulator to the gauged total parameter and will reset the accumulator to zero. The meter will then disable (00) the “gauge data request” parameter.
Register Type: Coil
Variable Type: 00/FF (Integer)
Low Address: 8000
High Address: none
Selection List: DISABLE (00), ENABLE (FF)
Default: DISABLE (00)

Fault word
This item displays the meter fault word and is updated every tube vibration period.
BIT 0: This bit is set during the first 20 seconds after power is applied to the meter.
BIT 1: This bit is set when the sensor A amplitude is more than 20% different than its setpoint.
BIT 2: This bit is set when the sensor B amplitude is more than 20% different than its setpoint.
BIT 3: This bit is set when the time between zero crossings of the tubes is greater than 250 μs.
BIT 4: This bit is set when the zero offset procedure is in progress.
BIT 5: This bit is set when the drive current fluctuations are excessive.
BIT 6: This bit is set when the temperature sensor is out of range.
BIT 7: This bit is set when the tube frequency is too low.
BIT 8: This bit is set when the tube frequency is too high.
BIT 9: This bit is set when the drive current is too low.
BIT 10: This bit is set during powerup when the integrity of the backup EEPROM is questionable.
BIT 11: This bit is set during powerup when the backup EEPROM does not match the active EEPROM
BIT 12: This bit is not used.
BIT 13: This bit is not used.
BIT 14: This bit is not used.
BIT 15: This bit is not used.
Register Type: Input register
Variable Type: Integer
Low Address: 8000
High Address: none
Units: hex bitwise word

Fluid mass flow rate
This item displays the mass flow rate through the meter and is updated every tube vibration period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9000
High Address: 9001
Units: selected mass flow rate units

Fluid volume flow rate
This item displays the volume flow rate through the meter and is updated every tube vibration period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9002
High Address: 9003
Units: selected volume flow rate units

Fluid density
This item displays the density of the fluid in the tubes and is updated every tube vibration period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9004
High Address: 9005
Units: selected density units

Fluid temperature
This item displays the temperature of the fluid in the tubes and is updated every tube vibration period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9006
High Address: 9007
Units: selected temperature units

Fluid pressure
This item displays the pressure of the fluid in the tubes and is updated every tube vibration period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9008
High Address: 9009
Units: selected pressure units

Drive current
This item displays the current required to drive the tubes into vibration and is updated every tube vibration period. The drive current plays a pivotal role in multiphase flow compensation.
Register Type: Input register
Variable Type: Floating point
Low Address: 9020
High Address: 9021
Units: mA

Sensor A amplitude
This item displays the amplitude of the induced voltage in the sensor A pickup coil and is updated every tube vibration period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9022
High Address: 9023
Units: mV

Sensor B amplitude
This item displays the amplitude of the induced voltage in the sensor B pickup coil and is updated every tube vibration period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9024
High Address: 9025
Units: mV

Tube frequency
This item displays the frequency of vibration of the tubes and is updated every tube vibration period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9026
High Address: 9027
Units: Hz

Oil density
When the “meter mode” parameter is set to “NET OIL” the “oil density” parameter displays the density of the oil produced by the well at the temperature and pressure measured by the meter. It is calculated from the “oil density ref.” setup, and the measured temperature and pressure of the fluid, using the algorithm in the API 11.1 standard. It is updated every tube vibration period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9042
High Address: 9043
Units: selected density units

Water density
When the “meter mode” parameter is set to “NET OIL” the “water density” parameter displays the density of the water produced by the well at the temperature and pressure measured by the meter. It is calculated from the “water density ref.” setup, and the temperature and pressure of the fluid, using a standard model for how the density of saline water changes with temperature and pressure. It is updated every tube vibration period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9044
High Address: 9045
Units: selected density units

Fluid volume flow rate
When the “meter mode” parameter is set to “NET OIL” the “fluid volume flow rate” parameter displays the fluid volume flow rate at the ambient fluid temperature and pressure. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9060
High Address: 9061
Units: selected volume flow rate units

Fluid volume flow rate ref
When the “meter mode” parameter is set to “NET OIL” the “fluid volume flow rate ref” parameter displays the fluid volume flow rate, corrected to a temperature of 60 °F and atmospheric pressure. The update time is determined by the value of the “data update period” parameter.

When the “meter mode” parameter is set to “REF. VOLUME” the “fluid volume flow rate ref” parameter displays the fluid volume flow rate, corrected to a temperature of 60 °F and atmospheric pressure. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9062
High Address: 9063
Units: selected volume flow rate units

Fluid volume accumulator
When the “meter mode” parameter is set to “NET OIL” the “fluid volume accumulator” parameter displays the net fluid volume that has passed through the meter at the ambient fluid temperature and pressure since the last gauge event. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9064
High Address: 9065
Units: selected volume units

Fluid volume accumulator ref
When the “meter mode” parameter is set to “NET OIL” the “fluid volume accumulator ref” parameter displays the net fluid volume that has passed through the meter since the last gauge event, corrected to a temperature of 60 °F and atmospheric pressure. The update time is determined by the value of the “data update period” parameter.

When the “meter mode” parameter is set to “REF. VOLUME” the “fluid volume accumulator ref” parameter displays the net fluid volume that has passed through the meter since the last gauge event, corrected to a temperature of 60 °F and atmospheric pressure. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9066
High Address: 9067
Units: selected volume flow rate units

Oil volume flow rate
When the “meter mode” parameter is set to “NET OIL” the “oil volume flow rate” parameter displays the oil volume flow rate at the ambient fluid temperature and pressure. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9068
High Address: 9069
Units: selected volume flow rate units

Oil volume flow rate ref
When the “meter mode” parameter is set to “NET OIL” the “oil volume flow rate ref” parameter displays the oil volume flow rate, corrected to a temperature of 60 °F and atmospheric pressure. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9070
High Address: 9071
Units: selected volume flow rate units

Oil volume accumulator
When the “meter mode” parameter is set to “NET OIL” the “oil volume accumulator” parameter displays the net oil volume that has passed through the meter at the ambient fluid temperature and pressure since the last gauge event. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9072
High Address: 9073
Units: selected volume flow rate units

Oil volume accumulator ref
When the “meter mode” parameter is set to “NET OIL” the “oil volume accumulator ref” parameter displays the net oil volume that has passed through the meter since the last gauge event, corrected to a temperature of 60 °F and atmospheric pressure. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9074
High Address: 9075
Units: selected volume flow rate units

Oil cut
When the “meter mode” parameter is set to “NET OIL” the “oil cut” parameter displays the percentage of the fluid volume that is oil at the ambient fluid temperature and pressure. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9076
High Address: 9077
Units: %

Oil cut ref
When the “meter mode” parameter is set to “NET OIL” the “oil cut ref” parameter displays the percentage of the fluid volume that is oil, corrected to a temperature of 60 °F and atmospheric pressure. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9078
High Address: 9079
Units: %

Water volume flow rate
When the “meter mode” parameter is set to “NET OIL” the “water volume flow rate” parameter displays the water volume flow rate at the ambient fluid temperature and pressure. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9080
High Address: 9081
Units: selected volume flow rate units

Water volume flow rate ref
When the “meter mode” parameter is set to “NET OIL” the “water volume flow rate ref” parameter displays the water volume flow rate, corrected to a temperature of 60 °F and atmospheric pressure. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9082
High Address: 9083
Units: selected volume flow rate units

Water volume accumulator
When the “meter mode” parameter is set to “NET OIL” the “water volume accumulator” parameter displays the net water volume that has passed through the meter at the ambient fluid temperature and pressure since the last gauge event. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9084
High Address: 9085
Units: selected volume flow rate units

Water volume accumulator ref
When the “meter mode” parameter is set to “NET OIL” the “water volume accumulator ref” parameter displays the net water volume that has passed through the meter since the last gauge event, corrected to a temperature of 60 °F and atmospheric pressure. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9086
High Address: 9087
Units: selected volume flow rate units

Water cut
When the “meter mode” parameter is set to “NET OIL” the “water cut” parameter displays the percentage of the fluid volume that is water at the ambient fluid temperature and pressure. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9088
High Address: 9089
Units: %

Water cut ref
When the “meter mode” parameter is set to “NET OIL” the “water cut ref” parameter displays the percentage of the fluid volume that is water, corrected to a temperature of 60 °F and atmospheric pressure. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9090
High Address: 9091
Units: %

Data valid period
When the "meter mode" parameter is set to either "NET OIL" or "REF. VOLUME", and the multiphase compensation mode parameter is set to "COMP. ON", the "data valid period" parameter displays the time interval during which the drive current is within the limits set by the multiphase compensation flow min and max drive current setups. It is updated every data update period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9122
High Address: 9123
Units: seconds

Max fluid volume flow rate
When the "meter mode" parameter is set to either "NET OIL" or "REF. VOLUME" the "max fluid volume flow rate" parameter displays the maximum fluid volume flow rate measured during a single tube vibration period. The update time is determined by the value of the "data update period" parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9124
High Address: 9125
Units: selected volume flow rate units

Min fluid volume flow rate
When the "meter mode" parameter is set to either "NET OIL" or "REF. VOLUME" the "min fluid volume flow rate" parameter displays the minimum fluid volume flow rate measured during a single tube vibration period. The update time is determined by the value of the "data update period" parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9126
High Address: 9127
Units: selected volume flow rate units

Max fluid density
When the "meter mode" parameter is set to either "NET OIL" or "REF. VOLUME" the "max fluid density" parameter displays the maximum fluid density measured during a single tube vibration period. The update time is determined by the value of the "data update period" parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9128
High Address: 9129
Units: selected density units

Min fluid density
When the "meter mode" parameter is set to either "NET OIL" or "REF. VOLUME" the "min fluid density" parameter displays the minimum fluid density measured during a single tube vibration period. The update time is determined by the value of the "data update period" parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9130
High Address: 9131
Units: selected density units

Max drive current
When the “meter mode” parameter is set to either “NET OIL” or “REF. VOLUME” the “max drive current” parameter displays the maximum drive current measured during a single tube vibration period. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9132
High Address: 9133
Units: mA

Min drive current
When the “meter mode” parameter is set to either “NET OIL” or “REF. VOLUME” the “min drive current” parameter displays the minimum drive current measured during a single tube vibration period. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9134
High Address: 9135
Units: mA

Mean fluid density
When the “meter mode” parameter is set to “NET OIL” the “mean fluid density” parameter displays the mean fluid density measured during the data update time period. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9136
High Address: 9137
Units: selected density units

Mean valid fluid density
When the “meter mode” parameter is set to “NET OIL” the “mean valid fluid density” parameter displays the mean fluid density measured during the portion of the data update time period when the drive current is within the limits set by the multiphase min and max drive current setups. The update time is determined by the value of the “data update period” parameter.
Register Type: Input register
Variable Type: Floating point
Low Address: 9138
High Address: 9139
Units: selected density units

Gauged fluid volume
When the “meter mode” parameter is set to “NET OIL” the “gauged fluid volume” parameter displays the net fluid volume that passed through the meter at the ambient fluid temperature and pressure during the time between the last two gauge events. It is updated whenever the “gauge data request” parameter is enabled. Typically the “gauge data request” parameter would be enabled once each day at exactly the same time in which case this parameter would display the net fluid volume for the previous day.
Register Type: Input register
Variable Type: Floating point
Low Address: 9160
High Address: 9161
Units: selected volume flow rate units

Gauged fluid volume ref
When the “meter mode” parameter is set to “NET OIL” the “gauged fluid volume ref” parameter displays the net fluid volume that passed through the meter, corrected to a temperature of 60 °F and atmospheric pressure, during the time between the last two gauge events. It is updated whenever the “gauge data request” parameter is enabled. Typically the “gauge data request” parameter would be enabled once each day at exactly the same time in which case this parameter would display the net fluid volume for the previous day.

When the “meter mode” parameter is set to “REF. VOLUME” the “gauged fluid volume ref” parameter displays the net fluid volume that passed through the meter, corrected to a temperature of 60 °F and atmospheric pressure, during the time between the last two gauge events. It is updated whenever the “gauge data request” parameter is enabled. Typically the “gauge data request” parameter would be enabled once each day at exactly the same time in which case this parameter would display the net fluid volume for the previous day.
Register Type: Input register
Variable Type: Floating point
Low Address: 9162
High Address: 9163
Units: selected volume flow rate units

Gauged oil volume
When the “meter mode” parameter is set to “NET OIL” the “gauged oil volume” parameter displays the net oil volume that passed through the meter at the ambient fluid temperature and pressure during the time between the last two gauge events. It is updated whenever the “gauge data request” parameter is enabled. Typically the “gauge data request” parameter would be enabled once each day at exactly the same time in which case this parameter would display the net oil volume for the previous day.
Register Type: Input register
Variable Type: Floating point
Low Address: 9164
High Address: 9165
Units: selected volume flow rate units

Gauged oil volume ref
When the “meter mode” parameter is set to “NET OIL” the “gauged oil volume ref” parameter displays the net oil volume that passed through the meter, corrected to a temperature of 60 °F and atmospheric pressure, during the time between the last two gauge events. It is updated whenever the “gauge data request” parameter is enabled. Typically the “gauge data request” parameter would be enabled once each day at exactly the same time in which case this parameter would display the net oil volume for the previous day.
Register Type: Input register
Variable Type: Floating point
Low Address: 9166
High Address: 9167
Units: selected volume flow rate units

Gauged water volume
When the “meter mode” parameter is set to “NET OIL” the “gauged water volume” parameter displays the net water volume that passed through the meter at the ambient fluid temperature and pressure during the time between the last two gauge events. It is updated whenever the “gauge data request” parameter is enabled. Typically the “gauge data request” parameter would be enabled once each day at exactly the same time in which case this parameter would display the net water volume for the previous day.
Register Type: Input register
Variable Type: Floating point
Low Address: 9168
High Address: 9169
Units: selected volume flow rate units

Gauged water volume ref
When the “meter mode” parameter is set to “NET OIL” the “gauged water volume ref” parameter displays the net water volume that passed through the meter, corrected to a temperature of 60 °F and atmospheric pressure, during the time between the last two gauge events. It is updated whenever the “gauge data request” parameter is enabled. Typically the “gauge data request” parameter would be enabled once each day at exactly the same time in which case this parameter would display the net water volume for the previous day.
Register Type: Input register
Variable Type: Floating point
Low Address: 9170
High Address: 9171
Units: selected volume flow rate units

Raw fluid volume flow rate ref
When the “meter mode” parameter is set to “REF. VOLUME” the “raw fluid volume flow rate ref” parameter displays the raw fluid volume flow rate, corrected to a temperature of 60 °F and atmospheric pressure, filtered with a time constant determined by the “flow filter” setup. It is updated every tube vibration time period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9260
High Address: 9261
Units: selected volume flow rate units

Raw oil volume flow rate
When the “meter mode” parameter is set to “NET OIL” the “raw oil volume flow rate” parameter displays the raw oil volume flow rate at the ambient fluid temperature and pressure, filtered with a time constant determined by the “flow filter” setup. It is updated every tube vibration time period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9262
High Address: 9263
Units: selected volume flow rate units

Raw oil cut
When the “meter mode” parameter is set to “NET OIL” the “raw oil cut” parameter displays the raw percentage of the fluid volume that is oil at the ambient fluid temperature and pressure, filtered with a time constant determined by the “flow filter” setup. It is updated every tube vibration time period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9264
High Address: 9265
Units: %

Raw water volume flow rate
When the “meter mode” parameter is set to “NET OIL” the “raw water volume flow rate” parameter displays the raw water volume flow rate at the ambient fluid temperature and pressure, filtered with a time constant determined by the “flow filter” setup. It is updated every tube vibration time period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9266
High Address: 9267
Units: selected volume flow rate units

Raw water cut
When the “meter mode” parameter is set to “NET OIL” the “raw water cut” parameter displays the raw percentage of the fluid volume that is water at the ambient fluid temperature and pressure, filtered with a time constant determined by the “flow filter” setup. It is updated every tube vibration time period.
Register Type: Input register
Variable Type: Floating point
Low Address: 9268
High Address: 9269
Units: %

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