Product Data Sheet
RXPS-002227, Rev D
December 2022

Roxar™ Watercut Meter

Emerson's Roxar Flow Measurement solutions has pioneered the development of microwave resonance technology for watercut measurement.

Roxar Watercut Meters are installed worldwide in some of the most challenging onshore and offshore environments. The Roxar Watercut Meter covers any application where accurate and drift-free determination of water content is crucial.

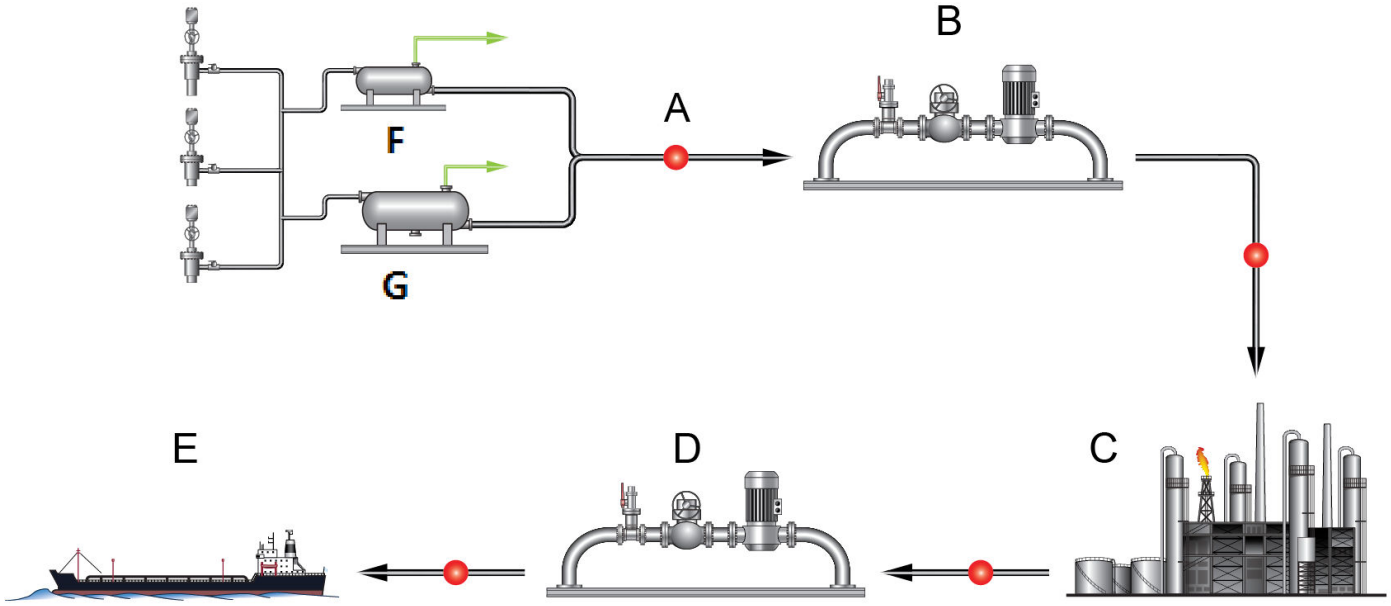
A commitment to providing support and service through our Flow Lifecycle Services organization ensures that the meters operate at peak performance throughout their field life cycle.

Watercut meter application overview

The Roxar Watercut Meter is used in a wide range of applications:

- **Production net oil**
  Oil outlet of a three-phase separator
- **Oil pipeline**
  Allocation, fiscal measurement and gathering (crude, BS&W and condensate water)
- **Refinery crude feed**
  Desalter feed and control
- **Refined pipeline**
  Fiscal quality measurement

Figure 1: Applications For Watercut Meter



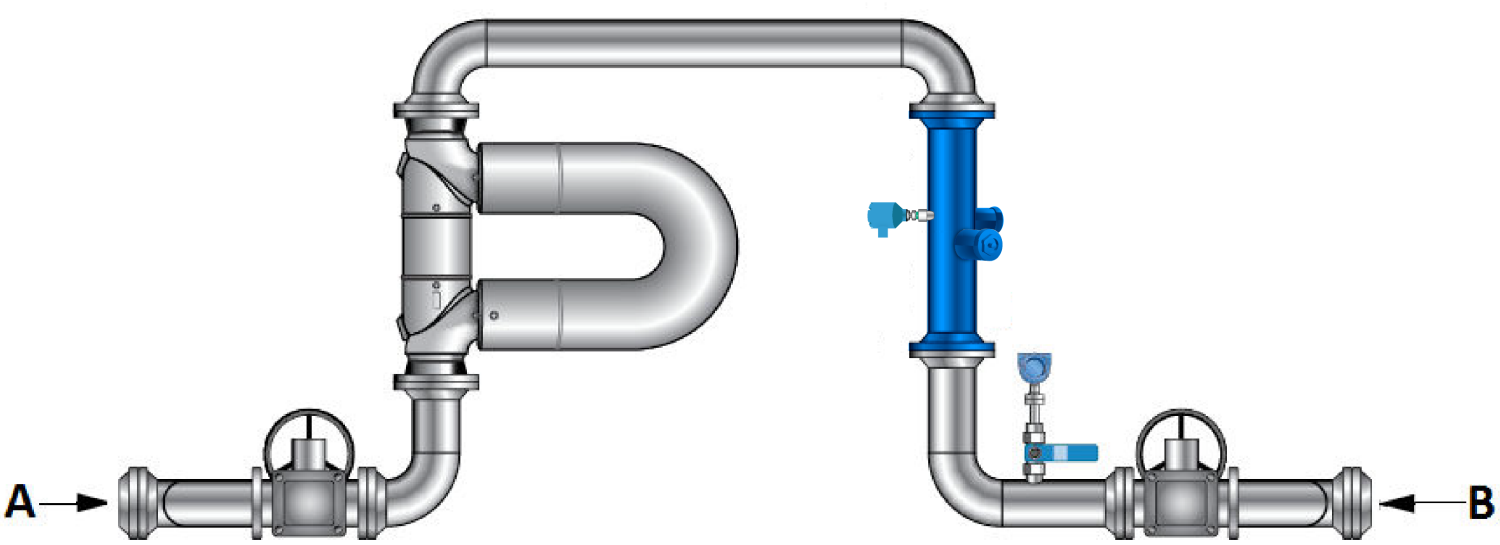
A. Production net oil
B. Oil pipeline
C. Refinery crude feed
D. Refined pipeline
E. Shipping terminals
F. Test separator
G. Production separator

Operator benefits

Roxar Watercut Meters provide the following benefits to operators:

- Determines continuously the watercut of an oil and water mixed flow without separation or sampling
- Maximizes production by showing the effects of enhancing oil and water separation and decreasing retention time
- Detects and tracks water content changes as low as 50 ppm – a sensitivity matched by no other technology
- Provides an innovative alternative to conventional sampling
  Several countries and oil companies have replaced conventional sampling methods with the Roxar Watercut meter for improved fiscal reporting, and for the automatic rerouting of oil back into the process when the watercut exceeds the commercial level.

Figure 2: Roxar Watercut Meter with inline Coriolis flow meter



A. Inlet
B. Outlet

Measurement principle

The Roxar Watercut Meter uses microwave technology to measure the permittivity of any oil and water mixture. The watercut is then calculated by comparing the mixture permittivity with the dry oil and water permittivities. The permittivities of water and oil are fundamentally different (typically 70 vs. 2) because of the difference in molecular structure between the two liquids.

The oxygen atom of the water molecule has an affinity for the electrons of the two hydrogen atoms. This results in a greater electron density for the oxygen atom. This also causes the water molecule to have a positively charged side and a negatively charged side. Consequently, the water molecules will continuously try to align themselves with the changing microwave field, which in turn will slow down the propagation of the microwaves.

Because hydrocarbon molecules have a much more symmetrical structure and do not respond to the changing microwave field, they have an insignificant effect on the propagation of the microwaves.

This distinct difference in dielectric properties between water and oil ensures that the industry has recognized this principle for providing superior sensitivity to water in oil over conventional density or optically-based principles.

Measurement technology

Unlike other technologies, the Roxar unique Microwave Resonance technology allows an energy peak to occur at a frequency defined solely by the contents of the sensor, and is unaffected by the temperature of the electronics, aging and calibration.

As the watercut increases, the propagation of the microwaves is increasingly counteracted, causing a corresponding decrease in microwave resonance frequency. The Microwave Resonance technology is the only method that allows for a very simple, scientific correlation between the microwave resonance frequency and the mixture permittivity.

The Microwave Resonance frequency with empty sensor is measured with high precision equipment at the factory and stored in each unit as a calibration constant. As a result, the meter does not need periodic recalibration.

This unique technology provides the following advantages over all other watercut meter technologies:

- Fiscal accuracy
- Long-term repeatability (no drift)
- Sensitivity as low as 50 ppm water
- Independence from electronics temperature
- Measurement of a full cross section
- Low maintenance

Representative measurement

Sampling has been used to periodically check watercut values; however, there are limitations in this method due to the errors introduced by sampling when the data is not representative.

The Roxar Watercut Meter ensures accurate results because the measurement is taken across the entire span of the flow, while an insertion probe is only able to provide measurement for the flow that the sensor comes into contact with. An insertion probe is challenged not only by its own accuracy uncertainty, but also by the variances within the flow.

Maintenance reliability

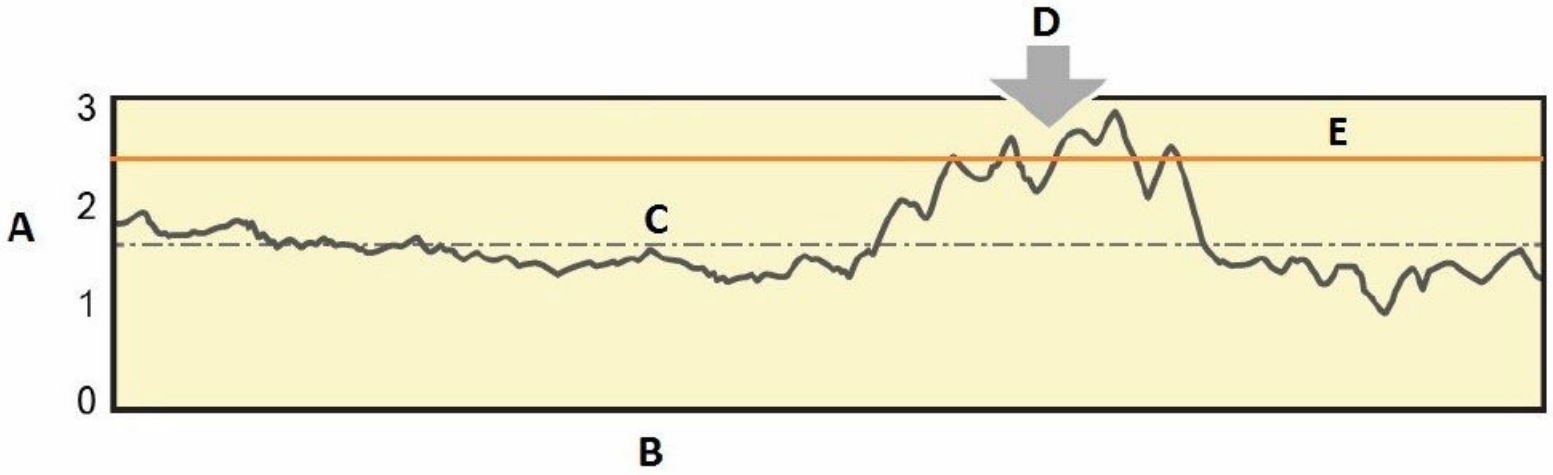
The Roxar Watercut Meter is designed for minimum maintenance. The meter has no moving parts and its full-bore design ensures that the measurement is not susceptible to issues related to scaling and waxing. By comparison, insertion devices can be compromised when the measurement element is coated or damaged by deposits.

Additionally, the Roxar Watercut Meter does not require any dynamic calibration for set up or continued performance.

Other considerations

Density measurement can be used to calculate watercut, but this requires accurate fixed inputs for component densities, and is limited when considering applications with heavy oil, very low watercut, or very high watercut.

Figure 3: Continuous Measurements Versus Sampling



A. Watercut
B. Time
C. Average watercut (dotted line)
D. Spot sample (sampling period does not represent average watercut)
E. Average watercut based on sample

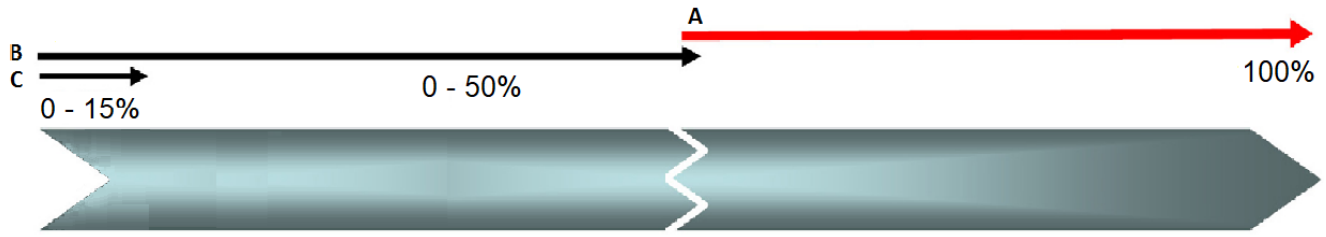
Standard operating range

The different Roxar Watercut Meter models are all in-line (flow through), measuring the watercut on the full cross section of the pipe.

Available sizes

- 1 – 4-inch, standard sizes (configured models)
- 6 – 24-inch, non-standard sizes

Figure 4: Roxar Watercut Meter Sizes



A. Extended Range with TopCut Feature
B. High Cut 0-50% WLR
C. Low Cut 0-15% WLR

Options

- TopCut feature
- AutoZero feature
- Local characterization
- Stock Tank mode
- Modbus Daniel Extension (only for WCM MK1 upgrades)

TopCut feature

The standard Roxar Watercut Meters Low Cut and High Cut have an upper limit for watercut (15% and 50% respectively). The TopCut function enables measurement when the meter is out of range by using a density calculation. This option is perfect when testing streams that are mainly in the 0-15% or 0-50% watercut range because it produces accurate measurements when the watercut exceeds the stated range of the meter.

AutoZero feature

AutoZero is a patented feature available with the Roxar Watercut Meter. Using a density input from a densitometer or a Coriolis meter (typically 4-20mA or a bi-directional serial connection), the Roxar Watercut Meters Low Cut and High Cut can automatically compensate for changes in oil density in real-time. The density input is available both as HART input as a digital signal on the 4-20mA loops and through Modbus registers. This ability gives operators the confidence that when properties of the fluids passing through the Roxar Watercut Meters Low Cut and High Cut are changing (for example, when testing multiple wells), the meter will use the live measured density for optimum accuracy.

Note
The TopCut feature can be retrofitted on most Roxar Watercut Meters by the Roxar service team, provided that density input is available to the watercut meter.

Local characterization

Local Characterization is a function for increased accuracy in applications with very low watercut and with varying oil properties. The method is to take use of the resent history of referencing grab samples to generate an corrective linear function related to the oil properties.

Stock Tank mode

Stock Tank mode enables % water by volume and % water by weight output at standard condition.

Note
The Local Characterization and Stock tank mode are feature that can be retrofitted on most Roxar Watercut Meters by the Roxar service team.

MODBUS Daniel Extension

Only applicable if the old Watercut Meter use MODBUS. This feature is strictly for upgrade of Watercut Meter flow computer from the old model Watercut Meter to the current model. The feature enables some of the input and output MODBUS registers with Daniel Extension protocol, as mapped for the older generations of Roxar Watercut Meter.

Watercut meter specifications

Specifications

PED required for all meters with the exception of all the 1-inch model, and 2-inch meters with flanges smaller than #300.

Table 1:

Parts	Types	Specifications
Watercut Meter sensor	Design temperature	5 °F (-15.0 °C) up to 248 °F (120.0 °C) standard (can be extended to -49 °F (-45.0 °C) -40 °F (-40.0 °C) up to 302 °F (150.0 °C) (available up to 4-in WCM sizes) with HP HT probes Standard: Design Pressure: 0-2,901 psig (200 barg) With HP Probes: 10,008 psig (690 barg), limited according to ASME B16.5 (available only with certain configurations)
	Materials and wetted parts	Roxar standard materials (see comments under the table)
	Manufacturing procedures	ASME / NORSOK compliant
	Pressure drop	Typically 0.3 bar
Electronics enclosure	Mounting	Typically less than 2 meters from the spool piece
	Ambient temperature	■ -4 °F (-20 °C) to 140 °F (60 °C) Non-IS signal ■ -4 °F (-20 °C) to 118 °F (48 °C) IS signal
	Voltage supply	21-35 VDC or 100 - 240 VAC
	Power consumption	Up to 24 W, maximum 30 W at start-up
	Enclosure types	Ex d, Ex de
	Ingress protection	IP66
	Material	Stainless steel
	Weight	68 kg / 70 kg
Digital I/O	Serial	MODBUS RTU over RS-485, maximum length 1200mm.
Sample input	Protocol	TTL
Optional transmitter inputs		
HART input	Protocol	HART 5, From Temperature transmitter and from Densitometer, Standard Non-IS, (Optional IS)
Analogue I/O	Input	2 * 4-20 mA: Temperature, mixture density
	Output	2 * 4-20 mA: Watercut, user selectable
Temperature transmitter	Model	Rosemount 644H
	Range	32 °F (0 °C) to 212 °F (100 °C)
	Accuracy	± 0.15° C
	Interface	4-20 mA HART
Field indicator (optional)	Interface	4-20 mA

Note
Intrinsically safe option for HART AI, AO: The total of maximum 4 Intrinsically safe ports can be fitted.

Sizes	Specifications
1-inch - 4-inches	Standard material: Duplex UNS S31803, NORSOK M-630 MDS D47, NACE MR0175/ISO 15156, NS-EN 10204, 3.1
6-inches upwards(1)	Standard material: Carbon steel, ASTM A350. Gr. LF2, NACE MR0175/ISO 15156, NS-EN 10204, 3.1

(1) *Available only with certain configurations.*

Performance specifications

Table 2: Performance specifications

Performance item	Low Cut Meters		High Cut Meters	
Calibration method	In-line(1)	TopCut(2)	In-line(1)	TopCut(2)
Range	0-1%(3)	15-100%	0-1%	50-100%
	1-15%		1-50%	
Uncertainty(4) o.r.: of reading	±0.05%	± 1.5% abs(2)	±0.05%	±1.5% abs(2)
	5% o.r.		+/- 5% of reading, maximum +/-1% abs.	
Repeatability(4)	± 0.01%		± 0.01%	
Sensitivity(4)	± 0.005%		± 0.005%	
Response time	0.4 - 0.7s	1s	0.4 - 0.7s	1s
Measurements per second	200		200	
Effect of temperature variations	Automatic compensation			
Effect of density variations	0.027% water per 1 kg/m3 (Automatic compensation with AutoZero option)			
Effect of pressure variations	0,0025% water per 1 bar (Automatic compensation with AutoZero option)			

(1) *The uncertainty specifications for the different ranges assume that the meter has been calibrated against a manual sample taken at the location of the meter. Maximum uncertainty when using such in-line calibration method is ± 1% absolute.*

(2) *Specifications in this column apply only if the TopCut option is included. The TopCut option requires a line density input from a densitometer, and provides a density-based estimation of percent (%) water if the watercut goes above the specified measurement range of the meter. The typical watercut uncertainty in the range 50 - 100% water, given densitometer accuracy +/- 1.5 KG/M^3 and either oil or water density ration less than 0.9, is less than =/- 1.5% abs.*

(3) *The uncertainty in this range is given at 95% confidence interval (approximately 2 standard deviations) in order to comply with ISO 3170 for manual sampling, which is normally used as the reference during in-line calibration. The expected accuracy (standard deviation) is approximately half of the given figures, therefore ± 0.025%.*

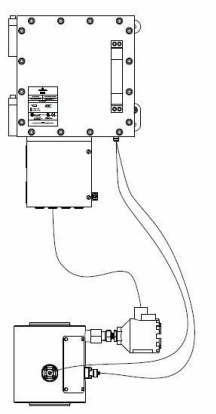
(4) *The values indicate absolute effect on percent water, except where % of reading (% o.r.) is indicated. Specifications require turbulent flow, for example, water droplets no bigger than 1/10th of the pipe diameter. Specifications in this column are applicable only if the TopCut option is included. The TopCut option requires a line density input from a densitometer, and provides a density-based estimation of % water if the watercut goes above the specified measurement of the meter.*

Ex safety details

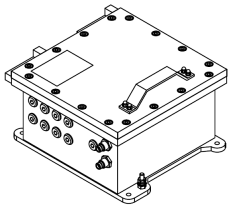
Figure 5: SS 316L Enclosure

The picture A is illustrating Watercut Meter flow computer Ex de with sensor, coaxial cables and temperature transmitter. B illustration shows Ex d Watercut Meter flow computer.

A



B



Certification		
	ATEX	**IECEx**
Roxar Watercut meter	II 2G Ex db eb [ib] IIB T4...T3 Gb with Ex enclosure	Ex db eb [ib] IIB T4...T3 Gb with Ex e enclosure
	II 2G Ex db [ib] IIB T4...T3 Gb without Ex e enclosure	Ex db [ib] IIB T4...T3 Gb without Ex e enclosure
Temperature transmitters (optional)	II 2G Ex db IIC T6...T1 Gb	Ex db IIC T6...T1 Gb
	II 1G Ex ia IIC T6...T4 Ga	Ex ia IIC T6...T4 Ga
Temperature sensor (optional)	II 2G Ex db IIC T6...T1 Gb	Ex db IIC T6...T1 Gb
	II 1G Ex ia IIC T5/T6 Ga	Ex ia IIC T5/T6 Ga
Sample taken box (optional)	II 2GD Ex db eb IIC T6 Gb	Ex db eb IIC T6 Gb

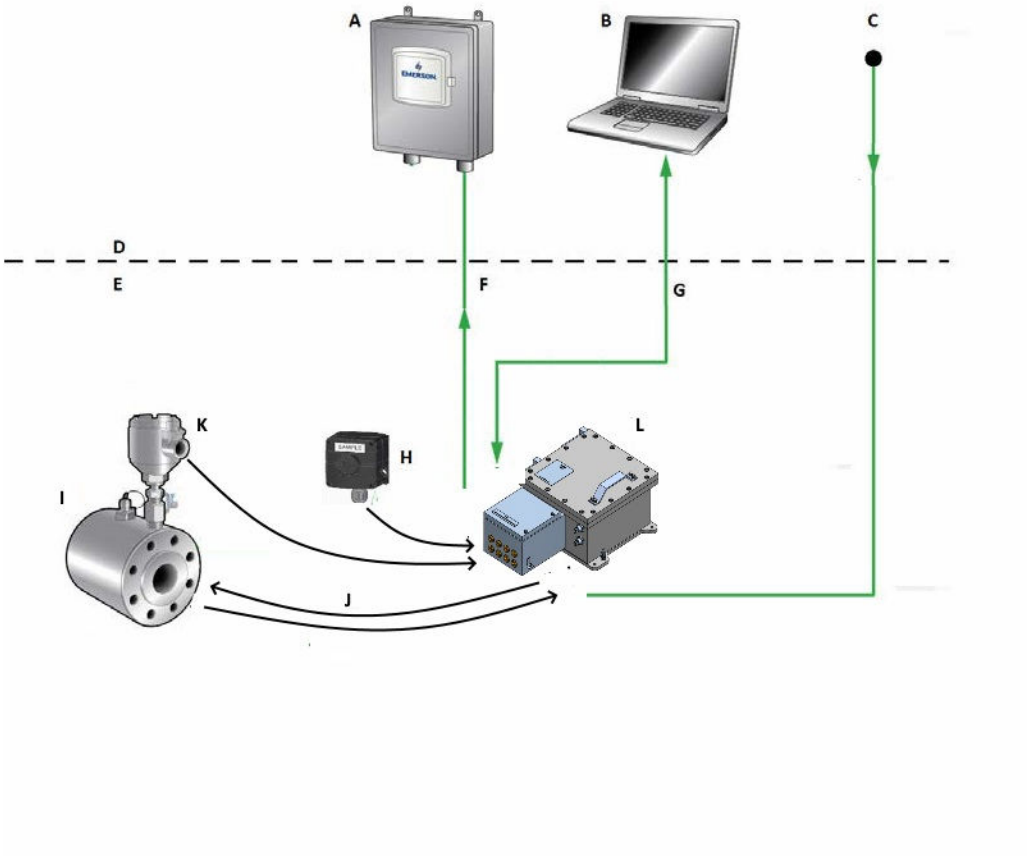
Installation requirements

The Roxar Watercut Meter should be installed in a location with a well-mixed flow.

- With flow rates lower than 1 m/s, additional mixing may be required. This mixing can be achieved by installing a static mixer, a blind-T or multiple pipe bends, or other instruments just upstream of the meter.
- The recommended maximum fluid velocity is 15 m/s for 1 to 4-inch meters and 7 m/s for larger sensors.

Important
A horizontal or vertical installation can be used. Because it assures the best mix of oil and water, vertical installation is preferred. An explosion-proof enclosure should typically be mounted within two meters of the meter body.

Figure 6: Typical Block Diagram for a Roxar Watercut Meter



A. DCS
B. Service PC
C. AC Power or DC power
D. Safe area
E. Hazardous area
F. Standard serial connections Modbus RTU, optional analog IO
G. Serial connection
H. Sample button box
I. Sensor
J. Coaxial cables (2)
K. Temperature transmitter and temperature sensor (if included in Roxar scope). Temperature transmitter cable (Roxar or client provided).
L. WCM Flow computer (Analog 4-20 mA/HART, MODBUS RTU over RS485)

Meter setup and calibration

During factory setup, the only test required is the determination of the resonance frequency of an empty sensor, which remains constant for the meter's life. A static calibration using known hydrocarbons is carried out as part of the factory acceptance test. In-line calibration can be periodically carried out comparing the meter to a representative sample.

Required customer information.

Provide the following required information to size and specify the Watercut meter:

- Minimum and maximum flow rates
- Fluid density
- Design pressure
- Design temperature
- Operating pressure
- Operating temperature
- Expected normal and maximum watercut

If there are any relevant client or project specifications that need to be considered, Emerson advises that these are sent as early as possible for review as they may impact cost and delivery. Emerson standard specifications for materials, documentation, and other services are more than sufficient to satisfy most requirements. In the event that these specifications are not received until purchase order placement, Emerson reserves the right to re quote with additional cost and delivery impact where applicable.

Options and services

Additional deliverables

Table 3: Roxar Watercut Meters Additional Deliverables

Deliverable	Definition
WFAT	Witness FAT according to Emerson standard procedure.
PMI	Positive Material Identification can be carried out upon request according to Emerson standard procedures.
Mounting stand and sunshield (recommended)	Stainless steel mounting stand for electronics enclosure including optional sunshield.
Temperature transmitter (recommended)	Rosemount, 644 series
Sample button box	

Post-delivery services

Table 4: Roxar Watercut Meters Post-Delivery Services

Service	Description
Class room training	One or two- days course for a minimum of 4 participants at an Emerson world area service center.
Installation & commissioning support	Ensures optimum set up for best performance and reliability.

Table 4: Roxar Watercut Meters Post-Delivery Services *(continued)*

Service	Description
Technical service agreements	Longer term service agreements with regular maintenance, 24/7 Help desk support, data analysis, spare parts to support ongoing operations, and secure long-term performance. For more details and to request a quotation for post-delivery services, please contact your local sales representative.

Flow Lifecycle services

As a critical component to any production process, you need to partner with a service provider that can ensure the integrity of your flow assets and help you maximize output, minimize cost, and manage risk.

Emerson's Flow Lifecycle Services understand the challenges and can help you overcome, improve, and progress your operation for the long term.

From an expanded network of service centers across the globe, Emerson offers access to local technicians and engineers for timely response and professional service support for the following:

- Installation, commissioning and start-up services
- Repair and maintenance services
- In situ (in-line) calibration
- Help desk service
- Original parts supply

Emerson-Certified Services

Emerson-Certified Services provide the following:

- Service Technicians and Engineers that are trained and certified according to rigorous standards and compliant with ISO 9001.
- Calibration, diagnostics and maintenance services follow approved processes by using certified equipment and original parts and delivering long lifetime and warranty for the products and services rendered.
- Certified service engineers are supported by Emerson Flow Global Support Teams offering them dedicated application experience to ensure the optimal solution for your challenges.

Refurbishment services

If Roxar instrumentation needs a major overhaul or repair, Emerson Service offers access to our ISO 9001:2004 certified manufacturing plants securing high quality workmanship and fast turnaround.

Performance evaluation services

By transforming measurement data into decisions, Performance Evaluation Services helps you build confidence in your decision-making process through clear and concise advice on integrity management and actionable recommendations for well and reservoir optimization.

Emerson can assist you in optimizing integrity and performance of assets safely through unmatched combination of instrument and analytic expertise, technical knowledge, and project experience.

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