Roxar Watercut meter

Emerson Process Management and its portfolio of Roxar Flow Measurement solutions is a pioneer in the development of microwave resonance technology for watercut measurement. Starting in the early 1990’s, we have built up a wealth of expertise and installations worldwide.

Roxar Watercut meters are installed across the world, often in some of the most challenging environments, both onshore and offshore.

With different models that measure from 500 ppm to 100% water, 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 our meters operate at peak performance throughout the field lifecycle. Roxar also offers a comprehensive portfolio of topside, subsea and downhole instrumentation and meters.
The Roxar Watercut meter uses microwave technology to measure the permittivity of any oil/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), due to 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 which results in the electron density on the oxygen atom being greater. This results in the water molecule having a positively charged side and a negatively charged side. Because of this, 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. As hydrocarbon molecules have a much more symmetrical structure and do not respond to the changing microwave field in the same way, they therefore have an insignificant affect on the propagation of the microwaves.

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

### Measurement Technology

#### Why microwave resonance technology?

A number of methods are used to determine the watercut. Unlike other methods, Roxar’s unique Microwave Resonance™ technology allows an energy peak to occur at a frequency defined solely by the contents of the sensor, unaffected by the temperature of the electronics, ageing and calibration etc. 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 $f_{mix}$ and the mixture permittivity $\varepsilon_{mix}$.

The Microwave Resonance™ frequency with empty sensor $f_{vac}$ is measured with high precision equipment at the factory and stored in each unit as a calibration constant. This means that the meter does not need periodic recalibration. This unique technology provides a number of advantages over all other watercut meter technologies. These include:

- Fiscal accuracy
- Long term repeatability (no drift)
- Sensitivity as low as 50 ppm water
- Independence from electronics temperature
- Measures full cross section of up to 32" pipe
- 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 data not being representative.

The Roxar Watercut meter solution ensures accurate results as the measurement is taken across the entire span of the flow, whereas an insertion probe, for example, is only able to provide measurement for the flow the sensor comes into contact with. Therefore should there be any variances in the water content within the flow, an insertion probe is challenged not only by its own accuracy uncertainty, but 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 means that the measurement is not susceptible to issues related to scaling, waxing etc. This compares to insertion devices which can be compromised when the measurement element is coated or damaged by deposits. In addition, 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.

Capacitance is a well established technology for measuring watercut. Whilst useful for applications with very stable process conditions and low watercuts, there are a number of limitations and in particular a dependency on periodic recalibration to...
Roxar Watercut meter

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:
- 2" – 3" standard sizes (FC)
- 1" – 12" standard sizes (LC/HC)
- 14" and upwards non-standard sizes (LC/HC)

Options:
- Top Cut Function*
- AutoZero
- AutoSalinity

*Extends LC/HC to 100% Watercut

AutoZero

AutoZero is a patented feature, only available with the Roxar Watercut meter. Using a density input from a densitometer or coriolis meter (typically 4-20mA or bi-directional serial connection), the Roxar Watercut meter can automatically compensate for changes in fluid density in real time. This ability is highly valuable as it gives operators confidence that even when properties of the fluids passing through the Roxar Watercut meter are changing (e.g. when testing multiple wells) then the meter will use the live measured density for optimum accuracy.

TopCut

The standard Roxar LowCut (LC) & HighCut (HC) Watercut meters 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 (requires AutoZero), and in this way is able to provide watercut readings up to 100%. This option is perfect when testing wells that are mainly in the 0-15% or 0-50% watercut range as it allows for measurements still to be achieved when the watercut exceeds the stated range of the meter.

Please note this feature can be retrofitted to most Roxar Watercut meters by our Service team as required.

AutoSalinity

AutoSalinity is a function exclusively for the FullCut (FC) meter, as it is implemented for water continuous conditions only. For the FC meter, the AutoSalinity function automatically compensates for the salt content in the water fraction. The meter interprets the microwave signal to find the salinity of the water, and then makes use of this to produce accurate measurements. LC and HC Watercut meters are not affected by varying salinity.

The AutoSalinity feature performs with all different types of salt and there is no need for the type of salt to be input. The AutoSalinity function actually measures conductivity, and uses this measured conductivity to correct watercut measurements.
General Information

Layout drawing aluminum enclosure

Layout drawing SS316L enclosure

| Meter body spool piece | Design temperature | -15 up to + 120° C (266° F) standard (can be extended to -29° C) 
-40 up to + 150° C (302° F) extended (available up to 10" WCM sizes) |
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<tr>
<td>Haz. area approval</td>
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<td>Roxar standard materials (see comments under the table)</td>
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<td>Manufacturing procedures</td>
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<td>Pressure drop</td>
<td>Max. 0.3 bar</td>
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<tr>
<th>Electronics Enclosure</th>
<th>Mounting</th>
<th>Typically 2 meters from spool piece</th>
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</table>
| Ambient Temperature   | -20 to 60° C (-29 to 140° F) Non-IS signal 
-20 to 48° C (-29 to 118° F) IS signal |
| Voltage Supply        | 18-24 VDC |
| Power Consumption     | Up to 24 W, max. 30 W at start-up |

<table>
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<th>Model</th>
<th>Rosemount 644 H</th>
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<td>0 - 100° C (32 - 212° F)</td>
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<tr>
<td>Accuracy</td>
<td>± 0.15° C</td>
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<tr>
<td>Interface</td>
<td>4 - 20 mA HART</td>
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| Digital I/O             | Transmission Length | 1200m (RS 485) |

PED certification is provided for all meters to be delivered in Europe, with the exception of the 1" LowCut meter as its small size falls outside the requirements of this certification.

1" - 4":
Standard: Duplex UNS S31803 NACE MR 0175, ISO 15156
Non Standard: SS316, others on request.

6" upwards:
Standard: carbon steel NACE MR 0175, ISO 15156
Non Standard: SS316, others on request.
Performance Specifications

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<th>LowCut</th>
<th>HighCut</th>
<th>FullCut</th>
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<tr>
<td>Calibration method</td>
<td>In-line(^2)</td>
<td>In-line(^2)</td>
<td>In-line(^2)</td>
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<tr>
<td>Range</td>
<td>0-1%(^4)</td>
<td>1-15%</td>
<td>± 0-1%(^4)</td>
</tr>
<tr>
<td></td>
<td>15-100%</td>
<td>1-50%</td>
<td>15-100%</td>
</tr>
<tr>
<td></td>
<td>± 5%</td>
<td>± 5%</td>
<td>± 5%</td>
</tr>
<tr>
<td>Uncertainty(^1)</td>
<td>±0.05%</td>
<td>±0.05%</td>
<td>±0.05%</td>
</tr>
<tr>
<td></td>
<td>± 5% o.r.</td>
<td>± 5% o.r.</td>
<td>± 5% o.r.</td>
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<tr>
<td>Repeatability(^1)</td>
<td>±0.01%</td>
<td>±0.05% (typ)</td>
<td>±0.01%</td>
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<tr>
<td></td>
<td>±0.25% (typ)</td>
<td>±0.05%</td>
<td>±0.25% (typ)</td>
</tr>
<tr>
<td>Sensitivity(^1)</td>
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<td>±0.25% (typ)</td>
<td>±0.005%</td>
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<tr>
<td></td>
<td>±0.05%</td>
<td>±0.05%</td>
<td>±0.05%</td>
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<tr>
<td>Response time</td>
<td>0.4 - 0.7s</td>
<td>1s</td>
<td>0.4 - 0.7s</td>
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<tr>
<td></td>
<td>1s</td>
<td>1s</td>
<td>0.7s</td>
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<tr>
<td>Effect of temperature variations</td>
<td>Automatic compensation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of density variations</td>
<td>0.027% water per 1 kg/m³ (Automatic compensation with AutoZero option)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of pressure variations</td>
<td>0.0025% water per 1 bar (Automatic compensation with AutoZero option)</td>
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</table>

1. The values indicate absolute effect on % water, except where % of reading (% o.r.) is indicated. Specifications require turbulent flow, i.e. water droplets no bigger than 1/10th of pipe diameter.

2. 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.

3. Specifications in this column are only applicable 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 range of the meter.

4. The uncertainty in this range is given at 95% confidence interval (approximately 2 std. 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 (std. deviation) is approximately half of the given figures, i.e. ± 0.025%.

Ex-enclosure Details

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<th>IECEx</th>
<th>CSA</th>
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<td>IECEx II 2G Ex d e[ib] IIB T6 Gb</td>
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<td>Stainless Steel</td>
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<td>70 kg</td>
<td>40 kg</td>
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<td>Size (W x H x D)</td>
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<td>665 x 360 x 215 mm</td>
<td>444 x 413 x 266 mm</td>
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<td>Cable entries</td>
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<td>6 x M20</td>
<td>4 x 1/2&quot; NPT, 2 x 3/4&quot; NPT</td>
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<td>Temperature transmitters (optional)</td>
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<td>EEEx d IIC T6</td>
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Installation Details and Requirements

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 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 7 m/s. Higher velocities are possible and should be checked with Roxar.

Horizontal or vertical installation can be used. An explosion proof enclosure should typically be mounted within 2m of the meter body.

Meter set-up and calibration

During factory set up, the only test required is the determination of \( f_{\text{vac}} \) which remains constant for the meter’s life.

A static calibration using known hydrocarbons can also be carried out as part of the factory acceptance test. Inline calibration can be periodically carried out comparing the meter to a representative sample.

Customer information required

For Budget Quotations, a price and delivery estimate can be provided on the basis that pipe size, flange rating and water % range are provided.

For Firm Quotations (and to be confirmed before placing any Purchase Order) then the following additional information should be provided:

- Minimum and maximum flow rates
- Fluid density
- Design Pressure
- Design Temperature
- Operating Pressure
- Operating Temperature

If there are any relevant client and/or project specifications that need to be considered, we advise that these are sent as early as possible for review as they may impact cost and delivery. In our experience, Roxar standard specifications for materials, documentation etc. are more than sufficient to satisfy most requirements. In the event that these types of specifications are not received until Purchase Order placement, then we reserve the right to re-quote with additional cost and delivery impact where applicable.
Options, documentation and service

Additional deliverables

Indicates which types of additional deliverable options are available:

**WFAT**
Witness FAT according to Roxar standard procedure.

**PMI**
Positive Material Identification can be carried out upon request and would be performed in accordance to EN 10204/3.1.

**PAINT**
Can be offered according to Roxar standard painting procedure. Customer should specify whether meter body painting requested or electronics enclosure painting requested. Customer should specify whether the meter body will be insulated after installation as this determines the paint system that is used.

**MOUNTING STAND AND SUNSHIELD**
Stainless steel mounting stand for electronics enclosure including optional sunshield recommended for ambient temperatures higher than 60 degrees Celsius.

**COAX 3.5**
1 pair, 3.5m long coaxial cables (24VDC only, can be provided on special request).

Spare parts

**COAX 1**
1 pair, 1m long coaxial cables

**COAX 2**
1 pair, 2m long coaxial cables

**TEMPERATURE TRANSMITTER**
Rosemount, 644 series

Documentation

Indicates which types of documentation options are available:

**STDDOC**
MRB, including pressure test report, material certificates, welding & test records etc., included with delivery. Please refer to VDL, page 17 of the brochure.

**CDF**
Roxar standard documentation plus customer front pages and decals.

**CUSTDOC**
Client specific documentation – 1 review cycle only.

Post delivery services

To get the most out of your equipment, Roxar can provide a full range of post delivery services including:

**Class room training**
Typically a two day course for a minimum of 4 participants at a Roxar world area service centre.

**Installation & commissioning support**
To ensure the optimum set up for equipment performance.

**Technical service agreements**
Longer term service agreements with regular maintenance, 24/7 helpdesk support, data analysis, spare parts etc. 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 or e-mail roxar.gsc@emerson.com.

Additional options

**Densitometer**

The Roxar Watercut meter can utilize density taken from a Densitometer in order to provide automatic compensation for changing fluid density.

We recommend MicroMotion Densitometers and can offer these as part of an integrated offer.

Customer-specific coating

If customers have specific project requirements for the coating of meter bodies or the electronics enclosure, it is possible that this can be accommodated at additional cost on the basis that the
appropriate specification is sent to Roxar for review in advance of any Purchase Order placement. Customers should specify whether the meter body will be insulated after installation as this determines the paint system that is used.

**Coriolis meter**

The Roxar Watercut meter can utilize density and flow measurements taken from a Coriolis flow meter in order to provide automatic compensation for changing fluid density and enable calculation of dry oil and water flow rates.

We recommend MicroMotion Coriolis flow meters and can offer these as part of an integrated offer for any two phase flow measurement solution where water and oil determination is needed.

**Flow Lifecycle Services**

As a critical component to any production process, you need to be able 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 we offer access to local technicians and engineers for timely response and professional service support for:

- Installation, Commissioning and Start-Up Services
- Repair and Maintenance Services
- In situ (inline) Calibration
- Helpdesk Service
- Original Parts Supply

Emerson-Certified Services secure:

- Service Technicians and Engineers that are trained and certified according to rigorous standards and compliant with ISO9001.
- Calibration, diagnostics and maintenance services follow approved processes by using certified equipment and original parts delivering long lifetime and warranty for the products and services rendered.
- Certified Service Engineers are supported by Roxar Global Support Teams offering them dedicated application experience to ensure the optimal solution for your challenges.

**Educational Services**

Knowledge of process control devices within a plant is often passed down from generation to generation. At the same time, if advances in process technology and methodology usually brought about by training aren’t brought into the plant, in-house standards for device setup and maintenance can become based on outdated theory. Emerson Educational Services has made a global commitment to helping our customers find and keep that promise of performance. Roxar Watercut meters are supported by a practical classroom conducted training program.

The aim of the course is to enable participants to take full advantage of the meter in real applications. Upon completion of the course participants should be able to efficiently run the instrument their own including delivering on-site quality reliable data, do normal routine maintenance, fault finding and troubleshooting.

Courses are run by certified instructors who combine their understanding of theory with their unrivalled, on site practical experience.

**Factory Calibration and Refurbishment Services**

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

**Performance Evaluation Services**

Transforming Measurement Data into Decisions

Performance Evaluation Services help you build confidence in your decision-making process through clear and concise advice on integrity management and actionable recommendations for well and reservoir optimization.

We are able to assist you in optimizing integrity and performance of assets safely through unmatched combination of instrument and analytics expertise, technical knowledge and project experience.

For more information on services contact us at roxar.gsc@emerson.com.
## Vendor Document List

<table>
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<tr>
<th>Doc No.</th>
<th>Rev.</th>
<th>Administrative Project Information</th>
<th>Delivered</th>
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### Design Information

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### Fabrication Information

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WP: With Proposal  
WAOA: Weeks After Order Acknowledgement  
WAD: Weeks After Delivery

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