



Optical Multiphase Flowmeter

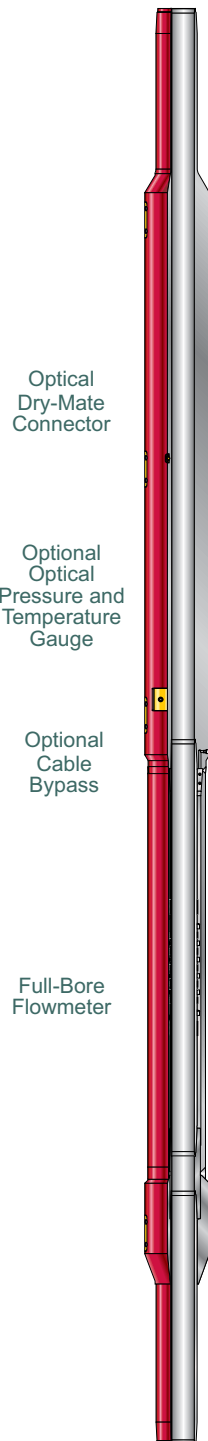
Weatherford's optical multiphase flowmeter delivers accurate, real-time measurements of downhole oil, gas, and water flow rates, enabling better production and reservoir management decisions and increased flexibility in well completion options. Typical applications for the multiphase flowmeter include on-demand production monitoring and allocation in single- and multi-zone completions.

The optical multiphase flowmeter technology is based on a flow-velocity measurement and a speed-of-sound measurement where the speed of sound is proportional to volume fraction of oil, water, and gas in the flowing mixture. The flowmeter is deployed as part of the production tubing and is typically integrated with one or two Weatherford optical pressure and temperature gauges ported to tubing and/or annulus. Each flowmeter is designed to fit specific completion requirements and is available in tubing sizes ranging from 2-3/8 to 5-1/2 in., with other sizes available on request.

Weatherford's optical flowmeters are field-proven in installations ranging from oil producers to high-rate gas condensate wells. Weatherford also offers a single-phase flowmeter designed for zonal allocation in water, gas, or water-alternating-gas (WAG) injectors.

Applications

- Zonal allocation in multi-zone intelligent completions.
- Identification and localization of production anomalies in real-time.
- Direct determination of well productivity index.
- Reduction of surface well tests and surface facilities.
- Subsea installations with fiber in the umbilical. Weatherford offers wet-mate optical connectors for both horizontal and vertical trees. The optical flowmeter allows for a distance of up to 31-mi (50-km) between in-well flowmeter and surface integration system.



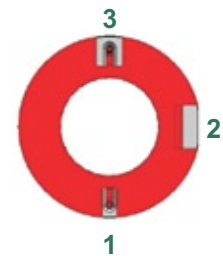


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Features, Advantages and Benefits

- Flowmeter is completely non-intrusive and allows for full through-bore access.
- Flowmeter is 100 percent optical, with no sensors exposed to well fluids. This design ensures high resilience to erosion and corrosion and measurement that is not affected by solid content in the flow.
- Low component count, no moving parts, and passive sensors make the flowmeter highly reliable; all complex components are located at the surface.
- Flowmeter measurement cannot drift and offers excellent long-term stability.
- Bi-directional flow measurement makes the flowmeter capable of measuring interzonal crossflow in multi-zone completions.
- Full-bore design means no flowing pressure loss.
- Rugged, shock-resistant design can handle perforating and hydraulic fracturing operations.
- Flowmeter is intrinsically safe, with no electrical energy downhole or at the wellhead.
- Multiple optical sensors, including pressure and temperature, seismic, distributed temperature sensing (DTS), and single-phase and multiphase flow, can be combined on a single cable for completion design flexibility.
- Flowmeter software can be configured to measure two-phase oil and water flow rates or liquid and gas flow rates.
- Flowmeter software offers integrated pressure-volume-temperature (PVT) for volume conversions and reports flow rate at downhole and surface conditions.
- Flowmeter is integrated with Weatherford's Reservoir Monitoring System (RMS) and offers numerous options for data interface, storage and analysis.

Cross-Sectional View



- 1 Annulus or Tubing Ported Pressure and Temperature Gauge
- 2 Cable Bypass
- 3 Optical Dry-Mate Connector

Options

- Integrated optical pressure and temperature gauge. One or two gauges can be connected and ported to annulus and/or tubing. Flowmeter and pressure and temperature gauges share one optical cable and a single dry-mate optical connector.
- Cable bypass slots for control lines.



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Specifications

| Performance Data | |
|--|--|
| Volumetric flow rate accuracy | ±1% (of measurement) |
| Flow rate accuracy, oil-water | ±5% (0 to 100% WLR) |
| Flow rate accuracy, liquid-gas | ±5% (<30% or >90% GVF) |
| | ±20% (30 to 90% GVF) |
| Turndown ratio (maximum/minimum flow rate) | >20 |
| Minimum flow velocity | Liquid: 3 ft/sec (0.9 m/sec) |
| | Gas: 10 ft/sec (3 m/sec) |
| Pressure rating | 10,000 psi (690 bar) ^a |
| Operating temperature | Standard: 77° to 257°F (25° to 125°C) |
| | High Temp: 77° to 302°F (25° to 150°C) |
| Storage temperature | Standard: -58° to 257°F (-50° to 125°C) |
| | High Temp: -58° to 302°F (-50° to 150°C) |
| Vibration | 15 g rms, random |
| | 10 to 2,000 Hz (Nav Mat) |
| Shock | 100 g, 10 ms half sine |
| Material | INCONEL® 718 |
| | Super Duplex 25 Chrome |
| Maximum tension and compression load | Contact Weatherford |
| Connections (pin x pin) | Premium ^b |
| Maximum fiber step-out length | 31 mi (50 km) ^c |
| Fiber-optic connector | 3-pin dry-mate |

^aPressure rating depends on flowmeter size, material, and options. Contact Weatherford for pressure rating of a specific design.

^bPremium connections are manufactured to client specifications.

^cMaximum step-out length depends on well design.

| Dimensions and Data ^{a, b} | | | | | | | | | |
|-------------------------------------|-------------------|------------|-------|------------|-------|--------------------------|-------|--------------------------------|---------------------|
| Size ^c (in.) | Weight (lb/ft) | Minimum ID | | Maximum ID | | Standard OD ^d | | Minimum Flow Rate ^e | |
| | | (in.) | (mm) | (in.) | (mm) | (in.) | (mm) | (bbl/d) | (m ³ /d) |
| 2-3/8 | 4 to 5.8 | 1.867 | 47.4 | 2.041 | 51.8 | 4.375 | 111.1 | 1,000 | 159 |
| 2-7/8 | 6.4 to 8.6 | 2.259 | 57.4 | 2.441 | 62.0 | 4.875 | 123.8 | 1,500 | 239 |
| 3-1/2 | 9.2 to 10.2 | 2.922 | 74.2 | 2.992 | 76.0 | 5.500 | 139.7 | 2,150 | 342 |
| 4-1/2 | 12.75 to 15.1 | 3.758 | 95.5 | 3.958 | 100.5 | 6.500 | 165.1 | 3,500 | 557 |
| 5-1/2 | 17 to 20 | 4.778 | 121.4 | 4.892 | 124.3 | 7.500 | 190.5 | 6,000 | 954 |

^aFlowmeter dimensions are designed to client specifications.

^bFor gas or multiphase, contact Weatherford for a detailed analysis.

^cOther sizes are available on request.

^dStandard ODs without cable bypass or integrated pressure/temperature gauge.

^eMinimum flowrate assumes liquid flow at flowmeter conditions.

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