

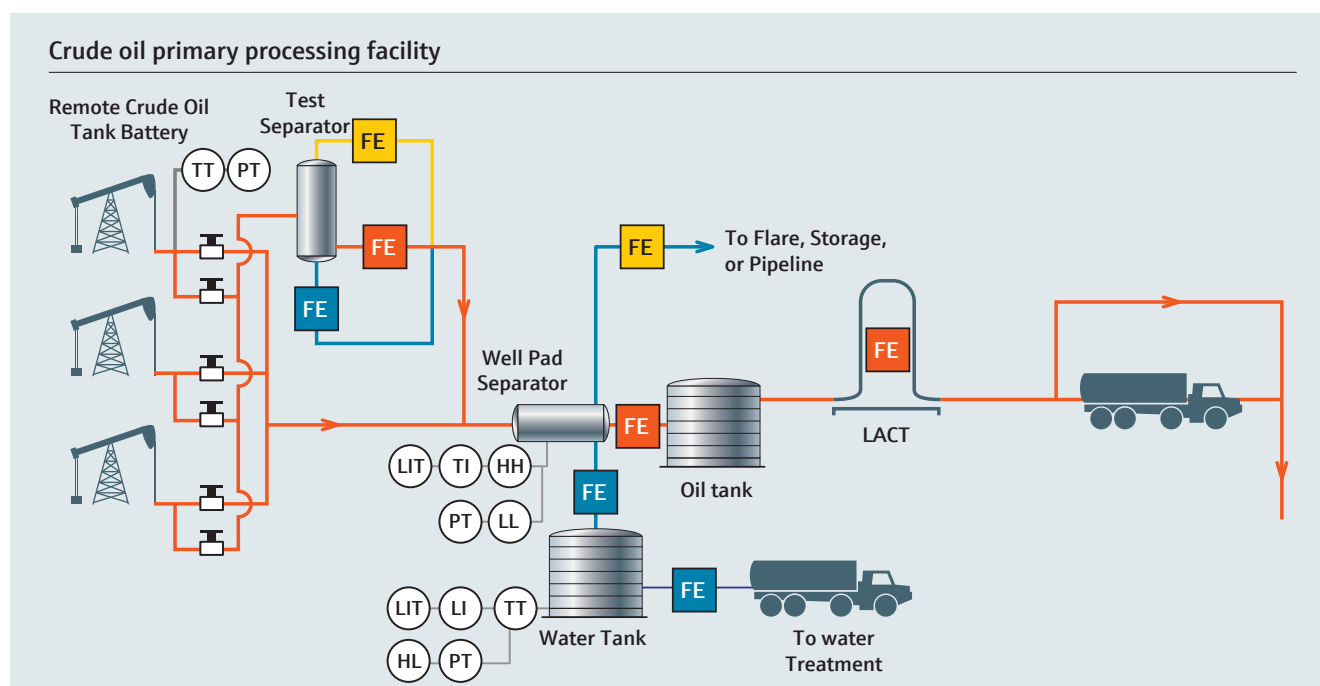
Optimize crude oil separation

Higher quality product with
efficient and safe operations



Supporting you in separation process applications

Crude oil, produced water and natural gas primary processing



Crude oil field processing includes one or more separation stages. Regardless of its specific complexities related mainly to the crude oil characteristics, the basic separation functions involve:

- Separating the crude oil from any entrained or emulsified water or brine
- Removing solids
- Separating entrained or free gas from the crude oil
- Stabilizing the crude oil by removing dissolved gas for safe transportation and storage

Accurate and reliable quantification of each phase of fluid coming from the separator, namely, produced water, natural gas and crude oil, is crucial for the separator operation. Fluids include produced water, natural gas and crude oil.

Other measurements required for the proper separation operation include the crude oil and continuous water levels (oil level and water or interface level), pressure and temperature.

However, consistent measurements of every relevant variable in the separation process can be affected by:

- The presence of emulsion rag layers in between the crude oil and the produced water
- Heavy and extra heavy crude oil (low oAPI and viscosity)
- Abrasive and contaminated produced water
- Highly corrosive gas stream (i.e. H₂S and water presence)

Endress+Hauser measurement technologies allow you to obtain not only reliable measurement results but also to optimize the separation process. This reduces operation costs and maximizes operator and asset safety.

Tradition versus innovation

Old technologies are affected by the variability of the fluid properties and process conditions

Traditionally, float devices have been used overall and for interface level measurement in separation vessels due to its low cost, easy installation and its well-known use. But these mechanical devices are typically affected by the following effects:

- Changes to the shape of the float due to warping
- Highly sensitive to the fluid densities
- Build up on the float which may cause inaccurate level measurement

In addition to the previous limitations, point level detection for low or high level alarm implemented with float technologies are unable to be tested online. Furthermore, the instrument cannot implement self-diagnostic procedures. These procedures are key factors in order to reduce the failure rates on demand.

Consequences of employing these technologies are related to:

- **High maintenance:** Moving parts that result in continuous tweaking of the floats to get quality back in check.

- **Loss of crude oil quality:** Every drop of oil costs you money. Therefore, you need to increase the quality of the produced oil by removing sufficient water, according to the quality specification of the process.

- **Poor environmental conformance:** Every spill must be reported to local environment agencies. This could result in fines and severe environmental damages.

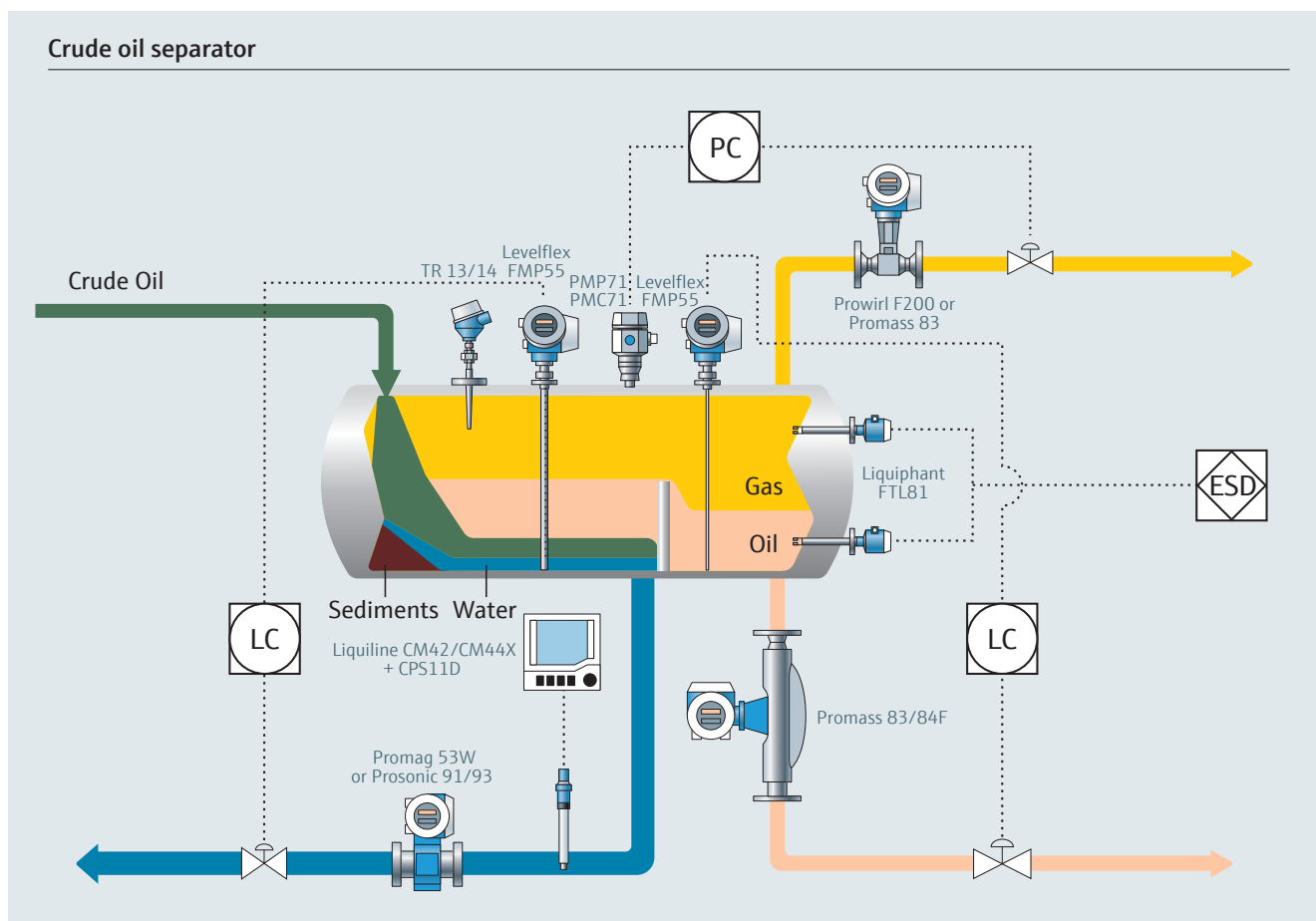
As result of years of innovation, Endress+Hauser offers you the Levelflex FMP55 Guided Wave Radar (GWR) with Sensor fusion. This instrument is the first capacitive and GWR combination in the same device. It has been designed to overcome the previous mentioned consequences of the process conditions.

The instrument guarantees safe measurement values acquisition of level and interface level simultaneously, even in presence of emulsion layers. The FMP55 sets new standards for multi-parameter level and interface level measurement, especially in the crude oil separation applications in Oil & Gas Industry.



Controlling the vessel levels

Combining technologies to obtain the best result



No matter the type of separator operated in a crude oil processing facility, the proper control of the fluid levels in both sections of the separator is crucial to assure stable, efficient and safe operations.

To reach this goal accurately, robust and repeatable level measurements are required. This must be reached regardless of the variability of the process and the characteristics of the fluids. This includes undesired conditions, such as high viscosity, presence of foam and emulsion layers thicker than 2 inches (5 cm) or dragged solids (sand or rocks).

Combining two different technologies, GWR and capacitive probe level measurement, the Levelflex FMP55 is able to maintain a reliable product and interface level measurement even in presence of the emulsion layer.

The instrument features virtually no maintenance, no moving parts, lifetime calibration and no risk of blocking due to build up. This can reduce operation costs and the risk of unplanned shut down. Resulting in increased plant availability and efficiency.

Considering the features mentioned, the substitution of old technology level sensors, those based on floats or displacers, represents a total benefit for you, including a very good measurement performance even with changing media.

Continuous and point level measurement

Accuracy and safety

Levelflex FMP55, our guided wave radar with coaxial probe, eliminates many process influences that may occur. The sensor comes pre-calibrated and can be used “out of the box”. This ensures an easy retrofit of existing separators. The sensor can be installed directly into the separator, or in a side pipe (bypass or bridle).

The same sensor can be used in the separation compartment and also in the oil compartment of the separator. This simplifies spare parts requirements.

Point level detection is one of the most important safety related variables of the unit. But dealing with sticky fluids is a big limitation for traditional level switches based on mechanical principles. Low or high level alarm conditions in the separator are consistently detected with Liquiphant FTL81, our vibronic point level detector. This SIL3 capable device is ready to be inserted in Safety Instrumented System (SIS) loops, intended to reduce the associated risks down to tolerable values.

High SIL rating for safety service

Instruments developed in accordance with IEC 61508/IEC 61511 with fail-safe and online diagnostics capabilities are able to provide the Safety Integrity Level (SIL) required to be part of the designed System Instrumented System (SIS).



Liquiphant (FTL81) is a tuning fork SIL3 capable point level detector, designed to fulfill the most stringent safety requirements in this kind of applications. Nivotester (FTL825) used in conjunction with FTL81 allows the continuous verification of the entire measuring system, including control and signal devices, by means of proof test button or activated from the HMI of the control system. FTL825 can be located in a separated field control cabinet or even the control room.



www.us.endress.com/SIL



Levelflex FMP55

- Reliable measurement even for changing product and process conditions
- HistoROM data management for easy commissioning, maintenance and diagnostics
- Highest reliability due to Multi-Echo Tracking
- Seamless integration into control or asset management systems
- Intuitive user interface in national languages
- Use in safety systems requiring functional safety up to SIL3 in accordance with IEC 61508 Ed.2.0/ IEC 61511-1/ISA 84-1
- Hardware and software developed according to IEC 61508 (up to SIL3)
- Easy proof test with interval up to 3 years



www.us.endress.com/FMP55



Liquiphant FTL81 (FailSafe)

- Use in safety systems requiring functional safety up to SIL3 in accordance with IEC 61508 Ed.2.0/ IEC 61511-1/ISA 84-1
- Easy integration via the switching unit (Nivotester FailSafe FTL825) with a two-channel output (safety contacts)
- Proof testing interval up to 12 years
- Permanent self-monitoring/internal redundancy
- Slave devices tested at the press of a button
- No adjustment: quick, low-cost startup
- No mechanically moving parts: no maintenance, no wear, long operating life
- Monitoring of fork for damage, corrosion, buildup and mechanical blocking
- Two process seal (2nd line of defense)



www.us.endress.com/FTL81

Dynamic measurements in three phases

The best performance for each flow measurement principle

Selecting the proper flowmeter for each fluid phase in a separator means to fulfill quite different and stringent measurement requirements, including:

- Produced water high pressure and abrasive behavior with presence of sand and solids drags
- Wet and sour natural gas stream prone to be corrosive
- Viscous, heavy and extra heavy crude oil
- Low pressure loss requirements of the flow metering instruments

Each one of these phases must be measured with accuracy and high repeatability.

We provide a set of unique flow measurement instruments, particularly suitable for each of these applications, from advanced Coriolis mass flowmeters to the traditional differential pressure, including consistent alternatives that increase your operational efficiency and drastically reduce maintenance costs.

Flow measurement instruments features and benefits



Promass F

- Highest performance regardless of the fluid properties
- Multivariable flow measurement with density and temperature
- Smallest footprint and space-saving installation
- Enhanced Measurement Accuracy (EMA) capability



Promag

- High pressure and abrasion resistance
- Energy-saving flow measurement – no pressure loss due to cross-section constriction
- Maintenance-free – no moving parts
- Easy calculation – bidirectional totalizers
- Automatic recovery of data for servicing



Prowirl

- High availability – proven robustness, resistance to vibrations and temperature shocks
- No maintenance – lifetime calibration
- Built-in inlet run correction
- AGA NX 19 and AGA 8 natural gas property calculations available



Prosonic

- Easy, safe and menu-guided sensor-mounting ensures precise measuring results
- Long-term system integrity thanks to robust sensor and industrial mounting kit design
- Automatic frequency scan for optimized installation and maximum measuring performance
- Available as insert version



Deltatop + Deltabar

- Operational compact version or modular remote version
- Measurement method is globally standardized according to AGA Reoprt No.3 and ISO 5167



www.us.endress.com/Flow

Measuring the right operating conditions

Temperature and pressure - beyond commodity measurements

Temperature and pressure in a separator are complementary variables and are required to reference volumetric measurements. Separator, as a pressurized vessel, requires strict pressure/temperature monitoring, because of the process operating and safety conditions. Monitoring temperature is always required in order to guarantee the right conditions for the separation process. PMC71/PMP71/PMP75 as well as RTD assemblies T13/T14, TR61/TR66 allow reliable measurement of these variables.

Sensor-thermowell assembly

Sensor-thermowell assembly must withstand permanent severe conditions, including residual vibration. The iTHERM Strong Sensor-QuickSens, with a globally unique fully automated production line that consistently combines the fastest response times for optimum process control and unsurpassed vibration resistance (> 60g), should be used for ultimate plant safety



www.pa.endress.com/temperature

Features and benefits

Omnigrad assemblies

- Long term stability RTDs sensors ($\leq 0.05\%$ per year)
- Thermowell design fulfilling ASME PTC 19.3
- RTD StrongSensor withstands up to 60g vibration
- Vanstone design available as standard

The Vanstone type thermowell

The Vanstone type is a special thermowell concept where the stem and the flange are built as independent pieces. A part of the thermowell stem is shaped as a collar, being clamped between two flanges to be fixed inside the process.



www.pa.endress.com/thermowell

Features and benefits

Vanstone Thermowell

- Stem and flange separately handled
- Reuse the flange if the thermowell is replaced
- Reduced spare parts concept: One flange can be used for a variety of thermowells

Ceramic and metallic diaphragm pressure

Our ceramic and metallic diaphragm pressure sensors are designed and built with your specific application in mind. Ceraphire and TempC membrane technologies guarantee the instruments high performance and long term stability in harsh process conditions.

Features and benefits

Cerabar

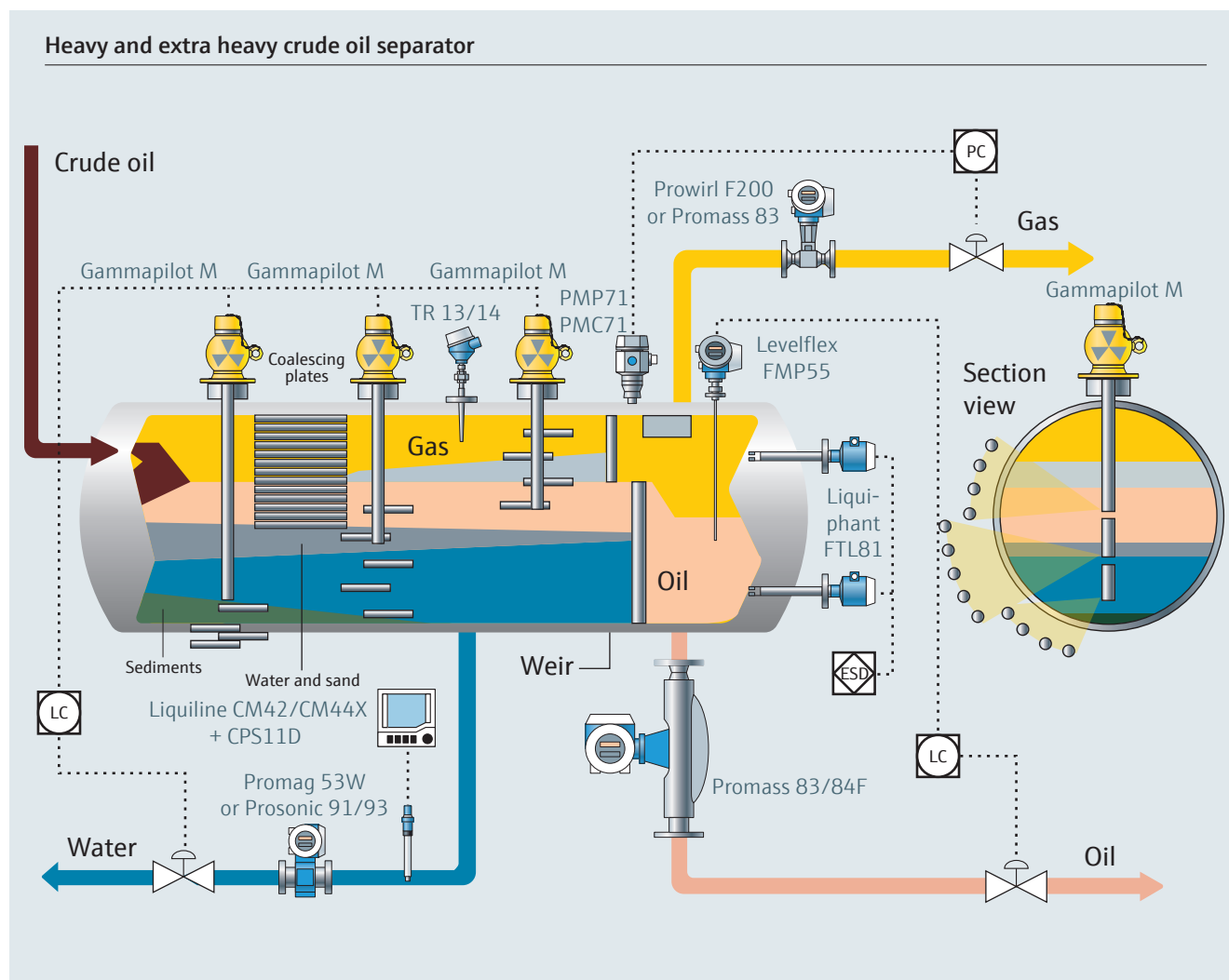
- Based on Ceraphire and TempC membrane technologies
- High reference accuracy down to 0.025%
- Turn down up to 100:1, higher on request
- SIL 3 capable IEC 61508 by TÜV SÜD



www.us.endress.com/pressure

Layers of oil, emulsion and water precisely determined

Dealing with heavy and extra heavy crude oils



Knowing the position and thickness of the oil/water separator is essential to control the dosing of the demulsifier and other additives.

Moreover, if the interface is not reliably monitored, water may flow over the weir and lead to problems in downstream processes. If the interface is too low, oil could be withdrawn instead of water. This can result in financial loss and environmental pollution.

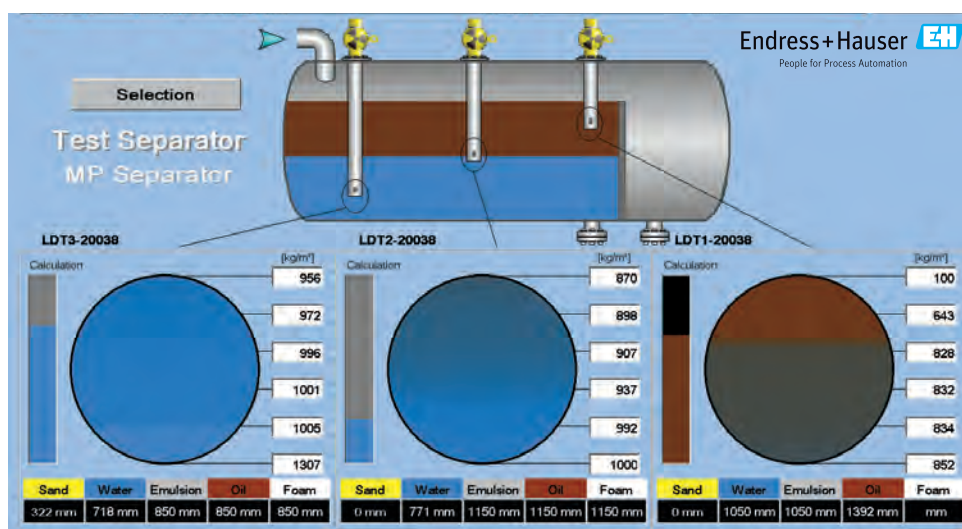
In the case of extra heavy and heavy crude oils, traditional technologies fail when dealing with very heavy and viscous fluids.

Endress+Hauser's Profile Vision is a "proven-in-use" solution based on Gammapiilot M that fits these specific process requirements by precisely determining the presence and thickness of each layer in every section of the separator.

Locate each fluid layer accurately

Density profiling with Profile Vision

Profile Vision allows you to represent the separator divided into density detection sections. A density profile is obtained for each section. Specific objectives of the profiling can be developed for each section. Visualization of different interface levels is possible for each section (sand, water, emulsion, oil and foam). At the end you know precisely where each layer of fluid is located and its thickness. With this information it is not possible to effectively:



Profile vision screen

- Guarantee the availability of the separator's entire volume by detecting and removing the presence of sand and rocks built-up in the bottom
- Save costs related to overdosing of chemicals additive (surfactants, foam reducers and others) by measuring the thickness of each layer
- Optimize the separator operation by measuring and controlling the crude oil level at the top

GammapiLOT radiometric set: features and benefits

FMG60 scintillator

- Multifunctional compact transmitter: One instrument for all measuring tasks which results in cost savings in spare parts and maintenance
- Highest availability, reliability and safety, even for extreme process and ambient conditions
- Highest sensitivity and accuracy at lowest dose rates (ALARA principle)
- Aluminium or stainless steel housing 316L for heavy-duty applications
- 4 to 20mA output for simple plant integration
- SIL2/3 approval in accordance with IEC 61508
- Temperature compensation for density measurements



FSG60-FSG61/FQG63 sources/source container

- Reliable measurement due to lightweight container and almost spherical design which provides optimized screening
- Compact, easy-to-mount device with the possibility of various angles of emission for optimum adaptation to the application
- Manual or pneumatic switching on/off and padlock, cylinder lock or locking bolt for fixing the switching position
- High safety (DIN 25426/ISO 2919) and safe and easy source replacement switch status easily identified
- High safety operation based on standards DIN 25426/ISO 2919
- Switch status easily identified



Continuous analytical measurements

Controlling your operational efficiency and environmental impact

Online monitoring of the produced water analytical parameters such as pH, conductivity and turbidity allows early deviation detection and reduces the consequence of these abnormal conditions.

The traditional approach is offline analysis of the produced water developed in a specialized laboratory. These lab tests are executed periodically, but rarely more than once a day. This means it may be too late when a deviation is detected.

Current operational requirements demand the use of expensive additive, which is intended to reduce environmental impact, corrosive effect or even to accelerate the separation function.

Considering the high water to oil ratio existing in a significant amount of wells and in addition to increased regulatory scrutiny, online analysis of produced water are important measurements. These measurements will prevent:

- Additive overuse
- Water phase contamination
- Increased environmental impact

Continuous pH, conductivity and even turbidity measurements give you reliable information to execute the required actions in a timely manner. Operational and environmental damages can be prevented or drastically reduced. In addition, the separator operation will be safer and more efficient.



www.us.endress.com/Analytics



Memosens: inductive transfer of data non affected by moisture, water or corrosion

Features and benefits Liquiline family

- Memosens: Plug & play laboratory-calibrated sensors
- Maximum process safety through non contact connection
- Inductive signals transmission
- Predictive maintenance system detects when a sensor needs to be cleaned, calibrated or replaced
- Less storage thanks to modular design
- Two-wire Ex transmitter
- Easy sensor replacement with automatic sensor recognition



Turbidity sensor OUSTF10 with Ex version
















Liquiline CM42 transmitter

Crude oil separator application matrix

The right choice for your measurement application

We provide you the most complete instrument basket for each of your measurement points. This wide-range proposal allows you to select the exact right approach for each separator variable. Resulting in maximum benefits by operating your crude oil separator with the lowest cost and in the safest conditions.

Application	Instrument	
Continuous crude oil and produced water (interface) level in inlet section	Levelflex FMP55	
Continuous crude oil level in output section	Levelflex FMP54	
Crude oil and produced water stratification layers (density profiling)	Gammapiilot M	
Alarm levels Low, Low-Low, High and High-High for ESD	Liquiphant FTL51/81 + Nivotester FTL 825	
Crude oil output flow rate	Promass 83/84F	
Produced water flow rate	Promag 53W Prosonic 91/93	
Natural gas (or accompanying gas) output flow rate	Prowirl F 200 (Promass 83/84F)	
Separator temperature	T13/14 assembly (sensor + transmitter+ thermowell)	
Separator pressure	Cerabar PMC71/PMP71	
Produced water pH	Liquiline CM42 + CPS11D	
Produced water conductivity	Liquiline CM42 + CLS50D	
Produced water turbidity	CVM40 + OUSTF10 Ex version	

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