ABB MEASUREMENT & ANALYTICS | APPLICATION NOTE

Electromagnetic flowmeter for the oil and gas industry

Application guide

ProcessMaster
electromagnetic flowmeter

Measurement made easy

Introduction

For decades ABB's flow measurement products deliver reliability, accuracy, repeatability and easy maintenance.
Customers worldwide benefit from our application-oriented know-how and comprehensive service.
Did you know? ABB is one of the world's largest automation suppliers to the oil and gas industry.

ABB has responded to the needs of the oil and gas industry adding features to the practice proven electromagnetic flowmeter-range in order to serve the industries' demanding flow measurement applications.
To learn more about our extensive portfolio visit abb.com/measurement.

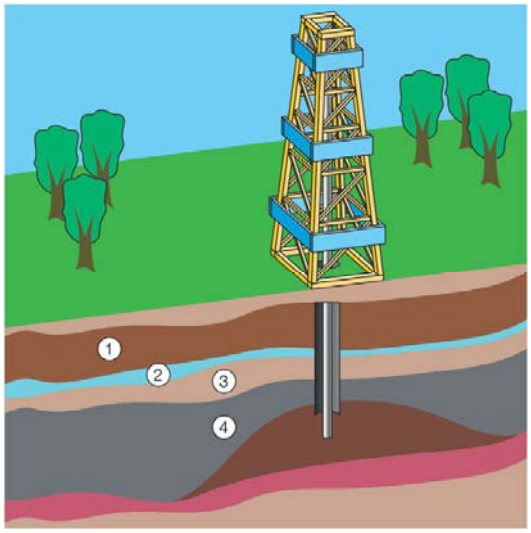
Introduction

— 01 Conventional accumulation

— 02 Unconventional accumulation

Where do oil and natural gas come from and how are they formed
Natural oil and gas are extracted from different geological sources. Most oil and gas fields are found in sedimentary rocks such as sandstone and limestone. These rocks have the porosity and rock permeability for oil and gas to move through and accumulate. The porosity determines the capacity of the reservoir and the permeability determines the productivity of the reservoir.

Drilling into a conventional accumulation would normally result in at least some flow of oil and gas immediately. To stimulate the oil or gas, either to begin, continue or increase flowing, water is pumped into underground rock layers. The high pressure of the water results in higher extraction flow rates and makes operating the well more economical. Precise measurement of the injected water can be achieved using ABBs electromagnetic flowmeters.



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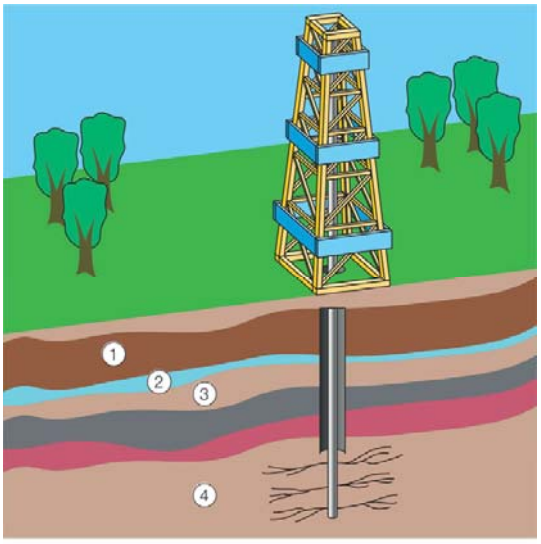

02

Pos.	Description
1	Soil
2	Water
3	Loam
4	Sandstone

Pos.	Description
1	Soil
2	Water
3	Loam
4	Shale gas

A different geological source is the natural oil and gas trapped in impermeable rock that cannot migrate into a trap and form a conventional deposit. These are often termed unconventional hydrocarbons. For example shale oil, shale gas and coal-bed methane. Because of the very low permeability, an unconventional accumulation has to be stimulated in some way before it will begin to flow. Hydraulic fracturing is a method to stimulate the oil or gas.

A mixture of water and sand is pumped underground. The high pressure of the fluid creates small fissures, or fractures, in the rock. The sand holds the fissures open, resulting in a higher permeability of the rock and allowing the oil or gas to move more freely from the rock pores where it is trapped to the producing well.
Precise flow rate measurement of the fracturing fluid and the blending of the additives is a chieved using ABBs electromagnetic flowmeters.
An Insight in Fracking is given in **Fracking** on page 12.

Preparing the well – Drilling and wellhead installation

— 03 Well

— 04 Drilling

The application
A hole is prepared using drilling mud which cools the drill bit, carries the rock cuttings back to the surface and stabilizes the wall of the well bore hole. Once the hole extends below the deepest aquifer, the drill pipe is removed and replaced with steel pipe, referred to as 'surface casing'. Next, cement is pumped down through the casing and then back up between the steel pipe to form the borehole wall, where it sets. This cement bond prevents the migration of any fluids vertically between the casing and the hole.

In doing so, it creates an impermeable barrier between the well bore and any freshwater sources. Once the drilling is finished and the final casing is installed, the drilling rig is removed. Then a connection between the final casing and the rock holding the oil and gas is established.
The well is now complete.

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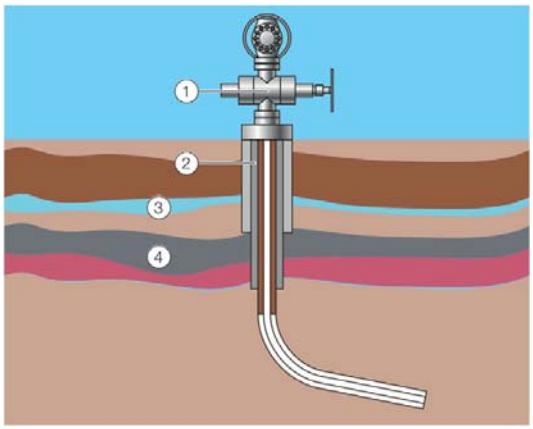

03

Pos.	Description
1	Well head
2	Cemented steel casing to protect aquifier
3	Drinking water aquifer
4	Impervious shale layer

— 05 Drilling mud

— 06 ProcessMaster sensor

The challenge

Precise control of the flow rate of the drilling mud used (to cool the drill bit) and measurement of the rock cuttings carried back to the surface is essential in preparing the well.

05

Drilling mud going down the borehole is a mixture of water, sand and a range of chemicals which makes flow measurement difficult due to abrasion.
In order to measure the drilling mud, the flowmeter has to be able to withstand abrasion of the drilling mud as well as harsh environmental conditions such as moisture, varying ambient temperature ranges and vibration in the drilling rig.

The solution

ABB's robust ProcessMaster electromagnetic flowmeter is designed to meet rigorous oil field production requirements helping reduce risks and increase process up-time.

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ProcessMaster provides features such as:

- Optimized, long lasting sensor lining materials to ensure resistance to chemical corrosion and abrasion resulting in longest sensor service life.
- Designed with flush mounted measuring electrodes, unlike many other flowmeter designs, ABB's ProcessMaster sensor has no rotating parts protruding into the pipe which can wear requiring regular maintenance and negatively impact process up-time.
- Potted sensor to protect internal sensor components against moisture and vibration, helping to assure lowest maintenance.

Oil / water separation

— 07 Oil / water separator

— 08 Separator

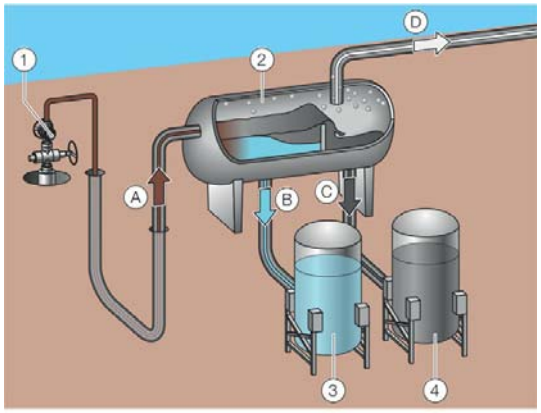
The application

Once the well is completed, the production begins. Natural gas and oil flows up the well bore.

The water collected along with hydrocarbons during the well's production life is referred to as 'produced water'.

A major amount of the produced water is the water that had been pumped underground to increase the flow of oil.

The water is separated from the oil in a separator. Usually, the volume of the water is stable throughout the well's life and a challenge for mechanical flowmeters due to abrasive solids.



07

Pos.	Description
Ⓐ	Inlet oil / water separator
Ⓑ	Outlet for water
Ⓒ	Outlet for oil
Ⓓ	Outlet for gas
①	Well head
②	Separator
③	Water storage
④	Oil storage

08

—
09 ProcessMaster

—
10 Oil / water separator

—
11 ProcessMaster's self cleaning measuring electrodes

The challange

The ‘produced wellhead fluid’ is a multi-part mixture. It carries gas, sand and chemicals. To maintain oil and gas production, continuous and reliable operation of the separator is essential.

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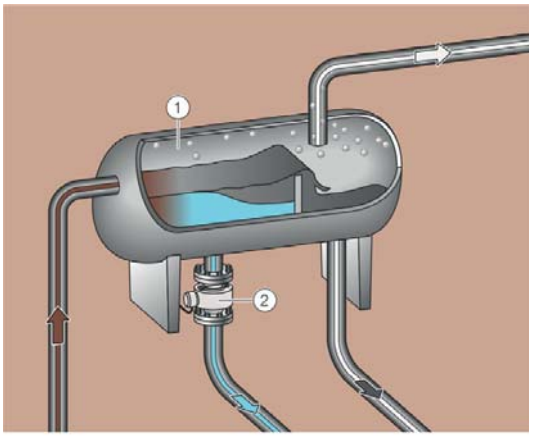

10

Pos.	Description
1	Separator
2	ProcessMaster

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Standard ProcessMaster features include:

- Long lasting sensor lining materials to ensure resistance to abrasion resulting in longest sensor service life resulting in low maintenance costs.
- Self-cleaning, measuring electrodes reduce the impact of oil build-up.
- Approvals according to ATEX, IEC, cFM allow for installation in hazardous areas.
- A range of communication protocols enable integration into management systems to maximize asset optimization.
- On initial installation, the self-configuration sequence automatically replicates all data from the sensor into the transmitter eliminating the potential for human errors and leading to faster start-ups.
- The user-friendly interface allows quick and easy data entry for all process parameters. The “Easy Setup” menu guides the operator step-by-step through the parameterization without the need for intensive training.

Produced water – Management

— 12 ProcessMaster display

— 13 Wellpad layout

The application
Oil production requires millions of gallons of water for a well.
Water for injection has to be sourced, transported or piped to the well site.
Water management plays a key role in operating a well. Every drop costs money and the well has to be operated as economically as possible.
Besides sourcing, transportation and storage, there are different ways to handle produced water.

Treatment and reuse on site
Produced water is treated on site and pumped back underground to maintain oil flow of the well.
Reusing the water reduces cost and reduces the dependency on fresh water sources.

Final disposal
Produced water goes into the pit, or is stored in tanks on-site, from where it is piped or trucked to the disposal well site, stored in a tank and injected underground for permanent storage using high pressure pumps.

The challange
Getting the best levels of efficiency and performance from the production process requires precise measurement of the total amount of water consumed or disposed.

The solution
ProcessMaster delivers the power to solve the most demanding flow measurement application.
Proven to be reliable and accurate, ProcessMaster will consistently give you proven and repeatable measurements to account for total amount of produced water.

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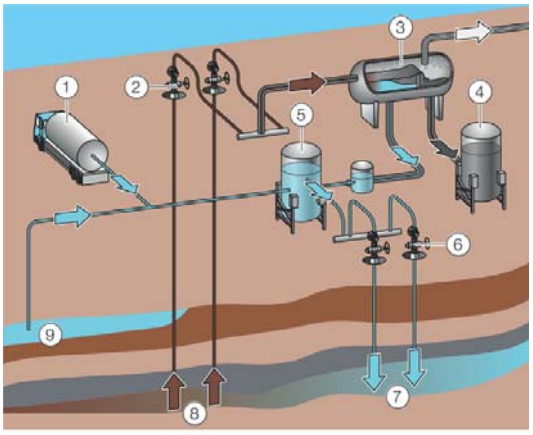
Produced water – Treatment

— 14 Wellpad layout

— 15 ProcessMaster with remote and integral mount design

The application
Produced water treatment includes oil/water separation, removal of large particles and additional filtering before being pumped into storage tanks. Further treatment is required to reduce suspended solids and dissolved solids. This results in thickened sludge which needs to be handled.
Final treatment of the water employs ultrafiltration to remove dispersed hydrocarbons.
Evaporation technology can potentially deliver a distillate meeting drinking water quality standards.
Depending on the produced water management treatment and disposal strategy, a range of these treatment processes are used.



14

Pos.	Description
1	Water trucked to and from the site
2	Oil / gas wellhead
3	Oil / water separation
4	Oil storage
5	Water storage
6	Wellhead for high pressure water injection
7	Produced water injected underground to boost oil production
8	Oil accumulation
9	Fresh water source

The challenge
To run this process most efficiently and reliably, a robust flowmeter is required to measure accurately chemicals that are used to reduce suspended solids and dissolved in the produced water.
Filtration technology requires a flowmeter capable of measuring forward flow while processing the water and reverse flow when cleaning the filters. Low conductivity could be another challenge for some electromagnetic flowmeters depending on the filtration technique employed.

The solution
Water filtering technologies that result in either low conductivity or gas bubbles are no challenge for ProcessMaster's advanced signal processing providing outstanding measurement performance with long-term stability.
Whether an integral, remote or pipe mounted installation is required, a configurable common electronics platform provides the best tailor-made solution.

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The Flowmeter provides features such as:

- Smallest outer dimensions to meet the needs for integration in skids.
- Forward and reverse flow measurement is a standard.
- No additional pressure drop from parts protruding into the pipe.
- Double sealed measuring electrodes minimize the risk for leakage enhancing reliability.
- Process optimized linings and measuring electrode materials ensure resistance to chemicals.

Produced water – Final disposal / wellhead injection

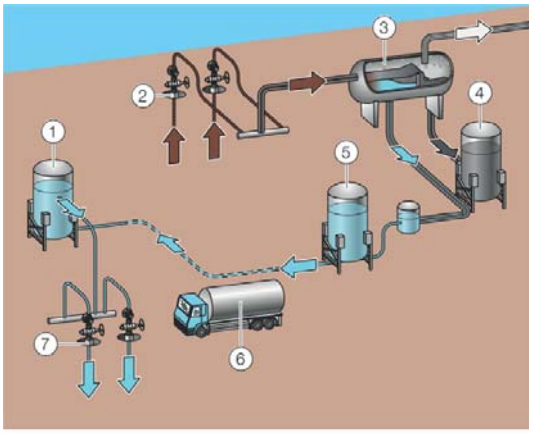
— 16 Wellhead injection

— 17 ProcessMaster wafer style and flange sensor

The application

Produced water goes into the pit or is stored in tanks on-site from where it is piped or trucked to the disposal well site, stored in a tank and injected underground for permanent storage using high pressure pumps.
Final disposal must be in accordance with environmental regulations.

The challenge



16

Pos.	Description
1	Produced water storage
2	Oil wellhead
3	Oil / water separation
4	Oil storage
5	Produced water storage
6	Produced water transportation
7	Final disposal

Based on the layout of the wellhead injection, the flowmeter sensor must withstand the high pressure produced as a result of pumping produced water underground.
Installed on the suction side of the pumps, the sensor has to withstand variations in pressure which could include vacuum.
Space is premium as most measurement is done on a provided skid.

The solution

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ProcessMaster compact version.
Sensor and transmitter are mounted as a single entity allowing for integration in skid.
The flanged sensor design covers pressure ratings as high as ANSI Class 2,500.
A wafer sensor is also available up to ANSI Class 300.

For ProcessMaster, powerful doesn't mean complicated.
The intuitive design allows for easy setup.

A sensor memory simplifies installation by eliminating configuration errors.
Take advantage of simple installation, commissioning, configuration and maintenance – start saving time and money from day one.

Water transportation

— 18 Produced water trucked to final disposal site

— 19 ProcessMaster product offering

The application

Water for injection into the ground has to be sourced, transported or piped to the well site. Produced water goes into the pit or is stored in tanks on-site from where it is piped or trucked to the disposal well site.

The challenge

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With the cost of trucking water to and from a site, a most reliable, accurate and repeatable flow measurement device is required to account for the total amount of water being transported.

The solution

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ProcessMaster delivers more than reliable and accurate measurements.
When integrated with an asset management solution, the instrument plays a key role in maximizing asset optimization.

Standard ProcessMaster features include:

- No rotating parts protruding into the pipe resulting in less maintenance compared to other flowmetering technologies.
- The user-friendly interface allows quick and easy data entry for all process parameters. The “Easy Setup” menu guides the operator step-by-step through the parameterization without the need for intensive training.
- Robust design withstands harshest environmental conditions.

Fracking

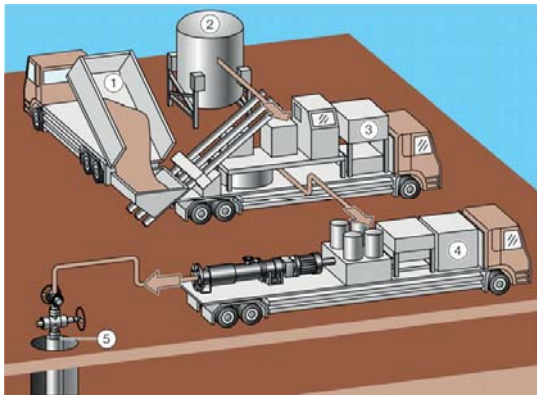
— 20 Component flows at hydraulic fracturing

— 21 Principle of hydraulic fracturing

The application

When natural oil and gas is trapped in impermeable rock and cannot migrate to form a deposit, this unconventional accumulation has to be stimulated in some way before it will begin to flow. Hydraulic fracturing is a method to stimulate the oil or gas.
A mixture of water, sand and chemicals, is pumped at high pressure into underground rock layers where the oil or gas is trapped. This is pumped from tanks with equipment mounted on trucks or skids on the surface. The high pressure of the fluid creates small fissures in the rock. The sand holds open the fissures, allowing the oil or gas to move more freely from the rock pores where it is trapped to a producing well where it can be brought to the surface at higher flow rates. The higher rate makes operation of the well more economical. The “fracturing fluid” consists of approximately 90 % water, 9 % sand and 1 % chemicals and gelling agents. The purpose of the gelling agent is for lubrication in order to make the fluid more viscous and better able to carry the sand.
This is necessary to hold the fractures open. Further chemicals reduce friction, fight microbes and prevent equipment corrosion. Precise control of the fracturing fluid and of the blending of the additives is achieved using ABBs electromagnetic flowmeters.
Once the fracturing process is complete, the production begins. Initially fracturing fluid, and then natural gas or oil, flows up the well bore.

In the course of initial production of the well, about 25 to 75 % of the fracturing fluid water is recovered. It is recycled back to the surface and is referred to as “flow back water”.
This water may contain hydrocarbons, fracturing sand and pieces of plastic, metal or cement from drilling. As the well comes more and more online, flow-back water transitions to produced water. Produced water is collected along with hydrocarbons during the well’s production life. Usually the volume, chemistry and suspended solids are stable throughout the well’s life and no challenge for ABBs ProcessMaster range of electromagnetic flowmeters.



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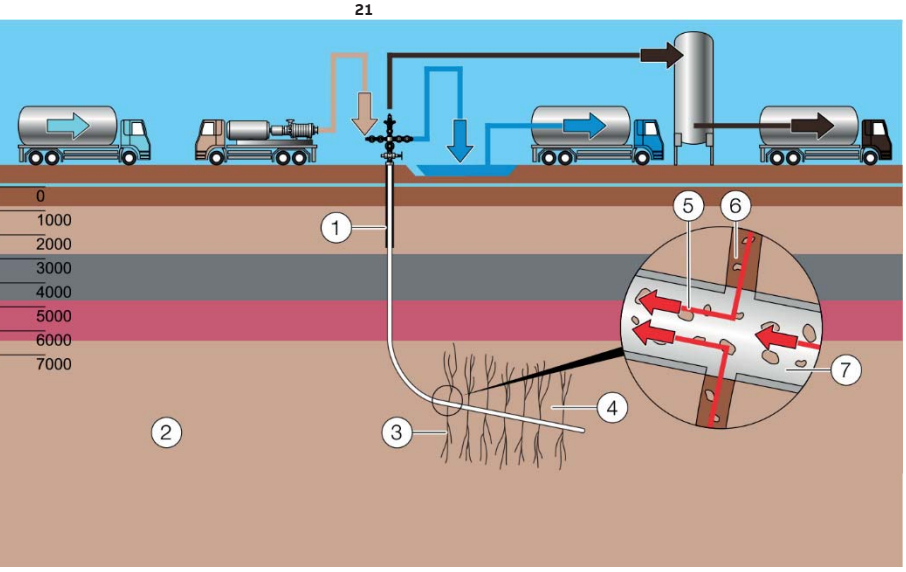
Pos.	Description
1	Dumper truck
2	Storage tank
3	Blender truck
4	Pumper truck
5	Well and wellhead

21



Pos.	Description
1	Well
2	Marcellus shale
3	Fissures
4	Shale is fractured by the pressure inside the well
5	Natural gas flows from fissures into well
6	Sand keeps fissures open
7	Mixture of water, sand and chemical agents

— 22 Acid dilution skid

— 23 Chemical additive blending

— 24 Blender truck

The challenge

Dilution skid

22

In this skid a range of additives and acids are diluted with water to form the fracturing gel. Corrosion resistant wetted parts can be a challenge for flowmeters.

Blender truck

23

The blender truck continuously blends the fracturing gel with sand to form the final (downhole) fracturing gel.
For optimum fracturing, precise control of the fracturing fluid and of the blending of the additives is key. Abrasion is the challenge here for the flowmeter.

Pumper truck

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The pumper truck sends the mixture of sand, water and additives down the borehole using high pressure pumps.

The solution

ABB's ProcessMaster range of electromagnetic flowmeters is the first choice for installations in fracking applications.
They are the perfect fit for skid installation, require minimal upstream/downstream straight pipe runs and provide high measurement accuracy. Unlike turbine meters, electromagnetic flowmeters have no moving parts to break or wear out, that can require downtime and maintenance. They reduce or even eliminate costly service, replacement part costs, and down time.
ProcessMaster is proven to be robust and reliable.
For installations on pumper trucks and for measuring acids and chemical additives, the sensor design covers pressure ratings as high as ANSI Class 2,500. Optimized linings such as rubber or ETFE ensure resistance to abrasion and chemicals.
Approvals according to ATEX, IEC as well as FM and cFM allow for installation in hazardous areas.

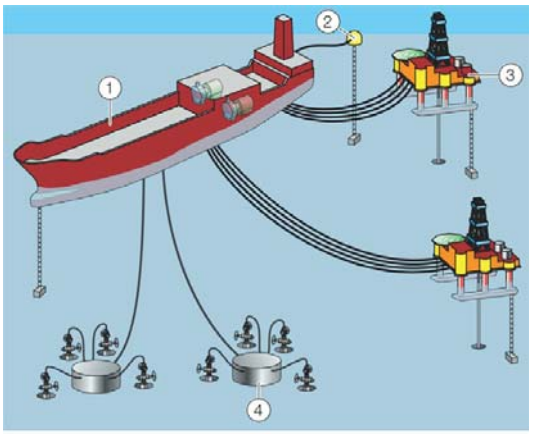
Offshore oil and gas rigs and FPSO's

— 25 Offshore oil production

— 26 ProcessMaster entirely made from stainless steel

The application

A FPSO (Floating Production, Storage and Offloading) is a standalone ship-shaped structure.
The wellheads or subsea risers from the sea bed are located on a central turret so that the ship can rotate freely to point into wind, waves or current.



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Pos.	Description
1	FPSO ship
2	Tanker offloading buoy
3	Drilling platform
4	Existing well centers

The processing equipment aboard the FPSO is similar to what would be found atop a production platform. Usually built in modules, FPSO production equipment can consist of water separation, gas treatment, oil processing, water injection and gas compression, among others.
Hydrocarbons are then transferred to the vessel's double-hull for storage. Crude oil is offloaded to a shuttle tanker at regular intervals.
The individual steps in O&G production are similar to the ones onshore, for example drilling and wellhead Injection to boost production. Also oil-water separation and produced water treatment. In addition to the oil and gas related water treatment / management, there is potable water, chilled water and ballast water to be managed and measured.
Ballast water is used to stabilize vessels and to maintain the structural integrity when not fully loaded.

The challenge

In addition to the challenges onshore, offshore installations require even a more robust, corrosion resistant flow metering devices. The outer housing has to withstand the harshest environmental conditions such as a sour gas or sea water atmospheres.

The solution

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ABB's robust ProcessMaster is designed to meet these challenging requirements:

- All 316 stainless steel construction for toughest operating environmental conditions.
- Fully welded sensor made from 316 stainless steel.
- Potted sensor to protect internal sensor components against moisture and vibration.
- Sensor design covers pressure ratings as high as ANSI Class 2,500.
- Optimized, long lasting sensor lining and electrode materials to ensure resistance to chemical corrosion and abrasion resulting in longest sensor service life.
- Approvals according to ATEX, IEC, as well as FM and cFMus allowing for installation in hazardous areas.
- Marine approvals (DNV).
- Smallest outer dimensions enable installation in restricted on-board spaces.

The user-friendly interface allows quick and simple data entry
for all process parameters without the need for intensive
training.

ABB Measurement & Analytics Your global partner

World-class measurement solutions
ABB measurement and analytics products provide world-class measurement solutions. Latest innovations deliver technological solutions to make it easier for you to run your plant.
ABB's measurement and analytics products are based on common technology, providing a common look and feel and method of operation. This results in products that are easy to configure, easy to integrate, and easy to maintain.

ABB's measurement and analytics products portfolio

- Analytical measurement
- Flow measurement
- Natural gas measurement
- Valve automation
- Pressure measurement
- Temperature measurement
- Recorders and controllers
- Level measurement
- Device management
- Force measurement
- Service

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