MEASUREMENT AND CONTROL

OIL AND GAS INDUSTRY

A Guide to Measurement and Control Instrumentation for Natural Gas, Water and Oil Separation

Oil and Gas Processing

Oil and gas wells produce a mixture of hydrocarbon gas, condensate or oil; water with dissolved minerals, usually including a large amount of salt; other gases, including nitrogen, carbon dioxide (CO_2), and possibly hydrogen sulfide (H_2S); and solids, including sand from the reservoir, dirt, scale, and corrosion by products from interaction with the tubing. The oil and gas surface processing facilities separate, remove, or transform these various components to prepare the hydrocarbons for further processing and/or sale.

Wellhead extracts the crude oil for processing

The **wellhead** provides support for the tubulars inside the well, a pressure seal between the tubulars, and a means of controlling production flow from the well. Typically, the wellhead consists of a casing head for each casing string, a tubing head, and a Christmas tree. Remote operation and control of a free-flowing surface well is accomplished by measuring the pressure at different points of the wellhead and Christmas tree, and then sending an electrical signal, representing the casing, tubing, and flowline pressures, to a data acquisition or control device.

Once fluids are brought to the surface, the oil, gas, water, and any produced solids must be separated for ease of measurement and transportation.

The crude oil mixture is separated into water, oil and gas

A **separator** is a pressurized vessel used to separate liquid from gas and solids; several physical processes are commonly used in the separation process such as centrifugal force, electrostatic precipitation, filtration, or gravity settling.

As depicted in **Figure 1**, the produced oil and water enters the separator and it begins filling the reservoir on the left side of the vessel. The water is more dense than the oil, causing it to sink to the bottom of the reservoir while the less-dense oil sits as a separate layer on top of the water. As the level of oil in the reservoir increases it spills over a weir into the right side of the vessel where it is now just oil and no water. The entrained gas flashes and is drawn off the top of the separator where some is utilized as supply pressure for pneumatic instrumentation on the separator and the remainder sent off via pipeline for further treatment at a Gas Processing Plant.

A tank is used for temporary storage until the liquid is sent offsite

Following separation, the oil and the water are sent to a **storage tank battery** which consists of separate tanks to hold the oil and the water for shipping, treatment, or disposal. Typically, there are multiple oil and water tanks at the surface facilities.

The volume of oil being shipped can easily be determined by measuring the height of fluid in the tank and applying appropriate strapping tables. Once enough oil has been collected in the tank it is then transferred to a downstream processing facility using a variety of transportation methods such as pipelines, tanker trucks, and railcars.

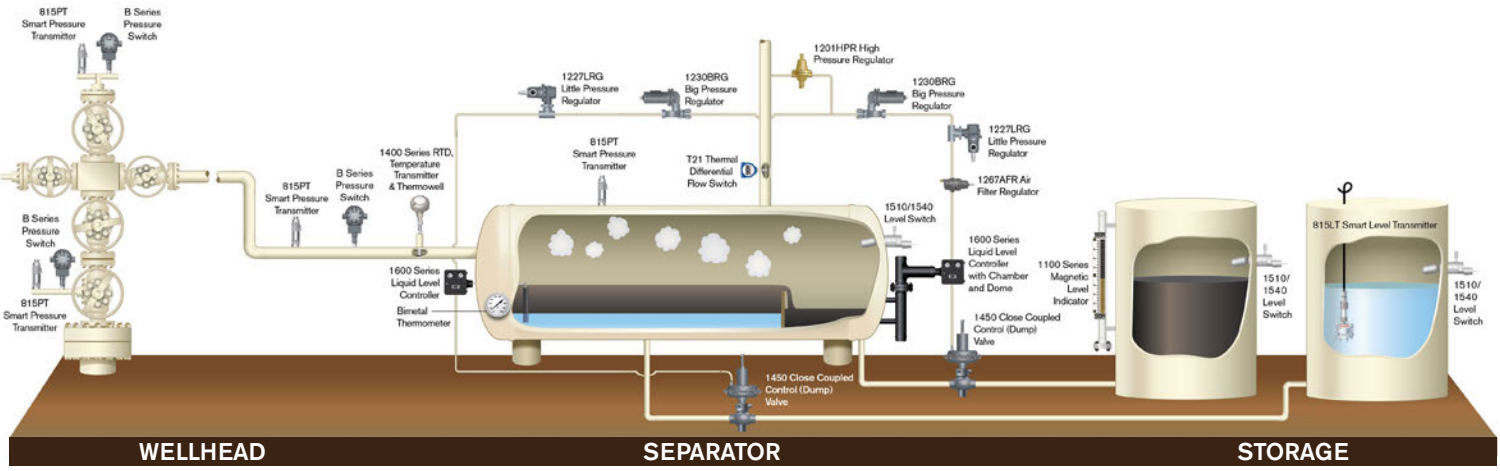

Figure 1

wellhead

An explosion proof **B-Series Pressure Switch** is installed with each pressure transmitter, shown in **Figure 2,** as a means of redundant measurement and protection; in the event power being supplied to the pressure transmitters is lost they will stop sending a signal, however the pressure switches are still able to detect changes in pressure and respond appropriately if their set pressure is reached.

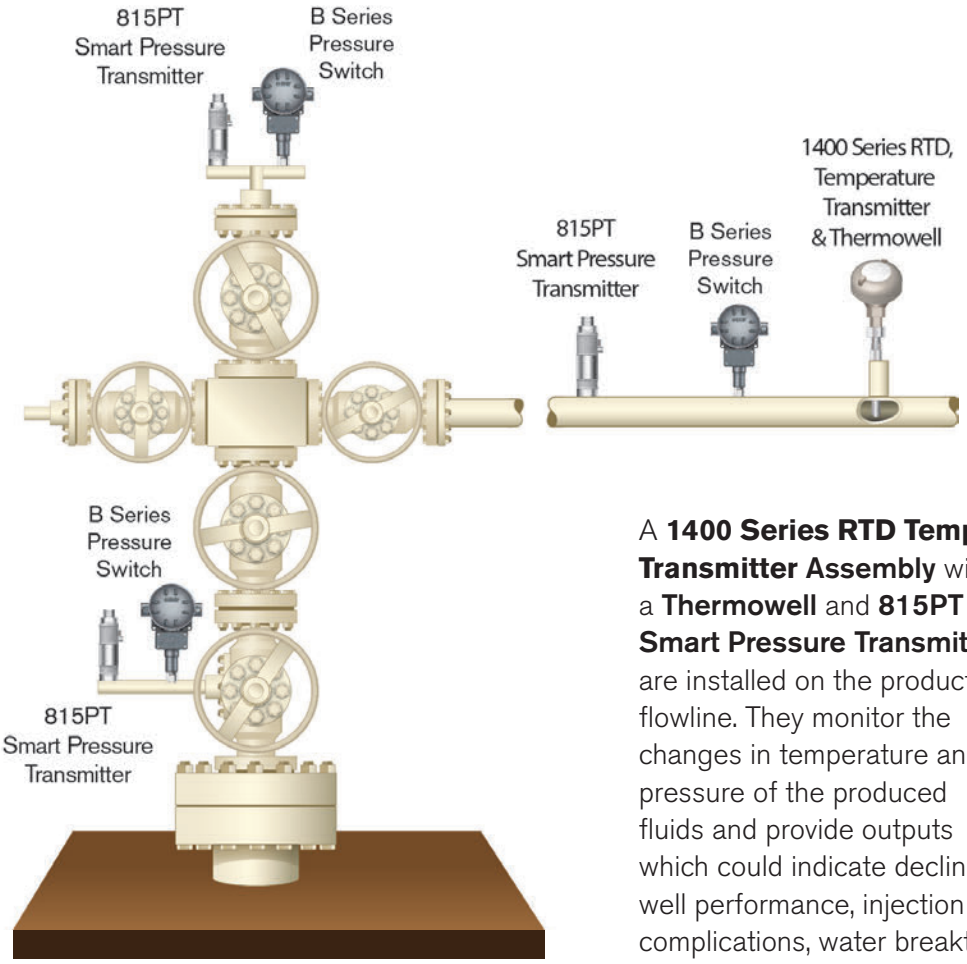

Figure 2

A **1400 Series RTD Temperature Transmitter Assembly** with a **Thermowell** and **815PT Smart Pressure Transmitter** are installed on the production flowline. They monitor the changes in temperature and pressure of the produced fluids and provide outputs which could indicate declining well performance, injection complications, water breakthrough into the well, or other upset conditions.

The bottom **815PT Smart Pressure Transmitter** measures the casing pressure and is used to monitor wellhead integrity to improve safety and lessen the likelihood of an environmental leak or spill.

The tubing pressure is measured by the top **815PT Smart Pressure Transmitter** and is used to detect changes in well production and abnormal conditions which could reduce output and lead to tubing failure and subsequent well workovers.

separation

WATER

1600 Series Liquid Level Controllers (LLC) and 1450 Close-Coupled Control Valve (CV). The LLC on the left side of **Figure 3** measures the interface between the oil and water to ensure the water level doesn't get too high and spill over the weir contaminating the oil. Once the water level set point is reached the LLC's pilot opens and the pneumatic signal is sent to a downstream CV (commonly called a dump valve) causing it to open. With the CV open, the level of water in the reservoir falls as it flows to the Water Storage Tanks in the tank battery. Once the water level reaches the minimum setpoint, the pilot closes, which in turn closes the CV, and water begins collecting in the reservoir again.

OIL

1600 Series Level Controllers (LLC) and 1450 Close-Coupled Control Valve (CV). Similarly, the LLC and CV on the right side of **Figure 3** work together to control the level of oil in the separator. The LLC's dump span begins at the top of the weir, which ensures the oil doesn't flow back over to the other side of the separator.

The **Bimetal Thermometer** measures the temperature of the produced oil and water and provides local indication for operators.

The **815PT Smart Pressure Transmitter** measures the gas pressure in the separator which provides protection against overpressurization and possible rupture; if the gas outlet stream was to become blocked, or if a restriction in the production line were to occur, it could cause an overpressure condition.

A **1510 or 1540 Level Switch** functions as a high level shut-off switch; in the event that oil is unable to be dumped from the right side of the separator via the CV the liquid level will increase. The 1510/1540 is installed at the same level as the separator inlet stream and will initiate a shut-in at the wellhead if the critical level is reached, preveting liquid from overflowing into the gas outlet stream.

The **T21 Flow Switch** measures flow rate of the gas outlet stream and signals low flow; low flow will not provide sufficient pressure for the pneumatic LLCs and CVs to operate.

1200 Series Pressure Regulators - Gas in the outlet stream initially goes through a **1201HPR High Pressure Regulator** for the first-cut pressure reduction. The 1201HPR includes 3 outlet connections. One outlet is used to send supply pressure for the LLC and CV on the water side, while the other outlet is used for the LLC and CV on the oil side. The second-cut pressure reduction occurs on the **1230BRG Big Pressure Regulator**. The third-cut pressure reduction occurs on the **1227LRG Little Pressure Regulator**. Finally, the outlet stream from each1227LRG is sent to a **1267AFR Air Filter Regulator** before it reaches the corresponding LLC and CV. The 1267AFR provides filtration of the natural gas, removing particulate matter and grit which can cause wear and tear on the LLC and CV. The 1267AFR reduces the pressure one final time, so the LLC has a suitable supply pressure for operation.

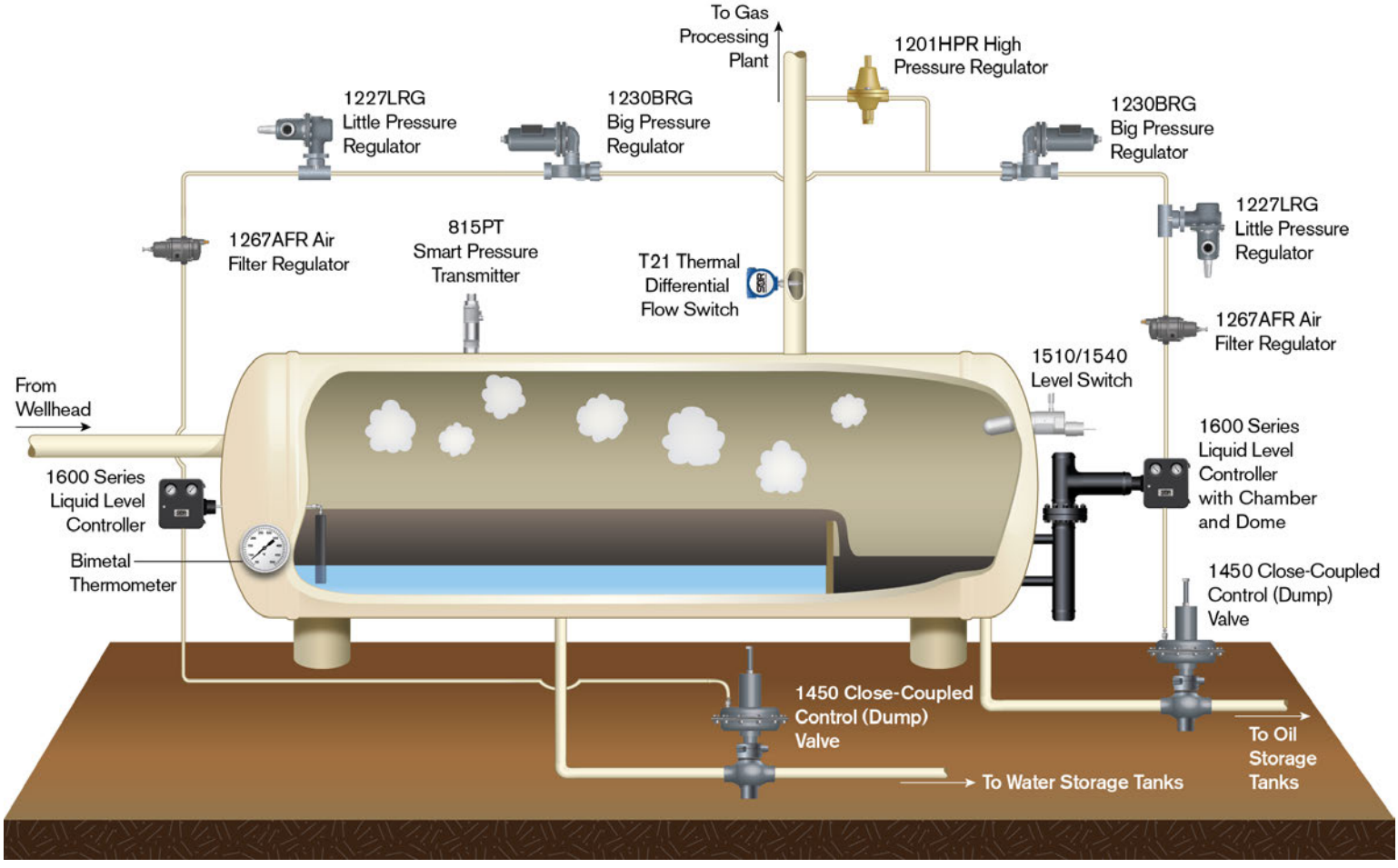

Figure 3

OIL TANK

The **1100 Series Magnetic Level Indicator** shown in **Figure 4** is used for visual onsite determination of oil level in the tank. It provides a quick visual reference for monitoring oil level in the tank as it is being filled and when offloading into a transport container.

A **1510 or 1540 Level Switch** is used as a high-level alarm to indicate when a sufficient volume of oil has accumulated in the tank. It may also be connected to an audible/visual indicator to alert operators when the oil tank is ready to be drained.

Since the water is considered a waste product, it is either transported offsite for treatment or injected into disposal wells.

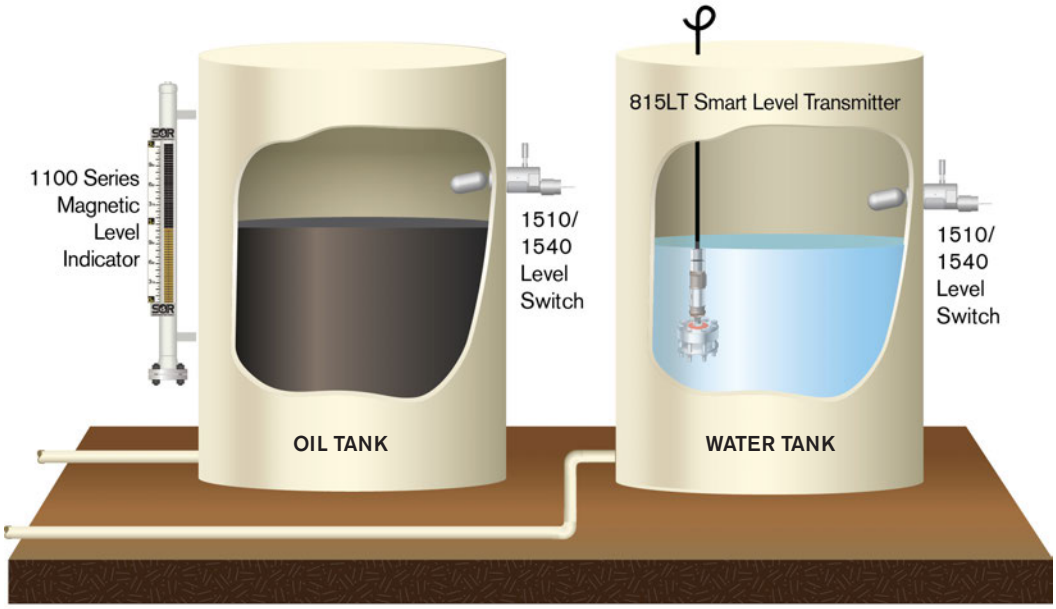

Figure 4

WATER TANK

The **815LT Submersible Level Transmitter** is used to constantly measure the level of water in the tank.

A **1510 or 1540 Level Switch** is used as a high-level alarm to indicate when a sufficient volume of water has accumulated in the tank. It may also be connected to an audible/visual indicator to alert operators when the water tank is ready to be emptied.

Application Notes

wellhead

Application Wellhead Pump Control and Shutdown

Product SOR® 800 Series Pressure Transmitters

Challenge One of the world's leading energy companies needed a pressure instrument for their pumping unit that provides both an analog output for controlling the pump and a switch output for use as an emergency failsafe device.

Solution An 805QS Pressure Switch-Transmitter was used as it includes 4-20mA output for primary control but also a solid state switch output for emergency shutdown. The switch output can be calibrated in 3 different ways; in this application a window switch operation was used, which closes when the pressure is between the minimum and maximum set-points and opens when the pressure is outside the window. Using the window switch mode has the added benefit that if the unit somehow loses power or stops working the switch output will open indicating a fault condition.

separation

Application Separator Level Control

Product SOR 1400 Series Control Valves (CV) and 1600 Series Liquid Level Controllers (LLC)

Challenge The composition of fluids produced by an oil well will vary geographically from site to site. It is often comprised of oil, gas, water, sand, dirt, and minerals. All of these different materials make it difficult to measure and control the liquid level inside a separator vessel.

Solution A 1600 Liquid Level Controller and 1450 Control Valve offer the versatility needed to measure and control liquid interface level with highly unpredictable process conditions. The LLC design incorporates a wide range of adjustability and can be calibrated in the field to operate with a customer's specific process resulting in more accurate level control. The configurability of the 1600 Series Liquid Level Controllers allows operators to control everything from the set point to the proportional band.

storage

Application Overfill Protection for Storage Tanks

Product SOR 1500 Series Level Switches

Challenge The most dangerous aspect of storing crude and other produced media is the risk of overfilling the storage tank. Not only can overfills damage the environment but they also expose onsite personnel to flammable gas and liquids. Walls are often built as a precautionary measure to contain liquid in case of overfill, however the best course of action is to prevent an overfill event from occurring in the first place.

Solution A 1510 Level Switch is the perfect solution for overfill protection. The float-opeated1510 utilizes an extremely simple design that limits moving parts and potential failure points. Once actuated, the 1510 sends a signal to turn on a pump or open a valve preventing the storage tank from being overfilled. The 1510 is also available with a manual check option which allows an operator to manually actuate the level switch to verify it's still working.

MEASUREMENT AND CONTROL

SALES OFFICES

Beijing, China | +86 10 5820 8767 | Fax +86 10 5820 8770

Chennai, India | +91 735 838 8250 | Fax 913-312-3572

Dubai, UAE | +971 4 278 9632 | Fax 913-312-3596

Houston, TX, US | 281-272-5333 | Fax 281-272-5332

Lenexa, KS, US | 913-888-2630 | Fax 913-888-0767

London, United Kingdon | 913-956-3092 | Fax 913-312-3571