Technical Publication

Level Switch Detects Oil and Nitrogen Interface to Support Effective PIG System Operation

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Figure 1: Trans-Alaska Pipeline System (TAPS)

A major oil producer in Alaska's North Slope region operates miles of transit pipeline as part of the Trans-Alaska Pipeline System (TAPS) within the U.S. National Petroleum Reserve – Alaska. The TAPS pipeline transports petroleum extracted from the North Slope southward to the port of Valdez for shipping by tanker to West Coast refineries.

The oil producer's pipeline travels through Alaska's environmentally sensitive wilderness and native tribal homelands. Due to extreme climate conditions, operating the pipeline is challenging and requires highly reliable equipment to avoid any leaks or other accidents that would compromise this pristine ecosystem.

Problem

As part of the pipeline maintenance process, pig systems *(Figure 1)* are deployed to remove debris from the interior of the pipe to ensure the oil is flowing continuously and smoothly through the pipe at all times. Pipelines are pigged frequently to prevent internal material build-up, which leads to corrosion and potential leaks. Pigs also can perform other maintenance tasks; "smart pigs," for example, can monitor pipe wall thickness to identify early potential leak sources.

The pig is run through the pipeline between a pig launcher station and a receiving station. The pig is first inserted into the launcher, from which the pressure-driven flow of the product in the pipeline is used to push the pig down the pipe until it reaches the receiving station. Sediment and other impurities are then dropped into a collection tank.

Following the pipe pigging process, the pig launcher and receiving stations are purged with nitrogen gas. The oil producer was searching for a more reliable means to detect the purged condition of the launcher and receiver stations, defined here as the level interface of liquid crude oil and nitrogen gas. More reliable detection would reduce the cost of the pigging and maintenance.

Solution

The oil producer's pipeline maintenance engineering staff contacted the applications team at Fluid Components International (FCI) to ask for assistance in optimizing its pig detection system. The maintenance staff's need to detect the interface of two dissimilar fluids such as crude oil and nitrogen gas is not an easy task that can be accomplished with standard density displacers or more typical mechanical level switches and high costs were to be avoided.

The applications team at FCI recommended the Model FLT93®S Insertion Style FlexSwitch™, which combines flow/level/temperature sensing capabilities in a single instrument

inserted to the exact location where measurement is required *(Figure 2)*. This interface switch is a no moving parts design with increased reliability over mechanical switches. A dual-function instrument, it can be configured for flow or level sensing; flow plus temperature sensing; or level plus temperature sensing. A single switch measures and monitors flow or level and temperature simultaneously with excellent accuracy and reliability. Dual trip points and 6A relay outputs are standard and assignable to flow, level or temperature.

The oil producer's maintenance engineering team agreed with FCI's recommendation and installed the FLT93S FlexSwitch with a 1.5-inch RF CL600 316SS flange process connection. The switch includes dual relay contact outputs and was supplied with a NEMA Type 4X aluminum enclosure. It was mounted at the bottom of the vessel in a 1.5-inch vertical drain line at each pig launcher/receiver station, avoiding pig contact.

For the pigging system application, the FCI interface switch measures the crude oil and nitrogen gas interface at a pressure of 300 psig [20,7 bar(g)] and within the instrument's standard process temperature range of - 40 °F to 350 °F [- 40 °C to 177 °C]. An optional configuration can be selected for application temperatures from - 100 °F to 850 °F [- 73 °C to 454 °C].

The interface switch setpoint for the pigging application was calibrated to the oil producer's specified parameters for the pipeline in the FCI Calibration Laboratory on NIST traceable equipment (U.S. National Institute for Standards and Technology). The company's Cal Lab allows instruments to be calibrated to specific gases and fluids under real world installed application environment conditions. The company also was able to meet the stringent quality assurance requirements and provide certified material test reports, along with pressure testing each switch to American Society of Mechanical Engineers (ASME) requirements.

The interface switch is designed to perform monitoring and alarming of levels of critical fluids such as nitrogen gas and crude oil. The switch is set to monitor and alarm the critical nitrogen gas and crude oil interface. For the pig system application, its rugged industrial design and housing provided superior reliability with virtually no maintenance and a long service life under the harshest oil/gas production environments.

Alarm setpoint and fail-safe verification with the FLT93S FlexSwitch is easily performed before installation or in-situ. The dual alarms are field-configured to fail-safe when used exclusively for flow rate, liquid level, or temperature alarm. With both pre-check capability and fail-safe operation, the oil producer's pipeline operations are protected from any unforeseen failure during pigging. This combination of features gives the interface switch exceptional reliability for the pipeline operations team.

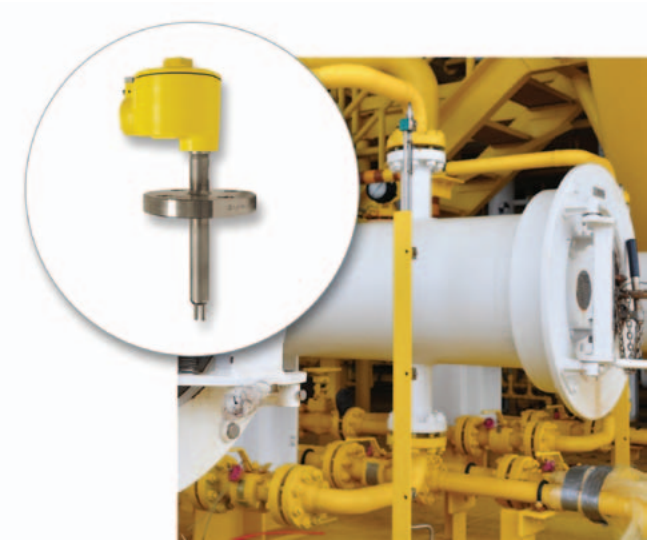

Figure 2: Typical pig system; FLT93 S FlexSwitch with flange

Unlike density displacers, which are often used for level and interface control, the thermal interface switch relies on the specific heat transfer properties of the media to identify the interface of the different fluid products *(Figure 3)*. With its unique thermal sensing capability, this switch can even monitor the interface of fluids with similar densities for highly reliable control.

The interface switch's thermal dispersion sensing technology places two thermowell protected platinum RTD temperature sensors in the process stream. One RTD is heated while the other senses the actual process temperature. The temperature difference between these sensors generates a voltage output, which is proportional to the media cooling affect and used to trip an alarm relay output.

FCI's interface switch identifies the interface between many common industrial fluids, including foam, emulsion layers, liquids and slurries. The instrument's dual relay option allows one instrument to detect two different product interfaces, which in this application were the crude oil and the nitrogen.

This versatile interface switch operates over a wide setpoint range. Depending on the configuration chosen, in hydrocarbon-based liquids the set point range is from 0.01 FPS to 5.0 FPS [0,003 MPS to 1,5 MPS]; in air/gas the setpoint range is from

0.25 SFPS to 120 SFPS [0,08 NMPS to 37 NMPS]; in water the set point range is from 0.01 FPS to 3.0 FPS [0,003 MPS to 0,9 MPS]. Level accuracy is ±0.25 inch [±6,4 mm], and measurement repeatability is ±0.125 inch [±3.2 mm].

With its advanced thermal flow sensor, the interface switch features built-in temperature compensation, which ensures repeatable and reliable operation even in extreme environments, such as those found in the oil/gas industry. This automatic compensation feature compensates for changes in process temperatures to ensure the trip points will remain accurate and repeatable. This helps prevent false alarms or alarm failures due to changes in process temperatures.

Thermal dispersion sensing technology provided the oil producer's pipeline operating team with a flow detection solution that is easy to install, with or without shutting down the process, to save time and costs. The insertion style flow/level instruments are particularly well suited for larger line size applications where the probe length and the number of sensors can be easily and economically added.

A wide selection of standard and custom process connections can be provided with the interface switch. The electronic control circuit can be integrally-mounted with the sensing element, or it can be located in a remote location. The standard enclosure is made from a coated aluminum alloy. It is rated for both ATEX and NEMA Type 4X (IP66) environments. Stainless steel or fiberglass enclosures can be supplied.

The FLT93S FlexSwitch is SIL 2 compliant for applications requiring a safety instrumented system (SIS). SIL ratings provide proof of reliability to allow the interface switch to be considered in safety related applications where instrument failure can result in a hazardous situation. The interface switch's SIL 2 safety compliance assures users that third-party testing has been performed to required levels.

Conclusions

The oil producer found the FLT93S FlexSwitch to be an economical and reliable solution to detect the interface between nitrogen gas and crude oil in its pig system. The team was pleased with the simple relay contact alarm output feature and the fail-safe design, featuring a release of the second relay contact for power fail detection.

In addition, this interface switch's no moving parts design requires virtually no maintenance, saving the oil producer additional maintenance time and operating costs. The oil producer has selected the FLT93S for multiple pipeline pigging operations. ■

Figure 3: Pigging system application with FCI FLT93 S FlexSwitch installed to measure crude oil and nitrogen gas interface