Wide beam technology provides unique LPG flow measurement solution

When an international oil company operating several oil and gas facilities in China had problems getting a Liquefied Petroleum Gas terminal to operate at 100% efficiency due to previously installed flowmeters, Siemens provided a solution. A SITRANS FUS1010 flowmeter based on the patented WideBeam ultrasonic measurement principle proved superior in performance, accuracy and repeatability; factors that were deemed crucial by the oil company.

The LPG (Liquefied Petroleum Gas) terminal in is designed to handle the import and storage of refrigerated butane and propane; the two main components of LPG. Distribution and export of the pressurized LPG in river barges, road tankers and LPG bottles is also part of the operation. The terminal consists of onshore as well as offshore facilities. The offshore comprises a jetty with refrigerated and pressurized LPG loading arms; the onshore includes pressurized LPG spherical tanks, tanker loading bays as well as a small LPG bottle filling plant.

Background

For storage purposes, the LPG is kept in liquid form because it takes up much less space than its gas counterpart. For the gas to stay liquefied there are two ways to go about it. One, it can either be stored at temperatures below -47°F (-44°C) for butane and below 25°F (-4°C) for propane and two, under ambient temperatures if the pressure is maintained above 145 psi (10 bar).

The facility was the first company in China to start using caverns for underground storage of the LPG. Each of these caverns is equipped with submersible export pumps, submersible seepage water pumps, and necessary measuring instruments connected to the above-ground installations through an intricate system of dedicated vertical shafts.

Underground storage has several benefits compared to storage tanks above the ground: they are safe from sabotage and natural disasters such as hurricanes and earth quakes; they pose no risk of leakage; they occupy much

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less space; and overall they require fewer investments in equipment and maintenance. Lastly, temperatures are lower in caverns, making the need for energy used to refrigerate the gases less prevalent. Inside the caverns butane and propane are stored in two separate locations, each with a capacity of 8.83 million ft³ (250.000 m³).

Both caverns are connected to the terminal jetty by two 16” (DN 400) pipes through which the refrigerated LPG is pumped from the barges to the underground storage sites. When the LPG has to be exported from the caverns it is pumped through an export manifold to either barges docked at the terminal jetty or tanker trucks via a 7-bay truck loading facility.

To monitor the amount of butane and propane that has been transported to each of the two caverns and to check how much LPG is left in the barge being unloaded, a flow reading is used as a reference to check the barge total versus the flowmeter total. Being that operators can detect discrepancies and possible leaks as well as controlling the flow of the LPG around the entire facility, flow measurement is considered a crucial tool for the proper operation of the terminal.

Normally, a Coriolis meter is used for custody transfer applications for pipe sizes less than 6” (DN 150) and orifice is used for larger pipes for process control. The oil company however, chose to install an insert ultrasonic flowmeter and a clamp-on ultrasonic flowmeter using the shear mode (narrow beam) technology because ultrasonic flowmeters have a much larger turn-down ratio than orifice plate meters. In addition, it has the capability of reading zero flow.

The problem

After a year of operating the two ultrasonic flowmeters, the company had learned that poor meter accuracy and frequent measurement failures were the direct reason for the terminal to be operating below maximum performance. Most failures were triggered by the temperature and density changes of the liquid LPG occurring during the process of pumping the liquefied gas between the offloading facility, the underground storage tanks and the tanker loading bay. An additional factor specific to this exact facility was the high temperatures variations between summer and winter.

All of these issues resulted in the beam injection angle of the ultrasonic meters to vary repeatedly, preventing the narrow beam transducer from receiving the transmitting signal. Due to the frequency of this failure the equipment manufacturer had to come to the site on a regular basis to re-adjust the spacing of the transducers to accommodate the fluctuating injection angle.

After a thorough analysis, it was found that the root of the problem was the shear mode technology employed by the ultrasonic flowmeters that had been installed one year prior. Shear mode does not match the phase velocity and frequency of the pipe wall, causing the transmitted beam to be interfered by pipe wall noise. The further down the pipe the beam travels, the more pipe wall noise interference it will encounter.

For this reason, only a very narrow part of the beam that originates from the front foot print of the transducer can be used for flow measurement; simply because it encounters much less noise. Since the shear mode technology is prone to be sensitive to fluctuations in liquid temperature, pressure, density and viscosity, variations in the injection angle are likely to occur, resulting in the beam to shift away from the receiving transducer. And this was exactly what caused the shear mode transducers to not work properly at the facility.

The solution

In looking for an alternative solution, the SITRANS FUS1010 clamp-on ultrasonic flowmeter from Siemens equipped with high precision transducers was selected. The meters' measurement principle is based on the patented WideBeam ultrasonic technology, which is very different from shear mode. By utilizing the pipe wall as an amplifier, the flowmeter shoots a wide beam with a variable frequency through the pipe in search for the pipe wall's intrinsic frequency. When a match is found the frequency is locked in by the meter and used for ultrasonic beam transmittal and flow measurement. This is done only once during meter installation and initialization.

The technology allows wide beams of ultrasonic signals to be shot across the flow stream between the two transducers to accommodate fluctuating beam angles without affecting flow measurement accuracy and without having to move the transducers. WideBeam also samples a much larger cross section than shear mode, offers better representation of the flow profile and allows for easier signal correlation because of more coherent beams. This optimizes the signal to noise ratio considerably.

In short, WideBeam makes up for the shortcomings of the shear mode technology, which was also what the customer came to realize after having used the meter for a period of time. The system has been working satisfactorily in terms of performance and reliability ever since the installation.

Looking forward

As a direct result of the success of the installation at this terminal, the oil company chose to install SITRANS FUS1010 clamp-on ultrasonic flowmeters at other terminal facilities in China: one was installed on a 20" (DN 500) carbon steel pipe at a booster pump inlet carrying LPG at a temperature of about -51°F (-46°C) and at a pressure of roughly 87 psi (6 bar).

An additional two were installed on 12" (DN 300) carbon steel pipes carrying liquefied propane and butane to the underground caverns at an operating temperature of 122°F (50°C) and 580psi (40 bar). Since the two terminals are operated in similar ways, the customer was able to leverage the knowledge in using the Siemens flowmeters, thereby taking full advantage of the performance, features and benefits that the SITRANS FUS1010 offered right from the point of installation.

The transducers of the SITRANS FUS1010 mounted on the pipes that transport the liquefied gas from the barges to the underground storage sites; each with a capacity of 8.83 million ft³ (250.000 m³).

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