Self-Conditioning Flow Meter Solves Measurement Challenges for LNG Processing and Distribution

Case Study

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With the continuous increase in demand for energy worldwide, the popularity of clean-burning natural gas has grown rapidly over the past decades. Its relatively abundant supply, along with new high efficiency production technologies and its lower carbon dioxide (CO_2) emission footprint compared to other energy resources, have all made it a cost-effective, environmental-friendly choice for consumer electric power generation systems and other energy applications.

Over long distances, the safest and most economic method of transporting natural gas is in a liquid state. Plants dedicated to turning raw natural gas into Liquefied Natural Gas (LNG) and later back into gas for distribution are either on-stream, under construction or planned all over the globe. The production, processing, storage, transportation and distribution of Natural Gas all require accurate, repeatable flow measurement.

Figure 1: Liquid Natural Gas tanker at port

The high-pressure, volatile nature of this valuable, but hazardous fluid makes it a challenge to measure in both its gaseous and liquefied state. While there are multiple gas and liquid flow measurement technologies, many of them rely on moving part designs (a potential safety hazard) or fail to measure accurately over a wide turndown range under upset conditions or require long straight runs of pipe upstream and downstream from the location of the meter that are difficult to achieve under the always crowded production and refining environment.

The Challenge

Converting natural gas to its liquefied LNG state reduces its volume by 600 percent. This reduction in volume facilitates transport by ship, export and distribution. The natural gas is first cooled to -260˚F (-162.2˚C), which condenses the fluid into the liquefied state. Flow is then measured again several times during transportation, storage, regasification and distribution through pipelines to the end users.

The liquefaction process takes place in hazardous, space-constrained facilities. LNG processing, transportation, storage and distribution require a flow meter that is rugged, dependable, simple to install and suitable for use in potentially explosive environments. Flow meter technologies with moving parts or those requiring complex

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installation, or frequent recalibration and other maintenance represent potential safety issues, accuracy problems and added operating costs that burden production and refinery operations.

The Solution

Featuring a unique self-conditioning flow technology, the versatile V-Cone® Flow Meter from McCrometer offers a lowest-installed cost, low-maintenance and highly reliable measurement solution for challenging hazardous applications in LNG processing, transportation, storage and distribution. The V-Cone Flow Meter's no-moving parts, high-reliability design offers safe, highly stable measurement in explosive environments with 25 years of proven service and the standard global agency approvals required for use worldwide.

The advanced V-Cone Flow Meter offers significant installed and operational cost savings in LNG facilities with complex or crowded equipment layouts, where the options for upstream and downstream piping are limited. The V-Cone Flow Meter utilizes a centrally located intrusion that redirects the flow to the outside of the pipe and conditions the flow by reshaping the velocity profile, all but eliminating the need for straight pipe runs.

The V-Cone requires straight pipe runs of only 0 to 3 pipe diameters upstream and 0 to 1 pipe diameters downstream. This smaller footprint, requiring up to 70% less straight pipe without being affected by flow disturbing equipment up or down stream, is more compact than any other differential pressure meters.

The V-Cone Flow Meter dramatically reduces installed and operational costs. The cost savings is especially common at both liquefaction and regasification facilities where large lines enter and exit the plant. Beyond the initial savings by installing much shorter pipe runs, there is an additional energy cost savings that accrues from maintaining the extreme cryogenic temperatures necessary over a much shorter distance. The need for costly pipe insulation also is reduced for the same reasons.

The V-Cone Flow meter is a differential pressure (dP) type flow meter. The principle of operation is based on Bernoulli's theory of conservation of energy. In a closed system, as the cross sectional area changes, so must velocity. By placing the cone in the pipe, the cross sectional area is reduced forcing velocity of the fluid to increase. As velocity increases, pressure drops and it is that pressure drop that can be measured and used to determine the fluid flow rate. This system can be used for both liquids and gases, as well as steam in other applications.

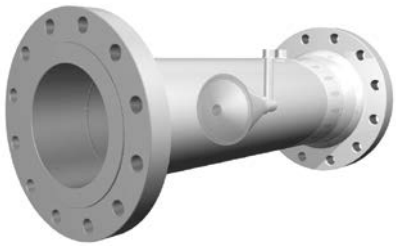

Figure 2: The V-Cone Flow Meter

The difference in pressure is incorporated into a derivation of the Bernoulli equation to determine fluid flow. As the fluid moves past the cone, very short vortices are formed that result in a low amplitude, high-frequency signal optimal for excellent signal stability. The V-Cone maintains ±0.5% accuracy and ±0.1% repeatability over a 10 to 1 turndown and the cone conditions the fluid such that there is relatively low permanent head loss.

The low permanent head loss achieved by the V-Cone Flow Meter results from the shape of the cone itself, which minimizes energy losses commonly caused by areas of

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low flow, cavitation and erratic flows. Each V-Cone Flow Meter is sized to meet desired application requirements and may be specifically designed to have high or low head loss. Regardless, the overall energy consumed by the V-Cone Flow Meter is minimized because of its inherently efficient design characteristics.

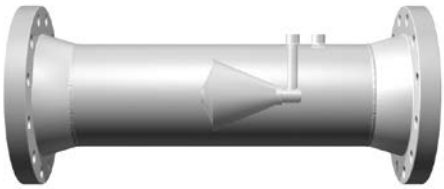

Figure 3: Cut-away side view shows the V-Cone flow meter's V-shaped conical intrusion in the center of the pipe.

The rugged, no moving parts V-Cone Flow Meter measures abrasive, dirty, and particle-laden fluids over a wide range of Reynolds numbers without wear or clogging concerns, resulting in an unprecedented standard 25 year operating life with virtually no need for maintenance. Reynolds numbers are a measure of whether flow is laminar or turbulent. With relatively low maintenance costs, which are an extremely important concern in LNG processing and distribution, the V-Cone Flow Meter helps reduce total operating costs.

The turbulent vortices produced by the V-Cone condition the fluid flow to be homogeneously distributed and extremely stable. It is this turbulent flow that actually protects the cone as well as the surrounding pipe. The turbulent flow forms a boundary layer against the pipe wall and cone protecting it from particle impingement which can cause deterioration or buildup on the surfaces.

Normal surface deterioration in flow meters, piping, and other equipment occurs as a result of fluid sheer stress. Shear stress creates a problem where there is a solid boundary layer in direct contact with the walls of the pipe. Shear stress occurs in laminar and unstable turbulent flows.

The V-Cone's very stable turbulent flow all but eliminates this shear stress and consequently results in no surface deterioration. Additionally, due to the shape of the cone, there is little chance of cavitation on the backside of the cone to erode the surface. Each V-Cone is calibrated during the manufacturing process and because the design is so robust, there is never a need for regular maintenance or recalibration after installation.

Conclusion

With its self-conditioning, no-moving parts differential pressure (dP) sensing technology, McCrometer's V-Cone Flow Meter is now installed in a wide variety of LNG applications all over the world. Hundreds of V-Cone Flow Meters have been installed to measure gas as it flows into liquefaction trains and then from the trains into storage tanks. It has even been used in specialized cryogenic applications where flow was never before measured. The versatile V-Cone® Flow Meter offers a lowest-installed cost, low-maintenance and highly reliable measurement solution for challenging hazardous applications in LNG processing, transportation, storage and distribution.

Engineers in the oil and gas industry have relied for over 25 years on the V-Cone Flow Meter to remain accurate in the toughest applications. Its low-maintenance, no-moving-parts design is proven to remain accurate for 25 or more years and all but eliminates the need to shut down production for calibrations, inspections or regular primary element replacement needed for an orifice plate. It saves money by increasing production up-time and reducing labor costs.

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