Pipeline Crude Pumping Station Solves Flow Measurement Problem With V-Cone Meter

Case Study

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A regional light crude pipeline operator in the mountain states of the U.S. was looking for an economical, accurate method to measure crude inventory flow within its pumping stations. The pipeline operator specializes in transporting partially processed crude to other lines or main terminals.

Accurate flow measurement is essential to the cost-effective operation of pipelines. While highly precise, and often expensive, flow meters are required to perform custody-transfer measurements for payment purposes, there are also intermediate process measurement points within pumping stations, for example, that can be served with less expensive technology.

When oil is moved over distances via pipelines, pumping stations maintain product throughout as it travels. The flow rate and volume must be monitored (metered) to optimize pump operation and throughput to the end destination at a terminal, refinery or point of custody transfer as well as serve as early warning for leak detection. The pipeline pumping stations are located in proximity to equipment or facilities or where there are mountain ranges, long valleys, etc.

The Challenge

The regional pipeline company's process engineers were searching for a low cost, but accurate flow measurement solution for internal inventory monitoring at its pump stations. There were no custody-transfer requirements and so a flow meter with an accuracy of ±0.5 percent was deemed suitable.

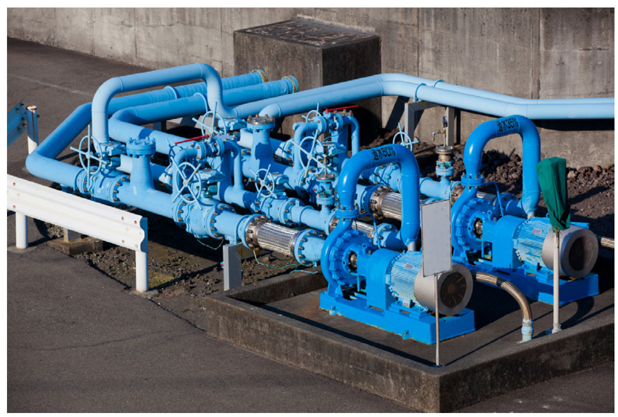

Figure 1: Example of Crude Oil Pumping Station

The light crude in the pipeline already had passed through heaters/treaters or main separators, which left it devoid of gases, water or other constituents that would disturb the specific gravity (SG) of the oil. In this region, the oil has an API gravity rating of 40 or above.

The light crude in the pipeline featured a viscosity of 2 to 8 centipoise (cP). With various pipeline sizes from 6 to 8 inches, the liquid velocity varied between 1 to 16 ft/s (0.3 to 4.9 m/s). Flow meters are mounted to both the pump suction and discharge lines.

The engineering team reviewed several flow meter technologies, including Coriolis, differential pressure (dP), positive

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displacement (PD) and turbine. While all the technologies do measure flow, the team needed to find the specific one that would be the best fit in the crowded pumping station environment. They also needed to look at installation requirements, maintenance and instrument life with a total life-cycle cost perspective to find the most cost-effective solution.

The Solution

When the pipeline engineering team contacted McCrometer, the company's applications group suggested the V-Cone® Flow Meter. Featuring a unique self-conditioning flow technology, the V-Cone Flow Meter offers a lowest-installed cost, low-maintenance and highly reliable measurement solution for light crude pipeline pumping station applications. Its no-moving parts, high-reliability design offers safe, highly stable measurement with several decades of proven service and the standard global agency approvals required for use worldwide.

The advanced V-Cone Flow Meter offered significant cost savings in light crude pipeline pumping station applications with complex or crowded equipment layouts. 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 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.

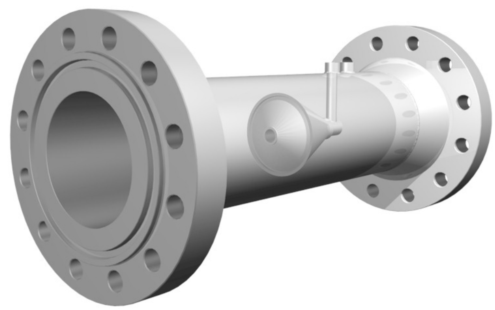

Figure 2: The V-Cone Flow Meter

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 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.

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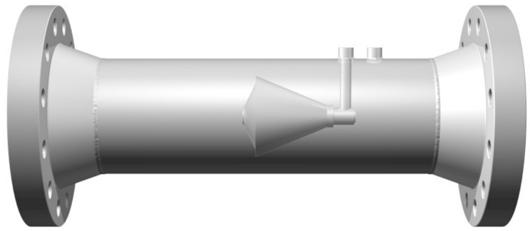

Figure 3: Cut-away side view shows the V-Cone flow meter's V-shaped conical intrusion in the center of the pipe.

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. The result is a long operating life of 25 or more years with virtually no need for maintenance, which greatly reduces costs for users.

The turbulent vortices produced by the V-Cone condition the liquid 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. McCrometer operates its own Calibration Laboratory and provides custom calibrations to specific user requirements.

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 oil production, refining and pipeline applications around the world. The versatile V-Cone® Flow Meter offers the lowest-installed cost, low-maintenance and highly reliable measurement solution for any industrial application.

Engineers in the oil industry have relied for several decades on the V-Cone Flow Meter to remain accurate in the toughest applications. Increasingly engineers are recognizing the benefits of the V-Cone and placing it in ever broadening applications traditionally held by the old guard dP technologies such as Venturi tubes.and Orifice plates as well as Turbine and PD. Its low-maintenance, no-moving-parts design is proven to remain accurate 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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