

## CASE STUDY

# Accurate Flow Meter Helps Sugar Mill Measure Steam Consumption of Distillery Plant Producing Bio-Ethanol

*Author:* Nick Voss, V-Cone Product Manager, McCrometer, Inc.

With demand for sugar products growing worldwide, production is rising at many mills including one in Latin America that relies on steam heat as part of its process that converts raw sugar cane into molasses, sugar and related products. The mill's production team was tasked recently with transferring excess steam from its production system to a nearby bio-ethanol plant operated by the same parent company.

A typical sugar mill first extracts raw sugar from the cane, and then processes it further for a variety of consumer and commercial uses. The mill cleans, cuts, chops and shreds the cane and then adds water before heavy rollers crush out the sucrose juice. The liquid is then mixed with other substances prior to further refinement in several complex steps that eventually create granulated sugar or other products.

The left-over pulverized sugar cane material is burned to fuel the mill's process steam boilers, which send steam to large turbines that create co-generation electric power. The co-gen electric power is then used in the plant and/or exported to the power grid for use by others. Surplus plant material also can be incorporated in feed for livestock and paper product production as well.

### The Challenge

The process engineers at the sugar mill in Latin America needed a new flow meter for steam custody transfer

purposes. They were required to measure the steam transferred via a 16-inch line from the sugar mill to its sister company bio-ethanol plant for cost accounting purposes. The mill's process engineers were looking for a reliable and accurate steam flow measurement



Figure 1: Sugar Mill

solution without routine maintenance requirements for operation in a high-heat, high-humidity dirty plant environment.

Choosing a new flow meter can be a complex and time-consuming process. There are numerous flow meter measurement technologies, and not all of them are equally suitable for measuring all fluids: steam, gas or liquids. A review of the plant's process requirements, however, will generally narrow the field of candidates if the following criteria are reviewed:

- Fluid to be measured: steam at the sugar mill
- Accuracy requirement: custody transfer for plant-to-plant co-generation
- Reliability or repeatability: potentially hazardous environment
- Environment: high pressure, high temperature, high humidity
- Installation Ease: straight-run requirements for accurate measurement
- Maintenance: no cleaning or recalibration
- Long Life: 25+ years
- Price: low life-cycle cost

In this particular application, the sugar mill's high pressure operating environment was a cause for concern with some flow sensing technologies. Those technologies that rely on moving turbines or plates can be problematic in high pressure (steam) applications. They can even pose a serious safety hazard if a piece should break off during operation and pass through the line into other equipment.

Variable line pressures occur when the steam flow is irregular due to seasonal high/low climate temperatures or changes in steam production relating to a drop or increase in feedstock. The result can be depressurization or a pressure spike that causes stress to the mechanical parts. These types of conditions eventually require costly maintenance and recalibration with some flow sensing technologies.

## The Solution

After the process engineers at the sugar mill reviewed a number of flow sensor technologies, they contacted the flow measurement applications team



*Figure 2: The V-Cone Flow Meter*

at McCrometer. The company has been supplying flow meters that rely on differential pressure, electromagnetic and propeller technologies for over 55 years in the process and other industries.

The team at McCrometer quickly recognized the harsh operating environment and low maintenance requirements, which led them to suggest the V-Cone Flow Meter for this application.

The V-Cone® Flow Meter developed by McCrometer not only provides precision flow measurement in steam, liquid, or gas, but requires virtually no maintenance in demanding processes where high pressure conditions exist. It is ideal for use in a wide range of industries from food/beverage, pharmaceutical, pulp/paper, oil/gas, water and wastewater treatment.

McCrometer's V-Cone® Flow Meter is based on advanced differential pressure technology requiring no moving parts that may fail due to high pressure and has no spaces that may clog during use. Built-in flow conditioning allows the V-Cone® to achieve accuracy of  $\pm 0.5\%$  and repeatability of  $\pm 0.1\%$  (high reliability) with straight pipe runs of only 0-3 pipe diameters upstream and 0-1 pipe diameters downstream.

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 flow meter requires straight pipe runs of only 0 to 3 pipe diameters upstream and 0 to 1 pipe diameters downstream.

The V-Cone flow meter's smaller footprint requires up to 70 percent less straight pipe without being affected by flow disturbing equipment up or down stream. Its self-conditioning design allows the sugar mill process team to place the flow meter exactly where it's needed without the costly addition of extra pipe, external flow conditioners or complicated space-consuming layouts.

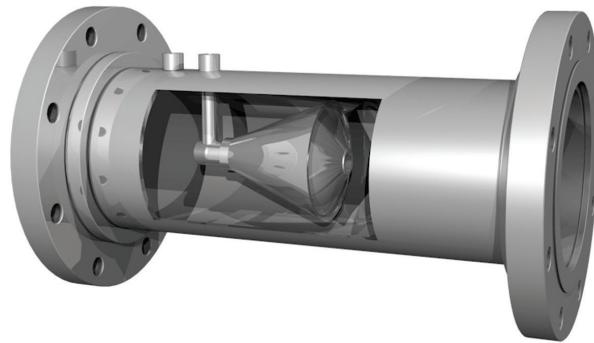
The V-Cone flow meter measures fluid flow by utilizing the conservation of energy theory, which basically states that in a closed system, energy can be neither gained nor lost. According to the  $PV=nRT$  equation, pressure multiplied by volume equals temperature while "n" and "R" are constants. Imposing a volume change within the pipe line, therefore, results in a differential pressure drop that can be measured directly.

McCrometer's V-Cone flow meter places a "V-shaped" conical intrusion centrally in the line, redirecting the fluid to the outside of the pipe and around the cone.

One pressure sensing tap located upstream from the Cone measures static pressure while another pressure sensing tap measures the low pressure created by the cone on the downstream face of the cone itself.

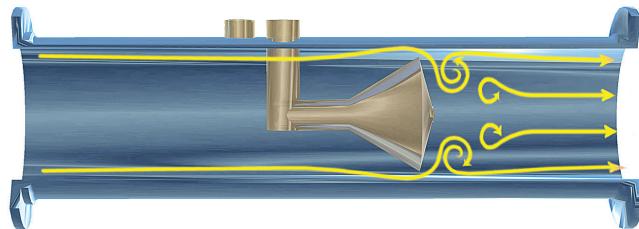
This pressure difference is incorporated into a derivation of the Bernoulli equation to determine fluid flow. As the fluid moves past the cone, very short vortices are formed that result in a low-amplitude, high-frequency signal optimal for excellent signal stability. The V-Cone flow meter maintains  $\pm 0.5$  percent accuracy and  $\pm 0.1$  percent 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. The shape of the cone minimizes energy losses commonly



*Figure 3: The V-Cone Flow Meter's Centrally Located Cone*

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 inherent characteristics.



*Figure 4: The V-Cone Redirecting Fluid Around the Cone*

The rugged, no moving parts V-Cone flow meter measures clean, 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 generally no need for maintenance. Reynolds numbers are a measure of whether flow is laminar or turbulent.

The turbulent vortices produced by the V-Cone flow meter 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 flow meter'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 meter 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

The first V-Cone was installed in a sixteen-inch line and has been operating successfully since 2005. The owners of the sugar mill plant are expanding the distillery plant where they will have the same application for a larger thirty-inch line. Since the plant found the original V-Cone flow meter reliable, repeatable, and accurate with no need for recalibration or adjustments for maximum uptime, purchasing a new thirty-inch V-Cone was an easy choice.