THE MASS APPEAL OF CORIOLIS FLOWMETERS FOR CUSTODY TRANSFER APPLICATIONS

The need for high accuracy calculation of oil and gas flows in custody transfer applications makes it vital to pick the right equipment that will help to minimise the risk of any measurement errors. In this article, David Bowers, Product Manager Pressure and Process Flow for ABB's Measurement & Analytics business, explains the benefits offered by Coriolis mass flowmeters for custody transfer installations and the key factors involved in selecting a flow computer to calculate measured values.

The need to ensure exact custody transfer of oil and gas from producer to customer calls for equipment that can offer the highest levels of measurement accuracy. With even a slight inaccuracy potentially resulting in losses of hundreds of thousands of dollars for either the vendor or the purchaser, the need to safeguard against errors is of paramount importance.

Without a precise account of what's been delivered, operations cannot accurately charge for their services, potentially resulting in major financial implications. As well as lost revenue, these implications can also include potential breach of contract and incorrect calculation of the taxes that need to be paid on the transaction, which could incur penalties from the relevant authorities.

For this reason, custody transfer measurement is closely monitored, with a number of industry bodies regulating standards around the world.

With accuracy key to correct custody transfer, it is vital to pick the equipment that will be able to offer the highest levels of measurement performance.

A typical custody transfer installation will comprise of flowmeters, pressure and temperature transmitters, installed in a pipeline close to the point of delivery. These devices will be connected to a flow computer that will combine the various measured values to calculate the quantities of oil or gas that are being transferred.

Choosing the right flowmeter

As the primary method of measuring flows of oil and gas from the pipeline to the customer, flowmeters effectively constitute the front end of a custody transfer system. The need for high measurement accuracy, coupled with the characteristics of oil and gas flows necessarily restricts the range of available flowmetering technologies to a handful of choices.

Of the various flow measurement technologies on offer, those most appropriate for use in custody transfer application can be divided into five main categories. Four of these - differential pressure flowmeters, turbine flowmeters, positive displacement (PD) flowmeters and ultrasonic flowmeters, operate on the volumetric flow principle, measuring the volume flow of liquids or gases. The fifth category, Coriolis flowmeters, operate on the mass flow measurement principle.

For the purposes of this article, we will look at the advantages of Coriolis mass flowmeters and how they can be used in conjunction with the latest flow computer technologies to offer high accuracy measurement in custody transfer applications.

Commercially introduced in the 1980s, Coriolis mass flowmeters have become one of the most versatile and reliable means of measuring the flow of liquids or gases. Their main strength is in their ability to measure multiple attributes over sustained periods with high repeatability and very little maintenance.

The mass appeal of mass flow measurement

Although liquids and gases can be measured using both volumetric and mass flow measurement, mass flowmeters are increasingly finding favour for high accuracy applications, as the measurement is mostly unaffected by the effects of temperature or pressure. Coriolis mass flowmeters use the momentum of the fluid to directly determine the mass flow.

The high accuracy of Coriolis mass flowmeters means they are ideal for liquid mass flow measurement applications, especially those subject to variations in product density or where a product is priced by weight. In addition, Coriolis meters also provide direct density measurement. Eliminating the need for an inline density meter, this capability is invaluable for product quality assurance purposes by enabling improved measurement of the composition of liquid and gas flows.

Fundamental versatility

Coriolis meters work by measuring the mass flow rate, fluid density and temperature of a fluid as it flows through a vibrating tube. Other measurement values can be derived from this information, such as the volumetric flow rate and percent concentration.

By measuring mass flow, density, concentration and temperature, a single Coriolis meter can effectively do the work of multiple instruments, eliminating the cost of purchasing separate devices and minimising the requirement for spare parts and overall maintenance.

Coriolis meters are steadily being adopted in growing numbers in upstream oil and gas applications. One reason for this is their resistance to the wear and tear that can cause other measurement techniques to lose accuracy over time and increase the frequency of inspection and maintenance.

With no moving parts that come in direct contact with the measured substance, whether gas or fluid, they require little maintenance or upkeep. This is particularly beneficial in the remote locations typical of many oil and gas installations, where it may

take several hours for an engineer to travel to site to carry out any necessary inspection or maintenance work.

With repeatability equally as important as accuracy in custody transfer applications, another key benefit offered by Coriolis flowmeters is the stability of calibration. Once calibrated at the factory, Coriolis meters tend to remain calibrated throughout their lifecycle. Although this can make them comparatively more expensive than other flowmetering technologies, any additional costs are more than offset by the benefits that stable calibration can bring during their operational life through a reduced need for checking and maintenance.

In addition, because Coriolis is the only principle capable of measuring mass flow of gas and liquids without any calculation, results are independent of changes in temperature or pressure. The use of Coriolis flowmeters also allows for density measurement, making them a true multi-variable metering solution capable of handling conditions that limit the effectiveness of other technologies.

One example is in applications with turbulent flow. Where flow is turbulent, other metering technologies may require a run of straight pipe to smooth the flow before it's measured. With no need for such measures, Coriolis meters can be installed in a small footprint, with the added option of the meters being able to work equally well when mounted either horizontally or vertically. For operators, this not only minimises the space required for installation, but can also help save money through reduced expenditure on pipework alterations and overall engineering.

Choosing the right flow computer

The next step is to turn flow information into cash. In this respect, flow computers are effectively the cash register in custody transfer applications. A flow computer is an electronic device that takes inputs from the flowmeter and pressure and temperature sensors to compute a corrected volume flow.

How this is done depends on whether the flow is a gas or a liquid. Where gas is being measured, some form of gas quality analyser will be used to provide information about gas composition, while for liquid measurements, the density is typically measured by the Coriolis meter or, for other type of flow meters, by a separate inline density meter. In addition, or alternatively, an inline sampling system may be used to obtain a representative sample for further analysis.

The flow computer corrects the measured volume at the reference pressure and temperature. The reference pressure is the atmospheric pressure, while the typical reference temperature is normally 15°C (60°F). Other reference temperatures of 0, 20 or 25°C may also sometimes be used.

Besides the corrected volume, the flow computer also calculates the mass and energy quantities.

Many devices claim to be a flow computer or to have flow computing capabilities. However, in application such as custody transfer where accuracy is critical, a true flow computer should not be a general-purpose control device like an RTU, a PLC or a DCS.

Instead, any flow computing device used for custody transfer should be especially designed for the purpose and should have been rigorously tested for immunity against electrical and magnetic disturbances. Where selecting a flow computer is concerned, there are five key factors to consider, specifically: accuracy, traceability, security, regulatory compliance and whether a liquid or gas flow computer is required. The importance of each of these, and how they are addressed is covered in outline below.

Accuracy

A flow computer incorporates special features that are not provided by other types of computing device. The need to obtain the most precise data means that flow computers for custody transfer applications utilise highly accurate analogue to digital input circuits.

Flow computers use the most accurate algorithms to calculate fluid properties such as density and heating value. They also offer accurate real-time and differential time measurement capabilities and can calculate the corrected flow rates and fluid properties at least once a second.

Beware of bits. 32-bit versus 64-bit floating point accuracy

Most calculation devices used in the process industry use 32-bit, single precision floating point variables. Without going into the technicalities of floating point numbers, 32-bit floating point calculations are accurate up to seven digits. In most cases, this is almost always sufficient, as the requirements for accuracy are rarely more than one percent.

This is not the case for custody transfer metering applications, however. In these applications, eternal totalizers are used. These totalizers store big numbers, typically running to nine digits or more, and are rarely, if ever, reset. These figures are normally included in daily measurement reports and so need to be as exact as possible. If 32-bit arithmetic is used to subtract two eternal totalizers to derive a flow measurement for a given period, significant errors can occur. Using 64-bit arithmetic will prevent such errors, as these calculations are accurate to up to 15 digits.

This accuracy can be further enhanced by utilising instruments such as ABB's CoriolisMaster flowmeters which operate on a 64-bit Modbus output. By enabling 64-bit arithmetic to be used throughout, the risk of errors caused by rounding of extremely large totalisations is eliminated.

Traceability

Traceability of data is another important consideration. A flow computer for custody transfer should be able to keep track of additional information such as the weighted averages of field inputs and fluid data, as well as any alarms or events that occurred and any changes to its configuration. The information should be recorded with a timestamp and user identification, which allows for future verification and, if needed, correction of the production totals.

Security

As protection against unauthorised access and tampering that could affect the calculation of the transaction value, custody transfer flow computers should incorporate a high level of security.

Regulations around flow computer security require the inclusion of a metrological switch to prevent any unauthorised modification to the flow computer's measurement functions. Operators should also be required to provide a logon password using either the controller's local access keypad or over a communication network, thus enabling data to be collected on anyone who accesses the device, together with the time and date they accessed it. Functions should also be included to ensure that production data records and reports are encrypted and signed, such that any unauthorised attempts at modification can be quickly and easily pinpointed.

Compliance with regulations and standards

The importance of flow computers in custody transfer applications means they are subject to a raft of standards and regulations. In the EU, the Measurement Instruments Directive (MID) sets down the essential requirements for flow computers. This includes EN12405, which stipulates the requirements and tests for devices that are used to determine the corrected volume and energy of fuel gases, including flow computers; and OIML Recommendation 117 for liquids other than water. MID also refers to Welmec 7.2, which provides guidance on software requirements and validation relating to the use of electronic volume conversion devices such as flow computers.

Welmec 8.4 and 8.8 set the requirements for the production, testing and fitness for purpose of electronic flow computers and their intended use as a calculating and indication device in gas and liquid measuring systems.

With custody transfer of oil and gas taking place in countries worldwide, there are also many other different national and company specific standards for flow computers. One example is Chapter 21 of the American Petroleum Institute's (API) Manual of Petroleum Measurement Standards, which sets out best practice and requirements relating to the use of electronic gas and liquid measurement systems.

Other provisions also relate to the way in which liquid and gas flows are measured and calculated, including specific calculations

set down by the API, the American Gas Association (AGA) and the Groupe Européen de Recherches Gazières (GERG)'s GERG-2008 multi-parameter equation of state for the prediction of natural gas mixture properties.

The need to demonstrate that flows were accurately measured in line with these requirements makes it vital to ensure that the flow computing device being used is fit for purpose. However, it can be difficult to find suppliers offering equipment capable of satisfying all these standards and requirements.

Do you need a liquid or gas flow computer?

A liquid flow computer provides additional features over a gas flow computer. Foremost amongst these is the inclusion of the many different API tables for the calculation of liquid properties such as density and vapor pressure. Because the transfer of liquid products is based on batch transactions, a liquid flow computer also maintains batch data in addition to period data.

A liquid flow computer needs to be able to recalculate batch totals based on laboratory analysis of liquid samples. Liquid flow meters used for custody transfer are typically calibrated in the field by a stationary or mobile proving system.

The liquid flow computer controls the proving sequence and calculates the new meter factor in accordance with the different API standards for meter proving. Furthermore, liquid flow computers are used for controlling the flow through the meter, the line-up of meters for proving and the sampling system.

Similarly, a gas flow computer also incorporates the necessary calculations to enable accurate metering and calculation of gas flows. These should include the calculations set out by the ISO (International Organization for Standardization) and/or American Gas Association (AGA) for the measurement of natural gas flows using different types of metering technologies. Specific provisions for custody transfer applications include: ISO6976 (calculation of calorific value and density from composition); AGA8 parts 1 and 2 (calculation of variations in gas compositions and determination of uncertainties); and AGA11, covering the measurement of natural gas flows using Coriolis flowmeters.

Conclusion

With oil and gas companies needing to adapt to meet the requirements of a changing market, the need to be able to charge correctly for their products is of paramount importance. This, coupled with the need to minimise total ownership costs and address problems caused by the absence of skilled engineering and maintenance staff, is calling for solutions that can offer the highest levels of accuracy and reliability.

The inherent benefits of Coriolis flowmeters, especially when used alongside a correctly specified flow computer, can help to address these needs and substantially reduce the risk of any discrepancies that could impact on custody transfer transaction calculations.

As a manufacturer and supplier of flow measurement and calculation technologies, ABB has the products and expertise to help you to satisfy the accuracy, traceability and compliance requirements of custody transfer applications. For more information, email enquiries.mp.uk@gb.abb.com or call 0870 600 6122 ref. 'Custody transfer'.

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