METERING BEST PRACTICES

Meha Jha and Julie Valentine, Emerson, USA, highlight the best practices for achieving measurement confidence in critical refining applications.

As competition and environmental regulations have increased and margins tightened, optimising operations, whether tied to unit performance or maintenance, has become increasingly important. A relatively simple way refiners have made operational improvements is by upgrading measurement instrumentation. Historically, refiners often focused on repeatability of measurement and capital cost as the most important factors for selecting measurement technology. In certain applications such as custody transfer and blending, accuracy was also a priority, but traditional high accuracy technologies required significant maintenance to ensure performance. Today, refiners no longer have to face these challenges and trade-offs. Modern instrumentation is designed to improve the reliability of measurement and the device while reducing maintenance either by the inherent design of the device or embedded diagnostics. These added benefits equate to increased uptime, improved safety, and optimisation in critical measurement applications.

Custody transfer measurements

Having accurate custody transfer and inventory measurements is not only important for transactional purposes, but also for distinguishing between real losses and apparent losses from measurement errors in mass balances. Custody transfer measurements are commonly measured by either tank gauging, inline metering systems, or usually both.

For tank inventory measurements and transfers, multiple accurate measurements such as level, tank temperature, density, basic sediment and water (BS&W), and tank strapping tables are needed to complete the volume correction calculations for tank contents. The installed uncertainty of tank gauging systems composed of these measurements depends on factors such as the intrinsic accuracy of the instrumentation, uncertainty due to the selected installation method, uncertainty of the density and temperature throughout the tank, and uncertainty in the strapping tables. Technologies for measuring tank contents have greatly improved in accuracy, safety, and reliability. Traditional tank gauging systems have moved from manual, high maintenance, contacting devices, such as float and tape or servo for measuring level, to high accuracy, non-contacting radar technologies that have no moving parts and diagnostics. Some of these radar technologies even have two-in-one capabilities in which two independent and continuous level measurements are taken through one tank opening, enabling redundancy, simplifying installation, and providing level gauging and overfill prevention in a single housing. Other advancements support best practice guidelines established by the American Petroleum Institute (API) to reduce uncertainty in varying temperature gradients across a tank by measuring multi-spot temperatures across a tank, which can now be done in a single integrated transmitter and sensor for as many as 16 spot elements. Leveraging these modern technologies makes it easier to achieve custody transfer certified accuracy on tank gauging systems.

Figure 1. Newer technologies such as radar gauges for level measurement and multi-spot temperature sensors reduce traditional challenges, including maintenance, safety, and inaccuracies in tank inventory measurements.

Not only have the accuracies, reliability, and safety of tank gauging technology improved, but also the installation of these devices. Challenges of upgrading legacy tank gauging systems because of flexibility and scalability are now alleviated with solutions such as wireless instruments and emulation. Wireless tank gauging instrumentation reduced installation costs by up to 70%. Emulation technology enables improved measurement performance by replacing legacy level gauges with modern radar-based tank gauging while using existing field wiring and host systems. Emulation and wireless make it possible to upgrade a system incrementally as tanks come out of service.

While these newer technologies greatly improve the accuracy, safety, and reliability of tank gauging systems, stratification caused by poor mixing, and outdated strapping tables, are still common challenges. As a result, for shipping and receiving tanks, which are the most critical transfer points, adding inline metering systems to measure transfers and reconcile against tank gauging measurements is a common best practice.

Figure 2. Leveraging technologies such as Coriolis flow meters and ultrasonic flow meters in custody transfer metering systems are best practices for reducing fiscal risk, ensuring regulatory compliance, and sustaining measurement performance.

Custody transfer metering systems are composed of many critical components and can include multiple, parallel meter runs with multiple pressure and temperature transmitters, flow computers, sampling systems, gas chromatographs, and in-situ provers. At the core of the system accuracy is the meter. Traditionally, mechanical meters, such as positive displacement or turbine flow meters, were commonly used to deliver the high accuracy required for custody transfer applications. However, the accuracy these meters delivered came at the expense of the high maintenance costs required to maintain accuracy over time, due to the mechanical nature of the meter.

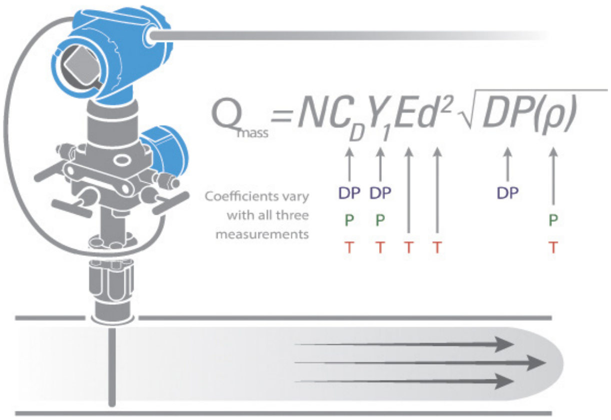

Figure 3. DP flow equation to compensate for temperature and pressure impacts to calculate mass flow.

Figure 4. Coriolis meters directly measure mass flow, density, and calculate volume. They do not require compensations due to changes in process conditions or fluids.

Mechanical wear on the meter is not the only factor that impacts accuracy; changes in fluid properties also impact the accuracy of these meters. Today, two highly accurate and repeatable flow measurement technologies, Coriolis flow meters and multiple-path ultrasonic flow meters, offer more sustainable measurement performance with minimal maintenance. Coriolis meters, in particular, directly measure mass flow, density, and calculated volume, making the accuracy of these meters independent of changes in properties.

Mass balance

Accuracy for custody transfer points and tank inventories is important for transactional purposes and the facility mass balance. However, another area where having confidence in the measurement is critical is unit charge and yield streams contributing to unit mass balance. Measurement errors result in poor quality data that can impact validating vendor performance guarantees, successful implementation of advanced control strategies, validating and updating optimisation models, closing the gap between planned and actual performance of the operating plan, and identifying unit constraints. Unreliable data has a snowball effect, throwing off efforts to optimise unit performance.

Errors contributing to unit mass balance stem from measurement errors inherent in the flow metering technology. Most flow measurement points in a refinery are measured by differential pressure (DP) flow meters, specifically orifice plate technology. Understandably, these meters are widely used because they are versatile, cost-effective, highly repeatable, and well understood. Utilising traditional DP orifice flow meters for most flow applications in a refinery is a common practice, however, in the few applications where accuracy is critical, the technology might not be the best fit for the application. Errors also occur when operating differently to design conditions, density sampling frequency and procedures, and changing fluid properties and process conditions impacting the accuracy of volumetric flow meters. As such, many factors are required to achieve the best possible accuracy with traditional DP orifice flow meters: first, verifying the meter is operating under the design conditions and the maintenance of the meter is up to date; second, verifying the correct installation and integrity of all the components of the meter, including the centring of the plate, plate dimensions, the proper straight run requirements, fill fluid levels, etc; and third, checking the compensation. Converting from volumetric to mass flow with a traditional DP flow meter can be tedious and requires additional data that may not be readily available.

As seen in the mass flow equation (Figure 3), temperature and pressure changes affect the coefficients used to convert DP to mass flow. Upgrading an existing DP transmitter to a multivariable transmitter, which can obtain DP, static pressure, and process temperature measurements, is one way to calculate mass flow. Multivariable transmitters are a cost-effective solution for improving flow measurement accuracy by continuously compensating the flow for the impacts of temperature and pressure changes on the flow coefficients used to convert the DP measurement to a flow rate. However, a key consideration for using multivariable transmitters on traditional DP orifice flow meters is to use these transmitters on streams where the composition of the fluid, and hence the specific gravity of the fluid, does not change significantly. The transmitter calculates the effect of temperature on the density but cannot compensate for density changes that occur due to fluid composition changes which often occur in many streams across a refinery. In such cases, an online densitometer, such as a fork density meter, can be added to the measured flow stream to provide a more continuous density measurement that can be used to correct the flows in the control system used for mass balance calculations.

However, the best way to improve accuracy is to use a Coriolis flow meter because these meters directly measure mass and can output calculated volume and require no compensation, regardless of changing process conditions or fluid properties. Coriolis flow meters also have the advantages of no impulse lines, no straight run requirements, and online diagnostics that can verify meter performance to factory standards as well as detect any abnormal conditions that impact meter performance.

Blending

Blending is another area in the refinery requiring higher accuracy measurements. Due to increasing regulation, tighter specifications, and tighter margins, blending on-spec is critical to minimising giveaway, rework, or demurrage costs. It is common to see refineries upgrade legacy blending systems including the control systems, analysers, and meters to reduce variability and improve throughput.

Traditionally, turbine meters were used on blending components for volumetric ratio control due to the blending accuracy requirements. Due to the moving parts and mechanical wear of the meter, frequent calibrations, lubrication, and maintenance are required to maintain the meter factor. Diagnostic information from the meter is not readily available to indicate when the meters may be out of calibration, so it is normally only discovered as blends begin to go out of spec or the blend deviates significantly from the planned recipe. Another factor that can contribute to uncertainty in measurement is two-phase flow caused by vapour in the line, which can cause overspinning and damage to turbine blades. This is especially prevalent in butane flows.

Two phase challenges and maintenance can be greatly reduced with Coriolis flow meters. The online meter health diagnostics can verify the meter is performing to factory standards in lieu of calibrations and the verification is done without disrupting the process. In addition, the diagnostics can detect if two phase flow is occurring and how it is impacting the performance of the meter. Improvements to the flexibility of the blending system is another advantage of utilising Coriolis technology. The accuracy of turbine meters is impacted by changing fluid properties, and if blend components change for different recipes, the meter factor needs to change. Coriolis flow meters enable better flexibility because they do not require any meter factor adjustments when changing process fluids. The turndown of Coriolis flow meters is also about five times better than turbine meters, so in many cases where two turbine meters were required to meet seasonal blend recipes, a single Coriolis flow meter could be used.

Sustaining measurement confidence

Sustaining and achieving measurement performance no longer requires the maintenance it used to. Diagnostics, robust designs, and newer measurement methods have resulted in sustaining measurement confidence at a much lower total cost of ownership. These measurement technologies deliver more than just process variables for control; they can be part of the strategy of achieving safety, reliability, efficiency, and optimisation goals. HE