TESTING TANK GAUGING IQ

Austin Alford and **Alexander Bukhman**, Gauging Systems Inc., USA, evaluate the advantages of mass and volume measurements, and how they can help to increase tank gauging IQ level.

Despite numerous technological advantages offered by new tank gauging technologies, there is a common misconception that accurate level measurement is all that is needed for operational use or inventory control.

It is, however, imperative to recognise that liquid level is only one facet of accurate hybrid tank gauging. While an installed liquid level gauge should be accurate to within 3/16 of an inch, as required by the API 3.lB standard for custody transfer applications, it still does not provide an accurate liquid quantity value by itself. The quantity, expressed in volumetric or mass units, would require very accurate average liquid temperature measurements, density measurements, as well as water measurements, including free, emulsified and entrained water. The acceptable measurement accuracy of those parameters become increasingly difficult to obtain for stratified products, and with the installation of multiple instruments at different tank locations, multiple influences and metrological errors are introduced into the measurement process.

An uncertainty in average temperature measurement can easily influence the product volume accuracy to a larger degree than level measurement uncertainty itself. The same applies to water measurement uncertainty affecting product quantity for custody transfer accuracy.

Since the introduction of Coriolis flow meters into the market, mass measurement capabilities in a tank gauge have become a significant advantage, even when volume alone is used for custody transfer. Since mass is the most accurate output of the Coriolis meter, the mass balancing between a tank gauge and a meter could provide significant advantages in total loss control and custody transfer evaluations.

Figure 1. Improvements in loss control and product quality.

Quality over quantity

The product quantity is not the only task or challenge for the modern tank gauging system. Product quality is of equal importance for eventual fiscal calculations. Product quality can be referred to as a ratio in a non-homogeneous liquid mixture between the desired product and anything else that is mixed in (usually water).

For petroleum products, and especially for crude, the quality of the product is directly related to its density as well. Quality measurements become increasingly valuable as the cost of the product increases. or example, if a company assumes it is purchasing a certain quantity of crude oil, but gets a significant percentage less due to water in the total mixture, then the chances are high that the company has overpaid by a substantial amount.

For tanks storing crude oil, the monitoring of density and density stratification is an important parameter of quality control for the ultimate purpose of benchmark crude preparation with significant fiscal impact.

Tank gauging instruments that focus solely on level are unable to make this distinction in quality. Even in cases where the interface between product and free water can be measured as a level, considerations need to be made to account for emulsified and entrained water in the product.

To obtain a proper product quality, density strata must be measured, especially for a stratified product. The density strata information can be used for optimal mixing and operation control, such as monitoring of product settling.

Advantages

The ability to measure product quality and quantity simultaneously, and to obtain these measurements continuously and in real-time, lends itself well to the optimisation of in-tank blending. This is useful for benchmark crude preparation, fuel oil optimisation, chemical blending, and other applications that require real-time feedback in order to properly control the processes.

The ability of some new tank gauging technologies to provide density, temperature, and water stratification over the entire liquid height, including multiple layers, allows for virtual sampling of product quality in real-time.

With the introduction of API MPMS Chapter 18.2 'Custody Transfer of Crude Oil from Lease Tanks Using Alternative Measurement Methods', such capability of new tank gauging systems could prove important for custody transfer operations in lease storage tanks. These new tank gauging systems can provide information for merchantability of the products in lease tanks.

The quality measurements are extremely important at pipeline crude oil terminals, lubricant plants and in many other applications. There are several other major financial and environmental advantages that systems designed primarily around liquid level measurement cannot provide.

Importantly, gauges only concerned with level cannot provide leak detection capabilities. The level of a product. even in the simple, ideal case of a thermally isolated, entirely rigid storage tank of any standard height, is too highly dependent on the product's minuscular temperature changes, making it unsuitable for any leak detection purposes. This extreme dependence on temperature makes the probability of true leak detection by means of level far too low, and the probability of false leak detection too great for feasible use. Advanced tank gauges, with direct mass sensitivity, allow for the detection of leaks and unauthorised movements by virtue of being much less dependent on temperature and density variations inside the product.

There are a few dedicated systems using mass measurements, based on the usage of external differential pressure sensors, for leak detection in tall, above and underground storage tanks. These systems mostly involve tank insulation and usually incur significant expenses for the contractor's labour, but still do not offer a permanent solution. Only a tank gauge with enough mass sensitivity would be able to adapt to regular tank operations and monitor any loss of product due to possible leaks, valve seepage, occasional unauthorised movement, or theft. In addition to direct leak detection capabilities, a mass tank gauging system meeting the previously described sensitivity requirements, working in conjunction with a mass flow meter, provides enough data for the statistical analysis needed to accomplish the purposes of loss control and prevention.

Loss control and environmental protection obligations are not only limited to leak detection; vapour emissions are a growing environmental concern, with regulatory agencies enacting standards to restrict pollution by region and by individual facilities. Tank gauges that track and, therefore, help to reduce vapour emissions can increase the production allowance of a facility by minimising each tank's contribution to the overall pollution cap. Modern tank gauging systems have the capability of comparing the data from sensors in atmosphere and those in the vapour space of the tank. This configuration of sensors constitutes a rupture protection system. Should a tank be nearing overpressure, an alert or alarm of some variety will notify the operators, enabling them to resolve the issue before the occurrence of a catastrophic tank rupture, which entails large environmental and financial ramifications. In addition, such systems are capable of inert gas blanketing monitoring.

Another impediment to the simple model is the fact that vessels are never perfectly rigid. Top-referenced tank gauges often do not take this into account. Large quantities of product will cause the tank floor and ceiling to flex. This, in turn, may cause bottom datum and/or tank reference height changes, which would affect total accuracy of the volumetric calculations for even a perfect level gauge.

Bottom-referenced tank gauges, extending through the entire height of the tank, follow the bottom movement and are independent of roof flexing. Thus they provide much more reliable quantity data than a top referenced gauge.

Additional functions, incorporated with some modern gauging technologies, allow for direct monitoring of the water settling process in crude settling tanks, usage in oil-water separators and even in so-called 'inverse' applications with a relatively narrow layer of crude or petroleum product floating on top of the large amount of water.

Conclusion

Tank gauging 'IQ' comes down to the multiplicity of functions of a modern system installed in a tank. The broadened functionality of these systems includes traditional and unconventional measurements such as level, temperature, free water, density, entrained water, mass and volume calculations, vapour emission parameter calculations, unauthorised movement and leak detection capabilities, and easy integration with modern flow meters for total product accounting and product balancing solutions.

Nonetheless, the potential benefits of extra functionality in tank gauges with a high 'IQ' should not turn into a tank gauging headache, with numerous instruments fitted to the tank, high maintenance requirements, multiple entry points, and the uncertainties inherent in combining measurements taken at different locations on the tank roof and wall. The expanded services of a modern tank gauge must be combined with minimal installation requirements, simple maintenance, and all measurements taken as close together as physically possible to reduce the uncertainties of their combined calculations.

Finally, the high 'IQ' tank gauge should require minimal wiring, offering standard, industry-recognised communication protocols capable of transmitting multiple measurements, with ease of integration into any existing istributed control system (DCS) or software systems.