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outlines an alternative method of LNG level measurement to tank strapping.

A DYNAMIC APPROACH

Due to the abundant reserves of natural gas, LNG is playing an ever-increasing role in the energy sector. It is easy to store for transportation over long distances by sea and is easy to process. As natural gas is clean-burning, LNG's carbon footprint also presents environmental advantages compared to conventional energy sources.

Global gasification capacity in 2016 reached 800 million tpy. The global LNG trade volume is expected to be 700 billion m^3 in 2030, valued at approximately US$172 billion. Increasing LNG trade across the world requires a concurrent increase in LNG metering points on the gasification, liquefaction and transportation chains.

LNG tank strapping – an overview

LNG tank level measurement systems are known for their poor accuracy in the context of custody transfer. Several factors can influence the measurement of the transferred volume. Among these are tank shape, tank level, liquid level stability measurement, the estimation of the vapour phase of LNG, liquid temperature, vapour temperature, and tank thermal expansion factor. The vapour phase volume is determined by estimating the vapour phase density relative to the top volume of the tank.

Therefore, the measurement accuracy of the filled (or transferred) volume is often poor compared to dynamic metering. Futhermore, when the measurement is carried out on a ship, the liquid level is unstable due to the movements of the vessel. 'Tank strapping' is time-consuming due to process operation time and because calculations have to be approved by the vendor and the buyer.

Metering accuracy and financial impact

The accuracy of the custody transaction has a financial impact on both the seller and the buyer. Tank level measurement uncertainties can easily exceed 3% in the worst conditions, especially when small volumes are transferred. If a mean uncertainty on the transferred volume is 1.5%, this represents a financial impact of US$2.58 billion within the global LNG trade.

Dynamic metering

There are several dynamic LNG metering technologies available, such as ultrasonic meters, mass coriolis meters, turbine meters, and positive displacement meters. Each technology has its advantages and disadvantages, and each is suited to specific liquid characteristics and process conditions (such as viscosity, density, flow range, and cryogenic or high temperature).

For LNG metering, the custody values that need to be metered are: energy, density, gross heating value, base volume, mass, and the transferred volume according to operating conditions during transfer. However, none of the above mentioned dynamic metering technologies can fulfil all of these custody metering values.

R&D undertaken by Meci has allowed for all of the custody values to be measured dynamically during the transfer (loading/unloading, pipe transfer) of LNG under real operating conditions. Its solution combines gas chromatography analysis with a dynamic measurement of the mass and volume of LNG under normal operating conditions using a mass coriolis meter.

The basic process and instrumentation of the method is illustrated in Figure 1.

The most critical pieces of equipment used for dynamic metering of LNG are the LNG sampler, LNG vaporiser, gas chromatograph (GC) analyser, pressure transmitter (PT), temperature transmitter (TT) and coriolis mass meter.

The LNG sampling system plays a key role in obtaining a representative sample of the LNG being transferred. The company has designed, developed and tested a robust vaporisation system that allows LNG phase transformation from liquid to gas. An in-line filtering system installed inside the pipe protects the vaporiser, while collecting the representative sample of the LNG in the liquid phase.

Vaporisation is ensured for all of the process conditions, including flow range, pressure range, temperature range, LNG composition change, filtration level, and climatic condition variations. During vaporisation, continuous thermo-regulated heating is provided to ensure that the sample is homogeneous, remains in the gas phase and is representative of the LNG being metered. Factory tests are performed to test all of the process conditions.

After obtaining a sample of the LNG, this sample is analysed by a specific GC to determine the gas composition and calculate both its density and gross heating value.

The second piece of critical equipment involved in the measure is the mass meter, certified for custody transfer. This measures the gross volume and gross mass in the operating conditions. It is developed for cryogenic metering, taking into account pressure and temperature effects on the measured values. The coriolis mass meter is calibrated in an ISO 17025 accredited laboratory with an accuracy of +/- 0.3%.

The transferred mass and base density are required to calculate the base volume of the LNG at the gas phase. Base density is calculated according to ISO 6976 by the GC or the flow computer. The transferred mass is measured by the mass coriolis meter.

Meci has also developed LNG metering calculation software, which has been implemented in its flow computers. These can be installed in safe areas (using the Flow computer CDN16) or in hazardous areas (using the CDV15 or Sm@rtFlow). The flow computers perform calculations based on the signals transmitted by the gas analyser, coriolis mass meter, and the temperature and pressure transmitters.

The flow computer checks that the LNG transfer is under liquid phase and calculates custody transaction values, such as transferred LNG mass, heating value, energy, volumetric flow at base conditions for gas phase, and volumetric flow in-line conditions for the liquid phase. The computer carries out all of the custody transfer values and records all quantities that are transferred during transfer, loading and unloading operations.

The CDN16 flow computer processes the cargo's mass, volume and energy, and provides reports of cargo loaded or unloaded to suit the commercial requirements of the charterer. The flow computer is also interfaced with the barge's control and alarm monitoring system, and supplies the data required to track operations.

The metering system is interfaced with the operator data control, supervision and management system. Overall uncertainty can reach (k=2) 0.6% on energy measurements, taking GC uncertainty, mass coriolis meter uncertainty, and pressure and temperature uncertainties under all process conditions into account.

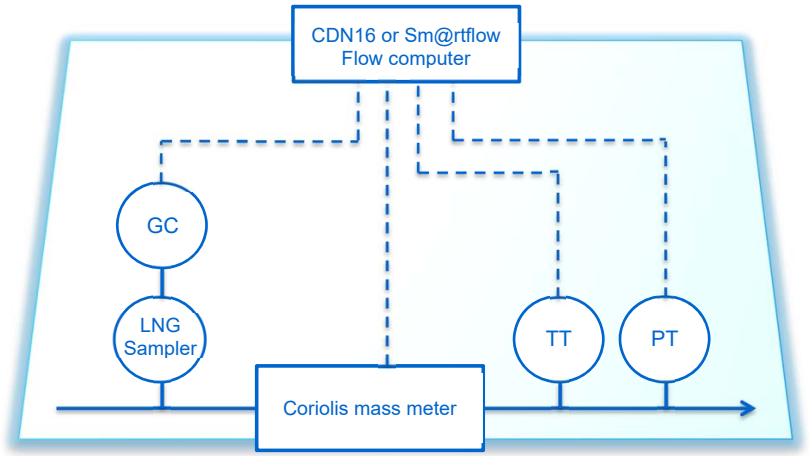

Figure 1. LNG metering piping and instrumentation diagram.

Case study

Metering systems can be installed onshore, offshore, on LNG bunkering stations and on transportation ships. Meci's latest project success is an LNG metering skid for a North American company (final user), installed on an LNG barge in the US (Figure 2).

In order to reduce the environmental impact of marine activity and provide economic advantages to marine transportation operators, Conrad Orange Shipyard Inc. started to build the first dedicated LNG bunkering barges for the marine market in the North America.

GAS Entec, a South Korean-based company specialising in the provision of small-mid scale LNG engineering, procurement and construction (EPC) solutions, awarded Meci a contract for the supply of the custody transfer system used to meter and record quantities transferred during the loading and unloading operations of LNG on the bunkering barge.

The metering solution that was set up is a standardised skid based dynamic metering package, including high-integrity and proven equipment, ready to be installed. The main equipment for this project included: a mass coriolis flow meter for measurement of LNG in cryogenic conditions; pressure and temperature transmitters; an LNG sampling probe and vaporiser to collect a representative gas sample; a GC analyser; and a flow computer with Meci LNG software. All equipment was designed, factory tested and calibrated for custody transfer.

The company successfully delivered a dynamic LNG metering package with an overall uncertainty of 0.6%.

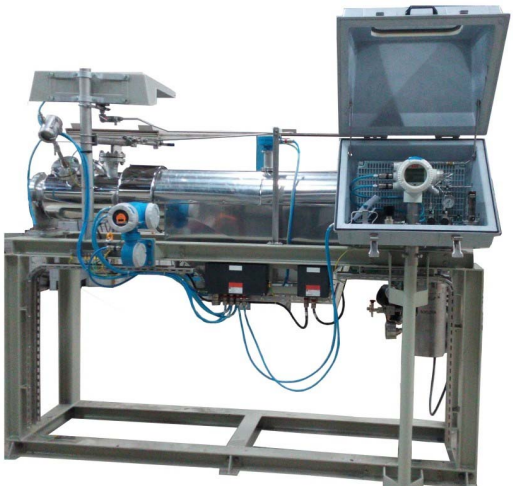

Figure 2. Typical Meci LNG metering skid.

Conclusion

LNG sampling and vaporising systems allow users to collect a representative sample, which can then be analysed by a specific GC. In addition, LNG metering software that is implemented into flow computers measure and report custody values. Meci's metering methods improve accuracy (0.6%) compared to a standard tank strapping method, which is subject to several uncontrolled parameters.

Note

Meci sas is a subsidiary of Clemessy, a company belonging to the Eiffage group.