



Bulk Tanker LNG Delivery Goes Digital

Delivery of LNG and other sub-cooled and cryogenic industrial gases such as liquefied oxygen, nitrogen and argon are often transported from the suppliers' terminal to the final users' sites by means of over-the-road bulk tankers. The delivery of these fluids is in virtually all instances considered to be the point at which title for the quantity delivered changes hands from the supplier to the customer. It is, in other words, the point of sale or transaction. In order to formalize this business transaction it is necessary to provide a reliable accounting of the amount of product delivered upon which a determination of the exact price to be paid by the customer to the supplier is to be calculated. In the world of metrology there are transactions that are regulated by a legal authority and those that are not but in both cases the measurement involved is used for calculating the value of the product delivered. Transactions that are not regulated by a legal entity are in all cases considered to take place between a supplier and a customer that are both "skilled-in-the-art" of the measurement principles required for the transaction. That is to say, both parties have adequate knowledge of the measurements needed, the techniques to be employed and their operations to enable them to enter into a contractual arrangement with the other party to establish the measurement means to be employed in the accounting and billing for product delivered under the terms of the agreement. Transactions in which a legal entity has regulatory authority the measurement systems used must meet the requirements of the regulator. Such systems that have demonstrated the ability for meeting these requirements to the satisfaction of the legal entity are said to have achieved "legal-for-trade" status.

A variety of measurement systems have been successfully employed in both regulated and non-regulated transactions for LNG associated with many different types of transport of the product from small volume dewars, to vehicle fueling, to over-the-road transports, to railcar tankers, to large marine vessels and pipelines. No single type of measurement system is universally appropriate for every type of installation and

application. In terms of the over-the-road bulk tanker, turbine flowmeter based measurement systems are one of if not the outright most popular legal-for-trade measurement systems used for this particular application. As a world leader in the design, certification and manufacture of turbine flowmeter-based legal-for-trade cryogenic and sub-cooled industrial gas applications, Hoffer Flow Controls has achieved many firsts in this field over its 50-year history. The first commercially successful turbine flowmeter based legal-for-trade systems for cryogenics, the first manufacturer to achieve more than 10,000 such installations globally, the first to incorporate self-lubricated bearings and subsequently hybrid-ceramic self-lubricated bearings in the turbine flowmeters used in these systems.



Basic elements of a Hoffer Cryogenic Flow Measurement System used on LNG road tankers.

A common element with all over-the-road bulk delivery tanker applications is the harsh environment that all components on the tankers must endure day-in and day-out in all types of weather and over all types of road surfaces in addition to the extremes in temperature caused by the very nature of the cryogenic and sub-cooled fluids being handled and delivered. Through all that the measurement systems used must provide accurate and reliable transactional data. In the case of turbine flowmeter based systems used on LNG road tankers, the basic elements of the measurement system as shown above, most often include:

1. The turbine flowmeter in sizes 1-1/2" to 3". End connections for these flowmeters are most often flanges with pressure ratings equal to ANSI Class 300# or 600# (PN/DIN 50 and 100). The predominant materials of construction for the flowmeter are 316/316L dual rated stainless steel.
2. A platinum RTD temperature sensor and transmitter.
3. A pressure sensor and transmitter.
4. A piping installation kit that encompasses mountings for the temperature and pressure sensors.
5. A purpose-built flow computer.
6. Interconnect cables.

These systems are most typically installed at the rear of the tankers as shown below:



Hoffer Cryogenic Flow Measurement System installation shown above for measurement of LNG on road tankers.



A closer view shows more detail of the Hoffer System which is typically installed in the rear of the tanker.

The essential principal of operation for such systems is the use of the turbine flowmeter to obtain an accurate volumetric rate of flow of the LNG being delivered, the use of the RTD sensor to accurately measure the temperature of the LNG being delivered and the pressure sensor to determine pressure of the LNG being delivered. All three signals are transmitted to the purpose-built flow computer. The computer integrates the flow rate signal over time to determine the total volume of LNG delivered and uses the temperature and pressure signals to determine the density of the LNG in real time against pre-loaded LNG fluid property tables. By knowing the volumetric total flow and the density of the LNG, the total mass or compensated volume of the LNG delivered can be determined within the legal requirements.

In these systems and because of the flammable nature of the LNG all the electronic components are mounted within explosion-proof/flame-proof enclosures to isolate them from any flammable vapors and to contain any potential ignition of flammable vapors that manage to penetrate those enclosures. This safety requirement does impose some not insignificant limitations of how the system can be operated and any changes that may need to be made. Selection of the appropriate LNG fluid property table (based on methane content) is more involved due to the safety enclosure around the flow computer. It also makes retrieving the delivery data from the flow computer to generate a delivery ticket and invoice more involved as well. Those traditional challenges, however, are now set to become a thing of the past due to new digital technology which also is bringing capabilities and advantages heretofore unknown in not only LNG delivery systems but in all other cryogenic delivery systems.

The combination of Bluetooth 5.0 (BLE) wireless communications and smart phones equipped with an industry first app for use with the [Hoffer ICE flow computer](#) is at the forefront of this digital revolution. Bluetooth has long been used by Hoffer and some other cryogenic system manufacturers to provide interfaces between the flow computers on the delivery tankers to proprietary hand-held printers used to produce delivery tickets. The primary advantage of such devices compared to permanently installed, hard-wired ticket printers has been their lower cost and lower exposure to over-the-road environmental conditions. With the introduction of smart phone apps, the need for any type of printer becomes purely optional. The smart phone apps provide the ability to wirelessly perform virtually all functions that are available from the front panel of the ICE flow computer. This includes the ability in the case of LNG applications for the operators to select the appropriate LNG fluid property table required for a delivery right from their smart phones.

The app can also capture all the data from the ICE flow computer required to create a delivery ticket and provides a signature screen for the customer. The delivery ticket can be emailed directly to the customer and at the same time delivered to the supplier's accounting system for rapid processing of the delivery invoice. It can also be uploaded to a cloud site as well for storage and retrieval. In the event no mobile phone service is available at the delivery location, multiple delivery tickets can be stored on the operators' smart phone. Any

errors generated by the flow computer during a delivery are also recorded by the smart phone app. The audit trail in the ICE that tracks any and all metrology related changes to its setup is also fully accessible through the smart phone app. All programming parameters contained within the ICE can be downloaded as well to the smart phone and transmitted to the supplier's technical center for evaluating any issues or to Hoffer for further evaluation. The entire delivery process can be monitored in real time from the smart phone by the operator without the need of being in a position to view the ICE computer display or even if the ICE computer screen is not functioning. Trip reports recorded by the ICE are also accessible and transmittable by the operator to his base of operation. The smart phone app option for the ICE is available for new-build units as well as a field-retrofit option. Finally, for clients that have existing ICE units with hard-wired printers or wireless hand-held printers or still need a hard copy ticket capability on their tankers, the new ICE smart phone apps are compatible with that requirement.

Beyond the considerable list of features available today, additional ones will inevitably be added in the future. Many of those will be driven by user demand as they gain experience with smart phone app technology. Some possible future capabilities include:

1. Enhanced equipment preventative maintenance based on actual usage data.
2. Decreased overall system costs.
3. Real-time trouble shooting of delivery system issues.
4. Interface with delivery schedules and GPS systems.
5. Geo-fencing for safety and anti-theft purposes.
6. Added interfaces with non-measurement related devices and sensors (pumps, tanker pressure and temperature sensors, etc.).
7. Inputs for improved delivery processes and procedures.



Hoffer ICE Integrated Cryogenic Electronics shown with Hoffer's New ICE Mobile App.

Conclusion:

Digital technology has become ubiquitous in most aspects of everyday life and it is now moving towards that same level of acceptance in business and industry. The potential applications and returns on investment are limited only by the imaginations of the developers and the users of the technology and that now includes those in the LNG bulk delivery industry.