LNG INDUSTRY

September 2020

AN ACCURATE UNDERTAKING

Hans-Peter Visser, Analytical Solutions and Products, the Netherlands, considers the need for accurate analysis of LNG during loading and unloading.

Nearly all LNG deliveries are subject to custody transfer where the LNG cargo is traded from one operator to another operator.

Once custody transfer comes into place, contracts are involved. In sales and purchase agreements (SPAs), the determination of the cargo value will be described and defined. As per current international standards, the value of the LNG is based on the amount of energy or Btus delivered.

Depending on the size of an LNG carrier, LNG is transported in batches from approximately 4000 m^3 up to 266 000 m^3. Contingent on region, type of contract, etc., these volumes may represent a monetary value between approximately US$200 000 and US$13 million at the current all-time low LNG price. However, in April 2012, at the all-time high, a cargo of 266 000 m^3 of LNG was representing a monetary value of nearly US$125 million.

It is evident that the enormous financial value per LNG cargo requires an extremely accurate determination of the energy quantity as delivered.

The challenges of accurate LNG measurements

Many technical articles and lectures have already been delivered on the important subject of the challenges of accurate LNG measurements, and in a nutshell it comes down to the following details.

The natural gas which is processed prior to liquefaction consists mainly of methane. Depending on the source of the explored natural gas, the heavier hydrocarbons, such as ethane, propane, butane, pentane, and even hexane, may vary in their composition. Often some nitrogen is present as well. During processing and liquefaction, LNG is produced as a liquid hydrocarbon mixture with a typical boiling point of -162˚C or -260˚F at atmospheric conditions.

During (un)loading and custody transfer of the LNG, the energy content and density of the LNG must be almost constantly sampled to dedicated cylinders and continuously measured as per most common SPAs. The composition of the LNG is typically measured by an online gas chromatograph (GC);

Figure 1. Custody transfer between an LNG carrier and an FSRU.

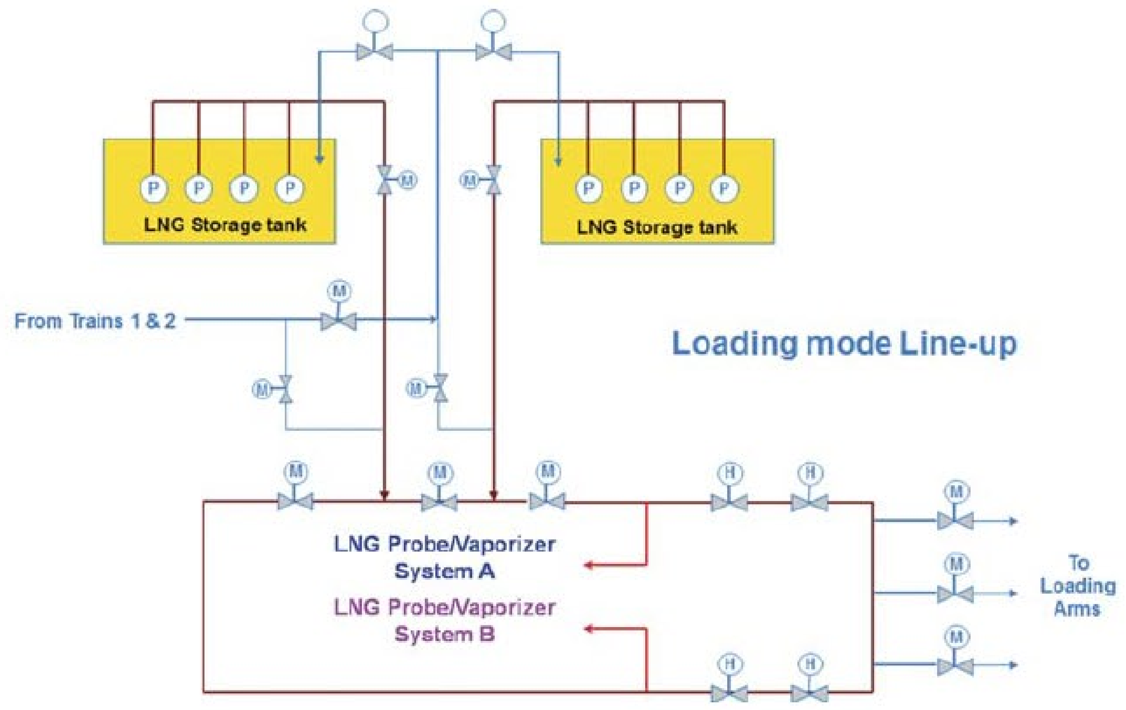

Figure 2. A typical layout of an LNG loading facility.

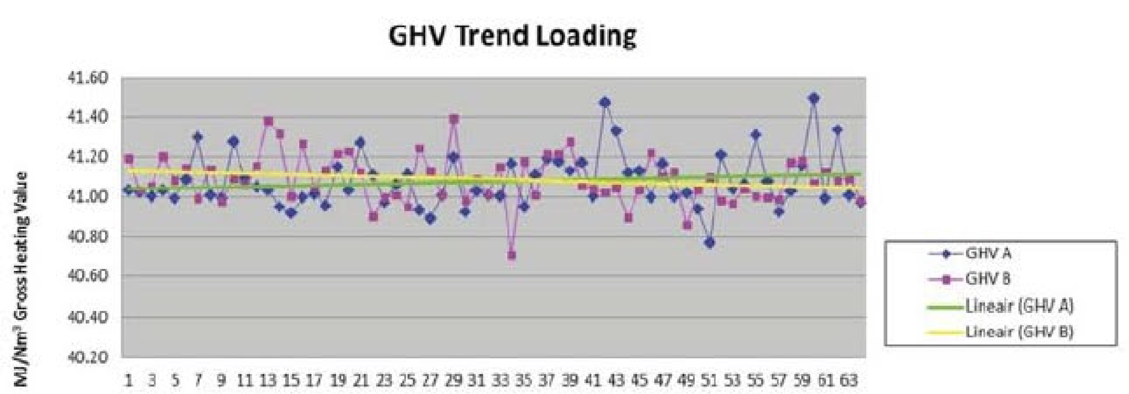

Figure 3. Gross heating value trending.

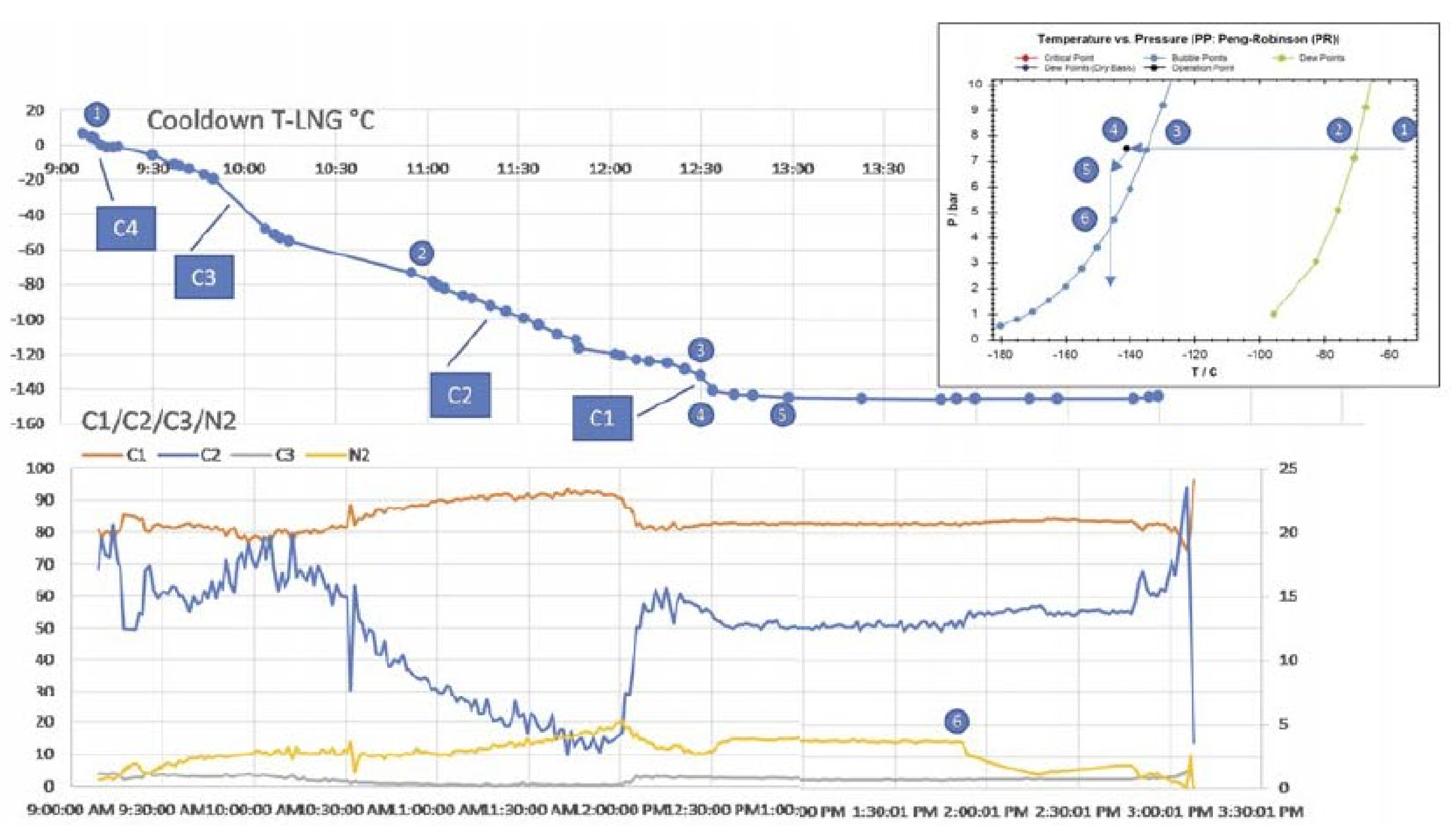

Figure 4. Left: LNG test. Right: LNG phase diagram.

derived from the composition of the physical properties, calorific value (Btu value), density, etc. of the gasified LNG are determined. In general, an online GC gives a measurement update between 3 - 15 min.

The most crucial and critical part of the measurement is the sampling. Specifically, at the point the LNG sample is taken from the LNG transfer line and transported to an analytical vaporiser. In the vaporiser the LNG must be converted into a stable and homogeneous hydrocarbon gas mixture, which represents the LNG at the time it passes in the transfer line. The process of sample taking and vaporisation of LNG is continuous and instantaneous.

Often the correct measures are not taken when transporting the LNG to the evaporator. Due to the large temperature difference between the LNG and the ambient temperature, the LNG tends to start boiling uncontrollably before it reaches the vaporiser. This is also referred to as pre-vaporisation.

Unfortunately, it is still often the case that, for cost saving reasons, vaporisers are used that are not designed for LNG. This therefore results in non-homogeneous and non-uniform vaporisation, also known as partial evaporation.

The results of instantaneous pre and partial vaporisation are not measured directly by a cyclic analyser like a GC. Therefore, the measurement results look (and are) erratic. Examples of more than 50% uncertainty are unfortunately not uncommon.

Figure 2 shows a typical layout of the loading area of an LNG production plant. An LNG loading line and the LNG recirculation line are both equipped with the same brand and model vaporiser, measuring the sample LNG by a common GC (stream switching by the GC).

Figure 3 illustrates the gross heating value (Btu content) of both vaporisers, represented by the dark blue and purple data points. The erratic character is obvious to see.

What makes it even worse are the trend lines of both vaporisers, represented by the yellow and green lines. These trendlines are completely opposite to each other. So the real question is which result is correct or true?

Unfortunately, nobody knows.

Current standard norms and test methods of LNG measurements

There are currently several norms and standards which manufacturers, end-users, and all others involved in the LNG measuring chain must adhere to. The most common include:

- ISO8943: 2007, which describes methods of sampling and gives guidance for proper LNG sampling and vaporisation. However, this standard – which has been in place for 13 years – does not give the uncertainty and/or accuracy values which must be met.
- GIIGNL 5th edition is an extensive standard which describes LNG in depth. It also refers to ISO 8943: 2007, as well as providing accuracy requirements and describing new analytical methods.
- EN12838: 2000 describes installations and equipment for LNG and the suitability testing of LNG sampling systems. Specific measures for multiple parameters are clearly detailed. However, up until now just one commercial test unit has been built by an Amsterdam based company for the Dutch Metrology Institute, VSL, in the Netherlands. This LNG test unit is part of a larger LNG test facility which is unfortunately not in operation yet. Once the plant is in operation, systems could receive a type approval based on one occasion testing.

The next step in LNG testing

One of the global leaders in LNG measuring technology has developed an LNG testing facility where LNG vaporisers and downstream LNG samplers can be tested under simulated process conditions.

The aim is to prove the LNG vaporisers and LNG systems are operated properly, meeting and even exceeding the analytical requirements of the international LNG measuring norms and standards prior to delivery of the vaporisers to their final destination and installation.

Up until now, the company has been the only one that has been testing every analytical vaporiser and the downstream LNG sampler with real LNG.

Handling LNG requires insight and knowledge of the physical properties and characteristics of LNG. It is essential

Figure 5. LNG test facility.

to remain 100% in the liquid phase for the vaporiser. As per Figure 4, the pressure and temperature of the LNG should be such that it is always on the left-hand side of the blue (bubble point) curve.

However, during start-up of a vaporiser it must be cooled down from ambient temperature to cryogenic conditions. This means that bulky metal parts of the vaporiser must be cooled, which takes a significant amount of time.

In the graph it is interesting to see when specific hydrocarbons of the natural gas mixture start to condense. At the start, at point 1 the mixture is 100% gas, and at point 2 the dewpoint is reached and the butanes start to condense. Point 3 to point 4 poses additional interest. At point 3 there is still a liquid/gas mixture in the phase envelope. Between point 3 and point 4, methane starts to condense and a 100% liquid is reached. At that time the analysis cycle can be started, which can also clearly be seen by the stable coloured trend lines (point 5). At point 6 the LNG pressure was lowered until the mixture passed the bubble point again. These types of tests have been impossible to undertake in a running LNG installation.

Another advantage of this test facility is that there is a possibility to insert a cryogenic camera into the vaporiser itself. During the test the camera was inserted into the primary ball valve of the vaporiser. It was very clear to see when the LNG was boiling and when it was a 100% liquid.

Figure 6. Left: 100% bubble-free LNG. Right: Boiling LNG.

Figure 7. LNG performance evaluation software.

Figure 8. Report of LNG online and continuous performance evaluation of the whole analytical installation.

Based on the gathered test data and additional knowledge it was possible to create a fast cooldown rate. This is essential particularly for batch (un)loading processes where the LNG transfer lines are emptied after usage.

Small scale plants/operations in particular have a relatively small window of operation where they need the vaporiser and analytical installation. With the seven minute cooldown cycle of this tested vaporiser, the operation criteria are completely met for small scale LNG installations and other LNG applications as well.

Taking testing to the next step

Only recently has it become possible in practice to perform these types of tests at a running LNG facility, and to use a camera inside the process.

As an alternative, a derivative test was developed to test the entire LNG measuring installation online and continuously.

With the current technology available it is practical and feasible to monitor the performance of the whole LNG measurement system from the tip of the sample probe completely up to the data generated by the GC.

With the complete system tested with LNG, a fingerprint of the original performance is made. Additionally, an ISO10723 performance evaluation of the GC can be generated to ensure the best performance of the GC.

Once the system is installed, commissioned, and started-up, the whole measurement chain can be monitored online and continuously.

Based on the data gathered during (un)loading, a continuous and online performance evaluation of the entire measurement installation is made. This ensures that all the data is valid and meets the delivery specifications of the LNG as per the SPA.

The performance evaluation is a module of the LNG sampler software and analyser management and data acquisition system (AMADAS).

Conclusion

From now on it is possible to continuously monitor the total performance of the whole LNG custody transfer energy measuring system during (un)loading online. The energy measurement system performance can be verified against GIIGNL, EN12838, and/or any SPA in place. Due to the system set-up, every part of the system, as well as every (un)loading batch, is traceable and recorded.

The next step

As a result of the continuous and online performance evaluation, the data can be used to generate an automatic Bill of Lading (BOL) of the LNG cargo transferred. At the time of writing this article, the software to generate the BOL was under validation. For the upcoming installation of projects in the US in Texas and Louisiana, the BOL software will be implemented. **LNG**