MADE TO MEASURE

Hans-Peter Visser, Analytical Solutions and Products B.V., the Netherlands, outlines the needs for fully-automated LNG custody transfer measurement systems.

Custody transfer refers to the process of transferring ownership and responsibility of a product or commodity from one party to another. It involves the transfer of physical possession, as well as the associated rights and obligations related to the product. Custody transfer is commonly applied in industries such as oil, gas, petrochemicals, and utilities, where the accurate measurement and verification of quantities and qualities of the transferred material are crucial for commercial transactions andaccountability.

In the context of LNG, custody transfer specifically involves the transfer of ownership and responsibility of LNG from the seller to the buyer. It encompasses the accurate measurement of the quantity and quality of LNG being transferred, typically at loading terminals, storage facilities, or during ship-to-ship transfers. Custody transfer ensures transparency, accuracy, and fairness in commercial transactions by providing a standardised process and reliable measurement systems to determine the value and quantity of the transferred LNG.

It is important to note that the specific details and procedures of LNG custody transfer may vary depending on the parties involved, contractual agreements, regional regulations, etc.

Current standards

LNG custody transfer is based on the GIIGNL Custody Transfer handbook 6th edition and ISO 8943: 2007. The ISO 8943: 2007 is focused on the quality of the

LNG by means of composite sampling and on-line (gas chromatograph) analysis, while the GIIGNL has it overall coverage. The GIIGNL advise also how to determine the quantity of the LNG transferred which is done by means of gauging.

Gauging is a manual procedure, taking in account various measured physical properties and process parameters, consulting tables, and the need for a highly-skilled and experienced surveyor. This is a labour-intensive, time-consuming and costly process where accuracy and reproducibility depend on the quality of the surveyor. Everyone knows that one surveyor is not like another surveyor, and that even the best surveyor has a bad day. In other words, there is a human error factor which may impact the determination of a high US dollar value of an LNG cargo.

More and more end-users, especially in the US, are requesting a fully-automated LNG custody transfer measurement system. This includes automated time and flow proportional LNG sampling according ISO 8943 as well.

EPC contractors require the same, including integration of the whole the system to a compact skid with clear battery limits. Their benefit is to have just one single point of contact for project execution, commissioning, and start-up.

LNG Vessel: Date Loading Commenced:
Cargo Number: Date Loading Completed:
Destination: Product Type: LIQUEFIED NATURAL GAS
Consignee:

Component	Unit	Method	Results	Specification
Methane - C1*	% mol	GPA 2261	93.44	>=85
Ethane - C2*	% mol	GPA 2261	6.24	<=8
Propane - C3*	% mol	GPA 2261	0.03	<=0.25
iso-Butane - i-C4*	% mol	GPA 2261	0.00	<=0.1
n-Butane - n-C4*	% mol	GPA 2261	0.00	<=0.1
Iso-Pentane - i-C5*	% mol	GPA 2261	0.00	<=0.1
n-Pentane - n-C5*	% mol	GPA 2261	0.00	<=0.1
Hexanes and heavier - C6+	% mol	GPA 2261	0.00	N/A
Nitrogen - N2*	% mol	GPA 2261	0.29	<=1.5
Carbon Dioxide - CO2	% mol	GPA 2261	0.00	N/A
Oxygen - O2	% mol	GPA 2261	0.00	<=0.001
TOTAL	% mol		100.00	

Mercaptans	mg/Nm³	BS ISO 19739	<0.02	N/A
Mercury	ng/Nm³	N/A	<1.0	N/A
Hydrogen Sulphide	mg/Nm³	BS ISO 19739	<0.02	<=5
Total Sulphur	mg/Nm³	ASTM D6667	0.22	<=30

Liquid Density @ -159.70°C	kg/m³	ISO 6578	439.09	N/A
Gross Heating Value	BTU/SCF	Calculation	1055.17	1025-1075
	MJ/m³	Calculation	0	N/A
Wobbe Index, Real	BTU/SCF	Calculation	1378.74	1300-1428
	MJ/m³	Calculation	0	N/A

The measurement of uncertainty is on request, available for LNG composition (N2, C1-C5)
*The test is covered by ISO/IEC 17025 accreditation.
The test result is an average result related to the sample collected during loading.

Figure 1. Anonymised quality certificate.

Figure 2. VSL LNG test facility in the Netherlands.

The need for in-line flow measurements and metrological traceability

With the current technology in place, it is possible to measure the flow of LNG either via Coriolis flow meters or Ultrasonic flow meters.

The major challenge for LNG flow meters was metrological traceability and how to determine the accuracy of a LNG flowmeter. Based on studies and tests, there was the assumption that there was a correlation between LNG and water measurements for LNG, which is currently used in the market. Recent tests show differently; to be sure that LNG flow meters measure correctly during use, they need to be calibrated at cryogenic conditions with LNG. Recently, a new standard – ISO 21903:2020 – was published by the International Standards Organisation (ISO), to specify the metrological and technical requirements for flow meters that can dynamically measure LNG and other refrigerated hydrocarbon fluids.

VSL's calibration and test facility for LNG flow meters

In March 2023, the Dutch National Metrology Institute VSL (re)opened its brand-new European Center for Flow Measurement on the Rotterdam Maasvlakte in the Netherlands. This unique test facility includes the LNG calibration and test facility for LNG flow meters for mass and volume at cryogenic conditions with LNG. VSL can determine any output signal utilising the master meter method of calibration. This calibration facility is traceable to the National Standard of the Netherlands, has a low measurement uncertainty (CMC), and is currently the only one in the world. All flow meter calibrations of VSL, including LNG, are well accepted around the world. Until now, the maximum flow meter size was 8 in.

Currently, for custody transfer measurement systems of LNG, several dynamic measurement systems are already delivered, installed, and in successful operation. Typical applications are LNG run-down line measurements and LNG allocation measurements.

The flow meters are typically built on so-called skids where nowadays also the complete quality package can be integrated, such as the LNG probe/vaporiser, the online quality measurement, and the composite sampling.

The market requests more and more, especially from the US, for complete custody transfer measurement systems (CTMS), with ultrasonic flow meters up to 36 in. Measurement systems are available now, including the complete analysis and sampling part.

It is even possible to integrate the analysis and sampling of both the cooling line and boil-off gas (BOG) return line to created a complete energy transfer equation. The challenge for large size LNG flow meters is how to calibrate these.

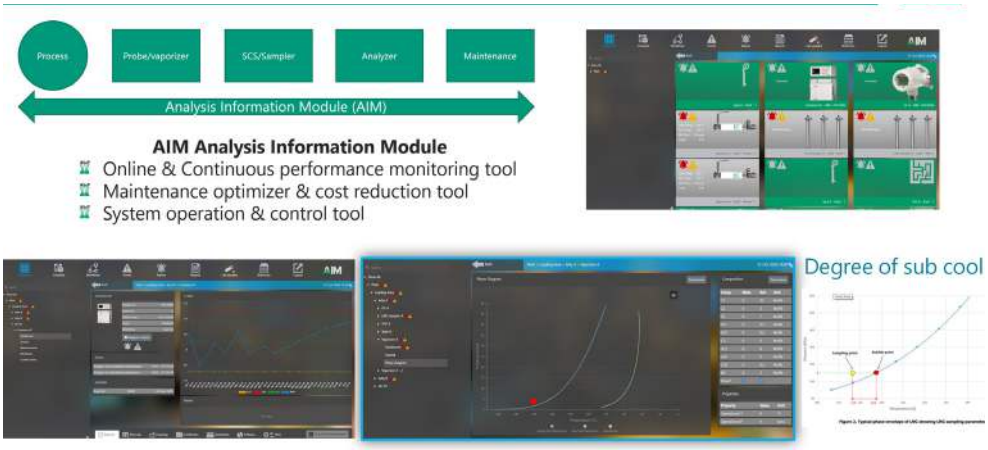

Figure 3. AIM overall and detailed performance monitoring dasboard

Continuous improvement of analytical measurement and sampling of LNG

With an average production of more than 20 LNG quality measurement and sampling systems per year, ASaP belongs to the top of value providers to LNG customers and end-users.

As a market leader, the company sees it as its obligation to the market to continuously innovate and to answer every analysis and sampling related question for every cryogenic application properly and effectively. In-depth application and system knowledge, combined with extensive field experience, creates more and more insights and value to those using the company's systems.

In May 2022, an article was published in LNG Industry about the right way to measure and sample in a cost effective and accurate manner. The purpose of this article was to outline the importance of continuously ensuring the proper operation of the analysis and sampling systems, and obtaining the highest available accuracy possible for high US dollar LNG cargo values.

ASaP's proprietary software, Analysis Information Module (AIM), is multifunctional. Its functions include the CTMS operating and control system, the online and continuous performance monitoring system, and the maintenance optimiser. It automatically generates both the cargo quality certificate and the Bill of Lading. If these two important documents are generated automatically, there is a guarantee that the measurements and calculations are matching the LNG cargo characteristics for 100%.

A new feature in AIM is the online generation of the LNG phase envelope. The phase envelop is determined by the measured process pressure and temperature near the sample take off probe, and the measuring results of the gas chromatograph downstream from the sample take-off probe. Based on the phase envelope and the sample take-off conditions, the degree of sub-cooling can be determined continuously and online.

As specified in ISO 8932: 2007, a sample must be taken at the highest possible degree of sub-cooling. Until now, it was not possible to determine the actual degree of sub-cooling. However, developments in software, like AIM, can give an update of the degree of sub-cooling every 10 seconds.

Recently, the value of the new feature of online phase diagram of LNG project determination became clear to a number of users. During the start-up of an LNG factory, it was assumed that the LNG transfer line was completely filled with LNG and that measurements were being carried out correctly under the right conditions.

However, due to the start up, there was a two-phase situation in the transfer line, which made the analysis results invalid. Further investigation learned, based on the AIM software, that the extraction sample probe was not installed at one of the LNG sample points at the shipyard.

Being aware of this flaw, a new extraction probe could be manufactured and installed on time. If the installation of the sample extraction probe had not happened at this time, the next opportunity would have been five years later during a maintenance shutdown. During these five years, the analysis and sampling results would not have been correct. Due to the standard feature of the online phase diagram determination, this measurement error with a huge financial impact has been prevented.

Added value of small scale (bio-)LNG (truck) loading facilities

In Europe, the use of sustainable bio-LNG becomes more and more common as fuel for trucks and ships. Also, these small installations have to measure the quality and quantity delivered.

For small scale LNG installations, the initial cost for measurement and sampling equipment has a significant impact on the overall plant construction costs. Therefore, a creative approach was required to fulfill all measurement requirements.

At the end of the day, all requirements are met and the first installations are in operation successfully. Some installations have both a truck weighing scale and an LNG end-product flow meter installed for automated custody transfer. Soon, a programme will start where the correlation between the absolute LNG mass delivered and LNG flow delivered will be determined. The results of this correlation programme may add a significant contribution for large scale LNG custody transfer measurement systems.

Conclusion

Fully automated custody transfer measurement systems are available but are limited by the LNG flow meter sizes due to their calibration. Meanwhile, various correlations tests are planned to obtain the uncertainly and traceability data of large LNG flow meters. LNG