Raman technology for LNG

Real-time composition measurement of LNG process streams

Endress+Hauser

People for Process Automation

Your challenges, our mission

Simplifying complexities in the LNG process

Balancing growth, productivity, and safety Fluctuating process and environmental conditions and variations in the composition of raw natural gas pose significant challenges for the efficient operation of liquefied natural gas (LNG) processing. The rapid growth in gas trade and the globally developing integrated gas market also make it difficult to balance growth and productivity while ensuring the safety of your plant.

Monitoring MR composition The majority of natural gas is transported in gaseous form via onshore or offshore gas pipelines. For stranded gas reserves or long transport distances, it becomes more economical to liquefy the natural gas prior to transportation or storage. The liquefaction of natural gas to LNG often involves the use of a mixed refrigerant (MR) process. Monitoring the composition of MR is essential for efficient liquefaction plant operation.

Measuring LNG composition and energy content Accurate measurement of LNG composition and energy content is critical for optimizing the liquefaction process and for rundown of the LNG to storage tanks. The highest precision is also required for custody transfer steps to ensure that both parties know the exact value of the transacted product. An uncertainty of as little as 1% energy transferred can have a large financial impact, potentially costing a buyer or seller several hundred thousand dollars.

Endress+Hauser's Raman-based LNG product portfolio solves these challenges by empowering you to measure and control your LNG processes safely, accurately, and economically.

700 million tons expected growth in LNG by 2040

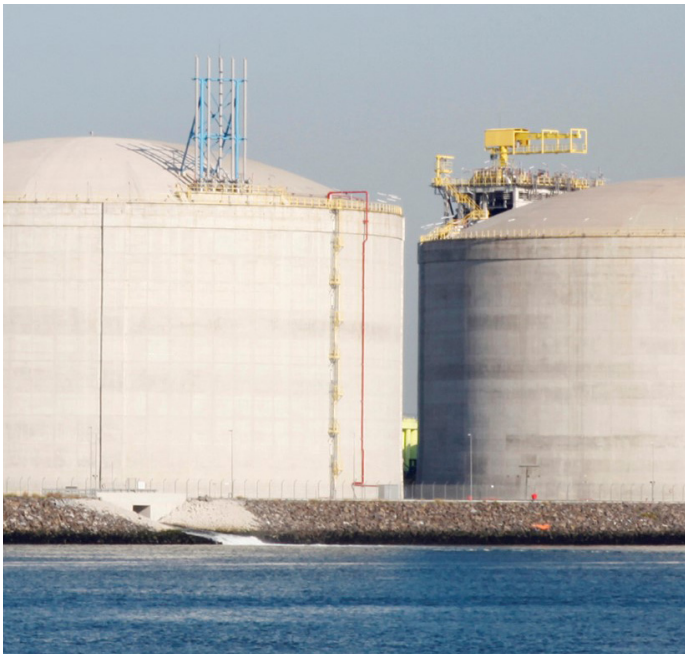
Future-proofed Raman technology

Fast, proven, and reliable LNG process measurement

Traditionally, composition measurement of LNG has involved the use of gas chromatographs (GCs) coupled with vaporizers, which are required to convert LNG to a gas for analysis. Incomplete vaporization and pre-vaporization can lead to accuracy errors, as well as poor precision, increasing uncertainty in transacted value. Vaporizers also have high maintenance requirements, increasing OPEX. Raman technology eliminates the need for vaporizers, solving many of these challenges.

LNG measurement systems based on Raman spectroscopy feature fiber-coupled probes inserted directly into the LNG sample, with probes able to be located hundreds of meters away from the analyzer. By measuring quantity and calorific value composition *in situ* and in real-time, Raman-based measurement technologies are simpler, more stable, and require less maintenance than other LNG measurement technologies. Raman systems measure LNG quality via complete compositional analysis—optimizing liquefaction and regasification processes and providing more reliable input for custody transfers.

Raman technology has been successfully installed in a wide range of LNG applications and global sites for years. Raman spectroscopy is reliable and field-tested, with validated metrology and many proven benefits. It is quickly becoming a preferred process measurement technology for the LNG industry.



Challenges of current LNG technologies

- Low data quality due to poor operation of vaporizers
- High maintenance for vaporization systems
- Complex installation and utilities (need for carrier & validation gas bottles, sample lines, and dedicated cabinets)
- Regular disputes between seller and buyer regarding installation of a retention sampling system

Benefits of Raman technology for LNG

- Eliminates the need for a vaporizer or GC
- Requires low consumables and minimal maintenance
- Speeds measurement times and drives efficiencies
- Ensures higher plant safety & availability
- Measures up to four streams from a single Raman analyzer

Our Raman LNG optical analysis portfolio

The most trusted Raman analyzer and probe technology

The Endress+Hauser Raman product portfolio for LNG performs compositional analysis with unparalleled precision. Powered by Kaiser Raman technology, our Raman analyzer systems deliver in-line, real-time measurement of LNG process streams. With full process transparency at your fingertips, you can maintain a continuous pulse on the safety and efficiency of your LNG operations while ensuring maximum plant availability.

Real-world LNG application expertise We offer tried and true LNG experience that comes from having Raman analyzers and probes successfully installed at multiple land- and sea-based sites around the globe. A proven measurement tool for LNG processes, our Raman technology has been field tested and independently metrology validated.

Unique features of our LNG Raman products

- Ability to measure up to four channels per analyzer
- Robust and reliable inline, real-time process measurement
- Increased process understanding, control, and monitoring of key quality parameters
- User-friendly embedded control software for 24/7 connectivity
- Streamlined calibration and verification procedures
- Unique self-monitoring and diagnostics
- Seamless analyzer/probe design
- Simplified process equipment and installation with minimal maintenance requirements
- ISO 9001:2015 and hazardous area certification
- Field tested with validated LNG metrology

The Endress+Hauser advantage When it comes to critical LNG process measurement points, properly installed instrumentation ensures safe and reliable operation. With Endress+Hauser, you get Kaiser Raman technology and LNG process automation expertise combined. Our service experts, who are available around the world, have the experience needed to fully support your LNG enterprise.

30+
years of Raman spectroscopy expertise

>2000
process Raman analyzers installed around the world

75+
U.S. patents in Raman and holographic technology

24/7 process visibility & control with our Raman systems

Compliance with globally accepted standards & certifications

Ensure plant safety

By analyzing samples *in situ*, using laser light transported via robust optical fiber cables, there is no need to transfer LNG to the analyzer or to an analyzer shelter. Samples can be analyzed up to 500 meters from the base unit, providing enhanced safety by reducing worker exposure to hazardous materials.

Optimize efficiencies

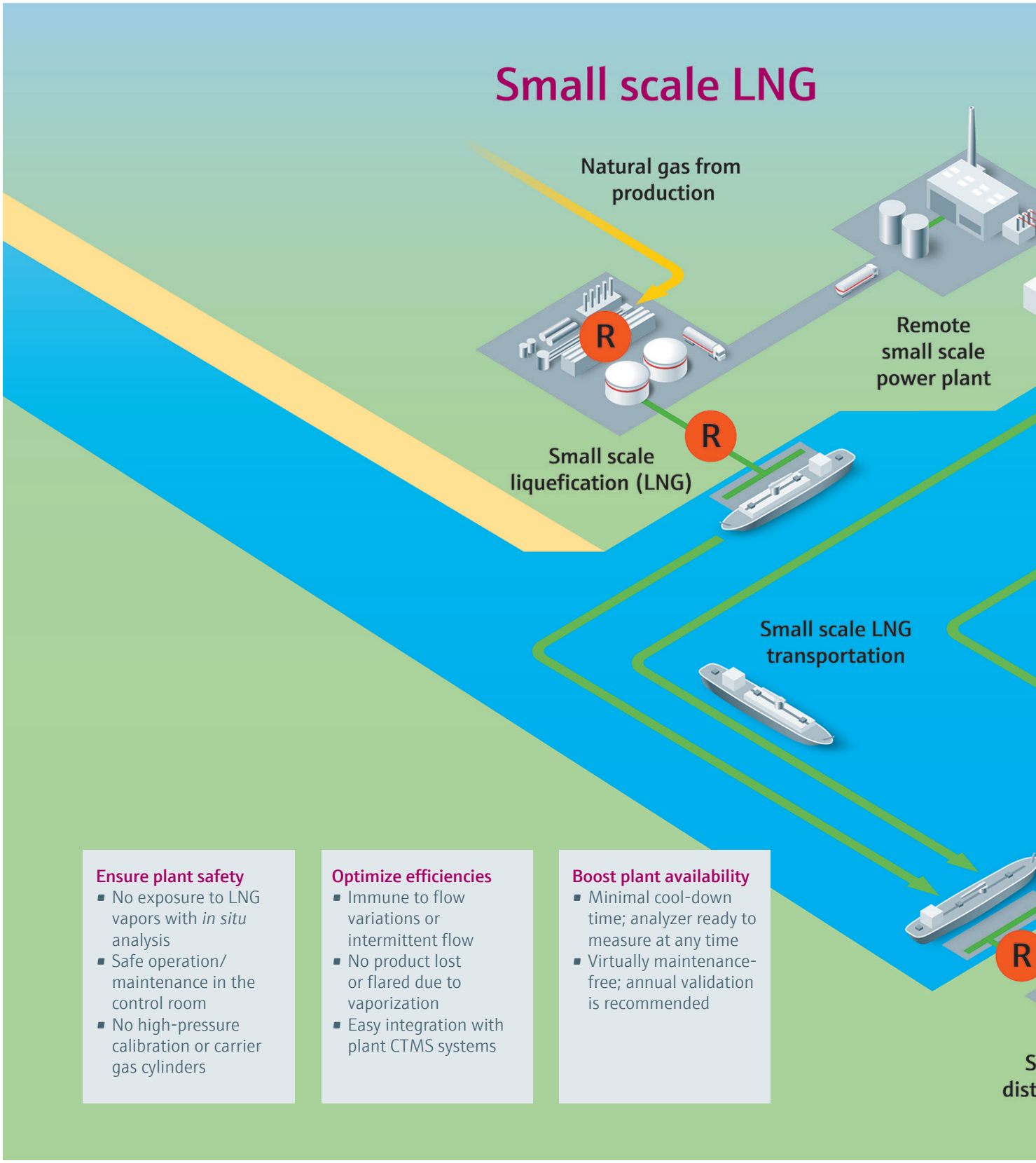
Our Raman systems can measure up to four streams in one analyzer, reducing the per-stream cost. By eliminating the need for vaporizers, Raman analyzers require significantly less maintenance to achieve equivalent measurement uncertainty. Measurements are also non-destructive, reducing waste and potential emissions or flaring events. With virtually no consumables, operational efficiency is also improved.

Boost plant availability

Our Raman analyzers measure the LNG *in situ* in the cryogenic liquid phase, eliminating the requirement for costly, high-maintenance vaporizers. Raman measurements do not require the lengthy cool-down times of vaporizers to ensure measurement quality and are ready to measure when the LNG flows. With minimal maintenance requirements, the systems can also run virtually unattended, further maximizing plant availability.

How we can support you

From reliable measurement of baseload custody transfer...

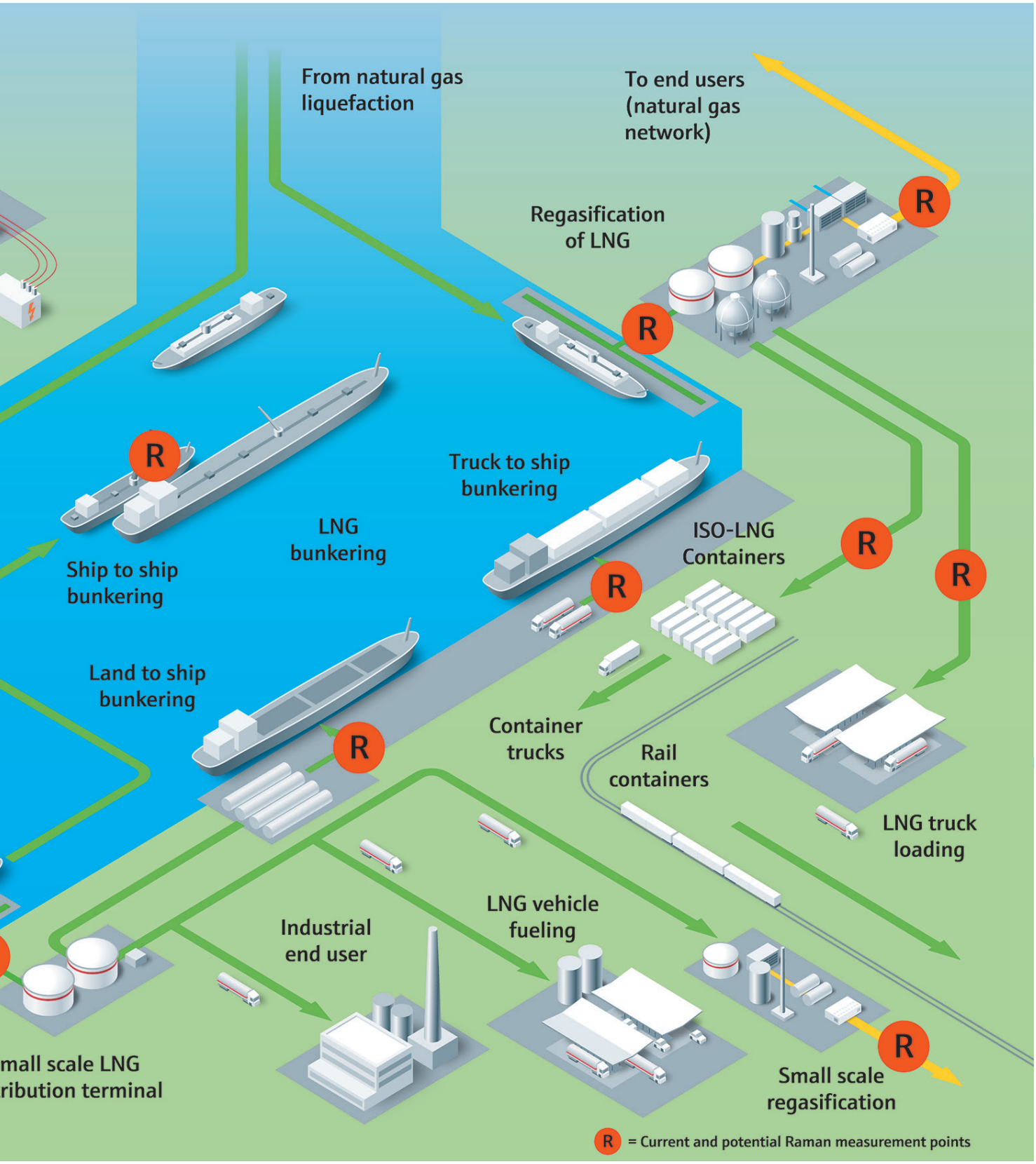


Ensure plant safety
- No exposure to LNG vapors with *in situ* analysis
- Safe operation/ maintenance in the control room
- No high-pressure calibration or carrier gas cylinders

Optimize efficiencies
- Immune to flow variations or intermittent flow
- No product lost or flared due to vaporization
- Easy integration with plant CTMS systems

Boost plant availability
- Minimal cool-down time; analyzer ready to measure at any time
- Virtually maintenance-free; annual validation is recommended

...to efficient LNG for truck loading and bunkering



Ensuring safety in LNG bunkering

A safer solution to LNG bunkering The use of LNG as a fuel for ships is increasing, in part due to the new IMO MARPOL lower sulfur emission standards. LNG bunker ships, which provide ship-to-ship transfer, are becoming more common. One of the challenges in measuring the energy content of LNG during bunkering is working with cryogenic fluids. In addition, LNG composition varies due to the mixing of LNG from different sources and the aging of the LNG under storage conditions. Providing reliable measurement of the quality of the cargo transferred is an essential part of the LNG bunker delivery note for the transaction, and it is essential for maintaining the safety of the operation.

Our expertise in the field Currently, our Raman analyzers and probes are installed on bunkering ships in multiple worldwide locations with proven application benefits. These Raman LNG bunkering systems have been verified at Effectech* and have been field validated at the Zeebrugge LNG terminal in Belgium. Our rack-mounted Raman Rxn4 analyzers for LNG custody transfer can be easily installed on bunker ships, located in the control room or instrument room, and connected to the ship's control computer. This location enables safe, reliable, and robust measurements of LNG, either transferred from the bunker ship to the receiving ship, or for LNG loaded onto the bunker ship from an onshore facility.

*Effectech has UKAS accredited calibration for direct measurement LNG analyzers

Key benefits

- Simplifies installation, with a fiber optic cable in a cable tray or conduit connecting the analyzer to the optical probe
- Provides precise and more reliable measurement of composition and calorific value directly in the LNG stream
- Reduces OPEX due to elimination of consumables
- Increases safety for the entire LNG operation

Optimizing LNG truck loading efficiencies

Ready-to-go LNG truck loading Transportation of LNG via truck is an essential part of the natural gas infrastructure as a cost-effective means of delivering natural gas to customers who do not have access to the natural gas pipeline infrastructure. These facilities transfer LNG as a 'batch mode' process, with each transfer taking 30 to 90 minutes. Custody transfer measurement systems for these facilities must be ready on short notice, and provide 'instant on' capabilities, able to measure at a moment's notice. Traditional vaporizer systems require up to two hours exposure to LNG to stabilize before accurate measurements can begin.

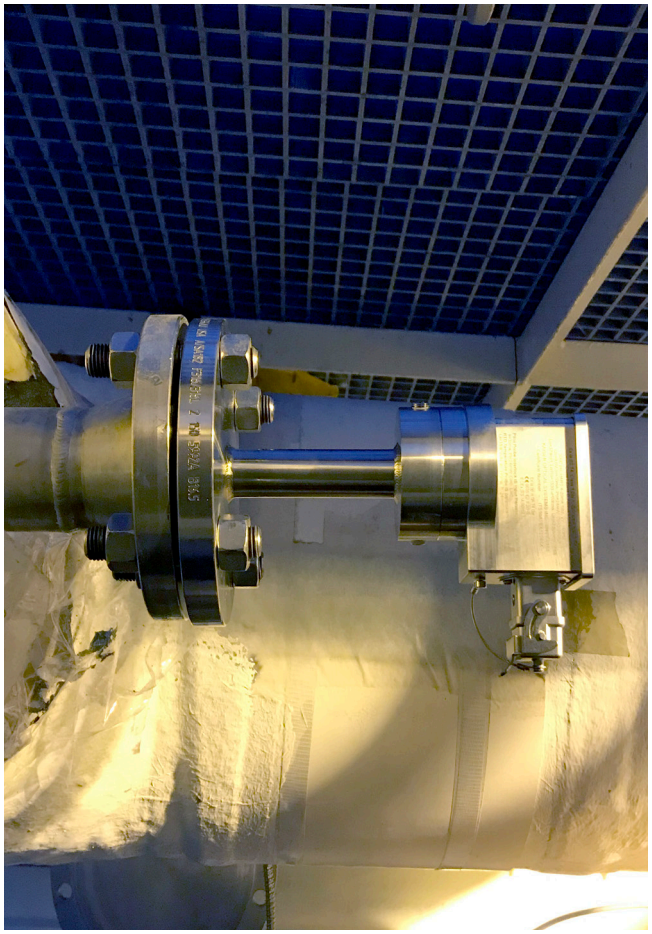
Leveraging our LNG industry experience to find the best solution for every customer application

Our expertise in the field Currently installed at multiple LNG truck loading sites around the world, our Raman systems have been verified at Effectech and found to be accurate and reliable. The Raman Rxn4 analyzer is ready to take measurements as soon as a truck-loading event commences. It provides high quality measurements immediately after steady-state flow is reached. The analyzer can be integrated into the facility's control room, measurements can be initiated, and results are displayed directly in the CTMS system.

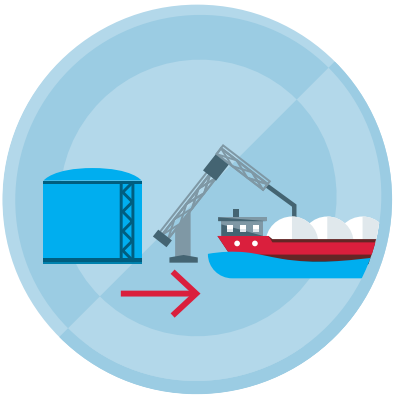
Key benefits

- Virtually eliminates cool-down time needed to make custody transfer measurements
- Requires only an annual verification
- Requires virtually no consumables (columns, valves, carrier gases), greatly reducing OPEX

Maximizing plant availability in LNG custody transfer



Efficient and precise LNG custody transfer Measurement of the composition of LNG is typically performed using GCs. However, using a GC requires LNG to be vaporized and the gas pressure regulated prior to measurement. Vaporizers typically require frequent downtime for maintenance to avoid incomplete vaporization or pre-vaporization. Poor vaporization of LNG can result in measuring a gas sample that has a different composition than the LNG it came from. This can introduce errors and uncertainty in the value of the cargo being transferred.



Equivalent performance with a well-engineered, well-maintained vaporizer/GC system with lower maintenance

Our expertise in the field We have done rigorous side-by-side testing of our Raman analyzers with vaporizer/GC systems at LNG baseload facilities across the globe. These systems, which are verified at Effectech and field validated at Fluxsys terminal, offer many advantages during LNG custody transfer. Raman Rxn4 analyzer performance is in close agreement with a well-engineered, well-maintained vaporizer/GC system without the high OPEX and technical expertise required by these traditional systems.

Key benefits

- Performs non-destructive optical measurement of LNG in the process pipe or using a fast loop
- Enables field calibration to original factory specifications using industry standard ASTM practices and NIST certified references, eliminating the need for calibration gases
- Measures streams up to 500 meters from the analyzer, with no lag time, using cryogenic Raman optical immersion probes and industrial fiber optic cables
- Operates virtually maintenance-free, ensuring that the analyzer is ready any time measurements are needed

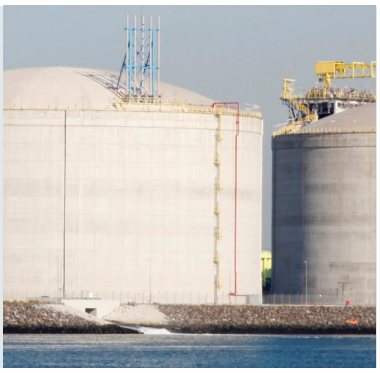
Which analyzer best fits your LNG application?

Process control application

Liquefaction rundown to storage tanks/ mixed refrigerant optimization

- Requires minimal sheltering (-20 °C to +50 °C ambient)
- Ingress protection rating IP56
- Class 1, Div 2 certification
- Up to four sample streams, simultaneously
- Fiber optic lengths up to 250 m

Raman Rxn5 analyzer



Custody transfer application

Marine bunkering

- Control room installation (0 °C to +30 °C ambient)
- Accuracy of ± 3 Btu/scf, verified at Effectech
- Properly calibrated system can achieve 0.07 MJ/kg uncertainty*
- Up to four sample streams, sequentially
- Fiber optic lengths up to 500 m
- Successfully installed around the globe

Raman Rxn4 analyzer

Custody transfer application

Baseload import/export terminals

- Control room installation (0 °C to +30 °C ambient)
- Accuracy of ± 3 Btu/scf, verified at Effectech
- Properly calibrated system can achieve 0.07 MJ/kg uncertainty*
- Up to four sample streams, sequentially
- Fiber optic lengths up to 500 m
- Field-validated at the Zeebrugge LNG terminal

Raman Rxn4 analyzer

Custody transfer application

LNG truck loading

- Control room installation (0 °C to +30 °C ambient)
- Accuracy of ± 3 Btu/scf, verified at Effectech
- Properly calibrated system can achieve 0.07 MJ/kg uncertainty*
- Up to four sample streams, sequentially
- Fiber optic lengths up to 500 m
- Successfully installed around the globe

Raman Rxn4 analyzer

* Requires verification on a high accuracy certified LNG standard

Raman Rxn5 analyzer

Mixed refrigerant liquefaction/LNG rundown to storage

The Raman Rxn5 analyzer is an industry-leading, turnkey, laser-based analyzer that uses Raman spectroscopy to provide on-line quantitative composition measurements of LNG for determining Btu and other critical parameters. The design of the Raman Rxn5 analyzer incorporates customer requirements for serviceability and hazard-area certification, provides a compact footprint, and minimizes utilities consumption. The unique properties of this laser-based Raman technology provide significant advantages when measuring the composition of LNG and mixed refrigerant streams to optimize the liquefaction process. With a separate dedicated laser per probe, the Raman Rxn5 analyzer can speed up LNG processes by measuring up to four streams simultaneously. The Raman Rxn5 analyzer is designed to be located outdoors and does not require an analyzer shelter. It is environmentally robust and able to be placed in a three-sided shelter or under a sun shield for convenient user access.

Benefits at a glance

- Non-destructive analysis of LNG and gas phase samples
- Compact, smaller than most wall-mount GCs
- No sample transport, no consumables, and minimal utility requirements
- Simultaneous measurement of up to four streams for faster results
- Compatible with three-sided shelter or sun shield installation
- Hazardous area certification: ATEX, North American, IECEx
- IP56 wall- or rack-mounted, sealed/purged enclosure
- Field tested, with validated metrology

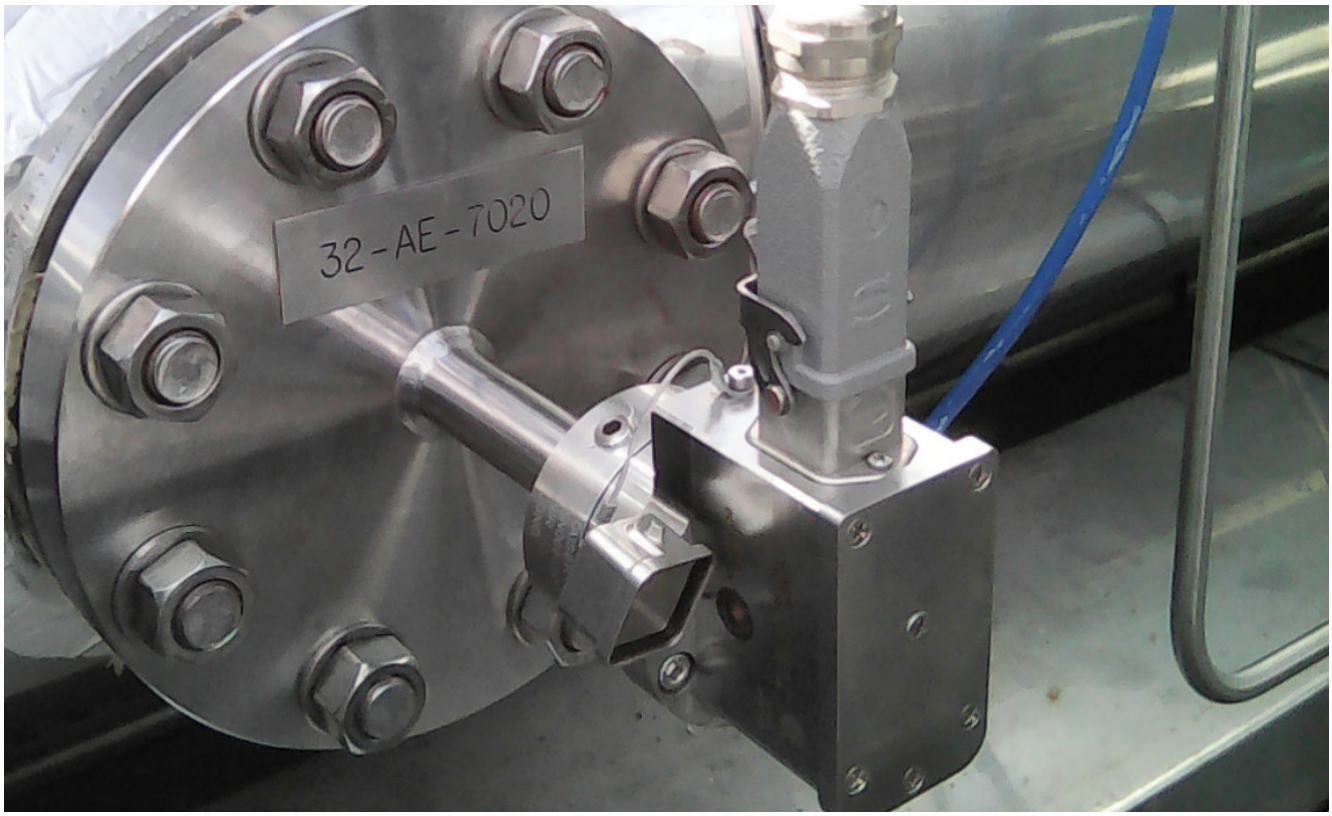
Raman Rxn4 analyzer

Baseload export & import custody transfer/LNG truck loading/LNG bunkering

The Raman Rxn4 analyzer is the optimal choice for liquid phase LNG processes where high measurement accuracy is essential. When fiber-optically coupled with the Rxn-41 probe for cryogenic liquids, the Raman Rxn4 analyzer provides a powerful tool for accurate, *in situ* analysis of LNG composition and energy content without needing to vaporize the sample. The Raman Rxn4 analyzer features fully embedded, user-friendly Raman RunTime control software and unique self-monitoring, diagnostics, and self-calibration capabilities to ensure the validity of each measurement. It is configurable with up to four probes for multi-location analysis. Stackable in a standard 19" rack, it is designed for easy integration into standardized installation packages and also offers location convenience for ship bunkering. The Raman Rxn4 analyzer is certified for output into hazardous areas, and is offered with an optional stainless steel NEMA 4X enclosure.

Benefits at a glance

- Direct inline measurement of process streams
- Up to four measurement points from a single analyzer
- Easy to install
- Minimal maintenance and maximum technician safety
- Rugged with minimal utility requirements, no sample transport, and no consumables
- Hazardous area certification: ATEX, North American, IECEx
- 19" rack installation; NEMA 4X enclosure also available
- Field tested, with validated metrology



Raman Rxn-41 probe for cryogenic liquids

Mixed refrigerants / LNG (rundown, baseload export & import custody transfer, truck loading, bunkering)

The Rxn-41 probe is a rugged insertion probe designed to optimize *in situ* process analysis of cryogenic liquids. Analyzing LNG as a cryogenic liquid eliminates the errors associated with vaporizers commonly used with traditional process analyzers, greatly improving the certainty of the value of LNG transacted during custody transfer. The combination of the Rxn-41 probe and our Raman analyzers yields powerful process analytical tools for real-time composition analysis of LNG and mixed refrigerants using quantitative Raman spectral analysis.

The configurable design of the Rxn-41 probe enables the sampling point to be customized for each customer's facility, providing flexible integration via direct flange mounting onto transfer pipes or integration into a slip-stream or fast loop for easier maintenance. Its single cable design further streamlines installation, eliminates risk scenarios, and minimizes installation cost for long fiber runs in the process environment. The Rxn-41 probe for cryogenic liquids is manufactured to meet the requirements of the ASME B31.3 piping standard, and supports a range of ASME, DIN EN, and JIS flanges.

Benefits at a glance

- Real-time, *in situ* measurement – no sample transport required
- Measures LNG as a cryogenic liquid – eliminates the need for a vaporizer
- Virtually maintenance-free operation
- Sealed probe design
- Compact, single cable design for easy installation
- Hazardous area certification: ATEX, North American, IECEx Class 1 Div 1, Zone 0

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