Optical analysis technologies for LNG

Reliable, real-time TDLAS and Raman measurement

Endress+Hauser

People for Process Automation

Your challenges, our mission

Simpler and more reliable LNG measurements

Balancing growth, productivity, and safety As demand for LNG continues to rapidly grow in response to the global energy transition, it is difficult to balance growth and productivity while ensuring the safety of your LNG operation.

Safely detecting contaminants in upstream LNG processing applications LNG storage, distribution and regasification facilities need state-of-the-art process control for maximum efficiency. Processing feed gas to remove contaminants is a crucial step. Safe, uninterrupted operation of gas pretreatment, dehydration, and liquefaction processes maximize plant availability and help to ensure on-time LNG delivery.

Measuring LNG composition and energy content
Accurate measurement of LNG composition and energy content is also critical to optimize the rundown of LNG to storage tanks and avoid disputes during custody transfers. The highest precision is required to confirm the exact value of the transacted product. An uncertainty of as little as 1% energy transferred can have a financial impact of up to several hundred thousand dollars.

Ensuring LNG quality before distribution
Competitiveness in a high-growth industry like LNG requires pinpoint measurement accuracy and enhanced control of all natural gas processes along the LNG value chain. After regasification, it is particularly important to ensure moisture levels are below the required quality specifications before the natural gas is injected into the local gas grid.

Serving as a trusted partner to help improve your LNG processes Endress+Hauser's tunable diode laser absorption spectroscopy (TDLAS) and Raman spectroscopy LNG measurement portfolio helps to solve these challenges. When it comes to critical LNG process monitoring and control, our properly installed optical analysis instrumentation ensures safe and reliable operation of your LNG plant. We offer tried and true LNG experience that comes from having analyzers and probes successfully installed around the globe. As proven measurement tools for LNG processes, our TDLAS and Raman technology has been field tested and independently metrology validated. You can rely our Endress+Hauser service experts around the world to have the expertise needed to fully support your LNG operation.

Global growth of LNG expected to pass 700 million tons by 2040*

*Source: www.shell.com/lngoutlook

Trusted optical analysis technology for LNG

Keep your LNG operation running safely and efficiently

Accurate, reliable LNG measurement along the LNG value chain Endress+Hauser's laser-based spectroscopy measurement systems empower you to monitor and control your LNG processes safely, accurately, and economically. Our proven TDLAS and Raman technology delivers critical real-time concentration and composition process measurements all along the LNG value chain—from pre-treatment and liquefaction through crucial custody transfers and regasification.

TDLAS Endress+Hauser tunable diode laser absorption spectroscopy (TDLAS) analyzers monitor H_2O, H_2S, and CO_2 concentrations in natural gas as it undergoes treatment to remove and control these contaminants prior to liquefaction. TDLAS moisture analyzers also provide a vital quality check of the final LNG product after LNG regasification.

Raman spectroscopy Endress+Hauser Raman spectroscopy-based analyzers perform critical on-line composition measurement of LNG at additional downstream key points in the LNG lifecycle such as during liquefaction rundown to storage tanks, baseload custody transfer, truck loading, and bunkering.

The Endress+Hauser advantage Our TDLAS and Raman analyzer systems are successfully installed at multiple land- and sea-based sites around the world. The instrumentation has been field tested and independently metrology validated so you can have full confidence in your LNG process measurement results. With Endress+Hauser as your LNG measurement partner, you get tried and true SpectraSensors TDLAS technology, Kaiser Raman technology, and Endress+Hauser LNG process automation expertise all rolled into one to optimize your entire LNG operation.

200+

U.S. patents in TDLAS and Raman technology

12,000+

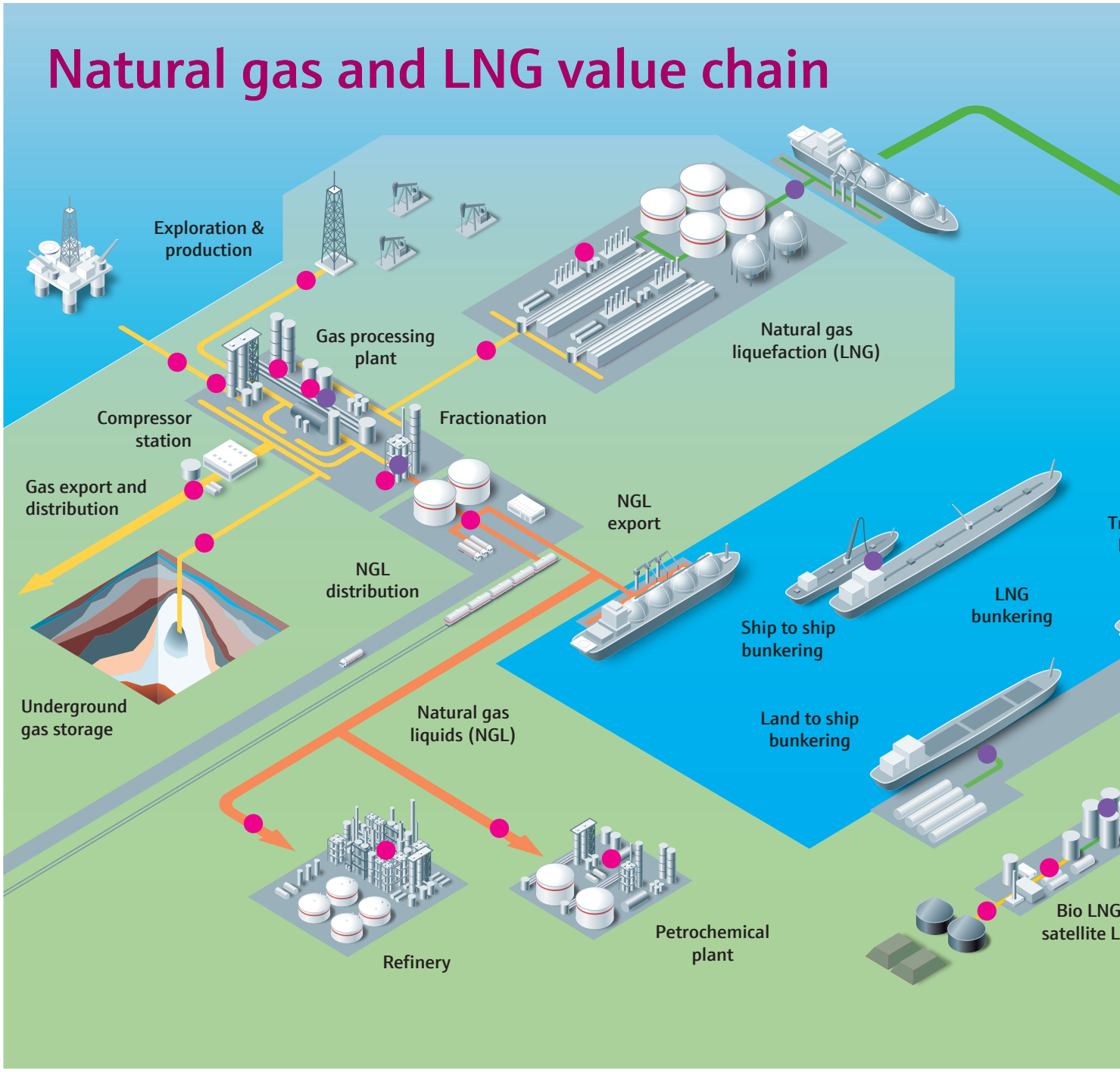
TDLAS and Raman analyzers installed around the world

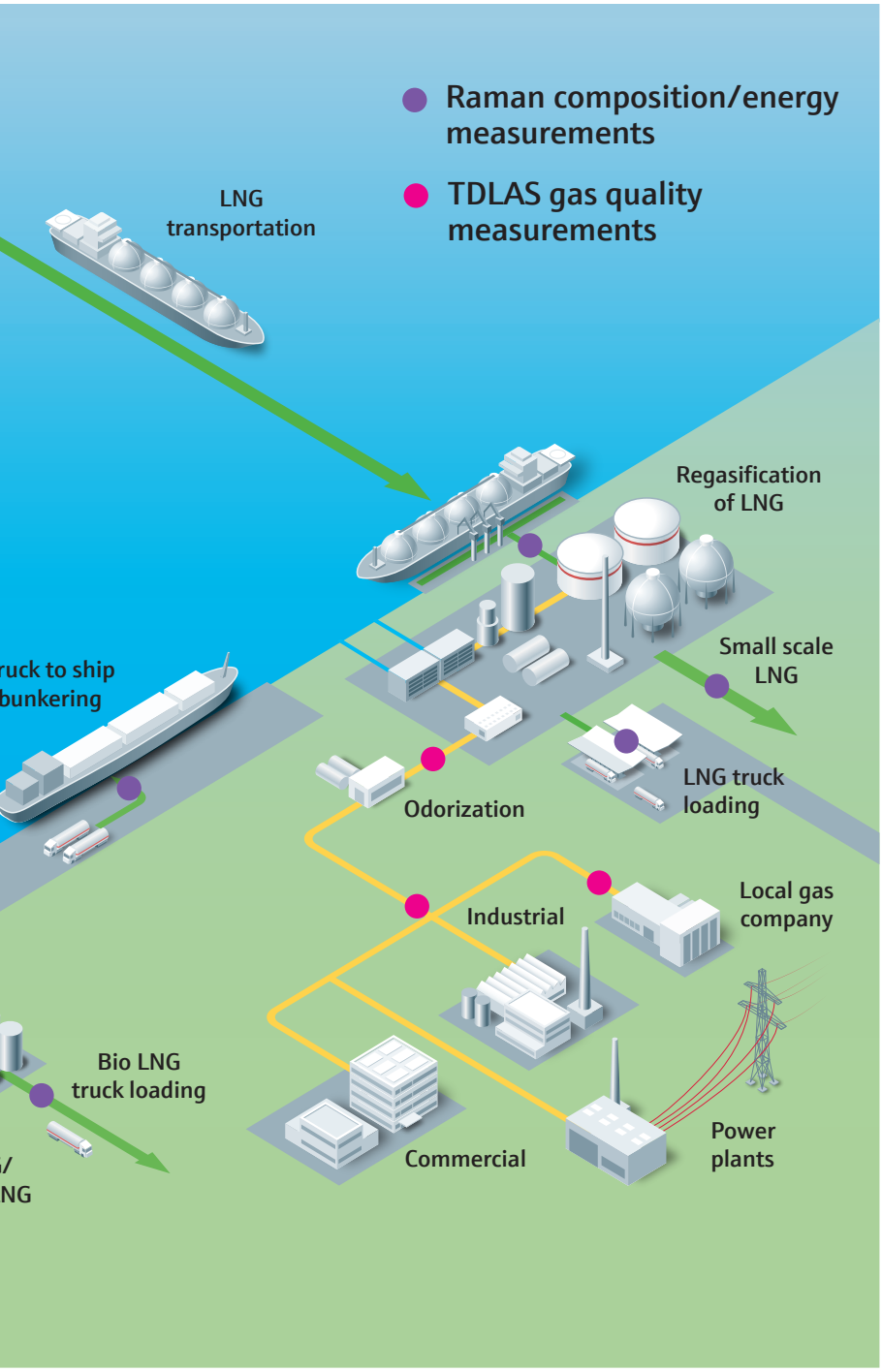
50+

combined years of TDLAS and Raman expertise

How we can support you

Reliable LNG analysis from pre-treatment to liquefaction through custody transfer and regasification





TDLAS gas concentration analysis
Trace contaminant analysis in process gas streams

- Process control measurements
  - Amine treatment inlet
  - Amine treatment outlet
  - Molecular sieve dehydration outlet
- Product quality measurements
  - Feed gas to plant
  - Re-gasified LNG to distribution

Raman spectroscopy LNG composition analysis
Compositional analysis of LNG quality and energy calculation

- Liquefaction and regasification
- Baseload custody transfer
- Marine bunkering
- LNG truck loading

Compliance with globally accepted standards & certifications

TDLAS gas analysis prior to liquefaction

Fast and reliable readings of trace H_2O, CO_2, and H_2S in process gas streams using one technology without expensive maintenance delays

TDLAS analyzers from Endress+Hauser perform on-line, real-time measurements of impurities in natural gas from sub-ppm to low percentage levels. The unique design of Endress+Hauser TDLAS analyzers provides significant advantages over other technologies for monitoring H_2O, H_2S and CO_2 in natural gas feed for LNG production.

- **Non-contact measurement** The laser and solid state detector components of TDLAS analyzers are isolated and protected from the process gas and entrained contaminants flowing through the sample cell. This design avoids the fouling, corrosion, and memory effects associated with aluminum oxide (Al_2O_3) moisture sensors and quartz crystal microbalances (QCM) analyzers, ensuring reliable long-term operation.
- **Fast response and analysis time** TDLAS analyzers detect changes in analyte concentration much faster than other techniques. The wet-up and dry-down times associated with QCMs can result in a delayed response or failure to detect a sudden increase in H_2O concentration, signaling breakthrough in a molecular sieve dehydration vessel. Gas chromatograph (GC) results can be delayed several minutes awaiting completion of a chromatographic run.
- **Fully automated analyzer validation** Endress+Hauser TDLAS analyzers for trace moisture measurement are equipped with an integrated permeation device to perform automated analyzer validation at user-specified time intervals.
- **Low cost of ownership** Unlike lead acetate tape analyzers or GCs, TDLAS analyzers have virtually no consumable components resulting in a lower overall cost of ownership due to lower service and maintenance burdens for technicians.

Which TDLAS analyzer fits best with your LNG application and your region?

LNG gas processing and quality applications - H_2O, H_2S, or CO_2 measurements for gas concentration and gas quality control

For H_2O and H_2S measurements

For H_2O, H_2S and CO_2 measurements

J22 and JT33 TDLAS gas analyzer – Global

- Ingress protection rating: IP66, Type 4X
- Hazardous area certification:
  - NEC & CEC Class I, Division 1 & Class I, Zone 1
  - ATEX/IECEx/UKEx Zone 1
  - Additional hazardous area certifications for China, Korea, India, Japan, Brazil, and EAEU countries*

SS2100 TDLAS gas analyzer – North America

- Ingress protection rating: Type 4X
- Hazardous area certification: NEC & CEC Class I, Division 2 & Class I, Zone 2

SS2100i TDLAS gas analyzer – Global

- Ingress protection rating: IP66
- Hazardous area certification: ATEX/ IECEx Zone 1
- Additional hazardous area certifications for China, Korea, India, Japan, Brazil, and EAEU countries*

*Check availability for specific countries and products

LNG regassification unit

Amine treatment

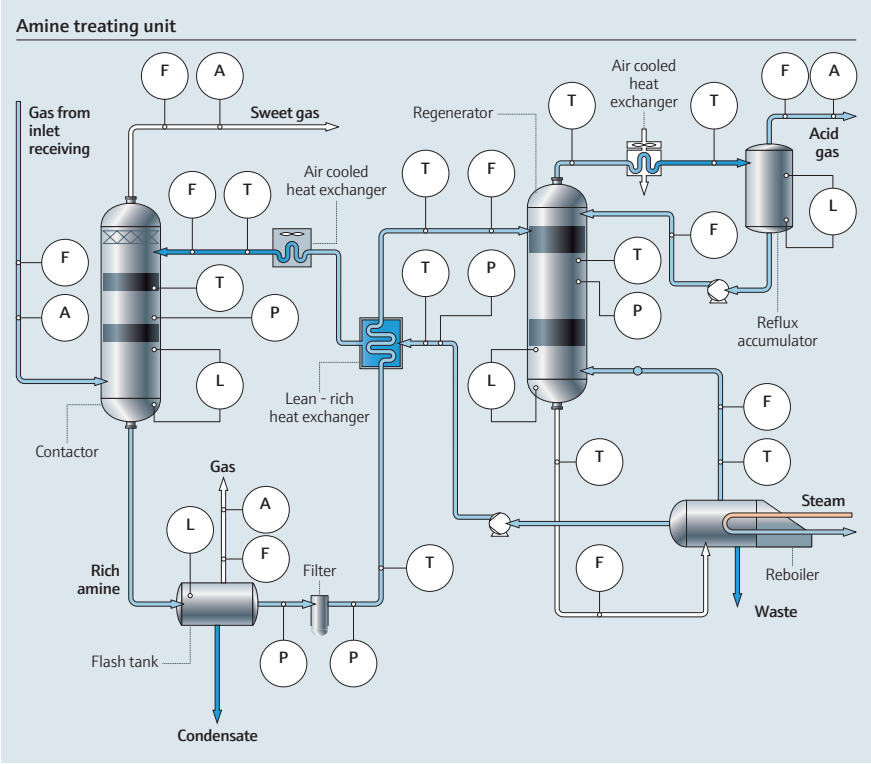
Molecular sieve dydration

Process optimization of amine treatment and gas sweetening with TDLAS

Optimal gas sweetening process control and gas quality output Raw natural gas from different geological formations contains varying amounts of acid gases (H_2S and CO_2). These contaminants must be removed from LNG feed gas to prevent CO_2 from freezing at cryogenic processing temperatures and H_2S from exceeding gas quality specifications. Acid gas containing elevated levels of H_2S, and CO_2 is a byproduct of the process which may be fed to a sulfur recovery unit (SRU) to convert and recover elemental sulfur from H_2S in the acid gas. Measuring the H_2S concentration in the acid gas stream is critical for optimization of the oxidation process occurring inside the SRU.

Gas sweetening processes are designed to remove acid gases from sour gas. Amine treatment is the most common process employed to scrub H_2S and CO_2 from natural gas. In operation, sour gas is contacted with an aqueous amine solution which removes H_2S and CO_2 by chemical reaction and absorption.

Our expertise in the field Endress+Hauser TDLAS analyzers offer rapid, reliable measurement of these corrosive acid gases for enhanced control and optimization of the gas sweetening treatment process. Our TDLAS analyzers enable real-time, on-line monitoring of the H_2S and CO_2 concentrations in sour gas at the inlet and sweet gas at the outlet of an amine treatment unit. Using our patented differential spectroscopy technique, our instruments react fast to analyte concentration changes, enabling high-resolution, continuous measurement and detection of trace H_2S and CO_2 in seconds. Measurement is reliable, with results immune to common interferences. Plus, with no field calibration, consumables, or moving parts, analyzer maintenance and overall ownership costs are minimal.



Key benefits of TDLAS measurement

- Provides fast and accurate low ppm-level measurements under varying operating conditions and feedstocks in real time
- Enhances the efficiency and safety of assets and personnel
- Eliminates errors caused by interference from other chemicals
- Reduces instrument ownership and maintenance costs due to no consumables or moving parts
- Ensures long-term operational stability without the need for field calibration

Endress+Hauser instrument measurements

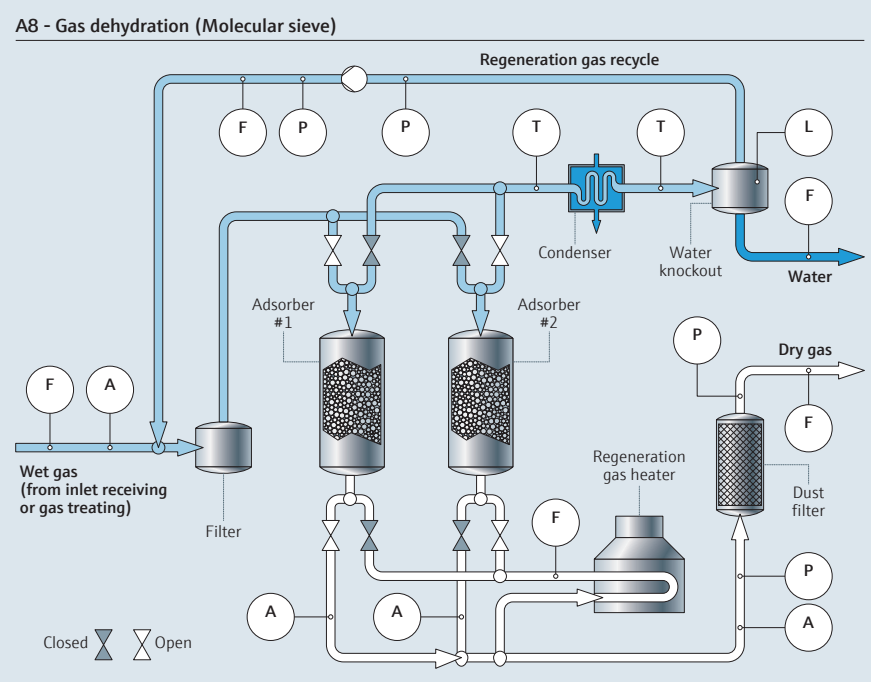
- A – TDLAS analysis measurement points
- F – flow measurement points
- T – temperature measurement points
- L – level measurement points
- P – pressure measurement points

Boosting productivity of molecular sieve dehydration with TDLAS

Keeping molecular sieve dehydration systems running efficiently During LNG processing, sweet natural gas exiting the amine treatment unit contains water vapor. Moisture can lead to freeze-up of the cold box heat exchanger tubes in liquefaction trains which could result in multiple-day production stops. To prevent damage to equipment and ensure on-time LNG deliveries, molecular sieve dehydration is used to meet stringent specifications for H_2O concentration (< 0.1 ppm) in LNG feed gas.

Initially, no H_2O is detected in the dry gas exiting a molecular sieve vessel. Over time, however, the adsorbent bed adsorbs more water and trace (sub-ppm) levels of H_2O are present in the gas. Three or four vessels containing molecular sieves are typically operated in parallel with a piping system that allows a saturated adsorbent bed to be taken off line for regeneration with heated gas. Highly accurate measurement is needed to rapidly detect moisture breakthrough in the adsorbent bed to enable the operator to switch gas flow to a vessel with a freshly regenerated adsorbent bed.

Our expertise in the field Endress+Hauser's patented differential TDLAS technology delivers reliable H_2O measurement in molecular sieve dryers for fast and reliable control of natural gas dryer processes without contaminant interferences or maintenance burdens. With real-time, on-line monitoring of H_2O concentration at the outlet gas stream of the dryer vessel, our TDLAS analyzers quickly detect adsorbent bed saturation and breakthrough. The instruments respond rapidly to these changes in H_2O concentration, ensuring the H_2O content of LNG feed gas does not exceed the user-specified process control set point, thereby protecting downstream assets and minimizing plant downtime. By optimizing dryer bed switching, near instantaneous moisture measurement also extends the life of the molecular sieve bed and helps to improve overall productivity of the LNG plant.



Key benefits

- Prevents elevated H_2O content from reaching the liquefaction train and damaging downstream assets
- Boosts the efficiency and life of the molecular sieve dehydration system by extending the cycle time between bed regenerations
- Generates significant cost savings due to less regeneration, maintenance, and downtime
- Improves the overall productivity of the LNG plant from processing to liquefaction

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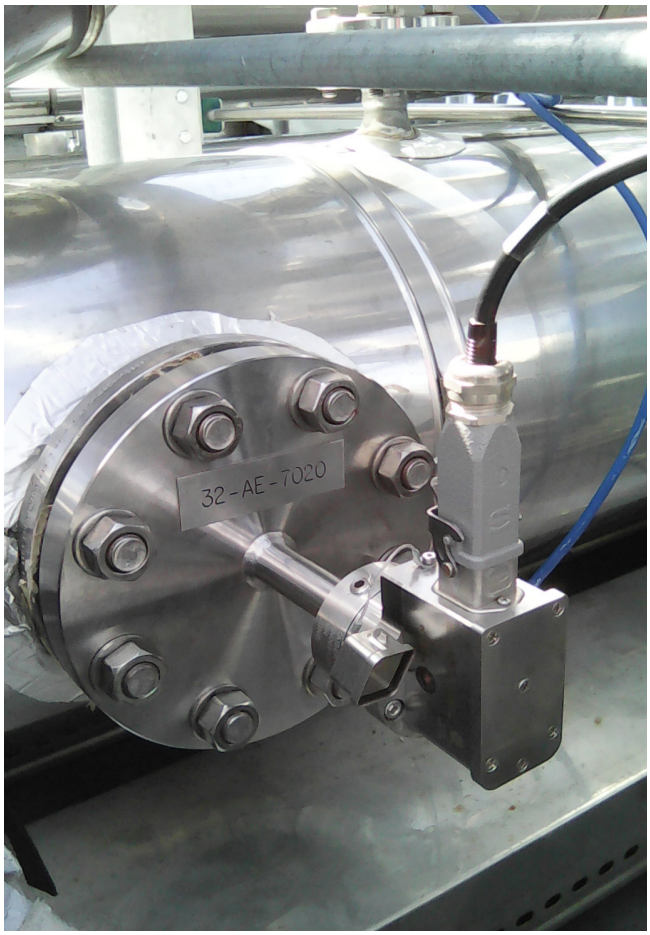
Raman analyzer systems for LNG composition and energy content measurement

Raman analyzers and probes for LNG from Endress+Hauser use Raman spectroscopy to perform on-line composition measurements to determine Btu, Wobbe Index, and other critical process parameters in downstream LNG processes. 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.

Our Raman technology eliminates the need for vaporizers, solving many of these challenges. Our 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 composition and determining calorific value *in situ* and in real time, Endress+Hauser Raman analyzer systems provide equivalent accuracy but are faster, more stable and require less maintenance than other LNG measurement technologies.



- **Enhance 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 with no loss in measurement accuracy. 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.

24/7 process visibility & control with our Raman systems

Raman Rxn4 analyzer - Fit for your LNG application

Custody transfer applications

Marine bunkering, baseload import/export terminals, & LNG truck loading

- Fast, in situ measurements of composition and energy
- Up to four measurement points from a single analyzer
- Low cost of ownership, no consumables
- Control room installation (5 ˚C to +35 ˚C ambient)
- Accuracy of ± 3 BTU/scf, verified at EffecTech UK
- 0.07 MJ/kg uncertainty when verified with high-accuracy certified LNG standard
- Up to four sample streams, sequentially
- Fiber optic lengths up to 500 m

Raman Rxn4 analyzer

Ensuring safety in LNG bunkering with Raman spectroscopy

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 key 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 connecting the analyzer to the optical probe, eliminating sample extraction or transport
- 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 with Raman spectroscopy

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 with 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 can 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 even before 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 (no columns, valves, or carrier gases), greatly reducing OPEX

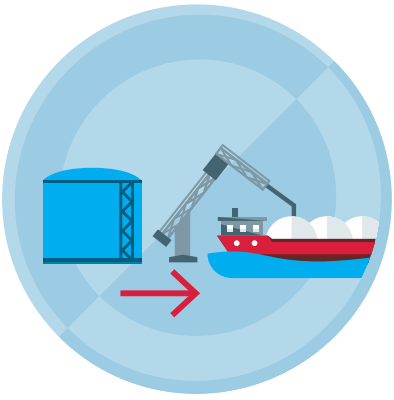
Maximizing plant availability during LNG custody transfers with Raman spectroscopy

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.

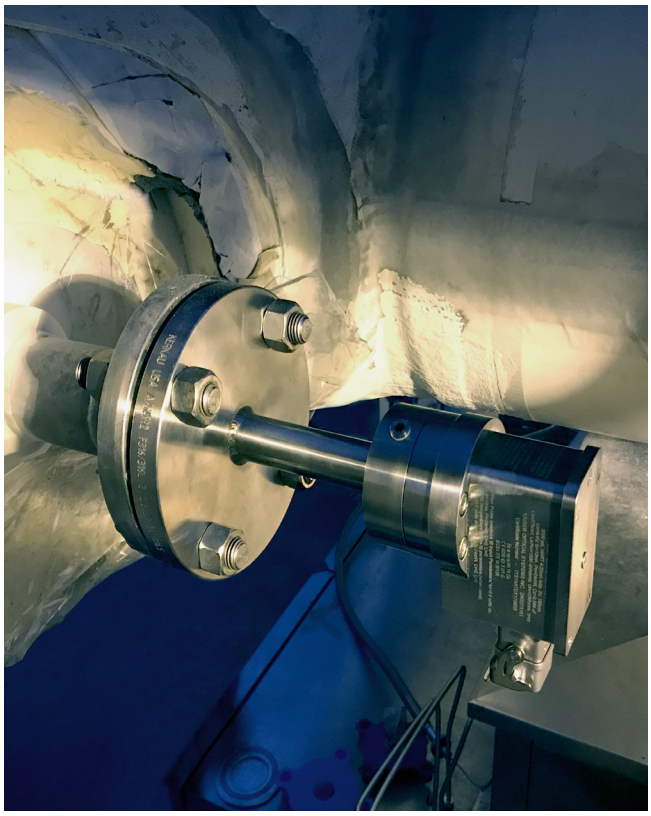
Key benefits

- 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

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



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