Bunker fuel metering systems

Our certified solutions offer maximum transparency

Endress+Hauser

People for Process Automation

Process automation by Endress+Hauser

Innovative solutions for the marine industry

Endress+Hauser is a global-leading supplier of measuring devices, services and solutions for industrial process engineering. We offer a wide range of measuring technologies to meet our customer's requirements – whether the application is bunkering, fuel consumption, exhaust scrubber monitoring or ballast water treatment.

Our devices for level, pressure, flow, temperature, analysis and registration are manufactured according to the highest quality standards. Endress+Hauser stands for continuity, industry-specific expertise and long-term customer relationships.

The marine industry has guidelines for offshore applications that not only consider safety concerns but also new requirements for carbon emission reporting. Our objective is to create trust with solutions that provide the highest level of accuracy in both quality and quantity. Our global network of over 600 experts as well as sales and service engineers ensures that everything works perfectly at your end.

For more information about Endress+Hauser:
www.endress.com

For more information about your industry:
www.endress.com/oil-gas

Transparency for greatest confidence

Bunkering process

Every day, large quantities of bunker fuel are pumped into the fuel tanks of cruise vessels, container ships, tankers and bulk carriers. Even the slightest measuring inaccuracies during the bunkering process cause discrepancies and time-consuming disputes.

Traditional quantity measurement via tank gauging, for example, can be associated with a greater amount of uncertainty due to error-prone volume to mass calculation as well as unconsidered air content caused by tank stripping and the "cappuccino effect". Very often, this leads to incorrect billing and unwanted bunker disputes between supplier and buyer.

For these reasons, ship owners and barge operators have been increasingly installing bunker fuel metering systems that ensure transparent bunkering operations and highly accurate bunker metering. These systems include MFMs (mass flowmeters), which have been tested and used for decades in custody transfer applications. Many port authorities request these measuring systems, including the port of Singapore, which has mandated their use over ten years ago with great success to the bunker industry. Endress+Hauser has developed a certified and reliable bunker fuel metering system for your business needs (see page 6).

At the same time, the demand for LNG (liquefied natural gas) as a marine fuel rises. This is partly due to the latest IMO MARPOL lower sulfur emission standards. As a sulfur-free fuel, LNG meets these new conditions without restrictions and is a cleaner alternative to traditional fossil fuels like HFO (heavy fuel oil). The LNG "fuel dispensers" are mobile or permanent. These can be trucks, bunker vessels or fixed land installations at terminals.

LNG bunkering is the process of providing liquefied natural gas fuel to a ship for its own consumption. While it is important to measure the quantity, it is also important to measure the quality of the transferred fuel to derive the energy content because LNG is traded according to this. The methane number and total energy transferred are calculated out of the composition, temperature, pressure and flow measurement. One of the challenges in measuring the energy content of LNG during bunkering is working with cryogenic fluids, another is the varying composition due to mixing of LNG from different sources and aging under storage conditions.

Endress+Hauser offers a LNG bunker metering solutions as standardized packages covering all common line sizes and flow conditions depending on the customer's marine bunkering needs. The offered solution (see page 10) consists of:

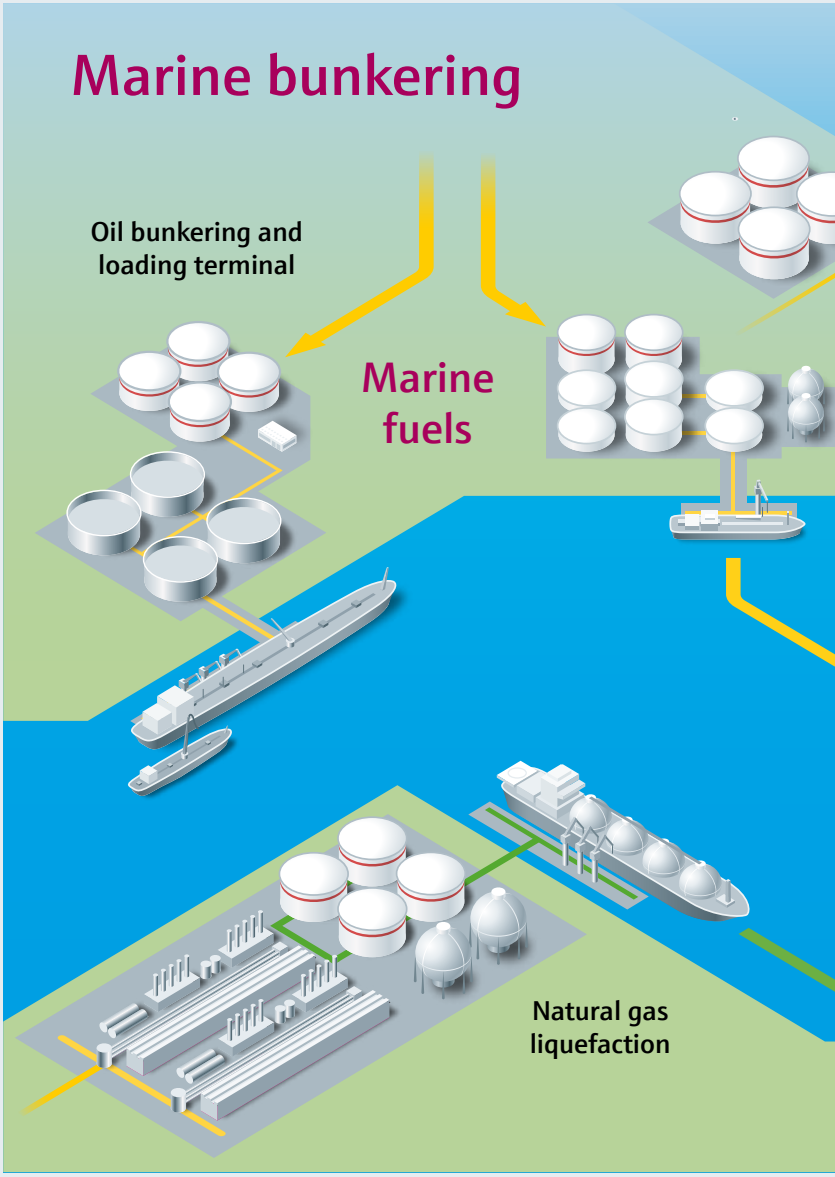
- Proline Promass MFMs
- Temperature sensors
- Pressure sensors
- Raman optical analyzers and Raman probes
- Regulatory-compliant monitoring system

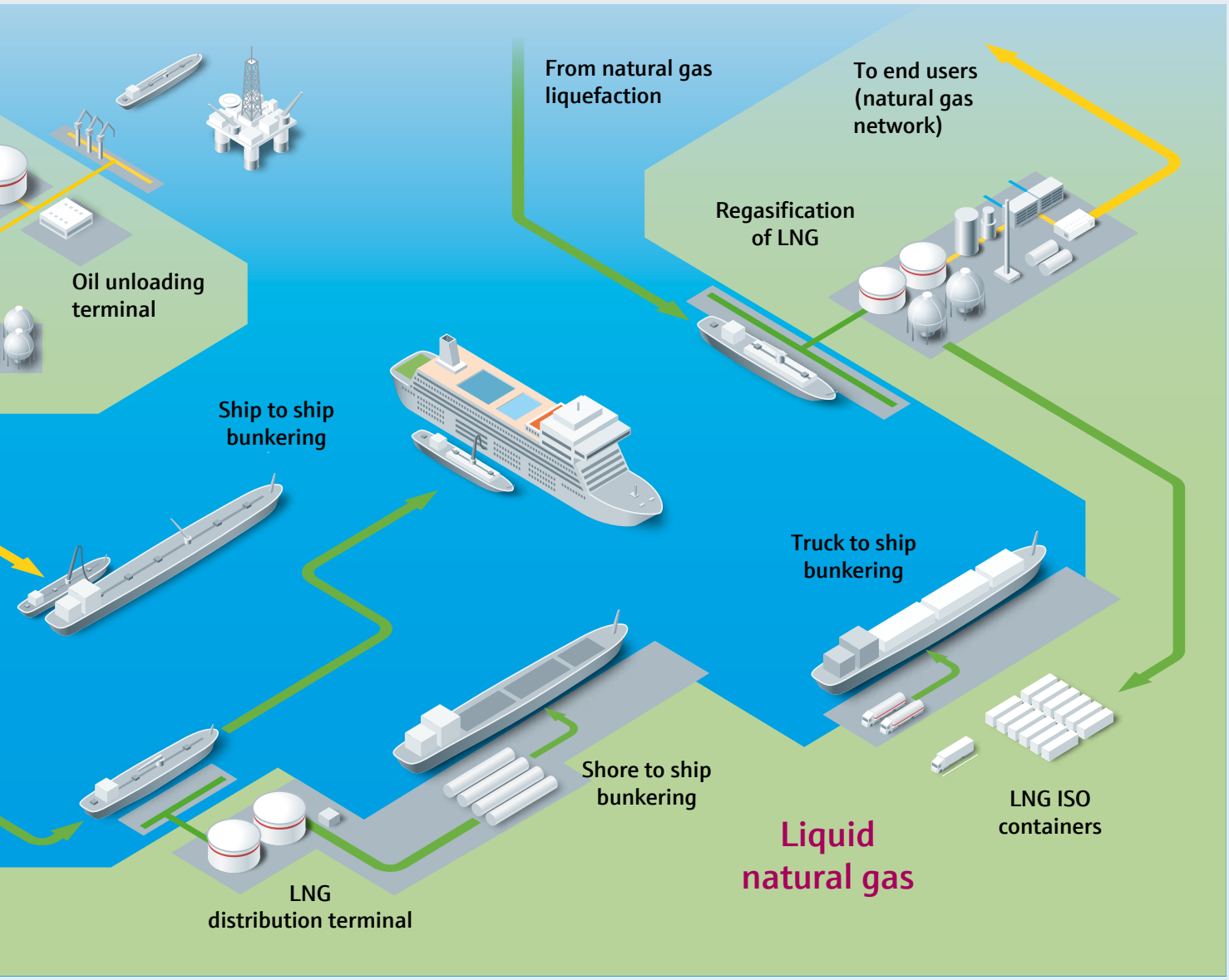
Solutions for the bunkering industry

On board vessels and at terminals

Day by day, large quantities of hydrocarbons are transported, stored, treated, received, and finally sold to a wide variety of consumers. Bunkering is a custody transfer process and needs to follow local regulations, approval standards and trading regulations.
The bunker metering solutions of Endress+Hauser ensure that the amount of hydrocarbons is measured with the highest accuracy.

Typical bunkering applications include:
- Ship to ship bunkering
- Shore to ship bunkering
- Truck to ship bunkering




From natural gas liquefaction
To end users (natural gas network)
Regasification of LNG
Oil unloading terminal
Ship to ship bunkering
Truck to ship bunkering
Shore to ship bunkering
LNG ISO containers
LNG distribution terminal
Liquid natural gas

Improved profitability

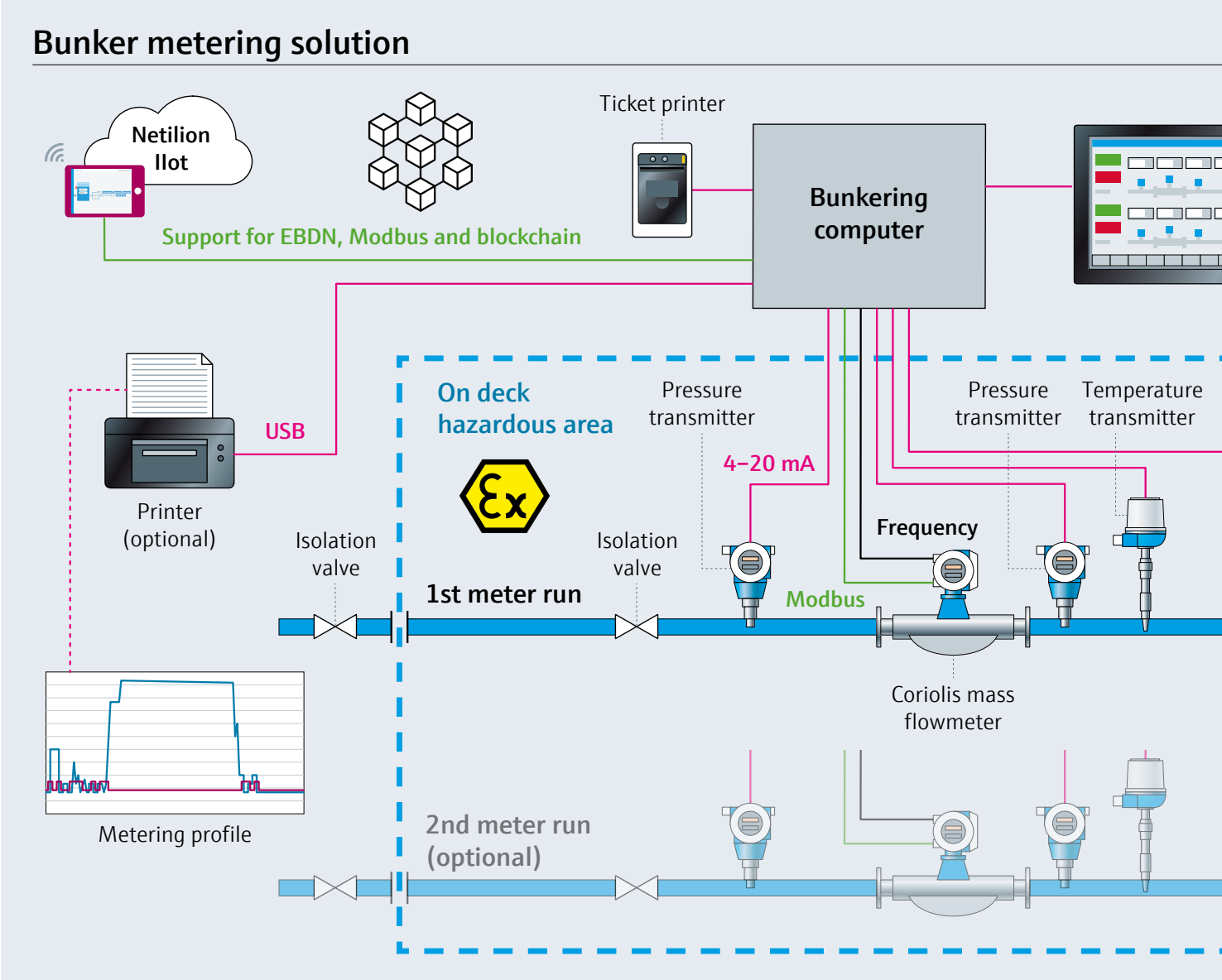
Our metering solution pays off

The patented bunker metering system is based on proven MFM technology and has been deployed on bunker tankers as well as receiving vessels. It has also been used successfully in custody transfer applications, on bunker barges, on vessels, as well as for ship offloading applications in various industries for decades.

Endress+Hauser has developed a bunker metering system that measures highly viscous and aerated bunker fuel with outstanding measuring accuracy and saves up to three hours per bunkering operation. Time-consuming manual tank sounding is no longer necessary.

Our solution offers continuous bi directional mass flow measurement using MFMs. Another advantage: the system employs a patented two-phase flow measurement, ensuring maximum accuracy even under aerated conditions like tank stripping. Additionally, it offers maximum application safety and measurement availability.

The metering profile allows for intervention during excessive tank stripping or air injection. With the advanced metering system in place, time-consuming and costly bunker disputes because of non-transparent bunkering operations become a thing of the past. The custody trans-



fer approved system delivers worldwide acceptance of measurement results, transparency and traceability. The intuitive and integrated 12" touch screen control panel guarantees safe operations with real-time visualization. Bunker operations become highly efficient, with reduced idle times in ports together with preventive measures in case of any irregularities.

Global support

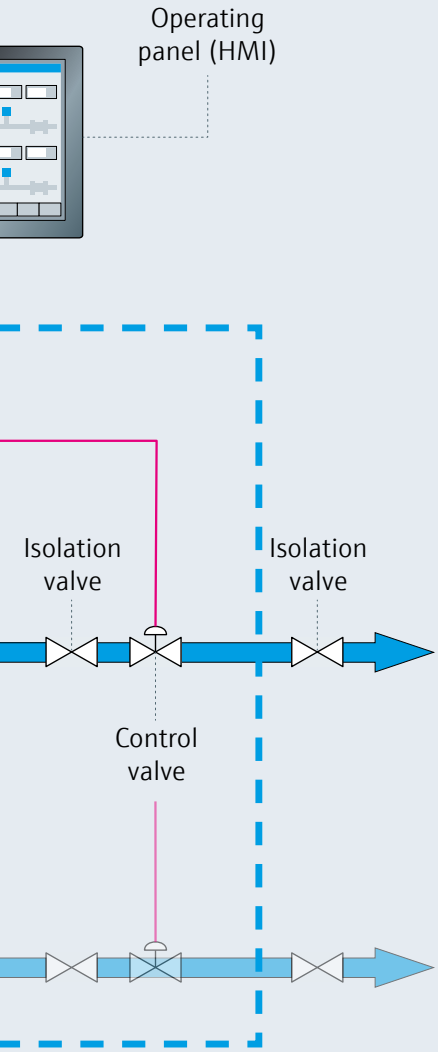
- 10 years of experience with over 500 global installations
- Global presence of approved verifiers for MID (Measurement Instruments Directive) Module D installations

Available options for bunker metering system

- Desktop or wall-mount control system in various housings
- Support for ship offloading and terminal operations
- One or two meter runs
- Digital communication interfaces including Modbus

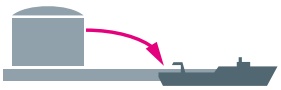
Your benefits

- Accurate billing thanks to the high accuracy of our bunker fuel measuring system (±0.5% o.r.)
- Up to three hours time savings for each bunkering operation – no time-consuming manual tank sounding necessary
- Direct mass measurement – no error-prone, time-consuming volume conversions
- Maintenance-free measuring system without moving parts
- Stable measurement – insensitive to external influences such as pipe vibrations and independent of fluid properties



Product flow:

Bunkering: Barge to ship



Loading: Port terminal to barge

Loading: Floating storage to barge

Loading: Barge to floating storage

Various measuring system installations:

- on the barge
- on the ship to be fueled
- on floating storage

Bunker Metering Computer SBC600 with bunker metering ticket printed on an approved custody transfer printer

System integrity

Our measuring system provides a high level of security

Given that a great deal of money is at stake in the bunker fuel business, a measuring system's integrity and reliability are paramount. You can trust us in this regard – no ifs, ands or buts. Both the individual devices and the entire measuring system are sealed after installation and thereby protected.

The EC type-examination certificate issued by NMi Certin (Netherlands) confirms that the hardware and software of our bunker fuel metering system meets all of the requirements in accordance with MID (MI-005) while also offering the required system integrity – for measuring black and white oils, biofuels and LNG. Our bunker fuel metering system is also recognized and approved for commercial use by the Maritime and Port Authority (MPA) of Singapore in compliance with SS648 and ISO 22192.

All of our devices are calibrated on accredited calibration facilities (ISO/IEC 17025), fulfilling the important requirement for seamless traceability according to national standards.

Our bunker metering system reflects more than a decade of installation and operational experience with bunker and receiving vessels. The purpose-built control system utilizes specialized algorithms in conjunction with dedicated monitoring for bunkering operations.

EC type-examination certificate

Accredited integrity

- Measurement integrity – all relevant system components are sealed either by approved verifiers of Endress+Hauser or by independent approved verifying agencies
- Certified measuring system in accordance with MID (MI-005) and ISO 22192
- Approved for commercial use by the Maritime and Port Authority of Singapore (MPA)
- Traceability – every device from Endress+Hauser is calibrated on accredited and traceable calibration rigs (ISO/IEC 17025)

Support for blockchain, supply chain and decarbonization tracking

Built-in support for multiple industrial protocols

The trading of marine fuels is increasingly looking to adopt new technologies to ensure transparency and continues to meet global demand for traceable decarbonization within the industry. The use of digital ledgers can leverage blockchain for bunkering transactions which enables end-to-end bunker transactions for tracing bunker quality and quantity, all in real time. Endress+Hauser's bunkering solutions come with a wide range of available industrial and open blockchain protocols to support the various technologies that are being adopted. They also support the Netillion IIoT cloud of Endress+Hauser.

Traceability in net zero shipping GHG emissions

The transparency of blockchain will continue to not only drive the commercial activities of global marine fuels trading, it will also be the primary method for tracking emissions within the shipping industry. Endress+Hauser's marine bunkering solutions already support this global initiative with our integrated systems that can share real-time data on both quantity and quality measurements. Whether it's traditional bunker fuels, methanol or even LNG – all of the bunkering solutions fully support the industry's digital transformation efforts towards net zero GHG (greenhouse gas) emissions.

Blockchain ready

Endress+Hauser has partnered with local governments, global maritime logistics companies and service providers in the development and deployment of new technologies. The goal is to provide secure real-time insights that support global trade connectivity. In addition to traditional industrial protocols like Modbus, the bunkering solutions of Endress+Hauser also support a wide variety of well-established methods and protocols to deliver integral data into private and government distributed blockchain ledgers.

LNG – increasing popularity as a marine fuel

The Endress+Hauser LNG bunkering solution is one of the most accurate and technologically advanced solutions available on the market today

The demand for LNG as a marine fuel is surging as ship owners and operators strive to comply with emissions reduction regulations set by the IMO and EU. LNG is the most efficient and viable means to readily transport, transfer and store the most amount of energy in the least amount of space, especially for large-scale marine operators who are now required to reduce their overall carbon footprint. The infrastructure for LNG bunkering is still developing, but it is growing rapidly as more ports and shipping companies adopt LNG as a marine fuel.

When bunkering with LNG, determining its energy content poses a challenge due to the handling of cryogenic fluids at extremely low temperatures (−160 °C). Often LNG composition varies due to mixing from different sources and aging under storage conditions. Providing reliable measurement of the quality of the cargo transferred is an essential component in the LNG bunker delivery transaction, and it is essential for maintaining safe marine operations. Measuring the composition of LNG is typically performed using gas chromatography (GC). However, using a GC requires that LNG is vaporized and the gas pressure regulated prior to analysis. Vaporizers normally demand frequent downtime for maintenance to avoid incomplete vaporization or pre-vaporization.

Endress+Hauser has developed a standardized LNG bunkering solution to provide the most accurate real-time metering of LNG deliveries using MFMs. This comes with a range of options to support mass transfers, energy calculations and boil-off-gas (BOG) measurement. Coupled with reliable, patented Raman technology designed for rugged cryogenic applications, the solution is the only one on the market that calculates energy transfers in real time. In addition, it has by far the smallest footprint compared to traditional systems that employ the use of GCs.

The LNG bunkering solution offering comes with options to meet the needs of bunkering operations, maritime operators, and ship builders:

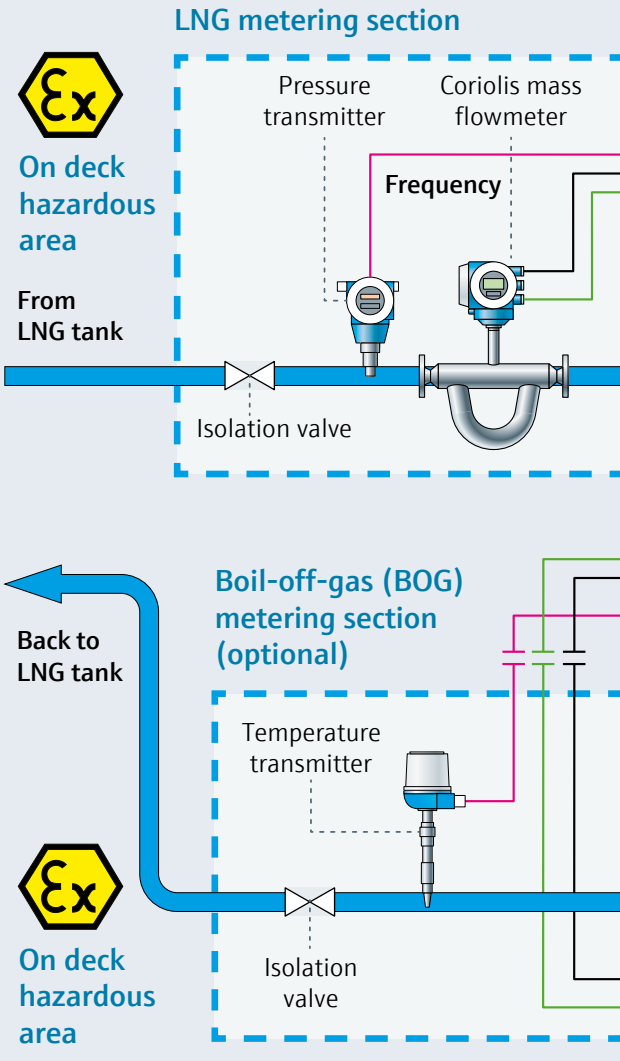
Equipment for LNG mass measurement
- MFM for LNG and BOG measurement
- Temperature sensors
- Pressure sensors
- Dedicated flow computers (LNG/BOG)
- Control panel

Standard additional equipment for energy measurement and LNG analysis
- Raman Rxn4 analyzer
- Raman Rxn-41 probe
- 800 mm control panel

Available options
- MFMs for fuel gas measurement for onboard engines
- Industry-accepted energy calculations and methane number calculations for engine performance
- Support for industrial and open blockchain protocols
- 3G/4G remote access
- Marine approvals for the instruments (ABS, DNV GL, BV, LR)

Your benefits
- Easy and safe to operate purpose-built HMI
- Single source provider for all equipment
- Support for several LNG and BOG line sizes with Proline Promass F and Q MFMs
- LNG in situ analysis in real time with patented Raman technology
- Space-saving installation compared to traditional systems using a GC
- Raman technology requires minimum maintenance compared to GC/vaporizer and reduces overall costs
- Fully certified by NMi Certin B.V. to meet WELMEC, OIML R117 and MID requirements for mass measurement

LNG bunkering solution




LNG Bunker Transfer Document

Endress+Hauser

LNG BUNKER BARGE

Operation Information

LNG Composition (FWA)

Mass Transferred (CT Result)

LNG Properties acc. ISO 6976:2016 for Real Gas (FWA)

LNG Density acc. ISO 6578:2017 (FWA)

Energy Transferred

Methane Number - PKI

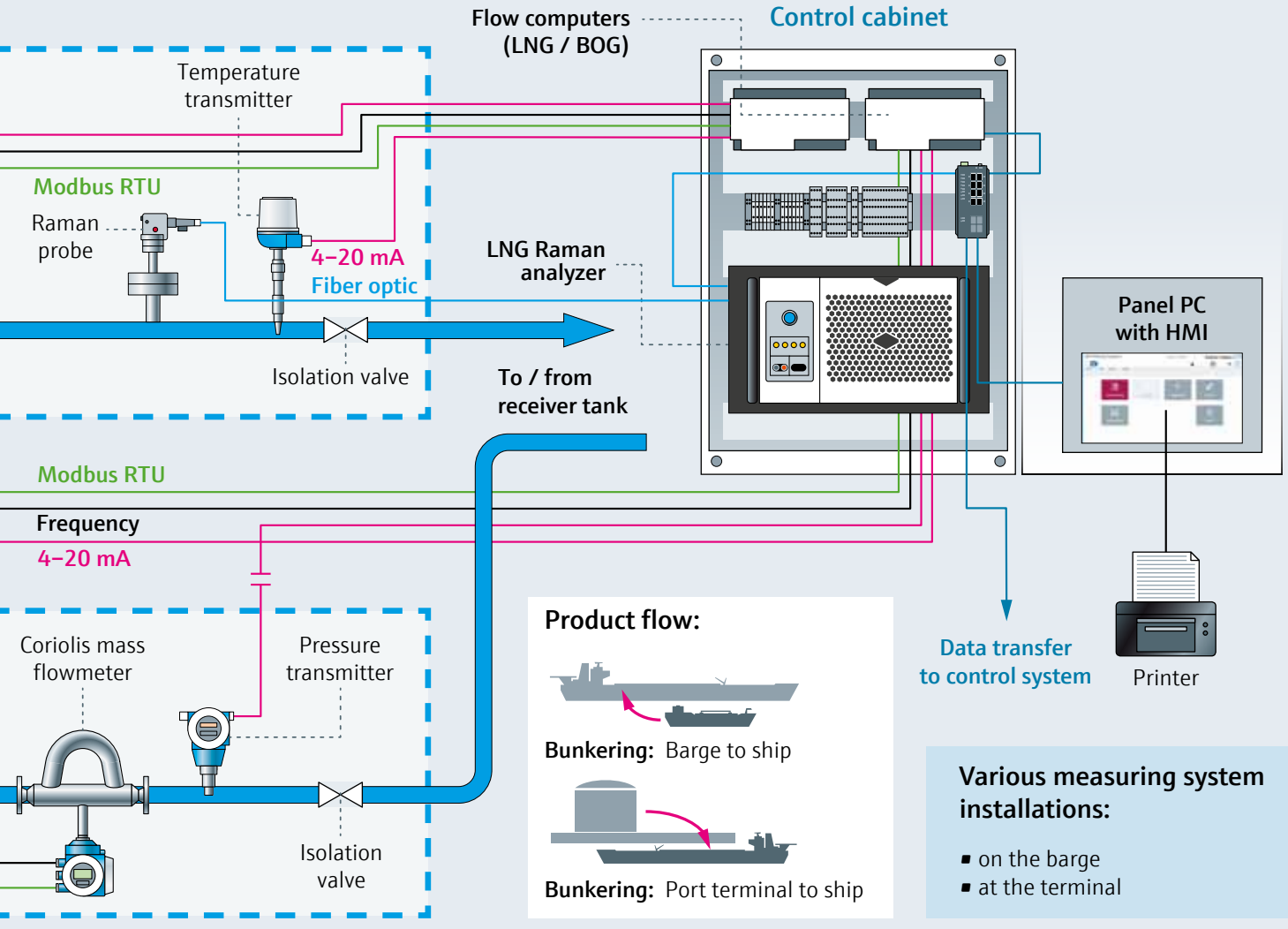
Calorific Value Applied to BOG Return Gas

Process Conditions (FWA)

Fully integrated control system with energy calculations

- Intuitive design for easy bunker operations and certified bunker transfer documents
- Standardized packages for systems with and without gas analysis
- Support for a wide range of energy measurements
- Including methane number calculations for: AVL, CARB, PKI, ISO & MWM
- Real-time diagnostics for safe and accurate measurement using Heartbeat Technology

The LNG bunkering control cabinet incuding flow computer, HMI and controller for Raman analyzer



Various measuring system installations:

- on the barge
- at the terminal

Proline Promass Q – the specialist for demanding applications

Outstanding accuracy for LNG bunker deliveries

The Coriolis flowmeter Proline Promass Q from Endress+Hauser is designed to be the specialist for accurate measurement of cryogenic liquids like LNG. The outstanding temperature stability results in best possible accuracy of the measured quantity, especially under cryogenic conditions. Thanks to its revolutionary 4-tube technology and an extended measuring range for sizes up to DN 250 (10"), customers benefit from low pressure loss and outstanding measuring accuracy for both minimal and very high flow rates. The reduced pressure loss also avoids unwanted cavitation effects or gas breakout, e.g., for very light hydrocarbons such as LNG.

Promass Q offers additional features, such as onboard diagnostics and verification with the integrated Heartbeat Technology, that enhance product and process safety. The complete sensor of the flowmeter, including measuring tubes and electronics, can be verified by the push of a button even from the control room without interrupting the process.

Your benefits

- Offers outstanding temperature stability
- Features an innovative meter design combined with patented MFT (Multi-Frequency Technology), which helps to reduce errors from entrained gas (i.e. boiling)
- Offers highest measuring accuracy: ±0.35% mass
- Utilizes a measuring principle that is independent of the physical fluid properties and the flow profile

Raman spectroscopy – real-time analysis in cryogenic conditions

Robust, reliable, and accurate: Rxn-41 probe and Raman Rxn4 analyzer

The combination of the Rxn-41 probe and the Raman Rxn4 analyzer results in powerful process analytical tools for real-time composition analysis of LNG and mixed refrigerants using quantitative Raman spectral analysis. The Raman Rxn4 analyzers and Rxn-41 probes are fully integrated into the overall LNG bunkering solution to provide customers with a complete system from a single vendor with the lowest OPEX of any solution on the market.

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 essentially immune to LNG flow variations and 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.

The **Raman Rxn-41 probe** is a rugged insertion probe designed to be inserted directly into the LNG stream so that it takes the reading in situ, with the moving liquid constantly refreshing the sample. The configurable design enables the sampling point to be customized for each customer's facility, providing flexible integration via direct flange-mounting on transfer pipes or integration into a slipstream 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 Category 1 pressure equipment safety standards.

Your benefits

- Real-time, in situ measurement, no vaporizer and no need for sample transport lines, valves, heaters, or regulators
- Up to four measuring points from a single analyzer
- Essentially immune to LNG flow variations
- Minimal maintenance, maximum technician safety
- Easy installation
- Rugged with minimal utility requirements, no sample transport, and no consumables
- Hazardous area certification: ATEX, QPS C/US, IECEx

▲ The Raman Rxn4 analyzer provides real-time and in situ gas analysis

▼ The Raman Rxn-41 probe enables direct insertion for composition measurement

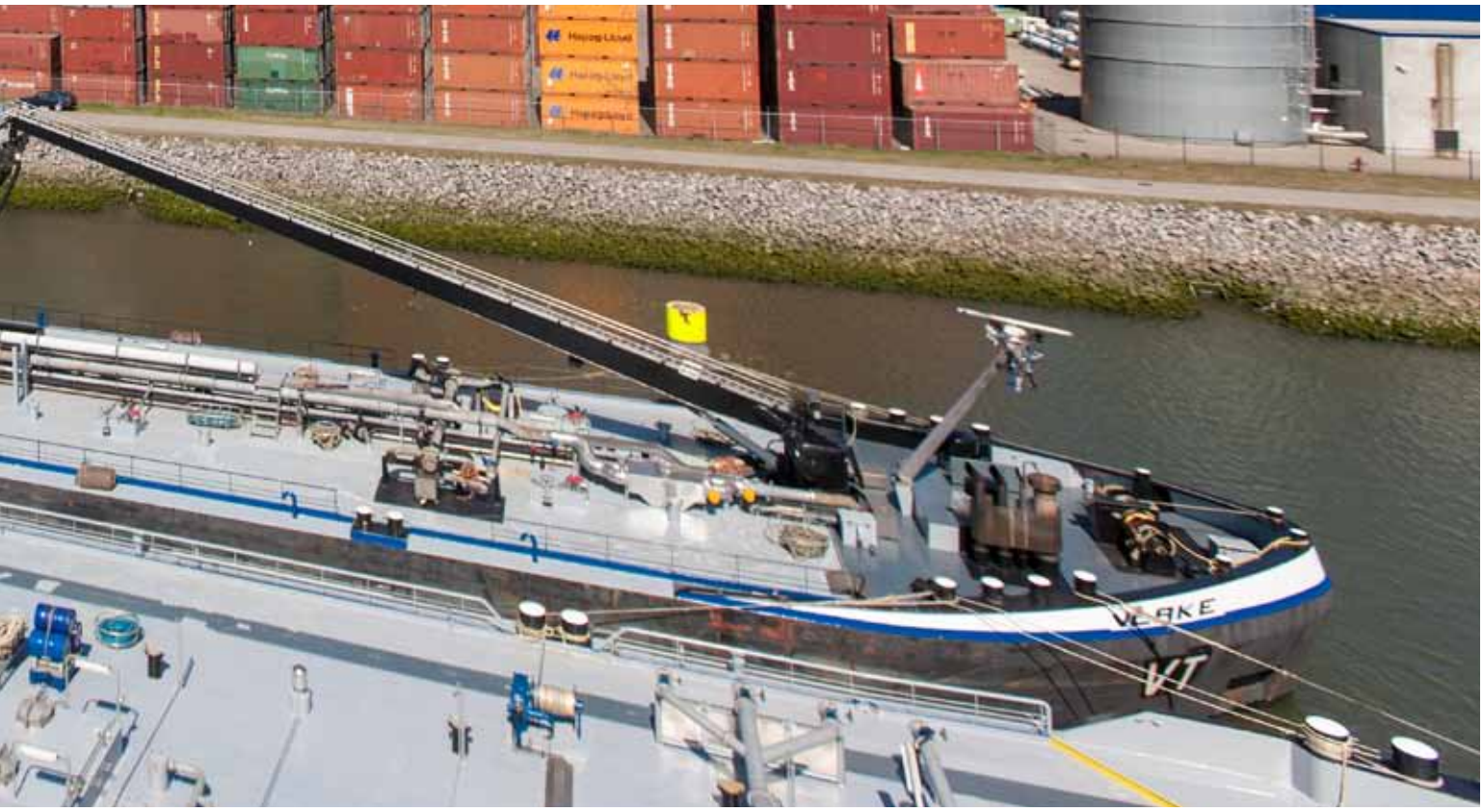
Expertise and service for the marine industry

Rely on a competent partner to support you in your tasks and challenges

As a marine operator, you are looking for a reliable partner to help increase productivity and performance. The Endress+Hauser service and project management philosophy, dedication, process knowledge and technical expertise are what sets us apart.

With our global workforce, we deliver outstanding service and project management and meet your most complex project requirements from start to finish, always with the aim to optimize your operations and performance. From help-desk support to request for quotation, from commissioning to start-up and from maintenance to calibration to replacement: All project phases are handled by an international team of experts, adhering to the same global standards and equipped with the same tools and skills.

We support you with open communication and transparency in bringing projects to completion on time and on budget. Regardless of the size of your project or location, our service and project management are tailored to your needs, taking into consideration the project variables to deliver the best solution for success.



Our project service

- Professional management of national and international projects
- Global service support from MID independently certified service engineers to support Module D and Module F certifications
- Installation and commissioning
- Inspection and maintenance (maintenance contracts)
- On-site calibration with our fully integrated master meter solution

Did you know ...

- that our LNG bunkering solution is the only one on the market that can analyze LNG in situ and in real time with our patented Raman technology?
- that our Proline Promass flowmeters provide the highest measuring accuracy for mass flow, volume flow as well as density, and are therefore the preferred choice for custody transfer applications?
- that we have a patented two-phase flow algorithm for aerated fuel oils?
- that our solution removes the need to invest in complex vaporizer technology and reduces operating costs for consumables, maintenance and calibration?
- that we offer a master meter solution for on-site recalibration of duty meters?
- that our Promass Coriolis meters have on-board diagnostics and verification using Heartbeat Technology without process interruption?
- that our Raman Rxn4 analyzer features unique self-monitoring, diagnostics, and self-calibration to ensure the validity of each measurement?

www.addresses.endress.com

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