Optimizing Ethylene Fractionation Control and Product Certification Using Rosemount™ Quantum Laser (QCL) Gas Analyzers

Application Note

Process Overview

Ethylene is one of the most common and important building blocks in the petrochemical industry. It is an intermediate chemical used to manufacture many commercial products. Nearly half of global ethylene demand is for polyethylene (PE) production, but it is also used to make vinyl chloride, ethylbenzene and many other valuable intermediate products, such as ethylene oxide, ethanol ethylene oxide and ethanol.

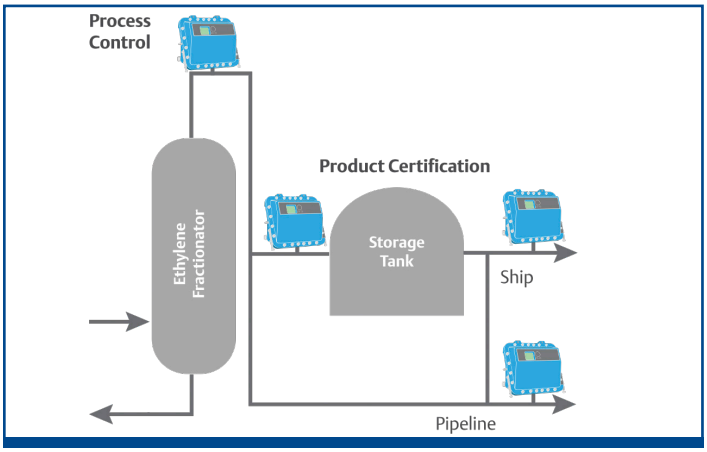
The goal of an ethylene plant is to produce 99.99% pure product. This purity is ensured during the final purification step, which takes place in an ethylene fractionation tower (Figure 1). At this process stage, ethane gets separated at the bottom of the column and recycled back to the process while the ethylene product leaves the overhead. An analysis of the ethane concentration is required for process control of the fractionator to ensure on-spec production.

Measurement Challenges

Ethylene Fractionator Overhead

Ethane and ethylene have similar physical properties making them difficult to separate. Process control of product purity requires a fine balance to maintain ethane close to the specification limit without going off spec or recycling ethylene.

Figure 1 - Typical Ethylene Fractionator



Operating the tower efficiently offers considerable economic advantages in reducing product give-away, minimizing energy usage and avoiding ethylene recycle. Measuring the C1 and C2 molecules, as well as CO and CO_2 allows the tower operation to be fine-tuned for maximum efficiency to ensure that ethylene production is on spec. Therefore, any upset process conditions in the ethylene fractionator can cause:

- Substandard product recycling incurring substantial reprocessing costs
- Costly flaring of the off spec product with additional environmental impact

Ethylene Product Certification

Before exporting to customers, ethylene must be analyzed to ensure that it meets product specifications (Table 1). This step is critical to profitability.Traditionally, this analysis has been carried out using grab samples and laboratory analysis. However, response time is critical during the delivery process. Fast, accurate multiple component measurements can now be achieved online with one analyzer using Emerson's hybrid laser technology, which enables real-time product certification.

The Emerson Solution

Laser Absorption Spectroscopy is a gas analysis method used to detect gas molecules and identify their concentrations. Rosemount Quantum Cascade Laser (QCL) Analyzers are continuous gas analyzers that utilize a unique hybrid laser spectroscopy technology which combines Quantum Cascade Lasers (QCL) with Tunable Diode Lasers (TDL) to provide fast, direct, and highly selective measurement of trace level impurities in complex gas mixtures.

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Combining QCL with TDL spectroscopy in a single instrument enables Rosemount Quantum Cascade Laser Gas Analyzers to broaden insight and monitor both the near and mid-infrared range of spectroscopic light. This hybrid approach uses QCLs to detect and identify gas molecules in the mid-infrared wavelength range, allowing the strongest absorption lines and highest sensitivities, in addition to TDLs which work in the near-infrared spectral region where laser sources exhibit higher performance. The results of this hybrid approach are a highly selective identification of the desired molecules and high-resolution measurements with very fast response times.

Meeting Ethylene Purification and Certification Demands

Ethylene's purity must be certified by measuring certain key contaminants once the ethylene product leaves the fractionator and before its distribution by pipelines or ships. Fast ethylene analysis allows for better process control as well as product quality certification. With the ability to detect multiple components simultaneously at parts per million (ppm) sensitivity levels, Rosemount Quantum Cascade Laser Gas Analyzers enable even trace levels of impurities to be identified.

The multi-component measurement is also valuable in product certification, which would normally take 3–6 analyzers to measure. Speed is critical at this stage of the delivery process, but precision of measurement should not be compromised for rapidity. The hybrid laser technology allows for both, enabling online, real-time product certification.

Response time is critical in optimizing process of the fractionation tower. Using a Rosemount QCL/TDL gas analyzer allows the sample to flow through a measurement cell where laser beams continuously analyze the gas. The response time is fast and the output is effectively continuous and in real time. This speed of the laser measurement is helpful because it can quickly detect a process upset that might otherwise cost hundreds of thousands of dollars per hour to correct.

Figure 2 *Designed for hazardous areas, the Rosemount CT5800 Continuous Gas Analyzer features an IP66 field flameproof enclosure ATEX II 2G Exd IIB + H2 T4 for ambient temperature from -20 to +55 °C.*

Benefits of the Hybrid QCL/TDL Gas Anaysis Technology for Ethylene Production and Purity

As the world's only hybrid QCL and TDL analyzers, Rosemount Quantum Cascade Laser Gas Analyzers deliver the most sophisticated industrial gas sensing and analysis, enabling operators increased process control and minimized operational cost. Benefits of the Rosemount QCL technology include include:

- Multiple QCL/TDL lasers in a single analyzer for fast detection and analysis of impurities, such as CO. CO_2, acetylene and moisture to ensure ethylene feedstock meets specifications
- Update time of <1 second delivers critical monitoring of gas quality to ensure the integrity of the ethylene process stream
- High sensitivity and selectivity allow the detection of multiple components and trace impurities simultaneously, even in complex mixtures and while remaining immune to cross-interference effects
- Patented laser chirp technique analyses the continuously down to sub-ppm concentrations, enabling sub-second measurements in real time
- No in-field enclosure or shelters and reduced consumables and calibration minimize cost and maintenance
- Interchangeable modular configuration of up to six lasers simplify field service and upgrades
- Easy-to-install instrumentation and fast technician training

TABLE 1. TYPICAL MEASUREMENT RANGES IN ETHYLENE

	TYPICAL MEASUREMENT RANGES		
	Component	**Range**	**LOD***
Process Control	Methane	0–1000 ppm	5 ppm
	Acetylene	0–20 ppm	0.2 ppm
	Ethane	0–500 ppm	5 ppm
	CO	0–5 ppm	0.05 ppm
	CO_2	0–5 ppm	0.05 ppm
Adders for Product Certification	Ammonia	0–20 ppm	0.2 ppm
	Water	0–20 ppm	0.2 ppm
	Methanol	0–100 ppm	1 ppm

**Repeatability is ±1% of reading or the Limit of Detection (LOD), whichever is greater. Other ranges are available. Please consult an Emerson application specialist.*

For more information, visit
Emerson.com/RosemountGasAnalysis

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