AMETEK®
PROCESS INSTRUMENTS

APPLICATION NOTE

ACETYLENE MEASUREMENTS IN ETHYLENE PRODUCTION USING TUNABLE DIODE LASER ABSORPTION SPECTROSCOPY (TDLAS)

5100HD TLDAS

Real-time and low-maintenance measurement of acetylene concentrations in ethylene production can be achieved with a tunable diode laser-based 5100HD analyzer.

ACETYLENE REMOVAL IN ETHYLENE PRODUCTION

Acetylene (C_2H_2) is a byproduct of the ethylene (C_2H_4) production process, and concentrations above five parts per million by volume (ppmv) are considered an impurity in the final product. To optimize reaction rates and minimize the production of off-spec C_2H_4, producers need fast, accurate and continuous C_2H_2 concentration measurements.

Real-time monitoring of the C_2H_2 concentration in the hydrogenation process is critical to minimize the impurities in the final product.

Potential measurements points for C_2H_2 measurements are the inlets and outlets of the C_2H_2 converters (Figure 1). The benefits of the measurements of C_2H_2 in two streams (inlet and outlet of one of the converters) at the same time are the optimization of hydrogen and carbon monoxide injection and reaction time to achieve the best conversion ratio for C_2H_2.

The levels of the C_2H_2 at the inlet of the first converter are typically over one percent. The levels of C_2H_2 at the mid bed of the converter are between hundreds and a few thousand ppmv; but for the outlet of the final converter bed, the C_2H_2 concentration should be in the range of 0-10 ppmv.

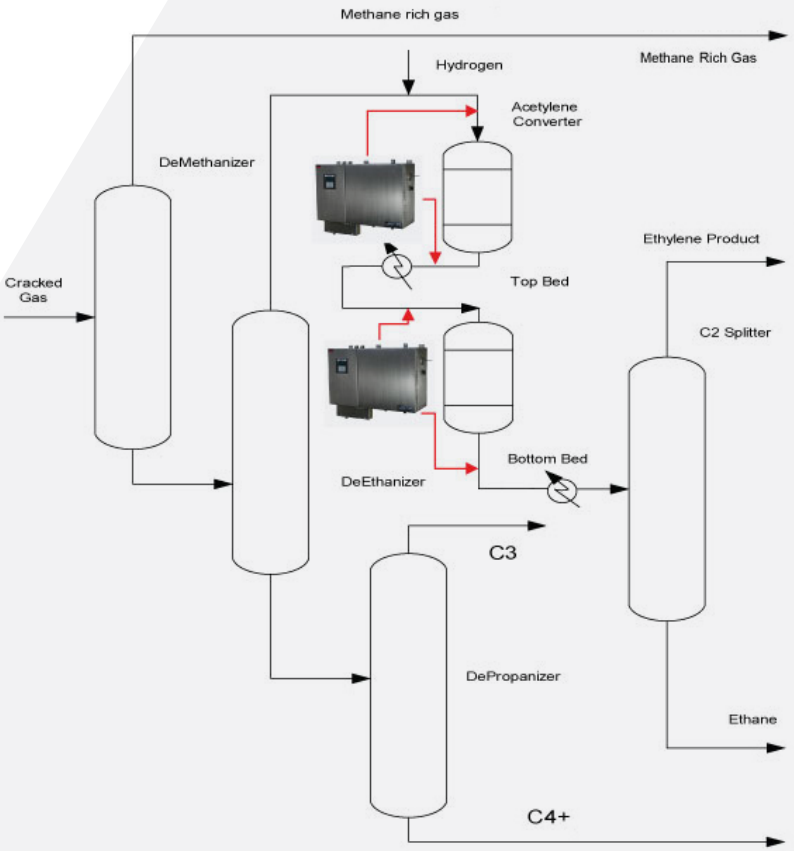

Figure 1. A diagram of a typical C_2H_4 production plant and sampling points for a TDLAS analyzer

MONITORING C_2H_2 CONCENTRATIONS

To ensure a near-complete conversion of the C_2H_2 and minimize the C_2H_4 to ethane (C_2H_6) reaction, the optimum conditions for the hydrogenation process should be determined by real time monitoring of the C_2H_2 concentration at several locations in the plant.

Traditionally, gas chromatography (GC) has been used to monitor C_2H_2 in C_2H_4 production. However, despite the high GC sensitivity allowing the measurement of sub parts per million levels of C_2H_2, GC disadvantages are slow response and high maintenance costs. Standard process gas chromatographs need several minutes for the chromatographic separation. As a result, the C_2H_2 concentration reading is only updated every 2-3 minutes, limiting the process optimization actions.

TDLAS is a non-contact analysis technique with long-term stability, high specificity and low cost of ownership. Laser-based C_2H_2 analysis offers the advantage of short response time (readings updated every two seconds), large dynamic range and low drift in comparison with GC. In applications such as monitoring the C_2H_2 levels at the inlets and outlets of the C_2H_2 converters, the above-mentioned attributes provide the real-time data needed to optimize the C_2H_4 production process.

The 5100HD TDLAS analyzer (Figure 2) provides an integrated heated sample compartment (up to 150°C (302°F)) containing one or two stainless steel gas cells and the sample conditioning system (membrane filter). All that is required for installation is mounting the analyzer back pan and attaching a heated transfer line (need dependent on the dew point temperature of the gas stream).

Figure 2. The AMETEK 5100 HD TDLAS C_2H_2 analyzer

The 5100HD analyzer is an option for customers looking to replace gas chromatographs for monitoring C_2H_2 in the C_2H_4 manufacturing process. There are no consumables with a TDLAS analyzer, resulting in a lower cost of ownership. A comparison of the capital and operating costs for a TDLAS analyzer as compared with a process GC analyzer are shown in Figures 3 and 4.

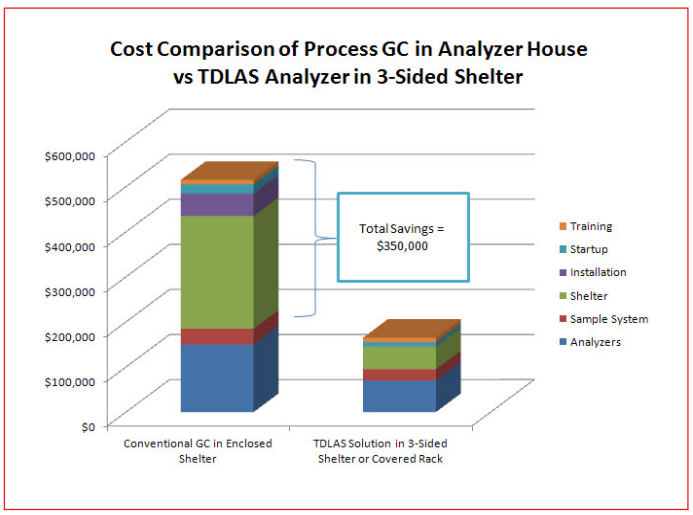

Figure 3. Capital cost of a TDLAS versus a process GC

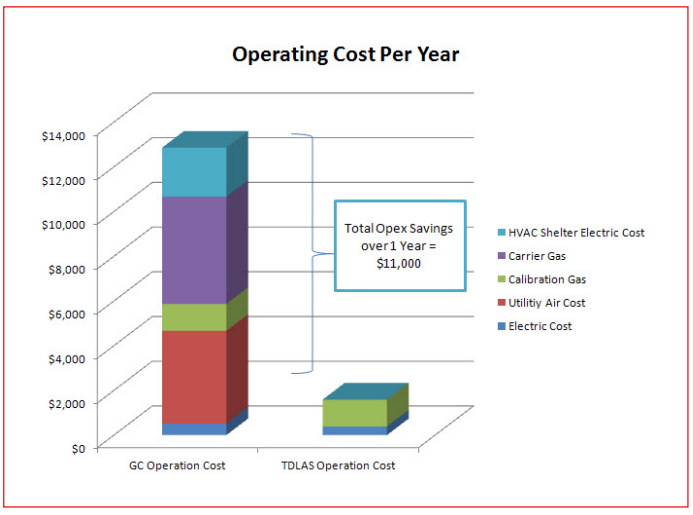

Figure 4. Operating cost of a TDLAS versus a process GC

MONITORING C_2H_2 CONCENTRATIONS

The data shown in Figure 5 represents the response of the instrument to a series of C_2H_2 in C_2H_4 challenges in the concentration range of 0-300 ppmv. The duration of each of the challenges was from 10 to 20 minutes with return to the 0% gas baseline. The zero gas was represented by a gas containing 60% C_2H_4 and 40% of C_2H_6, between challenges. The speed of the response T90 time was 20 seconds and was determined by the propagation of the gas in the sampling system with a flow rate of 2L/min. The data acquisition rate was two seconds per measurement.

Repeatability as a degree of agreement between replicate measurements of the same quantity was expressed in terms of standard deviation of the measurement results. Standard deviation of the C_2H_2 readings on each of the challenges was between 0.4 ppmv and 1.8 ppmv of the C_2H_2 concentration. The value of the accuracy evaluated at the levels of C_2H_2 from 25 to 300 ppmv was in the range of 0.8-3 ppmv.

Measurements in the low ppmv range of C_2H_2 concentrations corresponding to the outlet of the final C_2H_2 converter were achieved using a multi-pass gas cell integrated into an analyzer. The data are shown in Figure 6. Measurements were carried out in an C_2H_4/ethane stream. The repeatability of the measurements was better than 30 parts per billion by volume (ppbv) and the value of the accuracy was about 100 ppbv. The instrumental drift of the analyzer over 40 hours (Figure 7) had a standard deviation of 30 ppbv of C_2H_2.

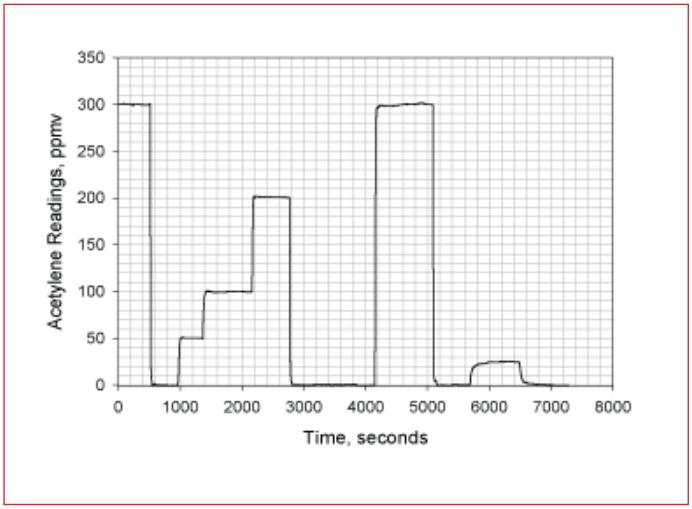

Figure 5. Typical performance in the C_2H_2 medium concentration range

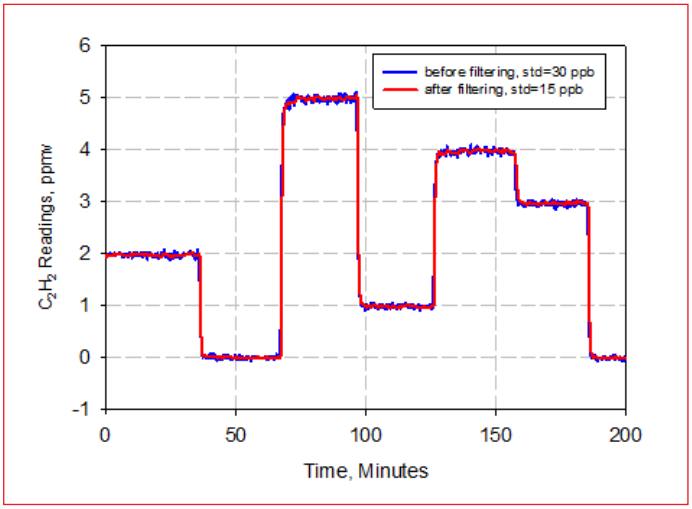

Figure 6. Low ppmv C_2H_2 measurements in a multi-pass gas cell integrated analyzer

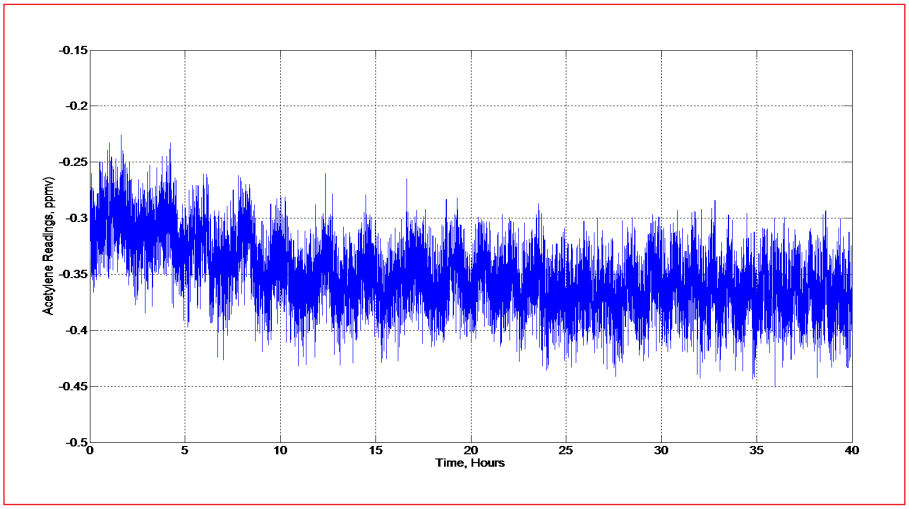

Figure 7. Instrumental drift of the analyzer over 40 hours

SUMMARY

AMETEK Process Instruments has a long history of providing highly reliable on-line instrumentation for the analysis of key components in process gases found in hydrocarbon and petrochemical production facilities.

The 5100HD TDLAS analyzer is a state-of-the-art laser-based analyzer that can be used to determine the concentration of C_2H_2 in an C_2H_4 plant providing the real time results needed to optimize the production process. The 5100HD can be configured with two sample cells to simultaneously monitor the inlet and outlet of the C_2H_2 converters. Concentrations down to 100 ppbv can be measured reliably and the cost of ownership of the 5100 HD is very low compared to a process gas chromatograph.

Benefits:

- Light source (laser) has a MTBF of more than eight years
- Real-time verification algorithms combined with the internal reference cell provide a continuous indication that the analyzer is operating properly
- The wavelength modulation spectroscopy (WMS) data collection eliminates any concentration effects resulting from moderate cell contamination and any major fouling of the analysis cell results in an alarm output
- The gas cell can be cleaned by plant technicians in less than an hour, minimizing down time in case of a condensation-related system upset

SALES, SERVICE & MANUFACTURING

USA - Pennsylvania
150 Freeport Road
Pittsburgh PA 15238
Tel: +1 412 828 9040
Fax: +1 412 826 0399

USA - Delaware
455 Corporate Blvd.
Newark DE 19702
Tel: +1 302 456 4400
Fax: +1 302 456 4444

Canada - Alberta
2876 Sunridge Way NE
Calgary AB T1Y 7H9
Tel: +1 403 235 8400
Fax: +1 403 248 3550

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Fax: +65 6481 6588

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Beijing
Tel: +86 10 8526 2111
Fax: +86 10 8526 2141
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Tel: +86 28 8675 8111
Fax: +86 28 8675 8141
Shanghai
Tel: +86 21 5868 5111
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