AMETEK®
PROCESS INSTRUMENTS

APPLICATION NOTE

TRACE MOISTURE (WATER VAPOR) ANALYSIS IN CARBON DIOXIDE PIPELINES USING TUNABLE DIODE LASER ABSORPTION SPECTROSCOPY (TDLAS)

The United States has more than 4,000 miles of pipelines dedicated to the transport of carbon dioxide (CO_2). These are primarily used for enhanced oil recovery (EOR), and there are plans to greatly expand the pipelines carrying captured CO_2 to sequestration sites. To prevent corrosion in these pipelines, it is essential to minimize the water content within them.

CARBON CAPTURE AND STORAGE

Carbon capture and storage (CCS) involves the sequestration of large amounts of CO_2 emitted from the industrial burning of fossil fuels. Carbon capture technologies can remove 80 to 95% of CO_2 emitted from a power plant or other industrial source. Power plants are the most likely initial candidates for CCS because they are large CO_2 generators producing approximately one-third of U.S. CO_2 emissions from fossil fuels.

There are many technological approaches to CCS. However, one common requirement for nearly all large-scale CCS schemes is a system for transporting CO_2 from capture sites (e.g. power plants) to storage sites (e.g. underground reservoirs). Transporting large amounts of captured CO_2 by truck, rail, and ship is impractical. Pipelines are currently the most common method for transporting large quantities of CO_2 over long distances.

CO_2 pipelines are operated at ambient temperature and high pressure, with primary compressor stations located where the CO_2 is injected, and booster compressors located as needed along the length of the pipeline. In overall construction, CO_2 pipelines are like natural gas pipelines, requiring the same attention to design, monitoring for leaks, and protection against overpressure. CO_2 pipeline technology is mature because of its extensive use for EOR. EOR via CO_2 injection is a well-developed technology that has been practiced in the U.S. for more than 40 years.

Whether pipelines are used for CCS or EOR, maintaining a very low level of water (H_2O) in the transported CO_2 is very important. If H_2O is present, it will react with the CO_2 to form carbonic acid (H_2CO_3). While H_2CO_3 is relatively weak, its presence will result in corrosion of the pipeline.

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

Due to the vulnerability of pipelines to the presence of H_2CO_3, one of the most critical factors to control is the H_2O content of the CO_2 entering the pipeline. H_2CO_3 can lead to corrosion depths up to 1 to 2 mm within a two-week period. A defective dehydration unit within a CO_2 capture facility, could lead to free H_2O either flowing into the pipeline or condensing at some point along the pipeline. If this H_2O collects at low points, corrosion could be an immediate issue. In contrast to atmospheric pressure gas phase CO_2, dense phase CO_2 can store several hundred parts per million (ppm) of H_2O, depending on the temperature. However, if the pressure falls or the temperature drops below the dew point, H_2O will precipitate out and create H_2CO_3.

Historically, electrochemical detectors have been used to monitor the H_2O level in CO_2 gas streams but this type of sensor degrades over time as it is exposed to low-level organic components in the stream. Electrochemical sensors require periodic replacement, calibration and can drift if exposed to interfering contaminants. In the case of the AMETEK 5100HD TDLAS system (see Figure 1), the detector element does not come into contact with the pipeline gas and, therefore, there is no change in the system response relative to the sensor contamination issues described above. The 5100HD analyzer is a highly reliable and low maintenance solution for this application.

Figure 1. The AMETEK 5100HD TDLAS for water vapor in CO_2

TDLAS is a highly selective analytical technique. The spectra of CO_2 and H_2O are shown in Figure 2. There is no interference from CO_2 down to a H_2O concentration of less than 2 ppm. The response of the analyzer is very linear and accurate over a wide dynamic range. Typical validation results for the analyzer are shown in Figure 3.

The 5100HD analyzer 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). The analyzer is designed to be NEMA 4X and is available in configurations to meet North America, ATEX and IECEx safety requirements.

The 5100HD analyzer can be used to determine the concentration of H_2O in a CO_2 pipeline to minimize damage due to corrosion. H_2O concentrations in CO_2 as low as 2 ppm by volume can be measured accurately with this technique.

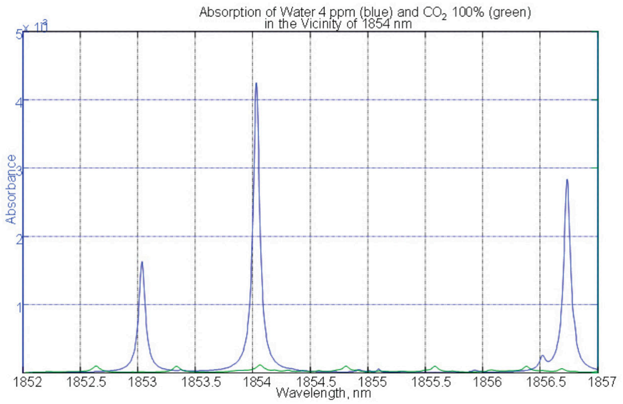

Figure 2. Spectra of H_2O and CO_2

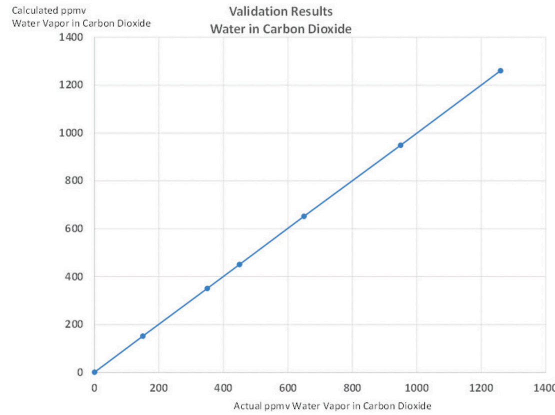

Figure 3. Actual versus calculated results for H_2O in CO_2

BENEFITS OF TDLAS

- Reduced maintenance: The laser source has no moving parts and does not contact the process gas, eliminating any exposure to contaminants or need for routine calibration or replacement
- Self-validation: Real-time verification algorithms combined with the internal reference cell provide a continuous indication that the analyzer is operating properly
- Highly specific: The wavelength modulation spectroscopy (WMS) data collection eliminates any concentration effects resulting from moderate cell contamination, and any other major fouling of the analysis cell results in an alarm output
- Reduced downtime: The gas cell can be cleaned by plant technicians in less than an hour, minimizing downtime in case of a condensation-related system upset

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