AMETEK® PROCESS INSTRUMENTS

TDLAS Application Note

Trace Water Analysis in Carbon Dioxide Pipelines Using Tunable Diode Laser Absorption Spectroscopy (TDLAS)

Introduction

There are currently over 3,600 miles of dedicated pipelines used to transport carbon dioxide (CO_2) in the U.S. These pipelines are primary used to carry carbon dioxide used for enhanced oil recovery (EOR). There are plans to greatly expand the quantity of pipelines in order to carry captured CO_2 to sequestration sites. Minimizing the water content in the pipelines is critical to prevent pipeline corrosion. This application note will describe the use of Tunable Diode Laser Absorption Spectroscopy (TDLAS) for the analysis of trace levels of water in carbon dioxide.

Carbon Capture and Storage

Carbon Capture and Storage (CCS) involves the sequestration of large amounts of carbon dioxide (CO_2) emitted from the industrial burning of fossil fuels. Carbon capture technologies can remove 80%-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. carbon dioxide 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, but moving the enormous quantities of CO_2 implied by a widespread implementation of CCS technologies would likely require a dedicated interstate pipeline network.

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 similar to natural gas pipelines, requiring the same attention to design, monitoring for leaks, and protection against overpressure. CO_2 pipeline technology is fairly mature, as a result of its extensive use for Enhanced Oil Recovery (EOR). EOR via CO_2 injection is a well-developed technology that has been practiced in the USA for more than 40 years. The largest provider of carbon dioxide for EOR in the U.S. is Denbury Resources.

Whether pipelines are used for CCS or EOR, maintaining a very low level of water in the transported CO_2 is very important. If water is present it will react with the carbon dioxide to form carbonic acid.

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

While carbonic acid is relatively weak its presence will result in corrosion of the pipeline. Due to the vulnerability of pipelines to the presence of carbonic acid, one of the most critical factors to control is the water content of the CO_2 entering the pipeline. Carbonic acid can lead to corrosion depths up to 1-2 mm within a two week period. A defective dehydration unit within a CO_2 capture facility could lead to free water either flowing into the pipeline or precipitating out at some point along the pipeline. If this water collects at low points, corrosion could be an immediate issue. In contrast to atmospheric pressure gas phase CO_2, dense phase CO_2 has the ability to store several hundred ppm of water, depending on the temperature. However, if the pressure falls or the temperature drops below the dew point, water will precipitate out and create carbonic acid.

Historically, electrochemical detectors have been used to monitor the water level in the samples such as carbon dioxide but this type of sensor degrades over time as it is exposed to low level organic components in the stream. In the case of the AMETEK 5100 HD TDLAS system, 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 AMETEK TDLAS analyzer (Figure 1) is a highly reliable and low maintenance solution for this application. 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 carbon dioxide down to a water vapor 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 AMETEK 5100 HD TDLAS analyzer provides an integrated heated sample compartment (up to 150°C) 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 AMETEK 5100 HD TDLAS analyzer can be used to determine the concentration of water in CO_2 pipeline to minimize damage due to corrosion. Water concentrations in CO_2 as low as 2 ppmv can be measured accurately with this technique.

Figure 1: The AMETEK 5100 HD TDLAS for Water Vapor in CO_2.

The additional benefits of the 5100 HD are numerous:

- The semiconductor laser used as the light source 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.

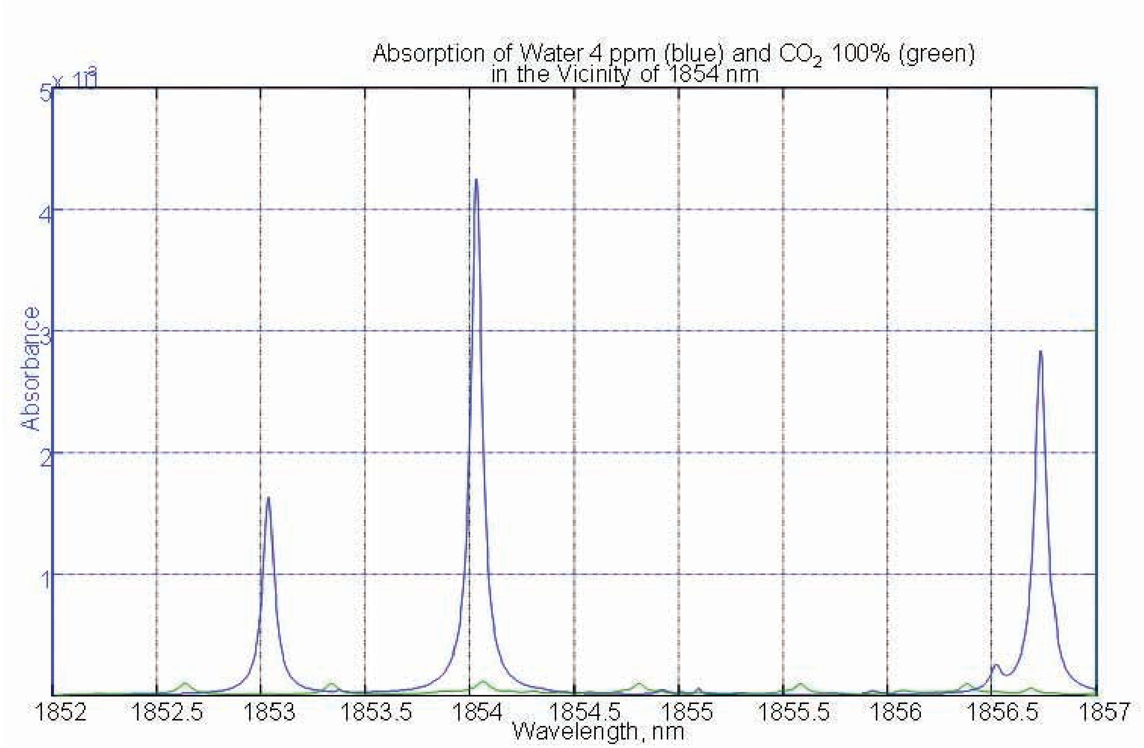

Figure 2: Spectra of Water Vapor and Carbon Dioxide.

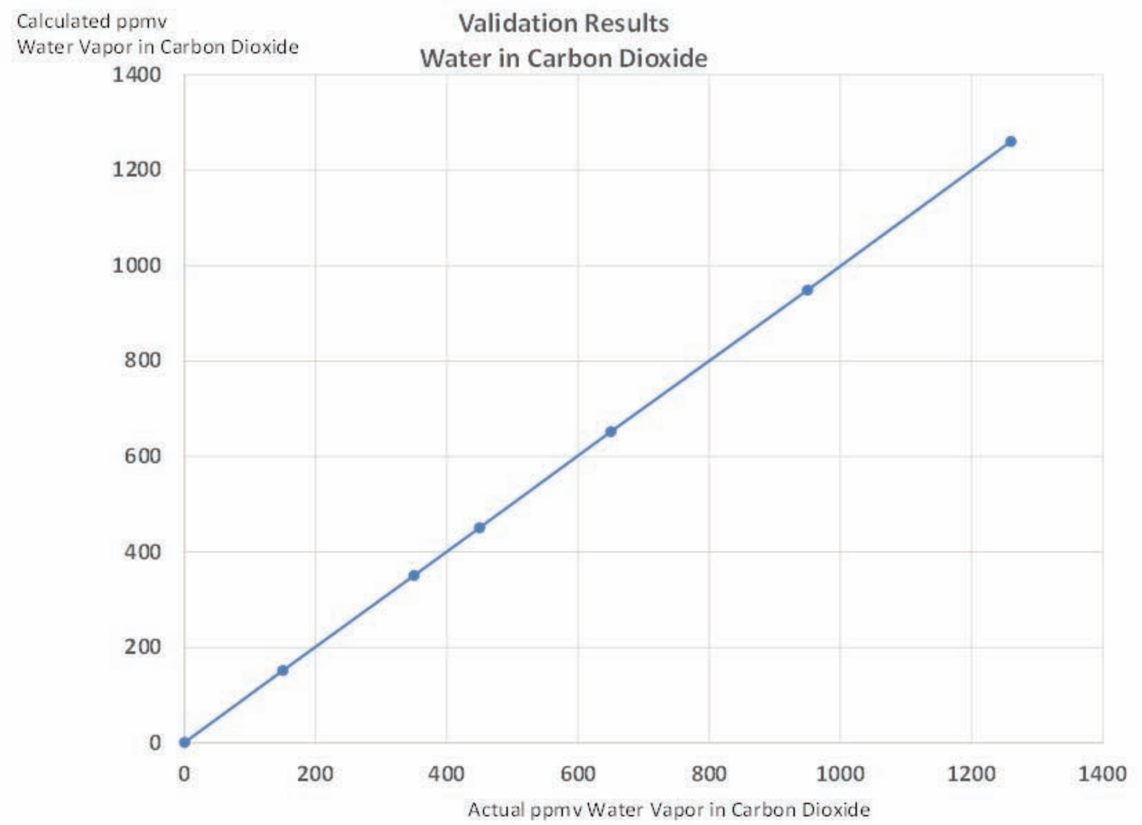

Figure 3: Actual Versus Calculated Results for Water Vapor in Carbon Dioxide.