H_2O, H_2S and O_2 measurements for carbon capture, utilization, and storage (CCUS) applications

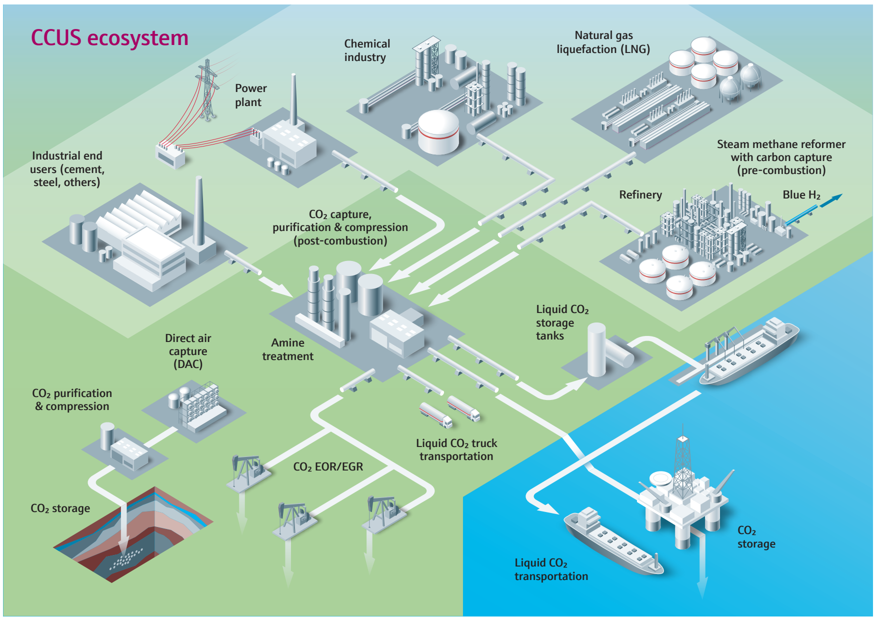

Figure 1: CCUS ecosystem

Benefits at a glance

- Reliable H_2O, H_2S, and O_2 analysis in CO_2 processes and pipelines
- High equipment availability due to durable design and proven reliability
- Improved safety, process control, and quality validation at key CCUS measurement points
- Accurate, real-time measurements without interferences
- No consumables and very low maintenance for low cost of ownership
- Easy to install and commission with remote monitoring for hands-off operation for years
- Simple in-field service for minimal downtime
- NIST-traceable calibration
- Compatible with ASTM test methods, and global hazardous area certifications

Rapid, reliable analysis of moisture (H_2O), hydrogen sulfide (H_2S), and oxygen (O_2) in carbon dioxide streams is vital to ensure safety, process control, and gas quality for carbon capture, utilization, and storage (CCUS) applications.

Energy transition and CCUS

Innovative measurement technologies are required to meet defined targets set by the United Nations Convention on Climate Change – to reduce global carbon dioxide emissions by 45% by 2030 (relative to 2010 levels) and to net zero by 2050. CCUS is an approach that can help to achieve these goals. CCUS involves separating CO_2 from fossil power generation or industrial sources (or the atmosphere) and transporting it for reuse or permanent deep geological storage.

CCUS measurement challenges

CO_2 pipelines can be susceptible to corrosion, and the presence of H_2O, H_2S, and O_2 can accelerate the corrosion rate. Measuring the concentration of these impurities helps pipeline operators control carbon removal processes and ensure that the CO_2 meets quality specifications.

Rapid, reliable readings of these compounds provide process validation, enable regulatory compliance, and ensure pipeline integrity.

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People for Process Automation

Many traditional measurement technologies have sensors that come in direct contact with CO_2 streams and are adversely affected by other gas components, resulting in errors, interferences, and failures. Ultimately, these analyzers often deliver unreliable measurements. They also cause lengthy downtimes and are costly to operate.

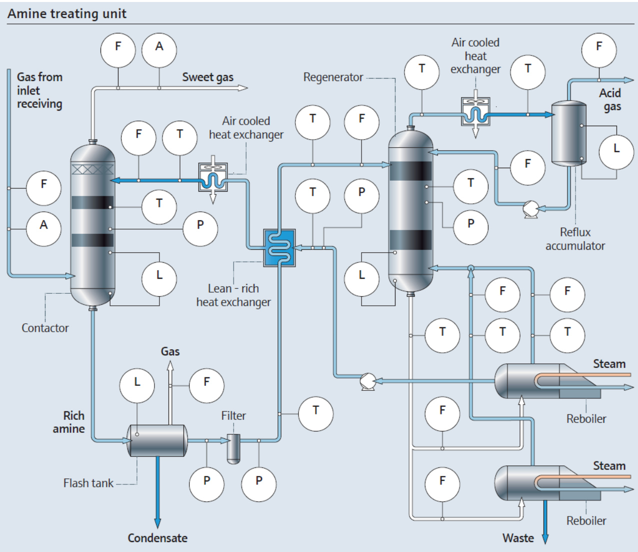

Figure 2: Amine treatment showing analysis (A) measurement points

Carbon capture and quality validation

One of the primary techniques for CO_2 capture is via chemical absorption using an amine treatment process. Amine gas scrubbing is highly effective for removing H_2S and separating CO_2. As shown in Figure 2, the exhaust gas is cooled and pumped into a chamber where chemical "scrubbers" bind to H_2S and CO_2 molecules. High-performance analyzers are then needed to perform a vital quality validation check of the CO_2 stream to ensure it meets specifications and regulatory standards.

Additionally, the presence of oxygen can affect the performance and efficiency of the amine plant. For example, it can react with the amine solvent and reduce its ability to absorb CO_2. Measuring the oxygen concentration allows operators to optimize the process to ensure maximum efficiency.

For information about the use of Raman spectroscopy to measure CO_2 in amine gas scrubbers, refer the application note, "Quantitative in-line measurement of CO_2 loading."

For a case study on the use of Raman technology for CCUS processes, please see "Optimizing carbon capture processes through Raman spectroscopy (ondemand.com)."

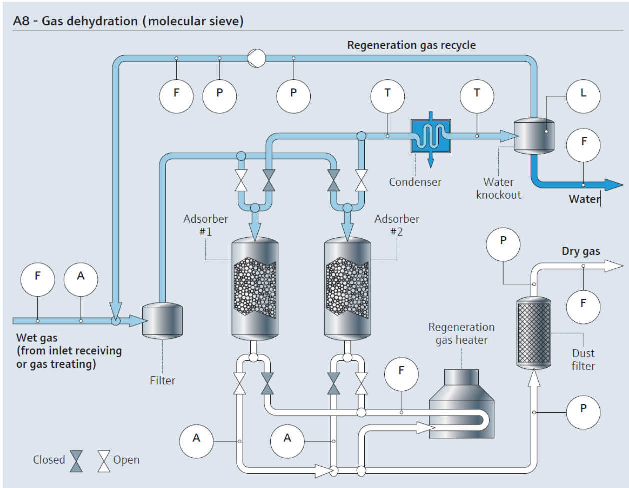

Figure 3: Molecular sieve dehydration process analysis (A) measurement points

CO_2 transportation

Before being compressed and transported via pipelines, the captured CO_2 must be dehydrated. Dehydration is necessary to avoid corrosion and ice/hydrate formation at high pressures. It is most commonly achieved using methods such as glycol or molecular sieve drying. A precise moisture measurement needs to be taken to maximize dehydration efficiency (Figure 3). After dehydration, the gaseous CO_2 is compressed and liquefied to make it ready for transportation. Here again, it is important to get a reliable moisture measurement to prevent condensation and subsequent corrosion from occurring at compressor stations.

During transport, CO_2 pipelines are at high risk of corrosion when subjected to H_2O, H_2S, and O_2. On-line, rapid and continuous analysis is required to detect these unwanted contaminants in the CO_2 stream to maintain ongoing pipeline and process integrity.

Recycled & stored CO_2

Compressed CO_2 can be recycled for use in products such as carbonated beverages or as feedstock for chemical reactions. Another traditional technique to reuse and store captured CO_2 is enhanced oil recovery (EOR). EOR is a win-win from both an economic and a climate change perspective. Injecting recycled CO_2 into mature oil fields can significantly boost oil production, yet the majority of CO_2 remains sequestered underground without being emitted into the atmosphere. To prevent corrosion and freezeups, reliable measurement of H_2O and H_2S is crucial. Additionally, total CO_2 quantity can be measured to determine the level of impurities, such as nitrogen and hydrogen, which can affect phase characteristics in the pipe (Figure 4).

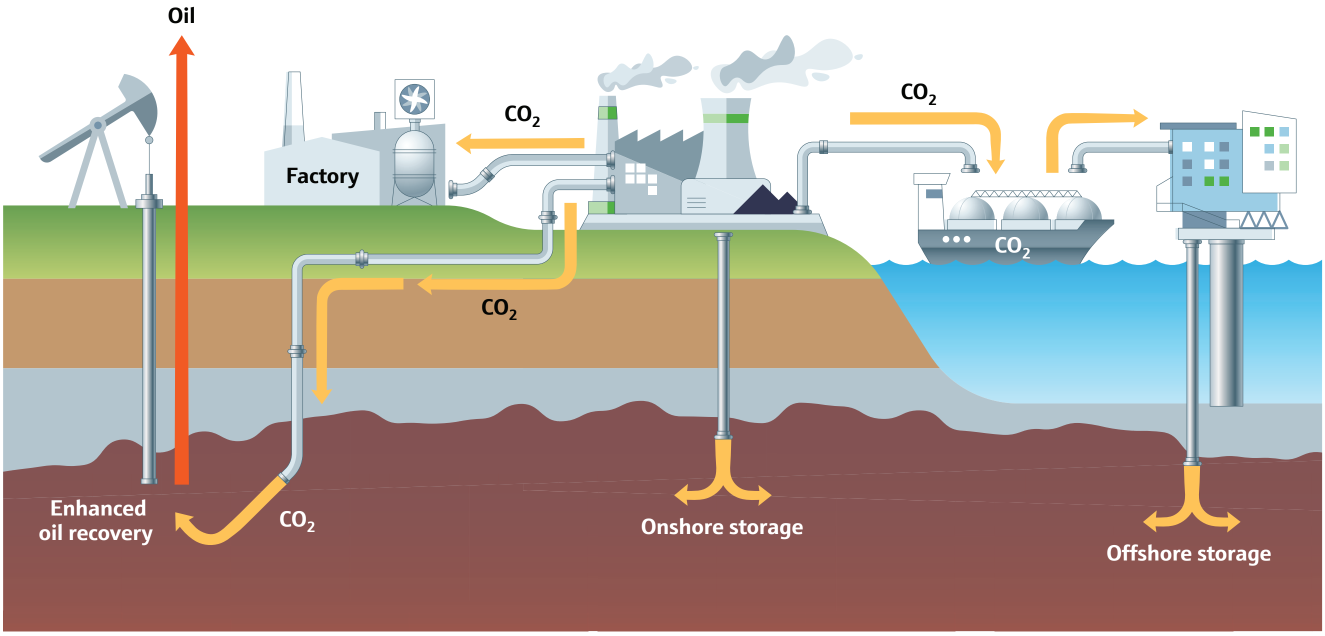

Figure 4: Applications of CO_2 storage and reuse

Endress+Hauser's solution

Endress+Hauser tunable diode laser absorption spectroscopy (TDLAS) and quenched fluorescence (QF) analyzers have proven reliability for numerous CCUS applications at installations worldwide. The laser-based technology provides real-time, non-contact measurements. Endress+Hauser TDLAS gas analyzers successfully monitor the amine sweetening process for carbon capture, accurately measuring H_2S in the CO_2 stream with high precision. They also perform important quality validation and moisture checks at compressors or in liquefaction processes before captured CO_2 is transported.

During CO_2 pipeline transport, these TDLAS analyzers perform analysis in real-time, while Endress+Hauser's QF analyzers help to further avoid corrosion by detecting O_2 leaks. Endress+Hauser TDLAS and QF analyzers are demonstrably faster, more accurate, and more stable than other CCUS process measurement alternatives, with no contaminant interferences and nearly zero maintenance.

Conclusion

As energy sources and gas mixtures continue to shift, the infrastructure to capture, utilize, store, and transport CO_2 will continue to be critically important. A changing mix of molecules and pipeline infrastructure, coupled with advancement in process automation, will further drive the need for on-line gas analysis in CCUS processes for enhanced safety, asset integrity, and quality control for decades to come.

Technical specifications[1]

Target component	H_2O in CO_2	H_2S in CO_2	O_2 in CO_2
Principle of measurement	Tunable diode laser absorption spectroscopy (TDLAS)	Tunable diode laser absorption spectroscopy (TDLAS)	Quenched fluorescence (QF)
Analyzer	J22	JT33, SS2100, SS2100a, or SS2100i	JT33 or OXY5500
Process measurement point	After dehydration, at custody transfer, after compression, and during transport	After acid gas removal, at custody transfer points	Upstream of acid gas removal, during transport
Typical measurement ranges	0 to 50 ppmv (minimum) 0 to 6000 ppmv (maximum)	0 to 10 ppmv (minimum) 0 to 5% volume (maximum)	0 to 100 ppmv (minimum) 0 to 20% volume (maximum)
Repeatability	± 1 ppmv or 1% of reading (whichever is greater)	SS2100, SS2100a, SS2100i: ± 250 ppbv or ± 2% of reading JT33: ± 100 ppbv or ± 1% of reading	± 1% of reading
Measurement update time[2]	<5 seconds	<5 seconds	User selectable 30 seconds standard 3 seconds minimum
Sample flow rate	0.5 - 1.0 slpm (1 - 2 scfh)	0.5 - 4.0 slpm (1 - 8.5 scfh)	0.5 - 1.0 slpm (1 - 2 scfh)”
Validation and calibration[3]	No calibration required; Validation through chilled mirror, portable TDLAS, or binary cal gas	No calibration required; Validation through binary cal gas bottle with methane or nitrogen background	Calibration with zero gas (nitrogen) and span gas (H_2O in nitrogen)

[1] Various product models with differing features are available for this application. For complete product specifications, refer to the respective Technical Information (TI) manual or go to www.endress.com.
[2] Total system response dependent on flow and sample volume.
[3] Consult the analyzer calibration certificate or contact Endress+Hauser prior to sourcing validation material.