

Gas analysis instrumentation for CCTUS

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Carbon capture is the foundation of carbon dioxide (CO₂) capture and storage, or utilisation. Since the CO₂ must be transported from the capture site to the utilisation or storage site, the phrase carbon capture, transportation, utilisation and storage, or CCTUS, is helpful to describe the full value chain.

Capturing CO₂ from a flue gas stream often relies on a solvent or solid adsorbent material that is sensitive to

other chemicals in the raw flue gas such as sulfur dioxide (SO₂). So, the CO₂ separation, or capture, is often the last stage in a complex arrangement of flue gas treatment (FGT).

Measurement and control of the CO₂ purity through the CCTUS process and the analysis of critical impurities relies on gas analysis instrumentation. Some of the gas analysers are like those that have been used in continuous emissions monitoring (CEM) for decades.

However, the measurement of CO₂ purity is an emerging requirement.

In addition to analysis of the gas purities, accurate measurement of the CO₂ transfer flow rate is essential. The ownership of captured CO₂ is often transferred from the emitting plant to another facility where it may be utilised or sequestered. Fiscal metering will become more important in the future to claim tax credits or carbon removal certificates.

In the case of utilisation, the CO₂ may have commercial value and invoicing will be required. In the case of sequestration, the CCS scheme operator is likely to charge a fee based on the amount of CO₂ transferred. In either case, precise flow measurement enables fair commercial practices.

Flue gas treatment

Much of the CO₂ captured from industrial processes today relies on a liquid amine solvent. It is a twin tower process where CO₂ from the flue gas is absorbed into the solvent in the first tower. The CO₂-lean flue gas then flows to atmosphere.

The CO₂-rich amine is pumped to a second tower where heat is used to strip

the CO₂ out of the amine solvent. The regenerated, CO₂-lean amine solvent is pumped back to the absorber tower to collect more CO₂ and the process operates continuously with the solvent being recirculated from the absorber to the stripper.

Variations of the amine-based carbon capture process use chilled ammonia, methanol, or potassium bicarbonate as the solvent to absorb the CO₂. In each case, the process configuration is similar.

Over time, the amine solvent is degraded through reactions with oxygen and other impurities in the flue gas such as SO₂ which is present in emissions from coal or heavy fuel oil combustion. Removal of SO₂ is already implemented on many combustion



© SICK AG | GMS800 gas analyser

plants in developed nations, to avoid the problem of acid rain. However, flue gas desulfurisation (FGD) is not universal, and it is only recently that developing nations such as China and India have implemented regulations to ensure that SO₂ emissions are reduced. It is likely that for some operators, implementation of CO₂ capture will require implementation of upstream SO₂ capture through FGD. ▶

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© SICK AG | FLOWSIC600-XT flow meter



► Aurélie Moll, Strategic Industry Manager CCUS at SICK in Germany, says that “we have been supporting industry with high precision gas analysers such as the MCS200HW for continuous emission monitoring (CEM) including SO₂ monitoring for many years. The same range of products will have direct relevance to the needs of CO₂ capture and any flue gas pre-treatment that may be required.”

The MCS200HW is a hot/wet extractive multicomponent gas analyser commonly used in continuous emissions monitoring systems. It uses gas filter correlation or interference filter correlation to monitor up to ten components, including CO₂ and SO₂. It can also measure ammonia and oxides of nitrogen for process control of selective and non-selective catalytic reduction flue gas DeNO_x systems.

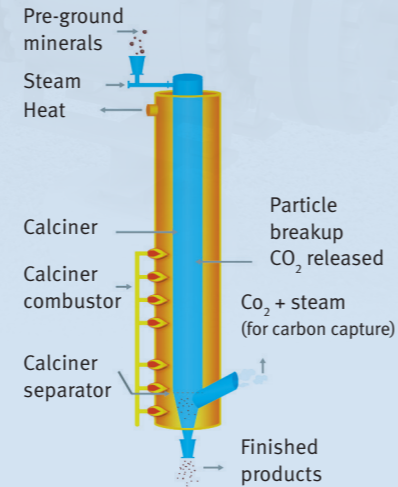
CO₂ purity measurement

“In addition to the measurement requirements between the raw flue gas

and the CO₂ amine solvent absorption system, we recommend the GMS800 extractive cold/dry gas analyser for CO₂ purity measurement as capture efficiency control after the Amine desorber,” adds Moll. When fitted with SICK’s UNOR NDIR sensor, it can accurately measure CO₂ purity in the 95-100% range.”

SICK also offers in-situ gas analysers for process control and CEMS applications. These have probes that are fitted into the flue stack to avoid the cost and complexity of sample extraction and conditioning. The GM35 was chosen for use at the Leilac-1 pilot plant. This is a groundbreaking CO₂ capture demonstration project at a HeidelbergCement production plant in Lixhe in Belgium. An innovative externally heated calciner, developed by Calix, has been undergoing field trials.

“The requirement for Leilac was to measure the CO₂ concentration and the moisture impurity simultaneously,” confirms Moll. The Calix calciner



© Calix | Calix calciner

generates very pure CO₂ and typical post-combustion gases such as SO₂ or oxides of nitrogen are not present. However, moisture is present, and this must be monitored to control downstream processes such as CO₂ drying, liquefaction, or compression.

After capture, CO₂ can be purified and liquefied for transportation by road, train, or ships to other commercial utilisation applications or for permanent storage. Prior to liquefaction, the CO₂ is dried on a regenerative dryer bed to avoid moisture freezing and blocking the cryogenic liquefaction system.

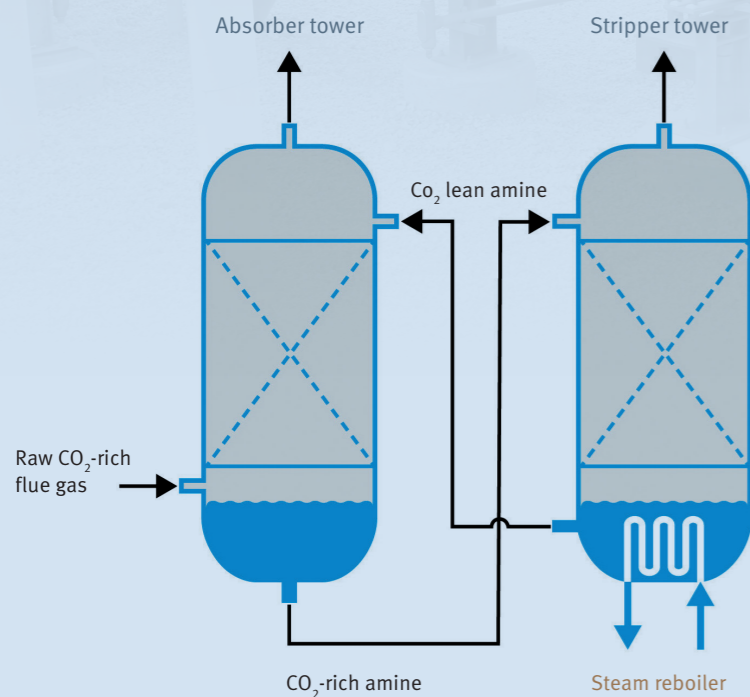
Gas analysis and flow metering for CO₂ pipelines

The alternative CO₂ transportation mode is compression to a supercritical fluid at around 90 bar and then transmission in a high-pressure steel pipeline. “As with liquefaction, CO₂ and moisture analysis for pipeline transmission is essential,” says Moll. If moisture is present, it can react with CO₂ to form a corrosive acid which could damage the steel pipeline.

Drying takes place during the compression stages to remove the moisture. Most of the water is condensed in the intercoolers between the multiple gas compression stages. Prior to the last ►

© APCI | CO₂ capture absorber and stripper towers.



© sbh4 consulting | CO₂ Capture with amine solvent.

► stage of compression, mono-ethylene glycol (MEG) can be used as a solvent to remove the final traces of moisture. Analysis of moisture and CO₂ at critical points in the drying process is vital.

The other critical measurement at this stage is the CO₂ flow rate in the pipeline. The transmission of captured CO₂ to an underground injection and sequestration location may be over many hundreds of kilometres and may cross international boundaries or change ownership. At several points, accurate flow measurement may be required.

Inside the pipeline, CO₂ exists as a supercritical fluid. This can be compressed like a gas but has a density and other physical properties like a liquid. Moll says that “the FLOWSIC600-XT is ideal to measure CO₂ in either gaseous or high-pressure supercritical phases. It uses ultrasonic technology with multiple measurement paths to ensure fiscal accuracy.”

This device from SICK is built for

maximum reliability and operability in long pipeline systems that may cross remote locations. In the event of mains power failure, it will use PowerIn Technology™ to remain in service for up to three weeks. For trouble shooting and diagnostics it is also fitted with SICK’s i-diagnostics™ system.

“The FLOWSIC600-XT gas flow meter is also designed for use in natural gas transmission with hydrogen content of up to 30% and operates with a metrologically approved custody transfer accuracy level,” adds Moll. “We believe that CCTUS and hydrogen will both be important pillars of decarbonisation and our product range has been developed to support both applications.”

The Porthos CO₂ transport and storage project in Rotterdam will offer permanent CO₂ sequestration under the North Sea. The CO₂ will be captured from several steam methane reformers (SMRs) which produce hydrogen for refineries in the port region.

Multiple CO₂ streams will combine into a single pipeline which goes out to the sub-sea CO₂ sequestration location. To ensure that each SMR operator is fairly charged for the CO₂ storage service, accurate metering of the amount of captured CO₂ that each SMR has transferred into the network is required.

Direct Air Capture (DAC) of CO₂ for storage or utilisation

Production of e-fuels and e-chemical such as e-kerosene or e-methanol involves the combination of green hydrogen and CO₂ to build hydrocarbon molecules. Green hydrogen is produced in a sustainable way using renewable electrical power and electrolysis.

In many cases, it is being proposed that additional renewable electricity is generated to operate a direct air capture (DAC) facility to ensure that the CO₂ in the e-fuels is also fully sustainable. DAC is a promising negative emission technology that will help to reach the climate target.

Monitoring of the CO₂ purity between the DAC unit and any downstream catalytic processes is essential to ensure that high purity CO₂ is used in these sensitive reactors. Flow metering may also be required, especially in the case that the DAC operator is capturing the CO₂ and selling that on to the e-fuels process operator.

DAC will also be used for major CO₂ sequestration schemes with underground geological storage. Projects such as IPointFive in Texas’s Permian Basin and Project Bison in Wyoming in the US are examples. As alternatives to e-fuels production, the business case for such schemes can be driven by utilisation of the CO₂ for enhanced oil recovery or the sale of carbon removal credits to other businesses. “In such situations, accurate metering of CO₂ flows is mission critical,” concludes Moll. [gw](#)