21GRD06 MetCCUS

A2.2.9 - GUIDANCE DOCUMENTS FOR THE MEASUREMENT AND QUANTIFICATION OF CO_2 EMISSIONS FROM CCUS EQUIPMENT AND INFRASTRUCTURE – OVERVIEW REPORT

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Summary

This report summarises the work of activities A2.2.1 - 2.2.8 of the project into a concise guidance document outlining the technologies and methodologies that can be utilised for detection and quantification of CO_2 leaks from Carbon Capture Utilisation and Storage facilities on both a component and site spatial scales.

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1 Introduction

Carbon Capture Utilisation and Storage is becoming an ever more important sector in the fight to reduce global emissions of greenhouse gases (GHG) to atmosphere through the stripping of carbon dioxide from emissions such as flue gases and then storage of this carbon either in its gaseous form in underground caverns or tanks, or used to generate other forms of carbon for use in industry e.g. bicarbonate. All of these processes will require CO_2 to be transported through pipe work, and building upon BS EN 15446 (British Standard Publication), it is imperative that a methodology for detection and quantification of leaks of CO_2 on both the site level and component level scales.

Another consideration is the importance of a unified vocabulary regarding the leak detection, fugitive emissions and monitoring methods as informed decisions cannot be made unless the metrics being considered are representative of the same metrics. A framework, based on taxonomies and common lexicon, has been proposed for the monitoring and reporting of methane leaks[1], and this is something that could be adopted for the monitoring and reporting of all fugitive emission sources such as CO_2.

The scope of this document is to address the detection and quantification of carbon dioxide (CO_2) leaks at Post Combustion Carbon Capture (PCC) sites and in Carbon Capture Utilisation and Storage (CCUS) infrastructure. This report covers both component scale e.g. pipelines, flanges, pressure relief devices and drains, as well as site scale measurement techniques. Varying techniques and instrumentation can be utilised for the measurement of CO_2 on different spatial and temporal scales, and their efficiency depends on a variety of factors that must be assessed prior to a measurement campaign begins.

2 Component scale

Before conducting a component scale measurement campaign, you first need to properly understand the risks associated with CO_2. In poorly ventilated areas, CO_2 can accumulate and in worst case scenarios accumulate in quantities large enough to displace oxygen and cause a risk of asphyxiation. To mediate this risk, staff must wear appropriate CO_2 or O_2 detectors and wear PPE appropriate for the site being surveyed.

Secondly the type of detector that is suitable for the task and site needs to be selected. The detection method, pumped, or passive sampling, response and recovery time, mechanical design and measurement range are important factors for operators to assess before selecting which instrument to use in the field.

Once an instrument is selected, various tests and proceeds need to be undertaken so that it can be ensured that measurements are reliable, reproducible and traceable. Calibration of the instrument must be undertaken, either by exposing the device to an accredited calibration gas or by using a traceable leak artefact such as a critical orifice. Calibrations should be undertaken by accredited laboratories traceable back to the SI. In addition to this, field verification can be undertaken on site to ensure that calibration remains accurate. Functional tests of the instrument can also be undertaken prior to deployment to ensure that the device is operating as expected. Finally environmental conditions such as temperature, pressure and humidity can influence the sensors behaviour. You should also ensure that all logistical preparations such as ensuring the batteries are fully charged and that data logging settings are working as expected to ensure that data is recorded properly.

It is essential that clear, quantitative thresholds of what is the minimum concentration or flow rate that constitutes a leak, the practical resolution of the selected detection device and the context of the installation. It is also important to differentiate between detection of a leak and quantitation of the leak rate. Detection only allows for the location of the leak to be known, whereas quantification of the leak involves estimation of the actual leak rate expressed in either mass or volume per unit of time.

Leaks can be quantified through a selection of methods suited to the leak magnitude, the equipment used and the field conditions. For small leaks, if the detector is equipped with a sampling pump the leak rate can be estimated by comparing the detector response to the calibrated reference leak, provided the actual leak is smaller than the detectors sampling flow.

For larger leaks the accumulation method, also referred to as “bagging” is often more suitable. This involves encasing the leak in a hood or bag, CO_2 concentration increases over time as it accumulates within the bag. By comparing the observed increase in CO_2 in the hood against that produced in the reference leak, the emission rate can be inferred.

Another technique for high leak rates is that of the high-flow sampling method. In this method a large sample of air is actively drawn in from around the leak, assuming that the entire leak is sampled. By combining the measured flow rate and gas concentration, the leak rate can be estimated.

The Leak Detection and Repair (LDAR) methods originally devised for the detection and quantification of methane leaks has been shown that it can be implemented at other industrial sites for different gaseous species with modification relating to the physiochemical properties of the gases and the site environment. More in depth description can be found within the annex.

3 Site scale

Larger industrial sites, particularly those with large emission rates or a high number of components, can present a challenge in regard to implementation of the methods described in the component scale assessment. Component scale fugitive surveys are time consuming and on sites with a high number of components or inaccessible areas they are no appropriate. More remote methods such as tracer correlation and differential absorption lidar (DIAL) can be used with success to quantify emissions on a site spatial level.

The tracer correlation method involves co-releasing a known tracer gas alongside CO_2 and measuring their concentrations downwind. By comparing the measured ratio of CO_2 to the tracer and knowing the tracer's release rate, the CO_2 emission rate can be calculated.

This method has demonstrated feasibility for the usage to quantify diffuse CO_2 emissions. However, emissions from large areas require high emission rates (>75 kg/h) to reach the lower limit of quantification. Smaller sites (50 x 50 m) have shown to have a quantification limit of around 12 kg/h. It has also been shown that atmospheric condition and distance from source, alongside the size of the site strongly influence the detection sensitivity.

DIAL is verified and proven to be an suitable method for the quantification of emissions to atmosphere and has a standardised method, EN 17628 (BSI Standards Publication), for the detection and quantification of Volatile Organic Compounds (VOCs) and this same method can be applied to the measurement of other species such as methane, ethane, SO_2, NO_x and benzene. During a campaign (N Howes) at a liquid natural gas (LNG) facility, it was shown that DIAL can be used at an absorption band of 2 µm to measure CO_2 emissions at ground level. This trial showed significant improvement when compared to the results obtained at the 1.5 µm absorption band. It was also demonstrated through the comparison with in-stack measurements of CO_2 that this method can be used to accurately quantify CO_2 emissions from industrial sources in the magnitudes of 50 t/h, however no maximum emissions rate for the DIAL has yet been established.

4 Conclusion

To accurately detect and quantify CO_2 emissions from a PCC plant, no single technique is wholly applicable and appropriate. An assessment of the scope, spatial scale and estimated emission rate are required to make an informed decision of which technique or suite of techniques is applicable to the site. For smaller sites, or those with a relatively low number of components, or smaller leak rates, detection and quantification of leaks through LDAR techniques are appropriate, however for sites with large spatial footprints or those with a large number of components or high emission rates, site level assessments through tracer correlation or with the use of DIAL methodologies are more appropriate.

Further assessment is needed on all methodologies so that their applicability for the measurement and quantification of CO_2 diffuse emissions from PCC infrastructure, as well as greater understanding of the limitations both in terms of lower and upper limits of quantification, as well as which technologies are most suited to these measurement campaigns.

5 Bibliography

British Standard Publication. “BS EN 15446:2008 Fugitive and diffuse emissions of common concern to industry sectors — Measurement of fugitive emission of vapours generating from equipment and piping leaks.” 2008.

BSI Standards Publication. “BS EN 17628:2022 Fugitive and diffuse emissions of common concern to industry sectors — Standard method to determine diffuse emissions of volatile organic compounds into the atmosphere.” 2022.

N Howes, F Innocenti, A Finlayson, C Dimopoulos, R Robinson & T Gardiner. “Remote Measurements of Industrial CO2 Emissions Using a Ground-Based Differential Absorption Lidar in the 2 µm Wavelength Region.” *Remote sensing* (2023).

6 Annex

Good Practice Guide for CO_2 Leak Detection and Measurement at Component Scale