



CO₂ PURITY MEASUREMENT IS ESSENTIAL FOR ENVIRONMENTALLY RESPONSIBLE CCS



The concept of Carbon Capture and Storage (CCS) is to recover carbon dioxide (CO₂) from industrial process gas emissions and inject the CO₂ deep into the ground for long term storage. Atmospheric emissions of CO₂ from existing combustion processes, such as cement production or electrical power generation can thereby be reduced to slow down climate change.

Several new projects have also been proposed to construct steam methane reformers (SMR), or auto thermal reformers (ATR) to produce large quantities of hydrogen for heating and mobility applications. CCS is an integral part of these schemes to ensure that they produce blue hydrogen and play a role in sustainable decarbonisation.

SMRs and ATRs are most commonly fed with natural gas which is rich in methane. When the natural gas rises from the underground gas reservoir, it is generally accompanied by large quantities of CO₂ which has existed with the methane in the underground gas field for thousands of years. Many CCS schemes plan to use depleted natural gas reservoirs for the long-term storage of CO₂, thereby refilling them with a gas that they previously contained. So, the CCS process can be thought of as returning CO₂ to its underground home.

According to Australia's National Hydrogen Strategy, which was published in November of 2019, there are several high potential onshore CCS locations in Australia, principally in Queensland and New South Wales. These may complement existing offshore CCS projects on Australia's north West coast such as the Gorgon CCS site on Barrow Island which is used to store carbon dioxide that comes to the surface from natural gas wells in that region. CCS is seen as a route to decarbonise the production of hydrogen from coal gasification or on natural gas fed SMRs.

CCS is also key to the future success of the K5 natural gas extraction project in Malaysia. The gas field, which lies 230km offshore from Bintulu, has an extremely high CO₂ content at circa 70%. Petronas are planning to use cryogenic techniques to remove the CO₂ from the natural gas on an offshore platform and reinject the CO₂ underground for permanent storage.

Before we store CO₂ deep underground, we must ensure that important gas purity criteria have been met. When we use CO₂ to freeze food or carbonate beverages the need for using a high purity gas is abundantly clear and there are equally compelling, but different reasons that CO₂ purity is also a critical issue in CCS applications. However, at present there is no common standard to define the quality of CO₂ that should be used in CCS projects. Many of the brightest minds in gas purity assay are working hard to address this gap.



Barrow Island North West Australia

Gas purity standards in Hydrogen and Healthcare can lead the way

The purity of Hydrogen for use in fuel cell electric vehicles is subject to an international standard, namely the 'ISO14678:2019 Hydrogen fuel quality – product specification'. Impurities such as carbon monoxide and hydrogen sulphide are capped at levels that will guarantee the hydrogen is compatible with standard modern fuel cells and does not poison the sensitive catalysts. The maximum combined argon and nitrogen concentration is also specified to avoid the long-term accumulation of these inert air gases in the fuel cell which would result in a potentially dangerous loss of vehicle power.

In patient healthcare, as has been highlighted by the many thousands of respiratory treatment cases caused by Covid-19

worldwide, oxygen is also used extensively as a medical therapy. It is directly inhaled by vulnerable people and its purity must be tightly controlled. In this medical application, there are also rigorous standards set by the main international Pharmacopeia which govern the production, identification and assay of medical oxygen to ensure that it will help to cure, not harm patients.

The examples above focus on two different gases: hydrogen and oxygen. What they have in common are a minimum purity for the gas and maximum concentrations of impurities which could be harmful to the application. Some also specify the analytical method to conduct the purity assay or the analysis of trace impurities. So, in the consideration of a future standardised purity specification for CO₂ in CCS applications, there are some parallels to learn from.



Bintulu Malaysia



NPL Gas mixture standard preparation

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The importance of carbon dioxide purity in CCS applications

In the realm of international metrology, many issues are being considered as the debate about the requirement for a CCS CO₂ standard is taking place. Dr Arul Murugan, Senior Research Scientist for Energy Gases at NPL in the UK says that “in some CCS schemes, the idea is to liquify the carbon dioxide either for immediate storage or to enable its transportation by ship to an offshore platform where it will be further processed. Incondensable gases such as nitrogen or methane could reduce the efficiency of this process by increasing the required energy input. Furthermore, these gases do not behave in the same way as CO₂ when injected underground and they take up valuable storage space”.

Murugan adds that “in other CCS schemes, the proposal is to compress CO₂ to a high pressure so that it can be cost effectively transported in long distance pipelines before being injected into suitable geological structures deep underground. These compressor stations and pipelines are highly valuable assets which must be protected.” If there are combinations of gases in the CO₂, that can result in corrosion, such as ammonia and moisture or hydrogen sulphide and moisture they may cause irreversible damage to the pipeline or even the storage site itself. This corrosion of the CCS infrastructure would be costly to repair. Corrosion could also pose a safety risk if it went unnoticed and caused a pipeline rupture. In these cases, detection of these trace contaminants is essential to prevent problems escalating.

Process performance and gas distribution asset integrity are not the only reasons for careful analysis and control of CCS CO₂ purity. The safety of the personnel operating the CCS equipment and the general public are also of paramount importance. CO₂ intended for CCS may also contain trace levels of highly toxic chemicals such as mercury or hydrogen cyanide. Whilst operators cannot always

prevent these molecules being present at tiny levels, they can monitor their concentrations to ensure that they exist in the gas only in minute traces which would ensure that any potential CO₂ leak from the CCS processing equipment or storage site does not pose a health risk. Murugan continues to say that “with all these operational, health and safety considerations in mind, my team at NPL are starting to develop the analytical methods and traceable reference materials required for performing these important purity analyses”.

Many nations in may also wish to participate in CCS schemes, but if their country does not have the appropriate geological profile, they must rely on exporting their CO₂. So, for the trade in CO₂ for CCS will inevitably become international. This is a key driver for the development of an international standard for CCS CO₂ purity to ensure a harmonised approach and consistent levels of safety. The standard will also lock in parameters that players in the CCS industry can design around to ensure optimal performance of their equipment.



ABB LGR-ICOS Online Natural Gas Analyser

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Accurate gas analysis closes the loop

Internationally acclaimed metrological bodies, such as NPL, play a role beyond defining the composition of gas standards for new applications. They also produce high precision gas standard mixture cylinders that contain the required chemical species at the relevant concentrations. These certified gas mixtures can be

used to calibrate gas analysers in the field which are in service to measure the CO₂ purity.

CCS asset owners need to be sure that their gas storage terminals, compression stations and distribution pipelines will not be attacked by corrosive impurities in the CO₂. Speaking as Head of Product Management for the continuous gas analyser product range within ABB's Measurement & Analytics business line, Steve Gibbons says that “our LGR-ICOS gas analyser is ideal to monitor trace levels of many gases, such as moisture, oxygen and hydrogen sulphide. Oxygen is a tracer that is used to provide early warning of pipeline leaks. Hydrogen sulphide is toxic and when combined with water, it causes corrosion problems. So, in one instrument we have the capability to address several concerns that these trace impurities raise”.

Operators also want to be sure that the inert gases, which rob power from the gas compressor, are present only at minimal concentrations. Methane and nitrogen are the most common inert gases found in carbon dioxide. Gibbons says that “in some cases, we would recommend a TCD gas analyser, such as the Caldos27 to measure nitrogen or an NDIR analyser like the Uras26 to measure methane”. In closing, he adds that “our gas analysers have been used for many years to uphold rigorous gas purity standards. For example, the EU and US Pharmacopeia monographs specify that a paramagnetic oxygen analyser must be used for the identification and purity assay of medicinal oxygen. That's an application where our Magnos28 has been used for decades”.



Medical oxygen

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