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Effective emissions monitoring and detection

Stephen Harrison of emissions monitoring specialists Linde Gases outlines and offers some solutions to the challenges the power generation industry face in meeting increasingly stringent emission regulations.

Requirements for reducing air pollution emissions have been evolving over the past couple of decades and today are an intricate mix of limits, targets and caps.

In many parts of the world, polluters not only must comply with rigid emission limits, but they also need to provide emissions data to numerous different agencies and bodies in order to comply with disparate legislative formats and reporting systems at regional, national and international level; and legislation will only become increasingly stringent.

The global community is working to improve cooperation between emitting sources, monitoring systems and the legislation they support in order to reduce the number of serious pollutants being released into the air, soil and water to help mitigate the negative impacts on human health and adverse effects on the environment in coming years.

What this means for industry is that more pollutants will require monitoring from a greater number of emitting sources. For example, mercury is rapidly moving up the agenda in the European Union (EU), the USA and Asia ahead of the legally binding United Nations Environment Programme's (UNEP) global treaty on mercury to be implemented in 2013.

Advanced systems and methods will be required to measure lower and lower concentrations of pollutants as emission limits tighten. Increased accuracy will become paramount as pollutants such as nitrous oxide, methane and possibly mercury are introduced to trading markets in the EU and USA. The change will mean that once a monetary value comes into play, measurement accuracy becomes an economic target, as well as an environmental one.

As legislation and action plans grow in number and stringency, the importance of monitoring and quantifying emission pollutants in an accurate and transparent manner are becoming priorities.

Real-time and online reporting systems will be the aim for most large sources. As Lisa P. Jackson, an administrator for the Environmental Protection Agency (EPA) says, "Our efforts to confront climate change must be guided by the best possible information. Through this new reporting, we will have comprehensive and accurate data about the production of greenhouse gases (GHGs). This is a critical step toward helping us better protect our health and environment."

POWER GENERATION SECTOR EMISSIONS

With issues over the environment and carbon dioxide (CO_2) so prolific in both the public and political eye, in addition to concerns over the more 'conventional' pollutants of nitrogen oxides (NOx) and sulphuer oxides (SOx), reducing emissions has become an enormous proposition for the power generation industry. Coal and oil fired power generating plants face one of the most difficult set of circumstances relating to the need to meet increasingly strict regulatory requirements.

Power generation accounts for about a quarter of total emissions of carbon dioxide, which is recognized as a significant factor in global warming – and China and the United States face the greatest challenge in responding to the issue. Power plants burning coal result in transforming sulphur in the coal to SOx, with sulphur dioxide (SO_2) being the major chemical form emitted from these plants.

Fossil fuel combustion also transforms nitrogen in the coal and combustion air to NOx. These gases are harmful because they contribute to the formation of acid rain and particulate matter, which reduces visibility – and multiple studies have linked particulate matter to a wide range of adverse health effects.

To add to the burden on the power generation industry, coal fired power generating plants, due to the nature of the fossil fuel employed, are the largest man-made source of mercury emissions – although mercury air emissions from individual power plants can vary greatly, depending on the concentration of mercury in coal, the chemical form of the mercury and the efficiency of pollution control devices in removing mercury.

Almost all the mercury in lakes in the EU has been deposited via atmospheric transport from sources abroad and the amount being used and released in the world is still increasing.

Although mercury use has gone down in industrialized nations, emissions are increasing in other regions. The burning of coal in small-scale power

plants and residential heaters, particularly in Asia, are major sources of current emissions. These emissions are likely to increase significantly because of the economic and population growth in this region.

As with most ores in the earth's crust, coal also contains low levels of uranium, thorium and other naturally occurring radioactive isotopes whose release into the environment leads to radioactive contamination. While these substances are present as very small trace impurities, enough coal is burned that significant amounts of these substances are released.

A 1000 MW coal burning power plant could release as much as 5.2 tonnes/year of uranium (containing 34 kg of uranium-235) and 12.8 tonnes/year of thorium. The radioactive emission from this coal power plant is 100 times greater than a comparable nuclear power plant with the same electrical output; including processing output, the coal power plant's radiation output is over three times greater.

In addition, small amounts of toxic metals such as arsenic, cadmium, chromium and nickel can also be released from coal and oil fired power plants. However, despite all the challenges, many power generation organizations across the globe have undertaken carbon reducing or carbon sequestration projects, and there are multiple technologies, know-how and services to help uncover solutions to mitigate harmful pollutants.

CARBON MITIGATION IN THE EUROPEAN UNION

At a Massachusetts Institute of Technology Energy Initiative Symposium held earlier this year, delegates heard that there is today no credible pathway towards stringent GHG stabilization targets without reducing CO_2 emissions from existing coal power plants. Wayne Leonard, CEO of the Energy Corporation, said at the symposium that an effective, sustainable response to climate change must include retrofit technologies to reduce CO_2 emissions from existing coal fired power plants that are likely to continue to operate for decades.

Reflecting this sentiment, the European Commission has set out plans to finance the demonstration of carbon capture and geological storage in cooperation with China. This arises from a commitment made by the EU and China to develop and demonstrate — in both regions — advanced, near-zero emissions coal technology through carbon capture and storage (CCS) by 2020.

Environment commissioner Stavros Dimas said: "We have taken action to put in place the regulatory framework and the incentives to facilitate CCS demonstration in Europe and now we are making good on our promise to China. This important cooperation between the EU and China on CCS can act as a model for cooperation under the post-2012 global climate change regime the world must agree at the Climate Conference Copenhagen."

As set out in the Commission's 'Copenhagen Communication', both developed and developing countries need to mitigate their GHG emissions in order to limit average global warming to less than 2 °C compared to pre-industrial levels. Under the UN Framework Convention on Climate Change, the EU and the other developed countries have agreed to help developing countries tackle climate change through financial and technical cooperation.

Depending on the choice of technology used and assuming China introduces some form of carbon pricing instrument, the additional cost of constructing and operating over 25 years a new power plant equipped with CCS in China is estimated at €300–€550 million ($446–817 million). The Commission will work closely with China, member states, other European Economic Area countries and industry to secure the additional financing required.

The Commission proposes to combine these funding sources in a public-private partnership, possibly in the form of a Special Purpose Vehicle. This investment scheme could serve as a model for other technology cooperation activities between developed countries and emerging/developing countries in the context of a post-2012 climate change agreement.

THE US CLEAN AIR ACT

Meanwhile, the American power generation industry is preparing for the implementation of the Clean Air Interstate Rule (CAIR) in 2010, expected to result in the greatest cuts in SO_2 and NOx in more than a decade. Currently however, legal challenges have resulted in the courts advising the EPA to re-write elements of the rule while allowing it to remain in place for the time being. CAIR will permanently cap emissions of SO_2 and NOx in the Eastern US.

When fully implemented, CAIR will reduce SO_2 emissions in these states by over 70 per cent and NOx emissions by over 60 per cent from 2003 levels. This will result in $85 billion to $100 billion in health benefits and nearly $2 billion in visibility benefits per year by 2015, and is expected to substantially reduce premature mortality in the region.

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Additionally, a closely related action – the EPA Clean Air Mercury Rule (CAMR) – was presented as the first finalized federally mandated requirement for coal fired electric utilities to reduce their emissions of mercury. While the regulation was rejected by the federal courts on the basis that it allowed its trading, and the courts determined that trading of mercury allowances was not acceptable, it perhaps illustrates the intention to bring in federally mandated regulation.

For the moment, CAMR has reverted back to the EPA for further review and rework. Depending on the outcome, a combination of a reworked CAMR and CAIR could create a multi-pollutant strategy to reduce emissions throughout the United States.

All coal fired power plants use particulate matter removal equipment, such as electrostatic precipitators or fabric filters to remove fly ash from boiler exhaust gases before they reach the stack. These particulate controls are very effective, capturing more than 99 per cent of the ash from exhaust gases. Ash particles that escape from the stack account for an extremely small amount of ground-level fine particulate matter in the air.

Power plant emissions are controlled by the use of low sulphur coal and/or scrubbers, while NOx emissions are decreased by using low-NOx burners or other furnace modifications, as well as through exhaust gas catalysts similar to the catalytic converters found in motor vehicles.

Particulate matter and SO_2 control yields mercury control as a co-benefit. Plants that employ flue gas desulfurization (FGD) plus fabric filters can control over 80 per cent and even over 90 per cent of mercury emissions from bituminous coal burning. FGD plus the use of a cold-side electrostatic precipitator (CS-ESP) may remove over half of it. While, CS-ESP alone may remove a quarter to a half

of mercury. Hot-side ESPs are much less effective. Selective catalytic reduction (SCR) of NOx can also enhance mercury removal.

In regard to mercury mitigation, a global crackdown on this poisonous pollutant was agreed upon by environment ministers at the United Nations Environmental Programme's (UNEP's) Governing Council meeting in Kenya in February 2009. The landmark decision, taken by over 140 countries, sets the stage for the lifting of a major health threat from the lives of hundreds of millions of people. Governments unanimously decided to launch negotiations on an international mercury treaty to deal with its worldwide emissions and discharges. They also agreed that the risk to human health and the environment was so significant that accelerated action under a voluntary Global Mercury Partnership was needed while the treaty was being finalized.

EMISSION MONITORING TRENDS

Environmental concerns have come a long way since the 1970s, when acid rain caused by SO_2 and NOx prompted power stations to install scrubbers and SCR units, and motor vehicles were fitted with catalytic converters. While these issues remain, global warming, GHGs and CO_2 emissions have become the concerns of the 21st century, bringing with them the requirement to measure emissions at progressively lower levels and with greater accuracy.

Up until quite recently, emissions measurement was carried out for compliance, resulting in fines for those who overstepped the mark. Now, however, day-to-day emissions measurement has financial implications and measurement is absolutely critical.

The automation enabled by technological advances favours continuous emission monitoring systems, while emission measurement instruments are becoming smaller and less expensive. This has heralded the way for gas phase measurement and gas phase calibration from gas cylinders, with a move away from manual and people-intensive 'wet chemistry' measurement.

Where government institutes used to carry out a lot of environmental or emission measurement themselves, today they have outsourced this function to a large extent. They retain control however, by checking that industry complies with relevant national and international standards.

What is seen is a definite trend moving from control to compliance. Today, metrology has been commercialized and the establishment of primary calibration standards has moved out of the government domain into that of the major gas companies. This development has been enabled by improved international standards and by global recognition of these standards, such as ISO 17025 and the emerging ISO Guide 34. However, many pockets of local, national and regional requirements are still in place, for instance the GBW standards in China the US-centric EPA.

According to Steve Mandel, manager SPECTRA brand environmental products at Linde: "Even though CAMR has been returned to the EPA for rework many states have already imposed the most stringent regulations in the world governing mercury emissions from power plants. The EU is currently on a track to tighten up its mercury monitoring legislation in the near future."

TECHNOLOGY FOR EMISSIONS MONITORING AND DETECTION

With the growing importance and prioritization of monitoring and quantifying emissions, accuracy and reliability in measurement calibration is critical. The demand for stable, accurate measurement is the cornerstone of emissions analysis. However, calibration standards of low-level reactive mixtures, typically those with levels below 5 ppm, can prove to be unstable over time and can result in incorrect measurements, lost productivity and with emissions monitoring potential legislative fines.

To keep pace with technological advances and increasing legislative requirements aimed at the power generation industries, Linde ensures its calibration gas mixtures, including its SPECTRA-SEAL range, remain at the forefront of gas technology. Linde, through its SPECTRA Environmental products, was the first company to offer a gaseous mercury standard as far down as a part-per-trillion level, for the monitoring and detection of emissions from power generation plants.

Its SPECTRA-SEAL calibration gas mixtures also employ state-of-the-art packaging technology – with a proprietary cylinder treatment process that exceeds the demanding requirements for consistency and long-term stability. This is supplied as standard for a wide range of calibration gases mixtures requiring low-level carbon monoxide, carbonyl sulphide, methyl mercaptan, hydrogen sulphide, nitric oxide, nitrogen dioxide, SO_2 or moisture.

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With any gas used for calibration purposes, the most important requirement is that it can accurately and repeatedly report values of the relevant instrument being measured. Linde's HiQ 60 specialty gas products were developed to provide accurate, stable gas products with a full 60-month performance guarantee. The development of what is an extended five-year shelf-life is a significant leap forward in the supply of calibration gases. Previously, gas suppliers across the market offered product expiration guarantees generally limited to 36 months, with many products available with only 12 months or 24 months of shelf-life. Gas products with these more limited shelf lives can impact measurement accuracy because gas stability in terms of consistency and quality can change over time. Where consistency or purity of the gas has been compromised, this can result in expensive system recalibration procedures, additional cylinder change-overs and wasted human resource time.

While the monitoring and detection of certain gases, including mercury, has led to the development of larger, more expensive measurement instruments, another development surrounding the more historical analytical techniques has been the miniaturization of emissions monitoring devices. These are often dispersed across remote locations in a plant and demand smaller, highly portable gas calibration solutions.

Linde's ECOCYL gas calibration solutions include compact, light-weight gas cylinders, which not only meet the challenge of calibrating distributed devices, but are significantly more environmentally-friendly and cost effective than more traditional, disposable cylinders. Refillable, they help mitigate environmental waste or costly regulatory cylinder return and waste handling issues often related with typical disposable cylinder packaging. The cylinders also have a pressure of 150 bar, containing at least 50 per cent more gas than most disposable cylinders.

All of Linde's solutions reflect global trends towards improved accuracy and reliability of emission monitoring, as well as product stability in the long term. They also address the requirements for reduced consumables usage, lower re-purchase cost and lower cost of ownership. ●