FULL STEAM AHEAD TO IMPROVED MARITIME AIR QUALITY

For several years, the International Maritime Organisation (IMO) has stipulated low levels of sulphur emissions close to densely populated coastal areas, such as the Baltic sea and the English Channel. As from the 1st of January 2020, lower sulphur emission levels in the IMO regulations became effective worldwide and the measures to monitor and reduce NOx emissions were also tightened. This will bring marine air pollution control more closely in line with smoke-stack industries such as power plants and refineries where continuous emissions monitoring systems (CEMS) have been used for decades to measure and mitigate NOx and SO_2 emissions.

Death in Venice

In 1929 the Nobel prize for literature was awarded to Thomas Mann. One of his short stories, 'Death in Venice' describes the slow but deadly spread of an infectious illness in Venice and the difficulties that policy makers had communicating responsibly without creating panic, whilst considering reasonable restrictions on the movement of people to contain the spread of disease. We might be tempted to draw a parallel to the recent Coronavirus outbreak which has turned millions of lives upside down and has been a major disruption to the luxury cruise industry. Prior to the Covid-19 pandemic cruise liners in Venice had a different connotation – they were major air quality pollution sources with their massive diesel engines and huge smokestacks. Imagine if a cement factory set up in your back garden. That might have been how Venice inhabitants reacted when a smoky cruise liner steamed up the grand canal in heart of this historic city.

Since 2015 the Baltic sea, where cities such as Stockholm are also busy ferry ports, and the North Sea, which includes the busy shipping lane of the English Channel and some of Continental Europe's busiest ports in Antwerp, Rotterdam and Hamburg has been a so called 'Emissions Control Area'. This has meant that the sulphur level in marine fuels has been capped at 0.1% to limit the amount of local SO2 emissions. With the advent of the wider geographic scope of the IMO 2020 marine emissions regulations, many other maritime cities such as Venice will also benefit from air quality improvements.

Cruiser in Venice, Italy

Prevention or mitigation: two options for emissions reduction

One option to reduce sulphur emissions from ship exhausts is to burn fuel with a low sulphur content. This solution mirrors the land-based transportation sector where low sulphur petrol and diesel are the norm. The second option for marine emissions reduction is for ships to use conventional high sulphur fuel oil and an exhaust gas cleaning systems (EGCS). This is like established technologies in land-based systems where power plants, for example, use scrubbers fed with lime to knock down sulphur emissions levels. With the demand for low sulphur fuels expected to increase, due to the IMO2020 regulations, the price for these fuels is also likely to rise. So, investment in an EGCS which enables the use of lower cost higher sulphur fuels may be highly attractive for shipping operators.

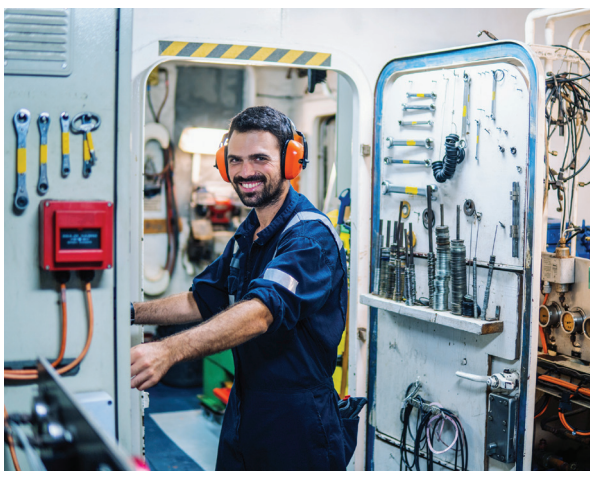
In general, EGCSs use either sea water in an open loop system or rely on internal recirculation of fresh water mixed with caustic soda or other alkaline chemical as the scrubbing medium in a closed loop system. Some ports have expressed concerns about the discharge of open loop scrubber wastewater, so the closed loop versions have an important role to play, despite their additional operating cost. However, the Finnish company Valmet has patented a scrubber process which can easily switch between the open or closed loop operation modes.

Speaking for Valmet as Product Manager of Scrubber Technology,

Cruise on Sunnylvsfjorden Fjord Norway

Juha Jokiluma says that "Valmet was one of the first companies to introduce the hybrid marine EGCS solution to the market. We have delivered several hybrid scrubber systems, including both open and closed loop operation modes, as well as dual water hybrid scrubbers that combine the benefits of both modes. This is particularly important in brackish waters such as river estuaries and means that the vessel can sail anywhere without over-dimensioning the scrubber system. Valmet has also developed its own water treatment system for treating closed loop wash water known as bleed-off. Cleaned water is continuously monitored to comply with strict IMO requirements and can be discharged overboard".

He goes on to explain the link to land-based scrubbing systems with the comment that "our expertise in flue gas desulphurisation (FGD) comes decades of involvement in the pulp and paper industry and diverse experience with other boilers. With more than 150 land based FGD systems as references, we were quickly able to grow to more than 100 marine EGCS as shipping operators geared up for IMO2020". Another aspect that the land-based and marine systems have in common is the requirement for CEMS gas analysers for process automation.



Maritime engineer

Maritime CEMS

With the increased focus on pollution control, gas analysis in the ship's funnel now stretches beyond process control and fuel efficiency to become a fully-fledged CEMS. Carbon monoxide (CO) and carbon dioxide (CO_2) emissions can indicate engine performance and efficiency. Additionally, measurement of the sulphur dioxide (SO_2) emissions and total oxides of nitrogen (NOx) emissions are now also required for environmental compliance. The selection of instrumentation for these ocean-based measurements can draw from lessons learned in power plants and other established CEMS applications. However, since the fuel on board is generally a liquid hydrocarbon, not coal or natural gas, and the measurement focus is on chemical species not particulates, some additional considerations come into play.

Simplicity is the key for stack emissions measurements at sea. In a sophisticated automotive emissions test-cell a chemiluminescence detector might be ideal for car NOx exhaust gases. However, that analyser requires an ozone generator, catalytic converter and a gas diluter. This configuration might be suitable for land-based research teams but might not meet the needs of shipping operators. For these reasons, some instrumentation OEMs have incorporated non-dispersive ultra-violet (UV) and non-dispersive infrared (NDIR) analysers into marine CEMS. They use light in the UV or IR wavelength to analyse NOx concentrations. For the SO_2 and CO_2 measurements most instruments rely NDIR technology using light in the infrared (IR) wavelength.

Sample handling is an important aspect to consider for maritime CEMS systems. The oily carry-over of unburned hydrocarbons from the combustion of liquid fuels means that hot-wet systems may get fouled quickly. Therefore, a cold-dry sample handling system can be more reliable and offer minimal maintenance requirements.

The CEMS systems must be installed to monitor the pollutants in the final smokestack gas emissions. They may also be installed for process control applications immediately after the combustion process and before a selective catalytic reduction (SCR) system that might be installed on the ship to reduce the NOx emissions levels through the reduction of this pollutant gas to harmless nitrogen through the reaction with ammonia. The ammonia is generally provided from a urea solution, which decomposes to form ammonia in the high temperature exhaust gases. The process control loop can be set up to either measure the NOx level in the feed to or exit from the SCR unit. Ammonia slip can also be measured using cross-stack TDLS instrumentation.

Stockholm cruise ship funnel

CEMS calibration made easy

Calibration of the CEMS instrumentation is a fundamental requirement for emissions monitoring compliance. An analyser that is not correctly calibrated cannot be relied upon to report the required precise environmental emissions data. Where the highest levels of accuracy and traceability are required, accredited specialty gases calibration mixtures are the best solution. Accreditation bodies around the world have worked together to harmonise data and through this collaboration the international aspect of the IMO regulations can be globally standardised. This ensures that 10ppm of S_{O2} emissions measured in the smokestack of a Russian oil tanker in the Black Sea is equivalent to an instrument on a Swedish passenger ferry crossing the Baltic to Estonia.

Space is at a premium on ships and carrying cylinders on board is not always easy. Also, with the chance of rough seas, cylinders can move around if they are not properly secured. For these reasons, the fewer cylinders that the operator needs to take on the high seas, the better. This is where multi-component mixtures score well – one cylinder contains all the gases that are needed to calibrate the suite of instruments required for marine CEMS. Mid-sized cylinders at 10 litres capacity are ideal for this offshore application. This seems to be the sweet spot combining portability and plenty of gas to ensure that calibration can take place on longer trips away from port.

No cruisers on the Venice Grand Canal

Gas detection - saving lives at sea

In November 2014 the IMO approved the new SOLAS regulation XI-1/7, making it mandatory for all applicable vessels to carry portable gas detectors. These regulations are designed to save lives at sea because effective gas detection is one of the most important safety concerns in the shipping industry. One third of the most dangerous incidents that happen offshore are gas related and fatalities among seafarers occur despite the observation of good practices and the use of safety equipment.

The regulations stipulate that every ship must carry at least one portable gas detection instrument which as a minimum is capable of measuring concentrations of oxygen, flammable gases or vapours, hydrogen sulphide and carbon monoxide. These so called 'quad gas' detectors must be used prior to entry into any confined space, and at appropriate intervals until the work is completed. Going beyond this minimum requirement, when roll-on, roll-off car ferries are loading and unloading in port the decks and ramp areas quickly become smoggy. For the personnel involved in supervising these traffic movements, wearing portable gas detectors may also be advisable.

Eliminating emissions – zero pollution cruises

The use of a battery or hydrogen powered fuel cell to drive propulsion system can eliminate maritime emissions on the oceans and in ports completely. In emissions free shipping, the cruise sector leads with their interest to adopt hydrogen as a propulsion system. Partly because nobody wants to get coated with dirty soot particles from the exhaust gases from the cruiser's funnel when sunbathing by the onboard pool. Furthermore, the type of people who book Arctic cruises tend to show an interest in sustainable energy usage on board the ship. There are also discussions taking place in Norway that some fjords will only be open to non-polluting ships in the future. So, to offer access to these jewels of nature, cruise operators will need to convert to a clean fuel such as hydrogen or consider battery powered ships.

Portsmouth harbour and ferries

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