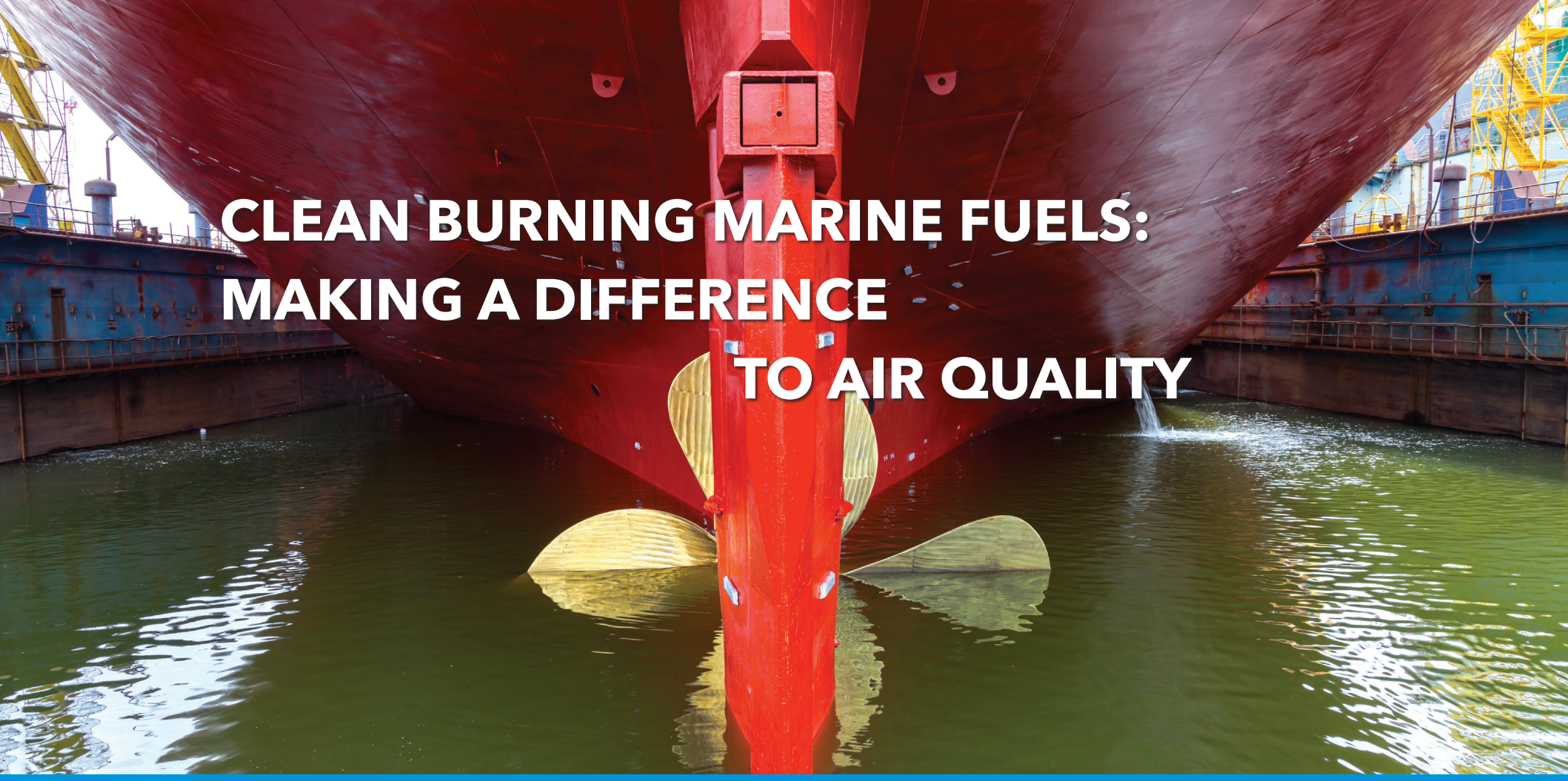


CLEAN BURNING MARINE FUELS: MAKING A DIFFERENCE TO AIR QUALITY

For several years, the International Maritime Organisation (IMO) has stipulated low levels of sulphur emissions from shipping operating close to densely populated coastal areas, such as the English Channel and the coastal waters off the United States. 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 refineries where continuous emissions monitoring systems (CEMS) have been used for decades to measure and mitigate NOx and SO_2 emissions.

No more rotten air in Rotterdam

Some of the world's most beautiful cities are blessed with an ocean setting or sit on the banks of a navigable river. Places such as Antwerp, Bangkok, Barcelona, Bremerhaven, Hamburg, Lisbon, Liverpool, London and Rotterdam might spring to mind. Through history, these cities have grown as centres of trade due to their maritime connections. Shipping in some of these locations, such as London, has predominantly moved out of the city centre to deeper water ports close such as the London Gateway at Thurrock and Tilbury. However, some other densely populated cities such as Rotterdam are still very much in the heart of the active port.

From a public health and air quality perspective, Rotterdam and other active ports are some of the biggest winners with the implementation of the IMO marine emissions standards. A major step forward for Rotterdam was taken in 2015 when the North Sea was designated an Emissions Control Area which capped sulphur level in marine fuels at 0.1%. With the advent of the wider geographic scope of the IMO 2020 marine emissions regulations, many other maritime cities will also benefit from air quality improvements.

To ensure that the regulations are being observed by shipping operators, the port of Rotterdam relocated an ambient air quality monitoring station in 2019 from the Hoek van Holland to the Maas entrance to the port. The new location at the top of the 'Lage Licht' on Splitsingsdam means that the air quality is being measured closer to the shipping lanes. The air sniffer uses highly sensitive gas analysers to measure sulphur dioxide in the air as ships steam in and out of the port. Monitoring such as this will ensure that shipping will take heed of the regulations and adapt to reduce their emissions – no more rotten air in Rotterdam.

Prevention: a refined option 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. Refineries are taking a variety of approaches to meet the changed demand for bunker fuels. Some have invested to increase the amount of low sulphur heavy fuel oil capacity through delayed coker construction projects.

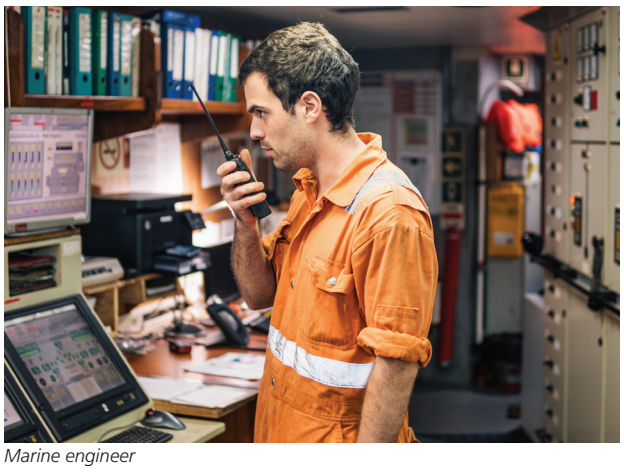
In 2018, ExxonMobil Petroleum & Chemical BVBA commissioned a delayed coker at its 320,000 barrels per day Antwerp refinery in Belgium. Designed to convert heavy, higher-sulphur residual oils into transportation fuels such as marine gas oil and diesel, the 50,000 barrels per day coker expanded the refinery's capacity to produce cleaner transportation fuels which will help meet the demand for lower-sulphur fuel oil to comply with the International Maritime Organization regulations.

The delayed coker was not an isolated project, it was part of a multi-billion Euro re-investment made at the Antwerp refinery over the past decade. The delayed coker follows other projects at the site, including a 130 MW cogeneration unit and a diesel hydrotreater. These increased the refinery's production capacity for low-sulphur diesel to enable modern cars and trucks to achieve lower exhaust emissions standards.

The economics and environmental aspects of marine pollution mitigation

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



Marine engineer

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, 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

Cruising through the port city of Rotterdam

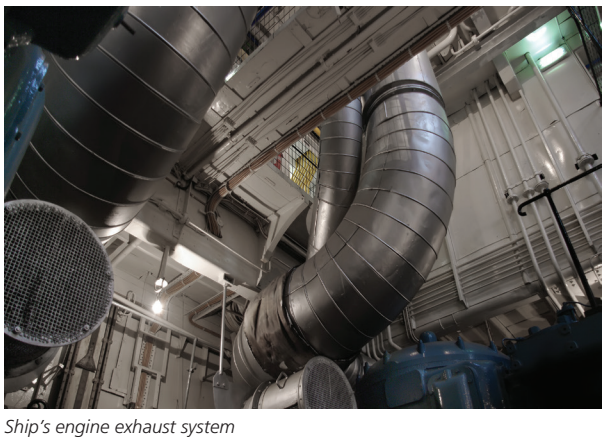
comply with strict IMO requirements and can be discharged overboard".

He continues 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 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 (CO2) 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.



Ship's engine exhaust system

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

Port of Bremerhaven Germany

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 SO_2 emissions measured in the smokestack of a Russian oil tanker in the Black Sea is equivalent to an instrument on a Chinese container ship steaming through the Strait of Malacca off the coast of Singapore.

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 maritime 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.

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.

MGO or HFO

A common cruise ship power system is a diesel-electric plant. These large piston engines can be fuelled with heavy fuel oil (HFO) or marine gas oil (MGO) depending on the local regulations regarding emissions. MGO produces much lower emissions but is much more expensive. Some cruisers are also fitted with a gas turbine generator fuelled by (MGO). This propulsion system is more expensive to run than the HFO fired generators, but is favoured in environmentally sensitive areas, such as Alaska. Due to its high power output, it can also be used when fast cruising is required to reach the next port destination more quickly.

Delayed Coker on a refinery

Alternative fuels may emerge

Liquified natural gas (LNG) and methanol are emerging as clean burning marine fuels. Both are ideal in locations where natural gas is abundant because methanol can be produced from natural gas through steam methane reforming and subsequent reactions. Whilst the storage of LNG required cryogenic equipment, the handling of methanol is very similar to traditional liquid fuels and is therefore favoured by some operators as a simpler option to which the ship's engineers will readily adapt.

Taking a step towards decarbonisation of shipping propulsion systems, some shipping operators are considering the use of hydrogen powered fuel cells to drive the propulsion system. This eliminates maritime emissions on the oceans and in ports completely. 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.

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