Reducing atmospheric emissions

If the growth of the past 150 years continues, the current 8 bill tonnes of cargo being transported across the globe annually will soar to 23 bill tonnes per year in the next 50 years.*

However, with the increasing volumes of cargo being transported annually, rising levels of marine emissions such as SOx, NOx, particulate matter (PM) and CO_2 from the fuel used to power these vessels, are under close scrutiny by world environmental authorities.

While the global shipping industry is currently responsible for only 3% of greenhouse gases, this contribution has prompted significant changes in the legislated control of emissions. A key concern is the health of communities living in close proximity to shipping lanes.

For example, almost 80,000 ships call into European ports each year, adding significantly to air pollution due to high sulphur and the heavy bunker fuels burnt at sea and also when in port. In Hamburg,for example, the population is in support of urgent action to reduce the sulphur emissions limit.

Another prime example is that of the 30 km Bosporus Strait, which is one of the most highly trafficked shipping channels in the world. Only 3.6 km wide at its broadest section and less than 1 km at its narrowest, the Bosporus flows directly through the city of Istanbul, which has a population of some 15 mill people.

On average, 140 vessels, including tankers, pass through the strait every day. Owing to strong currents in this channel, ships must use their engines on high power, which can lead to a significant issue regarding shipping emissions and its environmental impact on the city.

Maritime traffic on the Bosporus is increasing and exhaust emissions (NOx, CO_2, VOCs and PMs) from international shipping, as well as up to 300 vehicle and passenger transits, which cross the straits daily, are posing a health and general environmental hazard to the city's inhabitants. This potential human health issue has led to the Turkish government investigating the opening of a new open water channel before the problem increases in severity. And clearly, emissions control is another possible mitigation.

For environmental reasons, LNG and other solutions are occasionally employed to propel commercial shipping, but the majority still use a reciprocating diesel engine as their prime mover, fed by fuel oil. Combustion of bunker fuel in ships generates the same pollution components as those emitted from road transport vehicles and is similar to the emissions footprint from other fossil fuel burning industries, such as electrical power plants.

However, most of the sulphur emissions from land-based transport are eliminated by the use of low sulphur fuels, where the sulphur is removed at the refinery. And, there is also a growing trend for automotive sector NOx emissions to be reduced using selective catalytic reduction (SCR) with the addition of urea as a source of ammonia. By comparison, the control of these emissions from shipping has historically been less sophisticated, but the trend is going in a similar direction and is being driven by phased implementation of environmental protection legislation through MARPOL.

Marine pollution is regulated internationally and one of the key international conventions for the prevention of pollution at sea is MARPOL 73/78. Today, countries who have signed up to the MARPOL legislation represent 98% of international shipping.

New ECAs

As for ECAs, a new area, the US Caribbean Sea ECA, covering certain waters adjacent to the coasts of Puerto Rico and the US Virgin Islands was added to the list in January, 2014. Further ECAs are on the horizon for Norway and Japan, and possibly for the Mediterranean and Black Sea and the seas around Mexico, South Korea and, potentially also the heavily used Malacca Strait.

The issue of designating the Malacca Strait as an ECA is the subject of frequent debate, since the diversity and scale of shipping activities in this area is massive and it would be extremely challenging to monitor and enforce the emission regulations for each one. Effectively, this inclusion would mean regulating most of the world's shipping operators. Whilst this might be highly desirable from an environmental perspective, it would also be highly complex.

A phased reduction of SOx emissions in ECAs saw the allowable amount of fuel sulphur arrive at 0.1% in January, 2015. Outside of ECAs, the current global limit of 3.5% is likely to be reduced to below 0.5% in 2020 or 2025, depending on an IMO review to determine the availability of fuel to enable implementation of this standard.

In terms of NOx, an inevitable by-product of combustion of fuel with air, January, 2016 is expected to herald the IMO Tier III emission limits for ships constructed after that date operating within the North American and US Caribbean Sea ECAs. The Tier III standard represents a 75% reduction in NOx emissions compared to current Tier II engines and is valid for marine diesel engines with an output of more than 130 kW power.

Although it remains technology-neutral, the IMO regulation assumes that these standards will be met through the application of abatement technologies, such as selective catalytic reduction (SCR), that can either be used continuously while at sea, or can be activated only when entering the ECAs and thereby reducing commercial shipping & international trade operating costs.

A proposal was published in June, 2013 by the European Commission to regulate CO_2 emissions emanating from the shipping industry. The proposal aimed to reduce green house gas emissions by 2015 to levels 50% lower than those in 1990 through the establishment of a European MRV (monitor-report-verify) scheme. MRV can either be based on the calculation of fuel consumption or stack monitoring. In case of the latter, a monitoring plan is to be submitted to the authorised verifiers no later than August, 2017.

Little can be done to reduce the CO_2 produced by the combustion processes, but there are certainly proven and cost effective methods to reduce NOx, SOx (mainly SOx) and PM present in the emission stream. Mitigation measures focus on process control and management and detection of post-combustion emissions, to both protect the health and safety of the people on board the ship, and also to reduce environmental impact.

DeNOx technology can be retrofitted to the system to reduce NOx, while an interesting method of removing SOx emissions is the use of seawater for wet scrubbing. No additives are required in this method, as the inherent alkalinity of the seawater is used as the sorbent, and no by-products are produced beyond a slight increase in the natural concentration of sulphate in seawater.

In order to comply with these ever-tightening emission regulations, shipping operators could choose to adopt an integrated approach, which would include the use of lower sulphur content fuel, wet-gas scrubbing for SO_2 removal, SCR for NOx reduction or a conversion to LNG. However, this last option would require technology adjustments, similar to the engine retrofits currently being applied in the automotive industry.

Other emission management measures called for by the legislators include implementing a far higher level of measurement, analysis and reporting during voyages. Emissions, such as oxygen and carbon monoxide levels in the combustion process can be monitored to ensure that the process is functioning optimally. It is also possible to measure different hydrocarbons, such as methane, propane, butane, isobutane and pentane to determine if fuel is escaping from the engine.

Hydrogen sulphide is also often measured and controlled at various different points in the reaction pathway. Urea and ammonia levels also require monitoring to make sure the DeNOx equipment is working well and that the ammonia or urea is not being overdosed, which would result in ammonia 'slip'.

The Bosporus is a heavily polluted area.

Other stakeholders

The tightening legislation also impacts other players, notably the designers and manufacturers of marine diesel engines, and the associated emission reduction technologies, as well as the refineries implementing sulphur reduction technology to produce lower sulphur bunker fuels (lsfo) for shipping.

This lsfo introduction also impacts the bunker fuel oil stocking locations in the supply chain that hold inventory for ships. As part of this 'shore to ship' emissions reduction scenario, Linde works closely with refineries to supply gases, such as oxygen and hydrogen and implement technology to reduce sulphur levels at these refineries.

Oxygen enrichment technology has come to the fore as a viable and a cost-effective solution for significantly increasing a refinery's sulphur handling capacity, as well as addressing problems associated with contaminants, such as ammonia and hydrocarbons. In addition, analysis of sulphur compounds at a refinery has become a critical requirement and there are several different techniques available to accomplish this.

Linde Gases supports the global shipping industry and its associated supply industries with emissions management and mitigation technologies. A key area is the supply of high precision HiQ speciality gases calibration gas mixtures to the facilities where emissions testing of heavy marine engines is carried out during their development or production, to ensure compliance with emissions regulations.

This requires accurate calibration of the test instrumentation that detects and monitors emissions volume and type. Under the patented brand name HiQ, Linde offers a number of highly tailored calibration gas mixtures and pure speciality gas grades up to 99.99999% purity to ensure consistently accurate analytical measurement. The products are continually evolving to remain relevant to the needs of the industry, for example, as the MARPOL legislation evolves.

With LNG now being seriously evaluated as an alternative marine fuel, Linde has already developed the necessary technology to supply the maritime industry with this efficient and environmentally friendly replacement for bunker oil. The use of LNG allows for a significant reduction in SOx, NOx and CO_2 emissions. Other significant advantages are a very low safety risk and the possibility of combining LNG with other fuels in a dual-fuel engine.

Linde is one of the few companies in the world able to deliver a complete solution for LNG - from liquefaction and the safe and reliable delivery, handling and storage of cryogenic liquids to bunkering, vaporising and dispensing.

A shipping company - EMS AG - and Bomin Linde LNG, a provider of LNG as fuel for the marine market, signed the first contract for the delivery of LNG to Germany to be used on a ferry. The technical process for storage of LNG is comparable to bunkering operations for traditional fuels, but since the LNG is cooled down to approximately -163 deg C, appropriate personnel training is required.

Deliveries to the port of Emden for the ferry are currently covering initial supply requirements, while two LNG bunker terminals are being built at Hamburg and Bremerhaven. Once operational this year, these terminals will be able to supply LNG to ships operating in German ports along the North and Baltic Seas.

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**This article was taken from a paper published by the Linde Group written by Stephen Harrison, Global Head of Specialty Gases & Specialty Equipment, Germany and Ismail Erilhan, Global Product Manager Specialty Gases & Specialty Equipment, Linde Gases, Turkey.*