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Front-running NOx abatement technology approaches 3500 hours of real-world operation at sea

The Exhaust Gas Recirculation (EGR) solution being developed by MAN Diesel & Turbo with Alfa Laval support is proving its potential aboard two A.P. Moller-Maersk vessels. Between the Alexander Maersk and the Maersk Cardiff, nearly 3500 hours of EGR operation have been logged to date. These seagoing installations, which involve water cleaning with Alfa Laval's PureNOx, show why EGR is at the forefront of Tier III NOx abatement – and how fuel can be saved in Tier II operation.

EGR, which involves the recirculation of exhaust gas, is one of two technologies being developed to meet Tier III NOx limits without resorting to liquefied natural gas. Unlike Selective Catalytic Reduction (SCR), which is an after-treatment technology that removes NOx with the help of a catalyst, EGR is integrated into the engine and prevents the formation of NOx during combustion.

The advantages of EGR can be seen clearly in installations aboard two container vessels. The Alexander Maersk, a vessel of 1092 TEU whose MAN B&W 7S50MC engine was retrofitted with an EGR prototype in 2010, has spent more than 2200 hours operating at 50% NOx reduction over today's basis emission level. Lessons learned in this installation have gone into the 4500 TEU newbuild Maersk Cardiff, whose EGR-equipped engine is fully compliant with Tier III and also well past the 1000-hour operating mark.

“Alfa Laval is proud to be part of these pioneering EGR installations, where our PureNOx has the vital role of cleaning the wash water in the wet scrubber,” says Alfa Laval's Kristina Effler, Business Manager, Water Treatment Exhaust Gas Emissions. “No other vessel has EGR installed and operating reliably at Tier III. Moreover, it has been possible to demonstrate substantial fuel savings at Tier II.”

Fact box:

Tier III NOx limits

As determined at the recently held MEPC66 meeting, Tier III air pollution regulations will require the reduction of NOx emissions by 80% from existing Tier I limits during operation in Emission Control Areas (ECAs). This will apply to marine diesel engines of over 130 kW output power and installed from 1 January 2016 onwards, except for the engines of certain recreational vessels. At present, both North American coastal waters and the US Caribbean Sea are defined as NOx ECAs.

Tier III compliance with Tier II savings

The ability to save fuel in addition to complying with Tier III NOx limits is of vital interest to ship operators as they plan for 2016. A fuel-optimized Tier II operating mode, which facilitates an approximate 4 g/kWh reduction in fuel consumption at partial load, was introduced by MAN Diesel & Turbo with the two-stroke MAN B&W 6S80ME-C9 engine in 2012.¹ This is the engine now installed aboard the Maersk Cardiff, where it is operated entirely by the crew and has logged nearly 350 hours in this mode.

The availability of Tier II savings is important for cost-sensitive operators as they weigh the impact of NOx abatement choices. While SCR entails a slightly lower investment, the amount of consumables and maintenance puts its operating costs at 7-10% of the fuel costs. EGR on the other hand, with no catalyst to maintain and the ability to operate in fuel-optimized Tier II mode, has an operating cost of just 4-6% of the fuel costs in Tier III mode.

“EGR is the only NOx abatement technology that offers fuel savings in addition to Tier III compliance. As such, it is the only technology that will offset the initial investment over time,” says Effler. “The savings are more than theoretical, because they can be seen first-hand aboard the Maersk Cardiff.”

Fact box 2:

Investment vs. operating costs of NOx abatement alternatives²		
Alternative	Investment cost per kW installed power	Operating cost as a percentage of fuel costs
LNG	EUR 900-1300	NA
SCR	EUR 30-100	7-10%
EGR	EUR 45-60	4-6%

A perfect fit for vessel and crew

Costs, of course, are not the only factor in choosing a NOx abatement solution. Ship operators are also concerned about the size of the installation and the requirements it will place on the crew. Here as well, EGR offers substantial advantages over SCR, says Effler.

“An EGR system is compact, because nearly everything – including the water cleaning – is integrated into the engine itself. Compare this to an SCR system, where significant engine room space is needed for the reactor and other components,” Effler explains. “Likewise, EGR is fully automated and has no filling elements to clean or replace, so it requires very little from the crew.”

The importance of easy maintenance is confirmed by Kurt Larsen, Chief Engineer aboard the Alexander Maersk. “Today the workload for the crew is big enough already, so it’s essential that there isn’t yet another system to maintain frequently,” he says. “The potential of EGR seems good in terms of achieving a low-maintenance system.”

Consistency as engine load changes

Yet another prominent operator concern is reliability, especially in today’s world of varying engine loads. An SCR system has a critical minimum exhaust gas temperature for urea injection, as well as a maximum temperature, beyond which the NOx reduction is inefficient.

EGR, by contrast, is effective instantly and requires no warming up of the exhaust gas. Nor is it sensitive to engine load fluctuations, as verified aboard the Alexander Maersk. “There has been no effect whatsoever when changing engine load,” says Chief Engineer Larsen. “The EGR system has run without any problem and the emission reduction performance has not been affected.”

The important role of PureNOx

What EGR does depend on is the effective cleaning of the wash water in the wet scrubber, which operates in a closed loop. Since marine engines employ a variety of fuels, various combustion products with qualities harmful to the engine are formed. These products are effectively removed by Alfa Laval's PureNOx, a complete water treatment system based on high-speed centrifugal separation.

"PureNOx keeps soot and other compounds from the exhaust gas from accumulating in the scrubber," Effler explains. "It safeguards efficiency, reduces maintenance and prolongs the service life of engine components by protecting them against corrosion. In addition, PureNOx enables the discharge of excess water in accordance with IMO criteria."

Using centrifugal separation to clean the wash water ensures the highest possible efficiency and stability. Yet the space requirements and operating costs are very low. "It's difficult for other technologies to compete in efficiency at such a low operating cost," says Effler. "Alfa Laval has developed a separator that is tailor-made for cleaning scrubber wash water, which is a tricky and difficult task – especially for anyone lacking our core separation expertise."

With PureNOx as an integral part, the EGR system functions well under all operating conditions, as witnessed aboard the Alexander Maersk and Maersk Cardiff. "Between these two vessels," Effler says, "PureNOx has shown its capabilities in nearly 3500 hours of successful EGR operation."

Next steps for EGR and PureNOx

As the Alexander Maersk and Maersk Cardiff continue to sail, additional PureNOx systems have been delivered to Chevron Corporation for EGR on two lighter newbuilds powered by MAN B&W 6G70ME-C9.2 engines. A further delivery has also been scheduled to Mitsui Engineering & Shipbuilding. Meanwhile, Alfa Laval is looking ahead.

"We are actively pursuing new possibilities, such as the potential of combining the EGR water cleaning system with that of a wet SOx scrubber," says Effler. "What we've seen aboard the Alexander Maersk and Maersk Cardiff is exciting, and we on the PureNOx team expect further exciting developments as 2016 approaches."

References

¹ Press release, MAN Diesel & Turbo Copenhagen, 2012-10-26, "MAN Diesel & Turbo Engine Clinches World Emissions First"

² AIR POLLUTION AND ENERGY EFFICIENCY, information about the application status of Tier III compliant technologies, submitted by EUROMOT in Oct 2013

To learn more about PureNOx and Alfa Laval's approach to scrubber water cleaning, visit www.alfalaval.com/marine

Editor's notes

About Alfa Laval

Alfa Laval is a leading global provider of specialized products and engineering solutions based on its key technologies of heat transfer, separation and fluid handling.

The company's equipment, systems and services are dedicated to assisting customers in optimizing the performance of their processes. The solutions help them to heat, cool, separate and transport products in industries that produce food and beverages, chemicals and petrochemicals, pharmaceuticals, starch, sugar and ethanol.

Alfa Laval's products are also used in power plants, aboard ships, in the mechanical engineering industry, in the mining industry and for wastewater treatment, as well as for comfort climate and refrigeration applications.

Alfa Laval's worldwide organization works closely with customers in nearly 100 countries to help them stay ahead in the global arena.

Alfa Laval is listed on Nasdaq OMX, and, in 2013, posted annual sales of about SEK 29.9 billion (approx. EUR 3.45 billion). The company has today about 16,300 employees.

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