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IMO II in focus – MaK M 32 C Low Emission Engine available

Hamburg, Germany – Following the successful commercial debut of the MaK M 43 C LEE in late 2007, Low Emissions Engine technology is now also available for the MaK M 32 C series, which is widely used in general cargo and offshore support vessels like AHTS, PSV and ERV. Based on one of the most reliable medium-speed marine engines so far developed, the new M 32 C LEE already meets IMO II emission regulations which do not become effective until 2011.

A strategy for gradual emission reduction

Caterpillar has made sustainable development a challenging target of its “Vision 2020” strategy. Having monitored both the development of emission regulations and customer expectations, the company believes that electronically controlled engines will gradually become the norm. And, with its proprietary simulation and analysis tools for engine combustion, its expertise in fuel system manufacturing and its internal electronic control designs, Caterpillar is well-prepared to set the standard for environmental-friendly diesel engines. Strong evidence for this is provided by Caterpillar’s ACERT® Technology, the product of a \$ 500 million investment structured on the broadest possible product, application and manufacturing base in the industry.

“The goal for MaK medium-speed marine engines has been clearly defined”, comments Dr Udo Schlemmer-Kelling, Manager Research at Caterpillar Motoren in Kiel. “Exceed customer expectations by minimising emissions while at the same time maximising product value. Consequently, our strategy has had to comply with the MaK brand reputation: superior reliability in heavy fuel operation, best-in-class fuel efficiency and outstanding durability!”

Back in 2000, Caterpillar Motoren identified three emission levels for the MaK marine product in order to meet short to midterm emission regulations. These were a base line IMO engine, which fulfils MARPOL 73/78, Annex VI, requirements, an IMO-compliant engine with invisible smoke emissions and a Low Emission Engine (LEE) which meets the expected NO_x emission range of IMO II and is also smoke-invisible. In addition, this strategy favours proven technology inside the existing engine, which has clear advantages in terms of cost, complexity and maintenance.

LEE for low NO_x

The key requirement for low NO_x emissions is an increase in the compression ratio of the base engine. Ten years ago, a compression ratio of 11-12 was standard. For IMO I the ratio was raised to 14-15 and for IMO II ratios of 17 will be needed. Another cornerstone of the MaK LEE concept is the Miller Cycle, i.e. the modification of the engine's valve timing to achieve cooler combustion. For IMO I only a small Miller effect of 5% was utilised. However, IMO II requires a Miller effect of 20%. This is a big challenge for the turbo charger, which has to provide boost ratios of 5 in order to maintain today's Mean Effective Pressure (BMEP) values.

By combining increased compression ratio and the Miller effect, NO_x emissions can be reduced by around 30% without sacrificing engine efficiency (BSFC). However, such a simple LEE engine would suffer from poor load pick-up when idle and from visible soot emission at part load. Because of this, the MaK LEE concept uses a "flexible camshaft" to enable both low NO_x emissions, excellent load pick-up and invisible soot at all loads.

FCT for low soot

Flexible Camshaft Technology (FCT) enables variation of the fuel system and the air system at part load operation. By advancing the start of fuel injection and increasing injection pressure, combustion is improved and soot emissions are reduced by 50%. Shifted inlet valve timing switches off the Miller Cycle and contributes another 25% reduction in soot. Overall, MaK FCT reduces soot emissions at part load by 75% while improving engine performance during transient operation.

The system essentially consists of a modified lower valve train, a pneumatic adjusting unit and a Programmable Logic Controller (PLC). FCT is a robust mechanical solution, based on an eccentric lifter lever shaft automatically influencing both injection timing, pressure and valve timing. The engine load required to activate the lever can be flexibly set according to the vessel operator's needs. Either way, visible smoke is eliminated while IMO standards are complied with at all loads. To date, about 80 MaK M 32 C and M 43 C engines with FCT have been sold.

Retro-fitting to MaK LEE standard is quick and easy

After comprehensive simulation and prototyping of MaK LEE technology in 2001-2003 and after some final adjustments and improvements, Caterpillar Motoren, together with Caterpillar Marine Power Systems, was ready to put its unique technology to the test. In cooperation with Furetank Rederi AB of Donsö, Sweden, the MaK 7 M 43 C installation on the chemical tanker "Fure West" was converted to LEE standard in October 2007 and has performed as expected since then.

Meanwhile, retro-fitting to LEE standard has become an option for all MaK M 32 C series engines. It takes about four days to rework connecting rods, camshaft segments and lower valve trains to cope with the advanced requirements of LEE. First, a conrod spacer is mounted to lengthen the split-shaft connecting rod, thus reducing combustion volume and increasing compression ratio. As a result, the anti-wear ring also needs replacing with a shorter version.

In a second step, the camshaft segments are exchanged with modified FCT versions, enabling load-dependent variation of fuel and air systems. Lower valve trains, injection pumps and injection nozzles have to be replaced accordingly. In addition, the turbocharger needs to be rebuilt for increased loading pressure by replacing the diffusor and nozzle ring. A final sea trial confirms the quality of the retrofit and will lead to the required approval by Marine Classification Societies (MCS).

A win-win situation for operators and the environment

All existing MaK M 20 C, M 25 C, M 32 C and M 43 C series marine engines can be converted to MaK LEE standard – at about only 15-25% of the cost of a new IMO II-compliant engine. Built upon proven technology within the existing engine, MaK LEE offers many advantages for vessel owners and operators. MaK LEE already provides a power plant which complies with upcoming IMO II emission regulations. This allows shipping companies to increase their reputation for environmental-friendly marine business operations.

In addition, the emission levels achieved with MaK LEE enable shipping companies to obtain special environmental certification with the Marine Classification Societies, such as DNV Clean Design, GL Green Passport, LR Character N or the German Government's Blauer Engel. These environmental classes not only add to the vessel owner's image but also reduce harbour fees in some parts of the world.

IMO II no longer a threat

“With NO_x emissions more than 30% below current IMO regulations, and soot emissions reduced to less than 0.5 FSN (Filter Smoke Number) over the whole load range, our MaK LEE technology clearly deserves the name Low Emission Engine”, said Schlemmer-Kelling, highlighting the results of sea trials with a MaK 7 M 43 C LEE engine, achieved with a low NO_x trim of the FCT system and determined under ISO E2 cycle conditions. He added that “these results also guarantee the future of the MaK long-stroke marine engine design. I am very confident that our technology approach, together with Caterpillar Motoren's in-house engineering expertise, will find ways to cope with even more-stringent potential IMO III regulations.”

In the coming months, more MaK Low Emission Engines will be delivered to customers. By 2010, about half of all MaK M 20 C, M 25 C, M 32 C and M 43 C marine engines built will be of LEE design. Eventually, and once IMO II emission regulations take effect, every medium-speed marine engine produced at Caterpillar Motoren facilities in Kiel, Rostock or Guangdong in the P. R. China will be a state-of-the-art MaK Low Emission Engine.

Characters: 8,056

Pictures available on request:

- 1.) FCT Unit mounted on a MaK M 32 C LEE Marine Engine**
- 2.) FCT Pneumatic Adjusting Unit for MaK LEE Marine Engine**
- 3.) FCT Camshaft and Lower Valve Train for MaK LEE Marine Engine**

About Caterpillar Marine Power Systems

Caterpillar Marine Power Systems, with headquarters in Hamburg, Germany, brings together all the sales and service activities for Cat and MaK branded marine products within Caterpillar Inc. This organization provides premier marine power solutions (high and medium speed with outputs from 11 kW to 16,000 kW) and customer service from a single source for the global ocean-going, commercial and pleasure craft markets. The Caterpillar Marine Power Systems sales and service network includes more than 2,100 dealer locations world-wide and is well positioned to support customers wherever they are.

More information is available at www.cat-marine.com or www.mak-global.com.

About Caterpillar

For more than 80 years, Caterpillar Inc. has been making progress possible and driving positive and sustainable change on every continent. With 2006 sales and revenues of \$41.517 billion, Caterpillar is a technology leader and the world's leading manufacturer of construction and mining equipment, clean diesel and natural gas engines and industrial gas turbines.

More information is available at www.cat.com.

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