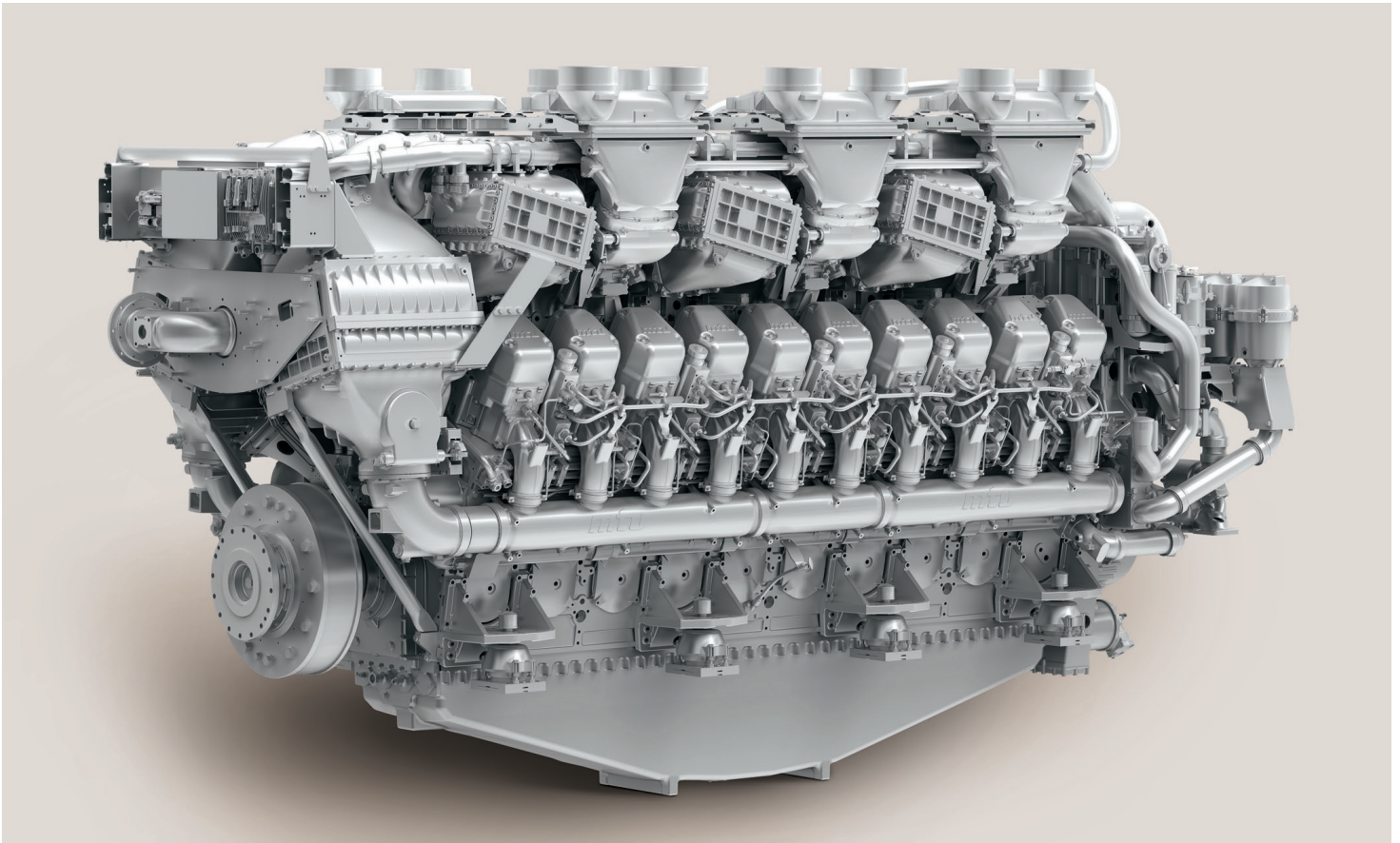


Marine Applications

Ready for the next emissions stage: Further development of MTU Series 1163 for IMO II

**Author:****Christoph Fenske**Senior Manager Application Center Marine,
Naval Surface Craft

Since the beginning of the 1980s, the MTU Series 1163 has been one of the most widely used engines in naval shipping. For compliance with IMO II an advanced version of the unit without exhaust treatment systems is to be launched. The future version will retain all the decisive engine characteristics of its predecessors that were so important to customers. Which means that reliability, high power density and optimum acceleration capabilities will remain the key features of the Series 1163.

Lighter and more powerful than all comparable engines, the Series 1163 fast-running large-scale diesels have been a success story for close to 30 years. Developed for naval applications and later adapted for use in commercial vessels, the Series 1163s reliably and potently power ships all

over the world – and anywhere where the emission limits imposed by the International Maritime Organization (IMO) have to be complied with. To ensure the engine continues to meet the requirements of the IMO II and IMO III regulations, MTU is upgrading the design of the Series 1163.





For its Meteor Class BAM (Buques de Acción Marítima) offshore patrol vessels, the Spanish Navy relies on 16-cylinder Series 1163 engines.

Development aims

Despite the strict emission restrictions, the efficiency of the engines is not to be compromised. On the contrary – they must demonstrate the same qualities as the previous version in terms of the key engine characteristics such as reliability, high power density and rapid acceleration. And they must do so using not more, but substantially less fuel than before. The interfaces are to remain virtually unchanged so that clients can continue to use the engine in ships and ship designs that are currently planned or in service – and continue to enjoy the accustomed higher power-to-weight ratio and smaller footprint than offered by competing engines in the comparable power class.

The proven system components are also to remain virtually identical. For the 04 version of the engine (1163 M04), three out of four components will be carried over directly from version 03 (1163 TB03). So existing stocks of spare parts and add-ons such as resilient mountings or acoustic enclosures will still be usable in future. Due to a reduction in the number of mechanical components, the amount of servicing work required is also less.

The planned concept will enable the nitrogen oxides (NO_x) limit of 8.5 g/kWh required by IMO II to be met by internal engine design features alone. From the outside, the changes will not be visible until 2016, when the IMO III NO_x emission limit of 2.1 g/kWh comes into force. The version 04 engines, which will be carried over unchanged for the IMO III overall system, will then be provided with what is currently the best technical solution available for compliance with the emission limits demanded – an SCR catalytic converter which chemically renders the emitted nitrogen oxides harmless.

Ongoing development of the engine will also take account of the latest requirements of the definitive classification societies and the navies. The 1163-04 will thus meet specifications such as those of the American Bureau of Shipping (ABS), Det Norske Veritas (DNV), Germanischer Lloyd, Lloyd's Register of Shipping or the Registro Italiano Navale (RINA) as well as naval demands for features such as low-noise and shock-resistant engines in accordance with electromagnetic compatibility regulations.

For use as a main propulsion unit, the three cylinder configurations of V12, V16 and V20 will

be retained. That relates to engines in high-speed vessels with high levels of capacity utilization, such as ferries and displacement yachts with an average output of 60 to 80 percent of rated power and up to 5,000 hours of duty per year. The engines are also designed for ships with medium to low capacity utilization such as patrol boats or high-speed yachts with outputs lower than 60 percent of rated power and up to 3,000 hours of service a year.

Technologies for IMO II and IMO III compliance

In order to upgrade the Series 1163 for IMO II and IMO III, MTU will modernize the fuel injection, the combustion process and the electronic engine management. Instead of the old unit-pump system, the advanced version of the Series 1163 will benefit from improved fuel injection using an electronically controlled common-rail system with an injection pressure of up to 1,800 bar.

Technologies for IMO II and IMO III compliance

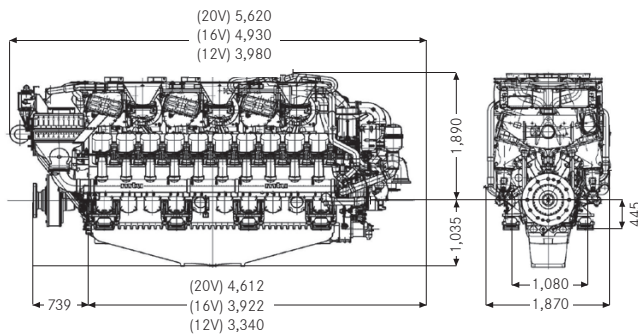
Miller Combustion Cycle

The Miller cycle aims at reducing the emission of nitrogen oxides (NO_x) while maintaining or even improving the fuel consumption of combustion engines.

The Miller cycle (named after the inventor Ralph Miller, who patented the principle in 1947) is based on a traditional diesel cycle, but with the difference that the inlet valve closes earlier than in the diesel cycle. This causes an expansion of the combustion air during the intake stroke, so that the gas temperature at the beginning of the compression stroke is lower and as a result the combustion temperature.

The formation of nitrogen oxides (NO_x) is influenced by the gas temperature, so that – with the lower combustion temperature of the Miller cycle – NO_x emissions are reduced significantly without a fuel penalty. To achieve the same power output from the same cylinder volume, the charge air pressure is to be increased to outweigh the pressure loss during the intake stroke and the expansion at the end of the intake stroke.

Technical Data, Series 1163 M04



Weight, dry with accessories fitted (as shown):

12V 1163:	16.0 tons
16V 1163:	20.0 tons
20V 1163:	24.5 tons

Power-to-weight ratio	0,30 kW / kg (20V)
Bore/stroke	230 mm / 280 mm
Bank configuration	60° V
Swept vol. per cylinder	11.63 l
Speed range	350 to max. 1,325 rpm

Cylinder configs	12V, 16V, 20V
Power density	> 200 kW/m ³ (20V)
Power range	3,600 to 7,400 kW (4,828 to 10,064 PS)

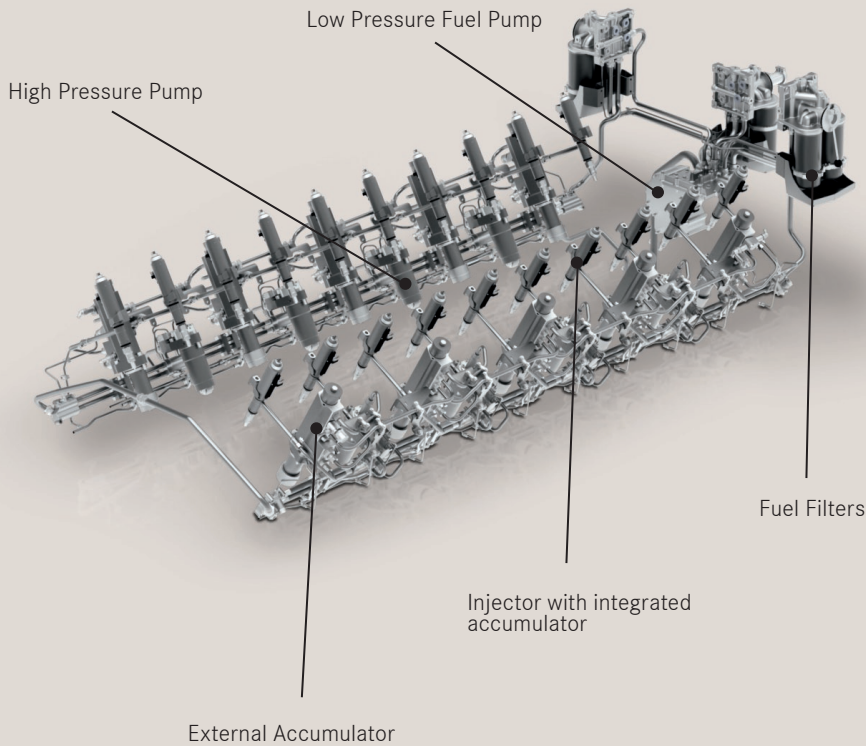
Common Rail Fuel Injection

The principle of common rail fuel injection is based on a high pressure accumulator system fed by one or more special high pressure fuel pumps. It provides the electronically-controlled injectors with a constant supply of fuel throughout the injection period regardless of engine speed.

This arrangement allows independent control of all injection parameters, which can be flexibly adapted to suit every set of operating conditions. Parameters included are timing, course and duration of the injection as well as fuel pressure.

At low and part load operation, where engines with conventional systems can suffer from inherent limitations due to dependence on speed, the common rail system offers optimisation possibilities regarding fuel and emission efficiency.

Fundamental part of the innovative system for the 1163M04 include a low pressure fuel supply pump for the up to eight high pressure fuel pumps (20V 1163), which in turn provide the accumulators in along the engine sides with pressures up to 1800 bar via double-walled piping. The volume of these buffers is sufficient enough to avoid any fluctuation or decrease of the pressure in the supply line and the injectors respectively, which the centrally-located nozzles.



Above all, that will give the engine a better performance map, i.e. lower fuel consumption, lower nitrogen-oxide and soot emission levels and more responsive acceleration. The efficiency of the two-stage sequential turbocharging has been optimized and the future versions of the 1163 will continue to use three (on the V12), four (V16) and five (V20) pairs of turbochargers. The maximum combustion pressure will be raised. That will enable more efficient combustion and, consequently, lower fuel consumption.

In conjunction with the latest-generation ADEC (Advanced Diesel Engine Control) engine management module, injection timing, volume and pattern can be controlled independently of engine speed, and combustion much more effectively tuned. The ADEC has already proven its qualities many times over on the Series 2000 and 4000 and consists of engine management and control systems and a local operating panel (LOP) in the engine room. That panel can be connected to the

MTU "Callosum" automation system or a third-party integrated engine management system via a CAN field-bus connection with redundant backup.

The new engine design will also feature the Miller combustion process. Earlier closure of the inlet valves causes expansion of the cylinder charge and a lower combustion temperature, which has a beneficial effect on NO_x emission levels. However, that requires a higher turbocharger boost pressure, which is effected by optimized-geometry and low-inertia turbochargers. They are brought into play according to engine load so that vessels are able to accelerate quickly and maneuver easily thanks to the large torque reserves. In addition, fuel consumption remains low even at low and medium power levels and hardly any black smoke is produced under acceleration.

Modern technology for merchant vessels

At present there are more than 550 Series 1163 units in service, almost all of them in naval appli-

cations where they power frigates and corvettes, either as single units or in combined propulsion systems. As a result of the boom in the market for fast ferries at the beginning of the 1990s, however, the engine became an attractive proposition in the commercial sector as well and in 1994 was officially presented as a propulsion solution for yachts and ferries for the first time. The modifications that came out of those tough operating conditions substantially increased the engine's durability and reliability. And since then, merchant vessels have been able to benefit from the super-fast acceleration it offers. For example, the "Shinas", the world's fastest diesel-powered passenger ferry with a top speed of 56.3 knots, set a new world speed record driven by a Series 1163 unit. But it is not just in terms of dynamic response that the Series 1163 achieves the highest standards; acoustics and low vibration are exemplary too. Unwanted noise and vibration in operation have been drastically reduced by specifically targeted engineering.



Along with its two 20-cylinder Series 1163 engines, the German frigate 'Sachsen' has a 20,000 kW gas turbine on board.



The "Shinas" was propelled to a world record by four Series 1163 engines. With a top speed of 56.3 knots, she is the fastest diesel-powered passenger ferry in the world.

The latest advancement of the Series 1163 design will retain the same characteristic features that ensured the success of its predecessors. The 1163 M04 is designed as a modern diesel engine for the civil and naval markets. With its high power-to-weight ratio, high power density and ultra-responsive acceleration characteristics, it ticks all the boxes for an efficient propulsion solution.

Technologies for IMO II and IMO III compliance

Sequential Turbo Charging

With naval and pleasure vessels operating often at low and medium speeds, the propulsion system's part load behaviour is of essence. One of the most efficient technologies to overcome the mismatch between the diesel engine and the turbo charger at part loads – commonly known as the "turbo hole" is Sequential Turbo Charging (STC). STC widens the performance envelope of engines, resulting in lower fuel consumption at part loads, lower emissions and dynamic response for acceleration and manoeuvring.

The basically simple working principle of the system – that can be applied to single stage as well as to two-stage turbo charging systems as on the 1163 TB03 and the 1163 M04 – is based on the switching in and out of turbochargers. This enables better matching of the number of turbo chargers to the available exhaust gas flow. Switchable flaps (on/off only) upstream of both turbine and compressor are activated based on turbo charger speed and engine speed.

Shipbuilders will benefit from the breadth of available power classes across the 12, 16 and 20-cylinder versions of the engine, which can be selected according to customer requirements. Because of the identical interface setup and the small engine footprint, existing ship designs can be implemented without having to reconfigure the driveline and its associated supply systems or repeat the stability calculations. As a provider of complete system solutions, MTU offers shipbuilders the advantage of obtaining all necessary products from one source. Complete systems consisting of diesel engines, gas turbines, power generators and automation systems purpose-built for them vastly simplify the procurement process. For ferry operators, yacht owners or naval services, the new generation of engines represents above all efficient, clean and economical propulsion systems for anything from semi-planing to full-displacement craft and from a naval patrol boat to a fast commercial ferry. The new Series 1163s reveal their strengths particularly in low/medium-power operation scenarios, which are equally important for naval vessels and civilian yachts. In those situations their fuel consumption is especially low.

Conclusion

The rated power and speed figures for the future Series 1163 models will be similar to those of the present incarnation, if not identical. The fuel consumption will be considerably lower than

that of the current Series 1163, especially when operating below full power. Emission levels will also be further reduced. The engines will meet the IMO II emission limits, which have been in force since 2011, by means of internal engine design features alone, i.e. without the use of exhaust treatment systems and without any loss of engine performance. So the Series 1163 success story will continue in the shape of a new generation that is simultaneously cleaner and more economical than its present incarnation.

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MTU is the brand name under which the Tognum Group markets engines and propulsion systems for ships, for heavy land, rail and defense vehicles and for the oil and gas industry. They are based on diesel engines with up to 9,100 kW and gas turbines up to 45,000 kW power output. The company also develops and produces bespoke electronic monitoring and control systems for the engines and propulsion systems.



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