MAN 51/60DF
Dual fuel flexibility
MAN Diesel & Turbo is the world’s leading designer and manufacturer of low and medium speed engines – engines from MAN Diesel & Turbo cover an estimated 50% of the power needed for all world trade. We develop two-stroke and four-stroke engines, auxiliary engines, turbochargers and propulsion packages that are manufactured both within the MAN Diesel & Turbo Group and at our licencees.

More than ever before, MAN Diesel & Turbo’s development focus lies in the environmental performance of our engines. Using our unrivalled grasp of large engine technology, we aim to make our engines progressively cleaner, more powerful and more efficient.

Our absolute commitment to reducing emissions while increasing fuel efficiency and power density starts with our active partnership in the emissions lawmaking process and ends with the delivery of engines that achieve an ideal synthesis of prime mover characteristics.
Let your fuel take you farther. By combining diesel and gasoline technologies in one engine, the MAN 51/60DF gives you absolute fuel flexibility. There’s no better way to keep your engine running effectively and economically. Full steam ahead.

Taking the long view
MAN Diesel & Turbo is committed to the future. With IMO Tier III emission limits on the horizon for 2016, developments for compliant technologies are already underway. Optimized fuel consumption and all-new levels of engine power and flexibility allow customers to plan with confidence.

In-house innovation
Leadership in engine design, development, and manufacturing is not enough. That’s why MAN Diesel & Turbo pours its expertise into the innovative development of core technologies that set new standards of economical and ecological engine performance. Whether running on liquid fuel, gas, or both, customers can rely on:

- Highly efficient exhaust gas turbochargers
- Advanced electronic fuel injection equipment
- Pioneering hardware and software for engine control, monitoring, and diagnostics

Yet innovation doesn’t stop there. Designs created with impressive CAD tools are brought to life at our foundry – one of the industry’s largest and best-equipped production sites. Shorter product development processes, streamlined application engineering, and mastery of engine technologies by the best minds in the business are the key to a long service life marked by low emissions, as well as low operating and lifecycle costs.

The range of technical features offered includes:

- Improved charge air cooling
- Enhanced turbocharging
- Miller valve timing
- Revised injection timing
- Higher compression ratios
- Fuel sharing operating mode
High efficiency, low emissions

When it comes to the environment, why meet eco-limits when it’s possible to stay far below them? Running on natural gas, the MAN 51/60DF undercuts IMO Tier II levels by a mile. In fact, in gaseous fuel mode, it even fulfills the strict IMO Tier III NOₓ limits prescribed for Emissions Control Areas (ECAs), without any exhaust gas aftertreatments. With liquid fuels, it meets IMO Tier II NOₓ emissions limits.

State-of-the-art ignition

Low emissions are a start, but in the MAN 51/60DF, these are complemented by cutting-edge “micropilot” gas ignition technology. The gaseous fuel is ignited by injecting a distillate pilot fuel, which makes up only 1% of total liquid fuel needed to achieve the engine’s full-rate output in liquid fuel back-up mode.

Common rail pilot-fuel injection

Underpinned by the very latest MAN Diesel & Turbo common rail technology, the MAN 51/60DF features an adjustable pilot injection system. Settings for injection timing, duration, and the pressure for each cylinder are easy to modify. This flexibility allows for optimized fuel consumption and emissions at any point in the engine’s operating profile. MAN Diesel & Turbo common rail technology also offers further advantages. For example, in gaseous fuel mode, the gas admission and pilot injection of the MAN 51/60DF can be very closely matched to power demand, even down to very low engine loads (e.g., when only meeting the vessel’s hotel load). And thanks to this technology, the engine can respond quickly to combustion knocking and misfiring on a cylinder-by-cylinder basis.

Intrinsically clean combustion (ICC)

The MAN 51/60DF was specially designed to burn methane and gases with high methane content. Methane plays a pivotal role in ICC because – as the simplest compound of carbon and hydrogen in the hydrocarbon series – it is intrinsically clean burning.
Engine Specifications
A powerhouse of reliability

Covering a performance range from 6,000 to 18,000 kW, this powerful marine engine epitomizes top performance at the highest level of versatility. For LNG carriers, the MAN 51/60DF is simply the right choice in every respect.

Versatile and fit for purpose
With the MAN 51/60DF, MAN Diesel & Turbo has created a dual-fuel marine engine that converts liquid fuel or natural gas into electrical or mechanical propulsion power. This is a highly efficient engine that produces low emissions and can be conveniently switched from gas mode to liquid fuel mode without interruption. Combined with a state-of-the-art safety concept designed by MAN Diesel & Turbo for LNG carriers, this multi-fuel capability makes this option the ideal drive solution for this type of vessel.

Fuel steam ahead
The MAN 51/60DF engine is designed to run on liquid or gaseous fuels. Whichever option is chosen, the engine is guaranteed to meet the very latest standards – even MAN Diesel & Turbo’s own directives for natural gas. Running on liquid fuel, the MAN 51/60DF engine can be operated with MGO, MDO, and heavy fuel oil with a viscosity of up to 700 mm²/s (cSt) at 50°C. Built to last and designed to spec, it meets modern specifications including the CIMAC 2003 H / K700 / DIN ISO 8217.

Electrical and mechanical propulsion
Mechanical propulsion is now also an option with the MAN 51/60DF engine, proving its versatility in a variety of marine applications. Compared to the diesel-electric approach, the mechanical drive yields a higher total efficiency and reduces the cost of investment in the ship’s propulsion train.

The main driving force
Another defining feature of the MAN 51/60DF’s versatility lies in its suitability for driving either CP propellers or generators. When driving CP propellers, the engine output is limited to 100% of the rated output. Engine output is limited to 110% of the rated output for engines driving a generator.

Auxiliary power on the high seas
The MAN 51/60DF can run briefly at loads up to 110% as this allows for a balancing of fluctuations in frequency during load acceptance in liquid fuel and gas mode.
An engine greater than the sum of its parts? Sometimes quality is not merely defined by performance, but by the attention to detail down to the last nut and bolt. That’s what make this engine the perfect choice.

Clever design, clever head
Thanks to superior combustion chamber geometry, the cylinder head is designed for optimum combustion of gaseous and liquid fuels. An ideal air/fuel mixture is achieved through unimpeded atomization of the fuel spray – regardless of the operating mode. As a result, customers can count on reduced fuel consumption across the board.

Understanding the ins and outs
No engine system would function efficiently without excellent parts. The MAN 51/60DF design underscores MAN Diesel & Turbo’s meticulous attention to detail, right down to the valves. As a result, the water-cooled, armored exhaust valve seat rings proactively contribute to low valve temperatures. And the propellers on the exhaust valve shaft allow gas flow to rotate the valve, effectively cleaning the sealing surfaces during operation. What’s more, the inlet valves are equipped with Rotocaps, meaning less wear and longer service intervals.

Ignition through injection
Any ignition is only as good as the selected injection system. During design and development of the MAN 51/60DF, MAN Diesel & Turbo took this into account for various types of fuel. In liquid fuel mode, even low-quality fuel is optimally atomized for ideal combustion. Gas mode works slightly differently. Here a small quantity of pilot fuel is injected through the common rail system. Overall, enhanced fuel injection systems spell lower consumption and lower levels of harmful emissions.

Rolling up the sleeves
In any engine, it is essential that the pistons run to perfection. To achieve this in the MAN 51/60DF, each cylinder jacket has its own durable cylinder liner. Naturally, this liner is completely free of any deformations that might arise from the engine frame. As a result, the pistons can move freely meaning that customers can rely on a long engine service life thanks to long service intervals.

A step in the right direction
The engineers at MAN Diesel & Turbo opted for stepped pistons in the design of the MAN 51/60DF. These stepped pistons feature a forged steel crown that’s highly resistant to deformation (with shaker cooling) and is made from high-grade material and nodular cast iron in the lower section. Used in combination with a flame ring, the pistons not only prevent undesirable “bore polishing” on the cylinder liner, they also keep lubricating oil consumption low – thus lowering overall operating costs. Also, there is a chrome/ceramic coating on the first piston ring. This is achieved with wear-resistant ceramic particles on the ring’s surface, meaning that this engine can enjoy a long service life.

Revolutionary rods and bearings
This engine is ideal for marine applications thanks to its optimized design. With a split joint in the upper shaft area, there is no need to release the con-rod bearing during piston extraction. The design also offers a low piston extension height. To ensure safe operation, the shells for the con-rod bearings have also been enhanced for superior performance.
Cross section of the MAN L51/60DF
Technical Specifications
Underscoring the “engine” in engineering

Engineering excellence is the cornerstone of success at MAN Diesel & Turbo. From innovative developments in control systems and turbocharging technology to service-friendly design – only the very best expertise flows into our engines.

**Turbocharged and ready to go**
MAN Diesel & Turbo offers a variety of modern turbochargers in its TCA series, each providing long over-haul intervals and excellent efficiency. As part of an enhanced charging system with uniform pressure, these make a major contribution to overall engine efficiency. The MAN 51/60DF is charged by just one TCA turbo charger. That means that all cylinders only share one exhaust gas collector pipe. This is an engine offering best partial load operation thanks to high turbocharger efficiency – even under low pressure conditions.

**Service-friendly design**
Servicing the engine is easy thanks to a number of ingenious design features:

- Hydraulic tools for cylinder head nuts, crankshaft bearings, and lower con-rod bearings
- Quick locks and clamp connections on pipes and lines
- Generously sized crankcase cover
- Geislinger sleeve spring vibration dampers

**SaCoSone**
The MAN 51/60DF comes fully equipped with SaCoSone – a safety and control system developed for full compliance with classification society standards. SaCoSone allows for safe engine operation in liquid fuel or gas mode, offering optimum fuel consumption and very low emissions. In gas mode, the control system guarantees safe operation between the knock and misfire boundaries. Under such use, all cylinders are controlled individually. For operation with liquid fuel, control is based on the standard SaCoSone control system for diesel engines. Since the complete system is subjected to test runs in the factory, fine tuning and functional testing during onboard commissioning involve minimal effort.

**Optimal soot reduction**
Thanks to optimized combustion and turbocharging, soot emissions from liquid fuel operation have been reduced in the MAN 51/60DF. For increased demands with respect to invisible soot emissions in the range of 20% output down to idle, special auxiliary equipment is offered that prevents the formation of visible smoke. In gas mode, soot emissions are not an issue.

**Flexible fuel sharing**
The MAN 51/60DF features optional, innovative fuel sharing. This means that mixtures of gas and HFO can be simultaneously burned in a single engine. For operators of LNG carriers, this feature offers maximum usage of boil-off gas under the most efficient engine operation possible.

**Low-load operation**
The state-of-the-art MAN 51/60DF offers customers an additional option for ultimate operational flexibility: Low-load operation enables customers to run the MAN 51/60DF at loads already above 10% MCR in gas mode.
Engine data for MAN L+V51/60DF

General
- Engine cycle: four-stroke
- Turbocharging system: constant pressure
- No. of cylinders, in-line engine: 6, 7, 8, 9
- No. of cylinders, V-engine: 12, 14, 16, 18
- Bore: 510 mm
- Stroke: 600 mm
- Swept volume per cyl.: 122.6 dm³

Power-to-weight ratio (MCR)
- In-line engine: 16.4 – 18.1 kg/kW
- V-engine: 14.7 – 16.2 kg/kW

Cylinder output (MCR)
- At 514 rpm: 1,000 kW
- At 500 rpm: 975 kW

MCR = maximum continuous rating

Cooling
- Cylinder cooling (one-stage): fresh water
- Charge air cooler (two-stage): fresh water
- Fuel injector cooling: fresh water
- Starting method: compressed air

General performance definition for diesel and dual-fuel engines as per ISO 3046-1:2002

ISO reference conditions:
- Air temperature: 298 K (25°C)
- Air pressure: 1 bar
- Fresh water temperature upstream of charge air cooler: 298 K (25°C)
- Relative humidity: 30%

No power reduction required below:
- Air temperature: 318 K (45°C)
- Air pressure: 1 bar
- Fresh water temperature upstream of charge air cooler: 311 K (38°C)
- Relative humidity: 50%

In gas operation
- Methane value ≥ 80
- Lower calorific value of gas ≥ 28.0 MJ/Nm³*)

IMO requirements
The engine detailed here complies with IMO Tier II emissions limits.

*)Nm³ corresponds to one cubic meter of gas at 0°C and 1.013 bar
Technical Data
Output, dimensions, and weight

In-line engine
MAN L51/60DF
Bore: 510 mm
Stroke: 600 mm
No. of cylinders: 6, 7, 8, 9

In-line engine MAN L51/60DF

<table>
<thead>
<tr>
<th>Engine type</th>
<th>No. of cyl.</th>
<th>L</th>
<th>L1</th>
<th>W</th>
<th>H</th>
<th>Weight</th>
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<td>9,915</td>
<td>3,283</td>
<td>5,340</td>
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All weights and dimensions are merely guide values and only apply to dry engines without a flywheel.
Minimum centerline distance for twin engine installation: in-line engine: 3,200 mm (project-specific requirements can lead to higher values).
More information available upon request.

Outputs MCR (maximum continuous rating)

<table>
<thead>
<tr>
<th>Engine speed</th>
<th>514 rpm</th>
<th>500 rpm</th>
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</thead>
<tbody>
<tr>
<td>Mean piston speed</td>
<td>10.3 m/s</td>
<td>10.0 m/s</td>
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<tr>
<td>Mean effective pressure</td>
<td>19.1 bar</td>
<td>19.1 bar</td>
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</table>

<table>
<thead>
<tr>
<th>kW</th>
<th>kW</th>
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<tr>
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<td>6,000</td>
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<tr>
<td>MAN 7L51/60DF</td>
<td>7,000</td>
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<tr>
<td>MAN 8L51/60DF</td>
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<tr>
<td>MAN 9L51/60DF</td>
<td>9,000</td>
</tr>
</tbody>
</table>
V-engine MAN V51/60DF
Bore: 510 mm
Stroke: 600 mm
No. of cylinders: 12, 14, 16, 18

V-engine MAN V51/60DF

<table>
<thead>
<tr>
<th>Engine type</th>
<th>No. of cyl.</th>
<th>L (mm)</th>
<th>L1 (mm)</th>
<th>W (mm)</th>
<th>H (mm)</th>
<th>Weight (t)</th>
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<tbody>
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All weights and dimensions are merely guide values and only apply to dry engines without a flywheel.
Minimum centerline distance for twin engine installation: v-type engine: 4,800 mm (project-specific requirements can lead to higher values).
More information available upon request.

Outputs MCR (maximum continuous rating)

<table>
<thead>
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<td>MAN 12V51/60DF</td>
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</tr>
<tr>
<td>MAN 14V51/60DF</td>
<td>14,000</td>
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<tr>
<td>MAN 16V51/60DF</td>
<td>16,000</td>
</tr>
<tr>
<td>MAN 18V51/60DF</td>
<td>18,000</td>
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</tbody>
</table>
World-Class Service
Marine propulsion, gensets, and stationary plants

The PrimeServ offering
The MAN Diesel & Turbo Group offers worldwide, round-the-clock service, 365 days a year. In addition to MAN Diesel & Turbo’s service headquarters in Augsburg, Copenhagen, Frederikshavn, Saint-Nazaire, Hamburg and Stockport, service centers on all continents provide comprehensive and continuous support.

MAN Diesel & Turbo engines are renowned for their quality and durability. We are a global organization with a strong local presence, delivering exceptional field service management, tailor-made solutions, and first-class technical support.

PrimeServ provides advice and assistance to customers throughout the product life cycle, from delivery to resale. With our far-reaching network of service centers, we respond rapidly to customer needs. Furthermore, we offer outstanding service and unrivalled technical expertise. Plus, we only use genuine spare parts – safeguarding the longevity of your engine.

PrimeServ’s aim is to provide:
- Prompt delivery of high-demand OEM spare parts within 24 hours
- Fast, reliable and competent customer support
- Individually tailored O&M contracts
- Ongoing training and qualification of operators and maintenance staff
- Global service, 24 hours a day, 365 days a year
- Diagnosis and troubleshooting with our high-performance Online Service
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