G-Type Engine
Revolutionary Ultra-Long-Stroke

Engineering the Future – since 1758.
MAN Diesel & Turbo
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G-Type Engine – Revolutionary Ultra-Long-Stroke
Promises lower rpm with significant fuel and CO₂ reductions of up to 7% as part of propulsion package

Introduction
The first G-type engine, designated G80ME-C, has a design that follows the principles of the large bore Mk 9 engine series that MAN Diesel & Turbo introduced in 2006. The G-type is designed with a longer stroke to reduce engine speed, thereby paving the way for ship designs with unprecedented high efficiency.

Ole Grøne, Senior Vice President Low Speed Sales and Promotion, MAN Diesel & Turbo, said: “MAN Diesel & Turbo always follows developments in the shipping market closely and we have kept a close eye on the trend for fuel optimisation in recent years. As such, we have experienced great interest in the G-type engine during extensive consultation with industry partners and are currently working on a variety of projects with shipyards and major shipping lines. As a result, we have reached the conclusion that the introduction of the G-type engine programme is both viable and timely.”

Grøne added: “The G-type is an ultra-long-stroke engine and represents the biggest development within our engine portfolio since the successful introduction of the ME electronic engine within the last decade.”

Rationale behind G-type introduction
Tankers and bulk carriers have traditionally used MAN B&W S-type engines with their long stroke and low engine speed as prime-movers, while larger container vessels have tended to use the shorter-stroke K-type with its higher engine speed.

Larger container vessels, in recent years, have also been specified with S80ME-C9 and S90ME-C8 engines because of the opportunity they offer to employ larger propeller diameters. Following efficiency optimisation trends in the market, MAN Diesel & Turbo has also thoroughly evaluated the possibility of using even larger propellers and thereby engines with even lower speeds for the propulsion of tankers and bulk carriers.

Such vessels may be more compatible with propellers with larger diameters than current designs, and facilitate higher efficiencies following adaptation of the aft-hull design to accommodate a larger propeller. It is estimated that such new designs offer potential fuel-consumption savings of some 4-7%, and a similar reduction in CO₂ emissions. Simultaneously, the engine itself can achieve a high thermal efficiency using the latest engine process parameters and design features.

G-type progress
MAN Diesel & Turbo reports that design work for the first G-type is already in progress and final drawings for the structure, moving parts and fuel equipment are scheduled to be ready for delivery in mid-2011. The delivery of piping and gallery drawings is scheduled to follow in the second half of 2011, assuming a final order confirmation has been received by the end of 2010.

MAN Diesel & Turbo also confirms that other G-type engines of different cylinder diameters will be introduced on demand.

The gas-driven version of the G-type, designated ‘ME-GI’ is also an option. Indeed, MAN Diesel & Turbo has recently announced plans to carry out full-scale ME-GI testing at the company’s Copenhagen test centre in early 2011.

The ME-GI engine is a gas-injection, dual-fuel, low speed diesel engine that, when acting as main propulsion in LNG carriers or any other type of merchant marine vessel, can burn gas or fuel oil port to port, depending on the energy source available on board and dictated by relative cost and owner preference.
For VLCCs, it is estimated that the application of a 7G80ME-C will prompt an overall efficiency increase of 4-5%, compared with a 7S80ME-C9 or an alternative engine design with the same engine speed.

**Mk 9 engines**

<table>
<thead>
<tr>
<th></th>
<th>S80ME-C</th>
<th>K80ME-C</th>
<th>K90ME</th>
<th>K90ME-C</th>
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<tbody>
<tr>
<td>Power kW per cyl.</td>
<td>4,510</td>
<td>4,530</td>
<td>5,720</td>
<td>5,730</td>
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<tr>
<td>Speed (rpm)</td>
<td>78</td>
<td>104</td>
<td>94</td>
<td>104</td>
</tr>
<tr>
<td>Bore (mm)</td>
<td>800</td>
<td>800</td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>Stroke (mm)</td>
<td>3,450</td>
<td>2,600</td>
<td>2,870</td>
<td>2,600</td>
</tr>
<tr>
<td>Mep (bar)</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>$P_{\text{max}}$ (bar)</td>
<td>160</td>
<td>160</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>Mps (m/s)</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Length (7 cyl.) (mm)</td>
<td>12,034</td>
<td>12,034</td>
<td>13,395</td>
<td>13,395</td>
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</table>

**Savings in operating costs**

<table>
<thead>
<tr>
<th></th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propeller</td>
<td>3.6</td>
</tr>
<tr>
<td>Engine</td>
<td>1.0</td>
</tr>
<tr>
<td>Total</td>
<td>4.6</td>
</tr>
</tbody>
</table>

**Fig. 2: G-type engine data**

**Fig. 3: Savings in operating costs**
**SFOC reductions**

The G-type achieves SFOC reductions through a combination of several factors, such as:
- increased scavenge-air pressure
- reduced compression ratio (two-stroke Miller timing)
- increased maximum combustion pressure
- adjustments of compression volume and design changes.

MAN Diesel & Turbo directs attention to the improved low-load optimising possibilities; made available for both standard and fuel-optimised versions. This can be achieved by using the low-load package technologies corresponding to and matching what others refer to as ‘delta’ and ‘low-load tuning’:
- exhaust gas bypass (EGB) for ME/ME-C, MC/MC-C and ME-B engines
- variable turbine area (VTA) of turbochargers for ME/ME-C, MC/MC-C and ME-B types
- part-load tuning of ME/ME-C engines
- turbocharger cut-out.

Documentation on low-load package technologies is currently being prepared for issue. In the intervening period, MAN Diesel & Turbo is ready to support interested customers with case studies of low-load package solutions for specific projects.

![Fig. 4: Illustration of low-load package SFOC performance possibilities for two-stroke engines](image)

**Controlled benefits**

The G-type engine is characterised by:
- low SFOC and superior performance parameters thanks to variable, electronically controlled timing of fuel injection and exhaust valves at any engine speed and load
- appropriate fuel injection pressure and rate shaping at any engine speed load
- flexible emission characteristics with low NOx and smokeless operation
- perfect engine balance with equalised thermal load in and between cylinders
- better acceleration in ahead and astern operation and crash stop situations
- wider operating margins in terms of speed and power combustions
- longer time between overhauls
- very low speed possible even for extended duration and Super Dead Slow operation manoeuvring
- individually tailored operating modes during operation
- fully integrated Alpha Cylinder Lubricators, with lower cylinder oil consumption
- an engine design lighter than its mechanical counterpart.
**Design features**

Power is also important, because a higher specific output means that engines with fewer cylinders can be applied, thereby significantly reducing costs. Besides the power aspect, MAN Diesel & Turbo has selected a number of design features to cater for the increased performance parameters while at the same time further increasing reliability.

There is also one major design change which yields a large weight saving, and this means introduction of differentiated cylinder distances. Typically, it is possible to utilise a shorter cylinder distance in the fore cylinder units because the torque to be transferred through the crank throws is smaller compared to the aft end of the engine.

**Bedplate**

In order to reduce production costs, no machining of bearing girder side walls is applied after welding.

Main bearings are of the well-proven thin shell design using white metal as bearing material. With a view to reducing production costs, the building-in of the bearing housing is modified in that the 25°/65° mating face between cap and bearing support in the present design, is changed to a horizontal assembly. This simplification necessitates a pair of high friction plates between the cap and bearing support in order for the assembly to be able to handle the shear forces.

For engines with 9-12 cylinders, the 360°-degree thrust bearing is used, which gives a weight saving compared to the traditional 240° degree thrust bearing, while at the same time achieving a stronger bedplate structure in the aft end, see Fig. 5. Also the diameter of the thrust cam is reduced, and so is the thrust bearing length. The thrust bearing housing forms a vessel and contains an oil bath which gives additional lubrication of the thrust bearing segments. Further benefits include only one type of segments, and optimal utilisation of the segments according to the magnitude of the thrust at the fore and aft ends by using 12 segments fore (360 deg.) and 8 segments aft (240 deg.).

A further advantage with this design is that the thrust acts on the centreline of the crank shaft compared with the traditional design where the force is somewhat offset from the centreline.

For engines with fewer cylinders than mentioned above, the 240-deg. thrust bearing will be maintained to cater for the lower thrust force to be transferred. In the thrust bearing design, our goal is to benefit from our latest design improvements. A common feature to all of them is that performance and reliability will be improved without increasing the cost.

![Fig. 5: Thrust bearing design – 240 degrees (left), 360 degrees (right)](image-url)
Twin staybolts
As has been practice for a number of years, the bedplate is designed for twin staybolts attached in the top of the bedplate. This well-known design feature is very important to obtain good main bearing performance, as tightening of the staybolts with this design does not give rise to geometrical distortion of the main bearing housing.

Flexible thrust cam
This design, see Fig. 6, has already been introduced on MAN Diesel & Turbo S65ME-C engine. The machined grooves in the thrust cam optimise the bearing load in the thrust bearing, which means:
- reduced oil film pressure whereby the max. bearing pressure is reduced
- increased oil film thickness
- improved load distribution on the thrust segments, thereby reducing the area and, thus, the thrust cam dimensions.

Fig. 6: Flexible thrust bearing cam
Cylinder frame

As standard, the cylinder frame of the updated engines is of the cast design. A welded cylinder frame is optional, see Fig. 7. This was decided in order to reflect the preference of the licensees as experienced over the later years. There are a number of inherent advantages in the welded design, such as increased rigidity and reduced weight. Furthermore, the welded design makes it possible to integrate the scavenge air receiver in the cylinder frame, see Fig. 8, giving rise to a total weight saving of 30%. In addition to this important feature, dimensions are smaller.

The reason why the welded design is made optional reflects a general preference among engine builders and is because foundry capacity in general has increased. The welded cylinder frame will also be available with a bolted on scavenge air receiver as an option in order not to take up too much time on large plane millers. Parts are interchangeable between the welded and cast cylinder frame designs.

Frame box

The G-type engines have a triangular plate frame box with twin staybolts (see Figs. 9 and 10) and have the following main design criteria:

- the design should match or be superior to any existing MAN Diesel & Turbo engine design in terms of functionality
- production costs should be reduced.
- there should be an uprating potential for the future, without losing production benefits
- it should be possible to introduce a design prepared for omission of PW-HT (Post Weld - Heat Treatment).
With the substitution of horizontal ribs with vertical plates, a continuous triangle profile is formed from top to bottom, providing an even stiffness along the guide bar, which improves the conditions for the guide shoes’ sliding surface. Contact simulations have verified this improvement, and service experience has also shown an excellent bearing condition.

In general, production costs are reduced – especially welding costs. With the lower stress level in the structure, weld joints with reduced quality requirements can be used – ideally suited for welding robot techniques.

After large-scale laboratory testing and two years of service with the ‘triangular plate’ design in our large bore engines, S90MC-C and K98MC/MC-C, tests were initiated regarding the omission of PW-HT.

The positive test led to the omission of PW-HT for frame boxes with a triangular plate guide bar design. In essence, the benefits of the design are:
- uniform higher rigidity
- lower stress level
- easier production.

**Combustion chamber**

MAN Diesel & Turbo large-bore engines have utilised the Oros combustion chamber since the late 1990s. The backbone of the Oros design is the piston and cylinder cover geometry, which concentrates the hot combustion gases around the fuel nozzles, and the high top land piston, which allows a low position of the mating surface between cylinder liner and cylinder cover, thereby reducing liner wall temperatures and giving controlled cold corrosion, which is good for refreshing the liner surface.

Besides these basic Oros design features, the piston ring pack is of the latest design to increase resistance against scuffing. Hard coating to the first and the fourth piston rings on K90 and K98 has been introduced, and the position of the CL grooves (controlled leakage grooves) has also been changed to secure a more even heat distribution. The CL groove depth has been reduced by 20%.
Piston cooling insert

In order to obtain a comfortably low piston temperature in service, the so-called spray cooling insert, see Fig. 11, is applied.

To further protect the piston, inconel is applied on the piston top.

Exhaust valve

The exhaust valve unit is of a modified type, implying the use of a low grade cast iron housing with water cooling around the spindle guide and bore cooled twin stud bosses. The upper part of the housing forms the bottom of the air spring and the lower part forms part of the cooling chamber in the cylinder cover, see Fig. 12.
Design improvements on the exhaust side

The scavenge air receiver and the exhaust gas receiver have undergone a series of design improvements. An increased focus on welding details, smoother design and rigidity have made this possible. Modifications have been carried out on the auxiliary blower inlet, scavenge air cooler housing, turbocharger foundation, scavenge air receiver and exhaust gas receiver.

Water mist catcher

MAN Diesel & Turbo recently upgraded this design involving a more rigid frame to ensure structural integrity, optimising the lamella profiles so as to further improve water mist catching efficiency, and improving the sealing around the water mist catcher to avoid by-pass of water mist.

Electronic technology

The G-type benefits from MAN Diesel & Turbo’s ME-technology as well as continuous modifications to low-speed hydraulic power-supply and piping systems.

Servo oil supply

The G-type also utilises two standards for hydraulic servo oil supply:

- engine-driven oil supply
- electrically driven oil supply