

# L16/24

## IMO Tier II – Marine Generating Sets



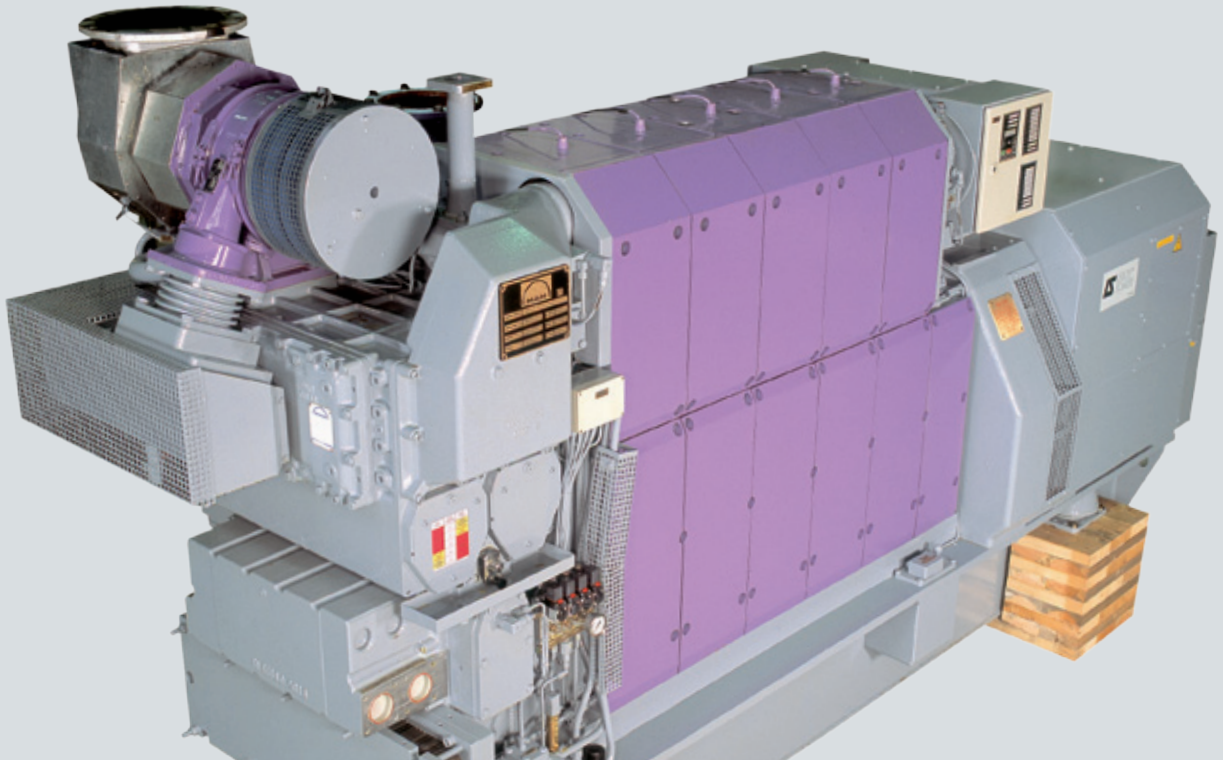
Engineering the Future – since 1758.

**MAN Diesel & Turbo**



# MAN L16/24

## GenSet power for marine applications



### The responsible way in leading technology

MAN Diesel & Turbo is the world's leading designer and manufacturer of low and medium speed engines – an estimated 50% of the world marine trade is powered by engines from MAN Diesel & Turbo.

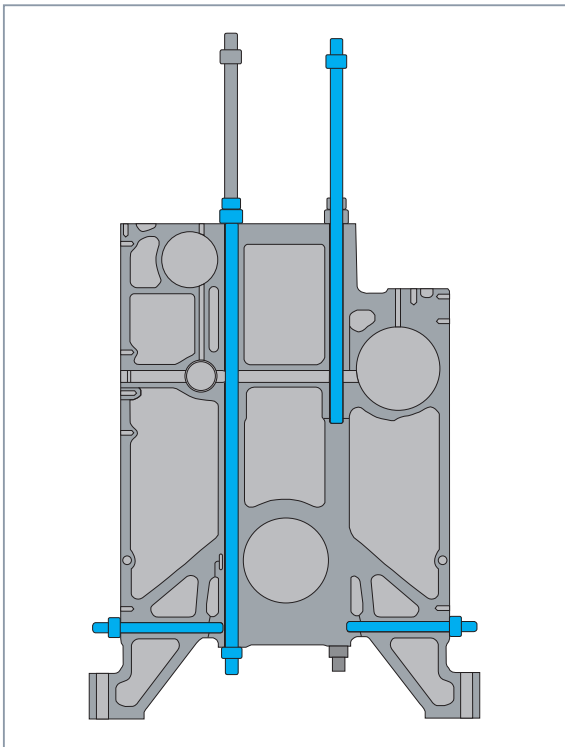
We develop two-stroke and four-stroke engines, auxiliary engines, turbochargers and propulsion packages that are manufactured both within the MAN Diesel & Turbo Group and at our licensees.

The foundation of MAN Diesel & Turbo's success in all applications, marine or stationary, is our unparalleled understanding of large engine technology. A vital part of our leadership stems from a firm belief

in the 'total systems approach' to engine building based on the identification of core competences and the pursuit of excellence in these areas.

### Basic concept

The cleanlined 'pipeless' design philosophy characterises the latest generation of MAN Generating Sets. A prize-winning concept, which has secured MAN Diesel & Turbo more awards. New ideas and features, however, are based on proven solid GenSet heritage. The MAN brand, has during generations, maintained and developed its position as the leading HFO-burning marine GenSet design.



*Engine block cross section*

The GenSet is designed as one unit, on a tailored and integrated base frame, complete with alternator and engine, with built-on auxiliary systems.

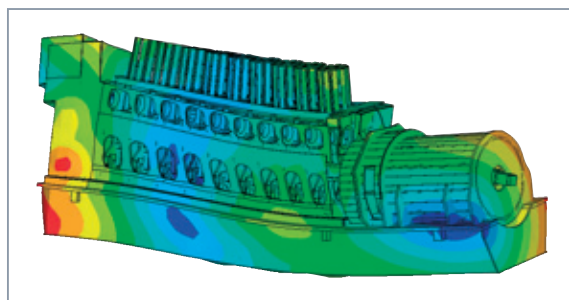
The hydraulically tightened tie rods are specifically positioned to maintain a static preloading of the engine block to absorb the dynamic loads generated by the impact from the combustion process and moving masses.

The complete GenSet is resiliently seated, vibration-analysed and balanced, and enclosed with specially designed covers to transmit minimal structure-borne and air-borne noise to ship and engine room.



### **Economic advantages**

The MAN L16/24 units are characterised by reliable and HFO-based GenSet power, delivered at the lowest possible accumulated costs during the entire lifecycle. A safe investment.



*Vibration analysis of the complete GenSet*



# Robustness and Reliability

for long-term trouble-free operation



## Basic design

The engine is designed for lifelong operational reliability. The sturdy engine block, stiff crankshaft and robust connecting rods are just some of the basic design characteristics, which secure trouble-free operation and long and safe overhaul intervals.

Like all MAN GenSets, the L16/24 is designed for reliability, availability and minimal downtime – it will be ready and running when you need it.

The company's dedicated strategy of continuous development and product refinement, which results from years of dedicated research, design innovations, performance follow-up and practical experience, means that you, with the MAN L16/24 GenSet as primary power source, are guaranteed peace of mind.

### Careful focus on key components

**Fuel injection pump.** The fuel injection pump, with integrated roller guide, is designed for safe cam contact. High injection pressure ensure perfect atomisation and efficient combustion of the heavy fuel oil. Low smoke values – ‘invisible smoke’ – is obtained over the entire load range.

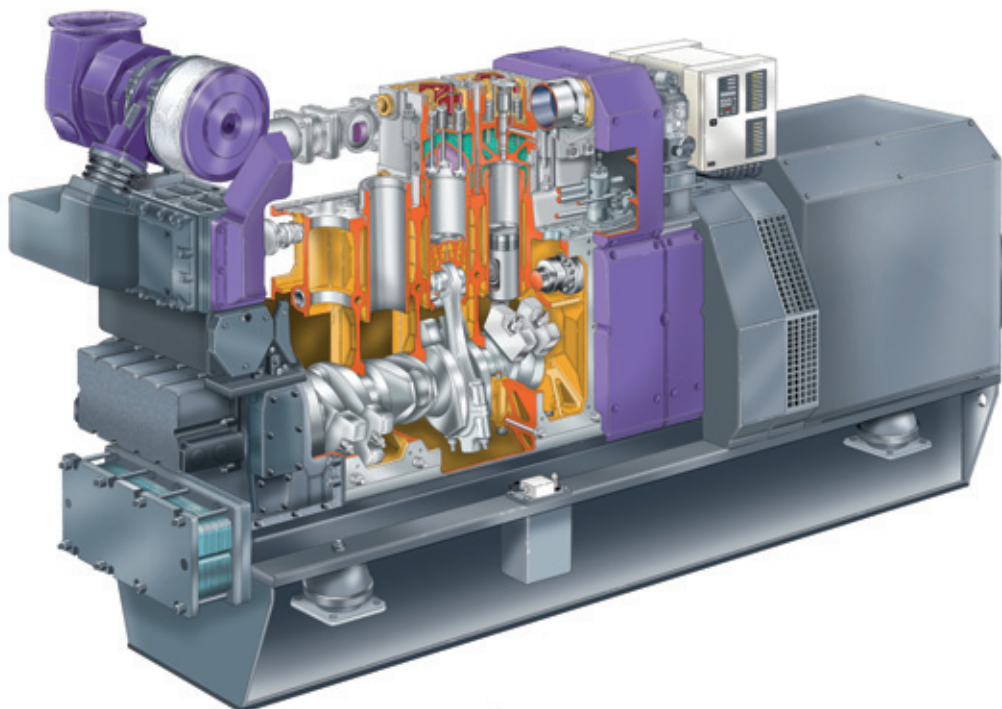
**Camshafts.** The camshafts are located for individual and direct activation of the fuel pump and valve gear respectively. Twin camshafts offer timing flexibility and special adaption possibilities. Surface hardened camshaft sections, optimally profiled for perfect activation, ensure good performance and long-term reliability.

**Cylinder liner with flame ring.** A thick-walled liner casting, which is cooled at the top, ensure stable geometry and good piston operating conditions under varying loads. The flame ring prevents bore polishing, ensures long liner life and low lube oil consumption.

**Piston and ring pack.** A robust composite piston design, with bore-cooled steel top, is the optimal choice for modern, high performance heavy fuel oil engines. The piston rings employ a special shape and material that control the wear properties for optimal long-term engine performance.

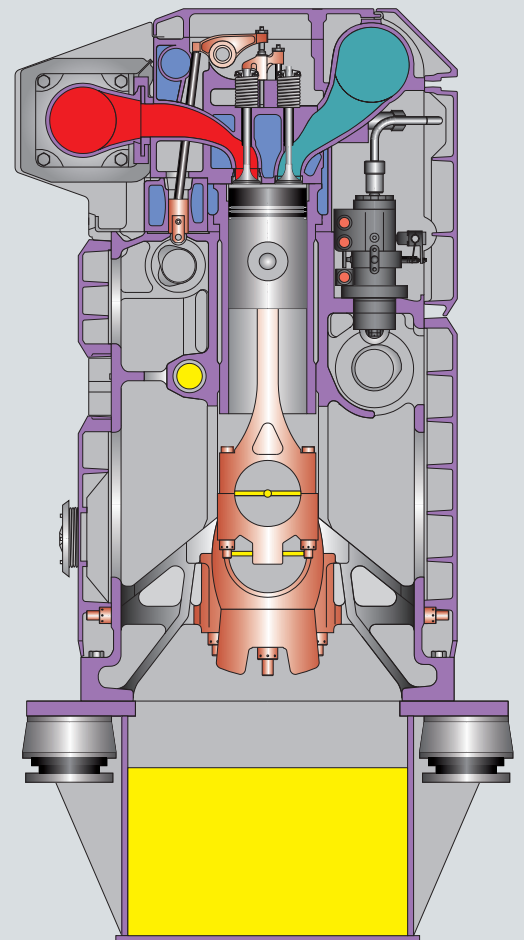
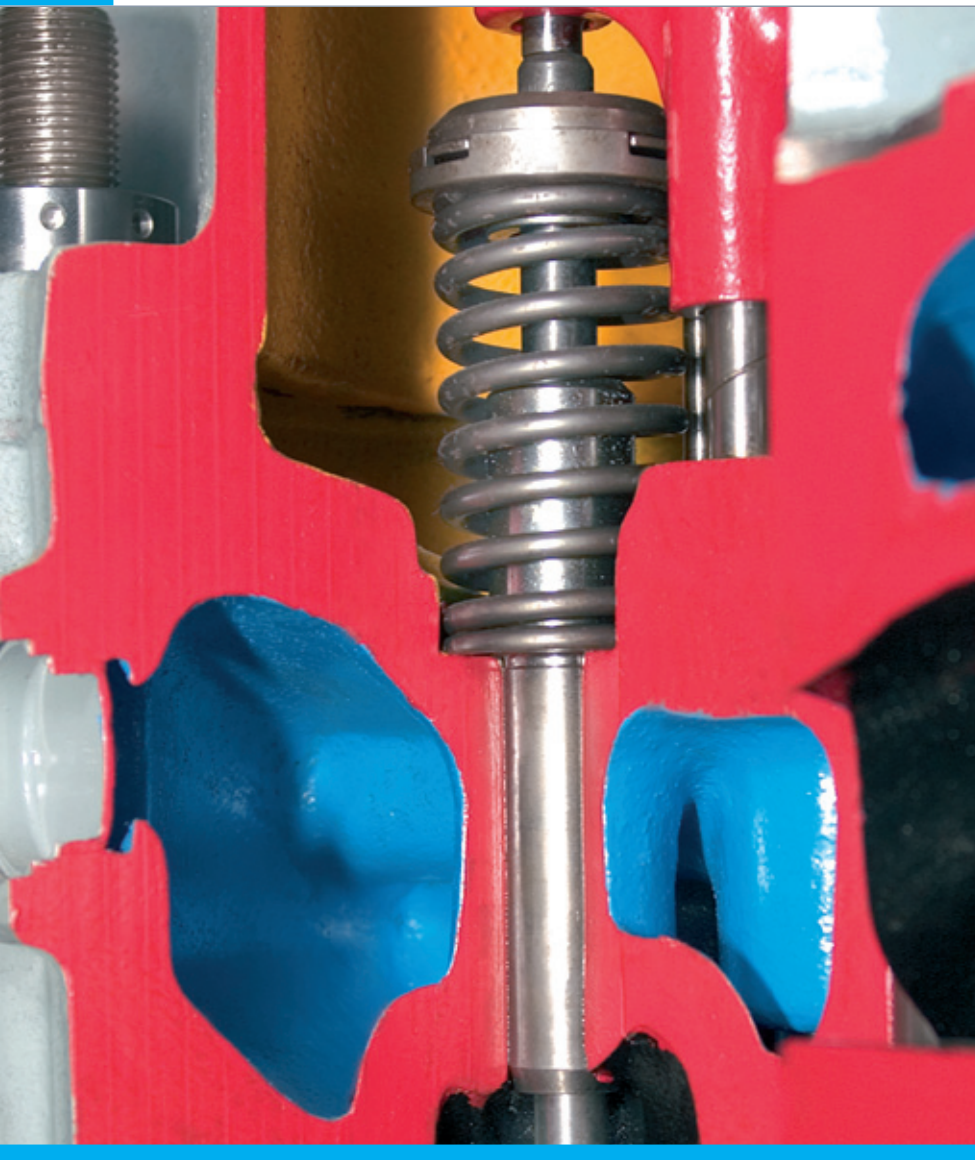
**Crankshaft and counter-weights.** The crankshaft is stiff and robustly designed, e.g. large crank pin diameters for large bearing surfaces. The finely tuned counter-weights on all crank webs reduce bearing loads and ensure a balanced and vibration-free engine.

**Bearings.** The long lifetime of bearings in general has been achieved through the use of the latest bearing materials in over-sized dimensions throughout the GenSet. Reduced stress, low specific bearing loads and large safety margins for the oil film improves the reliability of all components.



# Unique Design Features

## and key component benefits



### **Crossflow cylinder head**

The unique, crossflow designed cylinder head geometry, together with flow-optimised charge air and exhaust gas ducts produce the combustion chamber swirl-effect. This is the basis for a perfect mix of air and atomised fuel, optimal gas exchange and efficient combustion.



### Efficient MAN turbocharger

MAN Diesel & Turbo's latest TCR design of constant pressure high-efficiency turbocharger, with good acceleration properties, carefully matched with the engine gas exchange system, ensure charge air surplus at all engine loads and ability to handle large step loads with minimal smoke emission.

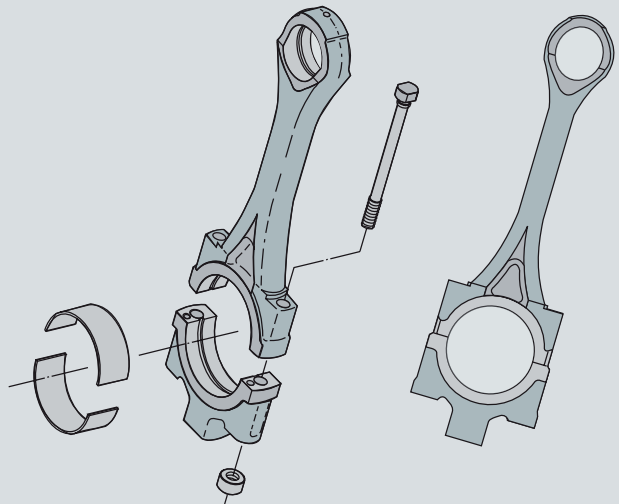
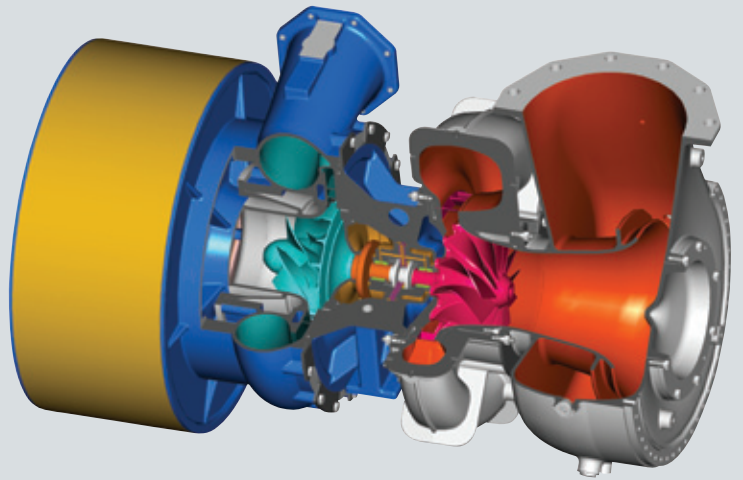
Long life and easy servicing are key parameters for the turbochargers. Overhaul and simple inspection intervals are extended to follow other routine maintenance of the engine.

### Connecting rod

A robust design feature for this size of engine. Due to the optimal flow of combustion forces, the solidly designed connecting rod offers stiffness and a high safety margin, which ensures an ideal housing for a good and stable long term bearing condition. For safe handling, the connecting rod is fitted with hydraulically tightened nuts.

### Valve train

The inlet and exhaust valve train has been designed with robust rotocaps, valve springs and valve guides for maximal safety margins at all operating conditions.



# Integrated Auxiliary Systems

## Temperature control, flow and cleanliness

For easy installation and maximum operational safety, the auxiliary systems are integrated and self-supported with the engine. The engine's advanced front-end box, which carries the turbocharger and charge air cooler, also incorporates engine driven cooling water pumps, lube oil pump, lube oil cooler, double full-flow depth lube oil filter and thermostatic valves.

### Cooling water system

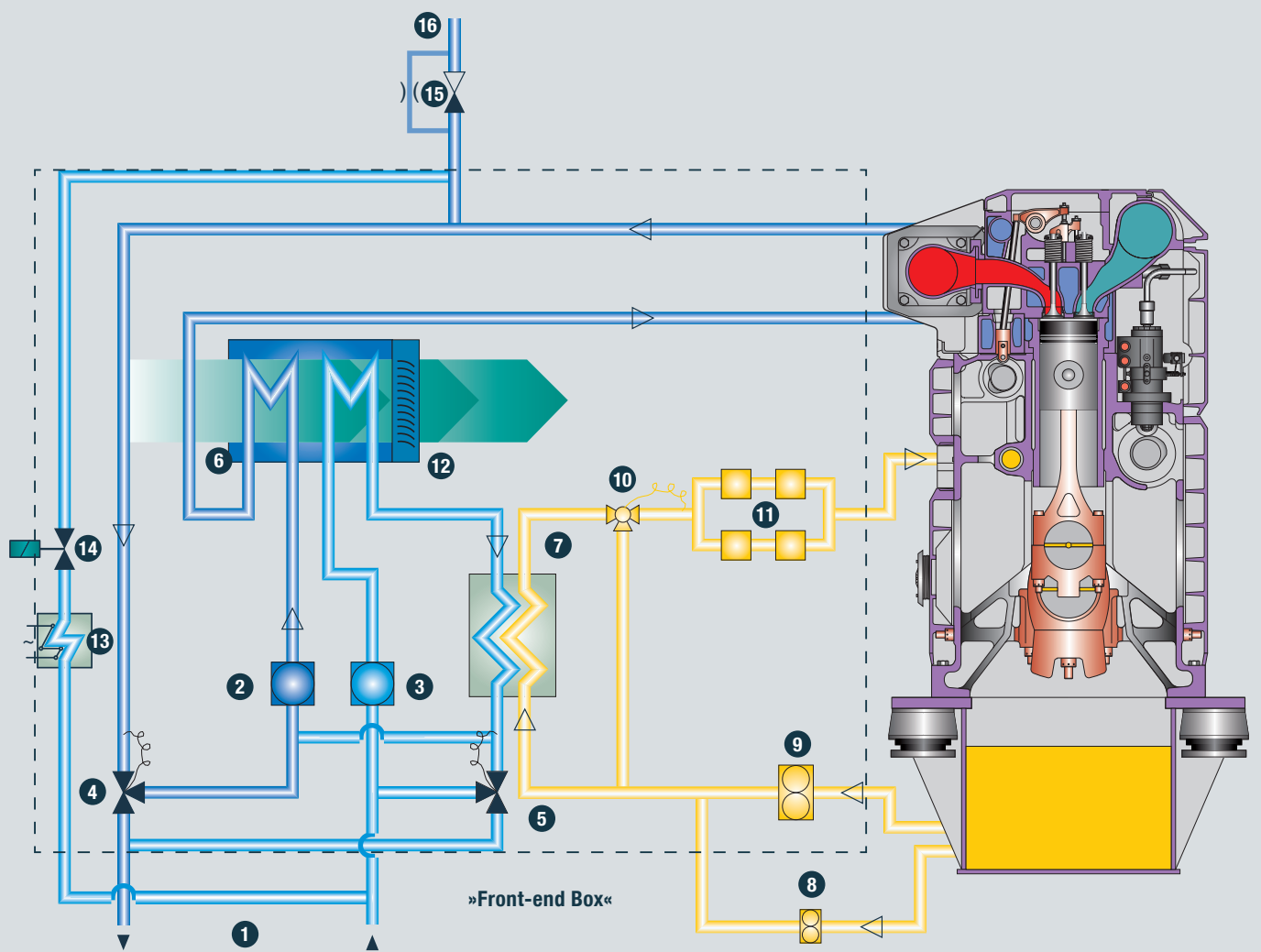
With only two flange connections, the system is easily handled by the shipyard. Optimal temperatures are ensured at all engine loads by each GenSets' intelligent and self-regulating internal cooling circuits. The charge air cooling/preheating is controlled in a two-stage system. The low temperature circuit controls the charge air (in 2nd stage of the charge air cooler) and the lube oil temperature, where as the high temperature circuit controls the temperatures in the cylinder heads, the water jackets around the combustion areas and in the 1st stage of the charge air cooler.

### Lubricating oil system

For maximum safety against possible contamination, the lube oil system, including filter and cooler, is a completely closed circuit. The full-flow lube oil filter has a mess-size of 10-15 microns, for maximum operational protection.

- (1) To/from central FW cooler
- (2) Engine driven FW HT pump
- (3) Engine driven FW LT pump
- (4) FW HT thermostatic valve
- (5) FW LT thermostatic valve
- (6) Two stage charge air cooler
- (7) LO cooler
- (8) Electrically driven pre LO pump
- (9) Engine driven LO pump
- (10) LO thermostatic valve
- (11) LO paper filter – duplex full-flow depth type
- (12) Water mist catcher (optional)
- (13) Preheater – electrical
- (14) Preheating valve
- (15) Non-return valve with restriction
- (16) To expansion tank

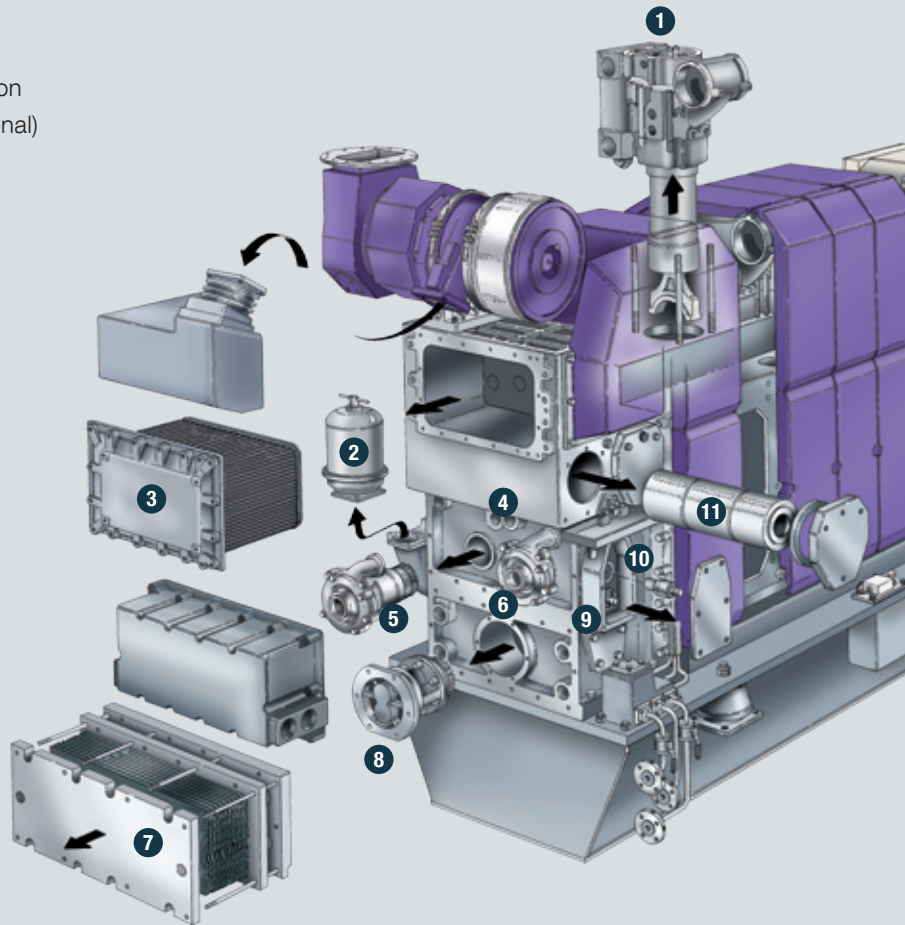




# Maintenance

## Easy, simple and safe

- (1) Cylinder unit – complete with piston
- (2) LO by-pass centrifugal filter (optional)
- (3) Two stage charge air cooler
- (4) FW HT thermostatic valve
- (5) FW HT pump
- (6) FW LT pump
- (7) LO cooler
- (8) LO pump
- (9) LO thermostatic valve
- (10) FW LT thermostatic valve
- (11) LO duplex full-flow depth filter



### Favoured by operators

The L16/24 engine is designed for minimal daily maintenance, few routine inspections and long time between overhauls. Engine inspections and overhauls can be carried out with a minimum of resources due to the pipeless design, the front-end box and the cylinder unit concept.

The front-end box design and the cylinder unit concept incorporate many features designed to make maintenance safe, easy and quick. Pumps, thermostats and filters are replaced by simple plug-out/plug-in actions.

The cylinder unit is handled as a single, complete removable item including piston and connecting rod, cylinder liner, water jacket and cylinder head.

Large engine covers provide quick, clear and easy access for inspections, overhauls and the necessary tools. Hydraulic tools are standardised for quick, easy and safe dismantling and assembly of, e.g., tie bolts/nuts for cylinder heads and connecting rods.



### Exchange service

The cylinder unit concept is ideal for various exchange service agreements.

A remarkable operator benefit realised by the engine's cylinder unit concept is the very short time needed to bring an engine back into service when replacing/overhauling the unit components. Maximum availability is ensured since the GenSet quickly can be brought back on the grid with a new set of interchangeable units, while the used set can be overhauled onboard – or, alternatively, be sent ashore for an authorised factory overhaul.

MAN PrimeServ's attractive 'EMC-Pit Stop' containerised exchange service option reduce the number of spares needed on board, including complete cylinder units – the spares being delivered when you need them.



### CoCoS

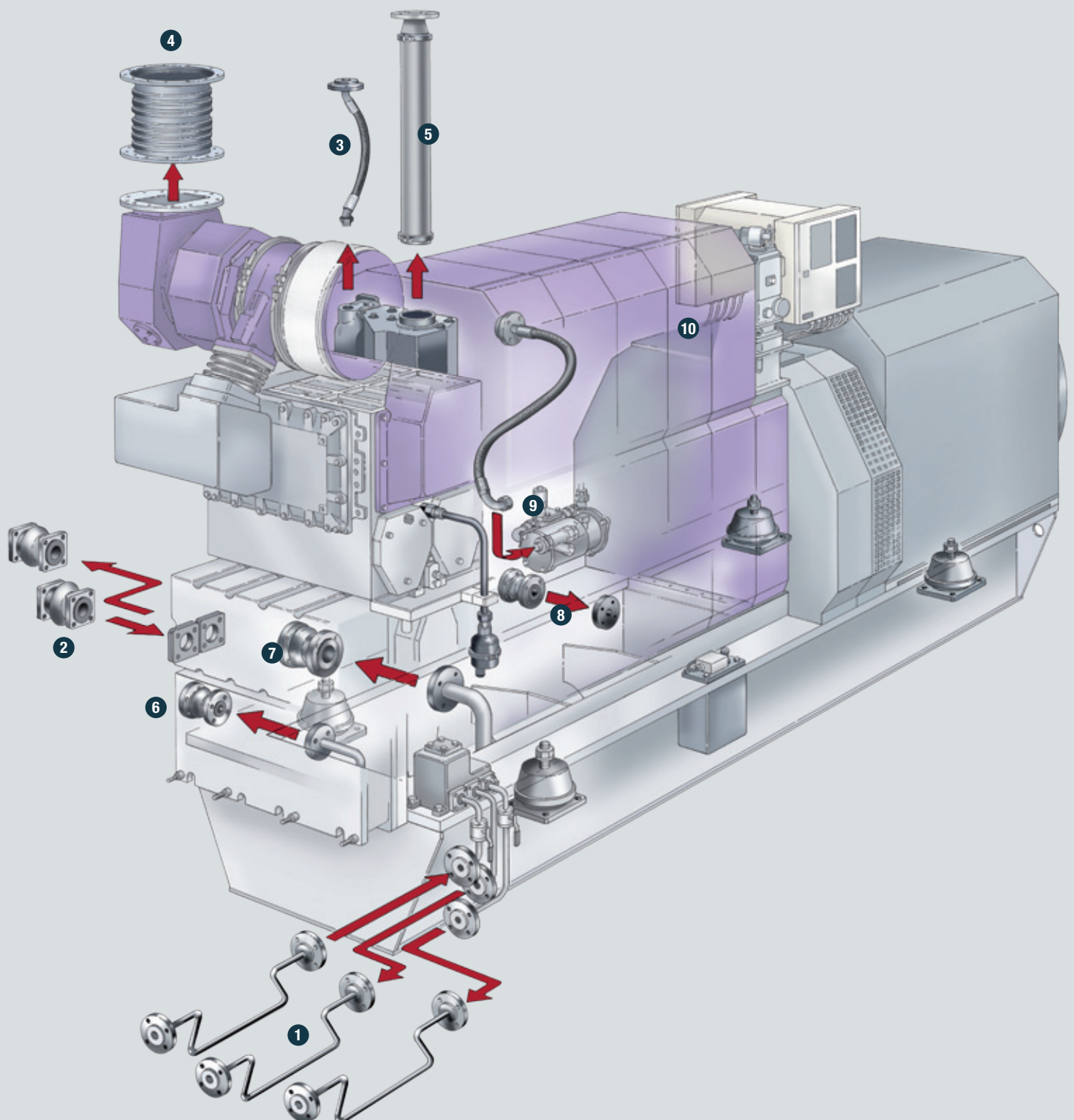
The CoCoS-EDS (Engine Diagnostics System) is a software developed by MAN Diesel & Turbo. CoCoS-EDS handles data logging, monitoring, trends and diagnostics. It can be operated with manual data entry or with operating values automatically transferred from the engine's monitoring and alarm system.

The comparison of actual running performance with the ideal situation permits the identification of problems and irregular running conditions. Data – presented as graphs, bar charts or alphanumerically – includes operating and reference values, pressure curves, load diagrams, characteristics maps and performance curves.



# Installation

Lift on board, plug and play



### System connections:

- (1) Fuel oil
- (2) Cooling water
- (3) Cooling water venting/preheating
- (4) Exhaust gas
- (5) Crankcase ventilation
- (6) To lube oil separator
- (7) Lube oil overflow
- (8) From lube oil separator
- (9) Starting air
- (10) Control, monitoring and alarm



### One compact unit

The L16/24 GenSet is supplied as a compact and very shipyard friendly unit. An efficient power package on an installation-ready common base frame – which takes up less space than comparable long-stroke engine powered GenSets.

### Save time and money

Easy seating and alignment simplifies the shipyard's tasks and reduces the man-hours needed to complete the work. Additionally, a minimal number of connecting points for, e.g., electrical cabling and pipe connections to the front-end box are easy accessible and optimally positioned for integration with the ships auxiliary systems.

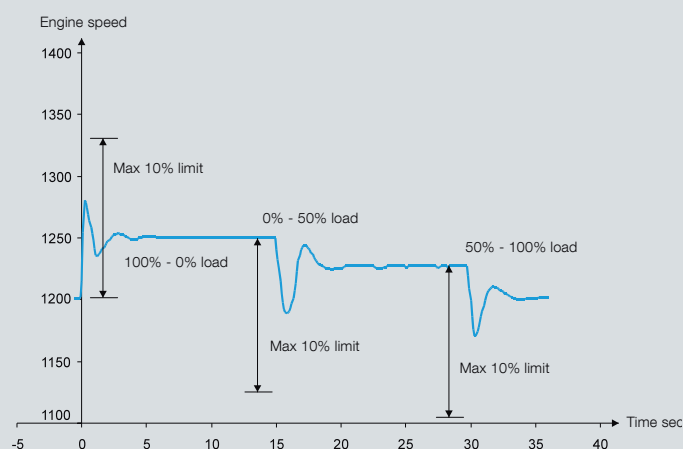
### 10 simple steps

– as part of the installation check list:

- Lift the GenSet on board
- Seat and align the unit on the foundation
- Connect cooling water
- Check lube oil connections
- Connect fuel oil
- Connect starting air
- Connect exhaust gas outlet
- Arrange for ventilation
- Connect electrical power cables
- Connect electrical control and alarm cables

# Environmental Characteristics

Well prepared for the future



*Perfect load response*

## Low sound levels

Together with the L16/24 engines' double block structure, special noise dampening engine covers are applied and result in low average sound levels.

## Invisible smoke

Low 'invisible smoke' values are obtained within the L16/24 GenSets' operating area. The smoke emission is suppressed at sudden load changes. Due to the lambda controller system, efficient turbo-charging and gas exchange system – the GenSets have proven unique ability to take 100% load in only two steps with a minimum of visible smoke.

## Man and machine

Operator safety and handling friendliness have been given high priority, with extensive use of ergonomically correct solutions related to lifting gear, hydraulic tools, flanges and couplings.

## Exhaust gas emission

As standard the NO<sub>x</sub> exhaust gas emissions from the L16/24 engines are below today's IMO Tier II limits.

## Measures for reducing NO<sub>x</sub> emissions

The latest step in the development of the MAN engine range is across-the-board compliance with the limits specified in Tier II of the emissions legislation of the International Maritime Organisation, IMO. Reduced emissions of NO<sub>x</sub> while still maintaining optimum operating economy:

**Improved charge air cooler.** A significant reduction in NO<sub>x</sub> emissions is attained on the L16/24 GenSet engines by the use of a larger capacity charge air cooler. This effects a reduction in the temperature of the charge air and hence of combustion temperature. This, in turn, reduces NO<sub>x</sub> formation significantly.



# L16/24 Main Data

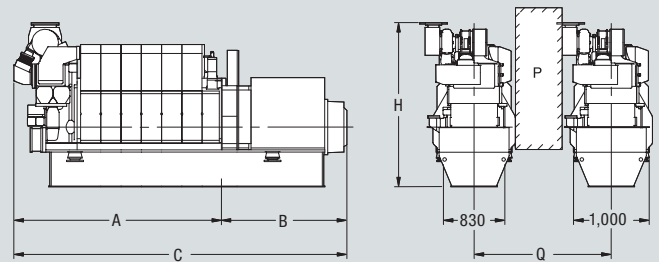
## Output and dimensions

**TCR with RCF33 wheel.** The use of MAN type TCR radial turbochargers equipped with the RCF33 compressor wheel can alleviate the  $\text{NO}_x$ -SFOC trade off. The better pressure ratio of the turbocharger increases the efficiency of the engine and thus compensates the increase in SFOC normally associated with the lower  $\text{NO}_x$  emissions. The higher compressor pressure ratio also increases the scope for Miller valve timing.

**Miller valve timing.** To reduce the temperature peaks which favour the formation of  $\text{NO}_x$ , Miller valve timings are employed. This method denotes the early closure of the inlet valve which causes the charge air to expand and cool. The resulting reduction in combustion temperature reduces  $\text{NO}_x$  emissions.

**Retarded injection.** As a counter-measure to the formation of  $\text{NO}_x$  at high combustion temperatures, injection timing is retarded. Combustion heat release is thus delayed resulting in lower combustion chamber temperatures.

**Increased compression ratio.** The use of a new piston contributes to compliance with the new, stricter IMO Tier II limit values. A higher compression ratio is achieved which leads to a faster reduction in temperature after the ignition of the fuel and thus reduced  $\text{NO}_x$  formation. In addition, the increase in compression ratio compensates the reduction in firing temperature due to retarded injection and hence the associated increase in SFOC.



Speed (r/min)	1,200		1,000	
Frequency (Hz)	60		50	
	Eng. kW	Gen. kW*	Eng. kW	Gen. kW*
5L16/24	500	475	450	430
6L16/24	660	625	570	542
7L16/24	770	730	665	632
8L16/24	880	835	760	722
9L16/24	990	940	855	812

Cyl. No.	5	6	7	8	9
A (mm)	2,751	3,026	3,501	3,776	4,051
B (mm)	1,400	1,490	1,585	1,680	1,680
C (mm)	4,151	4,516	5,086	5,456	5,731
H (mm)	2,457	2,457	2,495/2,457	2,495	2,495
Dry Mass (t)	9.5	10.5	11.4	12.4	13.1

Bore	160 mm
Stroke	240 mm
Cycle	Four-stroke
Cyl. configuration	In-line
Power range	450-990 kW
Speed (60/50 Hz)	1,000/1,200 r/min
Mean piston speed	8.0/9.6 m/s
Mean effective pressure	20.7-23.6 bar
Power per cyl.	90-110 kW
Max combustion pressure	170 bar
Fuel acceptance	MDO, MGO and HFO up to 700 cSt/50°C

\* Based on nominal generator efficiencies of 95%

P: Free passage between the engines, width 600 mm and height 2,000 mm  
Q: Min. distance between centre of engines: 1,800 mm

**MAN Diesel & Turbo**  
Østervej 2  
4960 Holeby, Denmark  
Phone +45 54 69 31 00  
Fax +45 54 69 30 31  
Info-hol@mandieselturbo.com  
www.mandieselturbo.com