MAN B&W S50MC6

Project Guide

Camshaft Controlled
Two-stroke Engines

This Project Guide is intended to provide the information necessary for the layout of a marine propulsion plant.

The information is to be considered as **preliminary**. It is intended for the project stage only and subject to modification in the interest of technical progress. The Project Guide provides the general technical data available at the date of issue.

It should be noted that all figures, values, measurements or information about performance stated in this project guide are **for guidance only** and should not be used for detailed design purposes or as a substitute for specific drawings and instructions prepared for such purposes.

Data updates
Data not finally calculated at the time of issue is marked ‘Available on request’. Such data may be made available at a later date, however, for a specific project the data can be requested. Pages and table entries marked ‘Not applicable’ represent an option, function or selection which is not valid.

The latest, most current version of the individual Project Guide sections are available on the Internet at: www.mandiesel.com under ‘Marine’ → ‘Low Speed’.

Extent of Delivery
The final and binding design and outlines are to be supplied by our licensee, the engine maker, see Chapter 20 of this Project Guide.

In order to facilitate negotiations between the yard, the engine maker and the customer, a set of ‘Extent of Delivery’ forms is available in which the basic and the optional executions are specified.

Electronic versions
This Project Guide book and the ‘Extent of Delivery’ forms are available on a DVD and can also be found on the Internet at: www.mandiesel.com under ‘Marine’ → ‘Low Speed’, where they can be downloaded.

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Engine Design

1

The MC/MC-C Engine

Whether the freight rates rise or fall, an attractive payback time for newbuildings starts with low investment cost. Once in operation, the ease and flexibility in assigning engineers to operate the engine plant are together with low consumption rates of fuels, lubes, parts and service among the important functional issues which contribute to the cost benefit. The MAN B&W MC/MC-C engine meets both requirements.

The world market-leading two-stroke MC/MC-C engine programme from MAN Diesel has evolved since the early 1980s to embrace bore sizes from 260 mm to 980 mm for propelling ocean-going ships of all types and sizes. In fact, low-speed two-stroke main engines of the MC/MC-C type have become industry standard in a huge number of ship types. Also land-based applications (power plants mainly) have found the MC/MC-C engine types attractive.

The MC/MC-C engine features chain driven camshaft, camshaft controlled fuel injection timing and exhaust valve opening as well as a conventional fuel oil pumps, all well-known and proven technology familiar to marine engineers all over the world.

To conclude, the MAN B&W MC/MC-C engine combines classic virtues of commonly known, well-proven technology continuously upgraded and up-rated to suit the requirements to modern prime movers. Consequently, our latest cutting edge design and manufacturing features are built into each component.

Concept of the MC/MC-C engine

The engine concept is based on a mechanical camshaft system for activation of the fuel injection and the exhaust valves. The engine is provided with a pneumatic/electric manoeuvring system and the engine speed is controlled by an electronic/hydraulic type governor.

Each cylinder is equipped with its own fuel injection pump, which consists of a simple plunger activated by the fuel cam directly. Fuel economy at part load is optimized by means of the Variable Injection Timing (VIT) incorporated in the fuel pumps (optional on certain MC-C engines).

The cam controlled exhaust valve is opened hydraulically and closed by means of an air spring.

Lubrication is either by means of a uni-lube oil system serving both crankshaft, chain drive, piston cooling and camshaft or a combination of a main lubricating oil system and a separate camshaft lube oil system.

Cylinder lubrication is accomplished by electronically controlled Alpha lubricators, securing a low lube oil consumption, or timed mechanical lubricators alternatively.

The starting valves are opened pneumatically by control air from the starting air distributor(s) and closed by a spring.

The MC-C engine is the shorter, more compact version of the MC engine. It is well suited wherever a small engine room is requested, for instance in container vessels.

The main features of the MC engine are described in the following pages.

For further information about the application of MC/MC-C engines based on ship particulars and power demand, please refer to our publications titled:

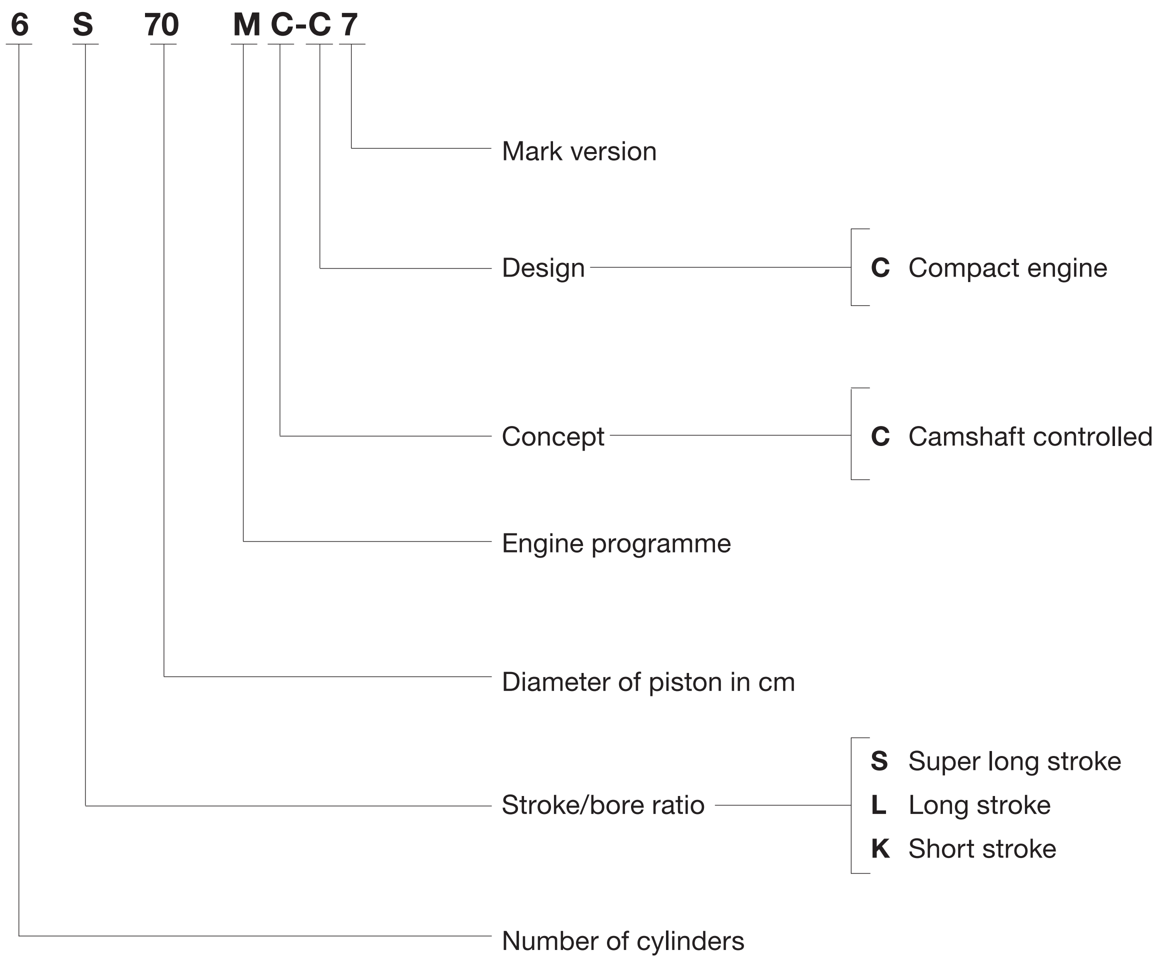
Propulsion Trends in Container Vessels

Propulsion Trends in Bulk Carriers

Propulsion Trends in Tankers

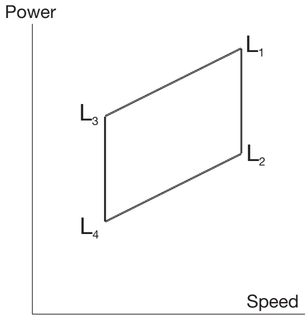
The publications are available at:
www.mandiesel.com under
‘Quicklinks’ → ‘Technical Papers’

Engine Type Designation



Power, Speed, Fuel and Lubricating Oil Consumption

MAN B&W S50MC6
Bore: 500 mm
Stroke: 1,910 mm



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Power and speed

Layout points	Engine speed r/min	Mean effective pressure bar	Power kW Number of cylinders 5	6	7	8
L_1	127	18.0	7,150	8,580	10,010	11,440
L_2	127	11.5	4,550	5,460	6,370	7,280
L_3	95	18.0	5,350	6,420	7,490	8,560
L_4	95	11.5	3,400	4,080	4,760	5,440

Fuel and lubricating oil consumption

	Specific fuel oil consumption g/kWh				Lubricating oil consumption		
	With high efficiency turbocharger		With conventional turbocharger			Cylinder oil g/kWh	
At load Layout point	100%	80%	100%	80%	System oil Approximate g/kWh	Mechanical cyl. lubricator	MAN B&W Alpha cyl. lubricator
L_1	171	168	173	170	0.15	1.0-1.5	0.7
L_2	159	157	161	159			
L_3	171	168	173	170			
L_4	159	157	161	159			

Fig. 1.03.01 Power, speed, fuel and lubricating oil consumption

Engine Power Range and Fuel Oil Consumption

Engine Power

The following tables contain data regarding the power, speed and specific fuel oil consumption of the engine.

Engine power is specified in kW for each cylinder number and layout points L_1, L_2, L_3 and L_4.

Discrepancies between kW and metric horsepower (1 BHP = 75 kpm/s = 0.7355 kW) are a consequence of the rounding off of the BHP values.

L_1 designates nominal maximum continuous rating (nominal MCR), at 100% engine power and 100% engine speed.

L_2, L_3 and L_4 designate layout points at the other three corners of the layout area, chosen for easy reference.

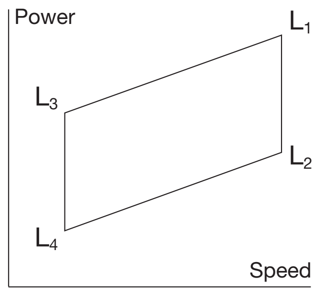

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Fig. 1.04.01: Layout diagram for engine power and speed

Overload corresponds to 110% of the power at MCR, and may be permitted for a limited period of one hour every 12 hours.

The engine power figures given in the tables remain valid up to tropical conditions at sea level as stated in IACS M28 (1978), i.e.:

Blower inlet temperature .... 45 °C
Blower inlet pressure .... 1000 mbar
Seawater temperature .... 32 °C
Relative humidity 60%

Specific fuel oil consumption (SFOC)

Specific fuel oil consumption values refer to brake power, and the following reference conditions:

ISO 3046/1-2002:
Blower inlet temperature .... 25°C
Blower inlet pressure .... 1000 mbar
Charge air coolant temperature .... 25 °C
Fuel oil lower calorific value .... 42,700 kJ/kg
(~10,200 kcal/kg)

Although the engine will develop the power specified up to tropical ambient conditions, specific fuel oil consumption varies with ambient conditions and fuel oil lower calorific value. For calculation of these changes, see Chapter 2.

SFOC guarantee

The figures given in this project guide represent the values obtained when the engine and turbocharger are matched with a view to obtaining the lowest possible SFOC values and fulfilling the IMO NO_x emission limitations.

The Specific Fuel Oil Consumption (SFOC) is guaranteed for one engine load (power-speed combination), this being the one in which the engine is optimised.

The guarantee is given with a margin of 5%.

As SFOC and NO_x are interrelated parameters, an engine offered without fulfilling the IMO NO_x limitations is subject to a tolerance of only 3% of the SFOC.

Lubricating oil data

The cylinder oil consumption figures stated in the tables are valid under normal conditions.

During running-in periods and under special conditions, feed rates of up to 1.5 times the stated values should be used.

Performance Curves

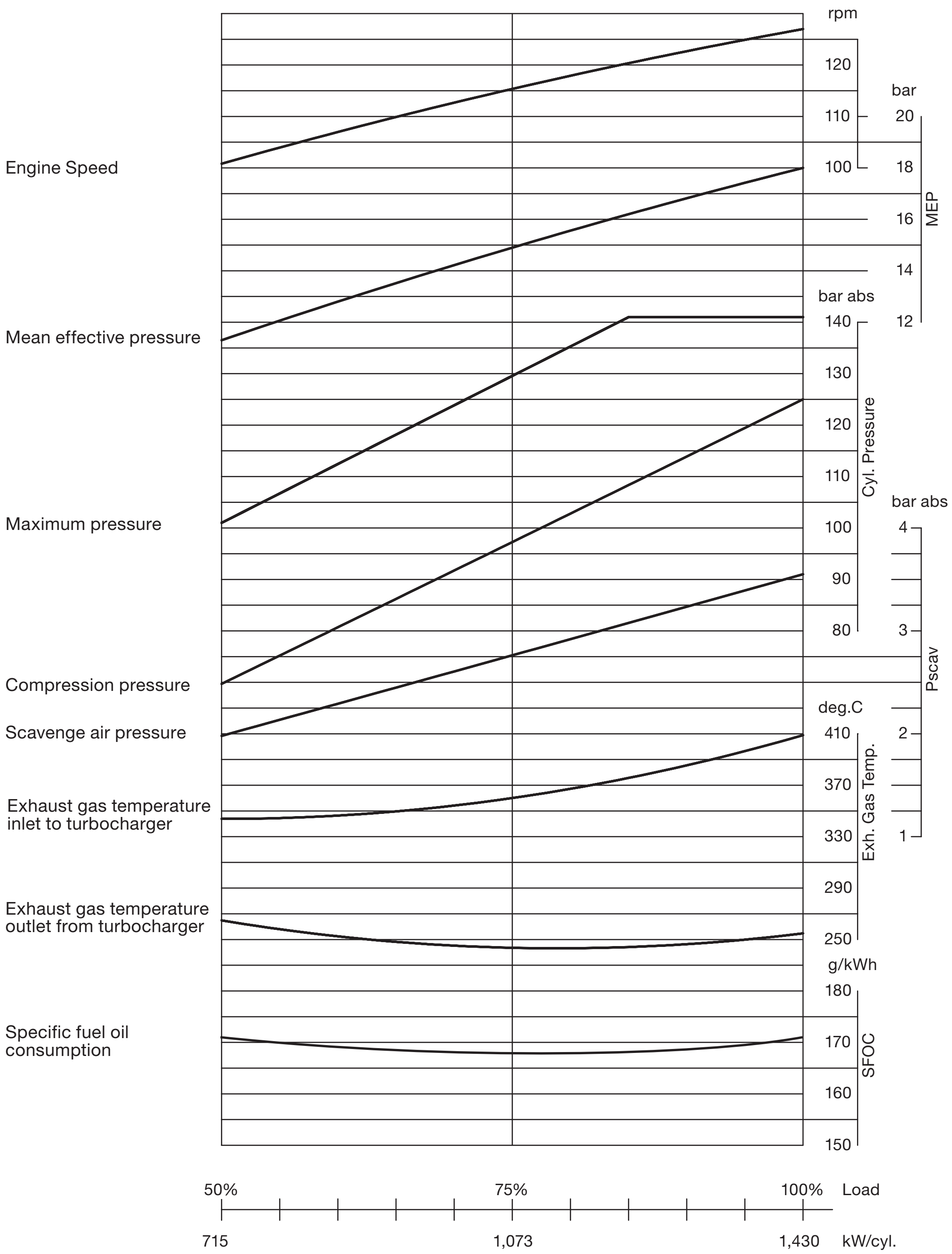

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Fig. 1.05.01: Performance curves

MC Engine Description

Please note that engines built by our licensees are in accordance with MAN Diesel drawings and standards but, in certain cases, some local standards may be applied; however, all spare parts are interchangeable with MAN Diesel designed parts.

Some components may differ from MAN Diesel's design because of local production facilities or the application of local standard components.

In the following, reference is made to the item numbers specified in the 'Extent of Delivery' (EoD) forms, both for the 'Basic' delivery extent and for some 'Options'.

Bedplate and Main Bearing

The bedplate is made with the thrust bearing in the aft end of the engine. The bedplate consists of high, welded, longitudinal girders and welded cross girders with cast steel bearing supports.

For fitting to the engine seating in the ship, long, elastic holding-down bolts, and hydraulic tightening tools are used.

The bedplate is made without taper for engines mounted on epoxy chocks.

The oil pan, which is made of steel plate and is welded to the bedplate, collects the return oil from the forced lubricating and cooling oil system. The oil outlets from the oil pan are normally vertical and are provided with gratings.

Horizontal outlets at both ends can be arranged for some cylinder numbers, however, this must be confirmed by the engine builder.

The main bearings consist of thin walled steel shells lined with bearing metal. The main bearing bottom shell can be rotated out and in by means of special tools in combination with hydraulic tools for lifting the crankshaft. The shells are kept in position by a bearing cap.

Frame Box

The frame box is of triangular plate welded or rib design. On the exhaust side, it is provided with relief valves for each cylinder while, on the manoeuvring side, it is provided with a large hinged door for each cylinder. The crosshead guides are welded onto the frame box.

The frame box is bolted to the bedplate. The bedplate, frame box and cylinder frame are tightened together by stay bolts.

Cylinder Frame and Stuffing Box

The cylinder frame is either welded or cast and is provided with access covers for cleaning the scavenge air space, if required, and for inspection of scavenge ports and piston rings from the manoeuvring side. Together with the cylinder liner, it forms the scavenge air space.

The cylinder frame is fitted with pipes for the piston cooling oil inlet. The scavenge air receiver, turbocharger, air cooler box, lubricators and gallery brackets are located on the cylinder frame. At the bottom of the cylinder frame there is a piston rod stuffing box, provided with sealing rings for scavenge air. Oil scraper rings in the stuffing box prevent crankcase oil from coming up into the scavenge air space and polluting the crankcase oil with combustion waste products.

Drains from the scavenge air space and the piston rod stuffing box are located at the bottom of the cylinder frame.

Cylinder Liner

The cylinder liner is made of alloyed cast iron and is suspended in the cylinder frame with a low-situated flange. The top of the cylinder liner is fitted with a cooling jacket.

The cylinder liner has scavenge ports, drilled holes for cylinder lubrication and is prepared for installation of temperature sensors, if required.

Cylinder Cover

The cylinder cover is of forged steel, made in one piece, and has bores for cooling water. It has a central bore for the exhaust valve, and bores for the fuel valves, a starting valve and an indicator valve.

The cylinder cover is attached to the cylinder frame with studs and nuts tightened with hydraulic jacks.

Crankshaft

The crankshaft is mainly of the semi-built type, made from forged or cast steel throws while fully forged in the S35MC7, L35MC6 and S26MC6 engines. In engines with 9 cylinders or more the crankshaft is supplied in two parts.

At the aft end, the crankshaft is provided with the collar for the thrust bearing, and the flange for the turning wheel and for the coupling bolts to an intermediate shaft.

At the front end, the crankshaft is fitted with the collar for the axial vibration damper and a flange for the fitting of a tuning wheel. The flange can also be used for a Power Take Off, if so desired.

Coupling bolts and nuts for joining the crankshaft together with the intermediate shaft are not normally supplied.

Thrust Bearing

The propeller thrust is transferred through the thrust collar, the segments, and the bedplate, to the end chocks and engine seating, and thus to the ship's hull.

The thrust bearing is located in the aft end of the engine. The thrust bearing is of the B&W-Michell type, and consists primarily of a thrust collar on the crankshaft, a bearing support, and segments of steel lined with white metal.

MAN Diesel's flexible thrust cam design is used for the thrust collar on a range of engine types. The thrust shaft is an integrated part of the crankshaft and lubricated by the engine's lubricating oil system.

Turning Gear and Turning Wheel

The turning wheel is fitted to the thrust shaft and driven by a pinion on the terminal shaft of the turning gear, which is mounted on the bedplate. The turning gear is driven by an electric motor with built-in gear with brake.

A blocking device prevents the main engine from starting when the turning gear is engaged. Engagement and disengagement of the turning gear is effected manually by an axial movement of the pinion.

The control device for the turning gear, consisting of starter and manual control box, can be ordered as an option.

Axial Vibration Damper

The engine is fitted with an axial vibration damper, mounted on the fore end of the crankshaft. The damper consists of a piston and a split-type housing located forward of the foremost main bearing.

The piston is made as an integrated collar on the main crank journal, and the housing is fixed to the main bearing support. For functional check of the vibration damper a mechanical guide is fitted, while an electronic vibration monitor can be supplied as an option.

Tuning Wheel/ Torsional Vibration Damper

A tuning wheel or torsional vibration damper may have to be ordered separately, depending on the final torsional vibration calculations.

Connecting Rod

The connecting rod is made of forged steel and provided with bearing caps for the crosshead and crankpin bearings.

The crosshead and crankpin bearing caps are secured to the connecting rod with studs and nuts tightened by means of hydraulic jacks.

The crosshead bearing consists of a set of thin-walled steel shells, lined with bearing metal. The crosshead bearing cap is in one piece, with an angular cut-out for the piston rod.

The crankpin bearing is provided with thin-walled steel shells, lined with bearing metal. Lube oil is supplied through ducts in the crosshead and connecting rod.

Piston

The piston consists of a piston crown and piston skirt. The piston crown is made of heat-resistant steel. A piston cleaning ring located in the very top of the cylinder liner scrapes off excessive ash and carbon formations on the piston topland.

The piston has four ring grooves which are hard-chrome plated on both the upper and lower surfaces of the grooves. The uppermost piston ring is of the Controlled Pressure Relief type (CPR), whereas the other three piston rings all have an oblique cut. All four rings are alu-coated on the outer surface for running-in.

The piston skirt is made of cast iron with a bronze band.

Piston Rod

The piston rod is of forged steel and is surface-hardened on the running surface for the stuffing box. The piston rod is connected to the crosshead with four bolts. The piston rod has a central bore which, in conjunction with a cooling oil pipe, forms the inlet and outlet for cooling oil.

Crosshead

The crosshead is of forged steel and is provided with cast steel guide shoes of low-friction design with white metal on the running surface.

The telescopic pipe for oil inlet and the pipe for oil outlet are mounted on the guide shoes.

Scavenge Air System

The air intake to the turbocharger takes place directly from the engine room through the turbocharger intake silencer. From the turbocharger, the air is led via the charging air pipe, air cooler and scavenge air receiver to the scavenge ports of the cylinder liners, see Chapter 14.

Scavenge Air Cooler

For each turbocharger a scavenge air cooler of the mono-block type is fitted. The cooler is designed as a central cooling system cooled by freshwater of maximum 4.5 bar working pressure. Alternatively, a seawater cooling system with up to 2.0 - 2.5 bar working pressure can be chosen.

The scavenge air cooler is so designed that the difference between the scavenge air temperature and the water inlet temperature at specified MCR can be kept at about 12 °C.

Auxiliary Blower

The engine is provided with electrically-driven scavenge air blowers. The suction side of the blowers is connected to the scavenge air space after the air cooler.

Between the air cooler and the scavenge air receiver, non-return valves are fitted which automatically close when the auxiliary blowers supply the air.

The auxiliary blowers will start operating consecutively before the engine is started in order to ensure sufficient scavenge air pressure to obtain a safe start.

Further information is given in Chapter 14.

Exhaust Gas System

From the exhaust valves, exhaust gas is led to the exhaust gas receiver where the fluctuating pressure from the individual cylinders is equalised, and the total volume of gas is led further on to the turbocharger(s). After the turbocharger(s), the gas is led to the external exhaust pipe system.

Compensators are fitted between the exhaust valves and the receiver, and between the receiver and the turbocharger(s).

The exhaust gas receiver and exhaust pipes are provided with insulation, covered by galvanised steel plating.

A protective grating is installed between the exhaust gas receiver and the turbocharger.

Exhaust Turbocharger

The engines can be fitted with either MAN Diesel, ABB or Mitsubishi turbochargers.

The turbocharger choice is described in Chapter 3, and the exhaust gas system in Chapter 15.

Camshaft and Cams

The camshaft is made in one piece with exhaust cams, fuel cams, and indicator drive cams.

The exhaust cams and fuel cams are made of steel, with a hardened roller race, and are shrunk onto the shaft. They can be adjusted and dismantled hydraulically.

The cam for the indicator drive can be adjusted mechanically.

The camshaft bearings mainly consist of one lower half-shell fitted in a bearing support, except on S50MC which has an upper half shell, too. The camshaft is lubricated by the main lubricating oil system.

Chain Drive

The camshaft is driven from the crankshaft by a chain drive, which is kept running tight by a manually adjusted chain tightener. The long free lengths of chain are supported by rubber-clad guidebars and the chain is lubricated through oil spray pipes fitted at the chain wheels and guidebars.

Indicator Drive

As separate options, the engine can be supplied with either an indicator drive, a mechanical indicator system, or the so-called PMI system, a pressure analyser system, described in section 18.02.

The indicator drive consists of a cam fitted on the camshaft and a spring-loaded spindle with a roller which moves up and down in accordance with the movement of the piston within the engine cylinder. At the top, the spindle has an eye to which the indicator cord is fastened after the indicator has been installed on the indicator valve.

Governor

The engine is to be provided with a governor of a make approved by MAN Diesel, controlling the fuel pump through an actuator. The governor must meet the ISO 3046 standard, part IV, 1997.

The speed setting of the actuator is determined by an electronic signal from the electronic governor based on the position of the main engine regulating handle. The actuator is connected to the fuel regulating shaft by means of a mechanical linkage.

Alternatively for engines without PTO, a mechanical/hydraulic Woodward governor for pneumatic speed setting could be provided.

Fuel Oil Pump and Fuel Oil High Pressure Pipes

The engine is provided with one fuel pump for each cylinder. The fuel pump consists of a pump housing of nodular cast iron, a centrally placed pump barrel, and a plunger of nitrated steel. In order to prevent fuel oil from mixing with the lubricating oil, the pump actuator is provided with a sealing arrangement.

The pump is placed on the roller guide housing and activated by the fuel cam. The volume injected is controlled by turning the plunger by means of a toothed rack connected to the regulating shaft.

As an option on S50MC-C, the fuel pumps incorporate Variable Injection Timing (VIT) for optimised fuel economy at part load (not applicable on smaller types). The VIT uses the governor fuel setting as the controlling parameter.

The fuel oil pump is provided with a puncture valve, which prevents high pressure from building up during normal stopping and shut down.

As an option on engines type 50, the roller guide housing is provided with a semi-automatic lifting device which, during rotation of the engine, can lift the roller guide free of the cam. On engines type 46 and smaller, a separate tool is used to lift the roller guide.

The fuel oil high-pressure pipes are either double-walled or of the hose type.

Further information is given in Section 7.01.

Fuel Valves and Starting Air Valve

Each cylinder cover is equipped with two or three fuel valves, starting air valve (SAV), and indicator valve.

The opening of the fuel valves is controlled by the high fuel oil pressure created by the fuel oil pump, and the valves are closed by a spring. The fuel valves are cooled by the fuel.

An automatic vent slide allows circulation of fuel oil through the valve and high pressure pipes when the engine is stopped. The vent slide also prevents the compression chamber from being filled up with fuel oil in the event that the valve spindle sticks. Oil from the vent slide and other drains is led away in a closed system.

The starting air valve is opened by control air from the starting air distributor and is closed by a spring. The control air supply is regulated so that the starting valves deliver starting air to the cylinders in the correct firing order.

Starting Air System

The starting air system comprises a main starting valve, a starting air distributor and a non-return valve, a bursting disc for the branch pipe and a starting valve on each cylinder. The main starting valve is connected with the manoeuvring system, which controls the start of the engine.

A slow turning valve can be ordered as an option. The slow-turning function is actuated manually from the manoeuvring console.

The starting air system is described in detail in Section 13.01.

Exhaust Valve

The exhaust valve consists of the valve housing and the valve spindle. The valve housing is made of cast iron and is arranged for water cooling. The housing is provided with a water cooled bottom piece of steel with a flame-hardened seat of the W-seat design.

On S50MC, the exhaust valve spindle is either a DuraSpindle or made of Nimonic. On S50MC-C and MC/MC-C engines type 46 and smaller, DuraSpindle is the basic execution and a spindle made of Nimonic an option. The housing is provided with a spindle guide in any case.

The exhaust valve is tightened to the cylinder cover with studs and nuts. It is opened hydraulically and closed by means of air pressure. The hydraulic system consists of a piston actuator placed on the roller guide housing, a high-pressure pipe, and a working cylinder on the exhaust valve. The piston actuator is activated by a cam on the camshaft.

In operation, the valve spindle slowly rotates, driven by the exhaust gas acting on small vanes fixed to the spindle.

On engines type 50, sealing of the exhaust valve spindle guide is provided by means of Controlled Oil Level (COL), an oil bath in the bottom of the air cylinder, above the sealing ring. This oil bath lubricates the exhaust valve spindle guide and sealing ring as well.

On engines type 46 and smaller, sealing of the exhaust valve spindle guide is provided by means of sealing air.

Cylinder Lubrication

The cylinder lubrication system can be of either the electronic MAN B&W Alpha cylinder lubrication system or a mechanical type.

The cylinder lubrication systems are described in detail in Chapter 9.

Manoeuvring System

The engine is provided with a pneumatic/electric manoeuvring and fuel oil regulating system. The system transmits orders from the separate manoeuvring consoles to the engine.

The regulating system makes it possible to start, stop, reverse the engine and control the engine speed. The speed control on the manoeuvring console gives a speed-setting signal to the governor, dependent on the desired number of revolutions.

At shut-down, the fuel injection is stopped by the puncture valves in the fuel pumps being activated, independently of the speed control. At reversing, the displaceable rollers in the driving mechanism for the fuel pumps are moved to the ‘Astern’ position by an air cylinder controlled by the starting air distributor.

The engine is provided with an engine side mounted console and instrument panel.

Reversing

On reversible engines (with Fixed Pitch Propellers mainly), reversing of the engine is performed by means of an angular displaceable roller in the driving mechanism for the fuel pump of each engine cylinder. The reversing mechanism is activated and controlled by compressed air supplied to the engine.

The exhaust valve gear is not to be reversed.

Gallery Arrangement

The engine is provided with gallery brackets, stanchions, railings, platforms, and ladders between platforms. The brackets are placed at such a height as to provide the best possible overhauling and inspection conditions.

The engine is prepared for top bracings on the exhaust side, or on the manoeuvring side.

Piping Arrangements

The engine is delivered with piping arrangements for:

- Fuel oil
- Heating of fuel oil pipes
- Lubricating oil, piston cooling oil and camshaft lubrication
- Cylinder lubricating oil
- Cooling water to scavenge air cooler
- Jacket and turbocharger cooling water
- Cleaning of scavenge air cooler
- Cleaning of turbocharger
- Fire extinguishing in scavenge air space
- Starting air
- Control air
- Safety air
- Oil mist detector
- Exhaust valve sealing air (types 46 and smaller)
- Various drain pipes.

All piping arrangements are made of steel piping, except the control air, safety air and steam heating of fuel pipes, which are made of copper.

The pipes are provided with sockets for local instruments, alarm and safety equipment and, furthermore, with a number of sockets for supplementary signal equipment. Chapter 18 deals with the instrumentation.

Engine Cross Section of S50MC6

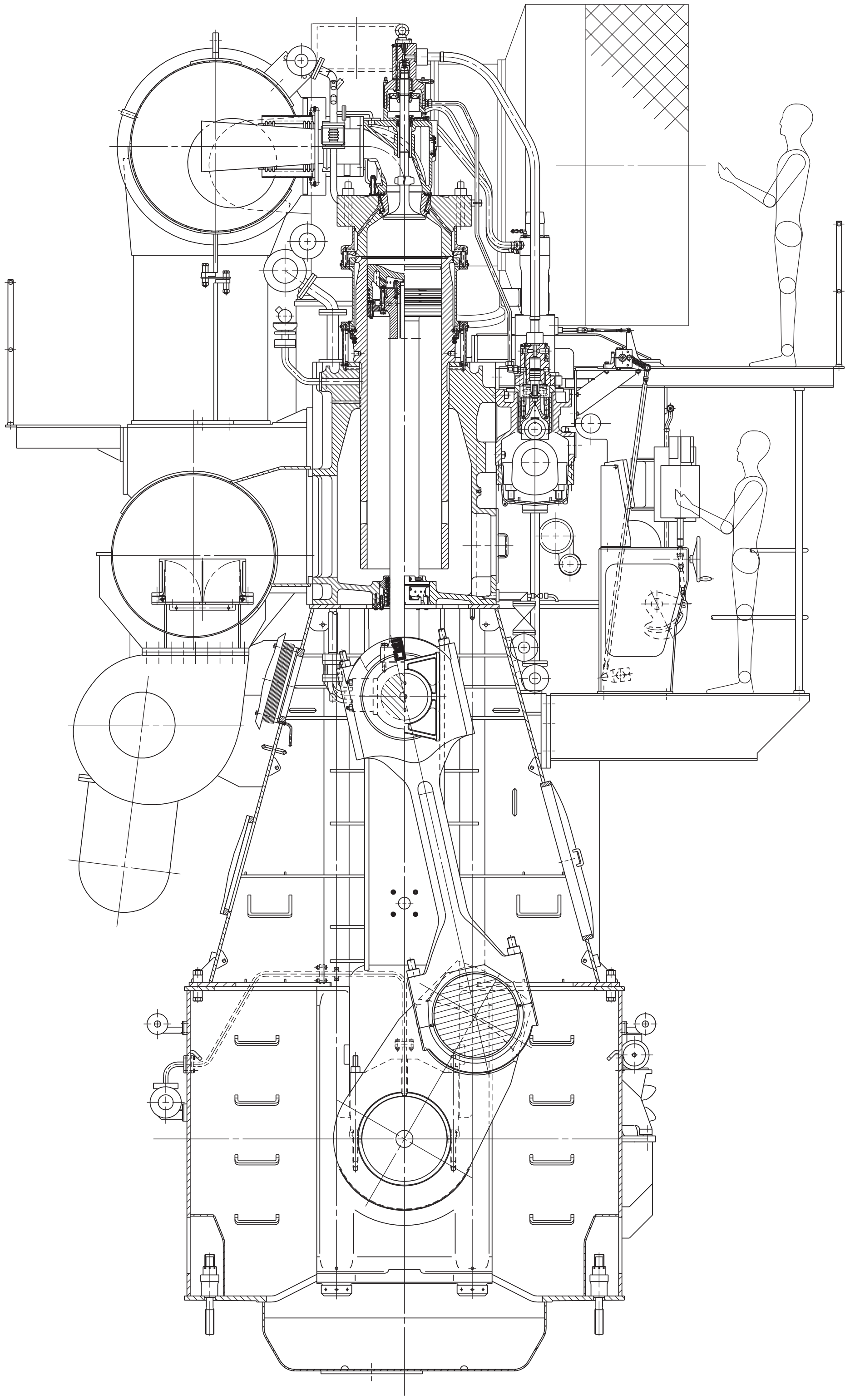

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Fig.: 1.07.01: Engine cross section

Engine Layout and Load Diagrams, SFOC

2

Engine Layout and Load Diagrams

Introduction

The effective power ‘P’ of a diesel engine is proportional to the mean effective pressure p_e and engine speed ‘n’, i.e. when using ‘c’ as a constant:

$$P = c \times p_e \times n$$

so, for constant mep, the power is proportional to the speed:

$$P = c \times n^1 \text{ (for constant mep)}$$

When running with a Fixed Pitch Propeller (FPP), the power may be expressed according to the propeller law as:

$$P = c \times n^3 \text{ (propeller law)}$$

Thus, for the above examples, the power P may be expressed as a power function of the speed ‘n’ to the power of ‘i’, i.e.:

$$P = c \times n^i$$

Fig. 2.01.01 shows the relationship for the linear functions, y = ax + b, using linear scales.

The power functions $P = c \times n^i$ will be linear functions when using logarithmic scales:

$$\log (P) = i \times \log (n) + \log (c)$$

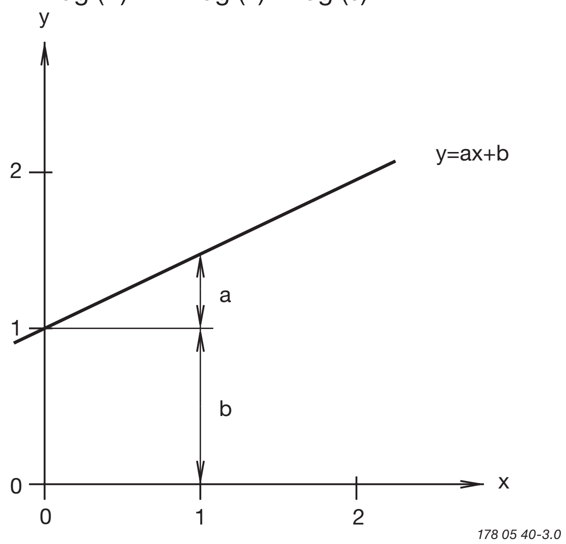


Fig. 2.01.01: Straight lines in linear scales

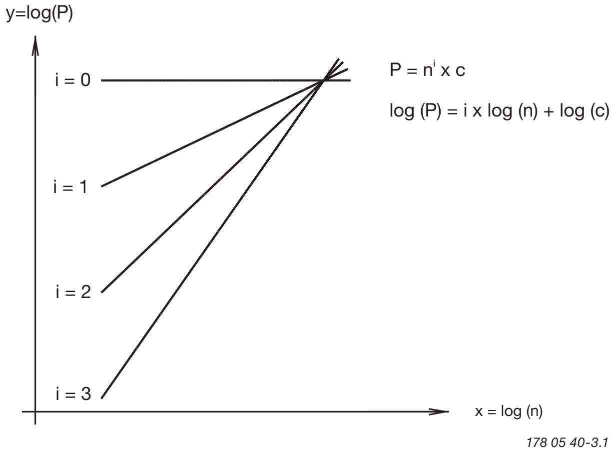


Fig. 2.01.02: Power function curves in logarithmic scales

Thus, propeller curves will be parallel to lines having the inclination i = 3, and lines with constant mep will be parallel to lines with the inclination i = 1.

Therefore, in the Layout Diagrams and Load Diagrams for diesel engines, logarithmic scales are used, giving simple diagrams with straight lines.

Propulsion and Engine Running Points

Propeller curve

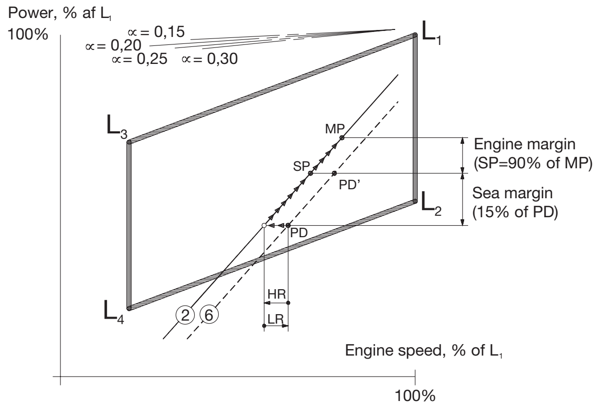
The relation between power and propeller speed for a fixed pitch propeller is as mentioned above described by means of the propeller law, i.e. the third power curve:

$$P = c \times n^3 \text{, in which:}$$

P = engine power for propulsion
n = propeller speed
c = constant

Propeller design point

Normally, estimates of the necessary propeller power and speed are based on theoretical calculations for loaded ship, and often experimental tank tests, both assuming optimum operating conditions, i.e. a clean hull and good weather. The combination of speed and power obtained may be called the ship’s propeller design point (PD), placed on the light running propeller curve 6. See below figure. On the other hand, some shipyards, and/or propeller manufacturers sometimes use a propeller design point (PD) that incorporates all or part of the so-called sea margin described below.



Line 2	Propulsion curve, fouled hull and heavy weather (heavy running), recommended for engine layout
Line 6	Propulsion curve, clean hull and calm weather (light running), for propeller layout
MP	Specified MCR for propulsion
SP	Continuous service rating for propulsion
PD	Propeller design point
HR	Heavy running
LR	Light running

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Fig. 2.01.03: Ship propulsion running points and engine layout

Fouled hull

When the ship has sailed for some time, the hull and propeller become fouled and the hull's resistance will increase. Consequently, the ship's speed will be reduced unless the engine delivers more power to the propeller, i.e. the propeller will be further loaded and will be heavy running (HR).

As modern vessels with a relatively high service speed are prepared with very smooth propeller and hull surfaces, the gradual fouling after sea trial will increase the hull's resistance and make the propeller heavier running.

Sea margin and heavy weather

If, at the same time the weather is bad, with head winds, the ship's resistance may increase compared to operating in calm weather conditions. When determining the necessary engine power, it is normal practice to add an extra power margin, the so-called sea margin, which is traditionally about 15% of the propeller design (PD) power.

Engine layout (heavy propeller)

When determining the necessary engine layout speed that considers the influence of a heavy running propeller for operating at high extra ship resistance, it is (compared to line 6) recommended to choose a heavier propeller line 2. The propeller curve for clean hull and calm weather line 6 may then be said to represent a 'light running' (LR) propeller.

Compared to the heavy engine layout line 2, we recommend using a light running of **3.0-7.0%** for design of the propeller.

Engine margin

Besides the sea margin, a so-called 'engine margin' of some 10% or 15% is frequently added. The corresponding point is called the 'specified MCR for propulsion' (MP), and refers to the fact that the power for point SP is 10% or 15% lower than for point MP.

Point MP is identical to the engine's specified MCR point (M) unless a main engine driven shaft generator is installed. In such a case, the extra power demand of the shaft generator must also be considered.

Constant ship speed lines

The constant ship speed lines ∝, are shown at the very top of the figure. They indicate the power required at various propeller speeds in order to keep the same ship speed. It is assumed that, for each ship speed, the optimum propeller diameter is used, taking into consideration the total propulsion efficiency. See definition of ∝ in section 2.02.

Note:
Light/heavy running, fouling and sea margin are overlapping terms. Light/heavy running of the propeller refers to hull and propeller deterioration and heavy weather, whereas sea margin i.e. extra power to the propeller, refers to the influence of the wind and the sea. However, the degree of light running must be decided upon experience from the actual trade and hull design of the vessel.

Propeller diameter and pitch, influence on the optimum propeller speed

In general, the larger the propeller diameter D, the lower is the optimum propeller speed and the kW required for a certain design draught and ship speed, see curve D in the figure below.

The maximum possible propeller diameter depends on the given design draught of the ship, and the clearance needed between the propeller and the aft body hull and the keel.

The example shown in the figure is an 80,000 dwt crude oil tanker with a design draught of 12.2 m and a design speed of 14.5 knots.

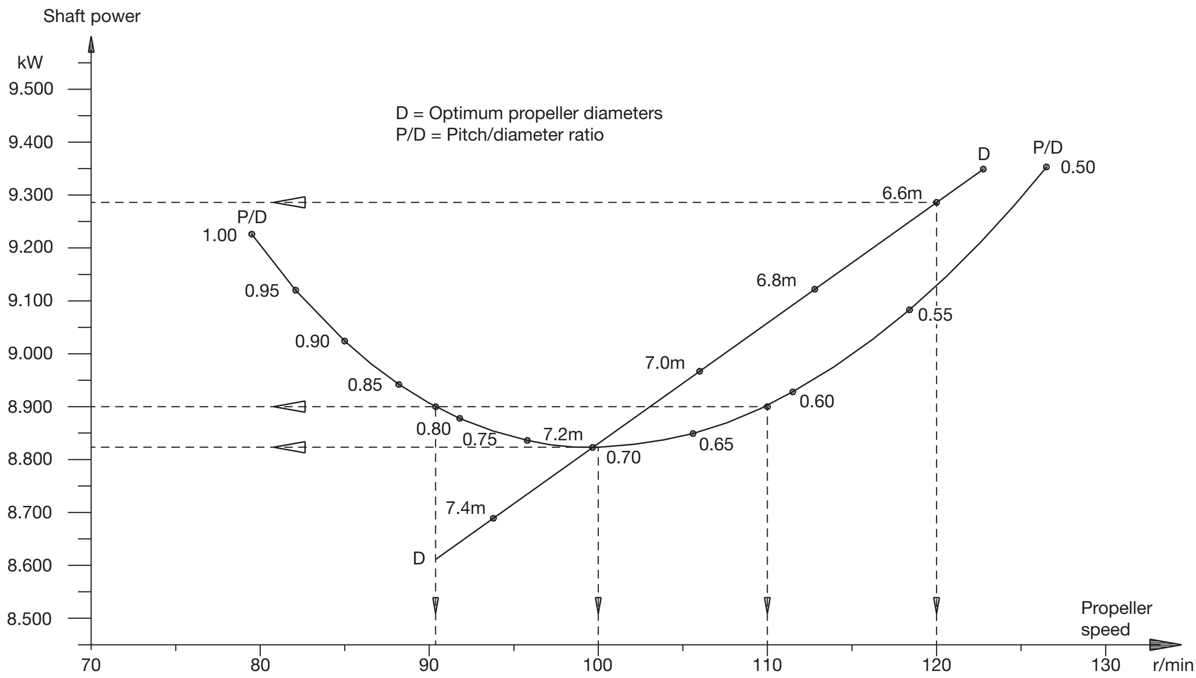
When the optimum propeller diameter D is increased from 6.6 m to 7.2. m, the power demand is reduced from about 9,290 kW to 8,820 kW, and the optimum propeller speed is reduced from 120 r/min to 100 r/min, corresponding to the constant ship speed coefficient ∝ = 0.28 (see definition of ∝ in section 2.02, page 2).

Once an optimum propeller diameter of maximum 7.2 m has been chosen, the corresponding optimum pitch in this point is given for the design speed of 14.5 knots, i.e. P/D = 0.70.

However, if the optimum propeller speed of 100 r/min does not suit the preferred / selected main engine speed, a change of pitch away from optimum will only cause a relatively small extra power demand, keeping the same maximum propeller diameter:

- going from 100 to 110 r/min (P/D = 0.62) requires 8,900 kW i.e. an extra power demand of 80 kW.
- going from 100 to 91 r/min (P/D = 0.81) requires 8,900 kW i.e. an extra power demand of 80 kW.

In both cases the extra power demand is only of 0.9%, and the corresponding 'equal speed curves' are ∝ =+0.1 and ∝ =-0.1, respectively, so there is a certain interval of propeller speeds in which the 'power penalty' is very limited.



178 47 03-2.0

Fig. 2.02.01: Influence of diameter and pitch on propeller design

Constant ship speed lines

The constant ship speed lines ∝, are shown at the very top of Fig. 2.02.02. These lines indicate the power required at various propeller speeds to keep the same ship speed provided that the optimum propeller diameter with an optimum pitch diameter ratio is used at any given speed, taking into consideration the total propulsion efficiency.

Normally, the following relation between necessary power and propeller speed can be assumed:

$P_2 = P_1 \times (n_2/n_1)^{\propto}$

where:
P = Propulsion power
n = Propeller speed, and
∝= the constant ship speed coefficient.

For any combination of power and speed, each point on lines parallel to the ship speed lines gives the same ship speed.

When such a constant ship speed line is drawn into the layout diagram through a specified propulsion MCR point 'MP_1', selected in the layout area and parallel to one of the ∝-lines, another specified propulsion MCR point 'MP_2' upon this line can be chosen to give the ship the same speed for the new combination of engine power and speed.

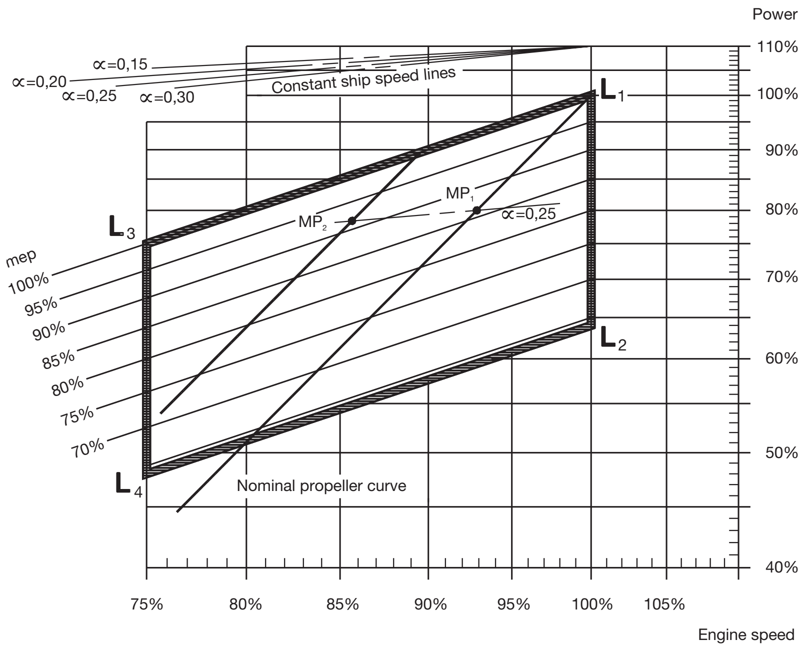
Fig. 2.02.02 shows an example of the required power speed point MP_1, through which a constant ship speed curve ∝= 0.25 is drawn, obtaining point MP_2 with a lower engine power and a lower engine speed but achieving the same ship speed.

Provided the optimum pitch/diameter ratio is used for a given propeller diameter the following data applies when changing the propeller diameter:

for general cargo, bulk carriers and tankers
∝= 0.25 -0.30

and for reefers and container vessels
∝= 0.15 -0.25

When changing the propeller speed by changing the pitch diameter ratio, the ∝ constant will be different, see above.



178 05 66-7.0

Fig. 2.02.02: Layout diagram and constant ship speed lines

Layout Diagram Sizes

This section is not applicable

Engine Layout and Load Diagram

Engine Layout Diagram

An engine's layout diagram is limited by two constant mean effective pressure (mep) lines L_1– L_3 and L_2– L_4, and by two constant engine speed lines L_1– L_2 and L_3– L_4. The L_1 point refers to the engine's nominal maximum continuous rating, see Fig. 2.01.03.

In the layout area, the engine's specified MCR point M can be set freely to suit the ship's demand for propeller power and speed.

On the horizontal axis and on the vertical axis the engine speed and the engine power are shown, respectively, on percentage scales. The scales are logarithmic which means that, in this diagram, power function curves like propeller curves (3rd power), constant mean effective pressure curves (1st power) and constant ship speed curves (0.15 to 0.30 power) are straight lines.

Specified maximum continuous rating (M)
Based on the propulsion and engine running points, as previously found, the layout diagram of a relevant main engine may be drawn-in. The specified MCR point (M) must be inside the limitation lines of the layout diagram; if it is not, the propeller speed will have to be changed or another main engine type must be chosen. Yet, in special cases point M may be located to the right of the line L_1-L_2, see 'Optimising Point' below'.

Continuous service rating (S)
The continuous service rating is the power needed in service - including the specified sea margin and heavy/light running factor of the propeller - at which the engine is to operate at the required design ship speed, and point S is identical to the service propulsion point (SP) unless a main engine driven shaft generator is installed.

Optimising point (O)
The optimising point O is the rating at which the turbocharger is matched, and at which the engine timing and compression ratio are adjusted.

The optimising point O is placed on line 1 of the load diagram, see below, and the optimised power can be from 85% to 100% of point M's power, when turbocharger(s) and engine timing are taken into consideration. When optimising between 85% and 100% of point M's power, overload running will still be possible (110% of M).

The optimising point O is to be placed inside the layout diagram. In fact, the specified MCR point M can, in special cases, be placed outside the layout diagram, but only by exceeding line L_1-L_2, and of course, only provided that the optimising point O is located inside the layout diagram, and that the MCR power is not higher than the L_1 power.

Engine Load Diagram

Definitions

The engine's load diagram defines the power and speed limits for continuous as well as overload operation of an installed engine having an optimising point O and a specified MCR point M that confirms the specification of the ship.

Point A is a 100% speed and power reference point of the load diagram, and is defined as the point on the propeller curve (line 1), through the optimising point O, having the specified MCR power. Normally, point M is equal to point A, but in special cases, for example if a shaft generator is installed, point M may be placed to the right of point A on line 7.

The service points of the installed engine incorporate the engine power required for ship propulsion and shaft generator, if installed.

Limits for continuous operation

The continuous service range is limited by four lines:

Line 3 and line 9:
Line 3 represents the maximum acceptable speed for continuous operation, i.e. 105% of A.

If, in special cases, A is located to the right of line L_1-L_2, the maximum limit, however, is 105% of L_1.

During trial conditions, the maximum speed may be extended to 107% of A, see line 9.

The above limits may in general be extended to 105%, and during trial conditions to 107%, of the nominal L_1 speed of the engine, if permitted by the torsional vibration conditions.

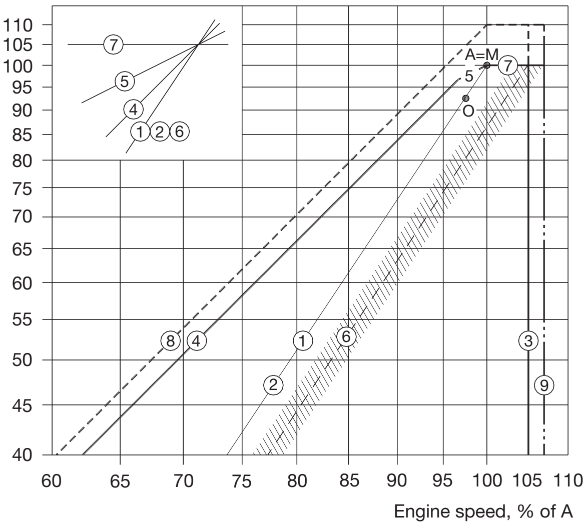
The overspeed set-point is 109% of the speed in A, however, it may be moved to 109% of the nominal speed in L_1, if permitted by torsional vibration conditions.

Running above 100% of the nominal L_1 speed at a load lower than about 65% specified MCR should, however, be avoided for extended periods. Only plants with controllable pitch propellers can reach this light running area.

Line 4:
Represents the limit at which an ample air supply is available for combustion and imposes a limitation on the maximum combination of torque and speed.

Line 5:
Represents the maximum mean effective pressure level (mep), which can be accepted for continuous operation.

Line 7:
Represents the maximum power for continuous operation.



A 100% reference point
M Specified MCR point
O Optimising point

Line 1 Propeller curve through optimising point (i = 3) (engine layout curve)
Line 2 Propeller curve, fouled hull and heavy weather – heavy running (i = 3)
Line 3 Speed limit
Line 4 Torque/speed limit (i = 2)
Line 5 Mean effective pressure limit (i = 1)
Line 6 Propeller curve, clean hull and calm weather – light running (i = 3), for propeller layout
Line 7 Power limit for continuous running (i = 0)
Line 8 Overload limit
Line 9 Speed limit at sea trial

Point M to be located on line 7 (normally in point A)

178 05 42-7.3

Fig. 2.04.01: Standard engine load diagram

Limits for overload operation

The overload service range is limited as follows:

Line 8:
Represents the overload operation limitations.

The area between lines 4, 5, 7 and the heavy dashed line 8 is available for overload running for limited periods only (1 hour per 12 hours).

Recommendation

Continuous operation without limitations is allowed only within the area limited by lines 4, 5, 7 and 3 of the load diagram, except for CP propeller plants mentioned in the previous section.

The area between lines 4 and 1 is available for operation in shallow waters, heavy weather and during acceleration, i.e. for non-steady operation without any strict time limitation.

After some time in operation, the ship's hull and propeller will be fouled, resulting in heavier running of the propeller, i.e. the propeller curve will move to the left from line 6 towards line 2, and extra power is required for propulsion in order to keep the speed of the ship.

In calm weather conditions, the extent of heavy running of the propeller will indicate the need for cleaning the hull and possibly polishing the propeller.

Once the specified MCR (and the optimising point) have been chosen, the capacities of the auxiliary equipment will be adapted to the specified MCR, and the turbocharger etc. will be matched to the optimised power, however, considering the specified MCR.

If the specified MCR (and/or the optimising point) is to be increased later on, this may involve a change of the pump and cooler capacities, retiming the engine, change of the fuel valve nozzles, adjusting the cylinder liner cooling, as well as rematching the turbocharger or even a change to a larger size of turbocharger. In some cases, it can also require larger dimensions of the piping systems.

It is therefore of utmost importance to consider, already at the project stage, if the specification should be prepared for a later power increase. This is to be indicated in item 4 02 010 of the Extent of Delivery.

Extended load diagram for ships operating in extreme heavy running conditions

When a ship with fixed pitch propeller is operating in normal sea service, it will in general be operating in the hatched area around the design propeller curve 6, as shown on the standard load diagram in Fig. 2.04.01.

Sometimes, when operating in heavy weather, the fixed pitch propeller performance will be more heavy running, i.e. for equal power absorption of the propeller, the propeller speed will be lower and the propeller curve will move to the left.

As the low speed main engines are directly coupled to the propeller, the engine has to follow the propeller performance, i.e. also in heavy running propeller situations. For this type of operation, there is normally enough margin in the load area between line 6 and the normal torque/speed limitation line 4, see Fig. 2.04.01. To the left of line 4 in torque-rich operation, the engine will lack air from the turbocharger to the combustion process, i.e. the heat load limits may be exceeded and bearing loads might also become too high.

For some special ships and operating conditions, it would be an advantage - when occasionally needed - to be able to operate the propeller/main engine as much as possible to the left of line 6, but inside the torque/speed limit, line 4.

Such cases could be for:

- ships sailing in areas with very heavy weather
- ships operating in ice
- ships with two fixed pitch propellers/two main engines, where one propeller/one engine is declutched for one or the other reason.

The increase of the operating speed range between line 6 and line 4 of the standard load diagram, see Fig. 2.04.01, may be carried out as shown for the following engine Example with an extended load diagram for speed derated engine with increased light running:

- Extended load diagram for speed derated engines with increased light running.

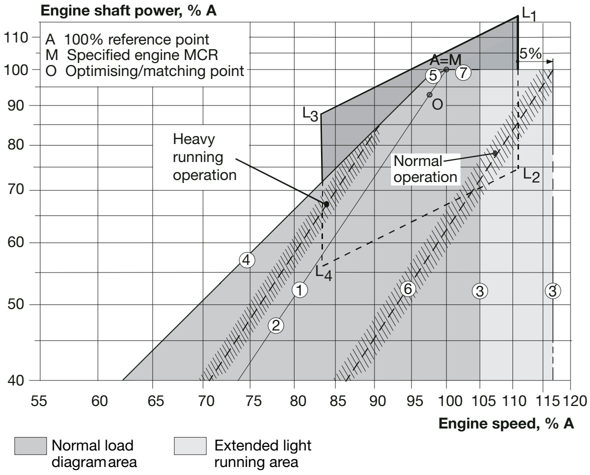
Extended load diagram for speed derated engines with increased light running

The maximum speed limit (line 3) of the engines is 105% of the SMCR (Specified Maximum Continuous Rating) speed, as shown in Fig. 2.04.01.

However, for speed and, thereby, power derated engines it is possible to extend the maximum speed limit to 105% of the engine’s nominal MCR speed, line 3’, but only provided that the torsional vibration conditions permit this. Thus, the shafting, with regard to torsional vibrations, has to be approved by the classification society in question, based on the extended maximum speed limit.

When choosing an increased light running to be used for the design of the propeller, the load diagram area may be extended from line 3 to line 3’, as shown in Fig. 2.04.02, and the propeller/main engine operating curve 6 may have a correspondingly increased heavy running margin before exceeding the torque/speed limit, line 4.

A corresponding slight reduction of the propeller efficiency may be the result, due to the higher propeller design speed used.



Line 1: Propeller curve through optimising point (O) - layout curve for engine
Line 2: Heavy propeller curve
- fouled hull and heavy seas
Line 3: Speed limit
Line 3’: **Extended speed limit**, provided torsional vibration conditions permit
Line 4: Torque/speed limit
Line 5: Mean effective pressure limit
Line 6: Increased light running propeller curve
- clean hull and calm weather
- layout curve for propeller
Line 7: Power limit for continuous running

178 52 25-6.0

Fig. 2.04.02: Extended load diagram for speed derated engine with increased light running

Examples of the use of the Load Diagram

In the following some examples are illustrating the flexibility of the layout and load diagrams and the significant influence of the choice of the optimising point O.

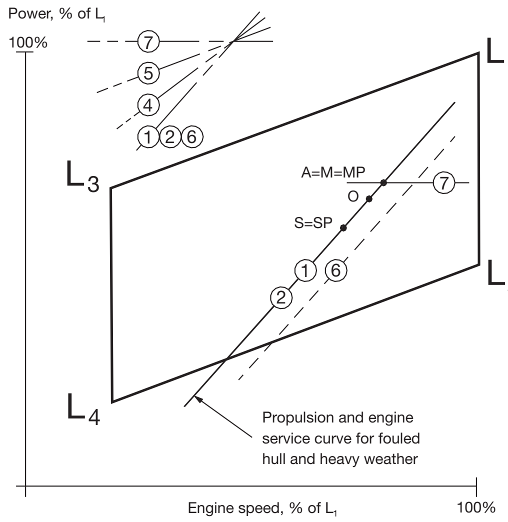
The diagrams of the examples show engines with VIT fuel pumps, for which the optimising point O is normally different from the specified MCR point M as this can improve the SFOC at part load running.

- Example 1 shows how to place the load diagram for an engine without a shaft generator coupled to a fixed pitch propeller.
- Example 2 comprises diagrams for the same configuration, here with the optimising point on the left of the heavy running propeller curve (2), providing an extra engine margin for heavy running.
- Example 3 shows the same layout for an engine with fixed pitch propeller (Example 1), but with a shaft generator.
- Example 4 shows a special case with a shaft generator. In this case, the shaft generator is cut off, and the gensets used when the engine runs at specified MCR. This makes it possible to choose a smaller engine with a lower power output.
- Example 5 shows diagrams for an engine coupled to a controllable pitch propeller, with or without a shaft generator, (constant speed or combinator curve operation).
- Example 6 shows where to place the optimising point for an engine coupled to a controllable pitch propeller, and operating at constant speed.

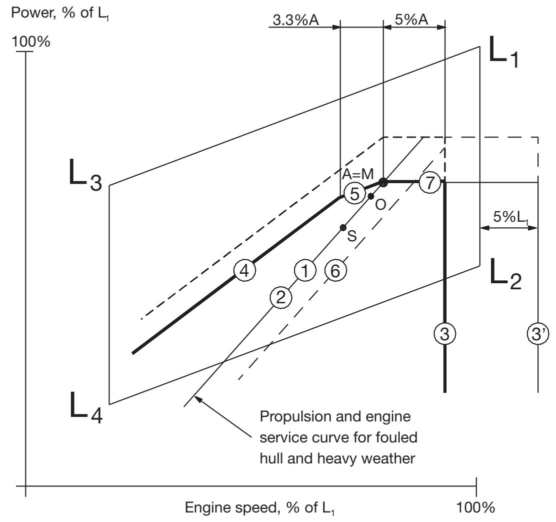
For a specific project, the layout diagram for the actual projects shown later in this chapter may be used for drawing of the actual load diagram.

Example 1: Normal running conditions.
Engine coupled to a fixed pitch propeller (FPP) and without a shaft generator

Layout diagram



Load diagram



M	Specified MCR of engine
S	Continuous service rating of engine
O	Optimising point of engine
A	Reference point of load diagram
MP	Specified MCR for propulsion
SP	Continuous service rating of propulsion

Point A of the load diagram is found:

Line 1	Propeller curve through optimising point (O) is equal to line 2
Line 7	Constant power line through specified MCR (M)
Point A	Intersection between line 1 and 7

The optimising point O and its propeller curve 1 will normally be selected on the engine service curve 2.

Point A is then found at the intersection between propeller curve 1 (2) and the constant power curve through M, line 7. In this case, point A is equal to point M.

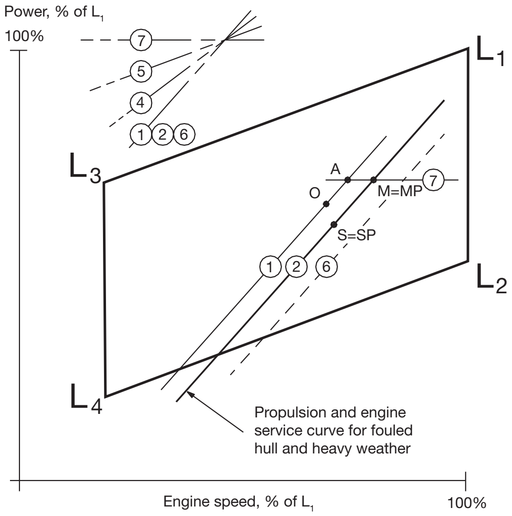
Once point A has been found in the layout diagram, the load diagram can be drawn, as shown in the above figure, and hence the actual load limitation lines of the diesel engine may be found by using the inclinations from the construction lines and the %-figures stated.

178 55 82-5.0

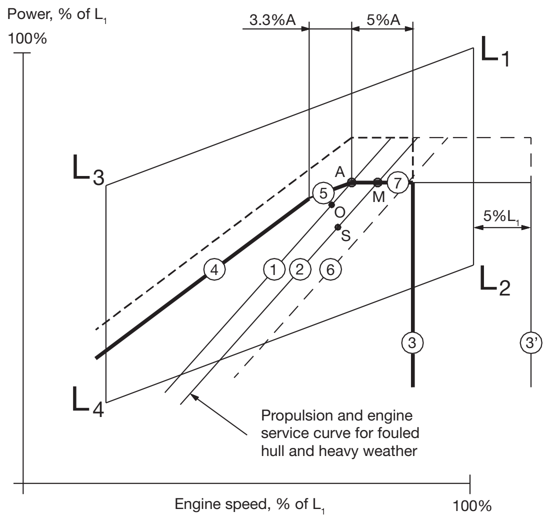
Fig. 2.04.03: Normal running conditions. Engine coupled to a fixed pitch propeller (FPP) and without a shaft generator

Example 2: Special running conditions.
Engine coupled to a fixed pitch propeller (FPP) and without a shaft generator

Layout diagram



Load diagram



M	Specified MCR of engine
S	Continuous service rating of engine
O	Optimising point of engine
A	Reference point of load diagram
MP	Specified MCR for propulsion
SP	Continuous service rating of propulsion

Point A of the load diagram is found:

Line 1	Propeller curve through optimising point (O) placed to the left of line 2
Line 7	Constant power line through specified MCR (M)
Point A	Intersection between line 1 and 7

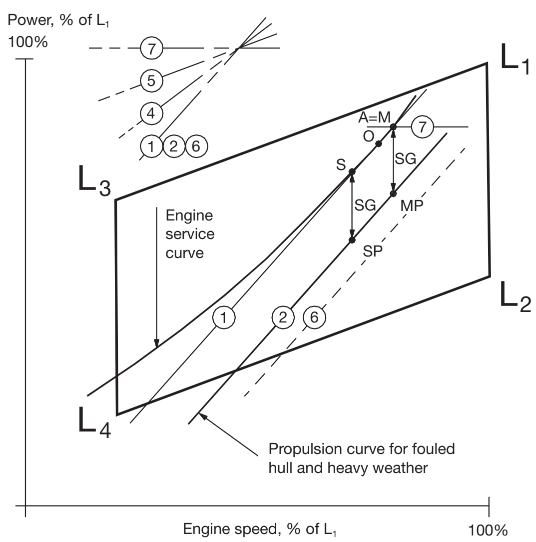
In this example, the optimising point O has been selected more to the left than in Example 1, providing an extra engine margin for heavy running operation in heavy weather conditions. In principle, the light running margin has been increased for this case.

178 55 83-7.0

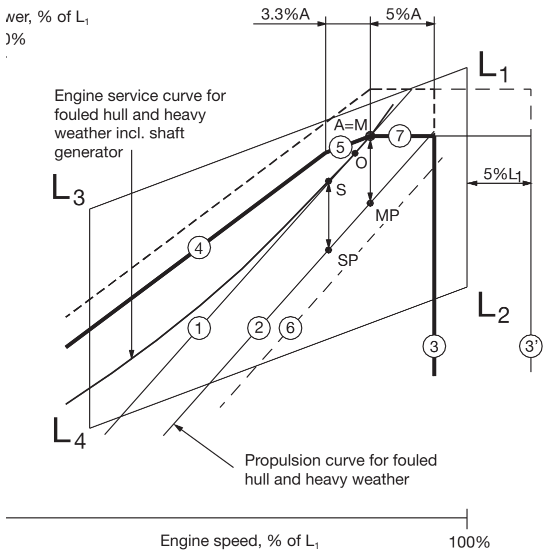
Fig. 2.04.04: Special running conditions. Engine coupled to a fixed pitch propeller (FPP) and without a shaft generator

Example 3: Normal running conditions. Engine coupled to a fixed pitch propeller (FPP) and with a shaft generator

Layout diagram



Load diagram



M	Specified MCR of engine
S	Continuous service rating of engine
O	Optimising point of engine
A	Reference point of load diagram
MP	Specified MCR for propulsion
SP	Continuous service rating of propulsion
SG	Shaft generator power

Point A of the load diagram is found:

Line 1	Propeller curve through optimising point (O)
Line 7	Constant power line through specified MCR (M)
Point A	Intersection between line 1 and 7

In Example 3, a shaft generator (SG) is installed, and therefore the service power of the engine also has to incorporate the extra shaft power required for the shaft generator's electrical power production.

In the figure, the engine service curve shown for heavy running incorporates this extra power.

The optimising point O will be chosen on the engine service curve as shown, but can, by an approximation, be located on curve 1, through point M.

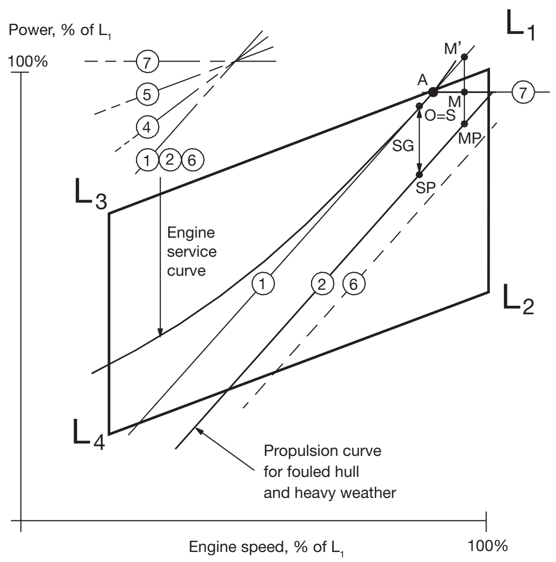
Point A is then found in the same way as in Example 1, and the load diagram can be drawn as shown in the above figure.

178 55 84-9.0

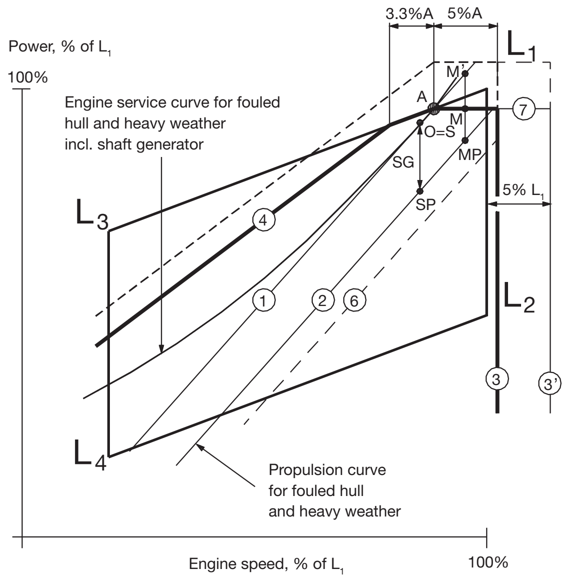
Fig. 2.04.05: Normal running conditions. Engine coupled to a fixed pitch propeller (FPP) and with a shaft generator

Example 4: Special running conditions. Engine coupled to a fixed pitch propeller (FPP) and with a shaft generator

Layout diagram



Load diagram



M	Specified MCR of engine
S	Continuous service rating of engine
O	Optimising point of engine
A	Reference point of load diagram
MP	Specified MCR for propulsion
SP	Continuous service rating of propulsion
SG	Shaft generator

Point A of the load diagram is found:

Line 1	Propeller curve through optimising point (O) or point S
Point A	Intersection between line 1 and line $L_1 - L_3$
Point M	Located on constant power line 7 through point A and with MP's speed.

Also in this special case, a shaft generator is installed, but compared to Example 3, this case has a specified MCR for propulsion, MP, placed at the top of the layout diagram.

This involves that the intended specified MCR of the engine M' will be placed outside the top of the layout diagram.

One solution could be to choose a larger diesel engine with an extra cylinder, but another and cheaper solution is to reduce the electrical power production of the shaft generator when running in the upper propulsion power range.

In choosing the latter solution, the required specified MCR power can be reduced from point M' to point M as shown. Therefore, when running in the upper propulsion power range, a diesel generator has to take over all or part of the electrical power production.

However, such a situation will seldom occur, as ships are rather infrequently running in the upper propulsion power range.

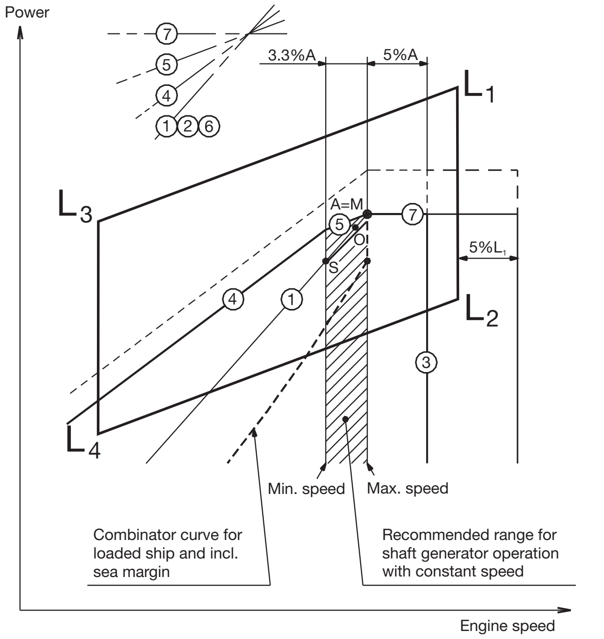
In the example, the optimising point O=S has been chosen equal to point S, and line 1 may be found.

Point A, having the highest possible power, is then found at the intersection of line $L_1 - L_3$ with line 1, and the corresponding load diagram is drawn. Point M is found on line 7 at MP's speed.

178 55 85-0.1

Fig. 2.04.06: Special running conditions. Engine coupled to a fixed pitch propeller (FPP) and with a shaft generator

Example 5: Engine coupled to a controllable pitch propeller (CPP) with or without a shaft generator



M	Specified MCR of engine
S	Continous service rating of engine
O	Optimising point of engine
A	Reference point of load diagram

178 55 86-2.0

Fig. 2.04.07: Engine with controllable pitch propeller (CPP), with or without a shaft generator

Layout diagram - without a shaft generator
If a controllable pitch propeller (CPP) is applied, the combinator curve (of the propeller) will normally be selected for a loaded ship including sea margin.

For a given propeller speed the combinator curve may have a given propeller pitch, and this may be heavy running in heavy weather like for a fixed pitch propeller.

Therefore, it is recommended to use a light running combinator curve (the dotted curve which includes the sea power margin) as shown in the figure to obtain an increased operation margin of the diesel engine in heavy weather to the limit, indicated by lines 4 and 5.

Layout diagram - with shaft generator
The hatched area shows the recommended speed range between 100% and 96.7% of the specified MCR speed for an engine with a shaft generator running at constant speed.

The service point S can be located at any point within the hatched area.

The procedure shown in examples 3 and 4 for engines with FPP can also be applied here for engines with CPP running with a combinator curve.

The optimising point O
O can be chosen on the propeller curve through point A = M with an optimised power from 85% to 100% of the specified MCR as mentioned before in the section dealing with the optimising point O.

Load diagram
Therefore, when the engine's specified MCR point (M) has been chosen, including engine margin, sea margin and the power for a shaft generator, if installed, point M can be used as point A of the load diagram, which can then be drawn.

The position of the combinator curve ensures the maximum load range within the permitted speed range for engine operation, and it still leaves a reasonable margin to the limit indicated by curves 4 and 5.

Example 6 will give a more detailed description of how to run at constant speed with a CP propeller.

Example 6: Engines running at a constant speed with a controllable pitch propeller (CPP)

Fig. A: Constant speed curve through M, normal and correct location of the optimising point O

Irrespective of whether the engine is operating on a propeller curve or on a constant speed curve through M, the optimising point O must be located on the propeller curve through the specified MCR point M or, in special cases, to the left of point M.

The reason is that the propeller curve 1 through the optimising point O is the layout curve of the engine, and the intersection between curve 1 and the maximum power line 7 through point M is equal to 100% power and 100% speed, point A of the load diagram - in this case A=M.

In Fig. A, the optimising point O has been placed correctly, and the step-up gear and the shaft generator, if installed, may be synchronised on the constant speed curve through M.

Fig. B: Constant speed curve through M, ***wrong position*** *of optimising point O*

If the engine has been service-optimised at point O on a constant speed curve through point M, then the specified MCR point M would be placed outside the load diagram, and this is not permissible.

Fig. C: Recommended constant speed running curve, lower than speed M

In this case, it is assumed that a shaft generator, if installed, is synchronised at a lower constant main engine speed (for example with a speed equal to O or lower) at which improved CP propeller efficiency is obtained for part load running.

In this layout example, where an improved CP propeller efficiency is obtained during extended periods of part load running, the step-up gear and the shaft generator have to be designed for the lower constant engine speed that is applied.

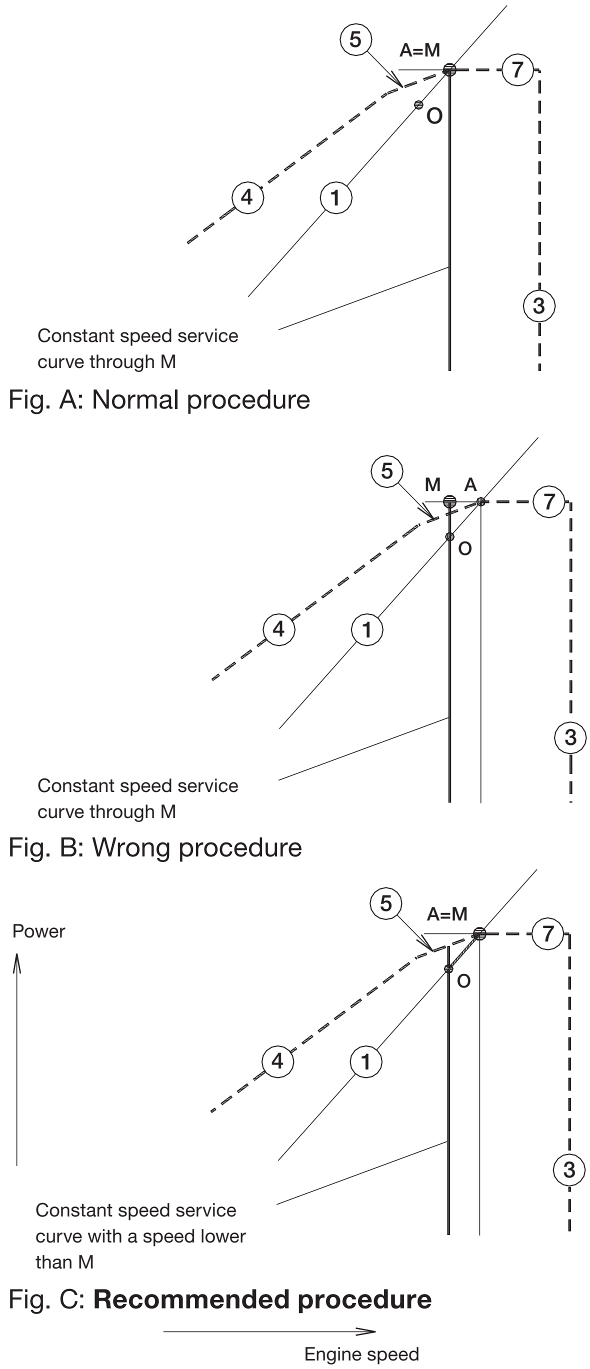


Fig. A: Normal procedure

Fig. B: Wrong procedure

Fig. C: **Recommended procedure**

Logarithmic scales

M: Specified MCR
O: Optimised point
A: 100% power and speed of load diagram (normally A=M)

Fig. 2.04.08: Engines running at a constant speed with a controllable pitch propeller (CPP)

178 19 69-9.0

Diagram for actual project

This figure contains a layout diagram that can be used for constructing the load diagram for an actual project, using the %-figures stated and the inclinations of the lines.

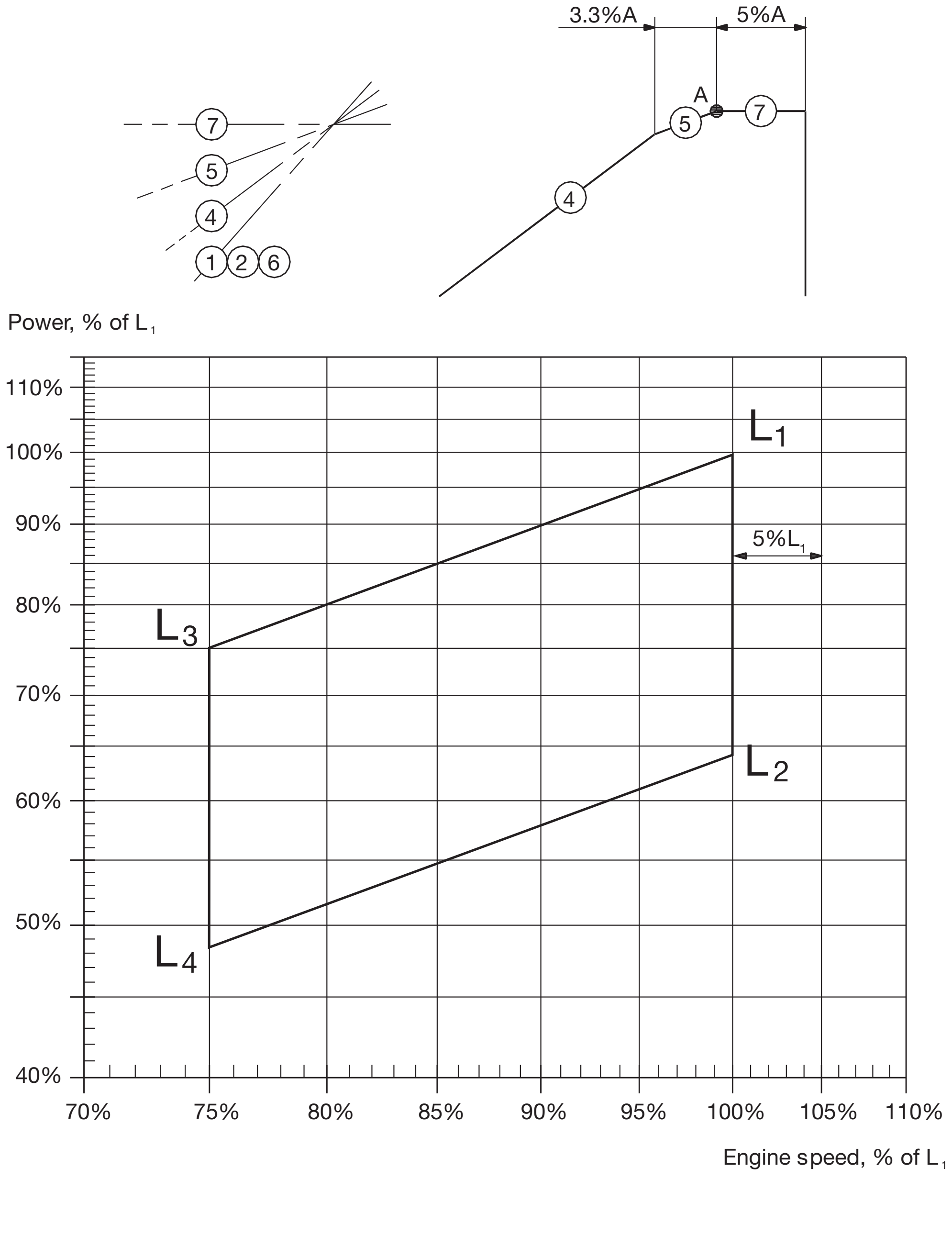


Fig. 2.05.01: Construction of layout diagram

Specific Fuel Oil Consumption, ME versus MC engines

This section is not applicable

SFOC for High Efficiency/Conventional Turbochargers

All engine types are as standard fitted with high efficiency turbochargers (EoD option: 4 59 104) but can alternatively use conventional turbochargers, option: 4 59 107.

The high efficiency turbocharger is applied to the engine in the basic design with the view to obtaining the lowest possible Specific Fuel Oil Consumption (SFOC) values, see curve A, Fig. 2.07.01.

With a conventional turbocharger the amount of air required for combustion purposes can, however, be adjusted to provide a higher exhaust gas temperature, if this is needed for the exhaust gas boiler.

The matching of the engine and the turbocharging system is then modified, thus increasing the exhaust gas temperature by 20 °C.

This modification will lead to a 7-8% reduction in the exhaust gas amount, and involve an SFOC penalty of 2 g/kWh, see curve B, Fig. 2.07.01.

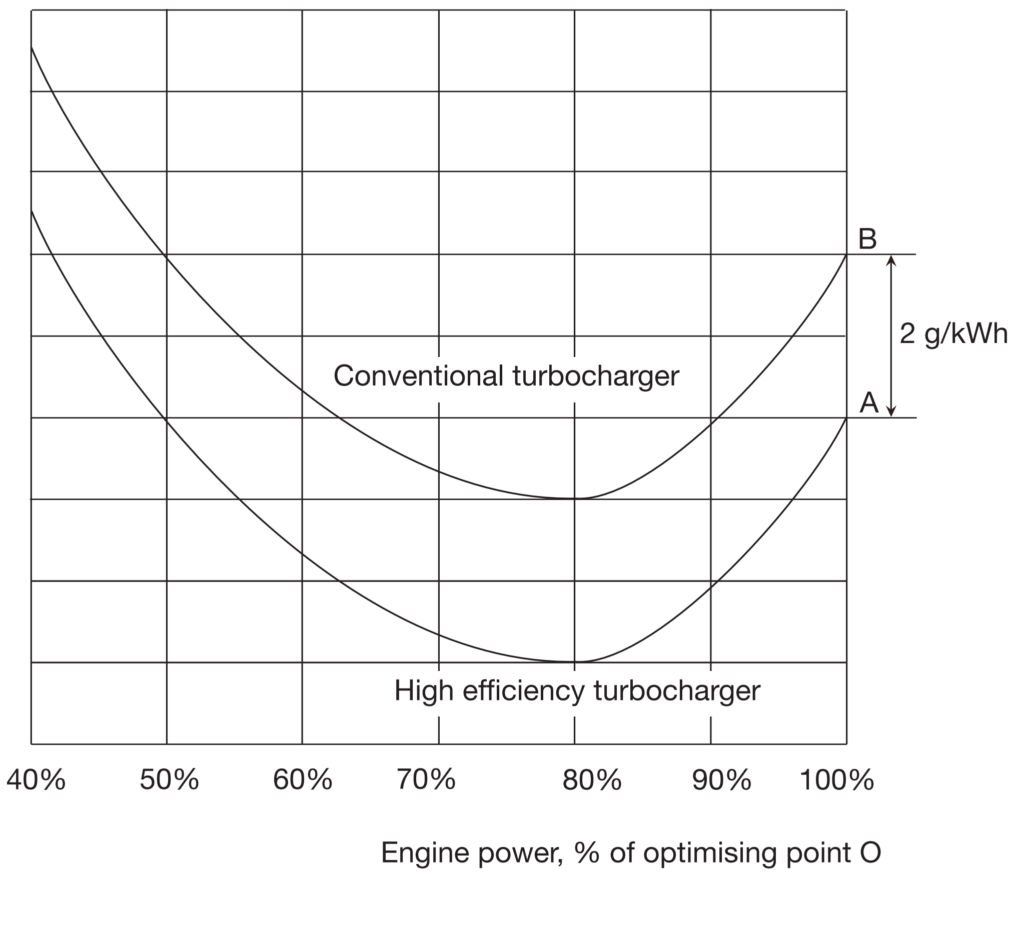


Fig. 2.07.01: Example of part load SFOC curves for high efficiency and conventional turbochargers

SFOC reference conditions and guarantee

SFOC at reference conditions

The SFOC is given in **g/kWh** based on the reference ambient conditions stated in ISO 3046:2002(E) and ISO 15550:2002(E):

- 1,000 mbar ambient air pressure
- 25 °C ambient air temperature
- 25 °C scavenge air coolant temperature,

and is related to a fuel oil with a lower calorific value of 42,700 kJ/kg (~10,200 kcal/kg).

Any discrepancies between g/kWh and g/BHPh are a result of the rounding of numbers for the latter.

For lower calorific values and for ambient conditions that are different from the ISO reference conditions, the SFOC will be adjusted according

		With p_{max} adjusted	Without p_{max} adjusted
Parameter	Condition change	SFOC change	SFOC change
Scav. air coolant temperature	per 10 °C rise	+ 0.60%	+ 0.41%
Blower inlet temperature	per 10 °C rise	+ 0.20%	+ 0.71%
Blower inlet pressure	per 10 mbar rise	- 0.02%	- 0.05%
Fuel oil lower calorific value	rise 1% (42,700 kJ/kg)	-1.00%	- 1.00%

With for instance a 1 °C increase in the scavenge air coolant temperature, a corresponding 1 °C increase in the scavenge air temperature will occur and involves an SFOC increase of 0.06% if p_{max} is adjusted to the same value.

SFOC guarantee

The SFOC guarantee refers to the above ISO reference conditions and lower calorific value. It is guaranteed for the power-speed combination in the optimising point (O) and the engine running ‘fuel economy mode’ in compliance with IMO NO_x emission limitations.

The SFOC guarantee is given with a tolerance of 5%

Examples of graphic calculation of SFOC

The following diagrams b and c, valid for fixed pitch propeller and constant speed, respectively, show the reduction of SFOC in g/kWh, relative to the SFOC for the nominal MCR L_1 rating.

The solid lines are valid at 100%, 80% and 50% of the optimising point (O).

Point O is drawn into the above-mentioned b or c diagram. A straight line along the constant mep curves (parallel to L_1-L_3) is drawn through point O. The intersections of this line and the curves indicate the reduction in specific fuel oil consumption at 100%, 80% and 50% of the optimising point, related to the SFOC stated for the nominal MCR L_1 rating.

An example of the calculated SFOC curves for an engine with fixed pitch propeller is shown in Diagram a, and is valid for two alternative engine optimising points:

- Optimising point O_1 at 100% of M

- Optimising point O_2 at 90% of M

See Fig. 2.10.01.

The optmising point typically chosen is 90%, randomly chosen between 85-100% in order to reduce SFOC at part load running.

SFOC Calculation for S50MC6

Data at nominel MCR (L_1)			SFOC at nominal MCR (L_1)	
			High efficiency TC	Conventional TC
Engine	**kW**	**r/min**	**g/kWh**	**g/kWh**
5 S50MC6	7,150	127	171	173
6 S50MC6	8,580			
7 S50MC6	10,010			
8 S50MC6	11,440			

Data optimising point (O):

	cyl. No.
Power: 100% of (O)	kW
Speed: 100% of (O)	r/min
SFOC found:	g/kWh

Diagram a

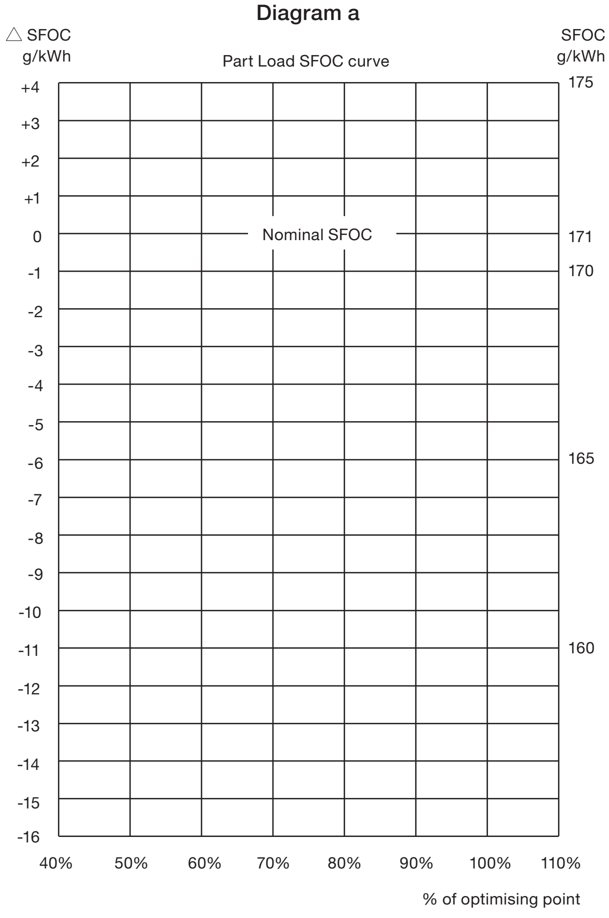


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Fig. 2.09.01

SFOC for S50MC6 with fixed pitch propeller

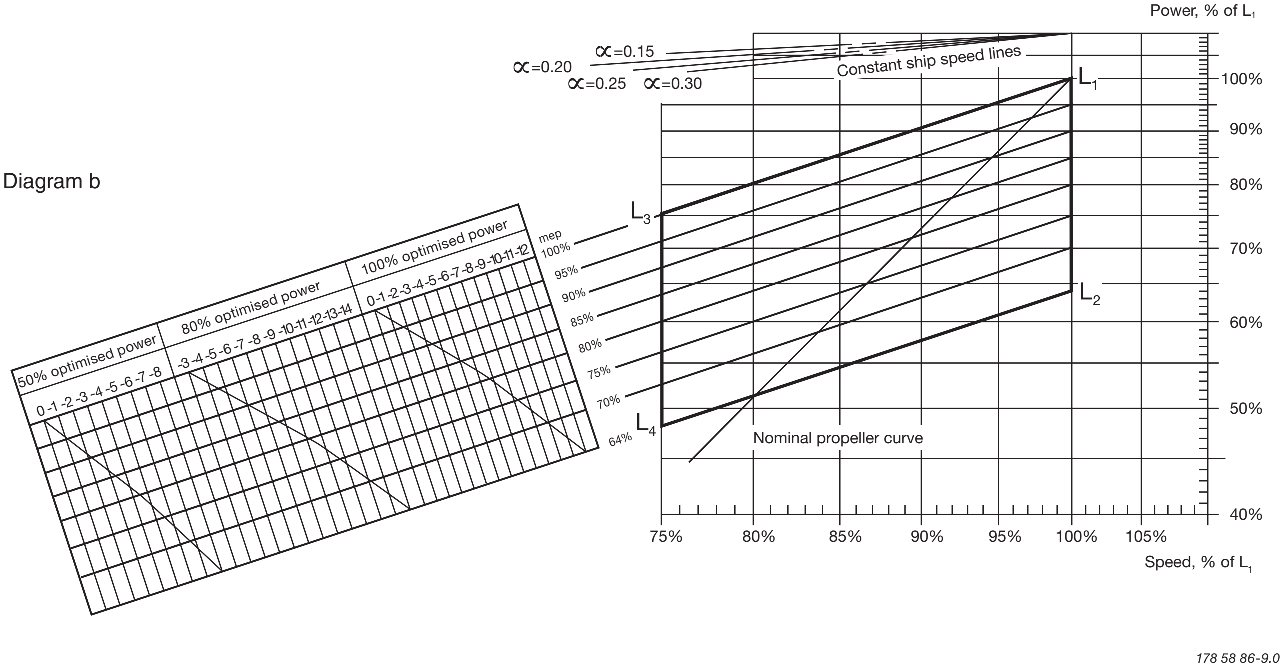


Fig. 2.09.02

SFOC for S50MC6 with constant speed

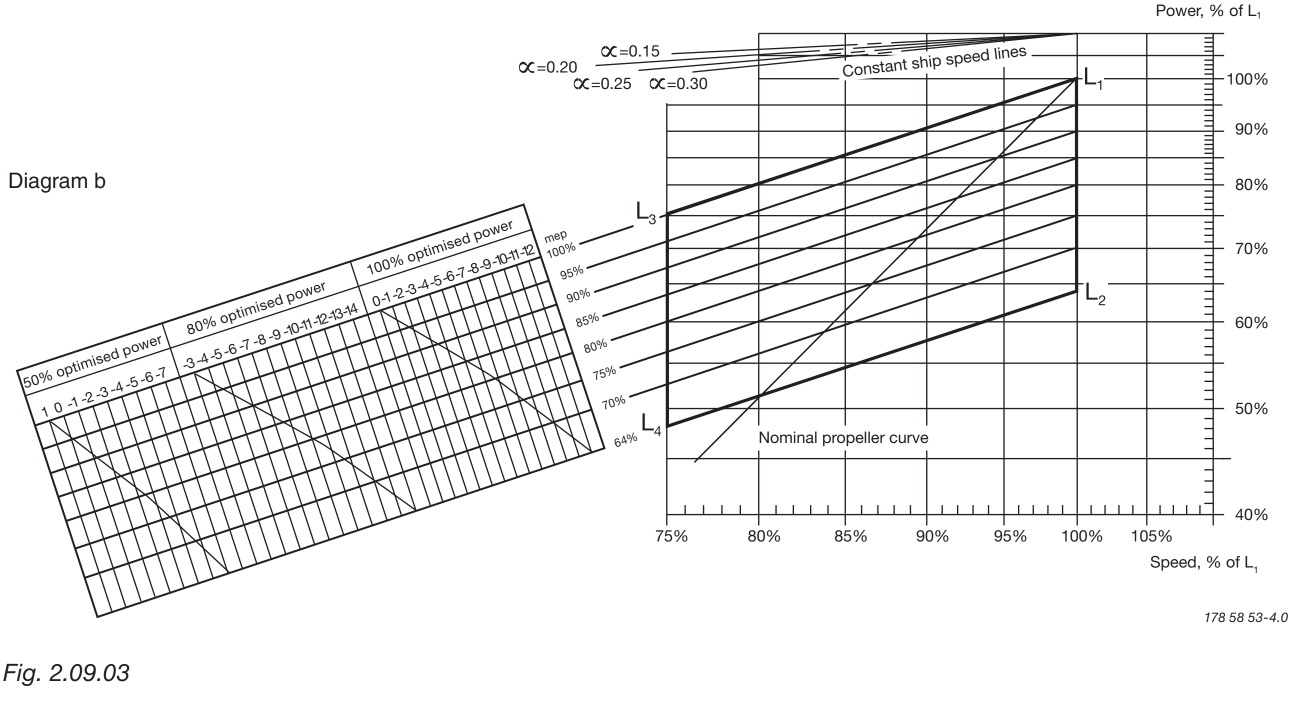


Fig. 2.09.03

SFOC calculations, example

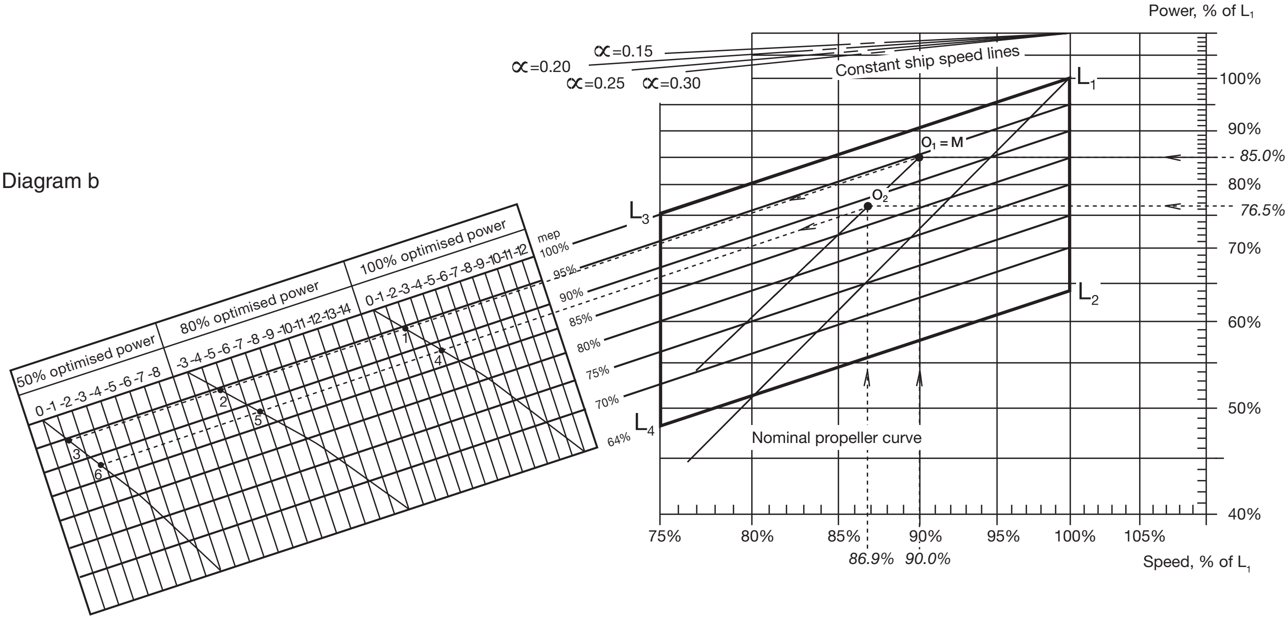
Data at nominel MCR (L_1): 6S50MC6	
Power 100%	8,580 kW
Speed 100%	127 r/min
Nominal SFOC:	
• High efficiency turbocharger	171 g/kWh
• Conventional turbocharger	173 g/kWh

Example of specified MCR = M		
Power	7,293 kW (85.0% L_1)	
Speed	114.3 r/min (90.0% L_1)	
Turbocharger type	High efficiency	
Optimising point (O) Two alternatives	O_1 100% SMCR	O_2 90% SMCR
Power of O	7,293 kW	6,564 kW
Speed of O	114.3 r/min	110.4 r/min
SFOC found in O	169.1 g/kWh	167.0 g/kWh

Two alternative optimising points, O_1 and O_2 are used in the above example for the SFOC calculations:

O_1 = 100% M = 85.0% L_1 power and 90.0% L_1 speed
O_2 = 90% M = 76.5% L_1 power and 86.9% L_1 speed

Diagram b



178 58 54-6.0

The reductions, see diagram b, in g/kWh compared to SFOC in L_1:

Power in	Part load points		SFOC g/kWh	SFOC g/kWh
100% O_1	1	100% M	-1.9	169.1
80% O_1	2	80% M	-4.7	166.3
50% O_1	3	50% M	-1.2	169.8
100% O_2	4	90% M	-4.0	167.0
80% O_2	5	72% M	-6.7	164.3
50% O_2	6	45% M	-2.7	168.3

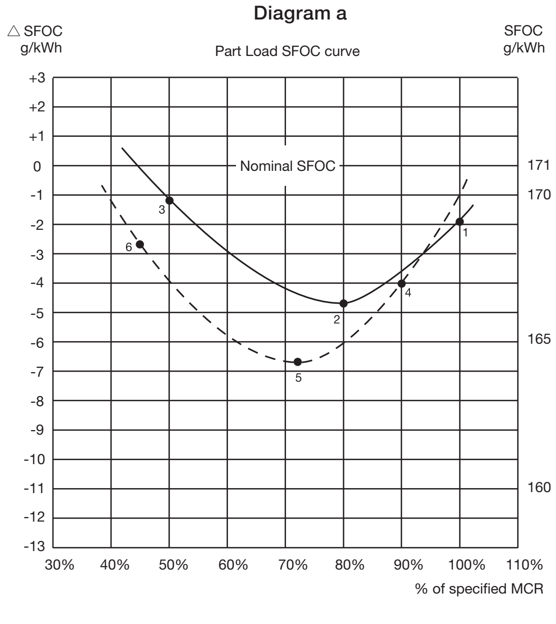


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Fig. 2.10.01: Example of SFOC for derated S50MC6 with fixed pitch propeller and high efficiency turbocharger

Fuel Consumption at an Arbitrary Load

Once the optimising point (O) of the engine has been chosen, the specific fuel oil consumption at an arbitrary point S_1, S_2 or S_3 can be estimated based on the SFOC at point '1' and '2'.

These SFOC values can be calculated by using the graphs for the relevant engine type for the propeller curve I and for the constant speed curve II, giving the SFOC at points 1 and 2, respectively.

Next the SFOC for point S_1 can be calculated as an interpolation between the SFOC in points '1' and '2', and for point S_3 as an extrapolation.

The SFOC curve through points S_2, on the left of point 1, is symmetrical about point 1, i.e. at speeds lower than that of point 1, the SFOC will also increase.

The above-mentioned method provides only an approximate value. A more precise indication of the expected SFOC at any load can be calculated by using our computer program. This is a service which is available to our customers on request.

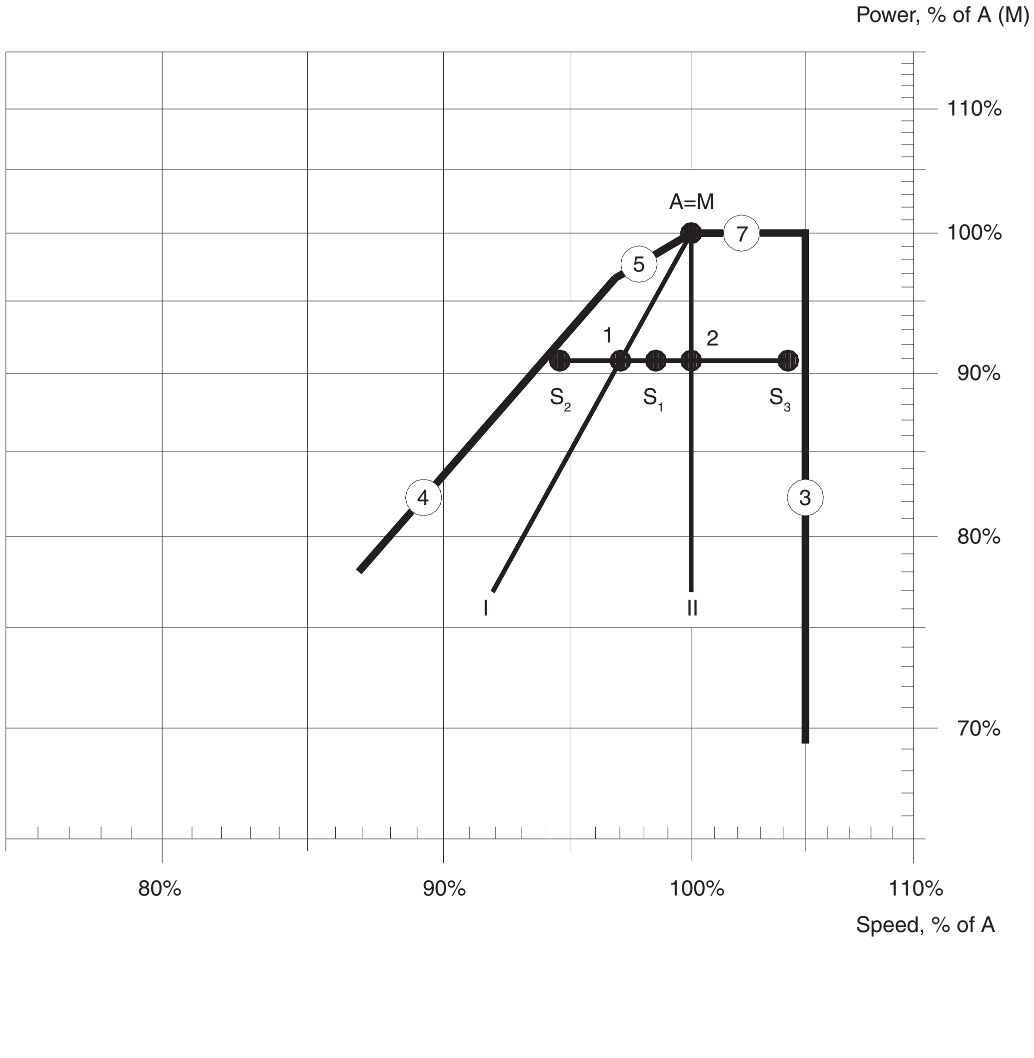

Fig. 2.11.01: SFOC at an arbitrary load

Emission Control

IMO NO_x Emission Limits

All MC and MC-C engines are, as standard, delivered in compliance with the IMO speed dependent NO_x limit, measured according to ISO 8178 Test Cycles E2/E3 for Heavy Duty Diesel Engines.

NO_x Reduction Methods

The NO_x content in the exhaust gas can be reduced with primary and/or secondary reduction methods.

The primary methods affect the combustion process directly by reducing the maximum combustion temperature, whereas the secondary methods are means of reducing the emission level without changing the engine performance, using external equipment.

0-30% NO_x Reduction

The MC and MC-C engines are as standard delivered to comply with IMO NOx emission limitations, EoD 4 06 060. Engine test cycles E2 and E3 has to be ordered as an option, 4 06 060a and 060b, and various conditions can be specified, options 4 06 060f, 060g and 060h. Compliance with other emission limits can be specified as an option, 4 06 065.

Regardless of the emission limit specified, the engines are matched for best economy in service.

For further information on engine operation options, see Extent of Delivery.

30-50% NO_x Reduction

Water emulsification of the heavy fuel oil is a well proven primary method. The type of homogenizer is either ultrasonic or mechanical, using water from the freshwater generator and the water mist catcher. The pressure of the homogenised fuel has to be increased to prevent the formation of steam and cavitation. It may be necessary to modify some of the engine components such as the fuel oil pressure booster, fuel injection valves and the engine control system.

Up to 95-98% NO_x Reduction

When operating at full load, this reduction can be achieved by means of secondary methods, such as the SCR (Selective Catalytic Reduction), which involves an after-treatment of the exhaust gas, see Section 3.02. At lower load a 80-90% NO_x reduction can be obtained, measured according to the ISO 8178 E2/E3 Test Cycles.

Plants designed according to this method have been in service since 1990 on five vessels, using Haldor Topsøe catalysts and ammonia as the reducing agent, urea can also be used.

The compact SCR unit can be located separately in the engine room or horizontally on top of the engine. The compact SCR reactor is mounted before the turbocharger(s) in order to have the optimum working temperature for the catalyst. However attention have to be given to the type of HFO to be used.

For further information about emission control, please refer to our publication:

Exhaust Gas Emission Control Today and Tomorrow

The publication is available at: www.mandiesel.com under ‘Quicklinks’ → ‘Technical Papers’.

Turbocharger Choice & Exhaust Gas By-pass

3

Turbocharger Choice

The MC/ME engines are designed for the application of either MAN Diesel, ABB or Mitsubishi (MHI) turbochargers.

The turbocharger choice is made with a view to obtaining the lowest possible Specific Fuel Oil Consumption (SFOC) values at the nominal MCR by applying high efficiency turbochargers.

The engines are, as standard, equipped with as few turbochargers as possible, see the table in Fig. 3.01.01.

One more turbocharger can be applied, than the number stated in the tables, if this is desirable due to space requirements, or for other reasons. Additional costs are to be expected.

The data specified in the printed edition are valid at the time of publishing.

However, for the latest up to date data, we recommend the 'Turbocharger selection' programme on the Internet, which can be used to identify a list of applicable turbochargers for a specific engine layout.

The programme will always be updated in connection with the latest information from the Turbocharger makers. This is available at: www.mandiesel.com, under 'Turbocharger' → 'Overview' → 'Turbocharger selection'.

For information about turbocharger arrangement and cleaning systems, see Section 15.01.

High efficiency turbochargers for the MAN B&W S50MC6 engine - L_1 output			
Cyl.	**MAN (TCA)**	**ABB (TPL)**	**MHI (MET)**
5	1 x TCA55-20	1 x TPL73-B12	1 x MET53MA
6	1 x TCA66-20	1 x TPL77-B11	1 x MET60MA
7	1 x TCA66-20	1 x TPL77-B12	1 x MET60MA
8	1 x TCA77-20	1 x TPL77-B12/CL	1 x MET66MA
Conventional turbochargers for the MAN B&W S50MC6 engine - L_1 output			
Cyl.	**MAN (TCA)**	**ABB (TPL)**	**MHI (MET)**
5	1 x TCA55-20	1 x TPL73-B12	1 x MET53MA
6	1 x TCA66-20	1 x TPL73-B12/CS	1 x MET53MA
7	1 x TCA66-20	1 x TPL77-B12	1 x MET60MA
8	1 x TCA66-20	1 x TPL77-B12	1 x MET60MA

Fig. 3.01.01: High / Conventional efficiency turbochargers

Exhaust Gas By-pass

Extreme Ambient Conditions

As mentioned in Chapter 1, the engine power figures are valid for tropical conditions at sea level: 45 °C air at 1000 mbar and 32 °C sea water, whereas the reference fuel consumption is given at ISO conditions: 25 °C air at 1000 mbar and 25 °C charge air coolant temperature.

Marine diesel engines are, however, exposed to greatly varying climatic temperatures winter and summer in arctic as well as tropical areas. These variations cause changes of the scavenge air pressure, the maximum combustion pressure, the exhaust gas amount and temperatures as well as the specific fuel oil consumption.

For further information about the possible countermeasures, please refer to our publication titled:

Influence of Ambient Temperature Conditions

The publication is available at: www.mandiesel.com under 'Quicklinks' → 'Technical Papers'

Arctic running condition

For air inlet temperatures below -10 °C the precautions to be taken depend very much on the operating profile of the vessel. The following alternative is one of the possible countermeasures. The selection of countermeasures, however, must be evaluated in each individual case.

Exhaust gas receiver with variable by-pass

option: 4 60 118

Compensation for low ambient temperature can be obtained by using exhaust gas by-pass system.

This arrangement ensures that only part of the exhaust gas goes via the turbine of the turbocharger, thus supplying less energy to the compressor which, in turn, reduces the air supply to the engine.

Please note that if an exhaust gas by-pass is applied the turbocharger size and specification has to be determined by other means than stated in this Chapter.

Emergency Running Condition

Exhaust gas receiver with total by-pass flange and blank counterflange
Option: 4 60 119

By-pass of the total amount of exhaust gas round the turbocharger is only used for emergency running in the event of turbocharger failure on engines, see Fig. 3.02.01.

This enables the engine to run at a higher load with only one turbocharger under emergency conditions. The engine's exhaust gas receiver will in this case be fitted with a by-pass flange of approximately the same diameter as the inlet pipe to the turbocharger. The emergency pipe is yard's delivery.

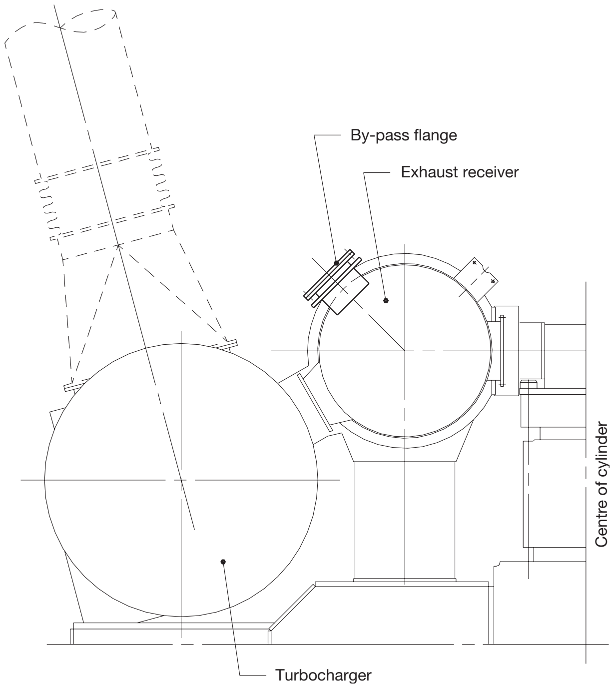

Fig. 3.02.01: Total by-pass of exhaust for emergency running

NO_x Reduction by SCR

The NO_x in the exhaust gas can be reduced with primary or secondary reduction methods. Primary methods affect the engine combustion process directly, whereas secondary methods reduce the emission level without changing the engine performance using equipment that does not form part of the engine itself.

For further information about emission control we refer to our publication:

Exhaust Gas Emission Control Today and Tomorrow

The publication is available at www.mandiesel.com under 'Quicklinks' → 'Technical Papers'

Engine with Selective Catalytic Reduction System
Option: 4 60 135

If a reduction between 50 and 98% of NO_x is required, the Selective Catalytic Reduction (SCR) system has to be applied by adding ammonia or urea to the exhaust gas before it enters a catalytic converter.

The exhaust gas must be mixed with ammonia before passing through the catalyst, and in order to encourage the chemical reaction the temperature level has to be between 300 and 400 °C. During this process the NO_x is reduced to N_2 and water.

This means that the SCR unit has to be located before the turbocharger on two-stroke engines because of their high thermal efficiency and thereby a relatively low exhaust gas temperature.

The amount of ammonia injected into the exhaust gas is controlled by a process computer and is based on the NO_x production at different loads measured during the testbed running. Fig. 3.03.01.

As the ammonia is a combustible gas, it is supplied through a double-walled pipe system, with appropriate venting and fitted with an ammonia leak detector (Fig. 3.03.01) which shows a simplified system layout of the SCR installation.

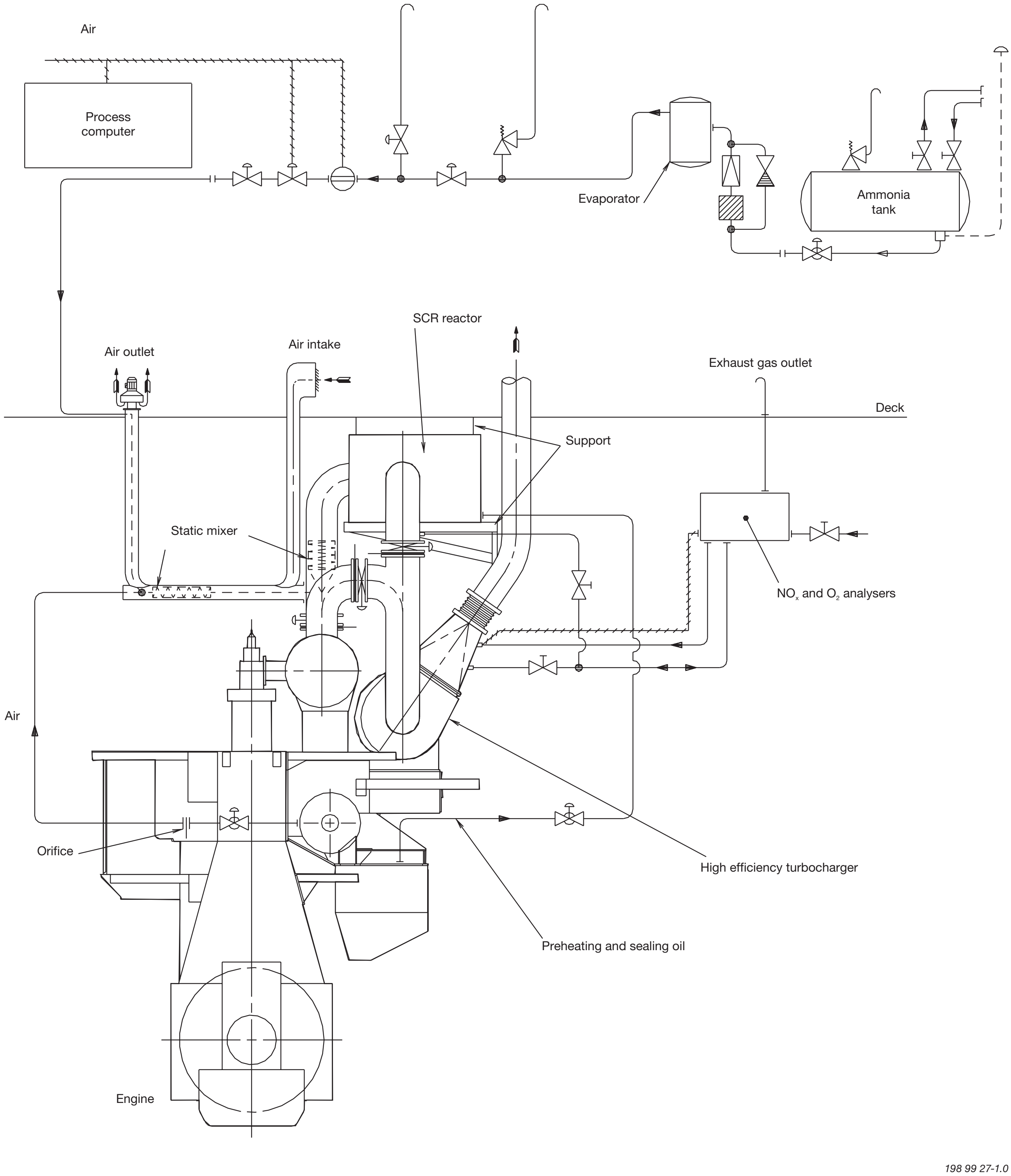

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Fig. 3.03.01: Layout of SCR system

Electricity Production

4

Electricity Production

Introduction

Next to power for propulsion, electricity production is the largest fuel consumer on board. The electricity is produced by using one or more of the following types of machinery, either running alone or in parallel:

- Auxiliary diesel generating sets
- Main engine driven generators
- Steam driven turbogenerators
- Emergency diesel generating sets.

The machinery installed should be selected on the basis of an economic evaluation of first cost, operating costs, and the demand for man-hours for maintenance.

In the following, technical information is given regarding main engine driven generators (PTO) and the auxiliary diesel generating sets produced by MAN Diesel.

The possibility of using a turbogenerator driven by the steam produced by an exhaust gas boiler can be evaluated based on the exhaust gas data.

Power Take Off

With a generator coupled to a Power Take Off (PTO) from the main engine, electrical power can be produced based on the main engine's low SFOC and the use of heavy fuel oil. Several standardised PTO systems are available, see Fig. 4.01.01 and the de-signations in Fig. 4.01.02:

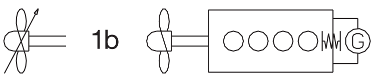
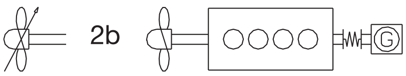
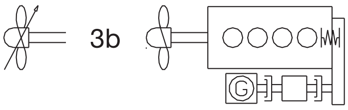
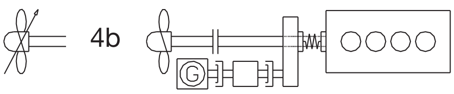
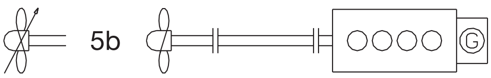
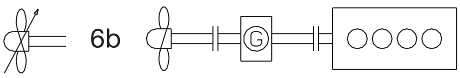
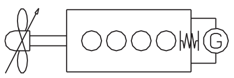
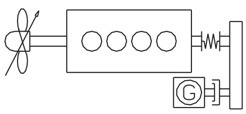
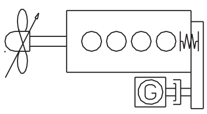
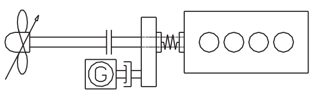
- PTO/RCF
  (Power Take Off/RENK Constant Frequency):
  Generator giving constant frequency, based on mechanical-hydraulical speed control.
- PTO/CFE
  (Power Take Off/Constant Frequency Electrical):
  Generator giving constant frequency, based on electrical frequency control.
- PTO/GCR
  (Power Take Off/Gear Constant Ratio):
  Generator coupled to a constant ratio step-up gear, used only for engines running at constant speed.

The DMG/CFE *(Direct Mounted Generator/Constant Frequency Electrical)* and the SMG/CFE (Shaft Mounted Generator/Constant Frequency Electrical) are special designs within the PTO/CFE group in which the generator is coupled directly to the main engine crankshaft and the intermediate shaft, respectively, without a gear. The electrical output of the generator is controlled by electrical frequency control.

Within each PTO system, several designs are available, depending on the positioning of the gear:

- BW I:
  Gear with a vertical generator mounted onto the fore end of the diesel engine, without any connections to the ship structure.
- BW II:
  A free-standing gear mounted on the tank top and connected to the fore end of the diesel engine, with a vertical or horizontal generator.
- BW III:
  A crankshaft gear mounted onto the fore end of the diesel engine, with a side-mounted generator without any connections to the ship structure.
- BW IV:
  A free-standing step-up gear connected to the intermediate shaft, with a horizontal generator.

The most popular of the gear based alternatives are the BW III/RCF types for plants with a fixed pitch propeller (FPP) and the BW IV/GCR for plants with a controllable pitch propeller (CPP). The BW III/RCF requires no separate seating in the ship and only little attention from the shipyard with respect to alignment.

	Alternative types and layouts of shaft generators	Design	Seating	Total efficiency (%)
PTO/RCF	1a 1b 	BW I/RCF	On engine (vertical generator)	88-91
	2a 2b 	BW II/RCF	On tank top	88-91
	3a 3b 	BW III/RCF	On engine	88-91
	4a 4b 	BW IV/RCF	On tank top	88-91
PTO/CFE	5a 5b 	DMG/CFE	On engine	84-88
	6a 6b 	SMG/CFE	On tank top	84-88
PTO/GCR	7 	BW I/GCR	On engine (vertical generator)	92
	8 	BW II/GCR	On tank top	92
	9 	BW III/GCR	On engine	92
	10 	BW IV/GCR	On tank top	92

178 19 66-3.1

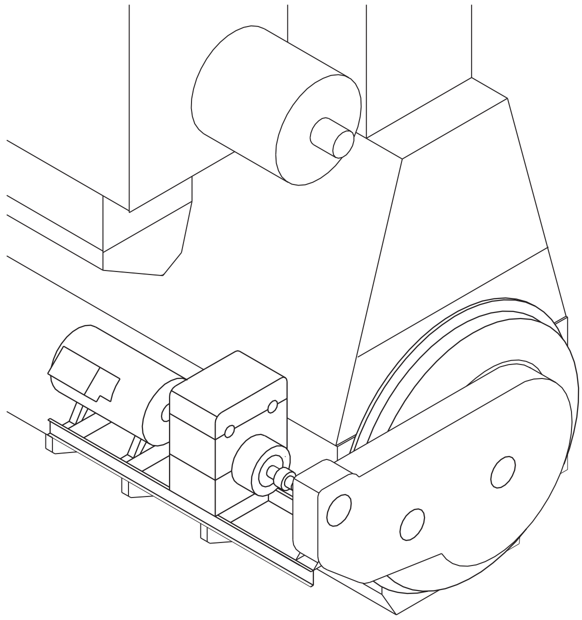
Fig. 4.01.01: Types of PTO

Designation of PTO

For further information, please refer to our publication titled:

Shaft Generators for MC and ME engines

The publication is available at: www.mandiesel.com under 'Quicklinks' → 'Technical Papers'



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Power take off:

BW III S60MC-C7/RCF 700-60

- 50: 50 Hz
  60: 60 Hz
- kW on generator terminals
- RCF: Renk constant frequency unit
  CFE: Electrically frequency controlled unit
  GCR: Step-up gear with constant ratio
- Mark version
- Engine type on which it is applied
- Layout of PTO: See Fig. 4.01.01
- Make: MAN Diesel

178 39 55-6.0

Fig. 4.01.02: Example of designation of PTO

PTO/RCF

Side mounted generator, BWIII/RCF
(Fig. 4.01.01, Alternative 3)

The PTO/RCF generator systems have been developed in close cooperation with the German gear manufacturer RENK. A complete package solution is offered, comprising a flexible coupling, a step-up gear, an epicyclic, variable-ratio gear with built-in clutch, hydraulic pump and motor, and a standard generator, see Fig. 4.01.03.

For marine engines with controllable pitch propellers running at constant engine speed, the hydraulic system can be dispensed with, i.e. a PTO/GCR design is normally used.

Fig. 4.01.03 shows the principles of the PTO/RCF arrangement. As can be seen, a step-up gear box (called crankshaft gear) with three gear wheels is bolted directly to the frame box of the main engine. The bearings of the three gear wheels are mounted in the gear box so that the weight of the wheels is not carried by the crankshaft. In the frame box, between the crankcase and the gear drive, space is available for tuning wheel, counterweights, axial vibration damper, etc.

The first gear wheel is connected to the crankshaft via a special flexible coupling made in one piece with a tooth coupling driving the crankshaft gear, thus isolating it against torsional and axial vibrations.

By means of a simple arrangement, the shaft in the crankshaft gear carrying the first gear wheel and the female part of the toothed coupling can be moved forward, thus disconnecting the two parts of the toothed coupling.

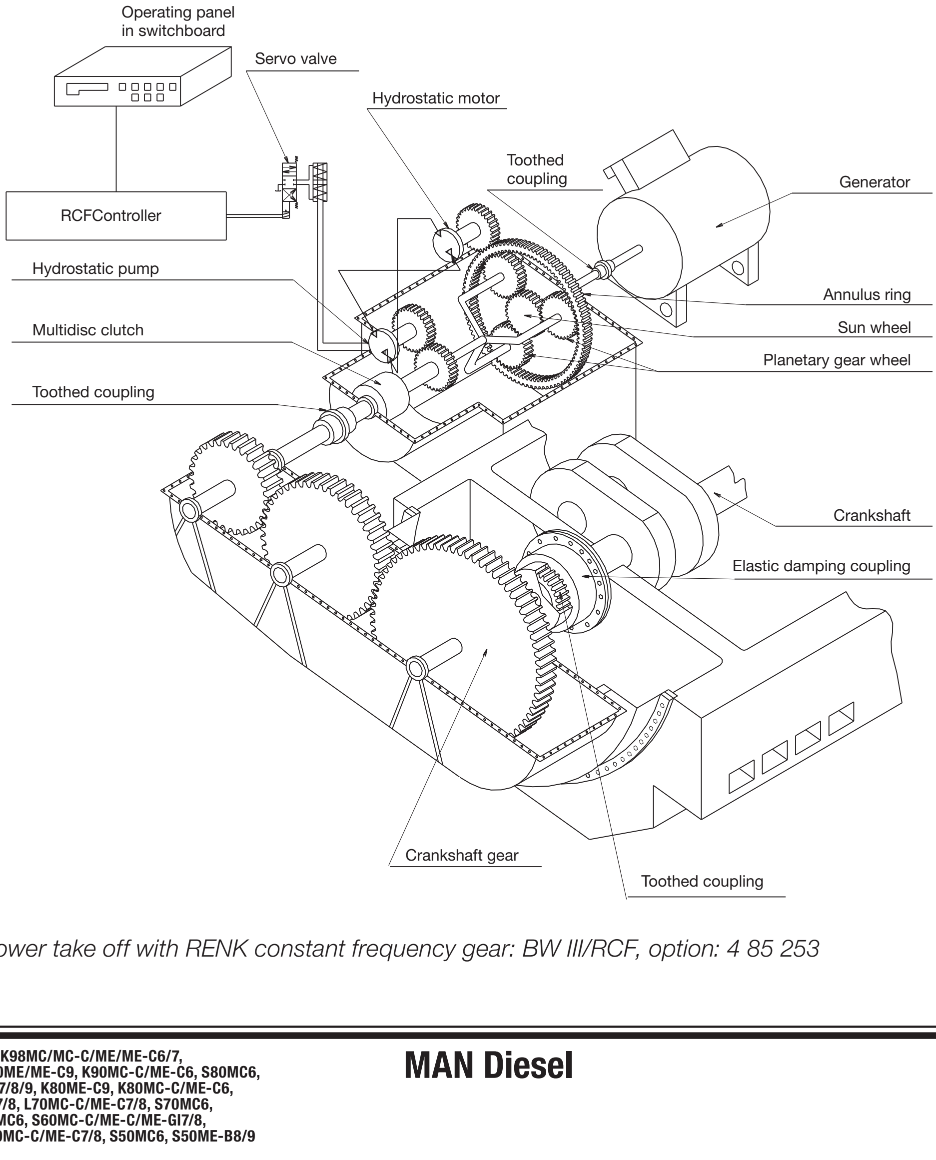

Fig. 4.01.03: Power take off with RENK constant frequency gear: BW III/RCF, option: 4 85 253

The power from the crankshaft gear is transferred, via a multi-disc clutch, to an epicyclic variable-ratio gear and the generator. These are mounted on a common bedplate, bolted to brackets integrated with the engine bedplate.

The BWIII/RCF unit is an epicyclic gear with a hydrostatic superposition drive. The hydrostatic input drives the annulus of the epicyclic gear in either direction of rotation, hence continuously varying the gearing ratio to keep the generator speed constant throughout an engine speed variation of 30%. In the standard layout, this is between 100% and 70% of the engine speed at specified MCR, but it can be placed in a lower range if required.

The input power to the gear is divided into two paths – one mechanical and the other hydrostatic – and the epicyclic differential combines the power of the two paths and transmits the combined power to the output shaft, connected to the generator. The gear is equipped with a hydrostatic motor driven by a pump, and controlled by an electronic control unit. This keeps the generator speed constant during single running as well as when running in parallel with other generators.

The multi-disc clutch, integrated into the gear input shaft, permits the engaging and disengaging of the epicyclic gear, and thus the generator, from the main engine during operation.

An electronic control system with a RENK controller ensures that the control signals to the main electrical switchboard are identical to those for the normal auxiliary generator sets. This applies to ships with automatic synchronising and load sharing, as well as to ships with manual switchboard operation.

Internal control circuits and interlocking functions between the epicyclic gear and the electronic control box provide automatic control of the functions necessary for the reliable operation and protection of the BWIII/RCF unit. If any monitored value exceeds the normal operation limits, a warning or an alarm is given depending upon the origin, severity and the extent of deviation from the permissible values. The cause of a warning or an alarm is shown on a digital display.

Extent of delivery for BWIII/RCF units

The delivery comprises a complete unit ready to be built-on to the main engine. Fig. 4.02.01 shows the required space and the standard electrical output range on the generator terminals.

Standard sizes of the crankshaft gears and the RCF units are designed for:
700, 1200, 1800 and 2600 kW, while the generator sizes of make A. van Kaick are:

Type DSG		440 V 1800 kVA	60 Hz r/min kW	380 V 1500 kVA	50 Hz r/min kW
62	M2-4	707	566	627	501
62	L1-4	855	684	761	609
62	L2-4	1,056	845	940	752
74	M1-4	1,271	1,017	1,137	909
74	M2-4	1,432	1,146	1,280	1,024
74	L1-4	1,651	1,321	1,468	1,174
74	L2-4	1,924	1,539	1,709	1,368
86	K1-4	1,942	1,554	1,844	1,475
86	M1-4	2,345	1,876	2,148	1,718
86	L2-4	2,792	2,234	2,542	2,033
99	K1-4	3,222	2,578	2,989	2,391

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In the event that a larger generator is required, please contact MAN Diesel.

If a main engine speed other than the nominal is required as a basis for the PTO operation, it must be taken into consideration when determining the ratio of the crankshaft gear. However, it has no influence on the space required for the gears and the generator.

The PTO can be operated as a motor (PTI) as well as a generator by making some minor modifications.

Yard deliveries are:

1. Cooling water pipes to the built-on lubricating oil cooling system, including the valves.

2. Electrical power supply to the lubricating oil stand-by pump built on to the RCF unit.

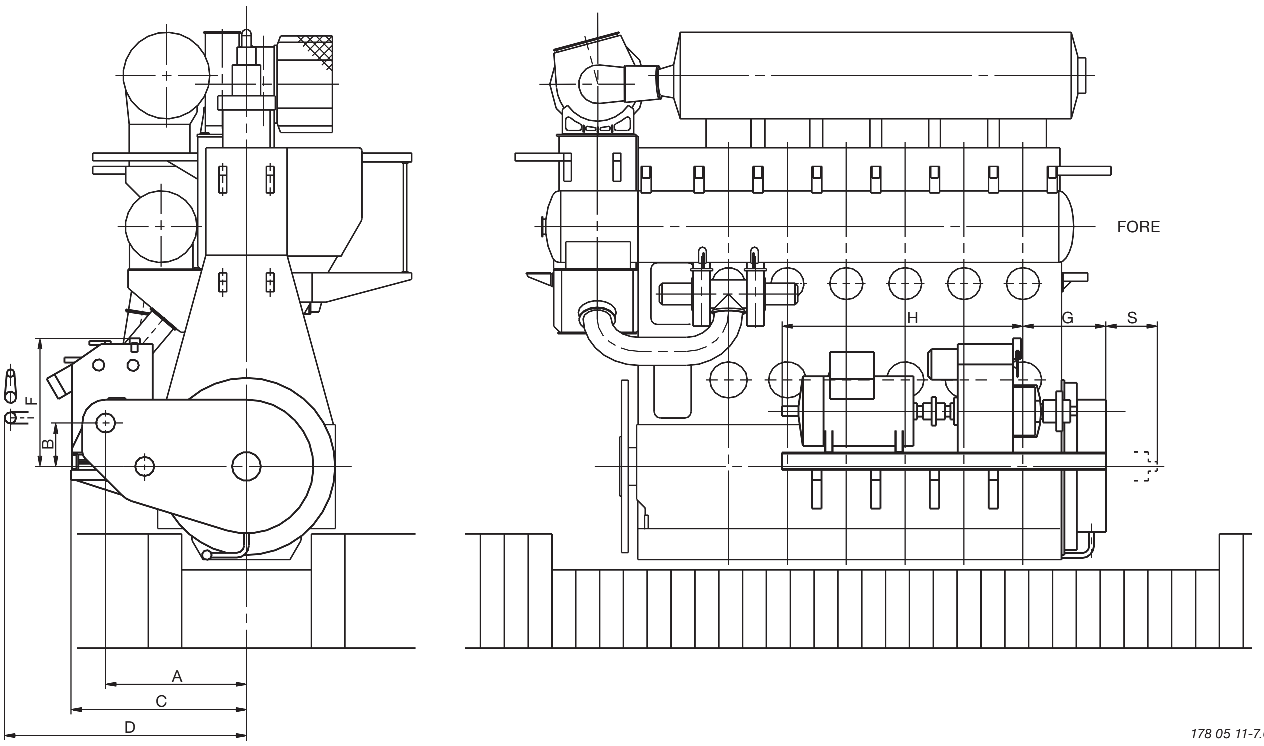
3. Wiring between the generator and the operator control panel in the switchboard.

4. An external permanent lubricating oil filling-up connection can be established in connection with the RCF unit. The system is shown in Fig. 4.03.03 ‘Lubricating oil system for RCF gear’. The dosage tank and the pertaining piping are to be delivered by the yard. The size of the dosage tank is stated in the table for RCF gear in ‘Necessary capacities for PTO/RCF’ (Fig. 4.03.02).

The necessary preparations to be made on the engine are specified in Figs. 4.03.01a and 4.03.01b.

Additional capacities required for BWIII/RCF

The capacities stated in the ‘List of capacities’ for the main engine in question are to be increased by the additional capacities for the crankshaft gear and the RCF gear stated in Fig. 4.03.02.



	kW generator			
	700 kW	1200 kW	1800 kW	2600 kW
A	2,355	2,355	2,495	2,495
B	776	776	776	776
C	3,015	3,015	3,295	3,295
D	3,410	3,410	3,690	3,690
F	1,826	1,946	2,066	2,176
G	2,210	2,210	2,510	2,510
H	2,293	2,795	3,200	4,530
S	380	470	500	590
	System mass (kg) with generator:			
	22,750	26,500	37,100	48,550
	System mass (kg) without generator:			
	20,750	23,850	32,800	43,350

The stated kW at the generator terminals is available between 70% and 100% of the engine speed at specified MCR

Space requirements have to be investigated case by case on plants with 2600 kW generator.

Dimension H: This is only valid for A. van Kaick generator type DSG, enclosure IP23, frequency = 60 Hz, speed = 1800 r/min

Fig. 4.02.01: Space requirement for side mounted generator PTO/RCF type BWIII S50/RCF

Engine preparations for PTO

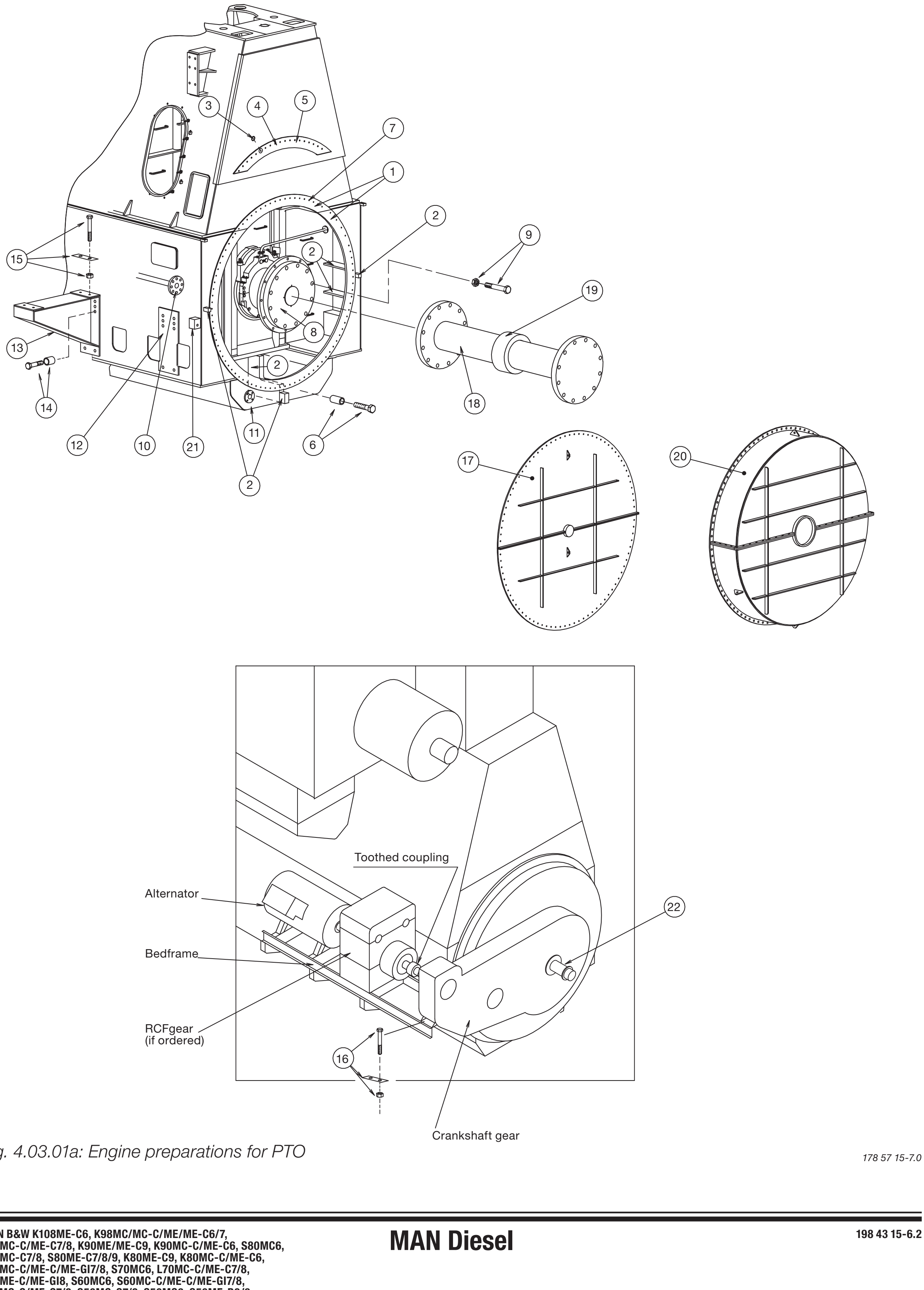


Fig. 4.03.01a: Engine preparations for PTO

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Pos.

1 Special face on bedplate and frame box

2 Ribs and brackets for supporting the face and machined blocks for alignment of gear or stator housing

3 Machined washers placed on frame box part of face to ensure that it is flush with the face on the bedplate

4 Rubber gasket placed on frame box part of face

5 Shim placed on frame box part of face to ensure that it is flush with the face of the bedplate

6 Distance tubes and long bolts

7 Threaded hole size, number and size of spring pins and bolts to be made in agreement with PTO maker

8 Flange of crankshaft, normally the standard execution can be used

9 Studs and nuts for crankshaft flange

10 Free flange end at lubricating oil inlet pipe (incl. blank flange)

11 Oil outlet flange welded to bedplate (incl. blank flange)

12 Face for brackets

13 Brackets

14 Studs for mounting the brackets

15 Studs, nuts and shims for mounting of RCF-/generator unit on the brackets

16 Shims, studs and nuts for connection between crankshaft gear and RCF-/generator unit

17 Engine cover with connecting bolts to bedplate/frame box to be used for shop test without PTO

18 Intermediate shaft between crankshaft and PTO

19 Oil sealing for intermediate shaft

20 Engine cover with hole for intermediate shaft and connecting bolts to bedplate/frame box

21 Plug box for electronic measuring instrument for checking condition of axial vibration damper

22 Tacho encoder for ME control system or Alpha lubrication system on MC engine

23 Tacho trigger ring for ME control system or Alpha lubrication system on MC engine

Pos. no:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
BWIII/RCF	A	A	A	A		B		A	B	A	A	A	A	A	B	B	A				A	A	
BWIII/CFE	A	A	A	A		B		A	B	A	A	A	A	A	B	B	A				A	A	
BWII/RCF								A	A									A	A	A	A		A
BWII/CFE								A	A									A	A	A	A		A
BWI/RCF	A	A	A	A		B		A	B								A				A		A
BWI/CFE	A	A	A	A		B		A	B	A	A						A				A		A
DMG/CFE	A	A			A	B	C	A	B								A				A		A

A: Preparations to be carried out by engine builder

B: Parts supplied by PTO-maker

C: See text of pos. no.

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Fig. 4.03.01b: Engine preparations for PTO

Crankshaft gear lubricated from the main engine lubricating oil system

The figures are to be added to the main engine capacity list:

Nominal output of generator	kW	700	1,200	1,800	2,600
Lubricating oil flow	m^3/h	4.1	4.1	4.9	6.2
Heat dissipation	kW	12.1	20.8	31.1	45.0

RCF gear with separate lubricating oil system:

Nominal output of generator	kW	700	1,200	1,800	2,600
Cooling water quantity	m^3/h	14.1	22.1	30.0	39.0
Heat dissipation	kW	55	92	134	180
El. power for oil pump	kW	11.0	15.0	18.0	21.0
Dosage tank capacity	m^3	0.40	0.51	0.69	0.95
El. power for Renk-controller		24V DC ± 10%, 8 amp			

From main engine:
Design lube oil pressure: 2.25 bar
Lube oil pressure at crankshaft gear: min. 1 bar
Lube oil working temperature: 50 °C
Lube oil type: SAE 30

Cooling water inlet temperature: 36 °C
Pressure drop across cooler: approximately 0.5 bar
Fill pipe for lube oil system store tank (~ø32)
Drain pipe to lube oil system drain tank (~ø40)
Electric cable between Renk terminal at gearbox and operator control panel in switchboard: Cable type FMGCG 19 x 2 x 0.5

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Fig. 4.03.02: Necessary capacities for PTO/RCF, BW III/RCF system

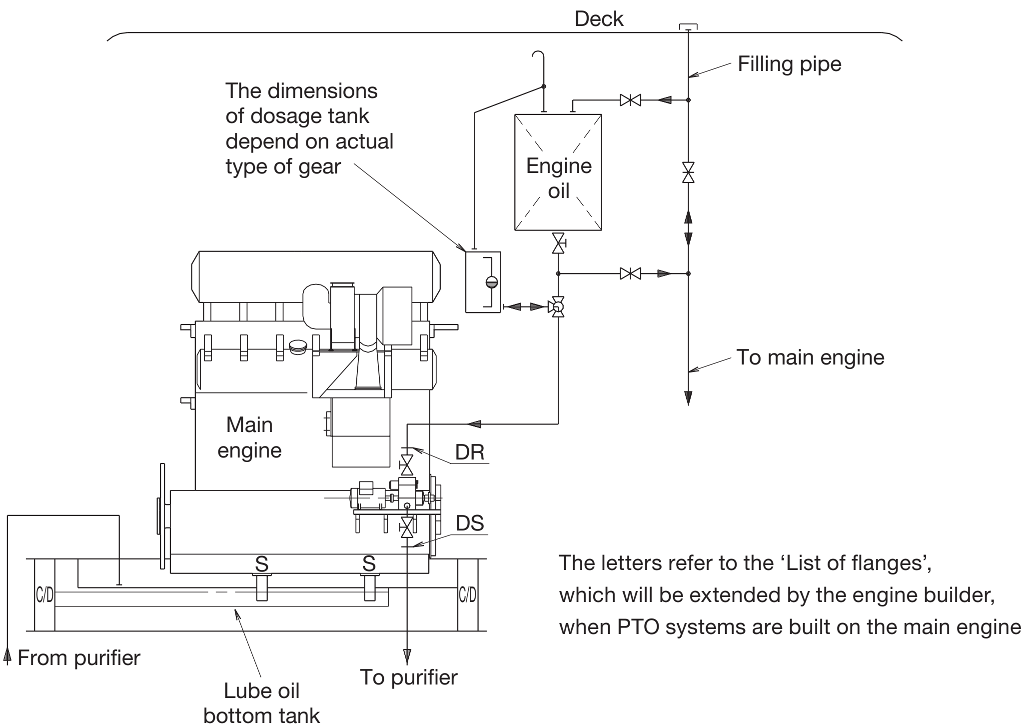

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Fig. 4.03.03: Lubricating oil system for RCF gear

DMG/CFE Generators
Option: 4 85 259

Fig. 4.01.01 alternative 5, shows the DMG/CFE (Direct Mounted Generator/Constant Frequency Electrical) which is a low speed generator with its rotor mounted directly on the crankshaft and its stator bolted on to the frame box as shown in Figs. 4.03.04 and 4.03.05.

The DMG/CFE is separated from the crankcase by a plate and a labyrinth stuffing box.

The DMG/CFE system has been developed in co-operation with the German generator manufacturers Siemens and AEG, but similar types of generator can be supplied by others, e.g. Fuji, Taiyo and Nishishiba in Japan.

For generators in the normal output range, the mass of the rotor can normally be carried by the foremost main bearing without exceeding the permissible bearing load (see Fig. 4.03.05), but this must be checked by the engine manufacturer in each case.

If the permissible load on the foremost main bearing is exceeded, e.g. because a tuning wheel is needed, this does not preclude the use of a DMG/CFE.

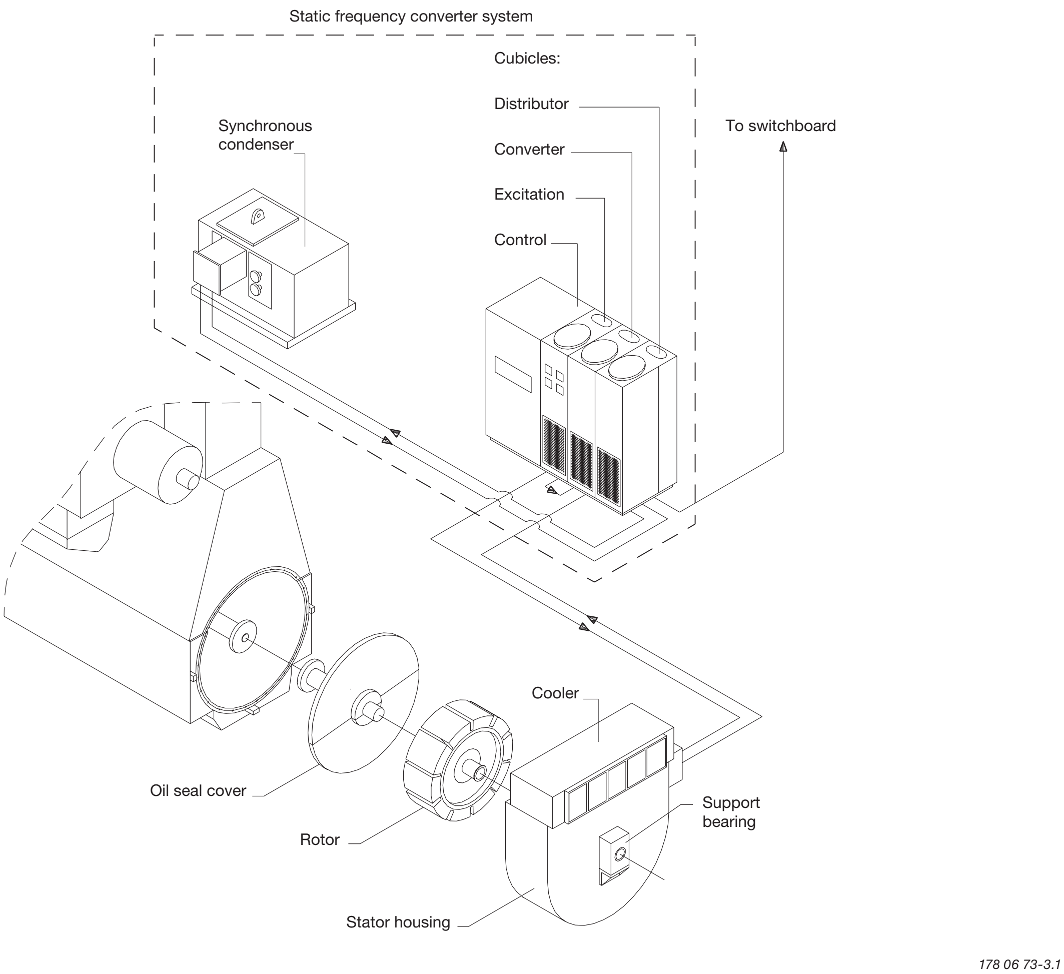


Fig. 4.03.04: Standard engine, with direct mounted generator (DMG/CFE)

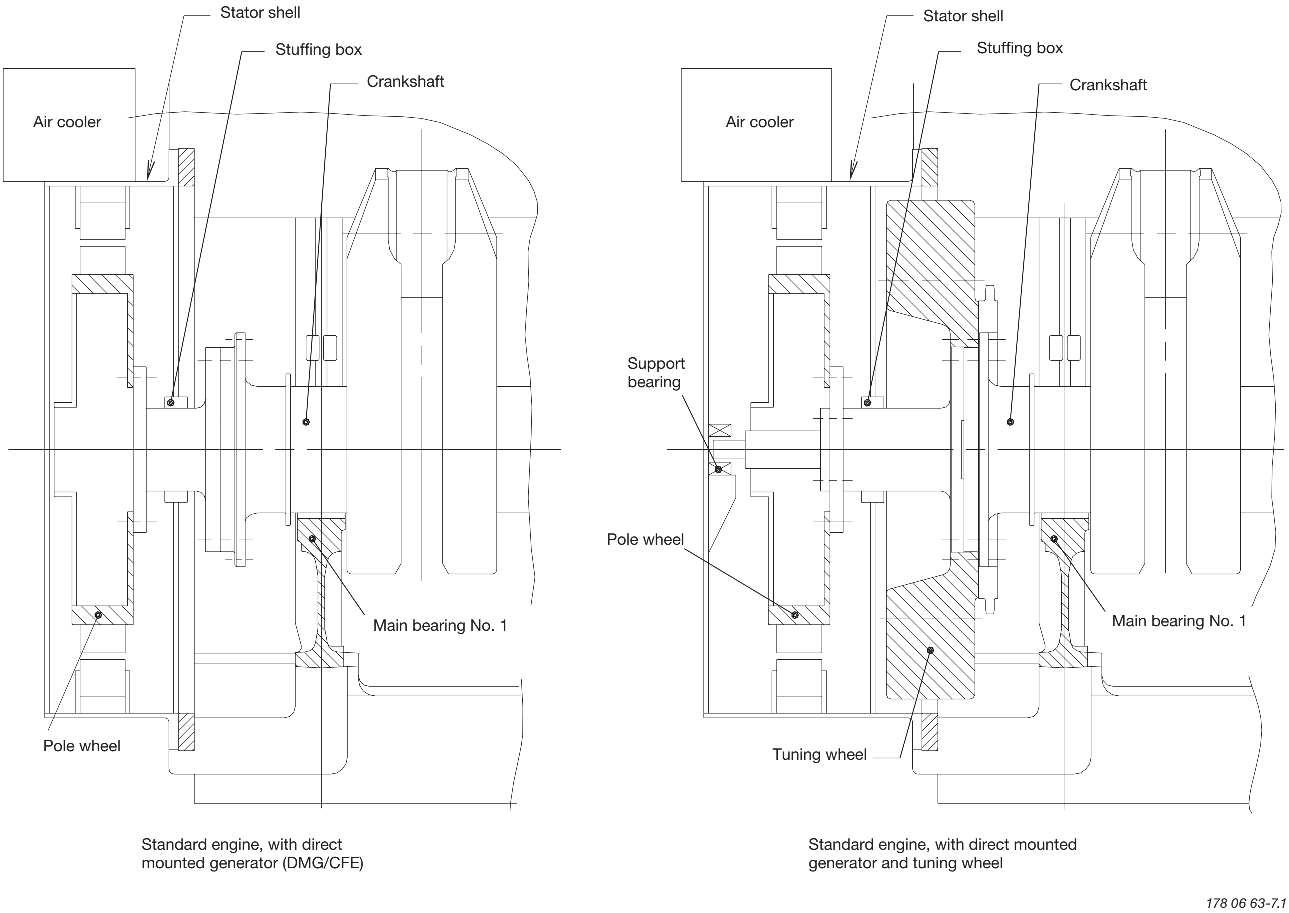


Fig. 4.03.05: Standard engine, with direct mounted generator and tuning wheel

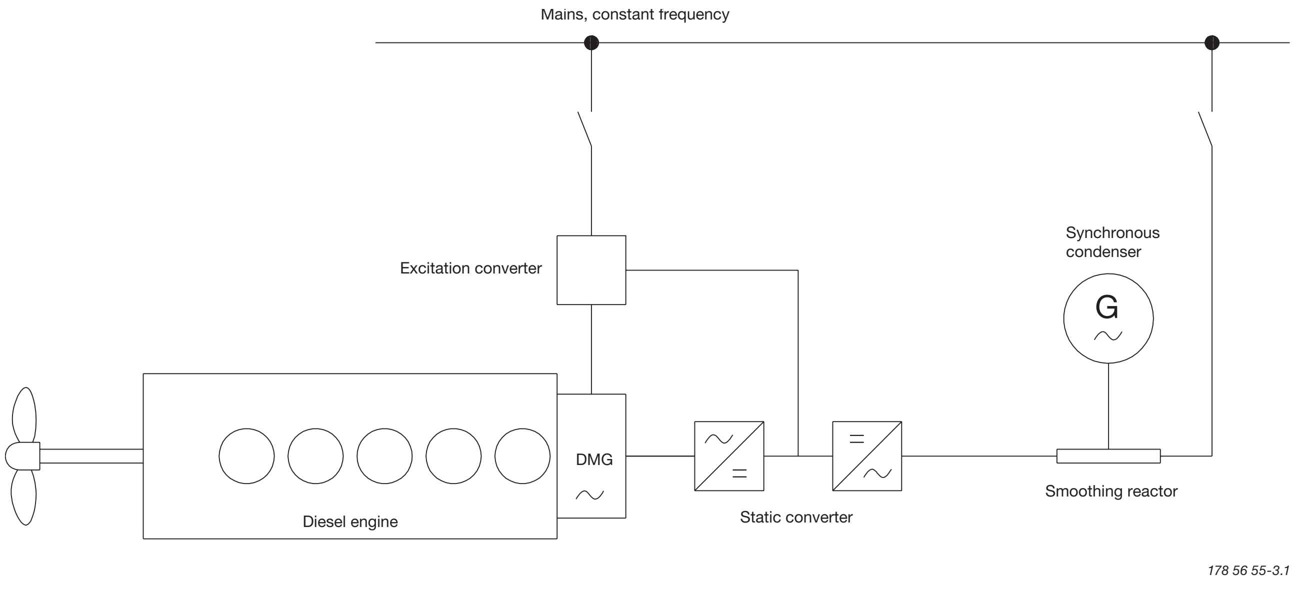


Fig. 4.03.06: Diagram of DMG/CFE with static converter

In such a case, the problem is solved by installing a small, elastically supported bearing in front of the stator housing, as shown in Fig. 4.03.05.

As the DMG type is directly connected to the crankshaft, it has a very low rotational speed and, consequently, the electric output current has a low frequency – normally of the order of 15 Hz.

Therefore, it is necessary to use a static frequency converter between the DMG and the main switchboard. The DMG/CFE is, as standard, laid out for operation with full output between 100% and 70% and with reduced output between 70% and 50% of the engine speed at specified MCR.

Static converter

The static frequency converter system (see Fig. 4.03.06) consists of a static part, i.e. thyristors and control equipment, and a rotary electric machine.

The DMG produces a three-phase alternating current with a low frequency, which varies in accordance with the main engine speed. This alternating current is rectified and led to a thyristor inverter producing a three-phase alternating current with constant frequency.

Since the frequency converter system uses a DC intermediate link, no reactive power can be supplied to the electric mains. To supply this reactive power, a synchronous condenser is used. The synchronous condenser consists of an ordinary synchronous generator coupled to the electric mains.

Extent of delivery for DMG/CFE units

The delivery extent is a generator fully built-on to the main engine including the synchronous condenser unit and the static converter cubicles which are to be installed in the engine room.

The DMG/CFE can, with a small modification, be operated both as a generator and as a motor (PTI).

Yard deliveries are:

1. Installation, i.e. seating in the ship for the synchronous condenser unit and for the static converter cubicles
2. Cooling water pipes to the generator if water cooling is applied
3. Cabling.

The necessary preparations to be made on the engine are specified in Figs. 4.03.01a and 4.03.01b.

SMG/CFE Generators

The PTO SMG/CFE (see Fig. 4.01.01 alternative 6) has the same working principle as the PTO DMG/CFE, but instead of being located on the front end of the engine, the alternator is installed aft of the engine, with the rotor integrated on the intermediate shaft.

In addition to the yard deliveries mentioned for the PTO DMG/CFE, the shipyard must also provide the foundation for the stator housing in the case of the PTO SMG/CFE.

The engine needs no preparation for the installation of this PTO system.

PTO type: BW II/GCR

Power Take Off/Gear Constant Ratio

The PTO system type BWII/GCR illustrated in Fig. 4.01.01 alternative 5 can generate electrical power on board ships equipped with a controllable pitch propeller, running at constant speed.

The PTO unit is mounted on the tank top at the fore end of the engine see Fig. 4.04.01. The PTO generator is activated at sea, taking over the electrical power production on board when the main engine speed has stabilised at a level corresponding to the generator frequency required on board.

The installation length in front of the engine, and thus the engine room length requirement, naturally exceeds the length of the engine aft end mounted shaft generator arrangements. However, there is some scope for limiting the space requirement, depending on the configuration chosen.

PTO type: BW IV/GCR

Power Take Off/Gear Constant Ratio

The shaft generator system, type PTO BW IV/GCR, installed in the shaft line (Fig. 4.01.01 alternative 6) can generate power on board ships equipped with a controllable pitch propeller running at constant speed.

The PTO system can be delivered as a tunnel gear with hollow flexible coupling or, alternatively, as a generator step-up gear with thrust bearing and flexible coupling integrated in the shaft line.

The main engine needs no special preparation for mounting these types of PTO systems as they are connected to the intermediate shaft.

The PTO system installed in the shaft line can also be installed on ships equipped with a fixed pitch propeller or controllable pitch propeller running in

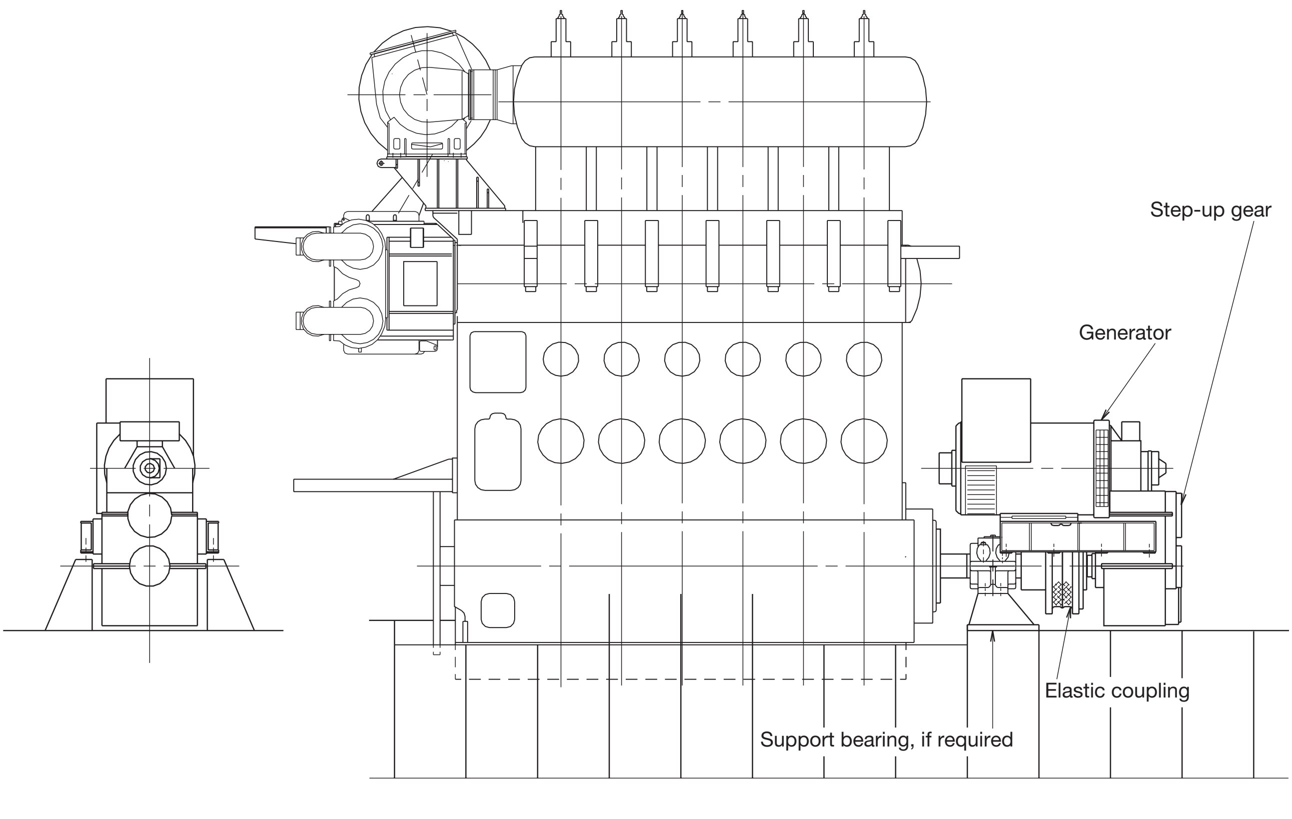


Fig. 4.04.01: Power Take Off (PTO) BW II/GCR

combinator mode. This will, however, require an additional RENK Constant Frequency gear (Fig. 4.01.01 alternative 2) or additional electrical equipment for maintaining the constant frequency of the generated electric power.

Tunnel gear with hollow flexible coupling

This PTO system is normally installed on ships with a minor electrical power take off load compared to the propulsion power, up to approximately 25% of the engine power.

The hollow flexible coupling is only to be dimensioned for the maximum electrical load of the power take off system and this gives an economic advantage for minor power take off loads compared to the system with an ordinary flexible coupling integrated in the shaft line.

The hollow flexible coupling consists of flexible segments and connecting pieces, which allow replacement of the coupling segments without dismounting the shaft line, see Fig. 4.04.02.

Generator step-up gear and flexible coupling integrated in the shaft line

For higher power take off loads, a generator step-up gear and flexible coupling integrated in the shaft line may be chosen due to first costs of gear and coupling.

The flexible coupling integrated in the shaft line will transfer the total engine load for both propulsion and electrical power and must be dimensioned accordingly.

The flexible coupling cannot transfer the thrust from the propeller and it is, therefore, necessary to make the gear-box with an integrated thrust bearing.

This type of PTO system is typically installed on ships with large electrical power consumption, e.g. shuttle tankers.

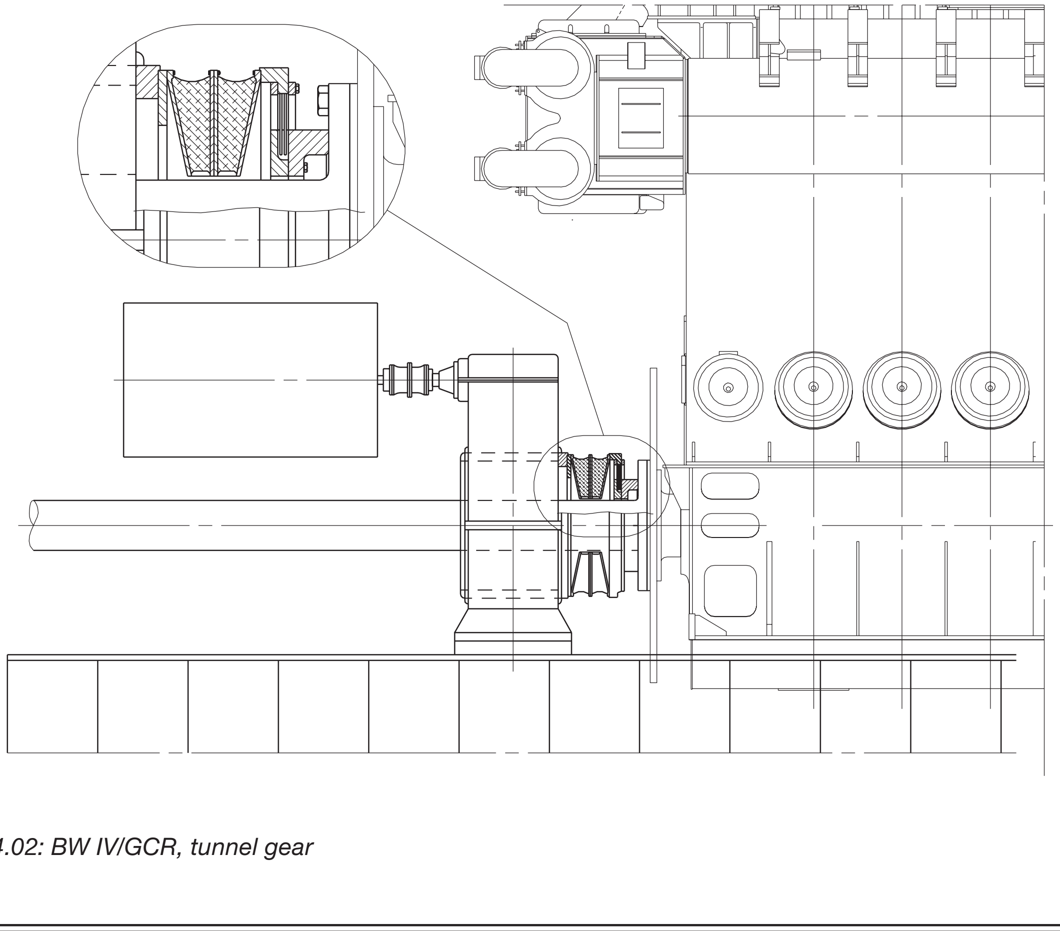


Fig. 4.04.02: BW IV/GCR, tunnel gear

Auxiliary Propulsion System/Take Home System

From time to time an Auxiliary Propulsion System/ Take Home System capable of driving the CP propeller by using the shaft generator as an electric motor is requested.

MAN Diesel can offer a solution where the CP propeller is driven by the alternator via a two-speed tunnel gear box. The electric power is produced by a number of GenSets. The main engine is disengaged by a clutch (RENK KAZ) made as an integral part of the shafting. The clutch is installed between the tunnel gear box and the main engine, and conical bolts are used to connect and disconnect the main engine and the shafting. See Figure 4.04.03.

A thrust bearing, which transfers the auxiliary propulsion propeller thrust to the engine thrust bearing when the clutch is disengaged, is built into the RENK KAZ clutch. When the clutch is engaged, the thrust is transferred statically to the engine thrust bearing through the thrust bearing built into the clutch.

To obtain high propeller efficiency in the auxiliary propulsion mode, and thus also to minimise the auxiliary power required, a two-speed tunnel gear, which provides lower propeller speed in the auxiliary propulsion mode, is used.

The two-speed tunnel gear box is made with a friction clutch which allows the propeller to be clutched in at full alternator/motor speed where the full torque is available. The alternator/motor is started in the de-clutched condition with a start transformer.

The system can quickly establish auxiliary propulsion from the engine control room and/or bridge, even with unmanned engine room.

Re-establishment of normal operation requires attendance in the engine room and can be done within a few minutes.

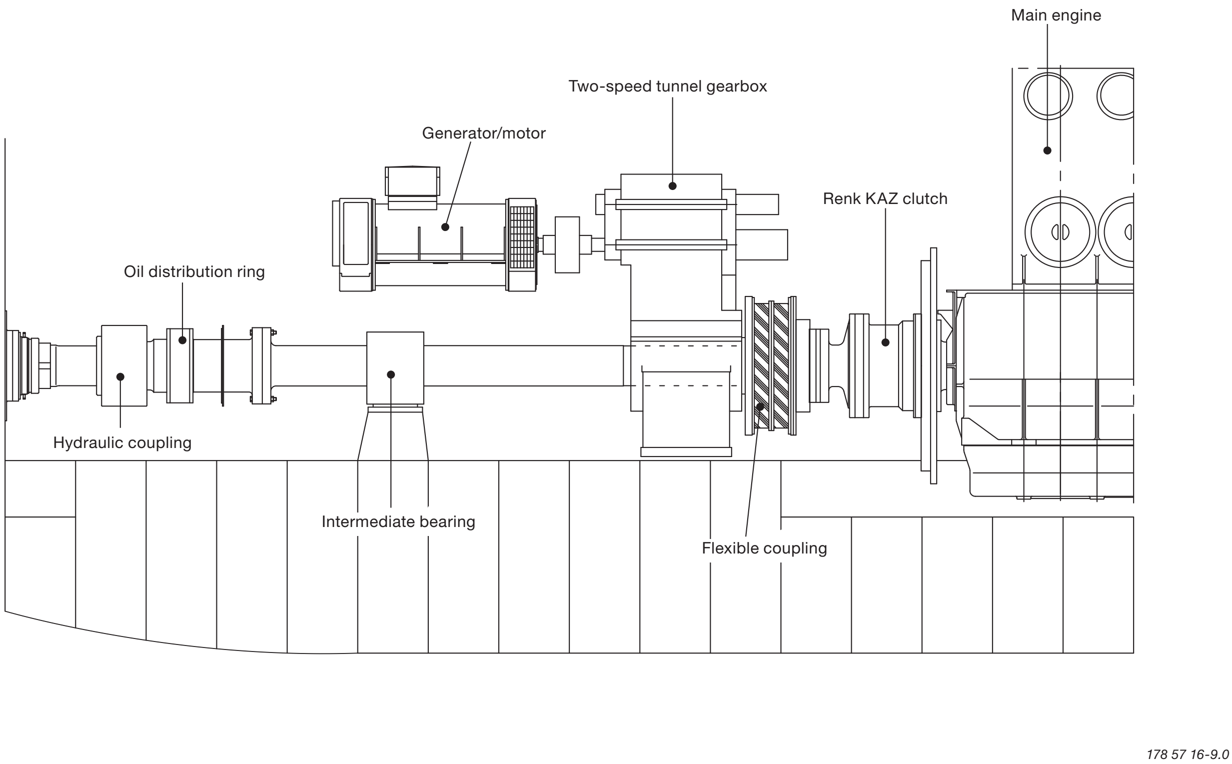


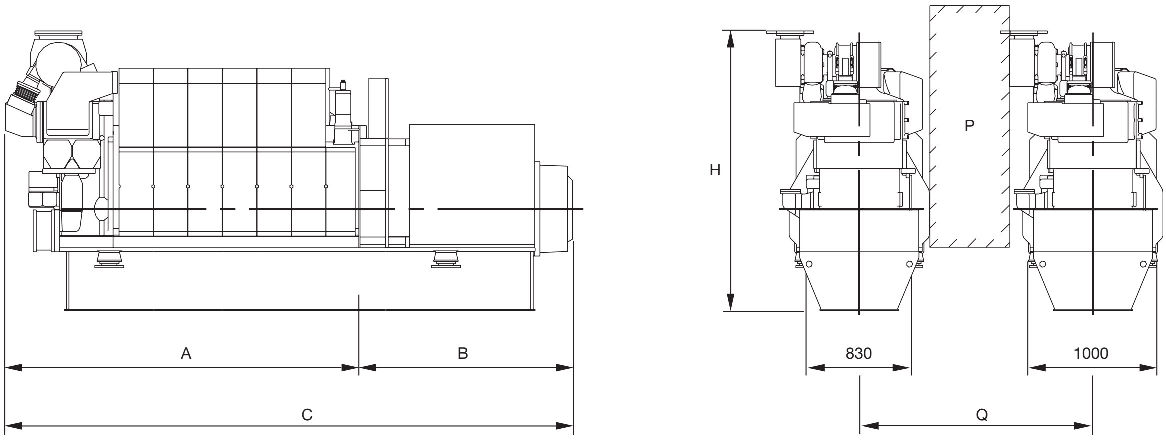
Fig. 4.04.03: Auxiliary propulsion system

Waste Heat Recovery Systems (WHR)

This section is not applicable

L16/24 GenSet Data

Bore: 160 mm				Stroke: 240 mm
	Power layout			
	1,200 r/min	60 Hz	1,000 r/min	50 Hz
	Eng. kW	Gen. kW	Eng. kW	Gen. kW
5L16/24	500	475	450	430
6L16/24	660	625	540	515
7L16/24	770	730	630	600
8L16/24	880	835	720	685
9L16/24	990	940	810	770



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No. of Cyls.	A (mm)	* B (mm)	* C (mm)	H (mm)	**Dry weight GenSet (t)
5 (1,000 r/min)	2,751	1,400	4,151	2,226	9.5
5 (1,200 r/min)	2,751	1,400	4,151	2,226	9.5
6 (1,000 r/min)	3,026	1,490	4,516	2,226	10.5
6 (1,200 r/min)	3,026	1,490	4,516	2,226	10.5
7 (1,000 r/min)	3,301	1,585	4,886	2,226	11.4
7 (1,200 r/min)	3,301	1,585	4,886	2,266	11.4
8 (1,000 r/min)	3,576	1,680	5,256	2,266	12.4
8 (1,200 r/min)	3,576	1,680	5,256	2,266	12.4
9 (1,000 r/min)	3,851	1,680	5,531	2,266	13.1
9 (1,200 r/min)	3,851	1,680	5,531	2,266	13.1

P Free passage between the engines, width 600 mm and height 2,000 mm
Q Min. distance between engines: 1,800 mm
* Depending on alternator
** Weight incl. standard alternator (based on a Leroy Somer alternator)
All dimensions and masses are approximate and subject to change without prior notice.

178 33 87-4.3

Fig. 4.06.01: Power and outline of L16/24

L16/24 GenSet Data

		Cyl.	5	6	7	8	9
Max. continuous rating at	**1,000 rpm**	kW	450	540	630	720	810
Engine Driven Pumps:							
H.T. cooling water pump	(2.0 bar)**	m³/h	10.9	12.7	14.5	16.3	18.1
L.T. cooling water pump	(1.7 bar)**	m³/h	15.7	18.9	22.0	25.1	28.3
Lubricating oil	(3-5.0 bar)	m³/h	21	23	24	26	28
External Pumps:							
Diesel oil pump	(5 bar at fuel oil inlet A1)	m³/h	0.31	0.38	0.44	0.50	0.57
Fuel oil supply pump	(4 bar discharge pressure)	m³/h	0.15	0.18	0.22	0.25	0.28
Fuel oil circulating pump	(8 bar at fuel oil inlet A1)	m³/h	0.32	0.38	0.45	0.51	0.57
Cooling Capacities:							
Lubricating oil		kW	79	95	110	126	142
Charge air L.T.		kW	43	51	60	68	77
*Flow L.T. at 36°C inlet and 44°C outlet		m³/h	13.1	15.7	18.4	21.0	23.6
Jacket cooling		kW	107	129	150	171	193
Charge air H.T		kW	107	129	150	171	193
Gas Data:							
Exhaust gas flow		kg/h	3,321	3,985	4,649	5,314	5,978
Exhaust gas temp.		°C	330	330	330	330	330
Max. allowable back press.		bar	0.025	0.025	0.025	0.025	0.025
Air consumption		kg/h	3,231	3,877	4,523	5,170	5,816
Starting Air System:							
Air consumption per start		Nm	0.47	0.56	0.65	0.75	0.84
Air consumption per start		Nm	0.80	0.96	1.12	1.28	1.44
Heat Radiation:							
Engine		kW	11	13	15	17	19
Alternator		kW	(see separate data from the alternator maker)				

The stated heat balances are based on tropical conditions, the flows are based on ISO ambient condition.

* The outlet temperature of the H.T. water is fixed to 80°C, and 44°C for L.T. water. At different inlet temperatures the flow will change accordingly.

Example: if the inlet temperature is 25°C, then the L.T. flow will change to (44-36)/(44-25)*100 = 42% of the original flow. If the temperature rises above 36°C, then the L.T. outlet will rise accordingly.

** Max. permission inlet pressure 2.0 bar.

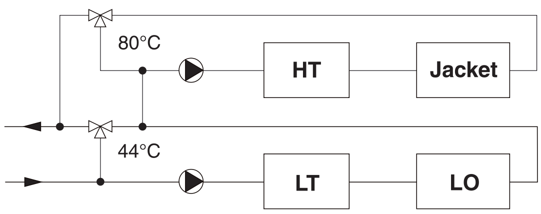

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Fig. 4.06.02a: List of capacities for L16/24 1,000 rpm

L16/24 GenSet Data

		Cyl.	5	6	7	8	9
Max continues rating	**1,200 rpm**	kW	500	660	770	880	990
Engine driven pumps:							
LT cooling water pump	2 bar	m³/h	27	27	27	27	27
HT cooling water pump	2 bar	m³/h	27	27	27	27	27
Lubricating oil main pump	8 bar	m³/h	21	21	35	35	35
Separate pumps:							
Max. Delivery pressure of cooling water pumps		bar	2.5	2.5	2.5	2.5	2.5
Diesel oil pump	(5 bar at fuel oil inlet A1)	m³/h	0.35	0.46	0.54	0.61	0.69
Fuel oil supply pump	(4 bar discharge pressure)	m³/h	0.17	0.22	0.26	0.30	0.34
Fuel oil circulating pump	(8 bar at fuel oil inlet A1)	m³/h	0.35	0.46	0.54	0.62	0.70
Cooling capacity:							
Lubricating oil		kW	79	103	122	140	159
Charge air LT		kW	40	57	70	82	95
Total LT system		kW	119	160	192	222	254
Flow LT at 36°C inlet and 44°C outlet		m³/h	13	17	21	24	27
Jacket cooling		kW	119	162	191	220	249
Charge air HT		kW	123	169	190	211	230
Total HT system		kW	242	331	381	431	479
Flow HT at 44°Cinlet and 80°C outlet		m³/h	6	8	9	10	11
Total from engine		kW	361	491	573	653	733
LT flow at 36°C inlet		m³/h	13	17	21	24	27
LT temp. Outlet engine (at 36°C and 1 string cooling water system)		°C	60	61	60	60	59
Gas Data:							
Exhaust gas flow		kg/h	3,400	4,600	5,500	6,200	7,000
Exhaust gas temp.		°C	330	340	340	340	340
Max. Allowable back press.		bar	0.025	0.025	0.025	0.025	0.025
Air consumption		kg/h	3,280	4,500	5,300	6,000	6,800
Starting Air System:							
Air consumption per start		Nm	0.47	0.56	0.65	0.75	0.84
Air consumption per start		Nm	0.80	0.96	1.12	1.28	1.44
Heat Radiation:							
Engine		kW	9	13	15	18	21
Alternator		kW	(see separate data from the alternator maker)				

The stated heat balances are based on tropical conditions.The exhaust gas data (exhaust gas flow, exhaust gas temp. and air consumption). are based on ISO ambient condition.

* The outlet temperature of the HT water is fixed to 80°C, and 44°C for the LT water

At different inlet temperature the flow will change accordingly.

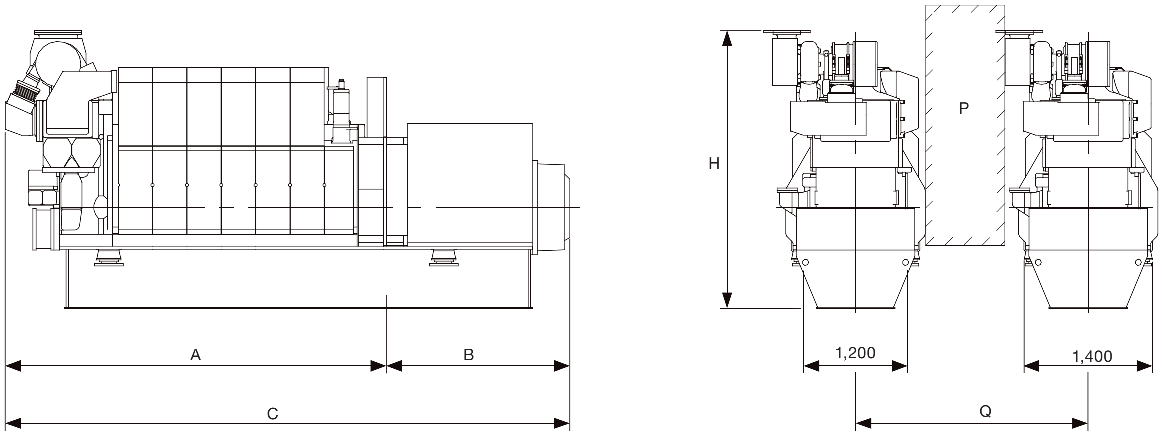
Example: If the inlet temperature is 25°C then the LT flow will change to (44-36)/(44-25)*100 = 42% of the original flow. If the temperature rises above 36°C, then the L.T. outlet will rise acordingly.

Fig. 4.06.02b: List of capacities for L16/24 1,200 rpm

L21/31 GenSet Data

Bore: 210 mm Stroke: 310 mm

	Power layout			
	900 r/min Eng. kW	60 Hz Gen. kW	1,000 r/min Eng. kW	50 Hz Gen. kW
5L21/31	1,000	950	1,000	950
6L21/31	1,320	1,254	1,320	1,254
7L21/31	1,540	1,463	1,540	1,463
8L21/31	1,760	1,672	1,760	1,672
9L21/31	1,980	1,881	1,980	1,881



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Cyl. no	A (mm)	* B (mm)	* C (mm)	H (mm)	**Dry weight GenSet (t)
5 (900 rpm)	3,959	1,820	5,680	3,180	21.5
5 (1000 rpm)	3,959	1,870	5,730	3,180	21.5
6 (900 rpm)	4,314	1,870	6,086	3,180	23.7
6 (1000 rpm)	4,314	2,000	6,216	3,180	23.7
7 (900 rpm)	4,669	1,970	6,760	3,180	25.9
7 (1000 rpm)	4,669	1,970	6,537	3,180	25.9
8 (900 rpm)	5,024	2,250	7,210	3,287	28.5
8 (1000 rpm)	5,024	2,250	7,176	3,287	28.5
9 (900 rpm)	5,379	2,400	7,660	3,287	30.9
9 (1000 rpm)	5,379	2,400	7,660	3,287	30.9

P Free passage between the engines, width 600 mm and height 2000 mm.
Q Min. distance between engines: 2400 mm (without gallery) and 2600 mm (with galley)

* Depending on alternator
** Weight incl. standard alternator (based on a Uljanik alternator)

All dimensions and masses are approximate, and subject to changes without prior notice.

Fig. 4.07.01: Power and outline of L21/31

L21/31 GenSet Data

		Cyl.	5	6	7	8	9
Maximum continuous rating at	**900 rpm**	kW	950	1,320	1,540	1,760	1,980
Engine-driven pumps:							
LT cooling water pump	(1-2.5 bar)	m³/h	55	55	55	55	55
HT cooling water pump	(1-2.5 bar)	m³/h	55	55	55	55	55
Lubricating oil pump	(3-5 bar)	m³/h	31	31	41	41	41
External pumps:							
Max. delivery pressure of cooling water pumps		bar	2.5	2.5	2.5	2.5	2.5
Diesel oil pump	(5 bar at fuel oil inlet A1)	m³/h	0.65	0.91	1.06	1.21	1.36
Fuel oil supply pump	(4 bar discharge pressure)	m³/h	0.32	0.44	0.52	0.59	0.67
Fuel oil circulating pump	(8 bar at fuel oil inlet A1)	m³/h	0.66	0.92	1.07	1.23	1.38
Cooling capacities:							
Lubricating oil		kW	195	158	189	218	247
LT charge air		kW	118	313	366	418	468
Total LT system		kW	313	471	555	636	715
LT flow at 36°C inlet and 44°C outlet*		m³/h	27.0	44.0	48.1	51.9	54.0
Jacket cooling		kW	154	274	326	376	427
HT charge air		kW	201	337	383	429	475
Total HT system		kW	355	611	709	805	902
HT flow at 44°C inlet and 80°C outlet*		m³/h	8.5	19.8	22.6	25.3	27.9
Total from engine		kW	668	1082	1264	1441	1617
LT flow from engine at 36°C inlet		m³/h	27.0	43.5	47.6	51.3	53.5
LT outlet temperature from engine at 36°C inlet (1-string cooling water system)		°C	55	58	59	61	63
Gas data:							
Exhaust gas flow		kg/h	6,679	9,600	11,200	12,800	14,400
Exhaust gas temperature at turbine outlet		°C	335	348	348	348	348
Maximum allowable back pressure		bar	0.025	0.025	0.025	0.025	0.025
Air consumption		kg/h	6,489	9,330	10,900	12,400	14,000
Starting air system:							
Air consumption per start incl. air for jet assist		Nm³	1.0	1.2	1.4	1.6	1.8
Heat radiation:							
Engine		kW		49	50	54	58
Alternator		kW	(See separate data from alternator maker)				

The stated heat balances are based on 100% load and tropical condition.

The mass flows and exhaust gas temperature are based on ISO ambient condition.

* The outlet temperature of the HT water is fixed to 80°C, and 44°C for the LT water.
At different inlet temperature the flow will change accordingly.

Example: If the inlet temperature is 25°C then the LT flow will change to (44-36)/(44-25)*100 = 42% of the original flow.
The HT flow will not change.

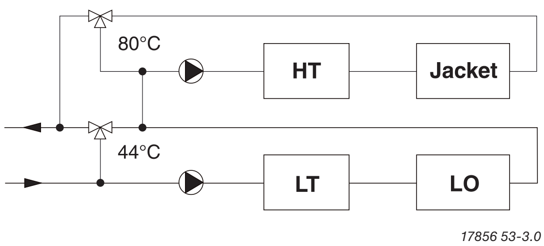

Fig. 4.07.02a: List of capacities for L21/31, 900 rpm

L21/31 GenSet Data

			Cyl.	5	6	7	8	9
Maximum continuous rating at		**1000 rpm**	kW	1,000	1,320	1,540	1,760	1,980
Engine-driven pumps:								
LT cooling water pump		(1-2.5 bar)	m³/h	61	61	61	61	61
HT cooling water pump		(1-2.5 bar)	m³/h	61	61	61	61	61
Lubricating oil pump		(3-5 bar)	m³/h	34	34	46	46	46
External pumps:								
Max. delivery pressure of cooling water pumps			bar	2.5	2.5	2.5	2.5	2.5
Diesel oil pump		(5 bar at fuel oil inlet A1)	m³/h	0.69	0.92	1.08	1.23	1.38
Fuel oil supply pump		(4 bar discharge pressure)	m³/h	0.34	0.45	0.53	0.60	0.68
Fuel oil circulating pump		(8 bar at fuel oil inlet A1)	m³/h	0.70	0.93	1.09	1.25	1.40
Cooling capacities:								
Lubricating oil			kW	206	162	192	222	252
LT charge air			kW	125	333	388	443	499
Total LT system			kW	331	495	580	665	751
LT flow at 36°C inlet and 44°C outlet*			m³/h	35.5	47.8	52.1	56.2	60.5
Jacket cooling			kW	163	280	332	383	435
HT charge air			kW	212	361	411	460	509
Total HT system			kW	374	641	743	843	944
HT flow at 44°C inlet and 80°C outlet*			m³/h	8.9	20.9	23.9	26.7	29.5
Total from engine			kW	705	1136	1323	1508	1695
LT flow from engine at 36°C inlet			m³/h	35.5	47.2	51.5	55.6	59.9
LT outlet temperature from engine at 36°C inlet (1-string cooling water system)			°C	53	57	59	60	61
Gas data:								
Exhaust gas flow			kg/h	6,920	10,200	11,900	13,600	15,300
Exhaust gas temperature at turbine outlet			°C	335	333	333	333	333
Maximum allowable back pressure			bar	0.025	0.025	0.025	0.025	0.025
Air consumption			kg/h	6,720	9,940	11,600	13,200	14,900
Starting air system:								
Air consumption per start incl. air for jet assist			Nm³	1.0	1.2	1.4	1.6	1.8
Heat radiation:								
Engine			kW	21	47	50	54	56
Alternator			kW	(See separate data from alternator maker)				

The stated heat balances are based on 100% load and tropical condition.

The mass flows and exhaust gas temperature are based on ISO ambient condition.

* The outlet temperature of the HT water is fixed to 80°C, and 44°C for the LT water.
At different inlet temperature the flow will change accordingly.

Example: If the inlet temperature is 25°C then the LT flow will change to (44-36)/(44-25)*100 = 42% of the original flow.
The HT flow will not change.

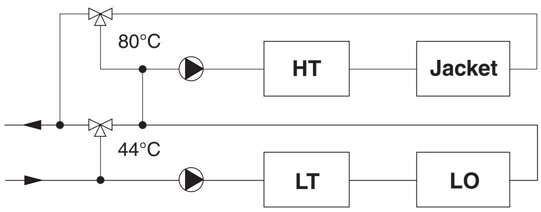

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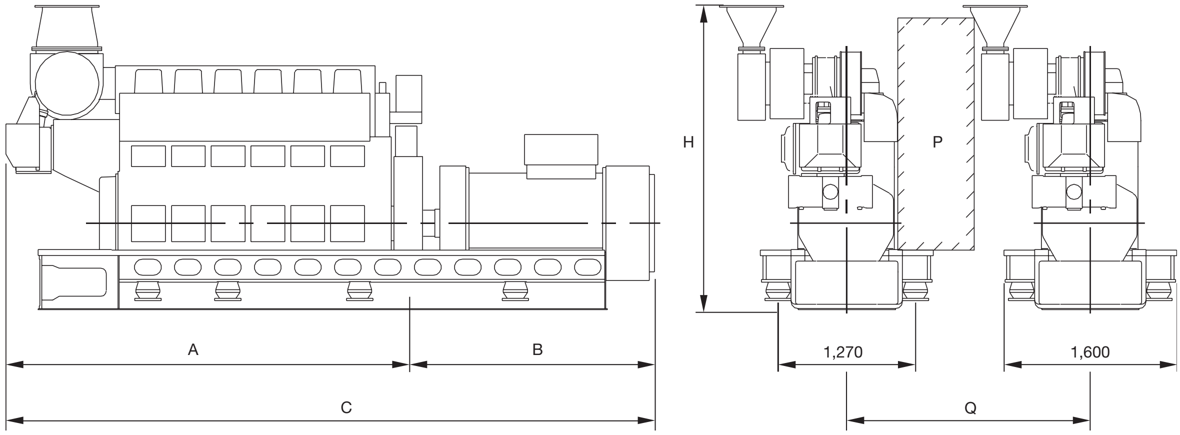
Fig. 4.07.02a: List of capacities for L21/31, 1,000 rpm

L23/30H GenSet Data

Bore: 225 mm **Stroke: 300 mm**

	Power layout					
	720 r/min Eng. kW	60 Hz Gen. kW	750 r/min Eng. kW	50 Hz Gen. kW	900 r/min Eng. kW	60 Hz Gen. kW
5L23/30H	650	620	675	640		
6L23/30H	780	740	810	770	960	910
7L23/30H	910	865	945	900	1,120	1,065
8L23/30H	1,040	990	1,080	1,025	1,280	1,215



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No. of Cyls.	A (mm)	* B (mm)	* C (mm)	H (mm)	**Dry weight GenSet (t)
5 (720 r/min)	3,369	2,155	5,524	2,383	18.0
5 (750 r/min)	3,369	2,155	5,524	2,383	18.0
6 (720 r/min)	3,738	2,265	6,004	2,383	19.7
6 (750 r/min)	3,738	2,265	6,004	2,383	19.7
6 (900 r/min)	3,738	2,265	6,004	2,815	21.0
7 (720 r/min)	4,109	2,395	6,504	2,815	21.4
7 (750 r/min)	4,109	2,395	6,504	2,815	21.4
7 (900 r/min)	4,109	2,395	6,504	2,815	22.8
8 (720 r/min)	4,475	2,480	6,959	2,815	23.5
8 (750 r/min)	4,475	2,480	6,959	2,815	23.5
8 (900 r/min)	4,475	2,340	6,815	2,815	24.5

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P Free passage between the engines, width 600 mm and height 2,000 mm
Q Min. distance between engines: 2,250 mm
* Depending on alternator
** Weight includes a standard alternator, make A. van Kaick
All dimensions and masses are approximate and subject to change without prior notice.

Fig. 4.08.01: Power and outline of L23/30H

L23/30H GenSet Data

		Cyl.	5-ECR	5	6	7	8
Max. continuous rating at	**720/750 RPM**	kW	525/550	650/675	780/810	910/945	1,040/1,080
Engine-driven Pumps:							
Fuel oil feed pump	(5.5-7.5 bar)	m³/h	1. 0	1.0	1.0	1.0	1.0
L.T. cooling water pump	(1-2.5 bar)	m³/h	55	55	55	55	55
H.T. cooling water pump	(1-2.5 bar)	m³/h	36	36	36	36	36
Lub. oil main pump	(3-5 bar)	m³/h	16	16	16	20	20
Separate Pumps:							
Diesel oil pump	(4 bar at fuel oil inlet A1)	m³/h	0.36/0.38	0.46/0.48	0.55/0.57	0.64/0.67	0.73/0.76
Fuel oil supply pump ***	(4 bar discharge pressure)	m³/h	0.18/0.19	0.22/0.23	0.27/0.28	0.31/0.33	0.36/0.37
Fuel oil circulating pump	(8 bar at fuel oil inlet A1)	m³/h	0.37/0.39	0.46/0.48	0.56/0.58	0.65/0.67	0.74/0.77
L.T. cooling water pump*	(1-2.5 bar)	m³/h	35	35	42	48	55
L.T. cooling water pump**	(1-2.5 bar)	m³/h	48	48	54	60	73
H.T. cooling water pump	(1-2.5 bar)	m³/h	20	20	24	28	32
Lub. oil stand-by pump	(3-5 bar)	m³/h	14.0	14.0	15.0	16.0	17.0
Cooling Capacities:							
Lubricating Oil:							
Heat dissipation		kW	63	69	84	98	112
L.T. cooling water quantity*		m³/h	4.6	5.3	6.4	7.5	8.5
L.T. cooling water quantity**		m³/h	18	18	18	18	25
Lub. oil temp. inlet cooler		°C	67	67	67	67	67
L.T. cooling water temp. inlet cooler		°C	36	36	36	36	36
Charge Air:							
Heat dissipation		kW	156	251	299	348	395
L.T. cooling water quantity		m³/h	30	30	36	42	48
L.T. cooling water inlet cooler		°C	36	36	36	36	36
Jacket Cooling:							
Heat dissipation		kW	154	182	219	257	294
H.T. cooling water quantity		m³/h	20	20	24	28	32
H.T. cooling water temp. inlet cooler		°C	77	77	77	77	77
Gas Data:							
Exhaust gas flow		kg/h	4,310	5,510	6,620	7,720	8,820
Exhaust gas temp.		°C	310	310	310	310	310
Max. allowable back. press.		bar	0.025	0.025	0.025	0.025	0.025
Air consumption		kg/s	1.17	1.49	1.79	2.09	2.39
Starting Air System:							
Air consumption per start		Nm³	2.0	2.0	2.0	2.0	2.0
Heat Radiation:							
Engine		kW	19	21	25	29	34
Generator		kW	(See separate data from generator maker)				

The stated heat dissipation, capacities of gas and engine-driven pumps are given at 720 RPM. Heat dissipation gas and pump capacities at 750 RPM are 4% higher than stated. If L.T. cooling are sea water, the L.T. inlet is 32° C instead of 36°C.

Based on tropical conditions, except for exhaust flow and air consumption which are based on ISO conditions.

* Only valid for engines equipped with internal basic cooling water system nos. 1 and 2.
** Only valid for engines equipped with combined coolers, internal basic cooling water system no. 3.
*** To compensate for built on pumps, ambient condition, calorific value and adequate circulations flow. The ISO fuel oil consumption is multiplied by 1.45.

Fig. 4.08.02a: List of capacities for L23/30H, 720/750 rpm

L23/30H GenSet Data

		Cyl.	6	7	8
Max. continuous rating at	**900 RPM**	kW	960	1,120	1,280
Engine-driven Pumps:					
Fuel oil feed pump	(5.5-7.5 bar)	m³/h	1.3	1.3	1.3
L.T. cooling water pump	(1-2.5 bar)	m³/h	69	69	69
H.T. cooling water pump	(1-2.5 bar)	m³/h	45	45	45
Lub. oil main pump	(3.5-5 bar)	m³/h	20	20	20
Separate Pumps:					
Diesel oil pump	(4 bar at fuel oil inlet A1)	m³/h	0.69	0.81	0.92
Fuel oil supply pump***	(4 bar discharge pressure)	m³/h	0.34	0.40	0.45
Fuel oil circulating pump	(8 bar at fuel oil inlet A1)	m³/h	0.70	0.82	0.94
L.T. cooling water pump*	(1-2.5 bar)	m³/h	52	61	70
L.T. cooling water pump**	(1-2.5 bar)	m³/h	63	71	85
H.T. cooling water pump	(1-2.5 bar)	m³/h	30	35	40
Lub. oil stand-by pump	(3.5-5 bar)	m³/h	17	18	19
Cooling Capacities:					
Lubricating Oil:					
Heat dissipation		kW	117	137	158
L.T. cooling water quantity*		m³/h	7.5	8.8	10.1
SW L.T. cooling water quantity**		m³/h	18	18	25
Lub. oil temp. inlet cooler		°C	67	67	67
L.T. cooling water temp. inlet cooler		°C	36	36	36
Charge Air:					
Heat dissipation		kW	369	428	487
L.T. cooling water quantity		m³/h	46	53	61
L.T. cooling water inlet cooler		°C	36	36	36
Jacket Cooling:					
Heat dissipation		kW	239	281	323
H.T. cooling water quantity		m³/h	30	35	40
H.T. cooling water temp. inlet cooler		°C	77	77	77
Gas Data:					
Exhaust gas flow		kg/h	8,370	9,770	11,160
Exhaust gas temp.		°C	325	325	325
Max. allowable back. press.		bar	0.025	0.025	0.025
Air consumption		kg/s	2.25	2.62	3.00
Startiang Air System:					
Air consumption per start		Nm³	2.0	2.0	2.0
Haeat Radiation:					
Engine		kW	32	37	42
Generator		kW	(See separat data from generator maker)		

If L.T. cooling are sea water, the L.T. inlet is 32° C instead of 36° C.

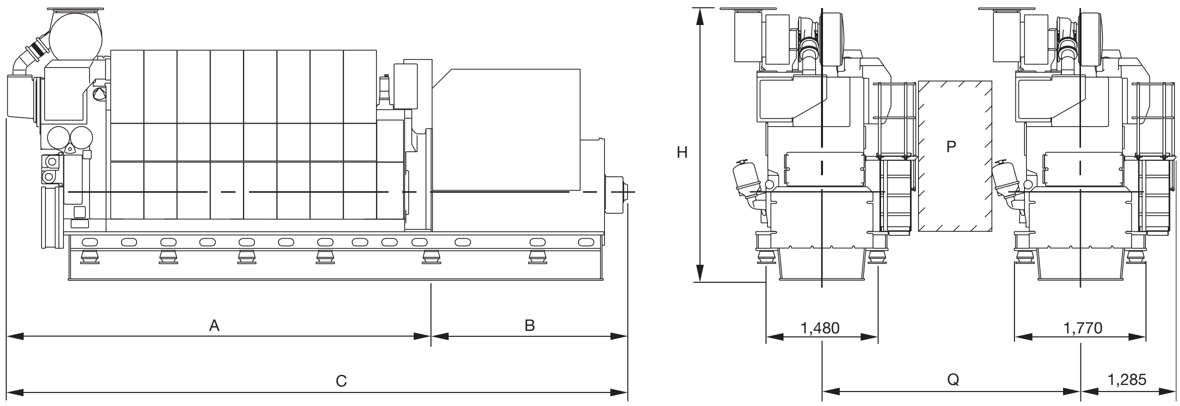
Based on tropical conditions, except for exhaust flow and air consumption which are based on ISO conditions.

* Only valid for engines equipped with internal basic cooling water system nos. 1 and 2.
** Only valid for engines equipped with combined coolers, internal basic cooling water system no. 3.
*** To compensate for built on pumps, ambient condition, calorific value and adequate circulations flow. The ISO fuel oil consumption is multiplied by 1.45.

Fig. 4.08.02b: List of capacities for L23/30H, 900 rpm

L27/38 GenSet Data

	Bore: 270 mm			Stroke: 380 mm
	Power layout			
	720 r/min	60 Hz	750 r/min	50 Hz
	Eng. kW	Gen. kW	Eng. kW	Gen. kW
5L27/38	1,500	1,440	1,600	1,536
6L27/38	1,980	1,900	1,980	1,900
7L27/38	2,310	2,218	2,310	2,218
8L27/38	2,640	2,534	2,640	2,534
9L27/38	2,970	2,851	2,970	2,851



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No. of Cyls.	A (mm)	* B (mm)	* C (mm)	H (mm)	**Dry weight GenSet (t)
5 (720 r/min)	4,346	2,486	6,832	3,705	42.3
5 (750 r/min)	4,346	2,486	6,832	3,705	42.3
6 (720 r/min)	4,791	2,766	7,557	3,705	45.8
6 (750 r/min)	4,791	2,766	7,557	3,717	46.1
7 (720 r/min)	5,236	2,766	8,002	3,717	52.1
7 (750 r/min)	5,236	2,766	8,002	3,717	52.1
8 (720 r/min)	5,681	2,986	8,667	3,717	56.3
8 (750 r/min)	5,681	2,986	8,667	3,717	58.3
9 (720 r/min)	6,126	2,986	9,112	3,797	63.9
9 (750 r/min)	6,126	2,986	9,112	3,797	63.9

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P Free passage between the engines, width 600 mm and height 2,000 mm
Q Min. distance between engines: 2,900 mm (without gallery) and 3,100 mm (with gallery)
* Depending on alternator
** Weight includes a standard alternator
All dimensions and masses are approximate and subject to change without prior notice.

Fig. 4.09.01: Power and outline of L27/38

L27/38 GenSet Data

		Cyl.	5	6	7	8	9
Max continues rating	**720 RPM**	kW	1,500	1,980	2,310	2,640	2,970
Engine driven pumps:							
LT cooling water pump	(2.5 bar)	m³/h	58	58	58	58	58
HT cooling water pump	(2.5 bar)	m³/h	58	58	58	58	58
Lubricating oil main pump	(8 bar)	m³/h	64	64	92	92	92
Separate pumps:							
Max. Delivery pressure of cooling water pumps		bar	2.5	2.5	2.5	2.5	2.5
Diesel oil pump	(5 bar at fuel oil inlet A1)	m³/h	1.02	1.33	1.55	1.77	2.00
Fuel oil Supply pump	(4 bar at discharge pressure)	m³/h	0.50	0.66	0.76	0.87	0.98
Fuel oil circulating pump	(8 bar at fuel oil inlet A1)	m³/h	1.03	1.35	1.57	1.80	2.02
Cooling capacity:							
Lubricating oil		kW	206	283	328	376	420
Charge air LT		kW	144	392	436	473	504
Total LT system		kW	350	675	764	849	924
Flow LT at 36°C inlet and 44°C outlet		m³/h	38	58	58	58	58
Jacket cooling		kW	287	486	573	664	754
Charge air HT		kW	390	558	640	722	802
Total HT system		kW	677	1,044	1,213	1,386	1,556
Flow HT at 44°Cinlet and 80°C outlet		m³/h	16	22	27	32	38
Total from engine		kW	1,027	1,719	1,977	2,235	2,480
LT flow at 36°C inlet		m³/h	38	58	58	58	58
LT temp. Outlet engine		°C	59	58	61	64	68
(at 36°C and 1 string cooling water system)							
Gas Data:							
Exhaust gas flow		kg/h	10,476	15,000	17,400	19,900	22,400
Exhaust gas temp.		°C	330	295	295	295	295
Max. Allowable back press.		bar	0,025	0,025	0,025	0,025	0,025
Air consumption		kg/h	10,177	14,600	17,000	19,400	21,800
Starting Air System:							
Air consumption per start		Nm³	2,5	2,9	3,3	3,8	4,3
Heat Radiation:							
Engine		kW	53	64	75	68	73
Alternator		kW	(see separate data from the alternator maker)				

The stated heat balances are based on tropical conditions. The exhaust gas data (exhaust gas flow, exhaust gas temp. and air consumption). are based on ISO ambient condition.

* The outlet temperature of the HT water is fixed to 80°C, and 44°C for the LT water

At different inlet temperature the flow will change accordingly.

Example: If the inlet temperature is 25°C then the LT flow will change to (46-36)/(46-25)*100 = 53% of the original flow. The HT flow will not change.

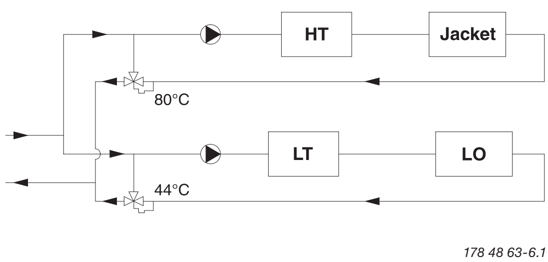
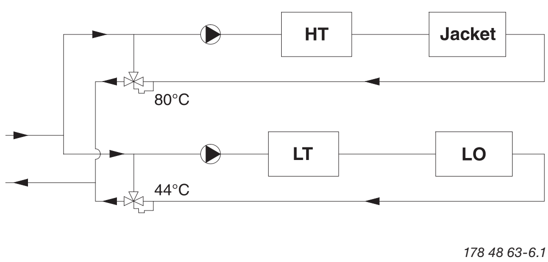


Fig. 4.09.02a: List of capacities for L27/38, 720 rpm

L27/38 GenSet Data

		Cyl.	5	6	7	8	9
Max continues rating	**750 RPM**	kW	1,600	1,980	2,310	2,640	2,970
Engine driven pumps:							
LT cooling water pump	2.5 bar	m³/h	70	70	70	70	70
HT cooling water pump	2.5 bar	m³/h	70	70	70	70	70
Lubricating oil main pump	8 bar	m³/h	66	66	96	96	96
Separate pumps:							
Max. Delivery pressure of cooling water pumps		bar	2.5	2.5	2.5	2.5	2.5
Diesel oil pump	(5 bar at fuel oil inlet A1)	m³/h	1.10	1.34	1.57	1.79	2.01
Fuel oil supply pump	(4 bar discharge pressure)	m³/h	0.54	0.66	0.77	0.88	0.99
Fuel oil circulating pump	(8 bar at fuel oil inlet A1)	m³/h	1.11	1.36	1.59	1.81	2.04
Cooling capacity:							
Lubricating oil		kW	217	283	328	376	420
Charge air LT		kW	155	392	436	473	504
Total LT system		kW	372	675	764	849	924
Flow LT at 36°C inlet and 44°C outlet		m³/h	40	70	70	70	70
Jacket cooling		kW	402	486	573	664	754
Charge air HT		kW	457	558	640	722	802
Total HT system		kW	859	1,044	1,213	1,386	1,556
Flow HT at 44°Cinlet and 80°C outlet		m³/h	21	22	27	32	38
Total from engine		kW	1,231	1,719	1,977	2,235	2,480
LT flow at 36°C inlet		m³/h	40	70	70	70	70
LT temp. Outlet engine		°C	62	55	58	61	64
(at 36°C and 1 string cooling water system)							
Gas Data:							
Exhaust gas flow		kg/h	11,693	15,000	17,400	19,900	22,400
Exhaust gas temp.		°C	330	305	305	305	305
Max. Allowable back press.		bar	0.025	0.025	0.025	0.025	0.025
Air consumption		kg/h	11,662	14,600	17,000	19,400	21,800
Starting Air System:							
Air consumption per start		Nm³	2.5	2.9	3.3	3.8	4.3
Heat Radiation:							
Engine		kW	54	64	75	68	73
Alternator		kW	(see separate data from the alternator maker)				



The stated heat balances are based on tropical conditions. The exhaust gas data (exhaust gas flow, exhaust gas temp. and air consumption). are based on ISO ambient condition.

* The outlet temperature of the HT water is fixed to 80°C, and 44°C for the LT water

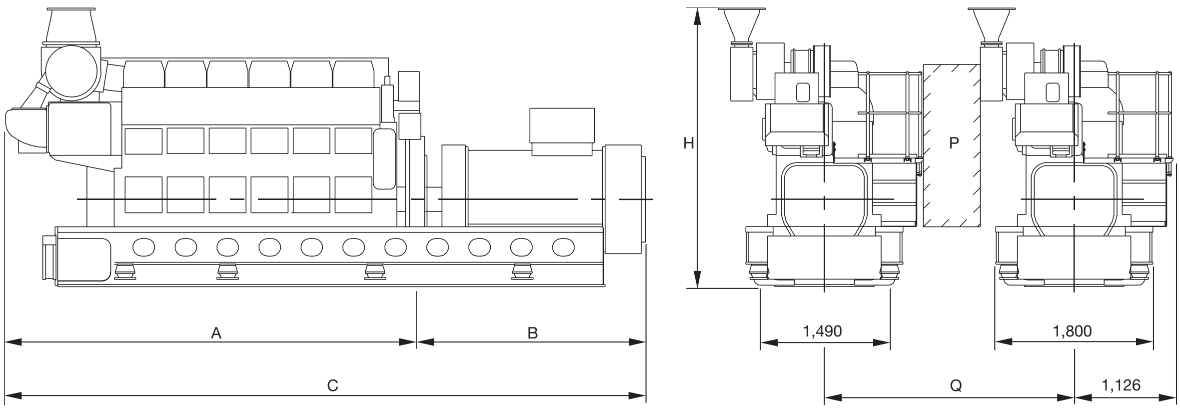
At different inlet temperature the flow will change accordingly.

Example: If the inlet temperature is 25°C then the LT flow will change to (46-36)/(46-25)*100 = 53% of the original flow. The HT flow will not change.

Fig. 4.09.02b: List of capacities for L27/38, 750 rpm

L28/32H GenSet Data

	Bore: 280 mm			Stroke: 320 mm
	Power layout			
	720 r/min Eng. kW	60 Hz Gen. kW	750 r/min Eng. kW	50 Hz Gen. kW
5L28/32H	1,050	1,000	1,100	1,045
6L28/32H	1,260	1,200	1,320	1,255
7L28/32H	1,470	1,400	1,540	1,465
8L28/32H	1,680	1,600	1,760	1,670
9L28/32H	1,890	1,800	1,980	1,880



178 23 09-2.0

No. of Cyls.	A (mm)	* B (mm)	* C (mm)	H (mm)	**Dry weight GenSet (t)
5 (720 r/min)	4,279	2,400	6,679	3,184	32.6
5 (750 r/min)	4,279	2,400	6,679	3,184	32.6
6 (720 r/min)	4,759	2,510	7,269	3,184	36.3
6 (750 r/min)	4,759	2,510	7,269	3,184	36.3
7 (720 r/min)	5,499	2,680	8,179	3,374	39.4
7 (750 r/min)	5,499	2,680	8,179	3,374	39.4
8 (720 r/min)	5,979	2,770	8,749	3,374	40.7
8 (750 r/min)	5,979	2,770	8,749	3,374	40.7
9 (720 r/min)	6,199	2,690	8,889	3,534	47.1
9 (750 r/min)	6,199	2,690	8,889	3,534	47.1

P Free passage between the engines, width 600 mm and height 2,000 mm
Q Min. distance between engines: 2,655 mm (without gallery) and 2,850 mm (with gallery)
* Depending on alternator
** Weight includes a standard alternator, make A. van Kaick

178 33 92-1.3

Fig. 4.10.01: Power and outline of L28/32H

L28/32H GenSet Data

		Cyl.	5-ECR	5	6	7	8	9
Max. continuous rating at	720/ 750 RPM	kW	875/ 925	1,050/ 1,100	1,260/ 1,320	1,470/ 1,540	1,680/ 1,760	1,890/ 1,980
Engine-driven Pumps:								
Fuel oil feed pump	(5.5-7.5 bar)	m^3/h	1.4	1.4	1.4	1.4	1.4	1.4
L.T. cooling water pump	(1-2.5 bar)	m^3/h	45	45	60	75	75	75
H.T. cooling water pump	(1-2.5 bar)	m^3/h	45	45	45	60	60	60
Lub. oil main pump	(3-5 bar)	m^3/h	23	23	23	31	31	31
Separate Pumps:								
Diesel oil Pump	(4 bar at fuel oil inlet A1)	m^3/h	0.60/0.64	0.73/0.77	0.88/0.92	1.02/1.08	1.17/1.23	1.32/1.38
Fuel oil supply pump ***	(4 bar discharge pressure)	m^3/h	0.29/0.31	0.36/0.38	0.43/0.45	0.50/0.53	0.57/0.60	0.64/0.68
Fuel oil circulating pump	(8 bar at fuel oil inlet A1)	m^3/h	0.61/0.65	0.74/0.78	0.89/0.93	1.04/1.09	1.18/1.25	1.33/1.40
L.T. cooling water pump*	(1-2.5 bar)	m^3/h	45	45	54	65	77	89
L.T. cooling water pump**	(1-2.5 bar)	m^3/h	65	65	73	95	105	115
H.T. cooling water pump	(1-2.5 bar)	m^3/h	37	37	45	50	55	60
Lub. oil stand-by pump	(3-5 bar)	m^3/h	22	22	23	25	27	28
Cooling Capacities:								
Lubricating Oil:								
Heat dissipation		kW	91	105	127	149	172	194
L.T. cooling water quantity*		m^3/h	6.4	7.8	9.4	11.0	12.7	14.4
SW L.T. cooling water quantity**		m^3/h	28	28	28	40	40	40
Lub. oil temp. inlet cooler		°C	67	67	67	67	67	67
L.T. cooling water temp. inlet cooler		°C	36	36	36	36	36	36
Charge Air:								
Heat dissipation		kW	305	393	467	541	614	687
L.T. cooling water quantity		m^3/h	37	37	45	55	65	75
L.T. cooling water inlet cooler		°C	36	36	36	36	36	36
Jacket Cooling:								
Heat dissipation		kW	211	264	320	375	432	489
H.T. cooling water quantity		m^3/h	37	37	45	50	55	60
H.T. cooling water temp. inlet cooler		°C	77	77	77	77	77	77
Gas Data:								
Exhaust gas flow		kg/h	7,710	9,260	11,110	12,970	14,820	16,670
Exhaust gas temp.		°C	305	305	305	305	305	305
Max. allowable back. press.		bar	0.025	0.025	0.025	0.025	0.025	0.025
Air consumption		kg/s	2.09	2.51	3.02	3.52	4.02	4.53
Starting Air System:								
Air consumption per start		Nm^3	2.5	2.5	2.5	2.5	2.5	2.5
Heat Radiation:								
Engine		kW	22	26	32	38	44	50
Generator		kW	(See separat data from generator maker)					

The stated heat dissipation, capacities of gas and engine-driven pumps are given at 720 RPM. Heat dissipation gas and pump capacities at 750 RPM are 4% higher than stated. If L.T. cooling are sea water, the L.T. inlet is 32° C instead of 36°C.

Based on tropical conditions, except for exhaust flow and air consumption which are based on ISO conditions.

* Only valid for engines equipped with internal basic cooling water system nos. 1 and 2.
** Only valid for engines equipped with combined coolers, internal basic cooling water system no. 3.
*** To compensate for built on pumps, ambient condition, calorific value and adequate circulations flow. The ISO fuel oil consumption is multiplied by 1.45.

Fig. 4.10.02: List of capacities for L28/32H

Installation Aspects

5

Space requirements and overhaul heights

Space Requirements for the Engine

The space requirements stated in Section 5.02 are valid for engines rated at nominal MCR (L_1).

The additional space needed for engines equipped with PTO is stated in Chapter 4.

If, during the project stage, the outer dimensions of the turbocharger seem to cause problems, it is possible, for the same number of cylinders, to use turbochargers with smaller dimensions by increasing the indicated number of turbochargers by one, see Chapter 3.

Overhaul of Engine

The distances stated from the centre of the crankshaft to the crane hook are for the normal lifting procedure and the reduced height lifting procedure (involving tilting of main components).
The lifting capacity of a normal engine room crane can be found in Fig. 5.04.01.

The area covered by the engine room crane shall be wide enough to reach any heavy spare part required in the engine room.

A lower overhaul height is, however, available by using the MAN B&W Double-Jib crane, built by Danish Crane Building A/S, shown in Figs. 5.04.02 and 5.04.03.

Please note that the distance E in Fig. 5.02.01, given for a double-jib crane is from the centre of the crankshaft to the lower edge of the deck beam.

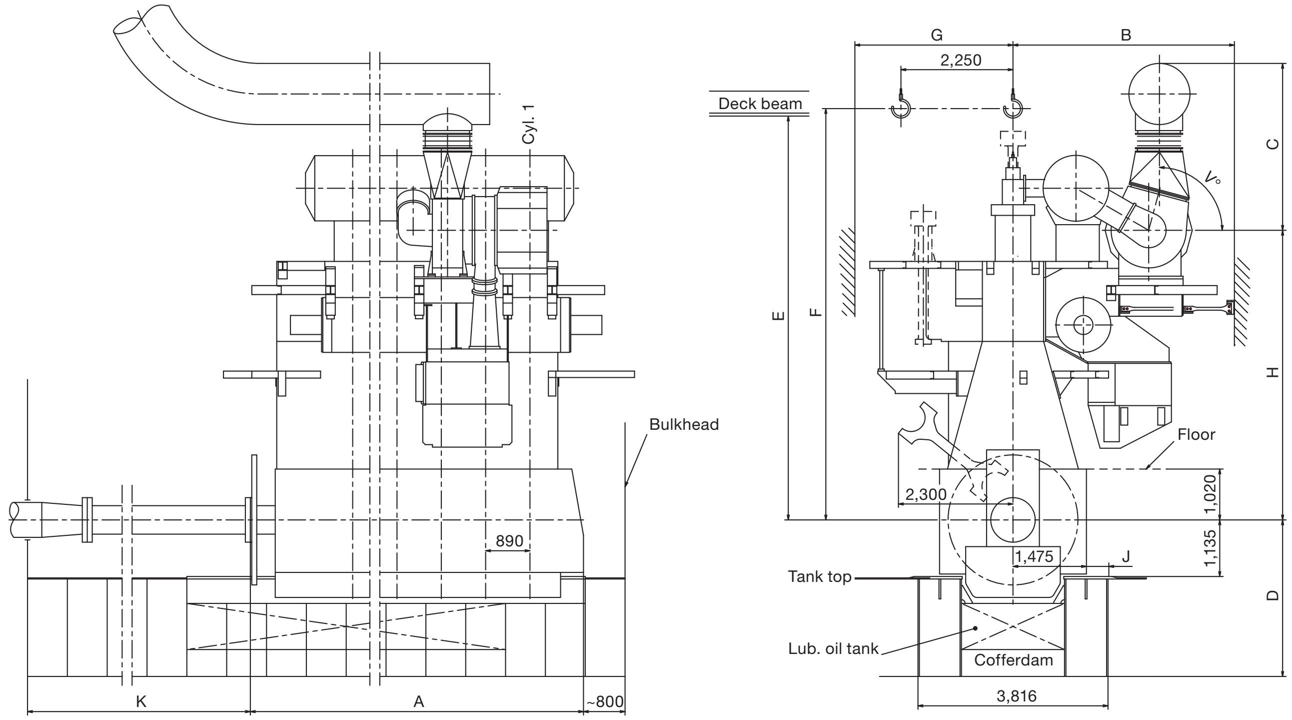
A special crane beam for dismantling the turbocharger must be fitted. The lifting capacity of the crane beam for dismantling the turbocharger is stated in Section 5.03.

The overhaul tools for the engine are designed to be used with a crane hook according to DIN 15400, June 1990, material class M and load capacity 1Am and dimensions of the single hook type according to DIN 15401, part 1.

The total length of the engine at the crankshaft level may vary depending on the equipment to be fitted on the fore end of the engine, such as adjustable counterweights, tuning wheel, moment compensators or PTO.

Please note that the latest version of the dimensioned drawing is available for download at www.mandiesel.com under 'Marine' → 'Low-Speed' → 'MC Engine Programme', choose engine type and click 'Download installation Drawings for...' the actual engine and turbocharger configuration. Select 'Engine outline' in the list of drawings available for download.

Space Requirement



178 47 52-2.1

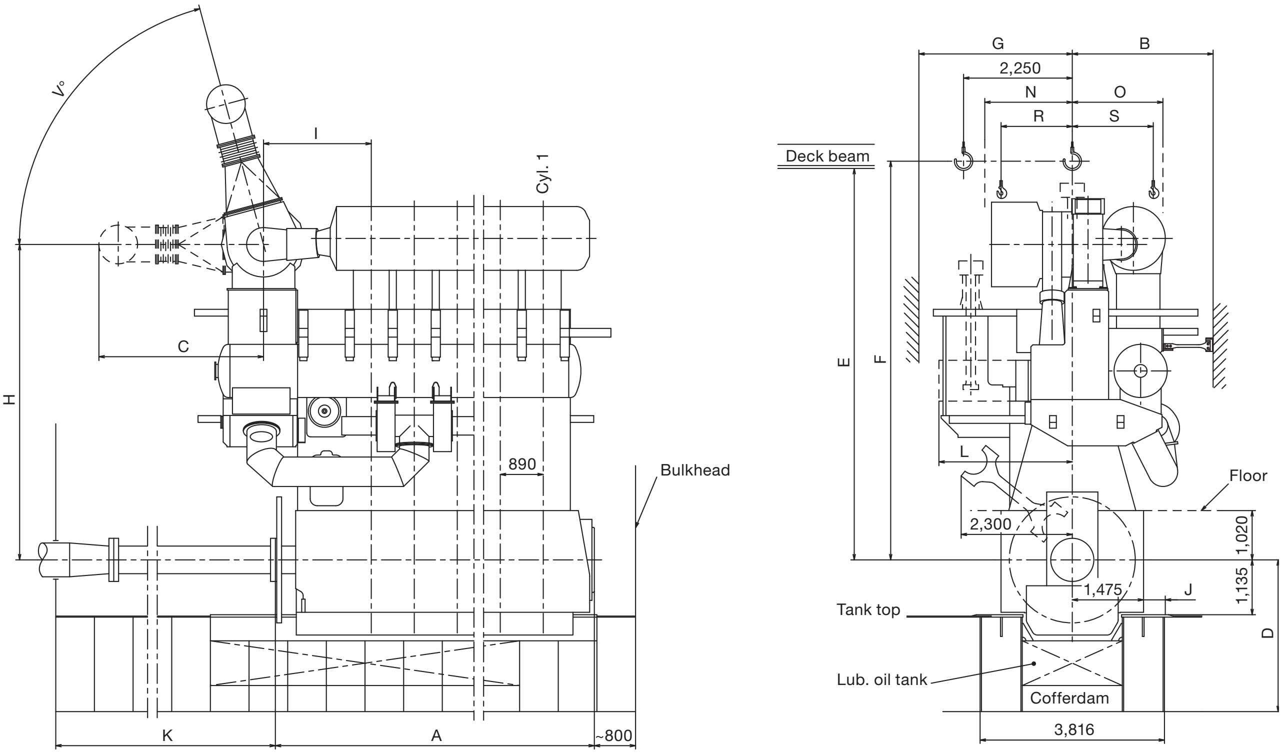
Normal/minimum centre line distance for twin engine installation: 5,800/4,750 mm (4,750 mm for common gallery for starboard and port design engines).

The dimensions are given in mm, and are for guidance only. If the dimensions cannot be fulfilled, please contact MAN Diesel or our local representative.

Fig. 5.02.01a: Space requirement for the engine, turbocharger on exhaust side (4 59 122)

<table>
<tr><th colspan="2">Cyl. No.</th><th>5</th><th>6</th><th>7</th><th>8</th><th colspan="2"></th></tr>
<tr><td rowspan="2">A</td><td>min.</td><td>6,602</td><td>7,492</td><td>8,382</td><td>9,272</td><td colspan="2" rowspan="2">Fore end: A minimum shows basic engine
A maximum shows engine with built-on tuning wheel
For PTO: See corresponding space requirement</td></tr>
<tr><td>max.</td><td>6,970</td><td>7,860</td><td>8,750</td><td>9,640</td></tr>
<tr><td colspan="2" rowspan="3">B</td><td>4,197</td><td>4,197</td><td>4,197</td><td>-</td><td>MAN Diesel TCA</td><td rowspan="3">The required space to the engine room casing includes mechanical top bracing</td></tr>
<tr><td>4,027</td><td>4,277</td><td>4,277</td><td>4,277</td><td>ABB TPL</td></tr>
<tr><td>4,027</td><td>-</td><td>-</td><td>4,277</td><td>Mitsubishi MET</td></tr>
<tr><td colspan="2" rowspan="3">C</td><td>3,017</td><td>3,342</td><td>3,542</td><td>3,787</td><td>MAN Diesel TCA</td><td rowspan="3">Dimensions according to turbocharger choice at nominal MCR</td></tr>
<tr><td>2,916</td><td>3,221</td><td>3,421</td><td>3,521</td><td>ABB TPL</td></tr>
<tr><td>2,911</td><td>3,255</td><td>3,455</td><td>3,546</td><td>Mitsubishi MET</td></tr>
<tr><td colspan="2">D</td><td>3,140</td><td>3,200</td><td>3,230</td><td>3,285</td><td colspan="2">The dimension includes a cofferdam of 600 mm and must fulfil minimum height to tank top according to classification rules</td></tr>
<tr><td colspan="2">E</td><td colspan="4">8,100</td><td colspan="2">The minimum distance from crankshaft centre line to lower edge of deck beam, when using MAN B&W Double Jib Crane</td></tr>
<tr><td colspan="2" rowspan="2">F</td><td colspan="4">8,850</td><td colspan="2">Minimum overhaul height, normal lifting procedure</td></tr>
<tr><td colspan="4">8,300</td><td colspan="2">Minimum overhaul height, reduced height lifting procedure</td></tr>
<tr><td colspan="2">G</td><td colspan="4">3,175</td><td colspan="2">See ‘Engine Top Bracing’, if top bracing fitted on camshaft side</td></tr>
<tr><td colspan="2" rowspan="3">H</td><td>5,705</td><td>5,739</td><td>5,739</td><td>6,163</td><td>MAN Diesel TCA</td><td rowspan="3">Dimensions according to turbocharger choice at nominal MCR</td></tr>
<tr><td>5,731</td><td>5,700</td><td>5,700</td><td>5,700</td><td>ABB TPL</td></tr>
<tr><td>5,790</td><td>5,644</td><td>5,644</td><td>5,767</td><td>Mitsubishi MET</td></tr>
<tr><td colspan="2">J</td><td colspan="4">450</td><td colspan="2">Space for tightening control of holding down bolts</td></tr>
<tr><td colspan="2">K</td><td colspan="4">See text</td><td colspan="2">K must be equal to or larger than the propeller shaft, if the propeller shaft is to be drawn into the engine room</td></tr>
<tr><td colspan="2">V</td><td colspan="4">0°, 15°, 30°, 45°, 60°, 75°, 90°</td><td colspan="2">Maximum 30° when engine room has minimum headroom
above the turbocharger</td></tr>
</table>

Fig. 5.02.01b: Space requirement for the engine



178 47 53-4.1

Normal/minimum centre line distance for twin engine installation: 5,800/4,750 mm (4,750 mm for common gallery for starboard and port design engines).

The dimensions are given in mm, and are for guidance only. If the dimensions cannot be fulfilled, please contact MAN Diesel or our local representative.

Fig. 5.02.02a: Space requirement for the engine, turbocharger on aft end (4 59 124)

Cyl. No.		5	6	7	8		
A	min.	6,602	7,492	8,382	9,272	Fore end: A minimum shows basic engine A maximum shows engine with built-on tuning wheel For PTO: See corresponding space requirement	
	max.	6,970	7,860	8,750	9,640		
B		2,655				MAN Diesel TCA	The required space to the engine room casing includes top bracing
						ABB TPL	
						Mitsubishi MET	
C		3,355	3,755	4,030	4,312	MAN Diesel TCA	Dimensions according to turbocharger choice at nominal MCR
		3,254	3,634	3,909	4,046	ABB TPL	
		3,249	3,668	3,943	4,071	Mitsubishi MET	
D		3,140	3,200	3,230	3,285	The dimension includes a cofferdam of 600 mm and must fulfil minimum height to tank top according to classification rules	
E		8,100				The minimum distance from crankshaft centre line to lower edge of deck beam, when using MAN B&W Double Jib Crane	
F		8,850				Minimum overhaul height, normal lifting procedure	
		8,300				Minimum overhaul height, reduced height lifting procedure	
G		3,175				See 'Engine Top Bracing', if top bracing fitted on camshaft side	
H		-	6,540	6,540	6,590	MAN Diesel TCA	Dimensions according to turbocharger choice at nominal MCR
		6,472	6,497	6,497	6,497	ABB TPL	
		6,527	-	-	6,542	Mitsubishi MET	
I		-	2,240	2,240	2,380	MAN Diesel TCA	Dimensions according to turbocharger choice at nominal MCR
		2,070	2,302	2,302	2,302	ABB TPL	
		2,240	-	-	2,269	Mitsubishi MET	
J		450				Space for tightening control of holding down bolts	
K		See text				K must be equal to or larger than the propeller shaft, if the propeller shaft is to be drawn into the engine room	
L		2,730	2,760	2,790	2,790	Space for air cooler element overhaul	
N		1,878				The distances cover required space and hook travelling width for turbocharger TCA66	
O		1,452					
R		1,742					
S		1,448					
V		0°, 15°, 30°, 45°, 60°, 75°, 90°				Maximum 15° when engine room has minimum headroom above the turbocharger	

Fig. 5.02.02b: Space requirement for the engine

Crane beam for overhaul of turbocharger

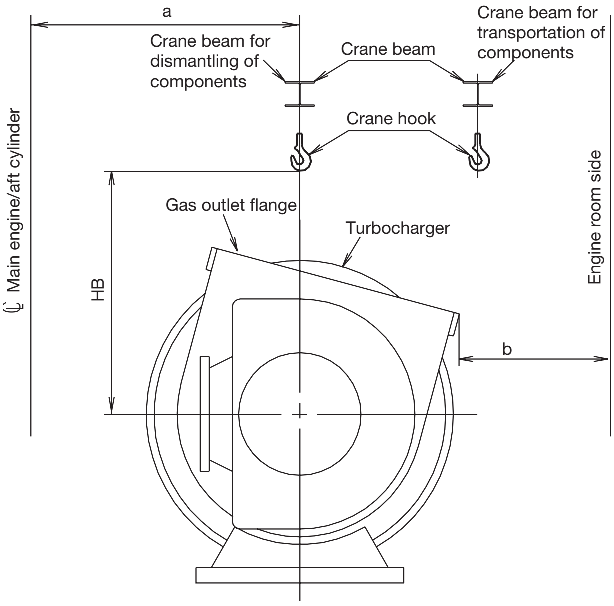


Fig. 5.03.01a: Required height and distance

MAN B&W				
	Units	**TCA55**	**TCA66**	**TCA77**
W	kg	1,000	1,200	2,000
HB	mm	1,400	1,600	1,800
b	m	600	700	800

ABB			
	Units	**TPL73**	**TPL77**
W	kg	1,000	1,000
HB	mm	1,400	1,550
b	m	600	700

Mitsubishi				
	Units	**MET53**	**MET60**	**MET66**
W	kg	1,000	1,000	1,500
HB	mm	1,500	1,600	1,800
b	m	700	700	800

The figures ‘a’ are stated on the ‘Engine and Gallery Outline’ drawing, Section 5.06.

Fig. 5.03.01b: Required height and distance and weight

For the overhaul of a turbocharger, a crane beam with trolleys is required at each end of the turbocharger.

Two trolleys are to be available at the compressor end and one trolley is needed at the gas inlet end.

Crane beam no. 1 is for dismantling of turbocharger components.
Crane beam no. 2 is for transporting turbocharger components.
See Figs. 5.03.01a and 5.03.02.

The crane beams can be omitted if the main engine room crane also covers the turbocharger area.

The crane beams are used and dimensioned for lifting the following components:

- Exhaust gas inlet casing
- Turbocharger inlet silencer
- Compressor casing
- Turbine rotor with bearings

The crane beams are to be placed in relation to the turbocharger(s) so that the components around the gas outlet casing can be removed in connection with overhaul of the turbocharger(s).

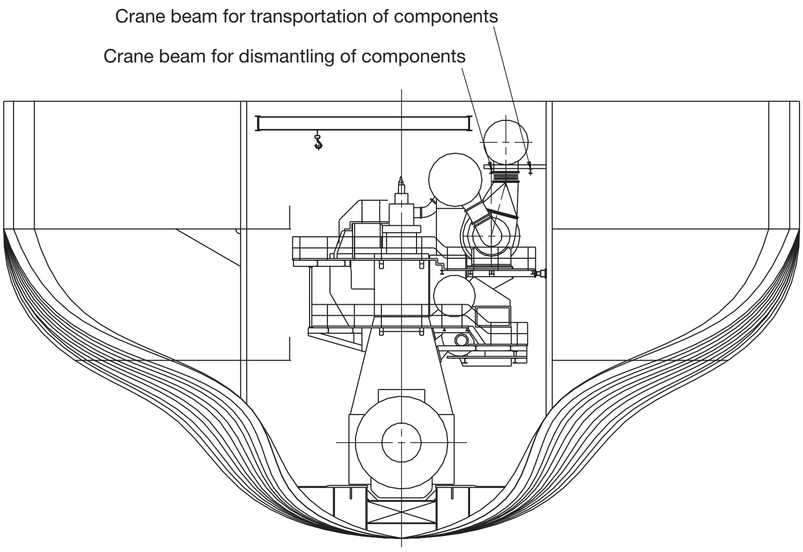
The crane beam can be bolted to brackets that are fastened to the ship structure or to columns that are located on the top platform of the engine.

The lifting capacity of the crane beam for the heaviest component ‘W’, is indicated in Fig. 5.03.01b for the various turbocharger makes. The crane beam shall be dimensioned for lifting the weight ‘W’ with a deflection of some 5 mm only.

HB indicates the position of the crane hook in the vertical plane related to the centre of the turbocharger. HB and b also specifies the minimum space for dismantling.

For engines with the turbocharger(s) located on the exhaust side, EoD No. 4 59 122, the letter ‘a’ indicates the distance between vertical centrelines of the engine and the turbocharger.

Crane beam for turbochargers



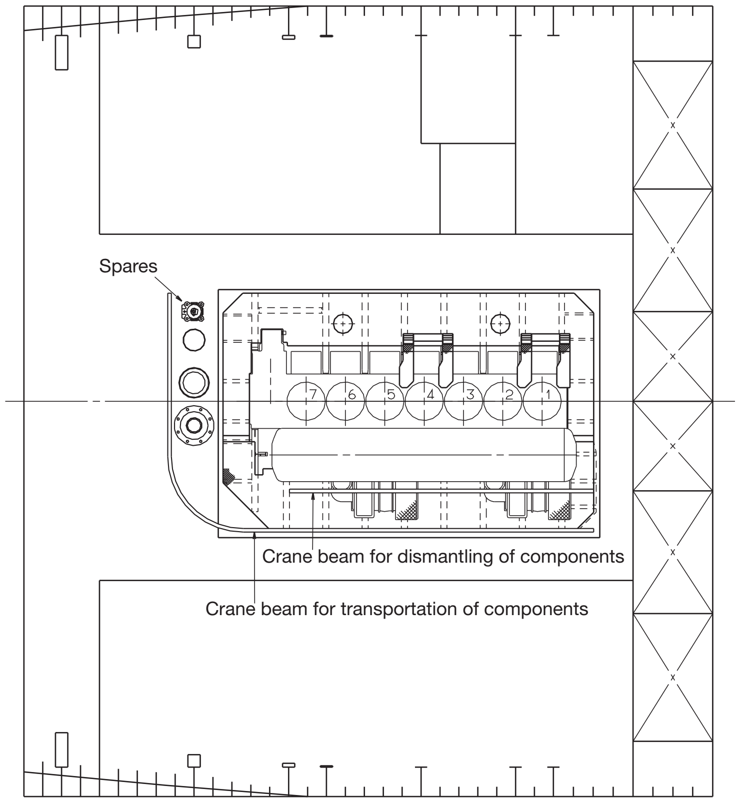


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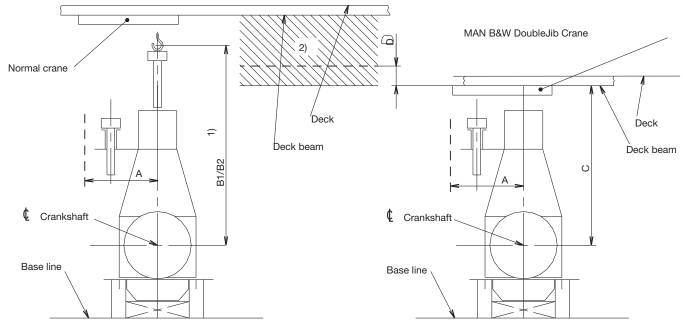
Fig. 5.03.02: Crane beam for turbocharger

Engine room crane



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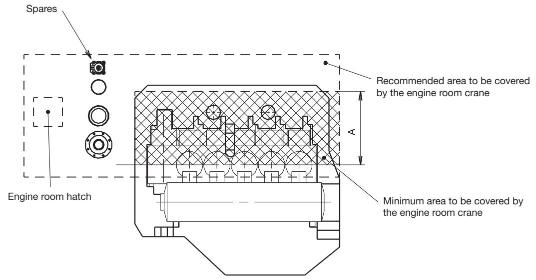


1) The lifting tools for the engine are designed to fit together with a standard crane hook with a lifting capacity in accordance with the figure stated in the table. If a larger crane hook is used, it may not fit directly to the overhaul tools, and the use of an intermediate shackle or similar between the lifting tool and the crane hook will affect the requirements for the minimum lifting height in the engine room (dimension B)

2) The hatched area shows the height where an MAN B&W Double-Jib Crane has to be used.

Fig. 5.04.01: Engine room crane

Weight in kg including lifting tools			**Crane capacity in tons selected in accordance with DIN and JIS standard capacities**		**Crane operating width in mm**	**Normal crane Height to crane hook in mm for:**		**MAN B&W Double-Jib Crane**	
						Normal lifting procedure	**Reduced height lifting procedure involving tilting of main components (option)**	**Building-in height in mm**	
Cylinder cover complete with exhaust valve	Cylinder liner with cooling jacket	Piston with piston rod and stuffing box	Normal crane	MAN B&W Double-Jib Crane	A Minimum distance	B1 Minimum height from centre line crankshaft to centre line crane hook	B1 Minimum height from centre line crankshaft to underside deck beam	C Minimum height from centre line crankshaft to under-side deck beam	D Additional height required for removal of exhaust valve without remov-ing any exhaust valve stud
1,650	1,650	925	2.0	2x1.0	2,250	8,850	8,300	8,100	550

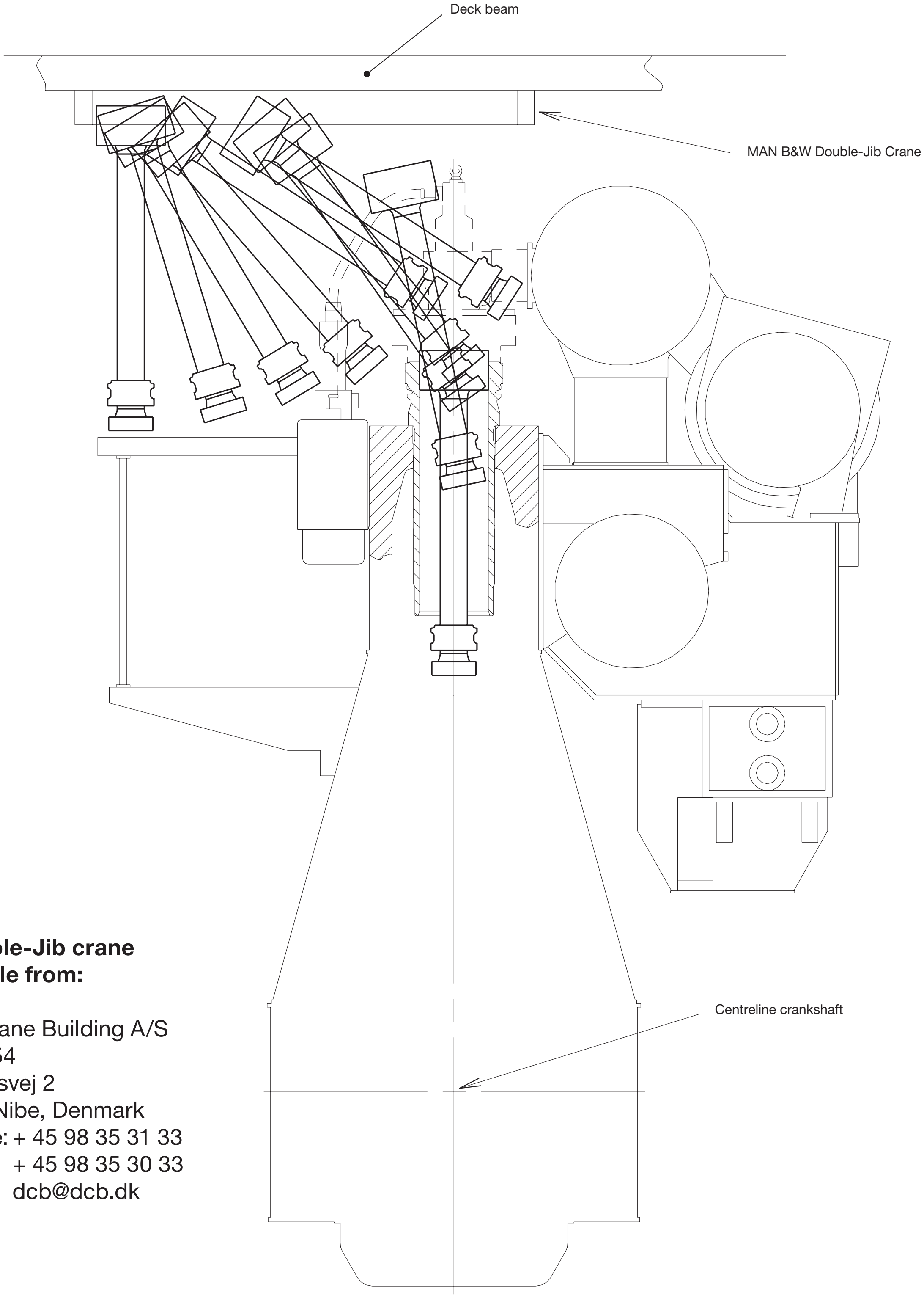
The crane hook travelling area must cover at least the full length of the engine and a width in accordance with dimension A given on the drawing, see cross-hatched area.

It is furthermore recommended that the engine room crane can be used for transport of heavy spare parts from the engine room hatch to the spare part stores and to the engine. See example on this drawing.

The crane hook should at least be able to reach down to a level corresponding to the centre line of the crankshaft.

For overhaul of the turbocharger(s), trolley mounted chain hoists must be installed on a separate crane beam or, alternatively, in combination with the engine room crane structure, see ‘Crane beam for overhaul of turbochargers’ with information about the required lifting capacity for overhaul of turbocharger(s).

Overhaul with MAN B&W Double-Jib crane



The Double-Jib crane is available from:

Danish Crane Building A/S
P.O. Box 54
Østerlandsvej 2
DK-9240 Nibe, Denmark
Telephone: + 45 98 35 31 33
Telefax: + 45 98 35 30 33
E-mail: dcb@dcb.dk

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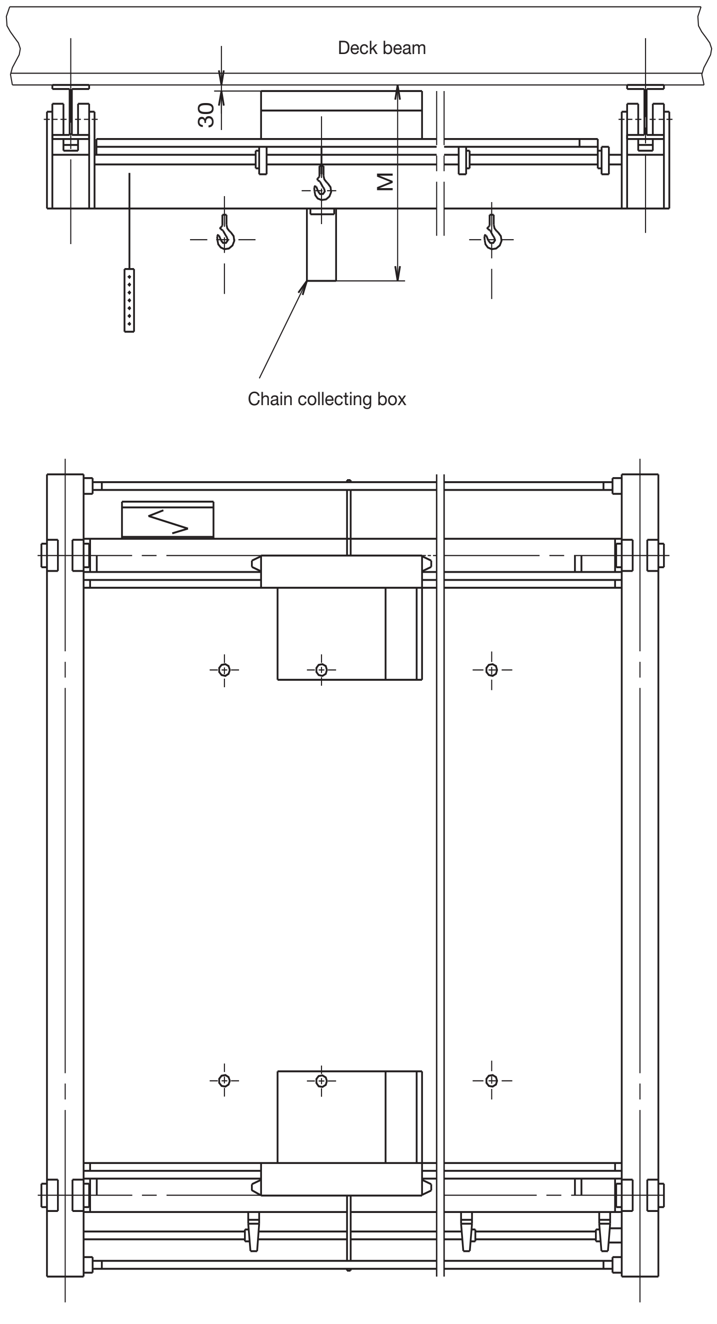
Fig. 5.04.02: Overhaul with Double-Jib crane

MAN B&W Double-Jib Crane



This crane is adapted to the special tool for low overhaul.

Dimensions are available on request.

Fig. 5.04.03: MAN B&W Double-Jib crane, option: 4 88 701

Engine Outline, Galleries and Pipe Connections

Engine Outline

The total length of the engine at the crankshaft level may vary depending on the equipment to be fitted on the fore end of the engine, such as adjustable counterweights, tuning wheel, moment compensators or PTO, which are shown as alternatives in Section 5.06

Engine Masses and Centre of Gravity

The partial and total engine masses appear from section 19.04, 'Dispatch Pattern', to which the masses of water and oil in the engine, Section 5.08, are to be added. The centre of gravity is shown in Section 5.07, in both cases including the water and oil in the engine, but without moment compensators or PTO.

Gallery Outline

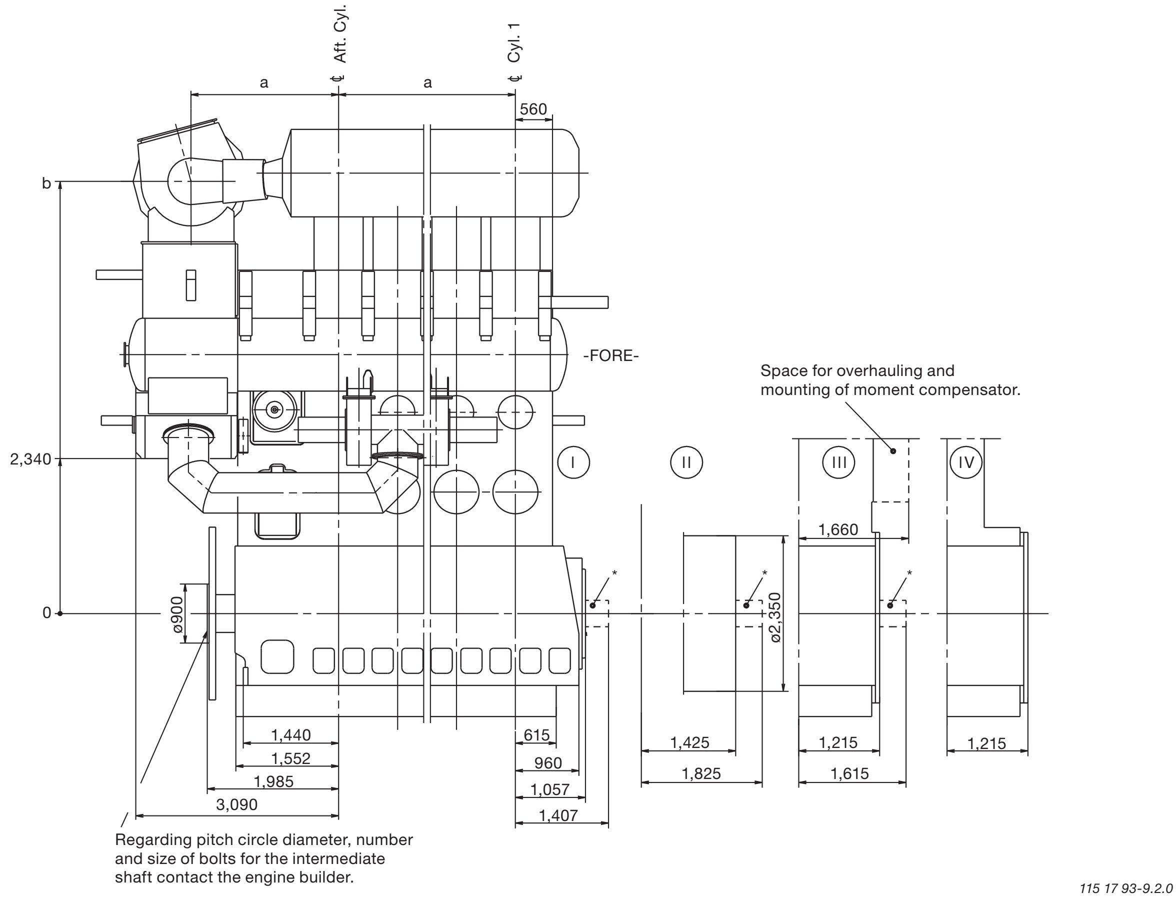
Section 5.06 show the gallery outline for engines rated at nominal MCR (L1).

Engine Pipe Connections

The positions of the external pipe connections on the engine are stated in Section 5.09, and the corresponding lists of counterflanges for pipes and turbocharger in Section 5.10.

The flange connection on the turbocharger gas outlet is rectangular, but a transition piece to a circular form can be supplied as an option: 4 60 601.

Engine and Gallery Outline

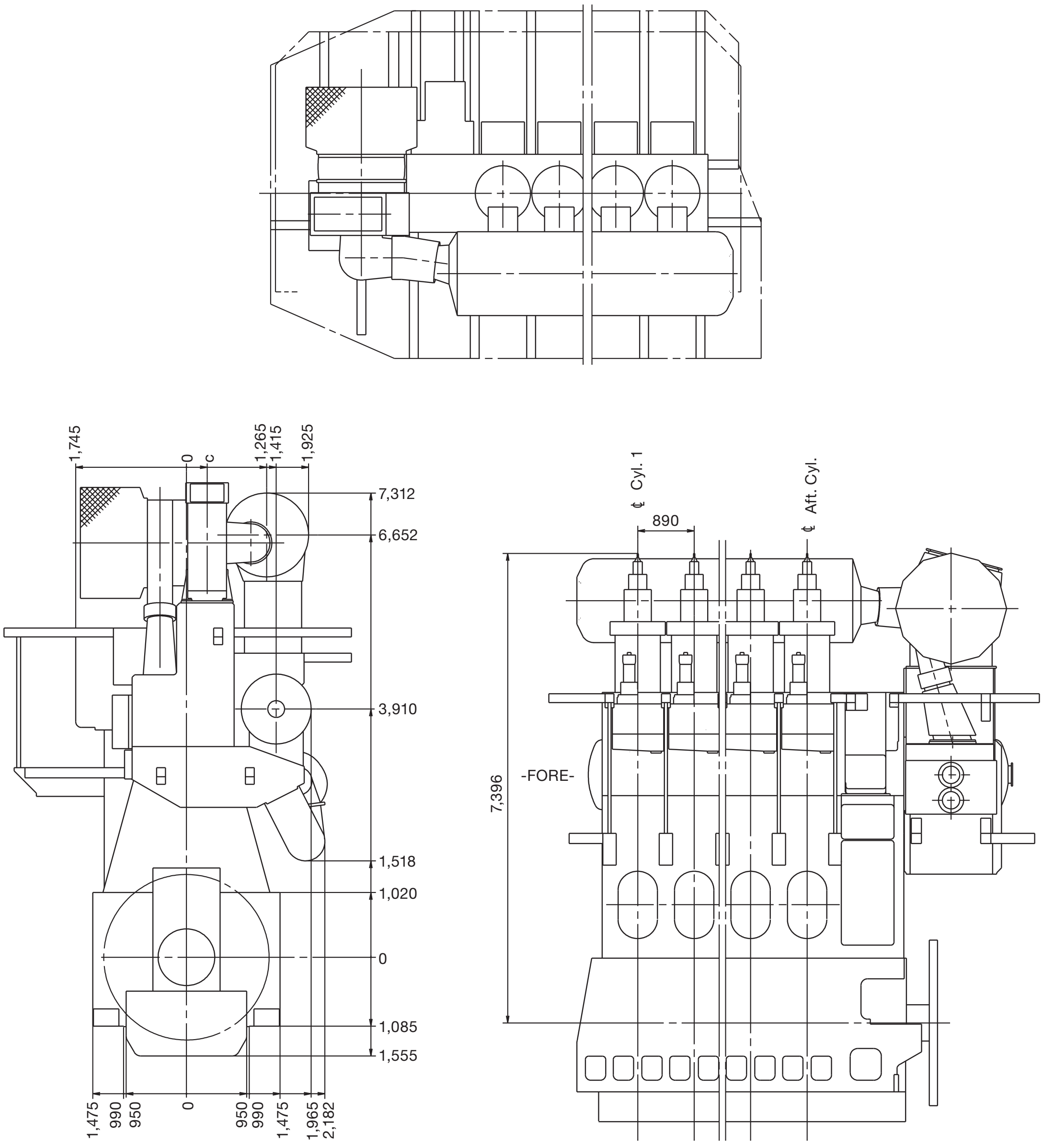


Cylinder	g
5	3,560
6	4,450
7	5,340
8	6,230

	T/C Type	a	b	c
MAN Diesel	TCA55	Available on request		
	TCA66	2,240	6,642	347
	TCA77	2,380	6,590	350
ABB	TPL73	2,070	6,472	209
	TPL77	2,304	6,497	460
	TPL80	2,362	6,497	460
MHI	MET53MA	2,240	6,527	415
	MET60MA	Available on request		
	MET66MA	2,269	6,542	553

Types of fore end	Typical for cylinder no.	Space demand valid for
I	5-6-7-8	Basic design
II	5-6	Built on tuning wheel
III	5-6	Built on 2nd order moment compensator.
IV	5-6-7-8	Engine prepared for TCS/PTI, PTO/RCF, PTO/PTI, se also corresponding space requirements.
*	Free space required for installation of equipment for measuring torsional and axial vibrations on engines without TCS or PTO. If the free space shown is not available, the shipyard should contact the engine supplier. On engines equipped with TCS or PTO, special measuring equipment is required.	

Fig. 5.06.01a: Engine outline, S50MC6 with turbocharger on aft end



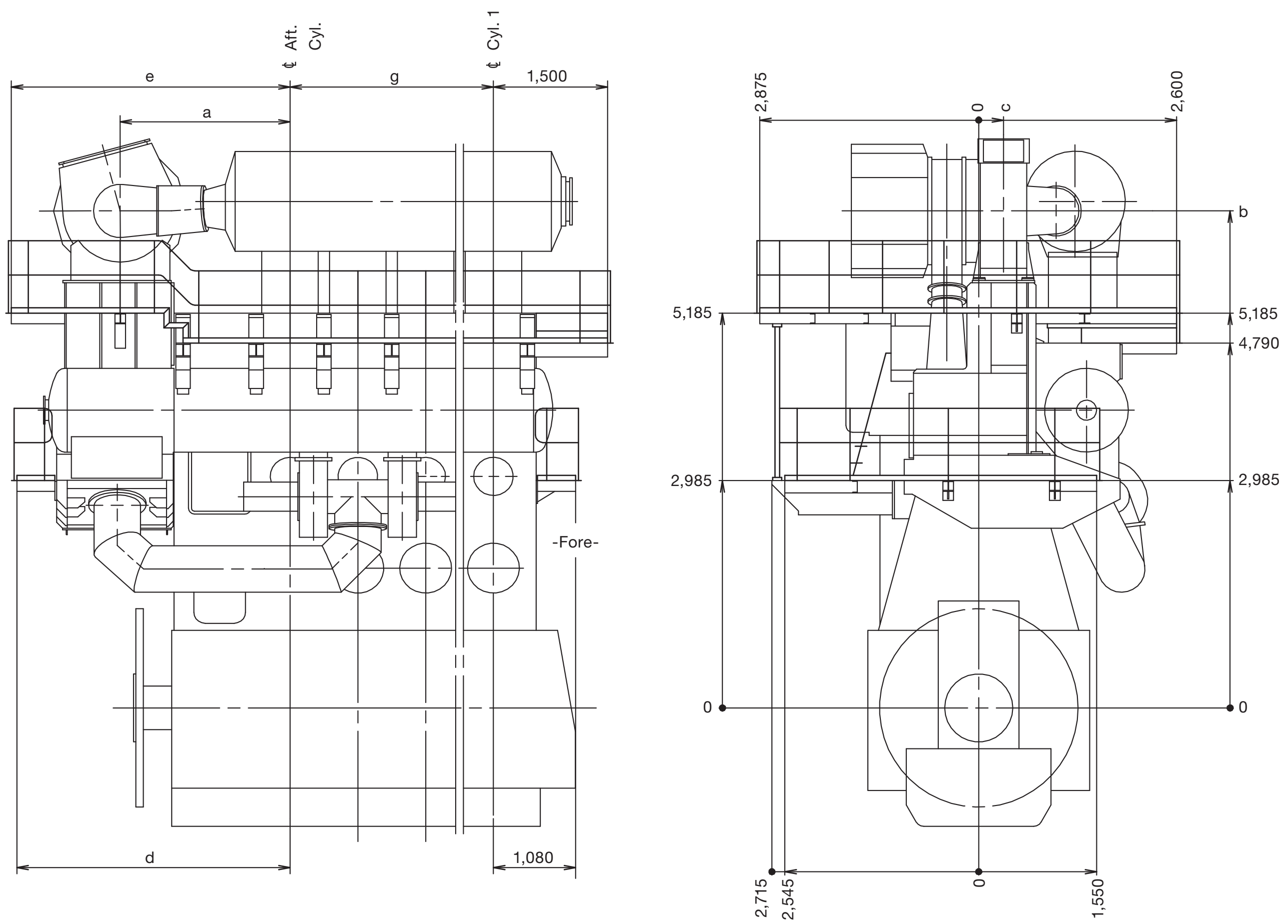
115 17 93-9.2.0

Please note that the latest version of the dimensioned drawing is available for download at www.mandiesel.com under 'Marine' → 'Low Speed' → 'Installation Drawings'. First choose engine series, then engine type and select 'Outline drawing' for the actual number of cylinders and type of turbocharger installation in the list of drawings available for download.

For platform dimensions, see 'Gallery Outline'.

Fig. 5.06.01b: Engine outline, S50MC6 with turbocharger on aft end

Upper platform



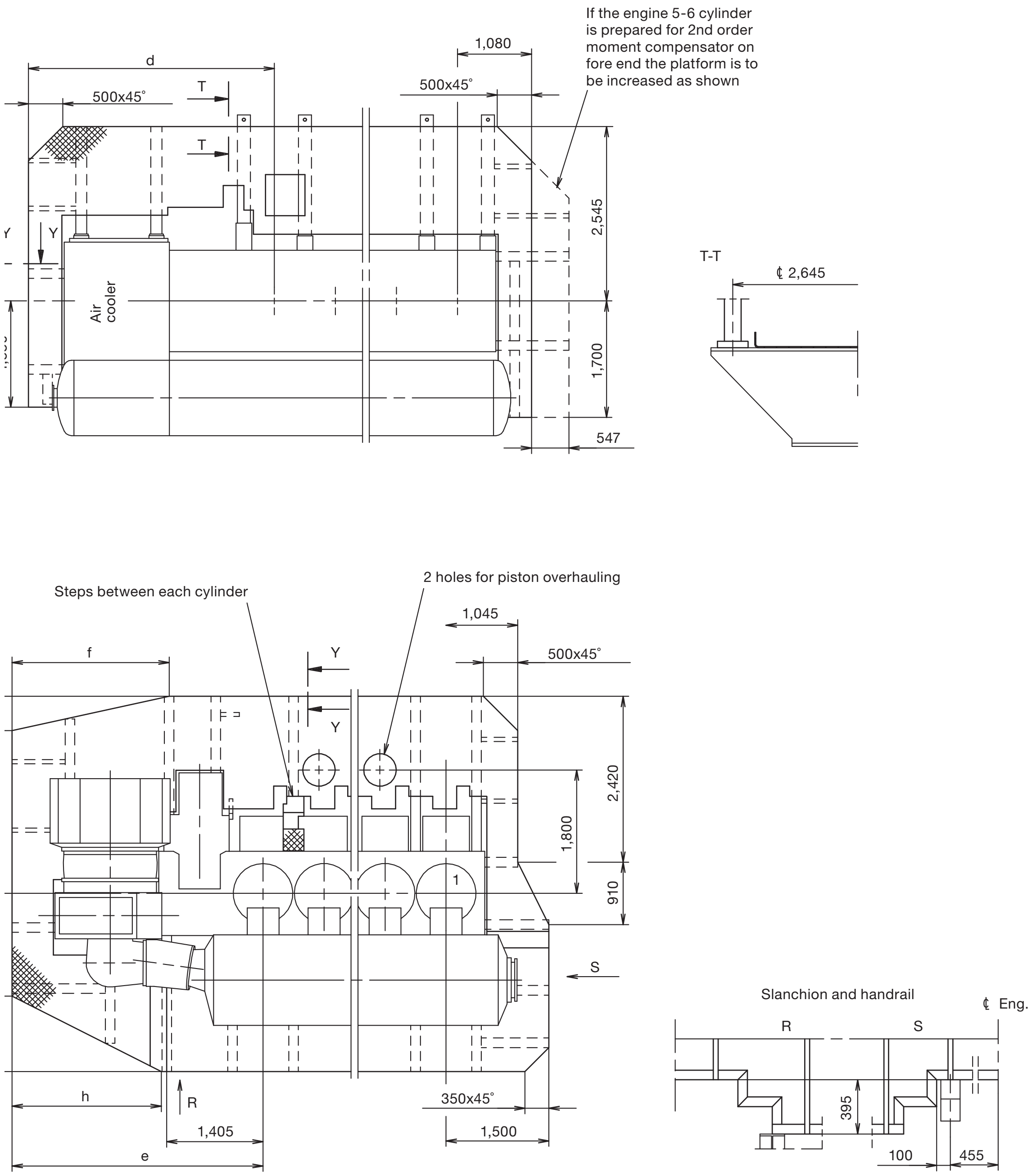
174 47 11-0.6.0

	T/C Type	a	b	c	d	e	f	h	k	l
MAN Diesel	TCA55	Available on request								
	TCA66									
	TCA77									
ABB	TPL73									
	TPL77	2,302	6,497	460	3,586	3,660	2,290	2,175	500	1,000
	TPL80	2,362	6,497	460	3,586	3,660	2,290	2,175	500	1,000
MHI	MET53MA	Available on request								
	MET60MA									
	MET66MA									

Cylinder	g
5	3,560
6	4,450
7	5,340
8	6,230

Fig. 5.06.02a: Gallery outline, S50MC6 with turbocharger on aft end

Lower platform

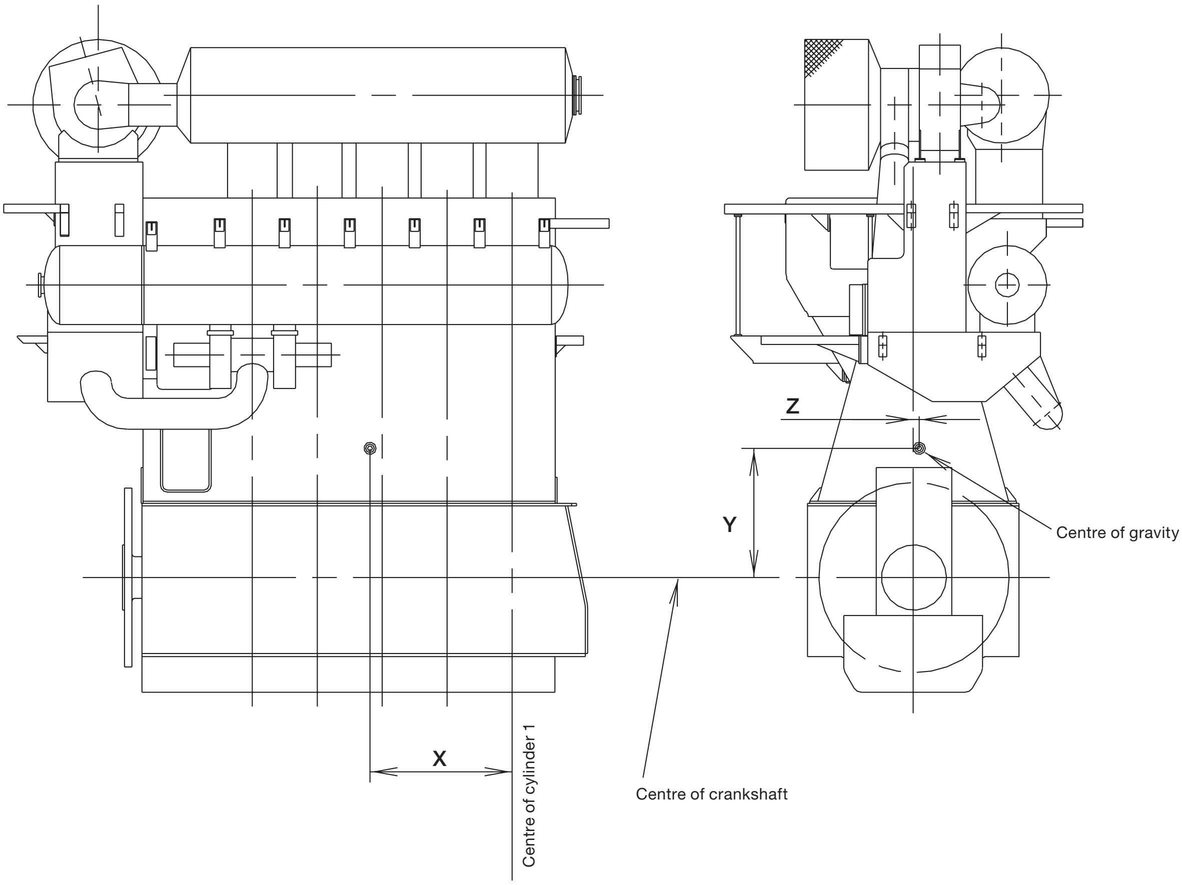


174 47 11-0.6.0

Please note that the latest version of the dimensioned drawing is available for download at www.mandiesel.com under ‘Marine’ → ‘Low Speed’ → ‘Installation Drawings’. First choose engine series, then engine type and select ‘Outline drawing’ for the actual number of cylinders and type of turbocharger installation in the list of drawings available for download.

Fig. 5.06.02b: Gallery outline, S50MC6 with turbocharger on aft end

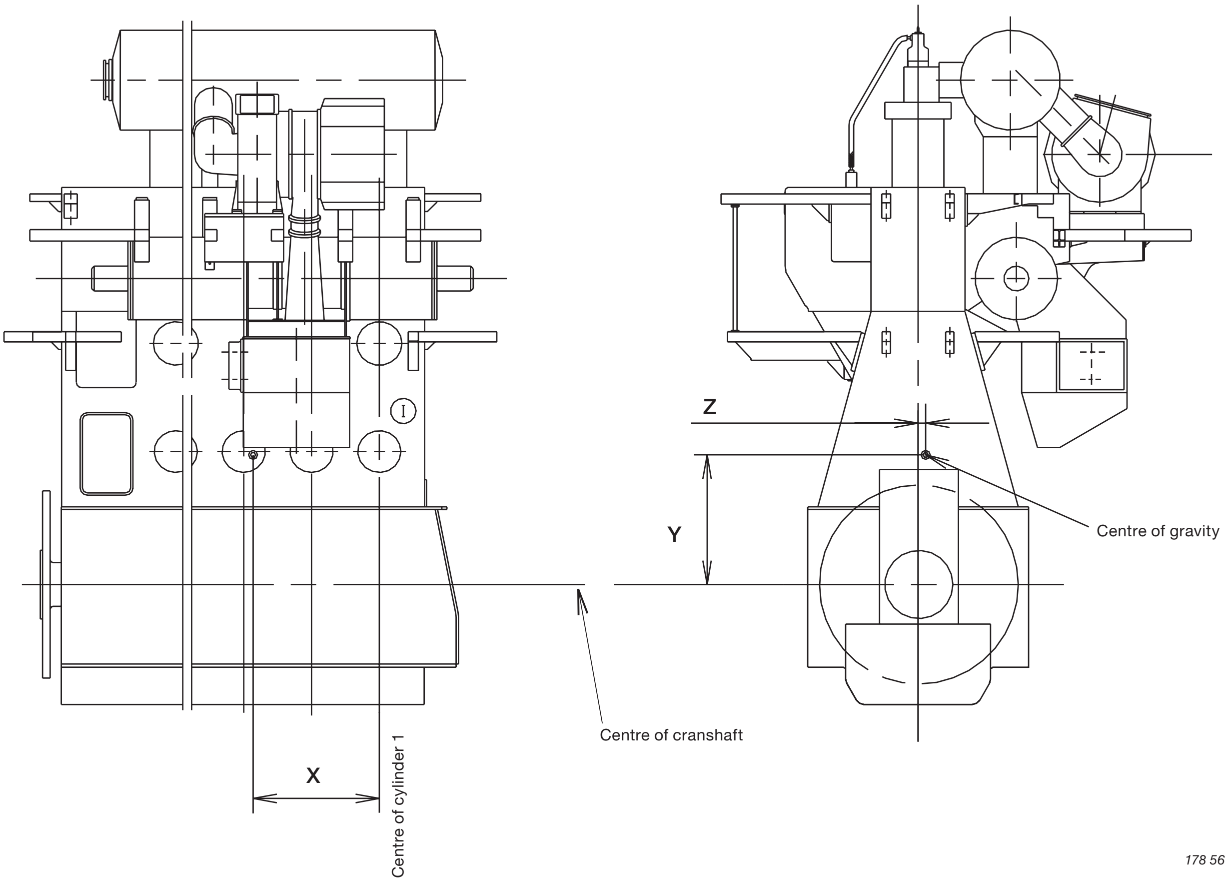
Centre of Gravity



For engines with one turbocharger				
No. of cylinders	**5**	**6**	**7**	**8**
Distance X mm	2,330	2,770	3,210	3,660
Distance Y mm	2,240	2,250	2,250	2,250
Distance Z mm	20	20	25	25

All dimensions and weights are approximate

Fig. 5.07a: Centre of gravity, turbocharger located on aft end of engine



For engines with one turbocharger				
No. of cylinders	**5**	**6**	**7**	**8**
Distance X mm	2,100	2,470	2,890	3,380
Distance Y mm	2,230	2,240	2,340	2,430
Distance Z mm	140	160	150	150

All dimensions and weights are approximate

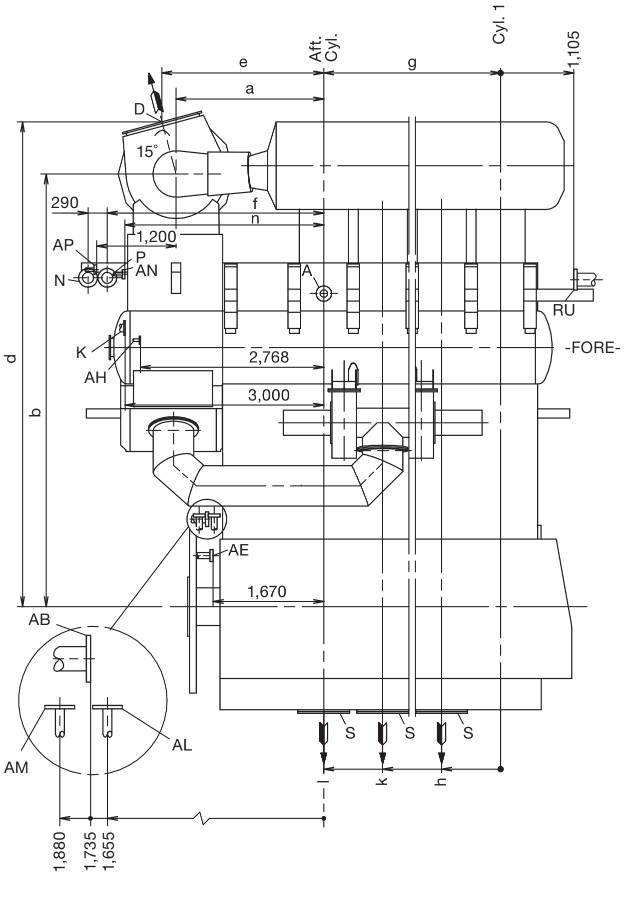
Fig. 5.07a: Centre of gravity, turbocharger located on exhaust side of engine, option 459 123

Mass of Water and Oil

No. of cylinders	Mass of water and oil in engine in service					
	Mass of water			Mass of oil		
	Jacket cooling water kg	Scavenge air cooling water kg	Total kg	Engine system kg	Oil pan kg	Total kg
5	340	280	620	250	480	730
6	405	340	745	300	670	970
7	470	390	860	350	580	930
8	535	430	965	400	690	1,090

Fig. 5.08.01: Water and oil in engine

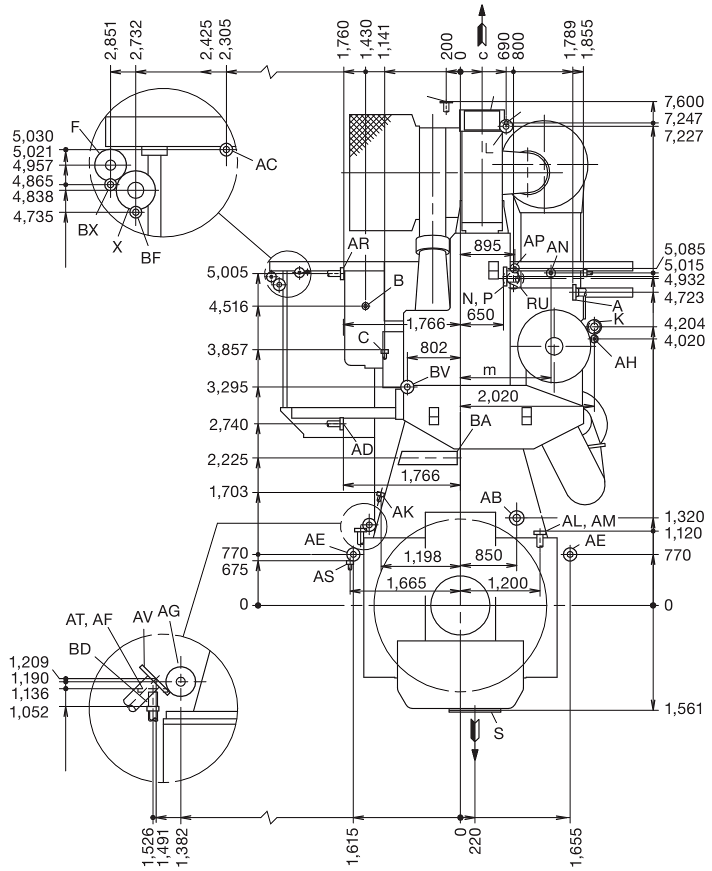
Engine Pipe Connections



502 55 08-1.0.0a

The letters refer to list of 'Counterflanges', Table 5.10.01

Fig. 5.09.01a: Engine pipe connections, S50MC with turbocharger on aft end

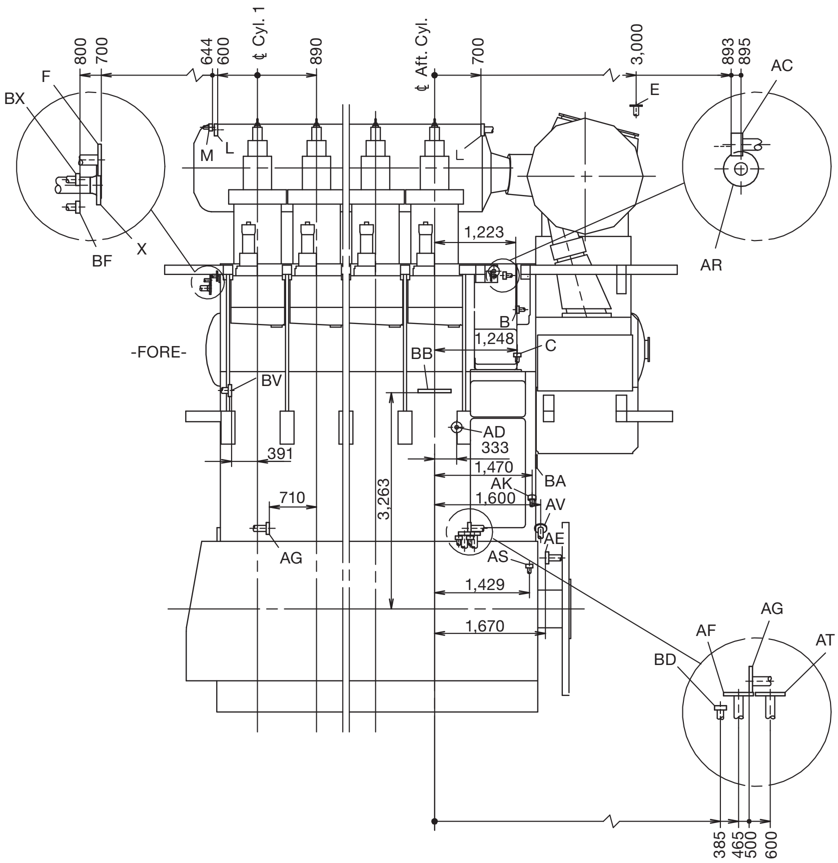


502 55 08-1.0.0b

The letters refer to list of ‘Counterflanges’, Table 5.10.01

	T/C Type	a	b	c	d	e	f	m	n
MAN Diesel	TCA55	Available on request							
	TCA66								
	TCA77								
ABB	TPL73	Available on request							
	TPL77	2,302	6,497	460	7,158	2,480	2,979	1,596	2,795
	TPL80	2,362	6,497	460	7,264	2,568	3,269	1,647	2,953
MHI	MET53MA	Available on request							
	MET60MA								
	MET66MA								

Fig. 5.09.01b: Engine pipe connections, S50MC with turbocharger on aft end



502 55 08-1.0.0c

The letters refer to list of 'Counterflanges', Table 5.10.01

Cyl.	g	h	k	l
5	3,560	890	-	3,560
6	4,450	890	-	4,450
7	5,340	890	3,560	5,340
8	6,230	890	3,560	6,230

Please note that the latest version of the dimensioned drawing is available for download at www.mandiesel.com under 'Marine' → 'Low Speed' → 'Installation Drawings'. First choose engine series, then engine type and select 'Outline drawing' for the actual number of cylinders and type of turbocharger installation in the list of drawings available for download.

For platform dimensions, see 'Gallery Outline'.

Fig. 5.09.01c: Engine pipe connections, S50MC with turbocharger on aft end

Counterflanges

Reference	Cyl. no.	Flange			Bolts		DN *	Description
		Diam.	PCD	Thickn.	Diam.	No.		
A	5-8	235	190	24	M20	8	100	Starting air inlet (Neck flange for welding supplied)
B	5-8	Coupling for 20 mm pipe						Control air inlet
C	5-8	Coupling for 16 mm pipe						Safety air inlet
D	5-8	See Fig. 5.10.02						Exhaust gas outlet
E	TCA55	125	130	14	M12	4	50	Venting of lub.oil discharge pipe turbocharger
	TCA66	180	145	18	M16	8	80	
	TCA77	180	145	18	M16	8	80	
	TPL73B	165	125	20	M16	4	50	
	TPL77B	165	125	20	M16	4	50	
	TPL80B	185	145	20	M16	8	65	
	MET56MA	Available on request						
	MET60MA							
	MET66MA							
F	5-8	150	110	16	M16	4	40	Fuel oil outlet (Neck flange for welding supplied)
K	5-6	200	160	20	M16	8	80	Fresh cooling water inlet
	7-8	220	180	20	M16	8	100	
L	5-6	200	160	20	M16	8	80	Fresh cooling water outlet
	7-8	220	180	20	M16	8	100	
M	5-8	Coupling for 30 mm pipe						Fresh cooling water de-aeration
N	5	250	210	26	M16	8	125	Sea cooling water inlet to air cooler
	6-7	285	240	28	M20	8	150	
P	5	250	210	26	M16	8	125	Sea cooling water outlet from air cooler
	6-8	285	240	28	M20	8	150	
RU	5-8	340	295	24	M20	8	200	System oil inlet
S	5-8	See special drawing of oil outlet						System oil outlet to bottom tank
X	5-8	185	145	22	M22	8	65	Fuel oil inlet (Neck flange for welding supplied)
Y	5-8	150	110	16	M16	4	40	Lubricating oil inlet to camshaft
AB	TCA55	220	145	18	M16	4	65	Lubricating oil outlet from MAN Diesel, MHI & ABB (TPL) turbocharger
	TCA66	200	160	20	M16	8	80	
	TCA77	220	180	22	M16	8	100	
	TPL73	185	145	18	M16	4	65	
	TPL77	210	170	18	M16	4	100	
	TPL80	210	170	18	M16	4	100	
	MET56MA	Available on request						
	MET60MA							
	MET66MA							

Reference		Cyl. no.	Flange			Bolts		DN *	Description
			Diam.	PCD	Thickn.	Diam.	No.		
AC		5-8	Coupling for 30 mm pipe						Lubricating oil inlet to cylinder lubricators
AD		5-8	115	85	14	M12	4	25	Fuel oil to cylinders from umbrella sealing
AE		5-8	140	100	16	M16	4	32	Drain from bedplate / cleaning turbocharger
AF		5-8	140	100	16	M16	4	32	Fuel oil to drain tank
AG		5-8	140	100	16	M16	4	32	Drain oil from piston rod stuffing boxes
AH		5-8	Coupling for 30 mm pipe						Fresh cooling water drain (main engine)
AH1		5-8	Coupling for 30 mm pipe						Fresh cooling water drain (turbocharger exh. side)
AK		5-8	Coupling for 30 mm pipe						Inlet cleaning air cooler
AL	TC Aft.	5-8	140	100	16	M16	4	32	Outlet air cooler cleaning/water mist catcher
AM		5-8	140	100	16	M16	4	32	Outlet air cooler to chemical cleaning tank
AL	TC Exh.	5-8	165	125	18	M16	4	50	Outlet air cooler cleaning/water mist catcher
AM		5-8	165	125	18	M16	4	50	Outlet air cooler to chemical cleaning tank
AN		5-8	Coupling for 30 mm pipe						Water inlet for cleaning of turbocharger
AP/TC Aft.		5-8	Coupling for 12 mm pipe						Air inlet for dry cleaning of turbocharger
AP/TC Exh.		5-8	Coupling for 30 mm pipe						Air inlet for dry cleaning of turbocharger
AR		5-8	165	125	18	M16	4	50	Oil vapour disharge
AS		5-8	Coupling for 30 mm pipe						Cooling water drain air cooler
AT		5-8	150	110	18	M16	4	40	Extinguishing of fire in scavenge air box
AV		5-8	185	145	18	M16	4	65	Drain from scavenge air box to closed drain tank
BA		5-8	Coupling for 8 mm pipe						Terminal plate for remote instruments
BB		5-8	Coupling for 10 mm pipe						Terminal plate for manoeuvring system
BD		5-8	Coupling for 16 mm pipe						Fresh water outlet for heating fuel oil drain pipes
BX		5-8	Coupling for 16 mm pipe						Steam inlet for heating fuel oil pipes
BF		5-8	Coupling for 16 mm pipe						Steam outlet for heating fuel oil pipes
BV		5-8	Coupling for 16 mm pipe						Steam inlet for cleaning of drain scavenge air box

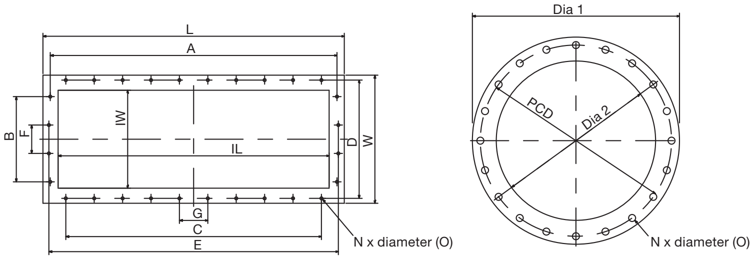
* DN indicates the nominal diameter of the piping on the engine. For external pipes the diameters should be calculated according to the fluid velocities (see list of capacities) or the recommended pipe sizes in diagrams should be used.

317 05 73-1.7.0

Table 5.10.01: List of counterflanges, S50MC6 with turbocharger on aft end. Reference is made to section 5.09 Engine Pipe Connections.

Counterflanges, Connection D

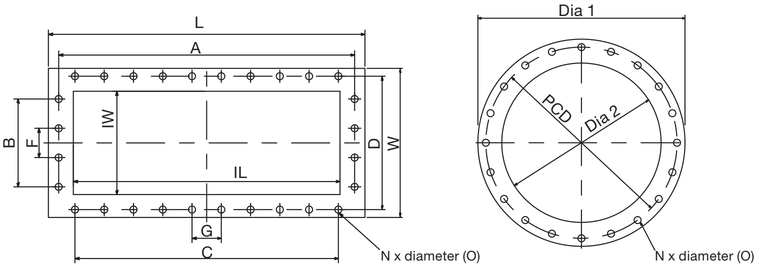
MAN Diesel Type TCA/TCR



Type TCA series													
T.C.	**L**	**W**	**I L**	**I W**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**N**	**O**
TCA55	1,206	516	1,080	390	1,143	360	1,000	472	1,155	120	125	26	ø18
TCA66	1,433	613	1,283	463	1,358	420	1,200	560	1,373	140	150	26	ø18
TCA77	1,694	720	1,524	550	1,612	480	1,280	664	1,628	160	160	34	ø22
TCA88	2,012	855	1,810	653	1,914	570	1,710	788	1,934	160	190	28	ø22
TCA99	2,207	938	1,985	717	2,100	624	1,872	866	2,120	208	208	28	ø22

Type TCR series					
T.C.	**Dia 1**	**Dia 2**	**PCD**	**N**	**O**
TCR18	425	310	395	12	ø22
TCR22	595	434	650	20	ø22

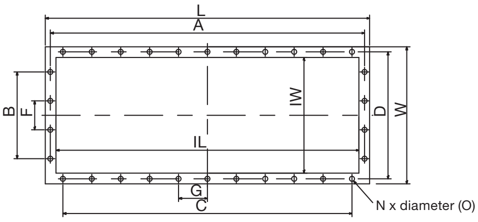
ABB Type TPL



Type TPL - Retangular type												
T.C.	L	W	I L	I W	A	B	C	D	F	G	N	O
TPL73	1,168	550	984	381	1,092	324	972	492	108	108	28	ø26
TPL77	1,372	638	1,176	462	1,294	390	1,170	580	130	130	28	ø26
TPL80	1,580	729	1,364	538	1,494	450	1,350	668	150	150	28	ø30
TPL85	1,910	857	1,740	690	1,812	700	1,540	796	140	140	36	ø30
TPL91	2,226	958	2,006	770	2,134	625	1,875	896	125	125	48	ø22

Type TPL - Round type					
T.C.	Dia 1	Dia 2	PCD	N	O
TPL69	650	500	600	20	ø22
TPL65	540	400	495	16	ø22

MHI Type MET



Type MET											
T.C.	L	W	I L	I W	A	B	C	D	F	G	N	O
MET33MA	Available on request										
MET42MA	883	365	793	275	850	240	630	335	80	90	24	ø15
MET53MA	1,122	465	1,006	349	1,073	300	945	420	100	105	28	ø20
MET60MA	1,230	660	1,120	388	1,190	315	1,050	500	105	105	30	ø20
MET66MA	1,380	560	1,254	434	1,330	345	1,200	510	115	120	30	ø24
MET71MA	1,520	700	1,400	480	1,475	345	1,265	640	115	115	34	ø20
MET83MA	1,740	700	1,586	550	1,680	450	1,500	640	150	150	30	ø24
MET90MA	1,910	755	1,750	595	1,850	480	1,650	695	160	165	30	ø24

503 26 38-6.0.0

Fig. 5.10.02: Turbocharger, exhaust outlet

Engine Seating and Holding Down Bolts

Please note that the latest version of the dimensioned drawing is available for download at www.mandiesel.com under ‘Marine’ → ‘Low-Speed’ → ‘MC Engine Programme’, choose engine type and click ‘Download installation Drawings for...’ the actual engine and turbocharger configuration. Select ‘Engine outline’ in the list of drawings available for download.

Engine Seating and Arrangement of Holding Down Bolts

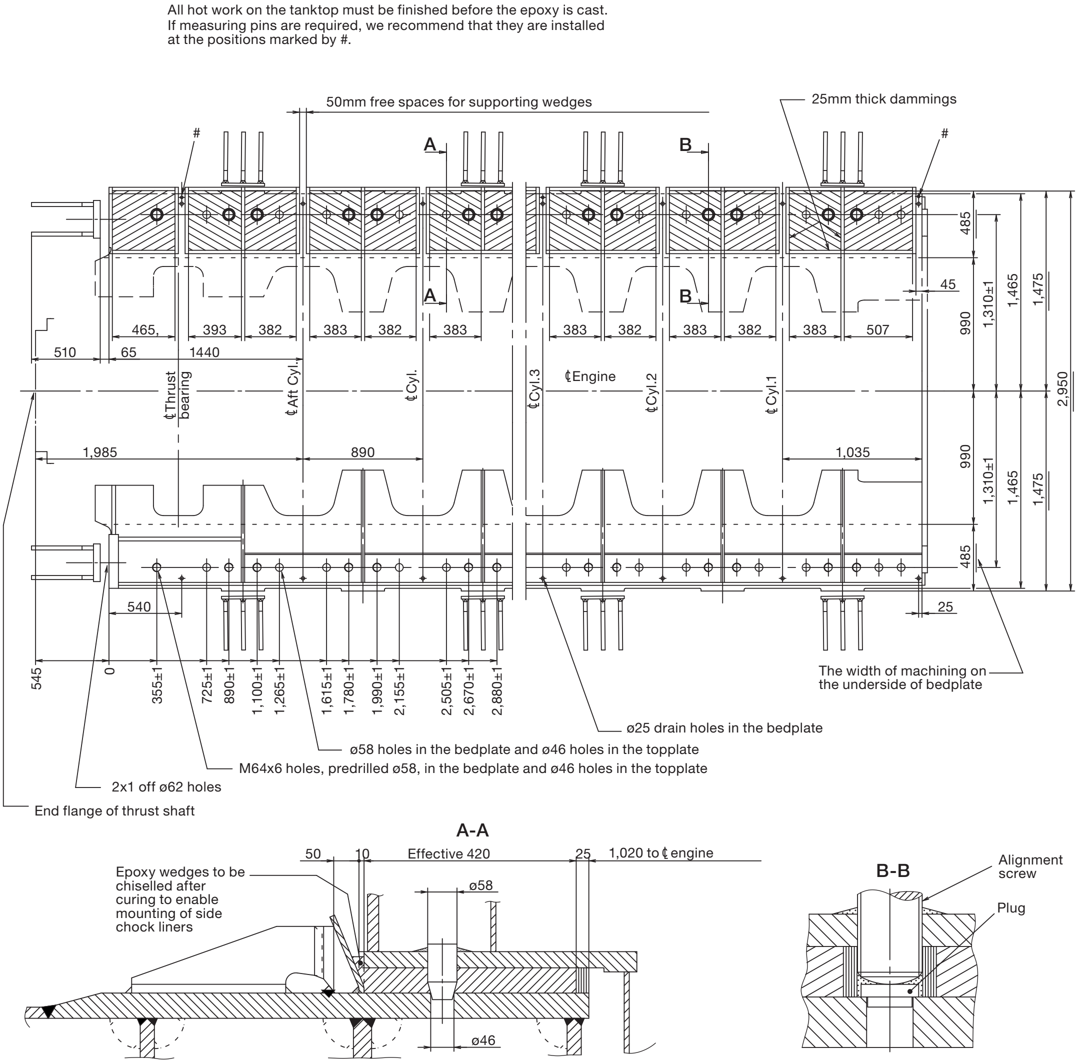
The dimensions of the seating stated in Figs. 5.12.01 and 5.12.02 are for guidance only.

The engine is designed for mounting on epoxy chocks EoD No. 4 82 102 in which case the underside of the bedplate’s lower flanges has no taper.

The epoxy types approved by MAN Diesel are:

- ‘Chockfast Orange PR 610 TCF from ITW Philadelphia Resins Corporation, USA’
- ‘Durasin’ from Daemmstoff Industrie Korea Ltd
- ‘Epocast 36’ from H.A. Springer - Kiel, Germany.

Epoxy Chocks Arrangement



178 15 09-9.3

For details of chocks and bolts see special drawings.

For securing of supporting chocks see special drawing.

This drawing may, subject to the written consent of the actual engine builder concerned, be used as a basis for marking-off and drilling the holes for holding down bolts in the top plates, provided that:

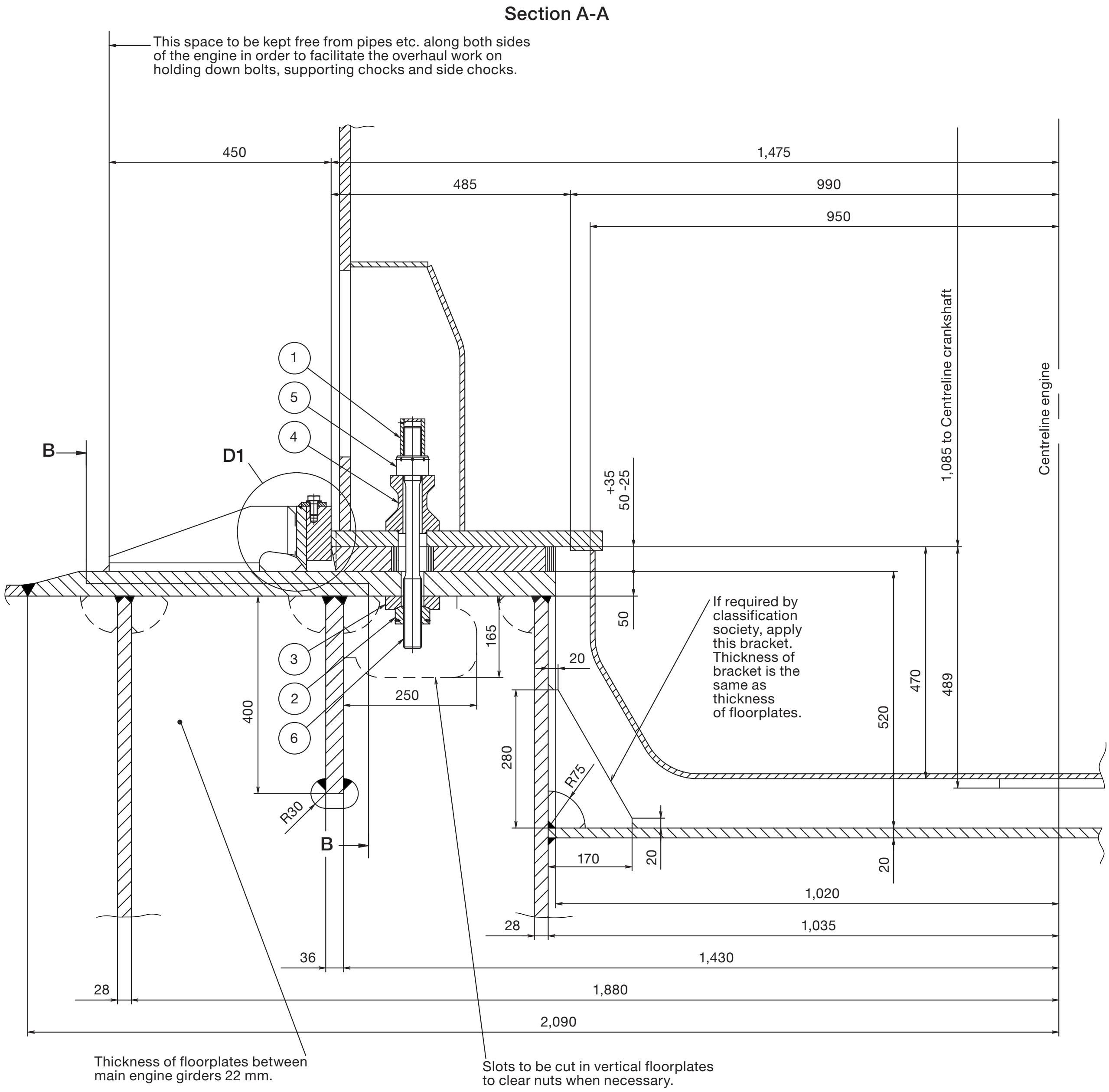
1) The engine builder drills the holes for holding down bolts in the bedplate while observing the toleranced locations indicated on MAN B&W drawings for machining the bedplate

2) The shipyard drills the holes for holding down bolts in the top plates while observing the toleranced locations given on the present drawing

3) The holding down bolts are made in accordance with MAN B&W drawings of these bolts.

Fig. 5.12.01: Arrangement of epoxy chocks and holding down bolts

Engine Seating Profile

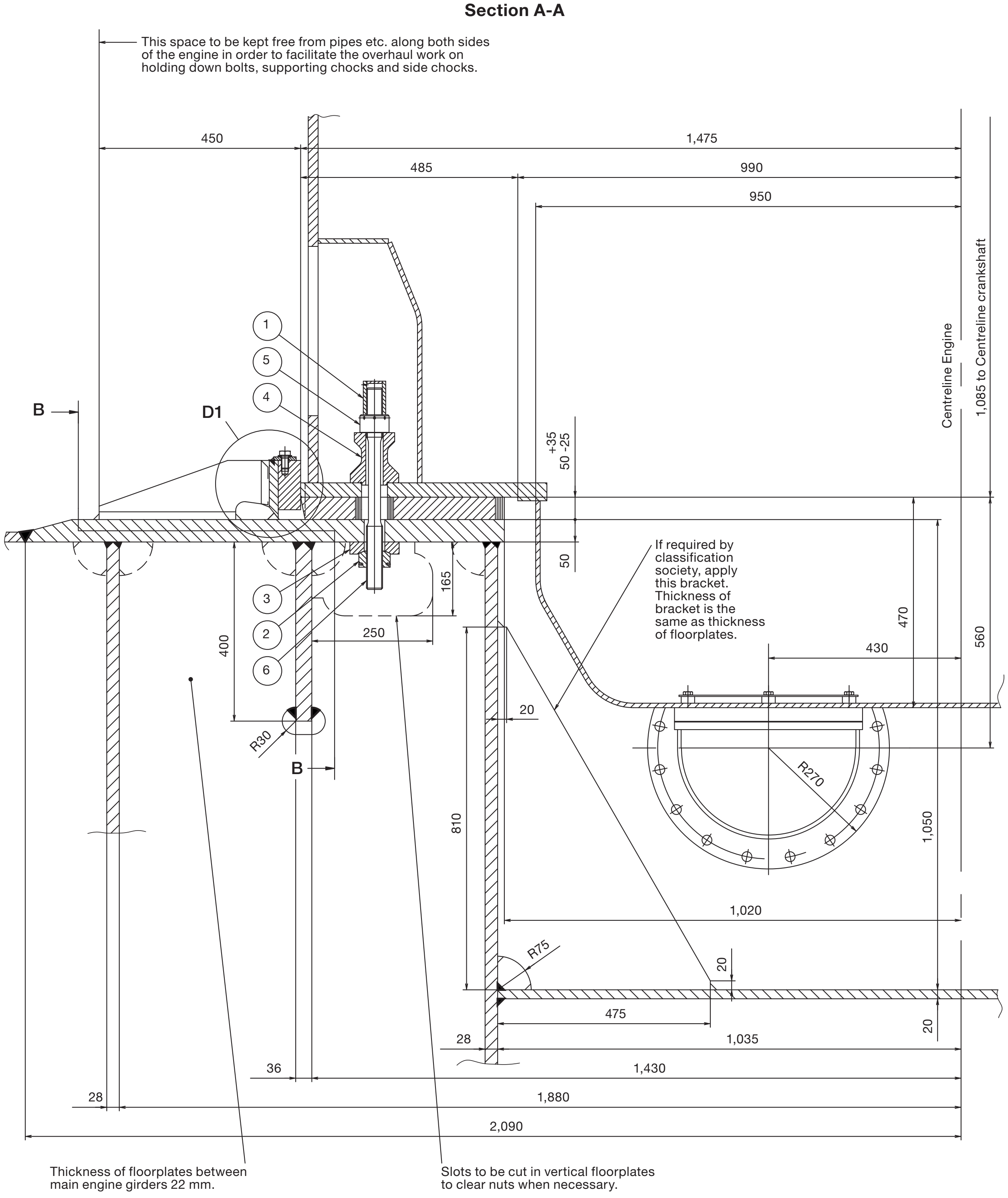


Holding down bolts, option: 4 82 602 include:

1. Protecting cap
2. Spherical nut
3. Spherical washer
4. Distance pipe
5. Round nut
6. Holding down bolt

178 15 07-5.3a

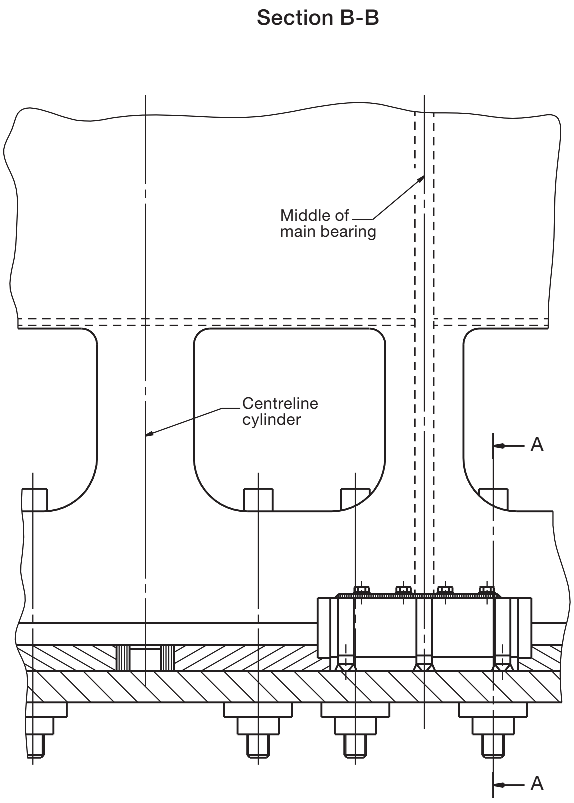
Fig.5.12.02a: Profile of engine seating with vertical oil outlet



Holding down bolts, option: 4 82 602 include:
1. Protecting cap
2. Spherical nut
3. Spherical washer
4. Distance pipe
5. Round nut
6. Holding down bolt

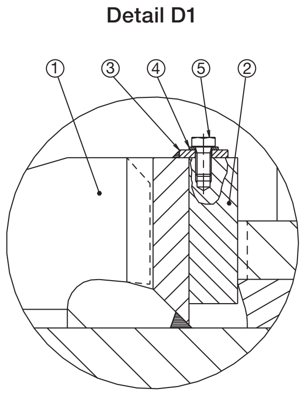
178 15 07-5.3b

Fig.5.12.02a: Profile of engine seating with horizontal oil outlet



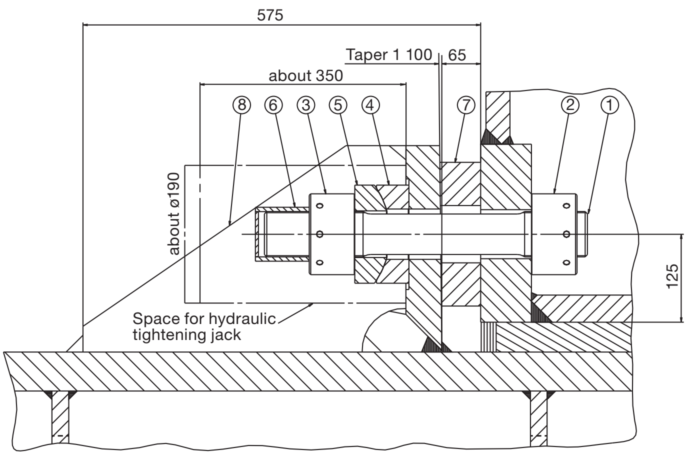
Side chock brackets, option: 4 82 622 includes:
1. Side chock brackets

Side chock liners, option: 4 82 620 includes:
2. Liner for side chock
3. Lock plate
4. Washer
5. Hexagon socket set screw



178 57 36-1.0

Fig. 5.12.02b: Profile of engine seating, end chocks, option: 4 82 620



End chock bolts, option: 4 82 610 includes:
1. Stud for end chock bolt
2. Round nut
3. Round nut
4. Spherical washer
5. Spherical washer
6. Protecting cap

End chock liner, option: 4 82 612 includes:
7. Liner for end chock

End chock brackets, option: 4 82 614 includes:
8. End chock bracket

178 57 20-4.0

Fig. 5.12.02c: Profile of engine seating, end chocks, option: 4 82 610

Engine Top Bracing

The so-called guide force moments are caused by the transverse reaction forces acting on the crossheads due to the connecting rod and crankshaft mechanism. When the piston of a cylinder is not exactly in its top or bottom position the gas force from the combustion, transferred through the connecting rod, will have a component acting on the crosshead and the crankshaft perpendicularly to the axis of the cylinder. Its resultant is acting on the guide shoe and together they form a guide force moment.

The moments may excite engine vibrations moving the engine top athwart ships and causing a rocking (excited by H-moment) or twisting (excited by X-moment) movement of the engine. For engines with less than seven cylinders, this guide force moment tends to rock the engine in the transverse direction, and for engines with seven cylinders or more, it tends to twist the engine.

The guide force moments are harmless to the engine except when resonance vibrations occur in the engine/double bottom system. They may, however, cause annoying vibrations in the superstructure and/or engine room, if proper countermeasures are not taken.

As a detailed calculation of this system is normally not available, MAN Diesel recommends that top bracing is installed between the engine's upper platform brackets and the casing side.

However, the top bracing is not needed in all cases. In some cases the vibration level is lower if the top bracing is not installed. This has normally to be checked by measurements, i.e. with and without top bracing.

If a vibration measurement in the first vessel of a series shows that the vibration level is acceptable without the top bracing, we have no objection to the top bracing being removed and the rest of the series produced without top bracing. It is our experience that especially the 7-cylinder engine will often have a lower vibration level without top bracing.

Without top bracing, the natural frequency of the vibrating system comprising engine, ship's bottom, and ship's side is often so low that resonance with the excitation source (the guide force moment) can occur close to the normal speed range, resulting in the risk of vibration.

With top bracing, such a resonance will occur above the normal speed range, as the natural frequencies of the double bottom/main engine system will increase. The impact of vibration is thus lowered.

The top bracing is normally installed on the exhaust side of the engine, but can alternatively be installed on the manoeuvring side. A combination of exhaust side and manoeuvring side installation is also possible.

The top bracing system is installed either as a mechanical top bracing or a hydraulic top bracing. Both systems are described below.

Mechanical top bracing

The mechanical top bracing comprises stiff connections between the engine and the hull.

The top bracing stiffener consists of a double bar tightened with friction shims at each end of the mounting positions. The friction shims allow the top bracing stiffener to move in case of displacements caused by thermal expansion of the engine or different loading conditions of the vessel. Furthermore, the tightening is made with a well-defined force on the friction shims, using disc springs, to prevent overloading of the system in case of an excessive vibration level.

The mechanical top bracing is to be made by the shipyard in accordance with MAN Diesel instructions.

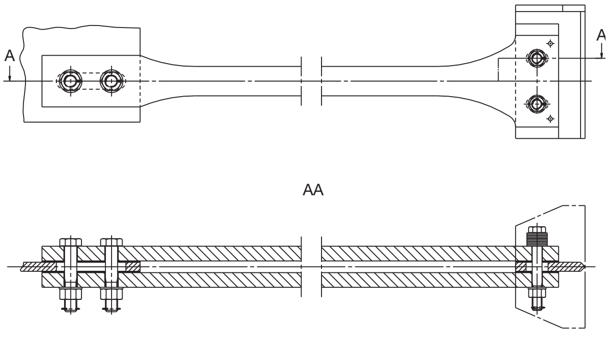


Fig. 5.13.01: Mechanical top bracing stiffener. Option: 4 83 112

Hydraulic top bracing

The hydraulic top bracing is an alternative to the mechanical top bracing used mainly on engines with a cylinder bore of 50 or more. The installation normally features two, four or six independently working top bracing units.

The top bracing unit consists of a single-acting hydraulic cylinder with a hydraulic control unit and an accumulator mounted directly on the cylinder unit.

The top bracing is controlled by an automatic switch in a control panel, which activates the top bracing when the engine is running. It is possible to programme the switch to choose a certain rpm range, at which the top bracing is active. For service purposes, manual control from the control panel is also possible.

When active, the hydraulic cylinder provides a pressure on the engine in proportion to the vibration level. When the distance between the hull and engine increases, oil flows into the cylinder under pressure from the accumulator. When the distance decreases, a non-return valve prevents the oil from flowing back to the accumulator, and the pressure rises. If the pressure reaches a preset maximum value, a relief valve allows the oil to flow back to the accumulator, hereby maintaining the force on the engine below the specified value.

By a different pre-setting of the relief valve, the top bracing is delivered in a low-pressure version (26 bar) or a high-pressure version (40 bar).

The top bracing unit is designed to allow displacements between the hull and engine caused by thermal expansion of the engine or different loading conditions of the vessel.

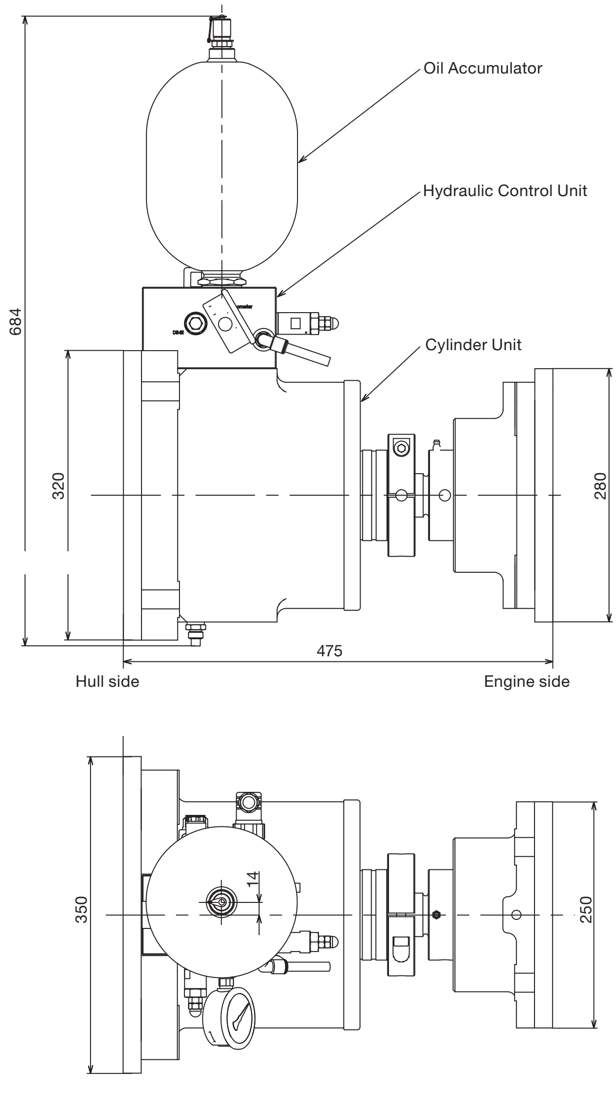
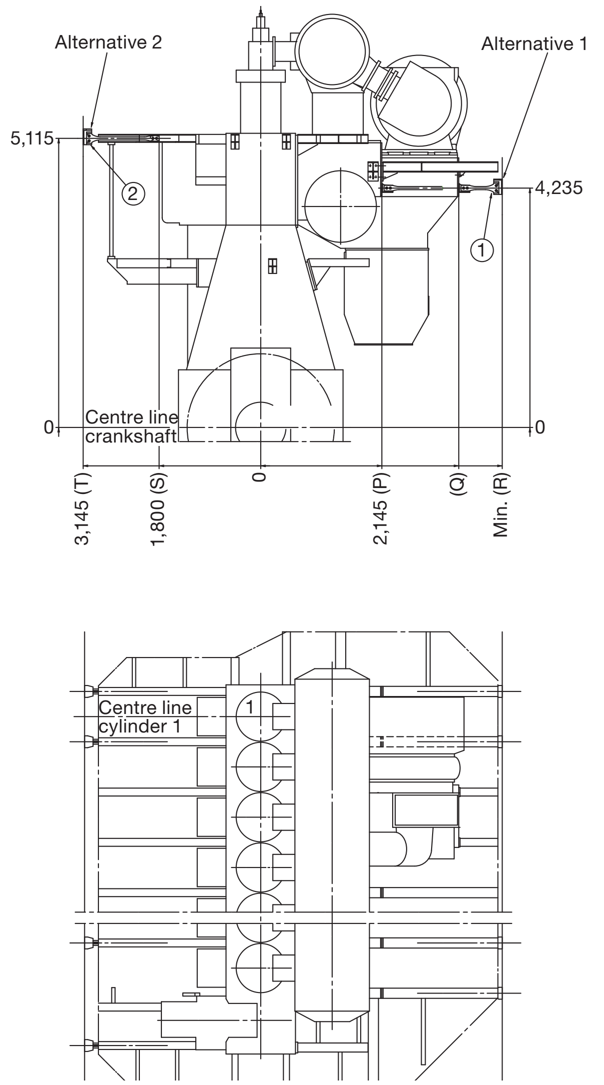
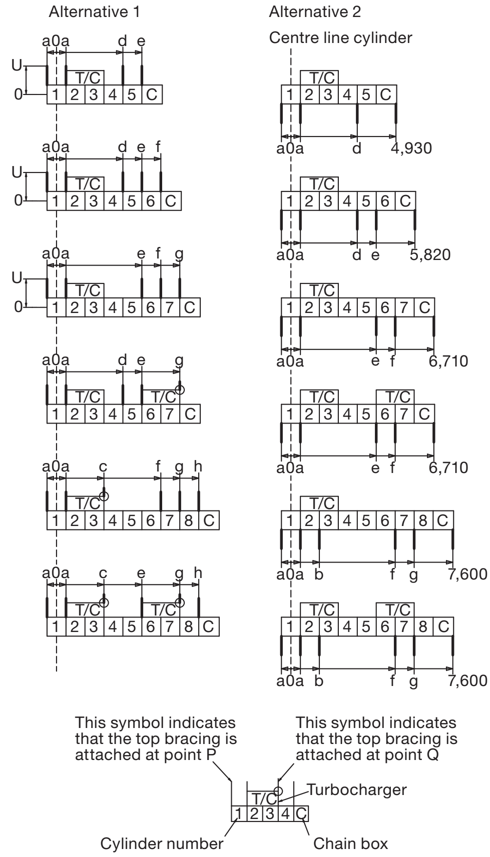


Fig. 5.13.02: Outline of a hydraulic top bracing unit. The unit is installed with the oil accumulator pointing either up or down. Option: 4 83 123

Mechanical Top Bracing





Horizontal distance between top bracing fix point and ℄ cylinder 1:

a	=	445	d	=	3,115	g	=	5,785
b	=	1,335	e	=	4,005	h	=	6,675
c	=	2,225	f	=	4,895			

Turbocharger	**Q**	**R**	**U *)**
TCA55	3,427	4,197	4,150
TCA66	3,427	4,197	4,150
TCA77	Available on request		
TPL73B	3,257	4,027	3,950
TPL77B	3,507	4,277	4,250
TPL80B	Available on request		
MET53MA			
MET60MA			
MET66MA			
MET71MA			

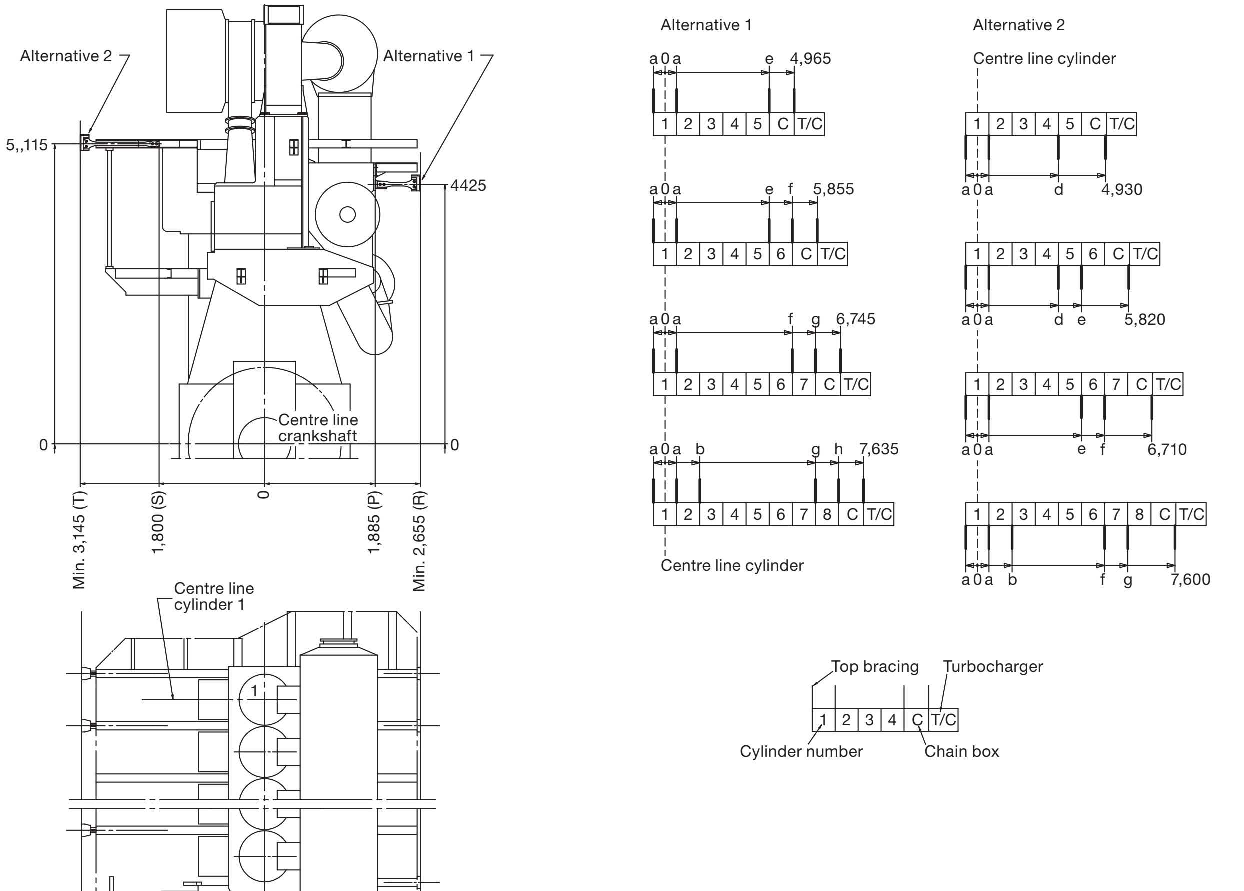
**) U: In case of all top bracings are attached at point P, the minimum attaching point 'R' could be reduced to 'U'.*

178 20 17-9.1

Force per mechanical top bracing minimum horizontal rigidity at attachment to the hull.

Force per bracing....................................... ±64 kN
Maximum horizontal deflection at the link's points of attachment to the hull...... 0.25 mm
Minimum horizontal rigidity in MN/m...........120 kN

Fig. 5.14.01: Mechanical top bracing arrangement, exhaust side



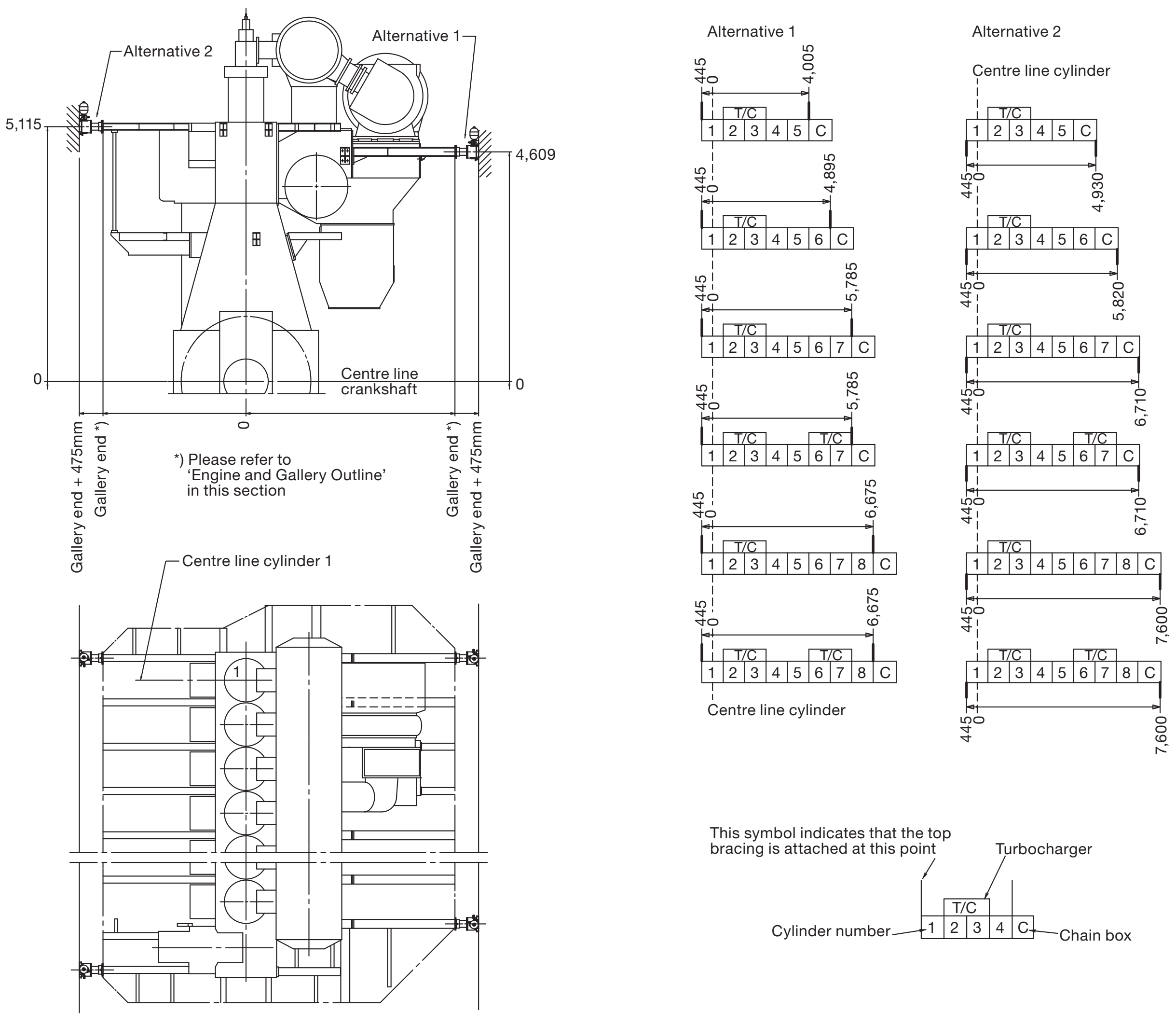
Horizontal distance between top bracing fix point and ℄ cylinder 1:

a	=	445		f	=	4,895
b	=	1,335		g	=	5,785
d	=	3,115		h	=	6,675
e	=	4,005				

178 15 17-1.2

Fig. 5.14.01: Mechanical top bracing arrangement, aft end

Hydraulic Top Bracing Arrangement



Force per bracing....................................... ±81 kN
Maximum horizontal deflection at the link's points of attachment to the hull for two cylinders...................................... 0.23 mm

178 20 18-0.1

Fig. 5.15.01: Hydraulic top bracing arrangement, exhaust side

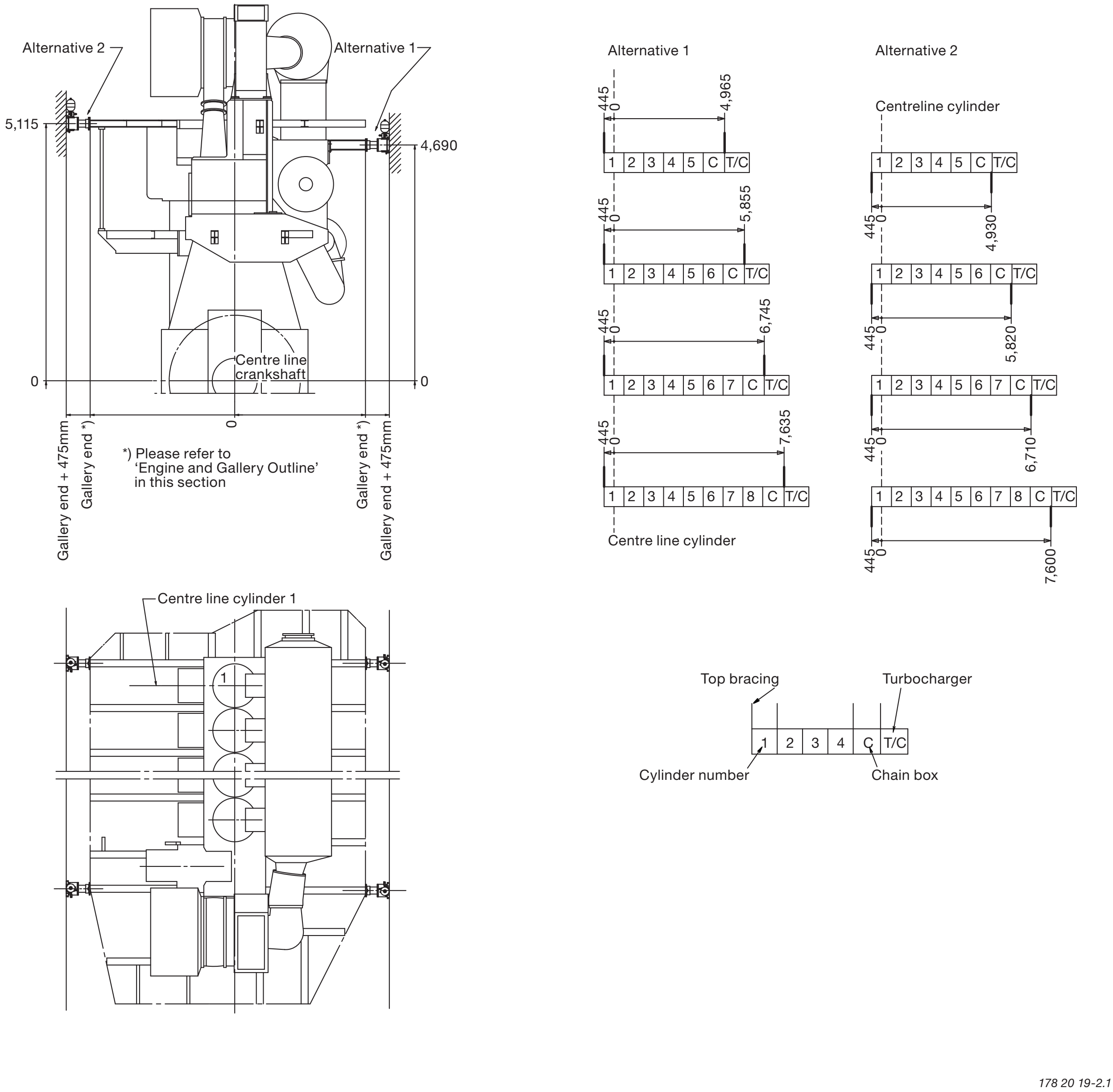


Fig. 5.15.01: Hydraulic top bracing arrangement, aft end

Components for Engine Control System

This section is not applicable

Shaftline Earthing Device

Scope and field of application

A difference in the electrical potential between the hull and the propeller shaft will be generated due to the difference in materials and to the propeller being immersed in sea water.

In some cases, the difference in the electrical potential has caused spark erosion on the thrust, main bearings and journals of the crankshaft of the engine.

In order to reduce the electrical potential between the crankshaft and the hull and thus prevent spark erosion, a highly efficient shaftline earthing device must be installed.

The shaftline earthing device should be able to keep the electrical potential difference below 50 mV DC, and a shaft-to-hull monitoring equipment with an mV-meter and with an output signal to the alarm system must be installed so that the potential and thus the correct function of the shaftline earthing device can be monitored.

Note that only one shaftline earthing device is needed in the propeller shaft system.

Design description of the shaftline earthing device

The shaftline earthing device consists of two silver slip rings, two arrangements for holding brushes including connecting cables and monitoring equipment with an mV-meter and an output signal for alarm.

The slip rings should be made of solid silver or back-up rings of cobber with a silver layer all over. The expected life span of the silver layer on the slip rings should be minimum 5 years.

The brushes should be made of minimum 80% silver and 20% graphite to ensure a sufficiently electrical conducting capability.

Resistivity of the silver should be less than 0.1µ Ohm x m. The total resistance from the shaft to the hull must not exceed 0.005 Ohm. For a well-functioning shaftline earthing device, the resistance is expected to be approximately 0.001 Ohm.

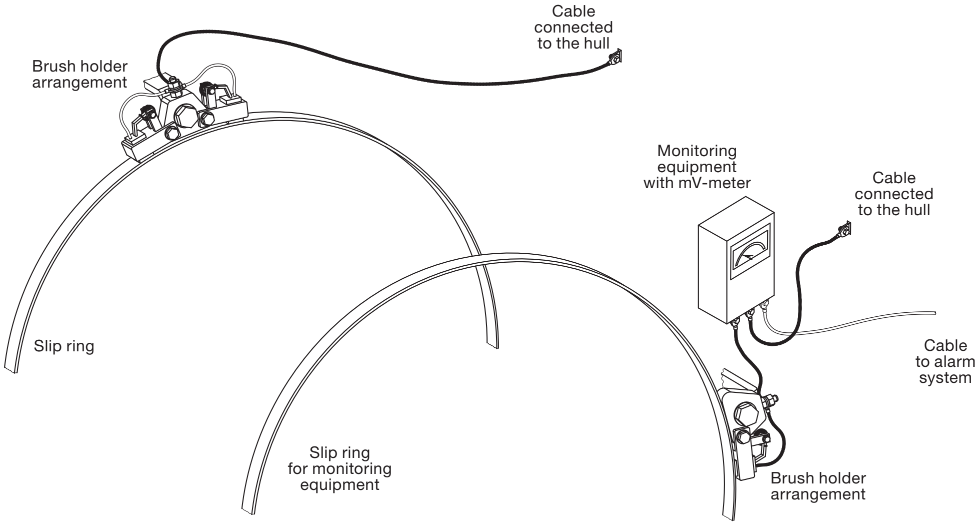


Fig. 5.17.01

079 21 82-1.2.1.0

A cable with a cross section not less than 45 mm² is used for cabling the shaftline earthing device to the hull. The length of the cable to the hull should be as short as possible.

Monitoring equipment should have a 4-20 mA signal for alarm and a two range mV-meter with a switch for changing range. Primary range from 0 mV to 50 -150 mV DC, and secondary range from 0 mV to 300-1500 mV DC.

When the shaftline earthing device is working correctly, the electrical potential will normally be within the range of 10-50 mV DC. The alarm set-points should be 5 mV for a low alarm and 80 mV for a high alarm. The alarm signals with an alarm delay of 30 seconds and an alarm cut-off, when the engine is stopped, must be connected to the alarm system.

Connection of cables as shown on the sketch, Fig. 5.17.01.

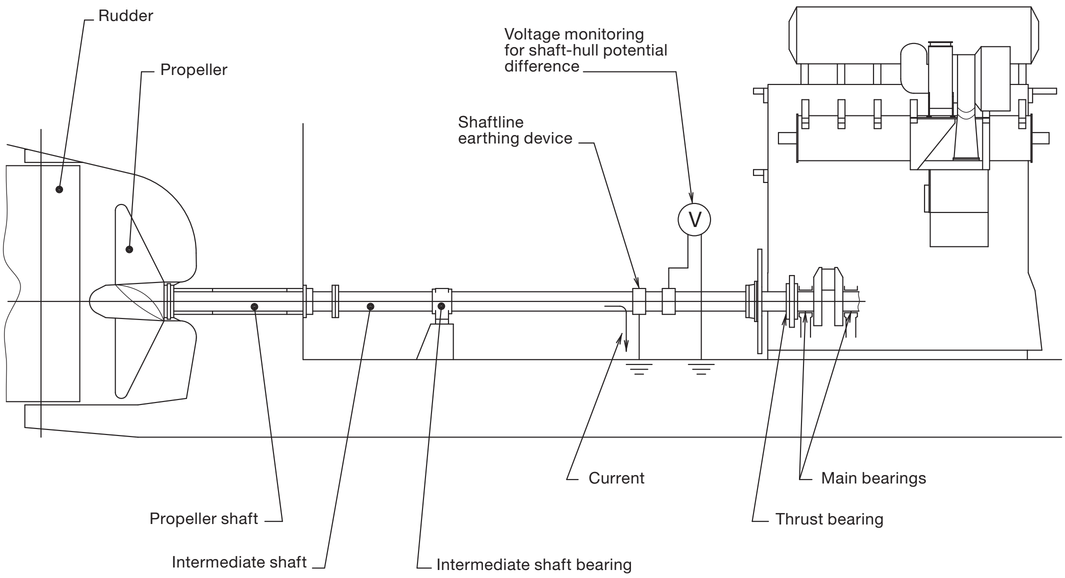


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Fig. 5.17.02: The shaftline earthing device slip rings must be fitted on the foremost intermediate shaft as close to the engine as possible

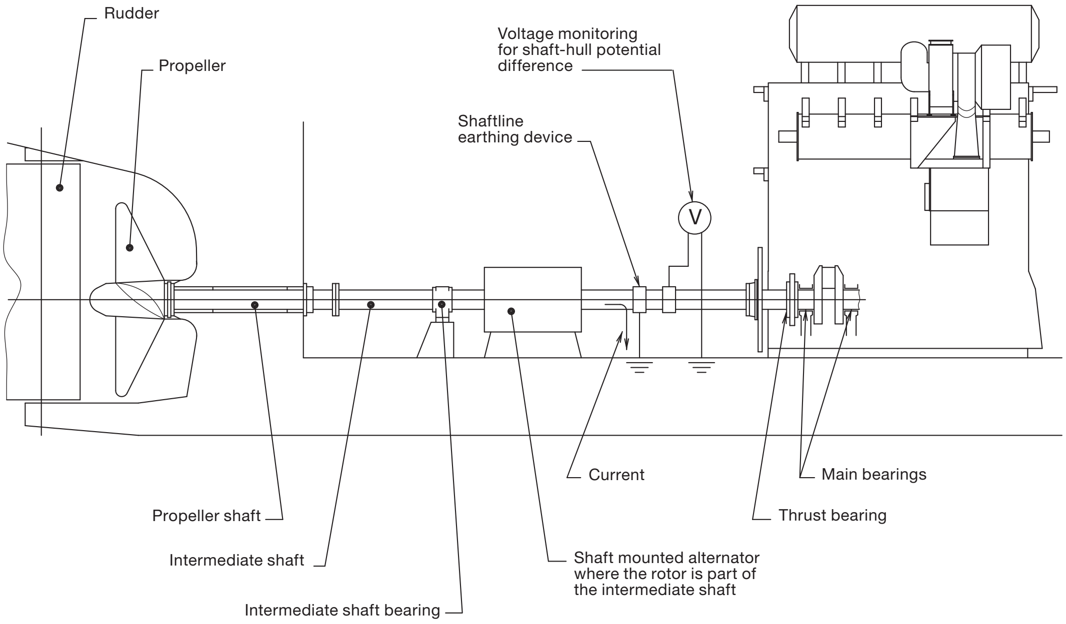


Fig. 5.17.03: When a generator is fitted, the shaftline earthing device must be placed between the generator and the engine

Suppliers

Supplier ref. no. 1386:

BAC Corrosion Control A/S
Faeroevej 7-9
DK-4681 Herfoelge, Denmark
Telephone: +45 70 26 89 00
Telefax: +45 70 26 97 00
Email: info@bacbera.dk
Website: www.bacbera.dk

Supplier ref. no. 1606:

M. G. Duff Marie Limited
1 Timberlaine Estate
Gravel Lane, Quarry Lane, Chichester
West Sussex, PO19 8PP, England
Telephone: +44 1243 533 336
Telefax: +44 1243 533 422
Email: sales@mgduff.co.uk
Website: www.mgduff.co.uk

MAN Diesel Controllable Pitch Propeller (CPP) and Remote Control

MAN Diesel Controllable Pitch Propeller

The standard propeller programme, Fig. 5.18.01 and 5.18.05 shows the VBS type features, propeller blade pitch setting by a hydraulic servo piston integrated in the propeller hub.

The figures stated after VBS indicate the propeller hub diameter, i.e. VBS1940 indicates the propeller hub diameter to be 1,940 mm.

Standard blade/hub materials are Ni-Al-bronze. Stainless steel is available as an option. The propellers are based on 'no ice class' but are available up to the highest ice classes.

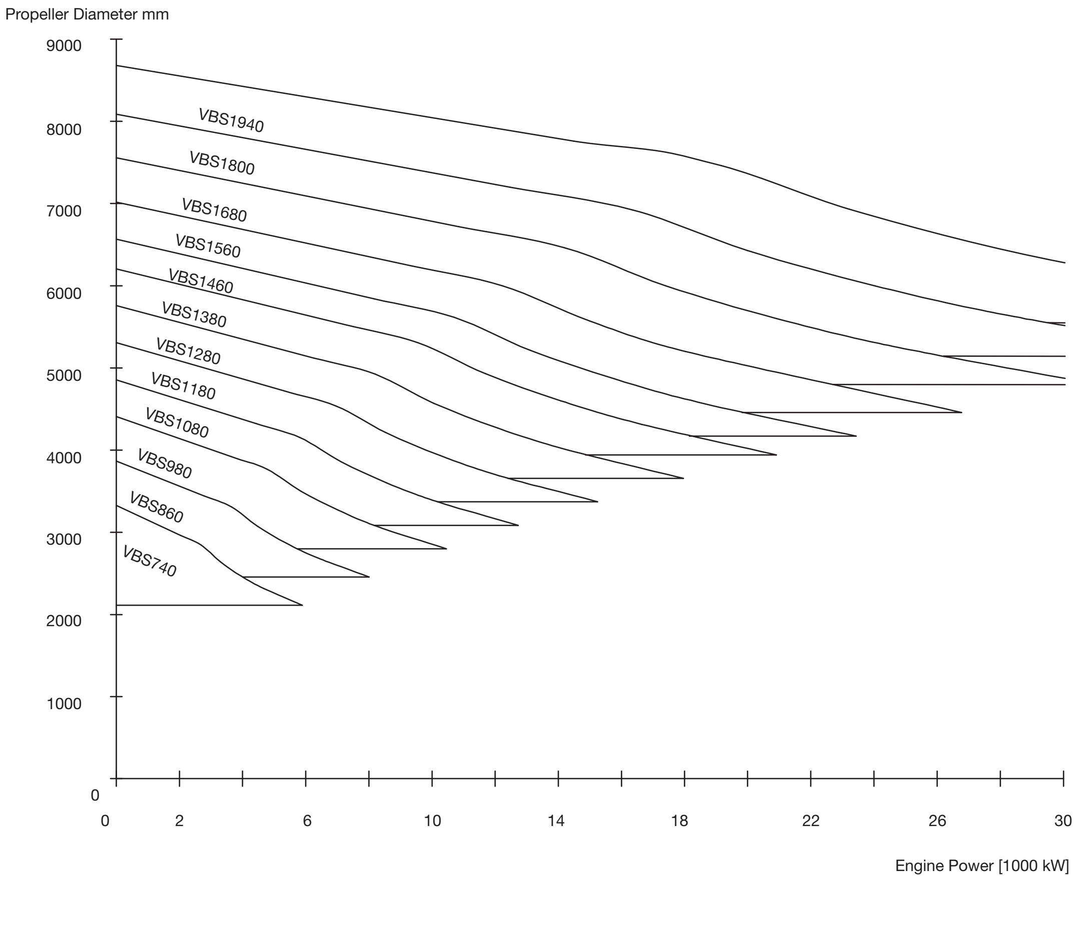


Fig. 5.18.01: Controllable pitch propeller diameter (mm)

Data Sheet for Propeller

Identification: ____________________________

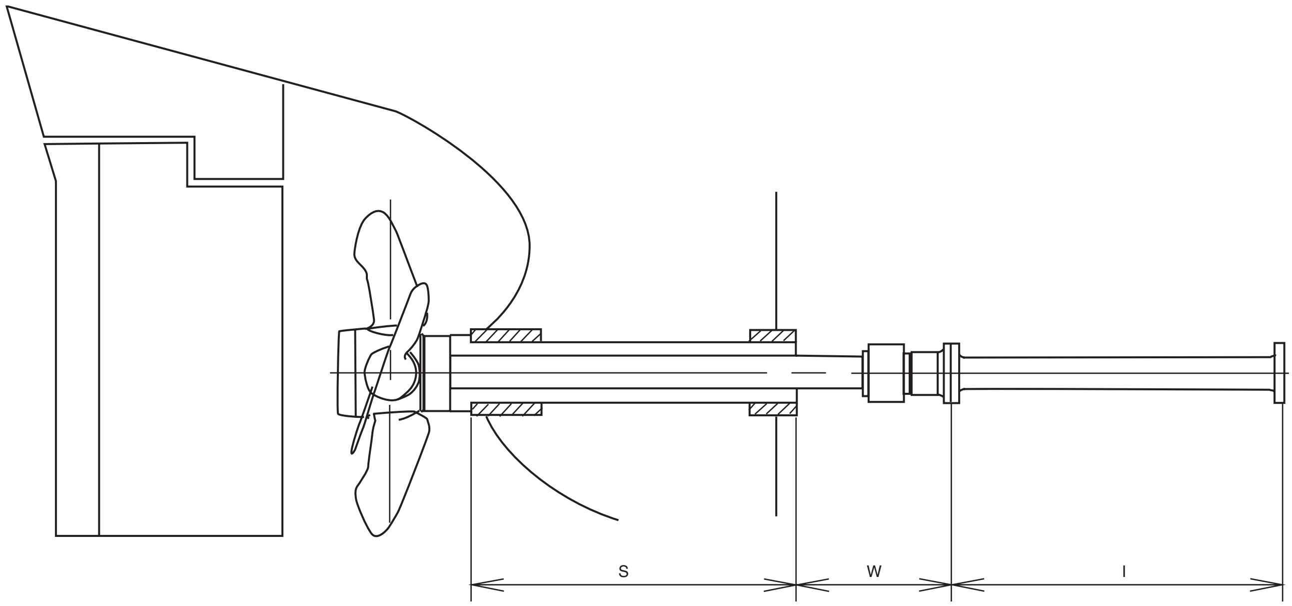


Fig. 5.18.02a: Dimension sketch for propeller design purposes

Type of vessel: ___________________________
For propeller design purposes please provide us with the following information:

1. S: ____________ mm
   W: ____________ mm
   I: ______________ mm (as shown above)

2. Stern tube and shafting arrangement layout

3. Propeller aperture drawing

4. Complete set of reports from model tank (resistance test, self-propulsion test and wake measurement). In case model test is not available the next page should be filled in.

5. Drawing of lines plan

6. Classification Society: _________
   Ice class notation: ____________

7. Maximum rated power of shaft generator: kW

8. Optimisation condition for the propeller:
   To obtain the highest propeller efficiency please identify the most common service condition for the vessel.

   Ship speed: ________________________ kn
   Engine service load: __________________ %
   Service/sea margin: __________________ %
   Shaft generator service load: ___________ kW
   Draft: ______________________________ m

9. Comments:

Table 5.18.02b: Data sheet for propeller design purposes

Main Dimensions

	Symbol	Unit	Ballast	Loaded
Length between perpendiculars	LPP	m		
Length of load water line	LWL	m		
Breadth	B	m		
Draft at forward perpendicular	TF	m		
Draft at aft perpendicular	TA	m		
Displacement	o	m3		
Block coefficient (LPP)	CB	-		
Midship coefficient	CM	-		
Waterplane area coefficient	CWL	-		
Wetted surface with appendages	S	m2		
Centre of buoyancy forward of LPP/2	LCB	m		
Propeller centre height above baseline	H	m		
Bulb section area at forward perpendicular	AB	m2		

178 22 97-0.0

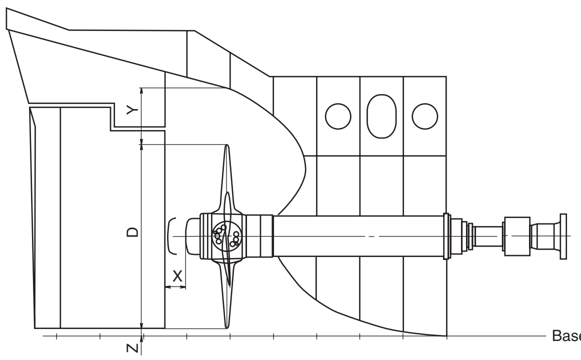
Table 5.18.03: Data sheet for propeller design purposes, in case model test is not available this table should be filled in

Propeller Clearance

To reduce pressure impulses and vibrations emitted from the propeller to the hull, MAN Diesel recommend a minimum tip clearance as shown in Fig. 5.18.04.

For ships with slender aft body and favourable inflow conditions the lower values can be used, whereas full afterbody and large variations in wake field cause the upper values to be used.

In twin-screw ships the blade tip may protrude below the base line.



178 22 37-2.0

Hub	Dismant-ling of cap X mm	High skew propeller Y mm	Non-skew propeller Y mm	Baseline clearance Z mm
VBS 1280	390	15-20% of D	20-25% of D	Min. 50-100
VBS 1380	420			
VBS 1460	450			
VBS 1560	480			

178 48 58-9.0

Fig. 5.18.04: Propeller clearance

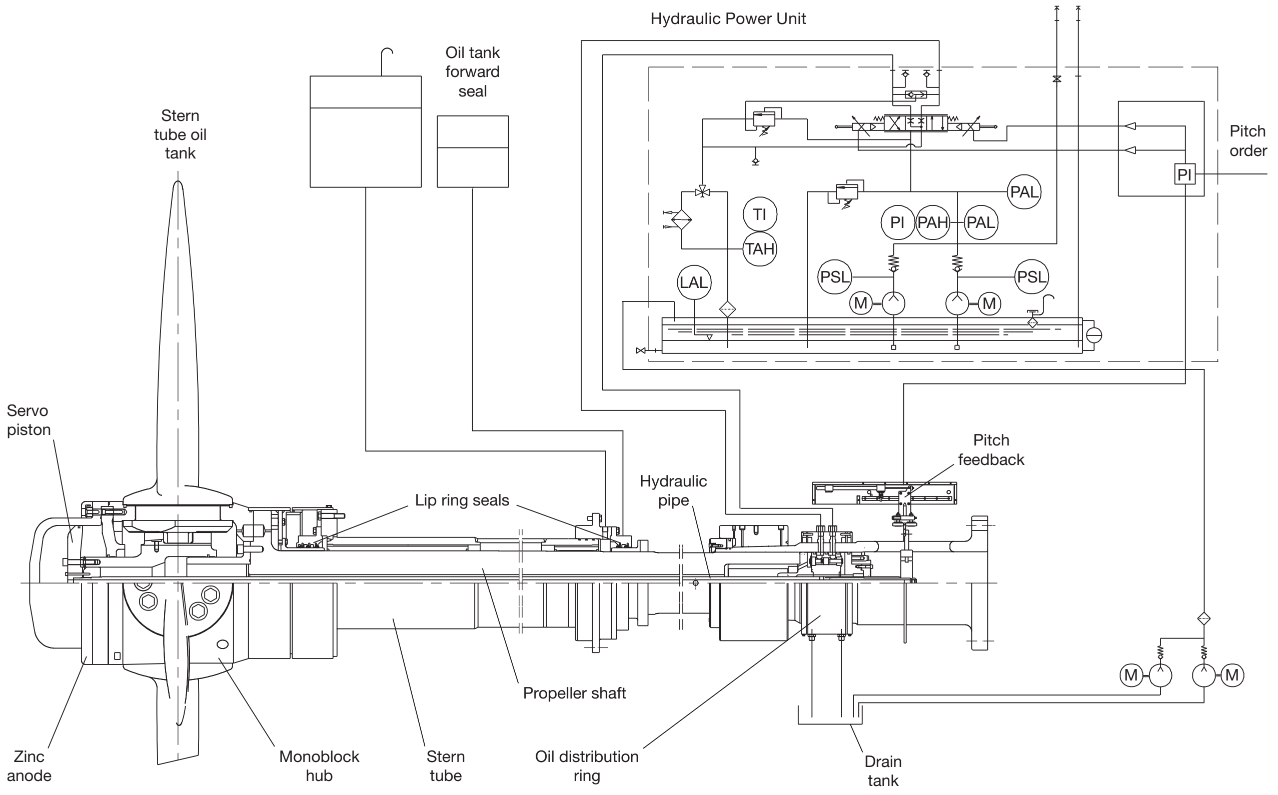


Fig. 5.18.05: Servo oil system for VBS propeller equipment

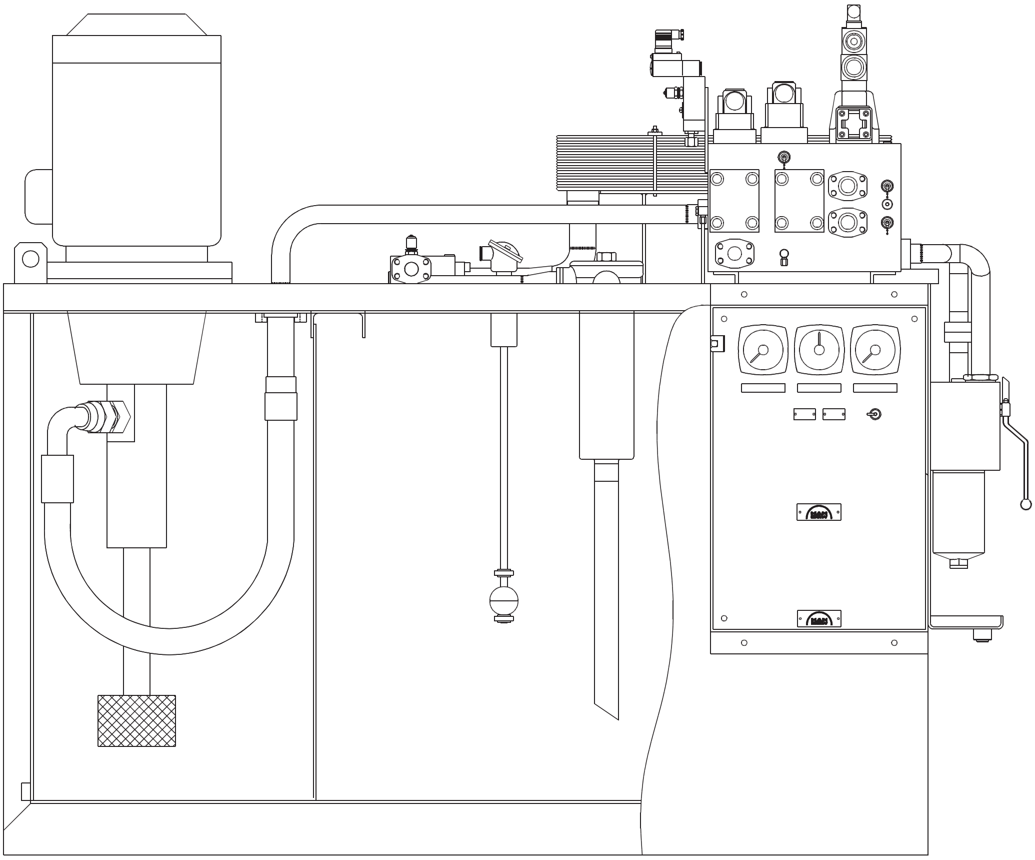
Servo Oil System

The principle design of the servo oil system for VBS is shown in Fig. 5.18.05.

The VBS system consists of a servo oil tank unit, the Hydraulic Power Unit, and a coupling flange with electrical pitch feedback box and oil distributor ring.

The electrical pitch feedback box continuously measures the position of the pitch feedback ring and compares this signal with the pitch order signal. If deviation occurs, a proportional valve is actuated.

Hereby high pressure oil is fed to one or the other side of the servo piston, via the oil distributor ring, until the desired propeller pitch has been reached. The pitch setting is normally remote controlled, but local emergency control is possible.



178 22 39-6.0

Fig. 5.18.06: Hydraulic Power Unit – Servo oil tank unit

Hydraulic Power Unit

The servo oil tank unit, the Hydraulic Power Unit Fig. 5.18.06, consists of an oil tank with all other components top mounted, to facilitate installation at yard.

Two electrically driven pumps draw oil from the oil tank through a suction filter and deliver high pressure oil to the proportional valve.

One of two pumps are in service during normal operation, while the second will start up at powerful manoeuvring.

A servo oil pressure adjusting valve ensures minimum servo oil pressure at any time hereby minimizing the electrical power consumption.

Maximum system pressure is set on the safety valve.

The return oil is led back to the tank via a thermostatic valve, cooler and paper filter.

The servo oil unit is equipped with alarms according to the Classification Society as well as necessary pressure and temperature indicators.

If the servo oil unit cannot be located with maximum oil level below the oil distribution ring, the system must incorporate an extra, small drain tank complete with pump, located at a suitable level, below the oil distributor ring drain lines.

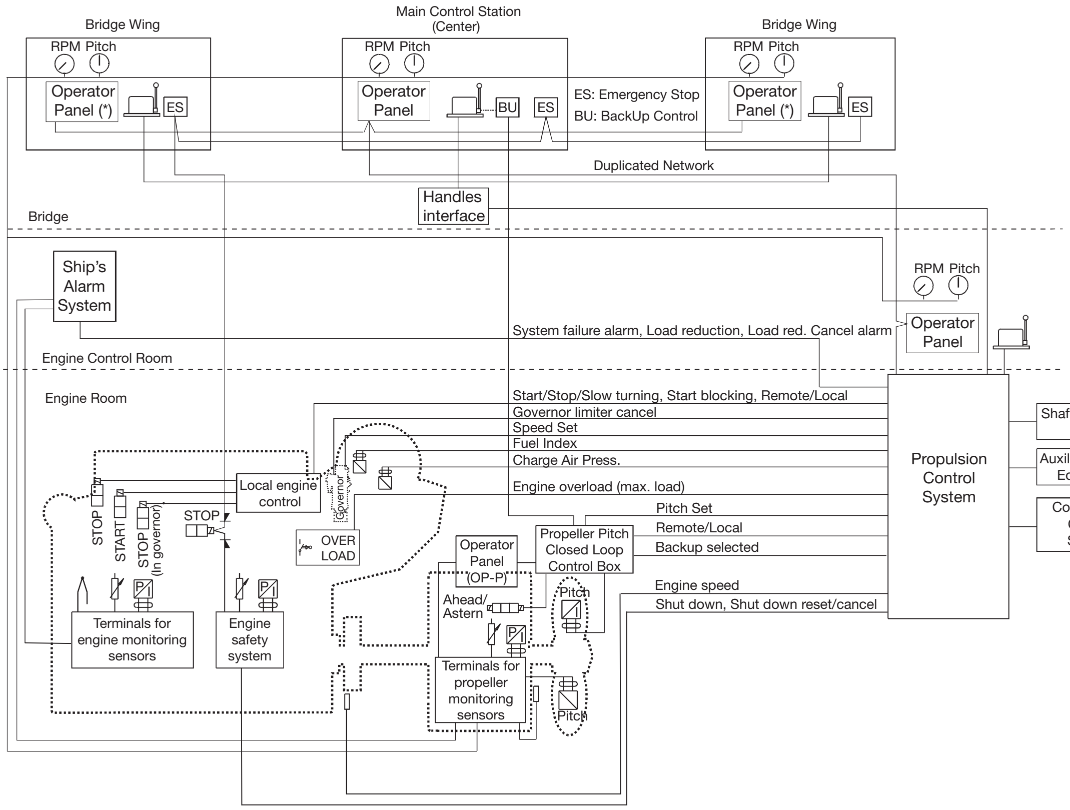


Fig. 5.18.07: Remote control system - Alphatronic 2000

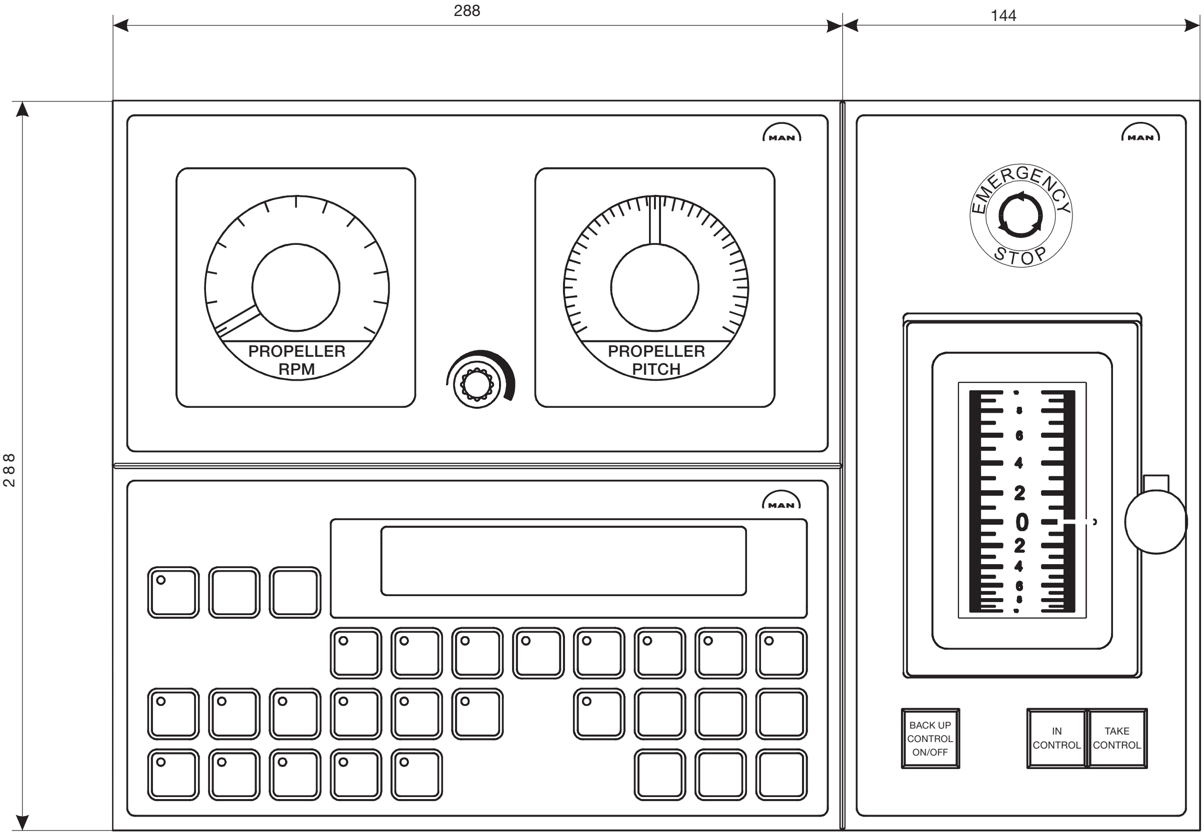
Remote Control System

The Alphatronic 2000 remote control system is designed for control of propulsion plants based on diesel engines with CP propellers. The plant configuration could for instance include tunnel gear with PTO/PTI, PTO gear, multiple engines on one gearbox as well as multiple propeller plants.

As shown on fig. 5.18.07, the propulsion remote control system comprises a computer controlled system with interconnections between control stations via a redundant bus and a hard wired back-up control system for direct pitch control at constant shaft speed.

The computer controlled system contains functions for:

- Machinery control of engine start/stop, engine load limits and possible gear clutches.
- Thrust control with optimization of propeller pitch and shaft speed. Selection of combinator, constant speed or separate thrust mode is possible. The rates of changes are controlled to ensure smooth manoeuvres and avoidance of propeller cavitation.
- A **Load control** function protects the engine against overload. The load control function contains a scavenge air smoke limiter, a load programme for avoidance of high thermal stresses in the engine, an automatic load reduction and an engineer controlled limitation of maximum load.
- Functions for **transfer of responsibility** between the local control stand, engine control room and control locations on the bridge are incorporated in the system.



178 22 41-8.1

Fig. 5.18.08: Main bridge station standard layout

Propulsion Control Station on the Main Bridge

For remote control, a minimum of one control station located on the bridge is required.

This control station will incorporate three modules, as shown on fig. 5.18.08:

- **Propulsion control panel** with push buttons and indicators for machinery control and a display with information of condition of operation and status of system parameter.
- **Propeller monitoring panel** with back-up instruments for propeller pitch and shaft speed.
- **Thrust control panel** with control lever for thrust control, an emergency stop button and push buttons for transfer of control between control stations on the bridge.

Renk KAZ Clutch for Auxilliary Propulsion Systems

The Renk KAZ Clutch is a shaftline de-clutching device for auxilliary propulsion systems which meets the class notations for redundant propulsion.

The Renk KAZ clutch facilitates reliable and simple ‘take home’ and ‘take away’ functions in two-stroke engine plants. It is described in Section 4.04.

Further information

For further information about the MAN Diesel Controllable Pitch Propeller (CPP) and the Alphatronic 2000 Remote Control System, please refer to our publications:

CP Propeller – Product Information

Alphatronic 2000 PCS Remote Control System

The publications are available at
www.mandiesel.com under
‘Quicklinks’ → ‘Technical Papers’

List of Capacities: Pumps, Coolers & Exhaust Gas

6

Calculation of List of Capacities and Exhaust Gas Data

This chapter describes the necessary auxiliary machinery capacities to be used for a nominally rated engine. The capacities given are valid for seawater cooling system and central cooling water system, respectively. For derated engine, i.e. with a specified MCR and/or optimising point different from the nominally rated MCR point, the list of capacities will be different from the nominal capacities.

Furthermore, among others, the exhaust gas data depends on the ambient temperature conditions.

Based on examples for a derated engine, the way of how to calculate the derated capacities, freshwater production and exhaust gas amounts and temperatures will be described in details.

Nomenclature

In the following description and examples of the auxiliary machinery capacities, freshwater generator pro-

Engine ratings	Point / Index	Power	Speed
Nominal MCR point	L_1	P_{L1}	n_{L1}
Specified MCR point	M	P_M	n_M
Optimising point	O	P_O	n_O
Service point	S	P_S	n_S

Parameters			Cooler index		Flow index	
Q	=	Heat dissipation	air	scavenge air cooler	sw	seawater flow
V	=	Volume flow	lub	lube oil cooler	cw	cooling/central water flow
M	=	Mass flow	jw	jacket water cooler	exh	exhaust gas
T	=	Temperature	cent	central cooler	fw	freshwater

Fig. 6.01.02: Nomenclature of coolers and volume flows, etc.

Engine configurations related to SFOC

The engine type is available in the following two versions with respect to the efficiency of the turbocharger:

- **A) With high efficiency turbocharger:** which is the basic design and for which the lists of capacities Section 6.03 are calculated.

- **B) With conventional turbocharger,:** Which is an optional design (EoD No. 4 59 107) if a higher exhaust gas temperature is required for the exhaust gas boiler. This modification will lead to a 7-8% reduction in the exhaust gas amount and a temperature increase of about 20°C. The SFOC penalty will be 2 g/kWh. The corresponding lists of capacities are shown in Section 6.03.

List of Capacities and Cooling Water Systems

The List of Capacities contain data regarding the necessary capacities of the auxiliary machinery for the main engine only, and refer to a nominally rated engine. Complying with IMO Tier I NO_x limitations.

The heat dissipation figures include 10% extra margin for overload running except for the scavenge air cooler, which is an integrated part of the diesel engine.

Cooling Water Systems

The capacities given in the tables are based on tropical ambient reference conditions and refer to engines with high efficiency/conventional turbocharger running at nominal MCR (L_1) for:

- **Seawater cooling system,** See diagram, Fig. 6.02.01 and nominal capacities in Fig. 6.03.01
- **Central cooling water system,** See diagram, Fig. 6.02.02 and nominal capacities in Fig. 6.03.01

The capacities for the starting air receivers and the compressors are stated in Fig. 6.03.01.

Heat radiation and air consumption

The radiation and convection heat losses to the engine room is around 1% of the engine nominal power (kW in L_1).

The air consumption is approximately 98.2% of the calculated exhaust gas amount, ie. $M_{air} = M_{exh} \times 0.982$.

Flanges on engine, etc.

The location of the flanges on the engine are shown in: 'Engine pipe connections', and the flanges are identified by reference letters stated in the 'List of flanges'; both can be found in Chapter 5.

The diagrams use the 'Basic symbols for piping', whereas the symbols for instrumentation according to 'ISO 1219-1' and 'ISO 1219-2' and the instrumentation list found in Appendix A.

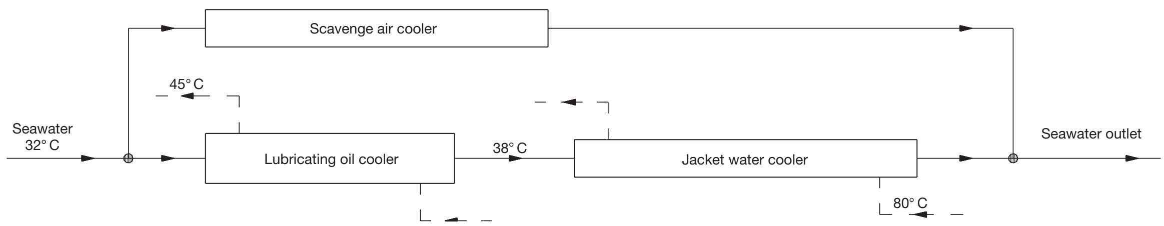


Fig. 6.02.01: Diagram for seawater cooling system

178 11 26-4.1

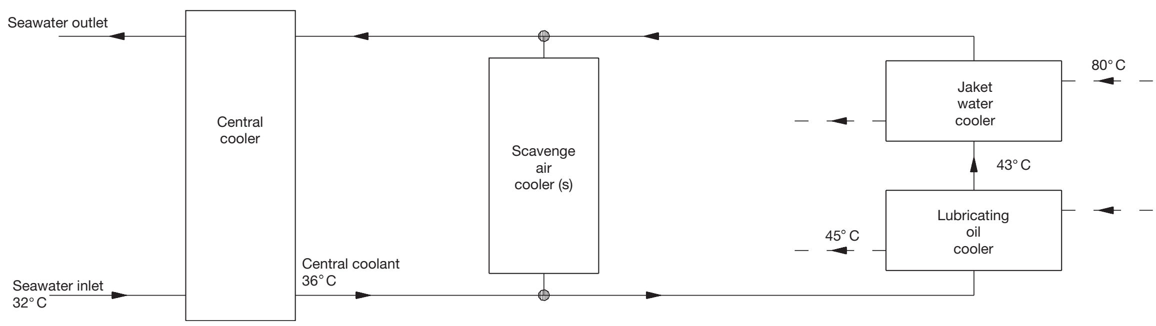


Fig. 6.02.02: Diagram for central cooling water system

178 11 27-6.1

List of Capacities for 5S50MC6 at NMCR - IMO NO_x Tier I compliance

		Seawater cooling						Central cooling					
		Conventional TC			High eff. TC			Conventional TC			High eff. TC		
		1 x TCA55-20	1 x TPL73-B12	1 x MET53MA	1 x TCA55-20	1 x TPL73-B12	1 x MET53MA	1 x TCA55-20	1 x TPL73-B12	1 x MET53MA	1 x TCA55-20	1 x TPL73-B12	1 x MET53MA
Pumps													
Fuel oil circulation	m³/h	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
Fuel oil supply	m³/h	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Jacket cooling	m³/h	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0
Seawater cooling *	m³/h	210.0	210.0	210.0	245.0	245.0	245.0	210.0	210.0	210.0	220.0	220.0	215.0
Main lubrication oil *	m³/h	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0
Central cooling *	m³/h	-	-	-	-	-	-	180	180	180	190	190	190
Scavenge air cooler(s)													
Heat diss. app.	kW	2,670	2,670	2,670	2,800	2,800	2,800	2,650	2,650	2,650	2,780	2,780	2,780
Central water flow	m³/h	-	-	-	-	-	-	100	100	100	110	110	110
Seawater flow	m³/h	130	130	130	165	165	165	-	-	-	-	-	-
Lubricating oil cooler													
Heat diss. app. *	kW	590	590	580	590	590	580	590	590	580	590	590	580
Lube oil flow *	m³/h	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0
Central water flow	m³/h	-	-	-	-	-	-	80	80	80	80	80	80
Seawater flow	m³/h	80	80	80	80	80	80	-	-	-	-	-	-
Jacket water cooler													
Heat diss. app.	kW	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050
Jacket water flow	m³/h	55	55	55	55	55	55	55	55	55	55	55	55
Central water flow	m³/h	-	-	-	-	-	-	80	80	80	80	80	80
Seawater flow	m³/h	80	80	80	80	80	80	-	-	-	-	-	-
Central cooler													
Heat diss. app. *	kW	-	-	-	-	-	-	4,290	4,290	4,280	4,420	4,420	4,410
Central water flow	m³/h	-	-	-	-	-	-	180	180	180	190	190	190
Seawater flow	m³/h	-	-	-	-	-	-	210	210	210	220	220	215
Starting air system, 30.0 bar g, 12 starts. Fixed pitch propeller - reversible engine													
Receiver volume	m³	2 x 4.0	2 x 4.0	2 x 4.0	2 x 4.0	2 x 4.0	2 x 4.0	2 x 4.0	2 x 4.0	2 x 4.0	2 x 4.0	2 x 4.0	2 x 4.0
Compressor cap.	m³	240	240	240	240	240	240	240	240	240	240	240	240
Starting air system, 30.0 bar g, 6 starts. Controllable pitch propeller - non-reversible engine													
Receiver volume	m³	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5
Compressor cap.	m³	150	150	150	150	150	150	150	150	150	150	150	150
Other values													
Fuel oil heater	kW	115	115	115	115	115	115	115	115	115	115	115	115
Exh. gas temp.	°C	265	265	265	245	245	245	265	265	265	245	245	245
Exh. gas amount	kg/h	62,000	62,000	62,000	67,000	67,000	67,000	62,000	62,000	62,000	67,000	67,000	67,000
Air consumption	kg/h	16.9	16.9	16.9	18.3	18.3	18.3	16.9	16.9	16.9	18.3	18.3	18.3

* For main engine arrangements with built-on power take-off (PTO) of a MAN Diesel recommended type and/or torsional vibration damper the engine's capacities must be increased by those stated for the actual system

For List of Capacities for derated engines and performance data at part load please visit http://www.manbw.dk/ceas/erd/

Table 6.03.01e: Capacities for seawater and central systems as well as conventional and high efficiency turbochargers stated at NMCR

List of Capacities for 6S50MC6 at NMCR - IMO NO_x Tier I compliance

		Seawater cooling						Central cooling					
		Conventional TC			High eff. TC			Conventional TC			High eff. TC		
		1 x TCA66-20	1 x TPL73-B12/CL	1 x MET53MA	1 x TCA66-20	1 x TPL77-B11	1 x MET60MA	1 x TCA66-20	1 x TPL73-B12/CL	1 x MET53MA	1 x TCA66-20	1 x TPL77-B11	1 x MET60MA
Pumps													
Fuel oil circulation	m³/h	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Fuel oil supply	m³/h	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Jacket cooling	m³/h	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0
Seawater cooling *	m³/h	255.0	250.0	250.0	290.0	295.0	290.0	255.0	250.0	250.0	260.0	260.0	260.0
Main lubrication oil *	m³/h	190.0	185.0	185.0	190.0	190.0	190.0	190.0	185.0	185.0	190.0	190.0	190.0
Central cooling *	m³/h	-	-	-	-	-	-	215	215	215	220	220	220
Scavenge air cooler(s)													
Heat diss. app.	kW	3,200	3,200	3,200	3,360	3,360	3,360	3,180	3,180	3,180	3,340	3,340	3,340
Central water flow	m³/h	-	-	-	-	-	-	120	120	120	125	125	125
Seawater flow	m³/h	156	156	156	195	195	195	-	-	-	-	-	-
Lubricating oil cooler													
Heat diss. app. *	kW	710	690	680	710	720	690	710	690	680	710	720	690
Lube oil flow *	m³/h	190.0	185.0	185.0	190.0	190.0	190.0	190.0	185.0	185.0	190.0	190.0	190.0
Central water flow	m³/h	-	-	-	-	-	-	95	95	95	95	95	95
Seawater flow	m³/h	99	94	94	95	100	95	-	-	-	-	-	-
Jacket water cooler													
Heat diss. app.	kW	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250
Jacket water flow	m³/h	66	66	66	66	66	66	66	66	66	66	66	66
Central water flow	m³/h	-	-	-	-	-	-	95	95	95	95	95	95
Seawater flow	m³/h	99	94	94	95	100	95	-	-	-	-	-	-
Central cooler													
Heat diss. app. *	kW	-	-	-	-	-	-	5,140	5,120	5,110	5,300	5,310	5,280
Central water flow	m³/h	-	-	-	-	-	-	215	215	215	220	220	220
Seawater flow	m³/h	-	-	-	-	-	-	255	250	250	260	260	260
Starting air system, 30.0 bar g, 12 starts. Fixed pitch propeller - reversible engine													
Receiver volume	m³	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5
Compressor cap.	m³	270	270	270	270	270	270	270	270	270	270	270	270
Starting air system, 30.0 bar g, 6 starts. Controllable pitch propeller - non-reversible engine													
Receiver volume	m³	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5
Compressor cap.	m³	150	150	150	150	150	150	150	150	150	150	150	150
Other values													
Fuel oil heater	kW	140	140	140	140	140	140	140	140	140	140	140	140
Exh. gas temp.	°C	265	265	265	245	245	245	265	265	265	245	245	245
Exh. gas amount	kg/h	74,400	74,400	74,400	80,400	80,400	80,400	74,400	74,400	74,400	80,400	80,400	80,400
Air consumption	kg/h	20.3	20.3	20.3	21.9	21.9	21.9	20.3	20.3	20.3	21.9	21.9	21.9

* For main engine arrangements with built-on power take-off (PTO) of a MAN Diesel recommended type and/or torsional vibration damper the engine's capacities must be increased by those stated for the actual system

For List of Capacities for derated engines and performance data at part load please visit http://www.manbw.dk/ceas/erd/

Table 6.03.01f: Capacities for seawater and central systems as well as conventional and high efficiency turbochargers stated at NMCR

List of Capacities for 7S50MC6 at NMCR - IMO NO_x Tier I compliance

		Seawater cooling						Central cooling					
		Conventional TC			High eff. TC			Conventional TC			High eff. TC		
		1 x TCA66-20	1 x TPL77-B12	1 x MET60MA	1 x TCA66-20	1 x TPL77-B12	1 x MET60MA	1 x TCA66-20	1 x TPL77-B12	1 x MET60MA	1 x TCA66-20	1 x TPL77-B12	1 x MET60MA
Pumps													
Fuel oil circulation	m³/h	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Fuel oil supply	m³/h	2.6	2.6	2.6	2.5	2.5	2.5	2.6	2.6	2.6	2.5	2.5	2.5
Jacket cooling	m³/h	77.0	77.0	77.0	77.0	77.0	77.0	77.0	77.0	77.0	77.0	77.0	77.0
Seawater cooling *	m³/h	295.0	295.0	295.0	380.0	385.0	380.0	295.0	295.0	295.0	305.0	305.0	305.0
Main lubrication oil *	m³/h	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0
Central cooling *	m³/h	-	-	-	-	-	-	250	250	250	275	275	275
Scavenge air cooler(s)													
Heat diss. app.	kW	3,730	3,730	3,730	3,930	3,930	3,930	3,710	3,710	3,710	3,900	3,900	3,900
Central water flow	m³/h	-	-	-	-	-	-	140	140	140	165	165	165
Seawater flow	m³/h	182	182	182	270	270	270	-	-	-	-	-	-
Lubricating oil cooler													
Heat diss. app. *	kW	810	820	790	810	820	790	810	820	790	810	820	790
Lube oil flow *	m³/h	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0
Central water flow	m³/h	-	-	-	-	-	-	110	110	110	110	110	110
Seawater flow	m³/h	113	113	113	110	115	110	-	-	-	-	-	-
Jacket water cooler													
Heat diss. app.	kW	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460
Jacket water flow	m³/h	77	77	77	77	77	77	77	77	77	77	77	77
Central water flow	m³/h	-	-	-	-	-	-	110	110	110	110	110	110
Seawater flow	m³/h	113	113	113	110	115	110	-	-	-	-	-	-
Central cooler													
Heat diss. app. *	kW	-	-	-	-	-	-	5,980	5,990	5,960	6,170	6,180	6,150
Central water flow	m³/h	-	-	-	-	-	-	250	250	250	275	275	275
Seawater flow	m³/h	-	-	-	-	-	-	295	295	295	305	305	305
Starting air system, 30.0 bar g, 12 starts. Fixed pitch propeller - reversible engine													
Receiver volume	m³	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5
Compressor cap.	m³	270	270	270	270	270	270	270	270	270	270	270	270
Starting air system, 30.0 bar g, 6 starts. Controllable pitch propeller - non-reversible engine													
Receiver volume	m³	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5
Compressor cap.	m³	150	150	150	150	150	150	150	150	150	150	150	150
Other values													
Fuel oil heater	kW	165	165	165	165	165	165	165	165	165	165	165	165
Exh. gas temp.	°C	265	265	265	245	245	245	265	265	265	245	245	245
Exh. gas amount	kg/h	86,800	86,800	86,800	93,800	93,800	93,800	86,800	86,800	86,800	93,800	93,800	93,800
Air consumption	kg/h	23.6	23.6	23.6	25.6	25.6	25.6	23.6	23.6	23.6	25.6	25.6	25.6

* For main engine arrangements with built-on power take-off (PTO) of a MAN Diesel recommended type and/or torsional vibration damper the engine's capacities must be increased by those stated for the actual system

For List of Capacities for derated engines and performance data at part load please visit http://www.manbw.dk/ceas/erd/

Table 6.03.01g: Capacities for seawater and central systems as well as conventional and high efficiency turbochargers stated at NMCR

List of Capacities for 8S50MC6 at NMCR - IMO NO_x Tier I compliance

		Seawater cooling						Central cooling					
		Conventional TC			High eff. TC			Conventional TC			High eff. TC		
		1 x TCA66-20	1 x TPL77-B12	1 x MET60MA	1 x TCA77-20	1 x TPL77-B12/CL	1 x MET66MA	1 x TCA66-20	1 x TPL77-B12	1 x MET60MA	1 x TCA77-20	1 x TPL77-B12/CL	1 x MET66MA
Pumps													
Fuel oil circulation	m³/h	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Fuel oil supply	m³/h	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Jacket cooling	m³/h	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0
Seawater cooling *	m³/h	335.0	335.0	335.0	390.0	390.0	390.0	335.0	335.0	335.0	345.0	345.0	345.0
Main lubrication oil *	m³/h	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0
Central cooling *	m³/h	-	-	-	-	-	-	285	285	285	280	280	280
Scavenge air cooler(s)													
Heat diss. app.	kW	4,270	4,270	4,270	4,480	4,480	4,480	4,240	4,240	4,240	4,450	4,450	4,450
Central water flow	m³/h	-	-	-	-	-	-	160	160	160	155	155	155
Seawater flow	m³/h	208	208	208	260	260	260	-	-	-	-	-	-
Lubricating oil cooler													
Heat diss. app. *	kW	910	920	890	930	920	920	910	920	890	930	920	920
Lube oil flow *	m³/h	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0
Central water flow	m³/h	-	-	-	-	-	-	125	125	125	125	125	125
Seawater flow	m³/h	127	127	127	130	130	130	-	-	-	-	-	-
Jacket water cooler													
Heat diss. app.	kW	1,670	1,670	1,670	1,670	1,670	1,670	1,670	1,670	1,670	1,670	1,670	1,670
Jacket water flow	m³/h	87	87	87	87	87	87	87	87	87	87	87	87
Central water flow	m³/h	-	-	-	-	-	-	125	125	125	125	125	125
Seawater flow	m³/h	127	127	127	130	130	130	-	-	-	-	-	-
Central cooler													
Heat diss. app. *	kW	-	-	-	-	-	-	6,820	6,830	6,800	7,050	7,040	7,040
Central water flow	m³/h	-	-	-	-	-	-	285	285	285	280	280	280
Seawater flow	m³/h	-	-	-	-	-	-	335	335	335	345	345	345
Starting air system, 30.0 bar g, 12 starts. Fixed pitch propeller - reversible engine													
Receiver volume	m³	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5	2 x 4.5
Compressor cap.	m³	270	270	270	270	270	270	270	270	270	270	270	270
Starting air system, 30.0 bar g, 6 starts. Controllable pitch propeller - non-reversible engine													
Receiver volume	m³	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5
Compressor cap.	m³	150	150	150	150	150	150	150	150	150	150	150	150
Other values													
Fuel oil heater	kW	185	185	185	185	185	185	185	185	185	185	185	185
Exh. gas temp.	°C	265	265	265	245	245	245	265	265	265	245	245	245
Exh. gas amount	kg/h	99,200	99,200	99,200	107,200	107,200	107,200	99,200	99,200	99,200	107,200	107,200	107,200
Air consumption	kg/h	27.0	27.0	27.0	29.2	29.2	29.2	27.0	27.0	27.0	29.2	29.2	29.2

* For main engine arrangements with built-on power take-off (PTO) of a MAN Diesel recommended type and/or torsional vibration damper the engine's capacities must be increased by those stated for the actual system

For List of Capacities for derated engines and performance data at part load please visit http://www.manbw.dk/ceas/erd/

Table 6.03.01h: Capacities for seawater and central systems as well as conventional and high efficiency turbochargers stated at NMCR

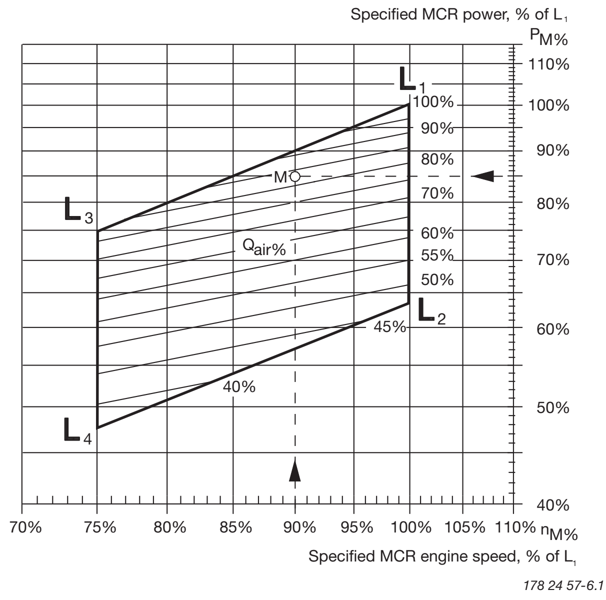
Auxiliary Machinery Capacities

The dimensioning of heat exchangers (coolers) and pumps for derated engines can be calculated on the basis of the heat dissipation values found by using the following description and diagrams. Those for the nominal MCR (L_1), may also be used if wanted.

The nomenclature of the basic engine ratings and coolers, etc. used in this section is shown in Fig. 6.01.01 and 6.01.02.

Cooler heat dissipations

For the specified MCR (M) the following three diagrams in Figs. 6.04.01, 6.04.02 and 6.04.03 show reduction factors for the corresponding heat dissipations for the coolers, relative to the values stated in the 'List of Capacities' valid for nominal MCR (L_1).



$$Q_{air\%} = 100 \times (P_M/P_{L1})^{1.68} \times (n_M/n_{L1})^{-0.83} \times k_O$$

$$k_O = 1 + 0.27 \times (1 - P_O/P_M)$$

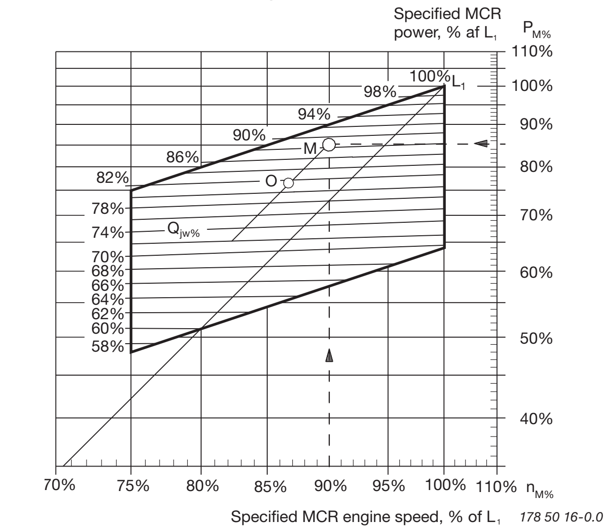
Fig. 6.04.01: Scavenge air cooler, heat dissipation $Q_{air\%}$ in point M, in % of the L_1 value $Q_{air, L1}$ and valid for $P_O = P_M$. If optimising point O lower than M, an extra correction k_O is used

The percentage power ($P_{M\%}$) and speed ($n_{M\%}$) of L_1

ie: $P_{M\%} = P_M/P_{L1} \times 100\%$

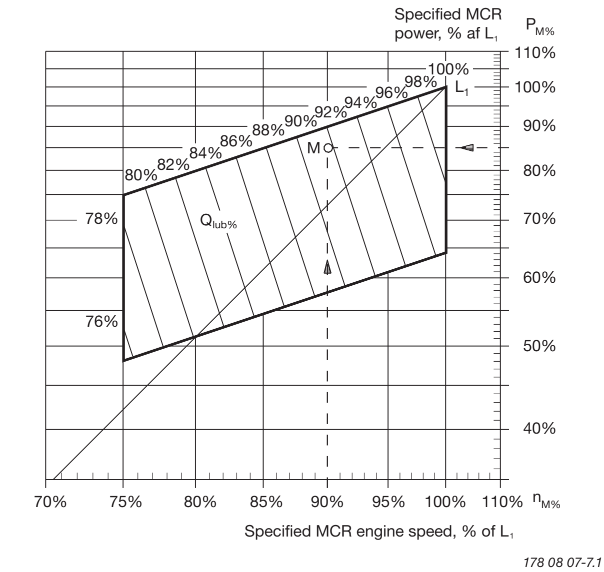
$n_{M\%} = n_M/n_{L1} \times 100\%$

for specified MCR (M) of the derated engine is used as input in the above-mentioned diagrams, giving the % heat dissipation figures relative to those in the 'List of Capacities',



$$Q_{jw\%} = e^{(-0.0811 \times \ln(n_{M\%}) + 0.8072 \times \ln(P_{M\%}) + 1.2614)}$$

Fig. 6.04.02: Jacket water cooler, heat dissipation $Q_{jw\%}$ in point M, in % of the L_1 value $Q_{jw, L1}$



$$Q_{lub\%} = 67.3009 \times \ln(n_{M\%}) + 7.6304 \times \ln(P_{M\%}) - 245.0714$$

Fig. 6.04.03: Lubricating oil cooler, heat dissipation $Q_{lub\%}$ in point M, in % of the L_1 value $Q_{lub, L1}$

The derated cooler capacities may then be found by means of following equations:

$Q_{air,\,M} \;=\; Q_{air,\,L1} \times (Q_{air\%} / 100)$
$Q_{jw,\,M} \;=\; Q_{jw,\,L1} \times (Q_{jw\%} / 100)$
$Q_{lub,\,M} \;=\; Q_{lub,\,L1} \times (Q_{lub\%} / 100)$

and for a central cooling water system the central cooler heat dissipation is:

$Q_{cent,M} = Q_{air,M} + Q_{jw,M} + Q_{lub,M}$

Pump capacities

The pump capacities given in the 'List of Capacities' refer to engines rated at nominal MCR (L_1). For lower rated engines, only a marginal saving in the pump capacities is obtainable.

To ensure proper lubrication, the lubricating oil pump must remain unchanged.

Also, the fuel oil circulating and supply pumps should remain unchanged.

In order to ensure reliable starting, the starting air compressors and the starting air receivers must also remain unchanged.

The jacket cooling water pump capacity is relatively low. Practically no saving is possible, and it is therefore unchanged.

Seawater cooling system

The derated seawater pump capacity is equal to the sum of the below found derated seawater flow capacities through the scavenge air and lube oil coolers, as these are connected in parallel.

The seawater flow capacity for each of the scavenge air, lube oil and jacket water coolers can be reduced proportionally to the reduced heat dissipations found in Figs. 6.04.01, 6.04.02 and 6.04.03, respectively i.e. as follows:

$V_{sw,air,M} \;=\; V_{sw,air,L1} \times (Q_{air\%} / 100)$
$V_{sw,lub,M} \;=\; V_{sw,lub.L1} \times Q_{lub\%} / 100)$
$V_{sw,jw,M} \;=\; V_{sw,lub,M}$

However, regarding the scavenge air cooler(s), the engine maker has to approve this reduction in order to avoid too low a water velocity in the scavenge air cooler pipes.

As the jacket water cooler is connected in series with the lube oil cooler, the seawater flow capacity for the latter is used also for the jacket water cooler.

Central cooling water system

If a central cooler is used, the above still applies, but the central cooling water capacities are used instead of the above seawater capacities. The seawater flow capacity for the central cooler can be reduced in proportion to the reduction of the total cooler heat dissipation, i.e. as follows:

$V_{cw,air,M} \;=\; V_{cw,air,L1} \times (Q_{air\%} / 100)$
$V_{cw,lub,M} \;=\; V_{cw,lub,L1} \times (Q_{lub\%} / 100)$
$V_{cw,jw,M} \;=\; V_{cw,lub,M}$
$V_{cw,cent,M} \;=\; V_{cw,air,M} + V_{cw,lub,M}$
$V_{sw,cent,M} \;=\; V_{sw,cent,L1} \times Q_{cent,M} / Q_{cent,L1}$

Pump pressures

Irrespective of the capacities selected as per the above guidelines, the below-mentioned pump heads at the mentioned maximum working temperatures for each system shall be kept:

	Pump head bar	Max. working temp. ºC
Fuel oil supply pump	4	100
Fuel oil circulating pump	6	150
Lubricating oil pump	4.1	70
Seawater pump	2.5	50
Central c ooling water pump	2.5	80
Jacket water pump	3.0	100

Flow velocities

For external pipe connections, we prescribe the following maximum velocities:

Marine diesel oil .... 1.0 m/s
Heavy fuel oil .... 0.6 m/s
Lubricating oil .... 1.8 m/s
Cooling water .... 3.0 m/s

Calculation of List of Capacities for Derated Engine

Example 1:

***Pump and cooler capacities for a** derated 6S50MC6 with high efficiency MAN Diesel turbocharger type TCA, fixed pitch propeller and central cooling water system.*

Nominal MCR, (L_1) P_{L1}: 8,580 kW (100.0%) and 127.0 r/min (100.0%)

Specified MCR, (M) P_M: 7,293 kW (85.0%) and 114.3 r/min (90.0%)

Optimising point, (O) P_O: 6,564 kW (76.5%) and 110.4 r/min (86.9%), P_O = 90.0% of P_M

The method of calculating the reduced capacities for point M ($n_{M\%}$ = 90.0% and $P_{M\%}$ = 85.0%) is shown below.

The values valid for the nominal rated engine are found in the 'List of Capacities', Figs. 6.03.01 and 6.03.02, and are listed together with the result in the figure on the next page.

Heat dissipation of scavenge air cooler
Fig. 6.04.01 which approximately indicates a $Q_{air\%}$ = 83.1% heat dissipation, and corrected for optimising point O lower than M, by applying correcting factor k_O, equal 83.1 x (1 + 0.27 x (1-0.900)) = 85.3%, i.e.:

$Q_{air,M} = Q_{air,L1} \times Q_{air\%} / 100$

$Q_{air,M} = 3{,}340 \times 0.853 = 2{,}849$ kW

Heat dissipation of jacket water cooler
Fig. 6.04.02 indicates a $Q_{jw\%}$ = 88.5% heat dissipation; i.e.:

$Q_{jw,M} = Q_{jw,L1} \times Q_{jw\%} / 100$

$Q_{jw,M} = 1{,}250 \times 0.885 = 1{,}106$ kW

Heat dissipation of lube oil cooler
Fig. 6.04.03 indicates a $Q_{lub\%}$ = 91.7% heat dissipation; i.e.:

$Q_{lub,M} = Q_{lub,\,L1} \times Q_{lub\%} / 100$

$Q_{lub,M} = 710 \times 0.917 = 651$ kW

Heat dissipation of central water cooler

$Q_{cent,M} = Q_{air,M} + Q_{jw,M} + Q_{lub,\,M}$

$Q_{cent,M} = 2{,}849 + 1{,}106 + 651 = 4{,}606$ kW

Total cooling water flow through scavenge air coolers

$V_{cw,air,M} = V_{cw,air,L1} \times Q_{air\%} / 100$

$V_{cw,air,M} = 125 \times 0.853 = 107$ m^3/h

Cooling water flow through lubricating oil cooler

$V_{cw,lub,M} = V_{cw,lub,L1} \times Q_{lub\%} / 100$

$V_{cw,lub,M} = 95 \times 0.917 = 87$ m^3/h

Cooling water flow through central cooler (Central cooling water pump)

$V_{cw,cent,M} = V_{cw,air,M} + V_{cw,lub,M}$

$V_{cw,cent,M} = 107 + 87 = 194$ m^3/h

Cooling water flow through jacket water cooler (as for lube oil cooler)

$V_{cw,jw,M} = V_{cw,lub,M}$

$V_{cw,jw,M} = 87$ m^3/h

Seawater pump for central cooler
As the seawater pump capacity and the central cooler heat dissipation for the nominal rated engine found in the 'List of Capacities' are 260 m^3/h and 5,300 kW the derated seawater pump flow equals:

Seawater pump:

$V_{sw,cent,M} = V_{sw,cent,L1} \times Q_{cent,M} / Q_{cent,L1}$

$= 260 \times 4{,}606 / 5{,}300 = 226$ m^3/h

		Nominal rated engine (L_1) High efficiency turbocharger (TCA)	Example 1 Specified MCR (M)
Shaft power at MCR		8,580 kW	7,293 kW
Engine speed at MCR		at 127.0 r/min	at 114.3 r/min
Power of optimising point %MCR		100%	90%
Pumps:			
Fuel oil circulating pump	m^3/h	5.3	5.3
Fuel oil supply pump	m^3/h	2.2	2.2
Jacket cooling water pump	m^3/h	66	66
Central cooling water pump	m^3/h	220	194
Seawater pump	m^3/h	260	226
Lubricating oil pump	m^3/h	190	190
Coolers:			
Scavenge air cooler			
Heat dissipation	kW	3,340	2,849
Central water quantity	m^3/h	125	107
Lub. oil cooler			
Heat dissipation	kW	710	651
Lubricating oil quantity	m^3/h	190	190
Central water quantity	m^3/h	95	87
Jacket water cooler			
Heat dissipation	kW	1,250	1,106
Jacket cooling water quantity	m^3/h	66	66
Central water quantity	m^3/h	95	87
Central cooler			
Heat dissipation	kW	5,300	4,606
Central water quantity	m^3/h	220	194
Seawater quantity	m^3/h	260	226
Fuel oil heater:	kW	140	140
Gases at ISO ambient conditions*			
Exhaust gas amount	kg/h	80,400	68,500
Exhaust gas temperature	°C	245	234.8
Air consumption	kg/s	21.9	18.7
Starting air system: 30 bar (gauge)			
Reversible engine			
Receiver volume (12 starts)	m^3	2 x 4.5	2 x 4.5
Compressor capacity, total	m^3/h	270	270
Non-reversible engine			
Receiver volume (6 starts)	m^3	2 x 2.5	2 x 2.5
Compressor capacity, total	m^3/h	150	150

The air consumption and exhaust gas figures are expected and refer to 100% specified MCR, ISO ambient reference conditions and the exhaust gas back pressure 300 mm WC
The exhaust gas temperatures refer to after turbocharger
* Calculated in example 3, in this chapter

Example 1 – Capacities of derated 6S50MC6 with high efficiency MAN Diesel turbocharger type TCA and central cooling water system.

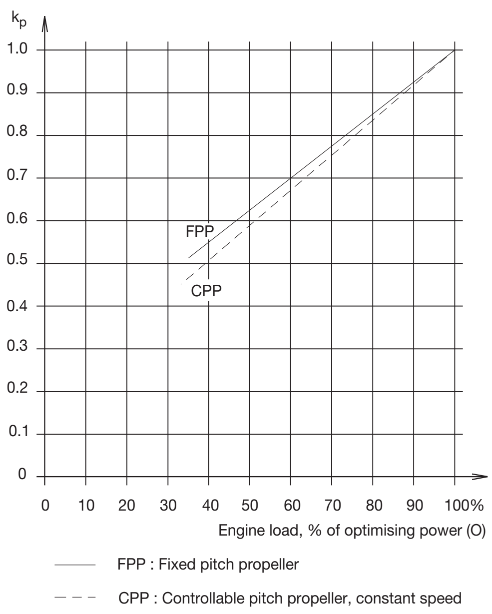
Freshwater Generator

If a freshwater generator is installed and is utilising the heat in the jacket water cooling system, it should be noted that the actual available heat in the jacket cooling water system is **lower** than indicated by the heat dissipation figures valid for nominal MCR (L_1) given in the List of Capacities. This is because the latter figures are used for dimensioning the jacket water cooler and hence incorporate a safety margin which can be needed when the engine is operating under conditions such as, e.g. overload. Normally, this margin is 10% at nominal MCR.

Calculation Method

For a derated diesel engine, i.e. an engine having a specified MCR (M) and/or a optimising point (O) different from L_1, the relative jacket water heat dissipation for point M and O may be found, as previously described, by means of Fig. 6.04.02.

Part load correction factor for jacket cooling water heat dissipation



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$$\text{FPP}: k_p = 0.742 \times \frac{P_S}{P_O} + 0.258$$

$$\text{CPP}: k_p = 0.822 \times \frac{P_S}{P_O} + 0.178$$

Fig. 6.04.04: Correction factor 'kp' for jacket cooling water heat dissipation at part load, relative to heat dissipation at optimising power

At part load operation, lower than optimising power, the actual jacket water heat dissipation will be reduced according to the curves for fixed pitch propeller (FPP) or for constant speed, controllable pitch propeller (CPP), respectively, in Fig. 6.04.04.

With reference to the above, the heat actually available for a derated diesel engine may then be found as follows:

1. Engine power between optimising and specified power.

   For powers between specified MCR (M) and optimising power (O), the diagram Fig. 6.04.02 is to be used, i.e. giving the percentage correction factor '$Q_{jw\%}$' and hence for optimising power P_O:

   $$Q_{jw,O} = Q_{jw,L1} \times \frac{Q_{jw\%}}{100} \times 0.9 \ (0.88) \qquad [1]$$

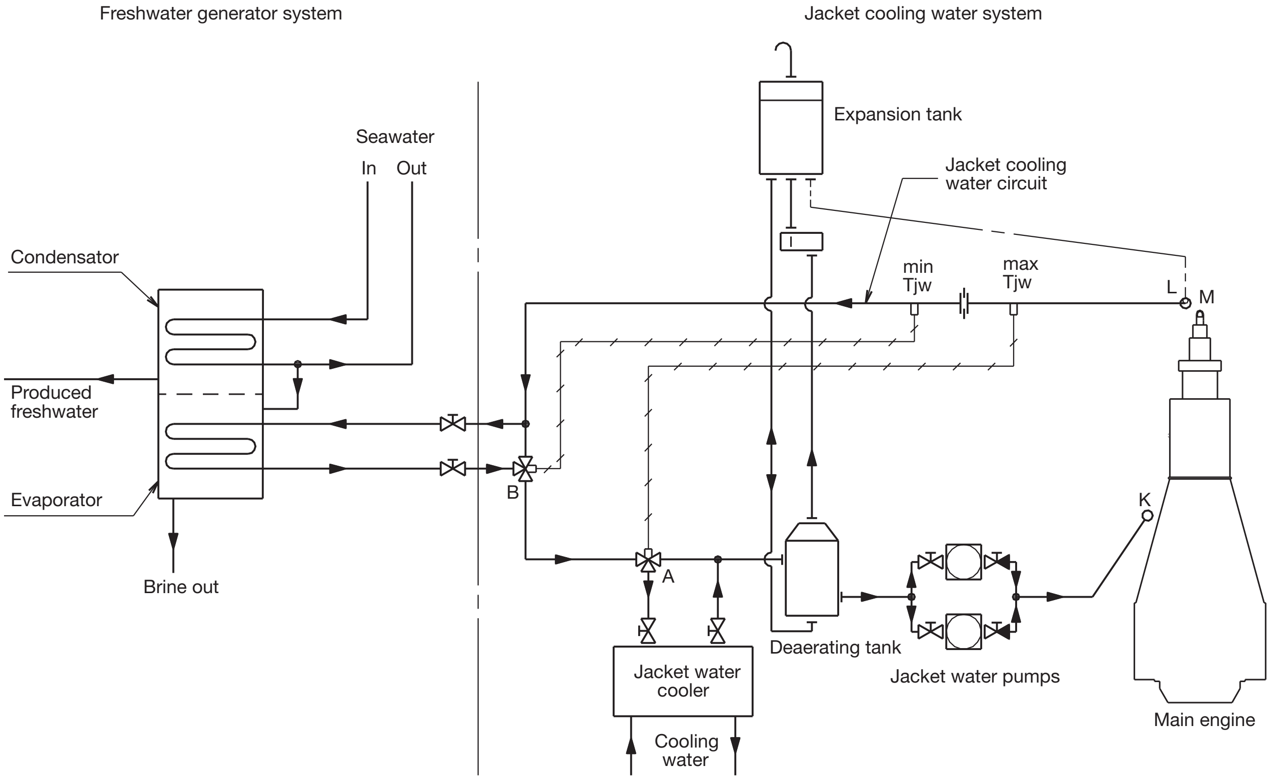
2. Engine power lower than optimising power.

   For powers lower than the optimising power, the value $Q_{jw,O}$ found for point O by means of the above equation [1] is to be multiplied by the correction factor k_p found in Fig. 6.04.04 and hence

   $$Q_{jw} = Q_{jw,O} \times k_p \ \text{-15\%/0\%} \qquad [2]$$

where
Q_{jw} = jacket water heat dissipation
$Q_{jw,L1}$ = jacket water heat dissipation at nominal MCR (L_1)
$Q_{jw\%}$ = percentage correction factor from Fig. 6.04.02
$Q_{jw,O}$ = jacket water heat dissipation at optimising power (O), found by means of equation [1]
k_p = part load correction factor from Fig. 6.04.04
0.9 = factor for safety margin of cooler, tropical ambient conditions

The heat dissipation is assumed to be more or less independent of the ambient temperature conditions, yet the safety margin/ambient condition factor of about 0.88 instead of 0.90 will be more accurate for ambient conditions corresponding to ISO temperatures or lower. The heat dissipation tolerance from -15% to 0% stated above is based on experience.



Valve A: ensures that T_{jw} < 85° C
Valve B: ensures that T_{jw} > 85 – 5° C = 80° C
Valve B and the corresponding by-pass may be omitted if, for example, the freshwater generator is equipped with an automatic start/stop function for too low jacket cooling water temperature
If necessary, all the actually available jacket cooling water heat may be utilised provided that a special temperature control system ensures that the jacket cooling water temperature at the outlet from the engine does not fall below a certain level

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Fig. 6.04.05: Freshwater generators. Jacket cooling water heat recovery flow diagram

Jacket Cooling Water Temperature Control

When using a normal freshwater generator of the single-effect vacuum evaporator type, the freshwater production may, for guidance, be estimated as 0.03 t/24h per 1 kW heat, i.e.:

M_{fw} = 0.03 x Q_{jw} t/24h -15%/0% [3]

where

M_{fw} is the freshwater production in tons per 24 hours

and

Q_{jw} is to be stated in kW

If necessary, all the actually available jacket cooling water heat may be used provided that a special temperature control system ensures that the jacket cooling water temperature at the outlet from the engine does not fall below a certain level. Such a temperature control system may consist, e.g., of a special by-pass pipe installed in the jacket cooling water system, see Fig. 6.04.05, or a special built-in temperature control in the freshwater generator, e.g., an automatic start/stop function, or similar.

If such a special temperature control is not applied, we recommend limiting the heat utilised to maximum 50% of the heat actually available at specified MCR, and only using the freshwater generator at engine loads above 50%. Considering the cooler margin of 10% and the minus tolerance of -15%, this heat corresponds to 50 x(1.00-0.15)x0.9 = 38% of the jacket water cooler capacity $Q_{jw,M}$ used for dimensioning of the jacket water cooler.

Calculation of Freshwater Production for Derated Engine

Example 2:

Freshwater production *from a derated 6S50MC6 with high efficiency MAN Diesel turbocharger TCA and fixed pitch propeller.*

Based on the engine ratings below, this example will show how to calculate the expected available jacket cooling water heat removed from the diesel engine, together with the corresponding freshwater production from a freshwater generator.

The calculation is made for the service rating (S) of the diesel engine being 80% of the specified MCR.

Nominal MCR, (L_1) P_{L1}: 8,580 kW (100.0%) and 127.0 r/min (100.0%)

Specified MCR, (M) P_M: 7,293 kW (85.0%) and 114.3 r/min (90.0%)

Optimising point, (O) P_O: 6,564 kW (76.5%) and 110.4 r/min (86.9%), P_O = 90.0% of P_M

Service rating, (S) P_S: 5,834 kW and 106.1 r/min, P_S = 80.0% of P_M and P_S = 88.9% of P_O

Ambient reference conditions: 20° C air and 18° C cooling water.

The expected available jacket cooling water heat at service rating is found as follows:

$Q_{jw,L1}$ = 1,250 kW from List of Capacities
$Q_{jw\%}$ = 81.5% using 76.5% power and 86.9% speed for O in Fig. 6.04.02

By means of equation [1], and using factor 0.88 for actual ambient condition the heat dissipation in the optimising point (O) is found:

$$Q_{jw,O} = Q_{jw,L1} \times \frac{Q_{jw\%}}{100} \times 0.88$$

$$= 1{,}250 \times \frac{81.5}{100} \times 0.88 = 897 \text{ kW}$$

By means of equation [2], the heat dissipation in the service point (S) i.e. for 88.9% of optimising power, is found:

k_p = 0.918 using 88.9% in Fig. 6.04.04
Q_{jw} = $Q_{jw,O} \times k_p$ = 897 x 0.918 = 823 kW
-15%/0%

For the service point the corresponding expected obtainable freshwater production from a freshwater generator of the single effect vacuum evaporator type is then found from equation [3]:

M_{fw} = 0.03 x Q_{jw} = 0.03 x 823 = 24.7 t/24h
-15%/0%

Exhaust Gas Amount and Temperature

Influencing factors

The exhaust gas data to be expected in practice depends, primarily, on the following three factors:

a) The specified MCR point of the engine (point M):

P_M : power in kW at SMCR point
n_M : speed in r/min at SMCR point

and to a certain degree on the optimising point O with the percentage power $P_{O\%}$ = % of SMCR power:

$P_{O\%} = (P_O/P_M) \times 100\%$

b) The ambient conditions, and exhaust gas back-pressure:

T_{air} : actual ambient air temperature, in °C
p_{bar} : actual barometric pressure, in mbar
T_{CW} : actual scavenge air coolant temperature, in °C
Δp_M : exhaust gas back-pressure in mm WC at specified MCR

c) The continuous service rating of the engine (point S), valid for fixed pitch propeller or controllable pitch propeller (constant engine speed):

P_S : continuous service rating of engine, in kW

Calculation Method

To enable the project engineer to estimate the actual exhaust gas data at an arbitrary service rating, the following method of calculation may be used.

The partial calculations based on the above influencing factors have been summarised in equations [4] and [5].

M_{exh} : exhaust gas amount in kg/h, to be found
T_{exh} : exhaust gas temperature in °C, to be found

$$M_{exh} = M_{L1} \times \frac{P_M}{P_{L1}} \times \left\{1 + \frac{\Delta m_{M\%}}{100}\right\} \times \left\{1 + \frac{\Delta M_{amb\%}}{100}\right\} \times \left\{1 + \frac{\Delta m_{s\%}}{100}\right\} \times \frac{P_{S\%}}{100} \quad \text{kg/h} \quad +/-5\% \quad [4]$$

$$T_{exh} = T_{L1} + \Delta T_M + \Delta T_O + \Delta T_{amb} + \Delta T_S \quad °C \quad -/+15\ °C \quad [5]$$

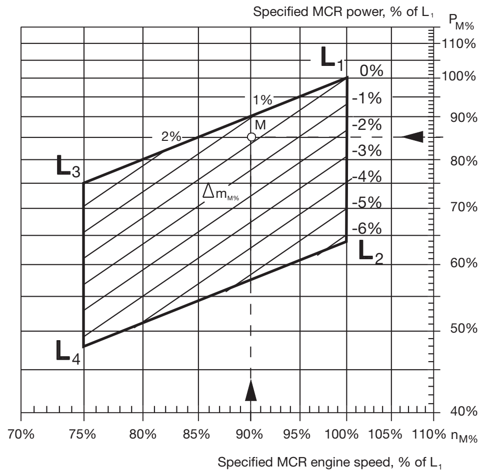
where, according to ‘List of capacities’, i.e. referring to ISO ambient conditions and 300 mm WC back-pressure and specified/optimised in L_1:
M_{L1}: exhaust gas amount in kg/h at nominal MCR (L_1)
T_{L1}: exhaust gas temperature after turbocharger in °C at nominal MCR (L_1)

Fig. 6.04.06: Summarising equations for exhaust gas amounts and temperatures

The partial calculations based on the influencing factors are described in the following:

a) *Correction for choice of specified MCR point*

When choosing a specified MCR point ‘M’ other than the nominal MCR point ‘L_1’, the resulting changes in specific exhaust gas amount and temperature are found by using as input in diagrams the corresponding percentage values (of L_1) for specified MCR power $P_{M\%}$ and speed $n_{M\%}$:
$P_{M\%} = P_M/P_{L1} \times 100\%$
$n_{M\%} = n_M/n_{L1} \times 100\%$



$\Delta m_{M\%}$ = 14 x ln (P_M/P_{L1}) – 24 x ln (n_M/n_{L1})

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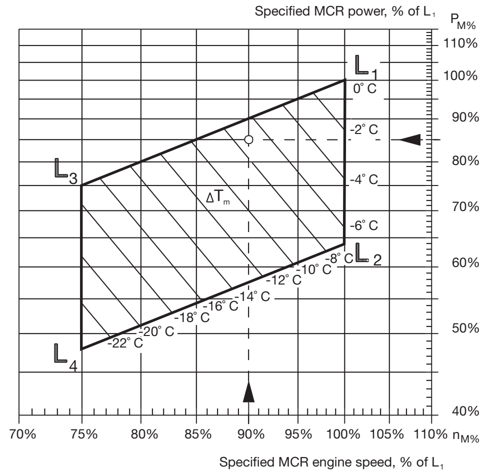
Fig. 6.04.07: Change of specific exhaust gas amount, $\Delta m_{M\%}$ in % of L_1 value and independent of P_O



ΔT_M = 15 x ln (P_M/P_{L1}) + 45 x ln (n_M/n_{L1})

178 59 34-9.0

Fig. 6.04.08: Change of exhaust gas temperature, ΔT_M in point M, in °C after turbocharger relative to L_1 value and valid for $P_O = P_M$

$\Delta m_{M\%}$: change of specific exhaust gas amount, in % of specific gas amount at nominal MCR (L_1), see Fig. 6.04.07.

ΔT_M : change in exhaust gas temperature after turbocharger relative to the L1 value, in °C, see Fig. 6.04.08. ($P_O = P_M$)

ΔT_O : extra change in exhaust gas temperature when optimising point O lower than 100% M: $P_{O\%} = (P_O/P_M)$ x 100%.

ΔT_O = - 0.3 x (100 - $P_{O\%}$) [6]

b) Correction for actual ambient conditions and back-pressure

For ambient conditions other than ISO 3046-1:2002 (E) and ISO 15550:2002 (E), and back-pressure other than 300 mm WC at specified MCR point (M), the correction factors stated in the table in Fig. 6.04.09 may be used as a guide, and the corresponding relative change in the exhaust gas data may be found from equations [7] and [8], shown in Fig. 6.04.10.

Parameter	Change	Change of exhaust gas temperature	Change of exhaust gas amount
Blower inlet temperature	+ 10° C	+ 16.0° C	- 4.1 %
Blower inlet pressure (barometric pressure)	+ 10 mbar	- 0.1° C	+ 0.3 %
Charge air coolant temperature (seawater temperature)	+ 10° C	+ 1.0° C	+ 1.9 %
Exhaust gas back pressure at the specified MCR point	+ 100 mm WC	+ 5.0° C	-1.1 %

Fig. 6.04.09: Correction of exhaust gas data for ambient conditions and exhaust gas back pressure

$$\Delta M_{amb\%} = -0.41 \times (T_{air} - 25) + 0.03 \times (p_{bar} - 1000) + 0.19 \times (T_{CW} - 25) - 0.011 \times (\Delta p_M - 300)\ \% \qquad [7]$$

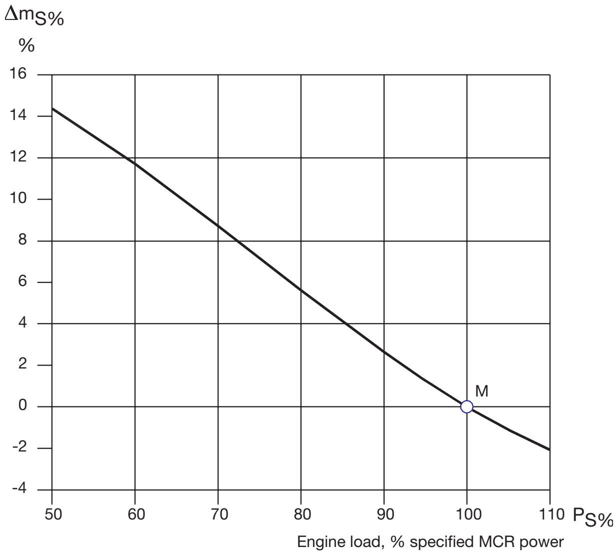
$$\Delta T_{amb} = 1.6 \times (T_{air} - 25) - 0.01 \times (p_{bar} - 1000) + 0.1 \times (T_{CW} - 25) + 0.05 \times (\Delta p_M - 300)\ °C \qquad [8]$$

where the following nomenclature is used:

$\Delta M_{amb\%}$: change in exhaust gas amount, in % of amount at ISO conditions

ΔT_{amb} : change in exhaust gas temperature, in °C compared with temperatures at ISO conditions

Fig. 6.04.10: Exhaust gas correction formula for ambient conditions and exhaust gas back pressure



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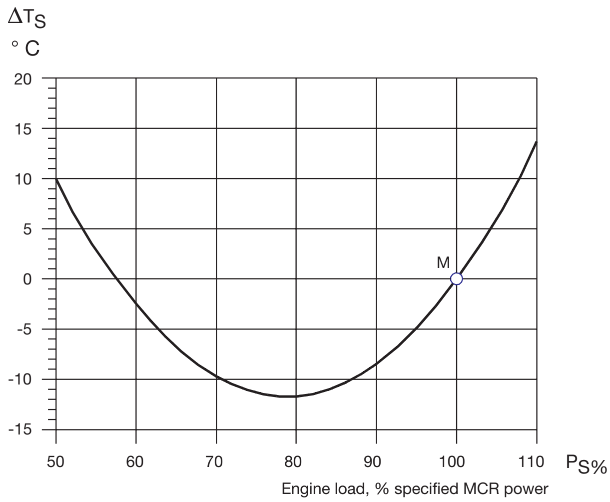

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$P_{S\%} = (P_S/P_M) \times 100\%$

$\Delta m_{S\%} = 37 \times (P_S/P_M)^3 - 83 \times (P_S/P_M)^2 + 31 \times (P_S/P_M) + 15$

Fig. 6.04.11: Change of specific exhaust gas amount, $\Delta m_{s\%}$ in % at part load, and valid for FPP and CPP

$P_{S\%} = (P_S/P_M) \times 100\%$

$\Delta T_S = 262 \times (P_S/P_M)^2 - 413 \times (P_S/P_M) + 151$

Fig. 6.04.12*: Change of exhaust gas temperature, ΔT_S in °C at part load, and valid for FPP and CPP*

c) Correction for engine load

Figs. 6.04.11 and 6.04.12 may be used, as guidance, to determine the relative changes in the specific exhaust gas data when running at part load, compared to the values in the specified MCR point, i.e. using as input $P_{S\%} = (P_S/P_M) \times 100\%$:

$\Delta m_{s\%}$: change in specific exhaust gas amount, in % of specific amount at specified MCR point, see Fig. 6.04.11.

ΔT_s : change in exhaust gas temperature, in °C, see Fig. 6.04.12.

Calculation of Exhaust Data for Derated Engine

Example 3:

Expected exhaust gas data *for a derated 6S50MC6 with high efficiency MAN Diesel turbocharger type TCA and fixed pitch propeller.*

Based on the engine ratings below, and by means of an example, this chapter will show how to calculate the expected exhaust gas amount and temperature at service rating, and for a given ambient reference condition different from ISO.

The calculation is made for the service rating (S) being 80%of the specified MCR power of the diesel engine.

Nominal MCR, (L_1) P_{L1}: 8,580 kW (100.0%) and 127.0 r/min (100.0%)

Specified MCR, (M) P_M: 7,293 kW (85.0%) and 114.3 r/min (90.0%)

Optimising point, (O) P_O: 6,564 kW (76.5%) and 110.4 r/min (86.9%), P_O = 90.0% of P_M

Service rating, (S) P_S: 5,834 kW and 106.1 r/min, P_S = 80.0% of P_M

Reference conditions

Air temperature T_{air} .... 20° C
Scavenge air coolant temperature T_{CW} .... 18° C
Barometric pressure p_{bar} .... 1,013 mbar
Exhaust gas back-pressure
at specified MCR Δp_M .... 300 mm WC

a) Correction for choice of specified MCR point M and optimising point O:

$$P_{M\%} = \frac{7,293}{8,580} \times 100 = 85.0\%$$

$$n_{M\%} = \frac{114.3}{127.0} \times 100 = 90.0\%$$

By means of Figs. 6.04.07 and 6.04.08:

$\Delta m_{M\%}$ = +0.25 %
ΔT_M = -7.2° C

As the engine is optimised in O lower than 100% M, and $P_{O\%}$ = 90.0% of P_M

we get by means of equation [6]

$$\Delta T_O = - 0.3 \times (100 - 90.0) = - 3.0° \text{ C}$$

b) Correction for ambient conditions and back-pressure:

By means of equations [7] and [8]:

$$\Delta M_{amb\%} = - 0.41 \times (20 - 25) + 0.03 \times (1,013 - 1,000) + 0.19 \times (18 - 25) - 0.011 \times (300 - 300) \%$$

$$\Delta M_{amb\%} = + 1.11\%$$

$$\Delta T_{amb} = 1.6 \times (20 - 25) - 0.01 \times (1,013 - 1,000) + 0.1 \times (18 - 25) + 0.05 \times (300 - 300) °\text{C}$$

$$\Delta T_{amb} = - 8.8° \text{ C}$$

c) Correction for the engine load:

Service rating = 80% of specified MCR power
By means of Figs. 6.04.11 and 6.04.12:

$\Delta m_{S\%}$ = + 5.6%

ΔT_S = - 11.7 °C

Final calculation

By means of equations [4] and [5], the final result is found taking the exhaust gas flow M_{L1} and temperature T_{L1} from the 'List of Capacities':

M_{L1} = 80,400 kg/h

$M_{exh} = 80{,}400 \times \frac{7{,}293}{8{,}580} \times (1 + \frac{+0.25}{100}) \times$

$(1 + \frac{1.11}{100}) \times (1 + \frac{5.6}{100}) \times \frac{80}{100} = 58{,}520$ kg/h

M_{exh} = 58,500 kg/h +/- 5%

The exhaust gas temperature

T_{L1} = 245° C

T_{exh} = 245 - 7.2 - 3.0 - 8.8 - 11.7 = 214.3 °C

T_{exh} = 214.3 °C -/+15 °C

Exhaust gas data at specified MCR (ISO)

At specified MCR (M), the running point may be in equations [4] and [5] considered as a service point where $P_{S\%} = 100$, $\Delta m_{s\%} = 0.0$ and $\Delta T_s = 0.0$.

For ISO ambient reference conditions where $\Delta M_{amb\%} = 0.0$ and $\Delta T_{amb} = 0.0$, the corresponding calculations will be as follows:

$M_{exh,M} = 80{,}400 \times \frac{7{,}293}{8{,}580} \times (1 + \frac{+0.25}{100}) \times (1 + \frac{0.0}{100})$

$\times (1 + \frac{0.0}{100}) \times \frac{100.0}{100} = 68{,}511$ kg/h

$M_{exh,M}$ = 68,500 kg/h +/-5%

$T_{exh,M}$ = 245 - 7.2 - 3.0 + 0 + 0 = 234.8 °C

$T_{exh,M}$ = 234.8 °C -/+15 °C

The air consumption will be:

68,511 x 0.982 kg/h = 67,278 kg/h <=>
67,278/3,600 kg/s = 18.7 kg/s

Fuel

7

Pressurised Fuel Oil System

The system is so arranged that both diesel oil and heavy fuel oil can be used, see figure 7.01.01.

From the service tank the fuel is led to an electrically driven supply pump by means of which a pressure of approximately 4 bar can be maintained in the low pressure part of the fuel circulating system, thus avoiding gasification of the fuel in the venting box in the temperature ranges applied.

The venting box is connected to the service tank via an automatic deaerating valve, which will release any gases present, but will retain liquids.

From the low pressure part of the fuel system the fuel oil is led to an electrically-driven circulating pump, which pumps the fuel oil through a heater and a full flow filter situated immediately before the inlet to the engine.

An in-line viscocity regulator located after the heater controls the heating temperature according to the prescribed viscosity of the specific fuel oil.

Design parameters

To ensure ample filling of the fuel injection pumps, the capacity of the electrically-driven circulating pump is higher than the amount of fuel consumed by the diesel engine. Surplus fuel oil is recirculated from the engine through the venting box.

To ensure a constant fuel pressure to the fuel injection pumps during all engine loads, a spring loaded overflow valve is inserted in the fuel oil system on the engine.

The fuel oil pressure measured on the engine (at fuel pump level) should be 7-8 bar, equivalent to a circulating pump pressure of 10 bar.

The built-on overflow valves, if any, at the supply pumps are to be adjusted to 5 bar, whereas the external bypass valve is adjusted to 4 bar. The pipes between the tanks and the supply pumps shall have minimum 50% larger passage area than the pipe between the supply pump and the circulating pump.

If the fuel oil pipe ‘X’ at inlet to engine is made as a straight line immediately at the end of the engine, it will be necessary to mount an expansion joint. If the connection is made as indicated, with a bend immediately at the end of the engine, no expansion joint is required.

Fuel Pumps and Drain

The introduction of the pump sealing arrangement, the so-called ‘umbrella’ type, has made it possible to omit the separate camshaft lubricating oil system.

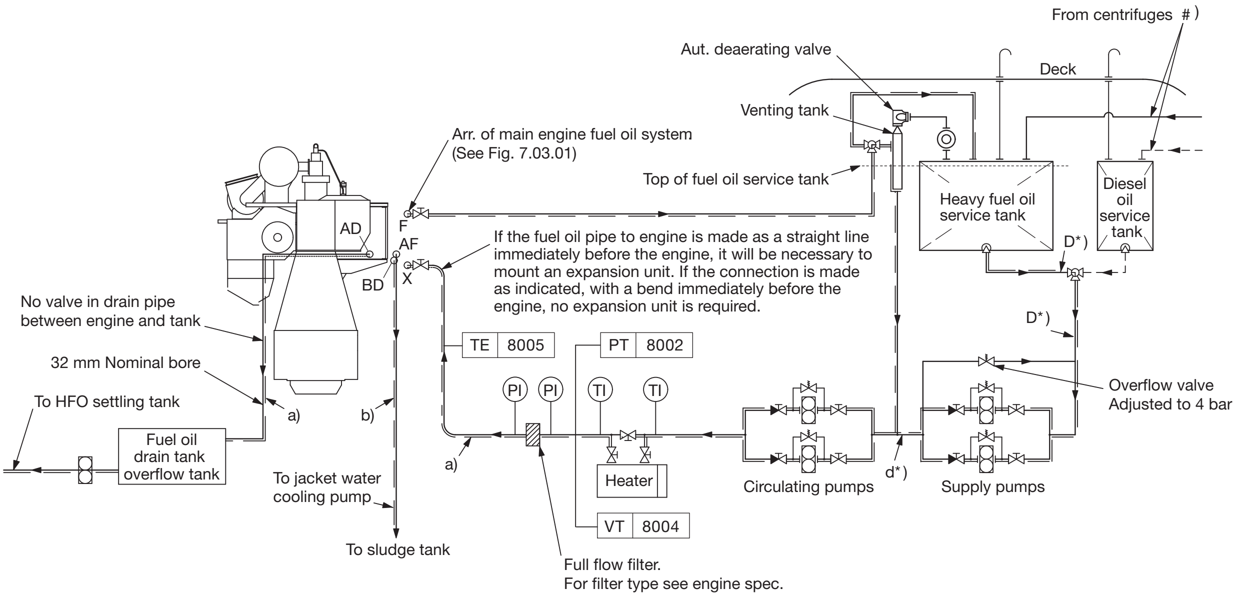
The umbrella type fuel oil pump has an additional external leakage rate of clean fuel oil which, through ‘AD’, is led to a tank and can be pumped to the heavy fuel oil service tank or settling tank. The flow rate is approx. 1.25 litres/cyl. h.

The main purpose of the drain ‘AF’ is to collect pure fuel oil from the fuel pumps as well as the unintentional leakage from the high pressure pipes. The drain oil is lead to a tank and can be pumped to the Heavy Fuel Oil service tank or to the settling tank.

The ‘AF’ drain is provided with a box for giving alarm in case of leakage in a high pressure pipes.

The main components of the pressurised fuel oil system are further explained in section 7.05.

Fuel Oil System



#) Approximately the following quantity of fuel oil should be treated in the centrifuges: 0.23 l/kwh as explained in Section 7.05. The capacity of the centrifuges to be according to manufacturer's recommendation.

*) D to have min. 50% larger passage area than d.

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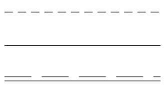


Diesel oil
Heavy fuel oil
Heated pipe with insulation
a) Tracing fuel oil lines: Max.150 °C
b) Tracing drain lines: By jacket cooling water

The letters refer to the list of 'Counterflanges'

Fig. 7.01.01: Fuel oil system

Fuel considerations

When the engine is stopped, the circulating pump will continue to circulate heated heavy fuel through the fuel oil system on the engine, thereby keeping the fuel pumps heated and the fuel valves deaerated. This automatic circulation of preheated fuel during engine standstill is the background for our recommendation:

Constant operation on heavy fuel

In addition, if this recommendation was not followed, there would be a latent risk of diesel oil and heavy fuels of marginal quality forming incompatible blends during fuel change over or when operating in areas with restrictions on sulpher content in fuel oil due to exhaust gas emission control.

In special circumstances a change-over to diesel oil may become necessary – and this can be performed at any time, even when the engine is not running. Such a change-over may become necessary if, for instance, the vessel is expected to be inactive for a prolonged period with cold engine e.g. due to:

- docking
- stop for more than five days
- major repairs of the fuel system, etc.

Heating of drain pipe

Owing to the relatively high viscosity of the heavy fuel oil, it is recommended that the drain pipe and the tank are heated to min. 50 °C.

The drain pipe between engine and tank can be heated by the jacket water, as shown in Fig. 7.01.01 ‘Fuel pipe heating’ as flange ‘BD’.

The size of the sludge tank is determined on the basis of the draining intervals, the classification society rules, and on whether it may be vented directly to the engine room.

This drained clean oil will, of course, influence the measured SFOC, but the oil is thus not wasted, and the quantity is well within the measuring accuracy of the flowmeters normally used.

For external pipe connections, we prescribe the following maximum flow velocities:

Marine diesel oil .... 1.0 m/s
Heavy fuel oil .... 0.6 m/s

The fuel viscosity is influenced by factors such as emulsification of water into the fuel for reducing the NO_x emission. This is further described in section 7.06.

An emulsification arrangement for the main engine is described in our publication:

Exhaust Gas Emission Control Today and Tomorrow

Further information about fuel oil specifications is available in our publication:

Operation on Heavy Residual Fuels

The publications are available at:
www.mandiesel.com under
‘Quicklinks’ → ‘Technical Papers’.

Fuel oils

Marine diesel oil:

Marine diesel oil ISO 8217, Class DMB
British Standard 6843, Class DMB
Similar oils may also be used

Heavy fuel oil (HFO)

Most commercially available HFO with a viscosity below 700 cSt at 50 °C (7,000 sec. Redwood I at 100 °F) can be used.

For guidance on purchase, reference is made to ISO 8217:1996 and ISO 8217:2005, British Standard 6843 and to CIMAC recommendations regarding requirements for heavy fuel for diesel engines, fourth edition 2003, in which the maximum acceptable grades are RMH 700 and RMK 700. The above-mentioned ISO and BS standards supersede BSMA 100 in which the limit was M9.

The data in the above HFO standards and specifications refer to fuel as delivered to the ship, i.e. before on-board cleaning.

In order to ensure effective and sufficient cleaning of the HFO, i.e. removal of water and solid contaminants, the fuel oil specific gravity at 15 °C (60 °F) should be below 0.991, unless modern types of centrifuges with adequate cleaning abilities are used.

Higher densities can be allowed if special treatment systems are installed.

Current analysis information is not sufficient for estimating the combustion properties of the oil. This means that service results depend on oil properties which cannot be known beforehand. This especially applies to the tendency of the oil to form deposits in combustion chambers, gas passages and turbines. It may, therefore, be necessary to rule out some oils that cause difficulties.

Guiding heavy fuel oil specification

Based on our general service experience we have, as a supplement to the above mentioned standards, drawn up the guiding HFO specification shown below.

Heavy fuel oils limited by this specification have, to the extent of the commercial availability, been used with satisfactory results on MAN B&W two-stroke low speed diesel engines.

The data refers to the fuel as supplied i.e. before any on-board cleaning.

Guiding specification (maximum values)		
Density at 15 °C	kg/m³	≤ 1.010*
Kinematic viscosity		
at 100 °C	cSt	≤ 55
at 50 °C	cSt	≤ 700
Flash point	°C	≥ 60
Pour point	°C	≤ 30
Carbon residue	% (m/m)	≤ 22
Ash	% (m/m)	≤0.15
Total sediment potential	% (m/m)	≤0.10
Water	% (v/v)	≤ 0.5
Sulphur	% (m/m)	≤ 4.5
Vanadium	mg/kg	≤ 600
Aluminum + Silicon	mg/kg	≤ 80
Equal to ISO 8217:2005 - RMK 700 / CIMAC recommendation No. 21 - K700		
* Provided automatic clarifiers are installed		
m/m = mass	v/v = volume	

If heavy fuel oils with analysis data exceeding the above figures are to be used, especially with regard to viscosity and specific gravity, the engine builder should be contacted for advice regarding possible fuel oil system changes.

Fuel Oil Pipes and Drain Pipes

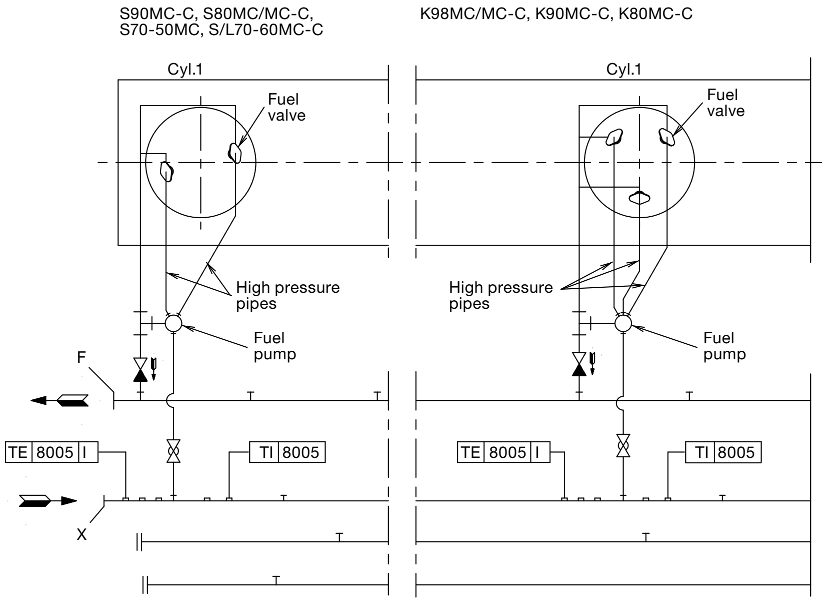
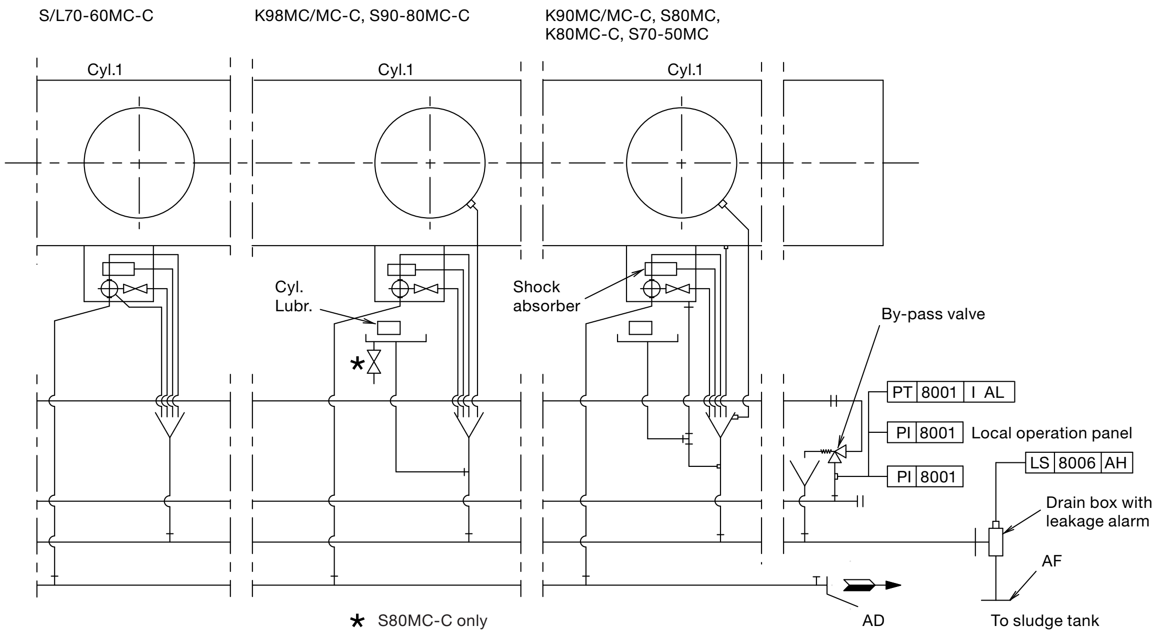


Fig. 7.03.01: Fuel oil pipes



The letters refer to list of 'Counterflanges'
The item Nos refer to 'Guidance values automation'

Fig. 7.03.02: Fuel oil drain pipes

Fuel Oil Pipe Insulation

Insulation of fuel oil pipes and fuel oil drain pipes should not be carried out until the piping systems have been subjected to the pressure tests specified and approved by the respective classification society and/or authorities, Fig. 7.04.01.

The directions mentioned below include insulation of hot pipes, flanges and valves with a surface temperature of the complete insulation of maximum 55 °C at a room temperature of maximum 38 °C. As for the choice of material and, if required, approval for the specific purpose, reference is made to the respective classification society.

Fuel oil pipes

The pipes are to be insulated with 20 mm mineral wool of minimum 150 kg/m^3 and covered with glass cloth of minimum 400 g/m^2.

Fuel oil pipes and heating pipes together

Two or more pipes can be insulated with 30 mm wired mats of mineral wool of minimum 150 kg/m^3 covered with glass cloth of minimum 400 g/m^2.

Flanges and valves

The flanges and valves are to be insulated by means of removable pads. Flange and valve pads are made of glass cloth, minimum 400 g/m^2, containing mineral wool stuffed to minimum 150 kg/m^3.

Thickness of the pads to be:
Fuel oil pipes .... 20 mm
Fuel oil pipes and heating pipes together.... 30 mm

The pads are to be fitted so that they lap over the pipe insulating material by the pad thickness. At flanged joints, insulating material on pipes should not be fitted closer than corresponding to the minimum bolt length.

Mounting

Mounting of the insulation is to be carried out in accordance with the supplier's instructions.

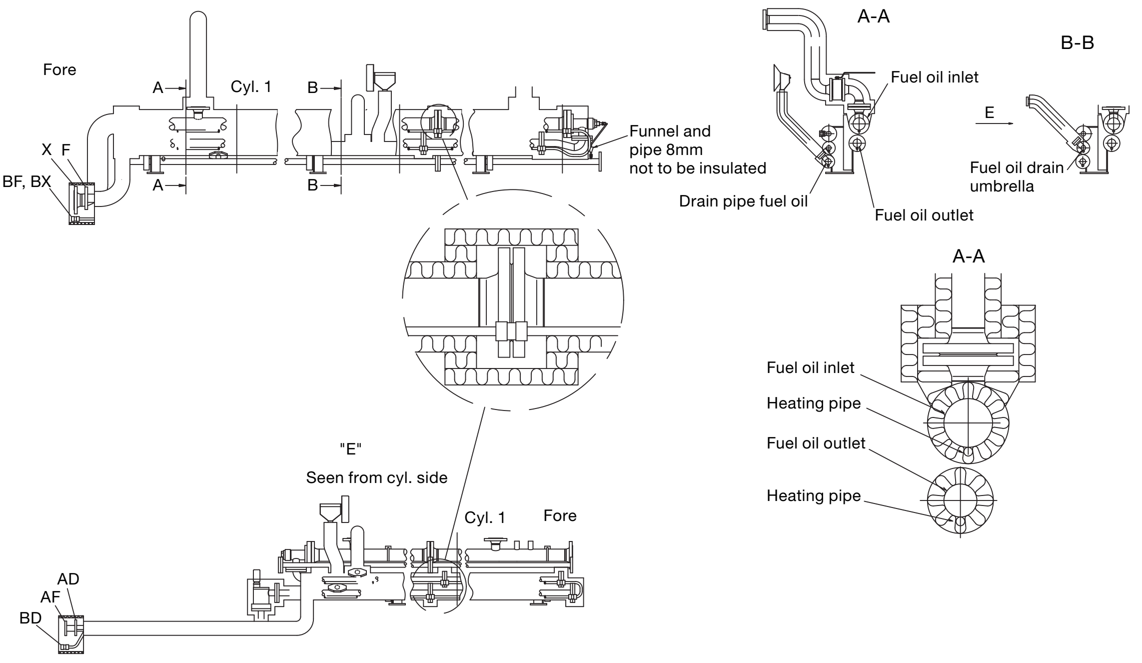


Fig. 7.04.01: Details of fuel oil pipes insulation, option: 4 35 121. Example from 98-50 MC engine

178 50 65 -0.2

Heat Loss in Piping

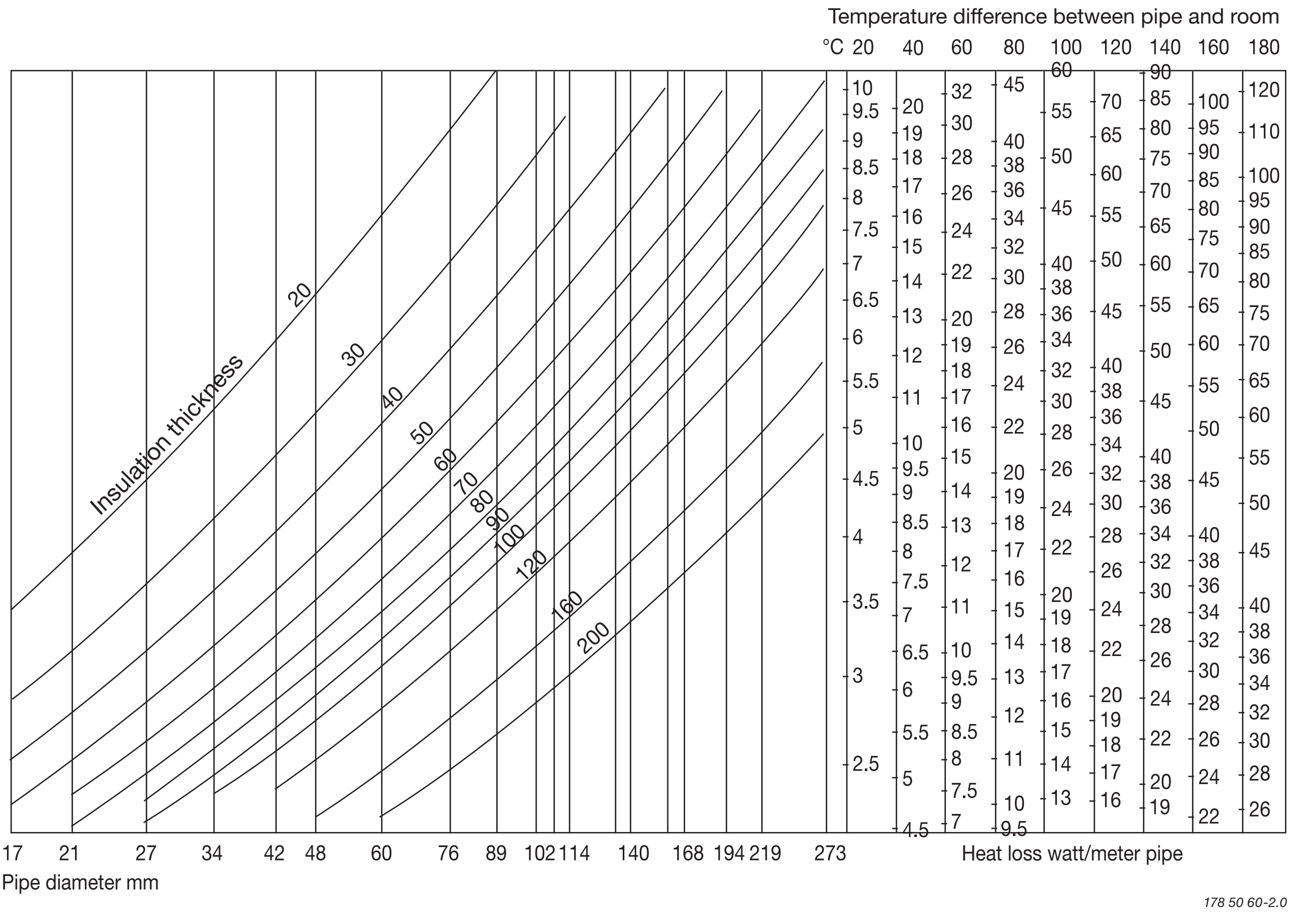


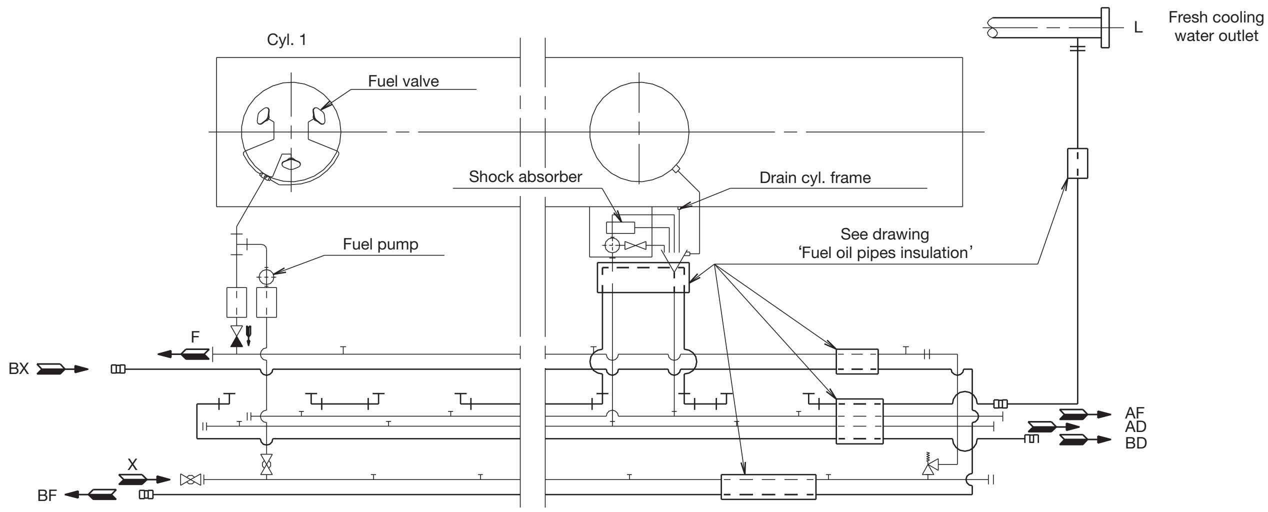
Fig. 7.04.02: Heat loss/Pipe cover

Fuel Oil Pipe Heat Tracing

The steam tracing of the fuel oil pipes is intended to operate in two situations:

1. When the circulation pump is running, there will be a temperature loss in the piping, see Fig. 7.04.02. This loss is very small, therefore tracing in this situation is only necessary with very long fuel supply lines.
2. When the circulation pump is stopped with heavy fuel oil in the piping and the pipes have cooled down to engine room temperature, as it is not possible to pump the heavy fuel oil. In this situation the fuel oil must be heated to pumping temperature of about 50 °C.

   To heat the pipe to pumping level we recommend to use 100 watt leaking/meter pipe.



The letters refer to list of 'Counterflanges'

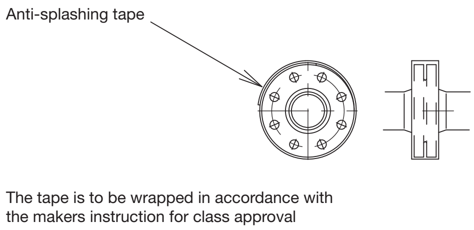
178 50 62-5.0

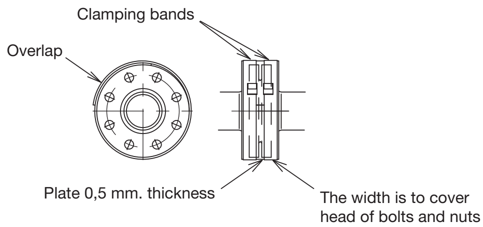
Fig. 7.04.03: Fuel oil pipe heat tracing

Fuel Oil and Lubricating Oil Pipe Spray Shields

In order to fulfil IMO regulations, fuel oil and lubricating oil pipe assemblies are to be enclosed by spray shields as shown in Fig. 7.04.04a and b.

To avoid leaks, the spray shields are to be installed after pressure testing of the pipe system.





178 52 55-5.2

Fig. 7.04.04a: Spray Shields by anti-splashing tape

Fig. 7.04.04b: Spray Shields by clamping bands

Components for fuel oil system

Fuel oil centrifuges

The manual cleaning type of centrifuges are not to be recommended, neither for attended machinery spaces (AMS) nor for unattended machinery spaces (UMS). Centrifuges must be self-cleaning, either with total discharge or with partial discharge.

Distinction must be made between installations for:

- Specific gravities < 0.991 (corresponding to ISO 8217 and British Standard 6843 from RMA to RMH, and CIMAC from A to H-grades
- Specific gravities > 0.991 and (corresponding to CIMAC K-grades).

For the latter specific gravities, the manufacturers have developed special types of centrifuges, e.g.:

Alfa Laval..Alcap
Westfalia.. Unitrol
Mitsubishi... E-Hidens II

The centrifuge should be able to treat approximately the following quantity of oil:

0.23 litres/kWh = 0.17 litres/BHPh

This figure includes a margin for:

- Water content in fuel oil
- Possible sludge, ash and other impurities in the fuel oil
- Increased fuel oil consumption, in connection with other conditions than ISO standard condition
- Purifier service for cleaning and maintenance.

The size of the centrifuge has to be chosen according to the supplier's table valid for the selected viscosity of the Heavy Fuel Oil. Normally, two centrifuges are installed for Heavy Fuel Oil (HFO), each with adequate capacity to comply with the above recommendation.

A centrifuge for Marine Diesel Oil (MDO) is not a must, but if it is decided to install one on board, the capacity should be based on the above recommendation, or it should be a centrifuge of the same size as that for lubricating oil.

The *Nominal MCR* is used to determine the total installed capacity. Any derating can be taken into consideration in border-line cases where the centrifuge that is one step smaller is able to cover *Specified MCR*.

Fuel oil supply pump

This is to be of the screw or gear wheel type.

Fuel oil viscosity, specified.... up to 700 cSt at 50 °C
Fuel oil viscosity maximum.......................1000 cSt
Pump head...4 bar
Fuel oil flow ....see 'List of capacities'
Delivery pressure ....4 bar
Working temperature .... 100 °C
Minimum temperature.................................... 50 °C

The capacity stated in 'List of capacities' is to be fulfilled with a tolerance of: ÷0% to +15% and shall also be able to cover the back-flushing, see 'Fuel oil filter'.

Fuel oil circulating pump

This is to be of the screw or gear wheel type.

Fuel oil viscosity, specified.... up to 700 cSt at 50 °C
Fuel oil viscosity normal................................20 cSt
Fuel oil viscosity maximum.......................1000 cSt
Fuel oil flow ....see 'List of capacities'
Pump head...6 bar
Delivery pressure ....10 bar
Working temperature .... 150 °C

The capacity stated in 'List of capacities' is to be fulfilled with a tolerance of: ÷0% to +15% and shall also be able to cover the back-flushing, see 'Fuel oil filter'.

Pump head is based on a total pressure drop in filter and preheater of maximum 1.5 bar.

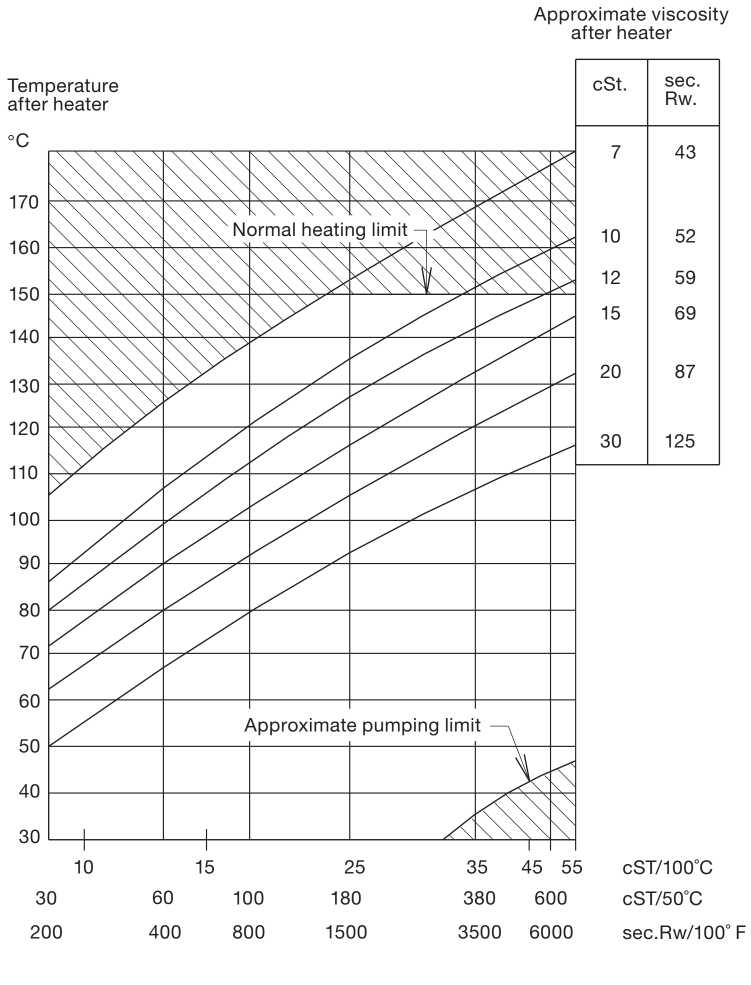


Fig. 7.05.01: Fuel oil heating chart

Fuel oil heater

The heater is to be of the tube or plate heat exchanger type.

The required heating temperature for different oil viscosities will appear from the 'Fuel oil heating chart'. The chart is based on information from oil suppliers regarding typical marine fuels with viscosity index 70-80.

Since the viscosity after the heater is the controlled parameter, the heating temperature may vary, depending on the viscosity and viscosity index of the fuel.

Recommended viscosity meter setting is 10-15 cSt.

Fuel oil viscosity specified ... up to 700 cSt at 50°C
Fuel oil flow .... see capacity of fuel oil circulating pump
Heat dissipation .... see 'List of capacities'
Pressure drop on fuel oil side .... maximum 1 bar
Working pressure .... 10 bar
Fuel oil inlet temperature................. approx. 100 °C
Fuel oil outlet temperature .... 150 °C
Steam supply, saturated .... 7 bar abs

To maintain a correct and constant viscosity of the fuel oil at the inlet to the main engine, the steam supply shall be automatically controlled, usually based on a pneumatic or an electrically controlled system.

Fuel oil filter

The filter can be of the manually cleaned duplex type or an automatic filter with a manually cleaned bypass filter.

If a **double filter** (duplex) is installed, it should have sufficient capacity to allow the specified full amount of oil to flow through each side of the filter at a given working temperature with a max. 0.3 bar pressure drop across the filter (clean filter).

If a **filter with backflushing** arrangement is installed, the following should be noted. The required oil flow specified in the 'List of capacities', i.e. the delivery rate of the fuel oil supply pump and the fuel oil circulating pump, should be increased by the amount of oil used for the backflushing, so that the fuel oil pressure at the inlet to the main engine can be maintained during cleaning.

In those cases where an **automatically cleaned filter** is installed, it should be noted that in order to activate the cleaning process, certain makers of filters require a greater oil pressure at the inlet to the filter than the pump pressure specified. Therefore, the pump capacity should be adequate for this purpose, too.

The fuel oil filter should be based on heavy fuel oil of: 130 cSt at 80 °C = 700 cSt at 50 °C = 7000 sec Redwood I/100 °F.

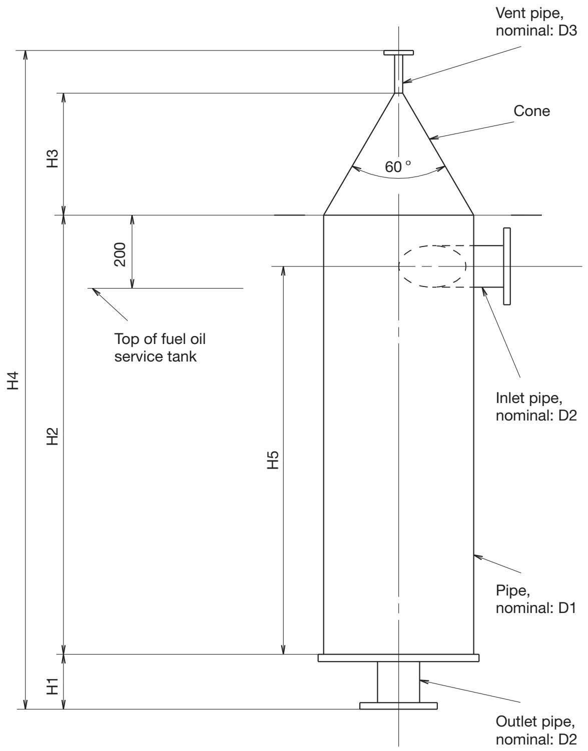
Fuel oil flow ....see 'List of capacities'
Working pressure..10 bar
Test pressure...................... according to class rule
Absolute fineness..50 µm
Working temperature .... maximum 150 °C
Oil viscosity at working temperature ....15 cSt
Pressure drop at clean filter........maximum 0.3 bar
Filter to be cleaned at a pressure
drop of ....maximum 0.5 bar

Note:
Absolute fineness corresponds to a nominal fineness of approximately 30 µm at a retaining rate of 90%.

The filter housing shall be fitted with a steam jacket for heat tracing.

Fuel oil venting box

The design of the Fuel oil venting box is shown in Fig. 7.05.02. The size is chosen according to the maximum flow of the Fuel oil circulation pump, which is listed in section 6.03.



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Flow m³/h	Dimensions in mm							
Q (max.)*	D1	D2	D3	H1	H2	H3	H4	H5
1.3	150	32	15	100	600	171.3	1,000	550
2.1	150	40	15	100	600	171.3	1,000	550
5.0	200	65	15	100	600	171.3	1,000	550
8.4	400	80	15	150	1,200	333.5	1,800	1,100
11.5	400	90	15	150	1,200	333.5	1,800	1,100
19.5	400	125	15	150	1,200	333.5	1,800	1,100
29.4	500	150	15	150	1,500	402.4	2,150	1,350
43.0	500	200	15	150	1,500	402.4	2,150	1,350

* The maximum flow of the fuel oil circulation pump

Fig. 07.05.02: Fuel oil venting box

Flushing of the fuel oil system

Before starting the engine for the first time, the system on board has to be flushed in accordance with MAN Diesel's recommendations 'Flushing of Fuel Oil System' which is available on request.

Water In Fuel Emulsification

The emulsification of water into the fuel oil reduces the NO_x emission with about 1% per 1% water added to the fuel up to about 20% without modification of the engine fuel injection equipment.

A Water In Fuel emulsion (WIF) mixed for this purpose and based on Heavy Fuel Oil (HFO) is stable for a long time, whereas a WIF based on Marine Diesel Oil is only stable for a short period of time unless an emulsifying agent is applied.

As both the MAN B&W two-stroke main engine and the MAN Diesel GenSets are designed to run on emulsified HFO, it can be used for a common system.

It is supposed below, that both the main engine and GenSets are running on the same fuel, either HFO or a homogenised HFO-based WIF.

Special arrangements are available on request for a more sophisticated system in which the GenSets can run with or without a homogenised HFO-based WIF, if the main engine is running on that.

Please note that the fuel pump injection capacity shall be confirmed for the main engine as well as the GenSets for the selected percentage of water in the WIF.

Temperature and pressure

When water is added by emulsification, the fuel viscosity increases. In order to keep the injection viscosity at 10-15 cSt and still be able to operate on up to 700 cSt fuel oil, the heating temperature has to be increased to about 170 °C depending on the water content.

The higher temperature calls for a higher pressure to prevent cavitation and steam formation in the system. The inlet pressure is thus set to 13 bar.

In order to avoid temperature chock when mixing water into the fuel in the homogeniser, the water inlet temperature is to be set to 70-90 °C.

Safety system

In case the pressure in the fuel oil line drops, the water homogenised into the Water In Fuel emulsion will evaporate, damaging the emulsion and creating supply problems. This situation is avoided by installing a third, air driven supply pump, which keeps the pressure as long as air is left in the tank ‘S’, see Fig. 7.06.01.

Before the tank ‘S’ is empty, an alarm is given and the drain valve is opened, which will drain off the WIF and replace it with HFO or diesel oil from the service tank.

The drain system is kept at atmospheric pressure, so the water will evaporate when the hot emulsion enters the safety tank. The safety tank shall be designed accordingly.

Impact on the auxiliary systems

Please note that if the engine operates on Water In Fuel emulsion (WIF), in order to reduce the NO_x emission, the exhaust gas temperature will decrease due to the reduced air / exhaust gas ratio and the increased specific heat of the exhaust gas.

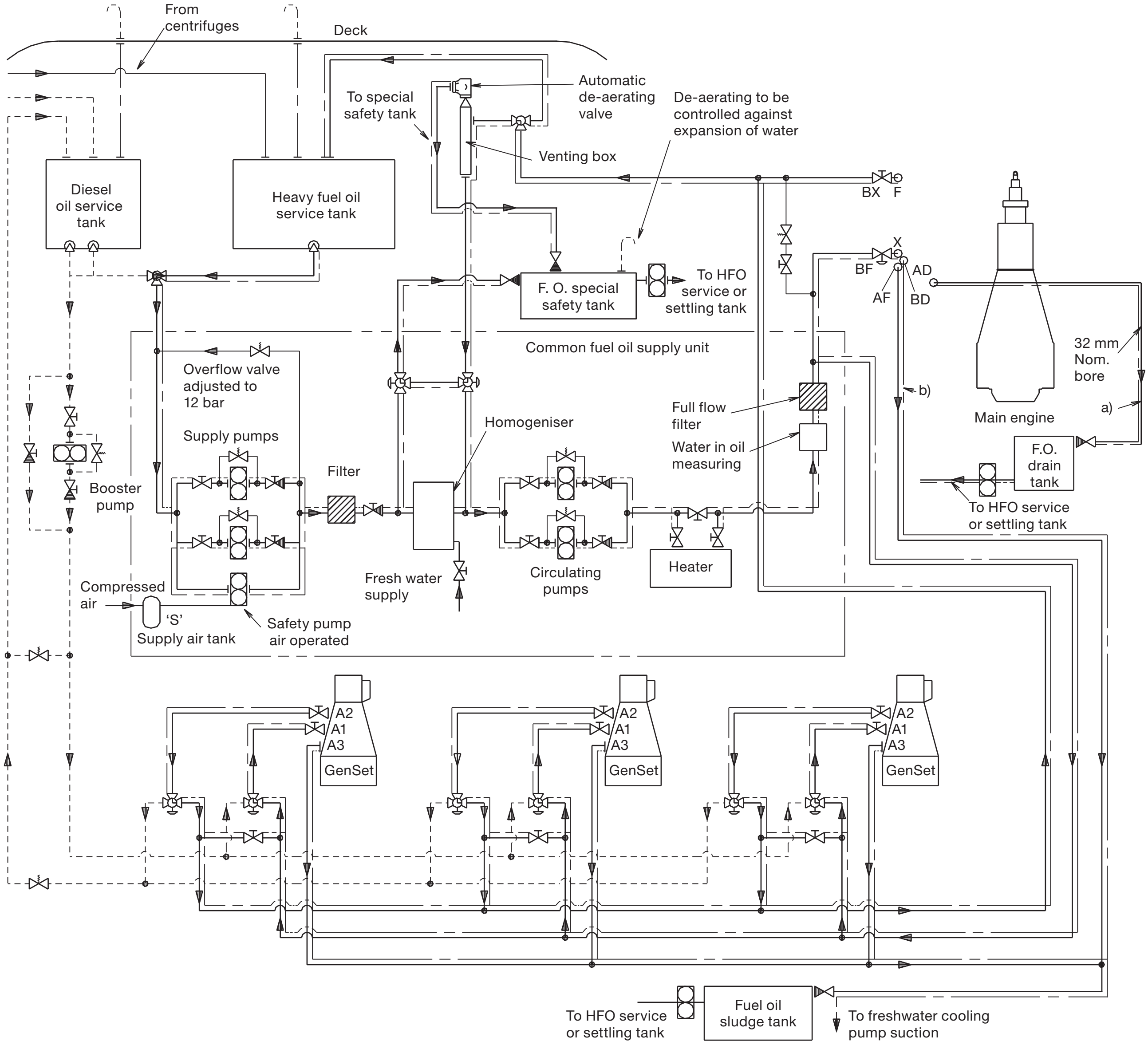
Depending on the water content, this will have an impact on the calculation and design of the following items:

- Freshwater generators
- Energy for production of freshwater
- Jacket water system
- Waste heat recovery system
- Exhaust gas boiler
- Storage tank for freshwater

For further information about emulsification of water into the fuel and use of Water In Fuel emulsion (WIF), please refer to our publication titled:

Exhaust Gas Emission Control Today and Tomorrow

The publication is available at: www.mandiesel.com under ‘Quicklinks’ → ‘Technical Papers



Diesel oil
Heavy fuel oil
Heated pipe with insulation

Number of auxiliary engines, pumps, coolers, etc. are subject to alterations according to the actual plant specification.

a) Tracing fuel oil lines: Max. 150 °C
b) Tracing fuel oil drain lines: Max. 90 °C, min. 50 °C for installations with jacket cooling water

The letters refer to the list of 'Counterflanges'.

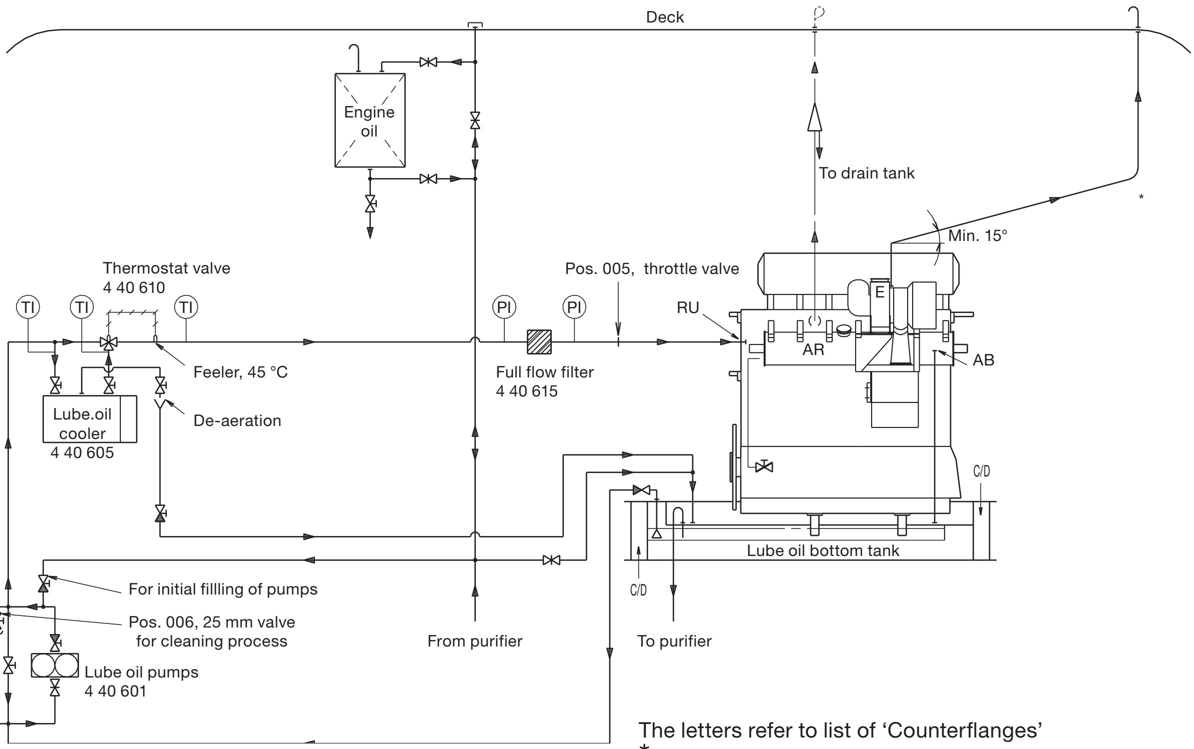
198 99 01-8.3

Fig. 7.06.01: System for emulsification of water into the fuel common to the main engine and MAN Diesel GenSets

Lubricating Oil

8

Lubricating and Cooling Oil System



The letters refer to list of 'Counterflanges'
* Venting for MAN Diesel or Mitsubishi turbochargers only

Fig. 8.01.01 Lubricating and cooling oil system

178 57 55-2.1

Since mid-1995 we have introduced, as standard, the socalled 'umbrella' type of fuel pump for which reason a separate camshaft lube oil system is no longer necessary.

The lubricating oil is pumped from a bottom tank, by means of the main lubricating oil pump (4 40 601), to the lubricating oil cooler (4 40 605), a thermostatic valve (4 40 610) and, through a full-flow filter (4 40 615), to the engine inlet RU, Fig. 8.01.01.

RU lubricates main bearings, thrust bearing, axial vibration damper, crankpin bearings, piston cooling, crosshead, camshaft and turbo charger bearings.

The major part of the oil is divided between piston cooling and crosshead lubrication.

From the engine, the oil collects in the oil pan, from where it is drained off to the bottom tank, see Fig. 8.06.01a 'Lubricating oil tank, with cofferdam' and Table 8.06.01b 'Lubricating oil tank, without cofferdam'.

The engine crankcase is vented through 'AR' by a pipe which extends directly to the deck. This pipe has a drain arrangement so that oil condensed in the pipe can be led to a drain tank, see details in Fig. 8.07.01.

Drains from the engine bedplate 'AE' are fitted on both sides, see Fig. 8.07.02 'Bedplate drain pipes'.

For external pipe connections, we prescribe a maximum oil velocity of 1.8 m/s.

Lubrication of turbochargers

Turbochargers with slide bearings are normally lubricated from the main engine system. AB is outlet from the turbocharger, see Figs. 8.03.01 to 8.03.03, which are shown with sensors for UMS.

Figs. 8.03.01 to 8.03.03 show the lube oil pipe arrangements for different turbocharger makes.

Lubricating and Cooling Oil Pipes

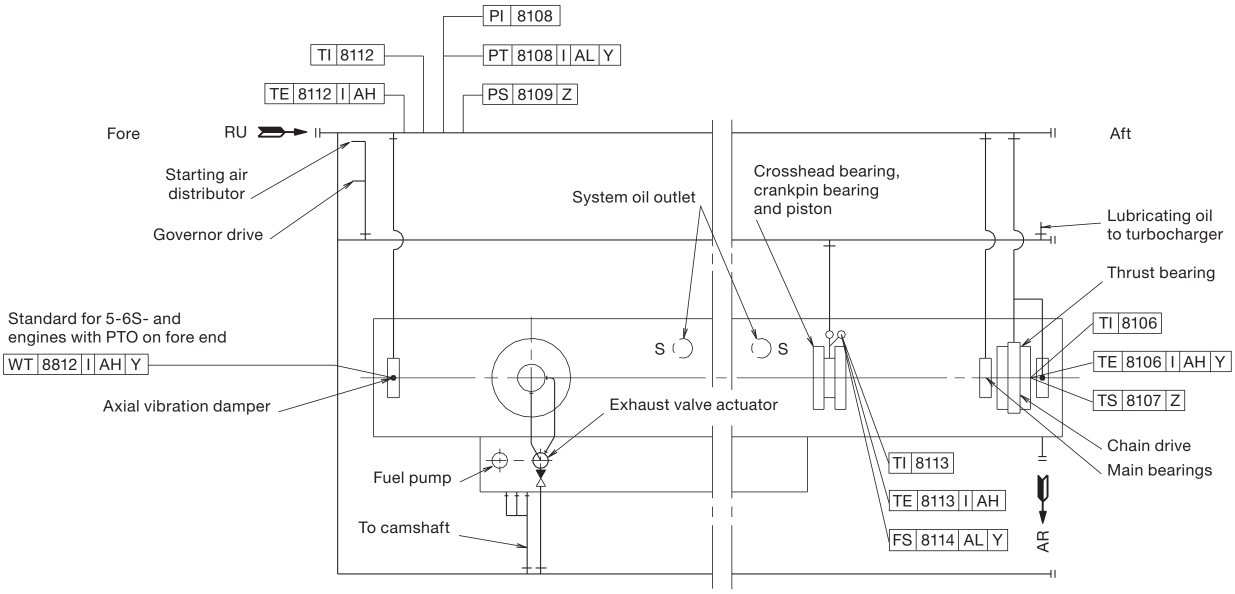


Fig. 8.01.02 Lubricating and Cooling Oil Pipes on engine

Hydraulic power supply unit

This section is not applicable

Lubricating Oil Pipes for Turbochargers

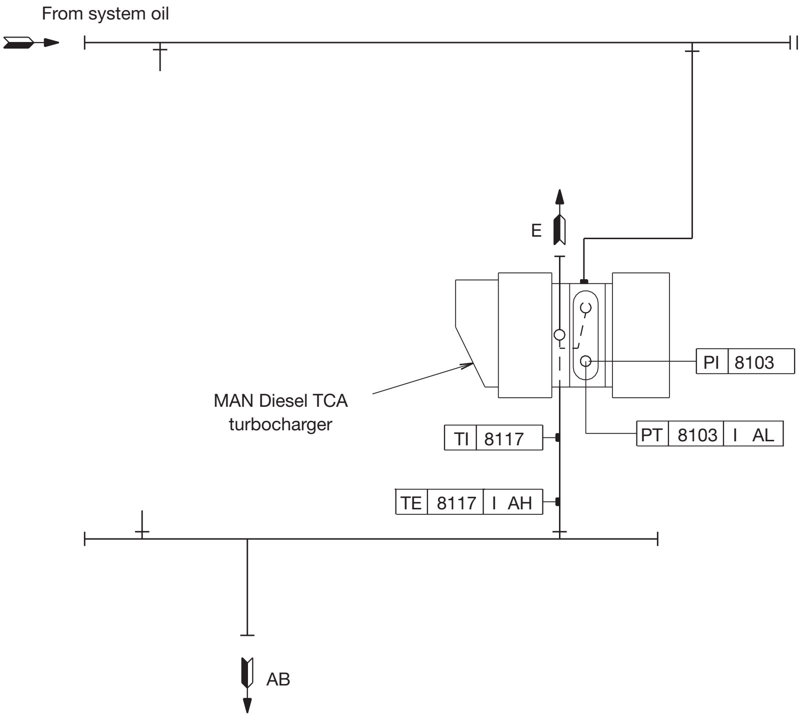


Fig. 8.03.01: MAN Diesel turbocharger type TCA

178 48 50-4.1

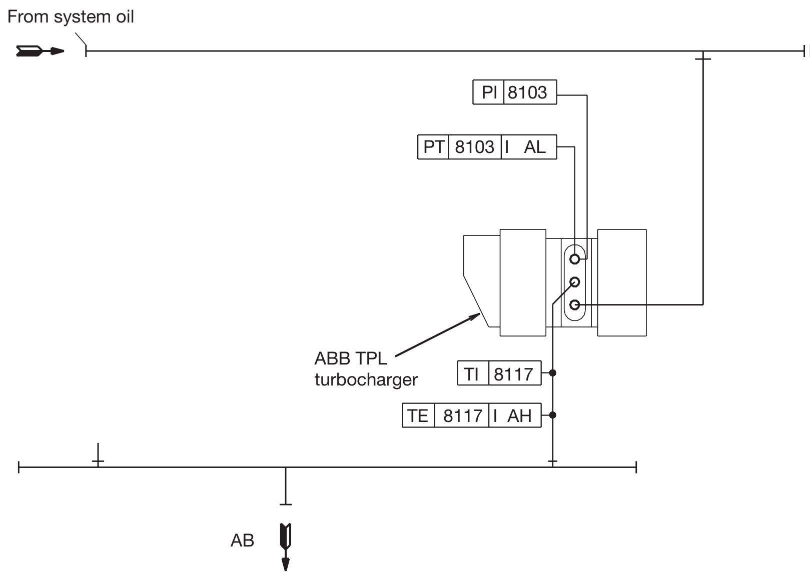


Fig. 8.03.02: ABB turbocharger type TPL

198 96 87-3.2

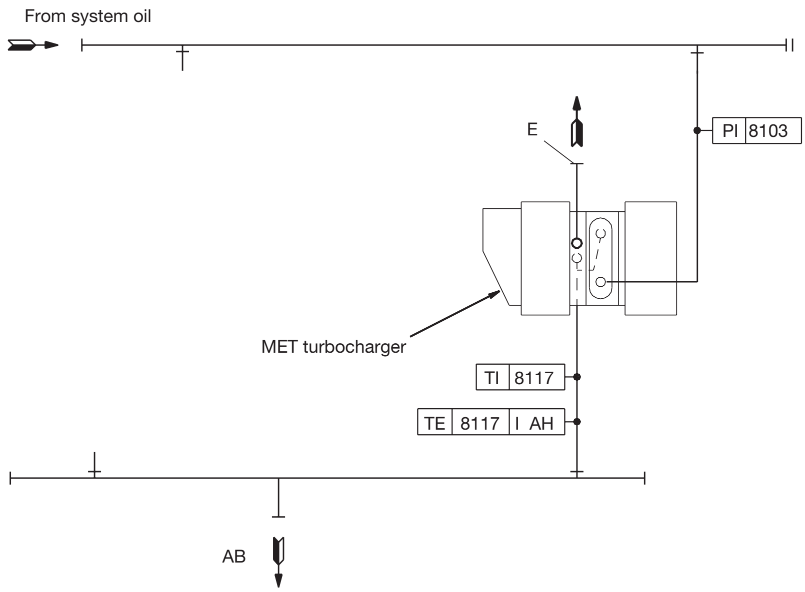


Fig. 8.03.03: Mitsubishi turbocharger type MET

198 96 88-5.2

Lubricating Oil Centrifuges and List of Lubricating Oils

Manual cleaning centrifuges can only be used for Attended Machinery Spaces (AMS). For Unattended Machinery Spaces (UMS), automatic centrifuges with total discharge or partial discharge are to be used.

The nominal capacity of the centrifuge is to be according to the supplier's recommendation for lubricating oil, based on the figures:

0.136 litre/kWh

The Nominal MCR is used as the total installed power.

List of lubricating oils

The circulating oil (lubricating and cooling oil) must be of the rust and oxidation inhibited type of oil of SAE 30 viscosity grade.

In order to keep the crankcase and piston cooling spaces clean of deposits, the oil should have adequate dispersion and detergent properties.

Alkaline circulating oils are generally superior in this respect.

Company	Circulating oil SAE 30/TBN 5-10
BP	Energol OE-HT/30
Total	Atlanta Marine D-3005
Castrol	CDX 30
Chevron	Veritas 800 Marine 30
Exxon	Exxmar XA
Mobil	Mobilgard 300
Shell	Melina 30/30S
Texaco	Doro AR 30

The oils listed have all given long-term satisfactory service in MAN B&W engine installations. Also other brands have been used with satisfactory results.

Components for Lubricating Oil System

Lubricating oil pump

The lubricating oil pump can be of the displacement wheel, or the centrifugal type:

Lubricating oil viscosity, specified...75 cSt at 50 °C
Lubricating oil viscosity .... maximum 400 cSt *
Lubricating oil flow ....see ‘List of capacities’
Design pump head .... 4.1 bar
Delivery pressure .... 4.1 bar
Max. working temperature .... 70 °C

* *400 cSt is specified, as it is normal practice when starting on cold oil, to partly open the bypass valves of the lubricating oil pumps, so as to reduce the electric power requirements for the pumps.*

The flow capacity must be within a range from 100 to 112% of the capacity stated.

The pump head is based on a total pressure drop across cooler and filter of maximum 1 bar.

The bypass valve shown between the main lubricating oil pumps Fig. 8.01.01 may be omitted in cases where the pumps have a built-in bypass or if centrifugal pumps are used.

If centrifugal pumps are used, it is recommended to install a throttle valve at position ‘005’ to prevent an excessive oil level in the oil pan if the centrifugal pump is supplying too much oil to the engine.

During trials, the valve should be adjusted by means of a device which permits the valve to be closed only to the extent that the minimum flow area through the valve gives the specified lubricating oil pressure at the inlet to the engine at full normal load conditions. It should be possible to fully open the valve, e.g. when starting the engine with cold oil.

It is recommended to install a 25 mm valve (pos. 006), with a hose connection after the main lubricating oil pumps, for checking the cleanliness of the lubricating oil system during the flushing procedure. The valve is to be located on the underside of a horizontal pipe just after the discharge from the lubricating oil pumps.

Lubricating oil cooler

The lubricating oil cooler must be of the shell and tube type made of seawater resistant material, or a plate type heat exchanger with plate material of titanium, unless freshwater is used in a central cooling water system.

Lubricating oil viscosity, specified...75 cSt at 50 °C
Lubricating oil flow ....see ‘List of capacities’
Heat dissipation ....see ‘List of capacities’
Lubricating oil temperature, outlet cooler...... 45 °C
Working pressure on oil side .... 4.1 bar
Pressure drop on oil side ....maximum 0.5 bar
Cooling water flow ....see ‘List of capacities’
Cooling water temperature at inlet:
seawater .... 32 °C
freshwater... 36 °C
Pressure drop on water side.......maximum 0.2 bar

The lubricating oil flow capacity must be within a range from 100 to 112% of the capacity stated.

The cooling water flow capacity must be within a range from 100 to 110% of the capacity stated.

To ensure the correct functioning of the lubricating oil cooler, we recommend that the seawater temperature is regulated so that it will not be lower than 10 °C.

The pressure drop may be larger, depending on the actual cooler design.

Lubricating oil temperature control valve

The temperature control system can, by means of a three-way valve unit, by-pass the cooler totally or partly.

Lubricating oil viscosity, specified....75 cSt at 50 °C
Lubricating oil flow ....see ‘List of capacities’
Temperature range, inlet to engine ....40 - 47 °C

Lubricating oil full flow filter

Lubricating oil flow .... see 'List of capacities'
Working pressure .... 4.1 bar
Test pressure.................... according to class rules
Absolute fineness..40 μm*
Working temperature .... approximately 45 °C
Oil viscosity at working temp. .... 90 - 100 cSt
Pressure drop with clean filter .... maximum 0.2 bar
Filter to be cleaned
at a pressure drop....................... maximum 0.5 bar

** The absolute fineness corresponds to a nominal fineness of approximately 25 μm at a retaining rate of 90%.*

The flow capacity must be within a range from 100 to 112% of the capacity stated.

The full-flow filter should be located as close as possible to the main engine.

If a double filter (duplex) is installed, it should have sufficient capacity to allow the specified full amount of oil to flow through each side of the filter at a given working temperature with a pressure drop across the filter of maximum 0.2 bar (clean filter).

If a filter with a back-flushing arrangement is installed, the following should be noted:

- The required oil flow, specified in the 'List of capacities', should be increased by the amount of oil used for the back-flushing, so that the lubricating oil pressure at the inlet to the main engine can be maintained during cleaning.
- If an automatically cleaned filter is installed, it should be noted that in order to activate the cleaning process, certain makes of filter require a higher oil pressure at the inlet to the filter than the pump pressure specified. Therefore, the pump capacity should be adequate for this purpose, too.

Flushing of lube oil system

Before starting the engine for the first time, the lubricating oil system on board has to be cleaned in accordance with MAN Diesel's recommendations: 'Flushing of Main Lubricating Oil System', which is available on request.

Lubricating oil outlet

A protecting ring position 1-4 is to be installed if required, by class rules, and is placed loose on the tanktop and guided by the hole in the flange.

In the vertical direction it is secured by means of screw position 4, in order to prevent wear of the rubber plate.

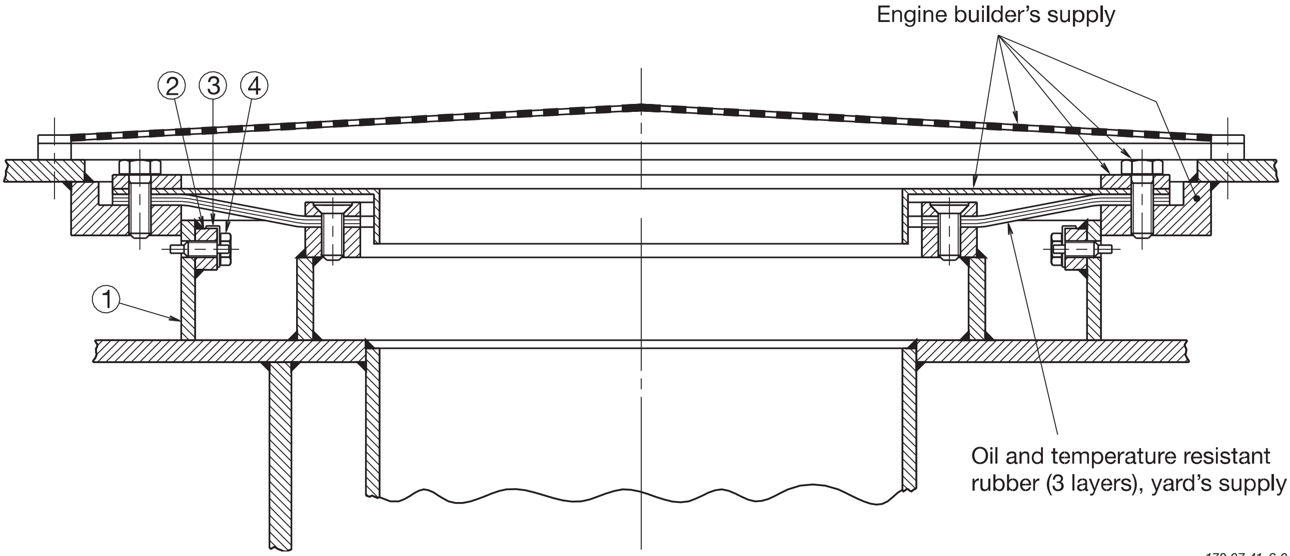
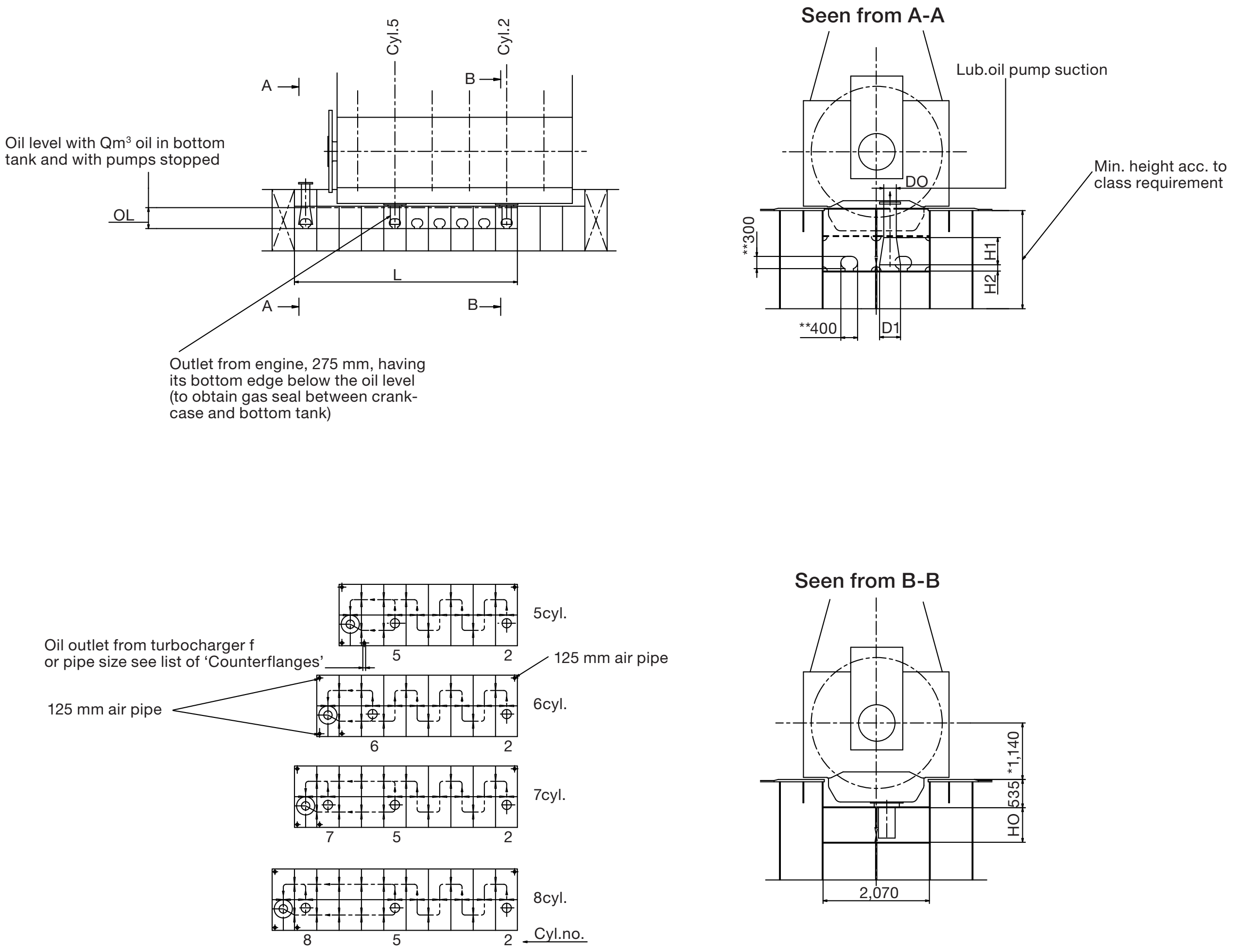


Fig. 8.05.01: Lubricating oil outlet

Lubricating Oil Tank



* Based on 55 mm thickness of supporting chocks
** Min. dimensions for manholes.

178 57 68-4.0

Fig. 8.06.01a: Lubricating oil tank, vertical outlet, with cofferdam

Note:
When calculating the tank heights, allowance has not been made for the possibility that a quantity of oil in the lubricating oil system outside the engine may be returned to the bottom tank, when the pumps are stopped.

If the system outside the engine is so designed that an amount of the lubricating oil is drained back to the tank, when the pumps are stopped, the height of the bottom tank indicated in Table 8.06.01b has to be increased to include this quantity. If space is limited, however, other solutions are possible.

Cylinder No.	Drain at cylinder No.	D0	D1	H0	H1	H2	L	OL	Qm^3
5	2-5	175	375	865	375	75	6,400	765	10.0
6	2-6	200	425	925	425	85	7,200	825	12.5
7	2-5-7	200	425	955	425	85	8,000	855	14.0
8	2-5-8	225	450	1,010	450	90	8,800	910	16.5

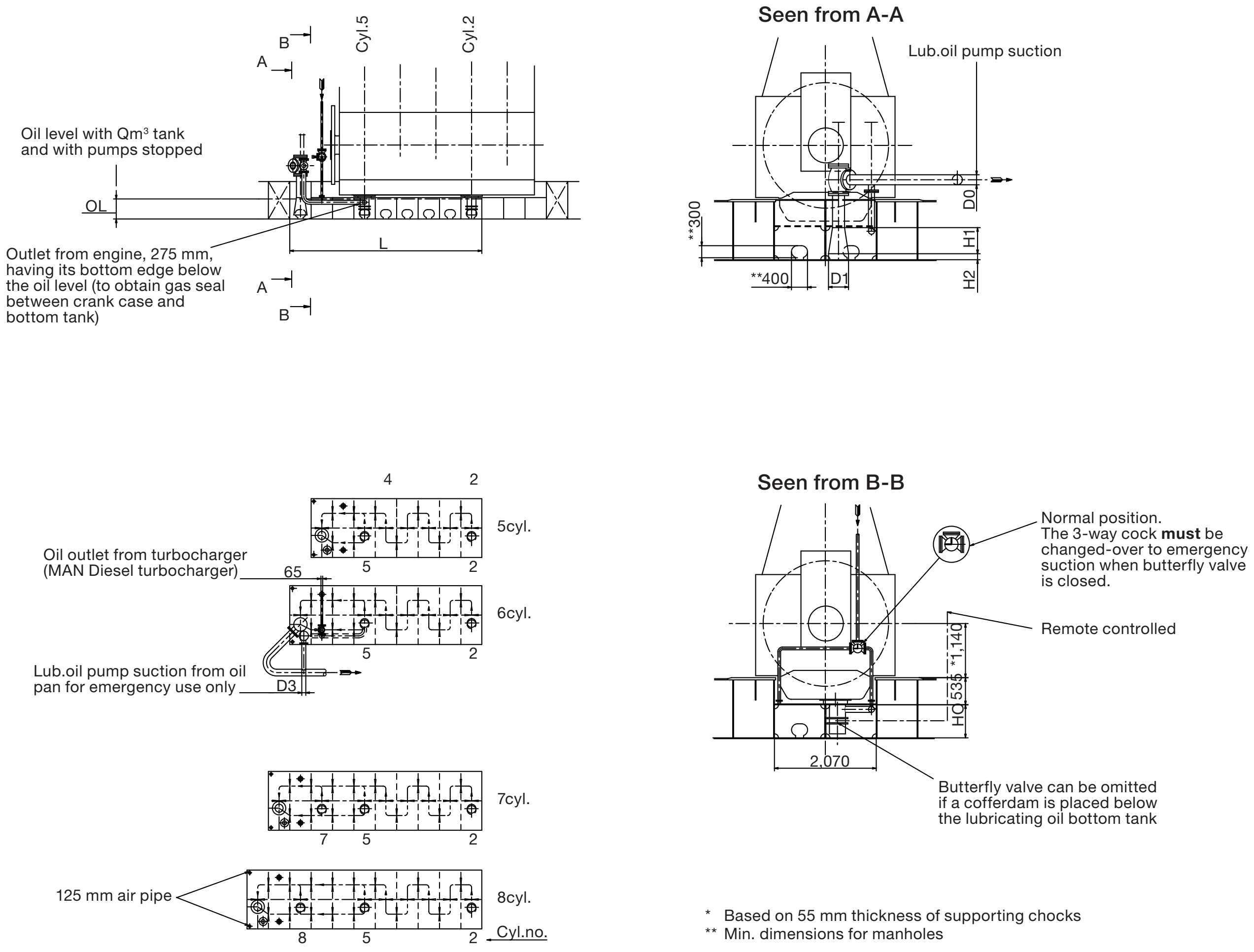
Table. 8.06.01b: Lubricating oil tank, vertical outlet, with cofferdam

Lubricating oil tank operating conditions

The lubricating oil bottom tank complies with the rules of the classification societies by operation under the following conditions:

Angle of inclination, degrees			
Athwartships		Fore and aft	
Static	Dynamic	Static	Dynamic
15	22.5	5	7.5

Lubricating Oil Tank



178 57 69-6.0

Fig. 8.06.02a: Lubricating oil tank, vertical outlet, without cofferdam

Note:
When calculating the tank heights, allowance has not been made for the possibility that a quantity of oil in the lubricating oil system outside the engine may be returned to the bottom tank, when the pumps are stopped.

If the system outside the engine is so designed that an amount of the lubricating oil is drained back to the tank, when the pumps are stopped, the height of the bottom tank indicated in Table 8.06.02b has to be increased to include this quantity. If space is limited, however, other solutions are possible.

Cylinder No.	Drain at cylinder No.	D0	D1	H0	H1	H2	L	OL	Qm³
5	2-5	175	375	865	375	75	6,400	765	10.0
6	2-5	200	425	925	425	85	7,200	825	12.5
7	2-5-7	200	425	955	425	85	8,000	855	14.0
8	2-5-8	225	450	1,010	450	90	8,800	910	16.5

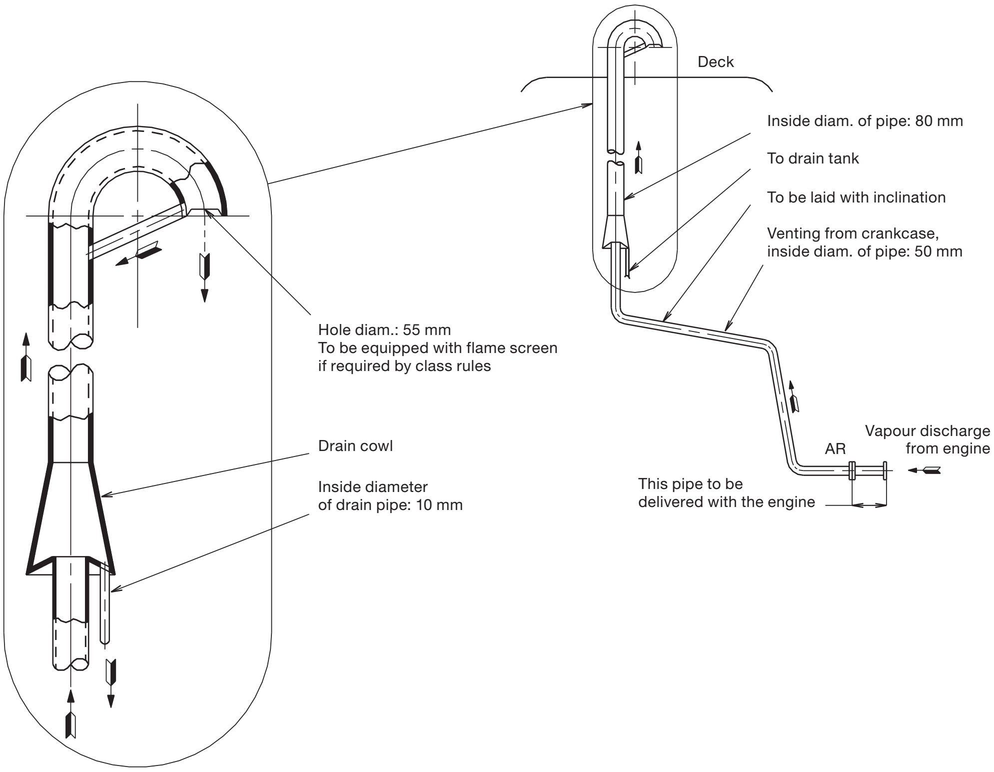
Table 8.06.02b: Lubricating oil tank, vertical outlet, without cofferdam

Lubricating oil tank operating conditions

The lubricating oil bottom tank complies with the rules of the classification societies by operation under the following conditions:

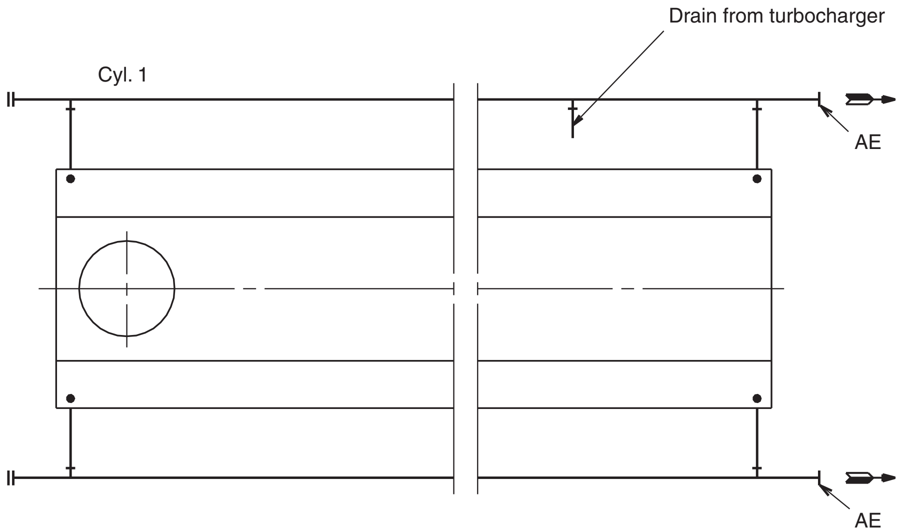
Angle of inclination, degrees			
Athwartships		Fore and aft	
Static	Dynamic	Static	Dynamic
15	22.5	5	7.5

Crankcase Venting and Bedplate Drain Pipes



178 57 79-2.0

Fig. 8.07.01: Crankcase venting



178 57 61-1.0

Fig. 8.07.02: Bedplate drain pipes

Cylinder Lubrication

9

Cylinder Lubricating Oil System

The cost of the cylinder lubricating oil is one of the largest contributions to total operating costs, next to the fuel oil cost. Another aspect is that the lubrication rate has a great influence on the cylinder condition, and thus on the overhauling schedules and maintenance costs.

It is therefore of the utmost importance that the cylinder lubricating oil system as well as its operation is optimised.

Cylinder Lubricator and Service Tank

As standard the engine is specified with MAN B&W Alpha Cylinder Lubricators (EoD: 4 42 104). Alternatively a mechanical cylinder lubricator driven by the engine can be installed.

The cylinder lube oil is supplied from a gravity-feed cylinder oil service tank to where it is being pumped from the cylinder oil storage tank. The size of the cylinder oil service tank depends on the owner's and yard's requirements, and it is normally dimensioned for minimum two days' consumption.

The cylinder lubricating oil consumption could be monitored by installing a flow meter on the pressure side of the pump in the supply line to the service tank, if required by the shipowner. Provided the oil level in the service tank is kept the same every time the flow meter is being read, the accuracy is satisfactory.

A cylinder lubricating oil supply system for engine plants with MAN B&W Alpha Cylinder lubricators is shown in Fig. 9.02.02 and for plants with mechanical cylinder lubricators in Fig. 9.03.03. In both cases a dual system for supply of two different BN cylinder oils is shown.

Cylinder Oils

Cylinder oils should, preferably, be of the SAE 50 viscosity grade.

Modern high-rated two-stroke engines have a relatively great demand for detergency in the cylinder oil. Therefore cylinder oils should be chosen according to the below list.

A BN 70 cylinder oil is to be used as the default choice of oil and it may be used on all fuel types. However, in case of the engine running on fuel with sulphur content lower than 1.5 % for more than 1 to 2 weeks, we recommend to change to a lower BN cylinder oil such as BN 40-50.

The cylinder oils listed below have all given long-term satisfactory service during heavy fuel operation in MAN B&W engine installations:

Company	**Cylinder oil SAE 50/BN 70**	**Cylinder oil SAE 50/BN 40-50**
BP	CLO-50 M	CL/CL-DX 405
Castrol	Cyltech 70	CL/CL-DX 405
Chevron	Delo Cyloil Special	Taro Special HT 50
Exxon	Exxmar X 70	Mobilgard L540
Mobil	Mobilgard 570	Mobilgard L540
Shell	Alexia 50	Alexia LS
Texaco	Taro Special HT 70	Taro Special HT 50
Total	Talusia HR70	Talusia LS 40

Also other brands have been used with satisfactory results.

Cylinder Oil Feed Rate (Dosage)

The recommendations are valid for all plants, whether controllable pitch or fixed pitch propellers are used.

In case of average sulphur content, the average cylinder oil feed rate at nominal MCR for MAN B&W Alpha Cylinder Lubricator is 0.7 g/kWh. Adjustment of the cylinder oil dosage of the MAN B&W Alpha Cylinder Lubricator to the sulphur content in the fuel being burnt is further explained in section 9.02.

The nominal cylinder oil feed rate at nominal MCR for a mechanical cylinder lubricator is typically 1.0 - 1.5 g/kWh.

MAN B&W Alpha Cylinder Lubrication System

The MAN B&W Alpha cylinder lubrication system, see Figs. 9.02.02 and 9.02.03, is designed to supply cylinder oil intermittently, every 2 to 20 engine revolutions with electronically controlled timing and dosage at a defined position.

Cylinder lubricating oil is fed to the engine by means of a pump station which as standard is mounted on the engine (EoD: 4 42 150) or could be placed in the engine room (option: 4 42 152).

The pump station has two pumps (one operating, the other stand-by with automatic start up) with in-line filters and a heater, see Fig. 9.02.02.

The oil fed to the injectors is pressurised by means of one or two Alpha Lubricators placed on each cylinder and equipped with small multi-piston pumps, see Fig. 9.02.03.

Accumulator tanks on the lubricator inlet pipes ensure adequate filling of the lubricator while accumulators on the outlet pipes serve to dampen the pressure fluctuations. The oil pipes fitted on the engine is shown in Fig. 9.02.03.

On engines with double lubricators, a by-pass valve allows for circulating and heating the cylinder oil before starting the engine under cold engine room conditions. On engines with one lubricator per cylinder, this is done by means of the valve on the cylinderblock intended for emptying the accumulator.

Prior to start-up, the cylinders can be pre-lubricated and, during the running-in period, the operator can choose to increase the lubricating oil feed rate to a max. setting of 200%.

System control units

The cylinder lubrication system is controlled by the Master Control Unit (MCU) which calculates the injection frequency on the basis of the engine-speed signal given by the tacho signal (ZE) and the fuel index.

Lubricating control functions such as ‘mep dependent’ and ‘load change dependent’ are all incorporated in the MAN B&W Alpha cylinder lubrication system.

The MAN B&W Alpha Cylinder Lubricator is preferably to be controlled in accordance with the Alpha Adaptive Cylinder oil Control (Alpha ACC) feed rate system. The Alpha ACC is explained in the following page.

The MCU is equipped with a Backup Control Unit (BCU) which, if the MCU malfunctions, activates an alarm and takes control automatically or manually, via a Switch Board Unit (SBU), Fig. 9.02.04.

The MCU, BCU and SBU together comprise the Alpha Cylinder Lubricator Control Unit (ALCU) in shape of a single steel cabinet which is, as standard, located in the Engine Control Room. Fig. 9.02.05 shows the wiring diagram for the MAN B&W Alpha Cylinder Lubrication System.

The yard supply should be according to the items shown in Fig. 9.02.02 within the broken line.

Alpha Adaptive Cylinder oil Control (Alpha ACC)

It is a well-known fact that the actual need for cylinder oil quantity varies with the operational conditions such as load and fuel oil quality. Consequently, in order to perform the optimal lubrication – cost-effectively as well as technically – the cylinder lubricating oil dosage should follow such operational variations accordingly.

The Alpha lubricating system offers the possibility of saving a considerable amount of cylinder lubricating oil per year and, at the same time, to obtain a safer and more predictable cylinder condition.

The name of the algorithm which controls the cylinder oil dosage proportional to the sulphur content in the fuel is Alpha Adaptive Cylinder oil Control, Alpha ACC.

Working Principle

The basic feed rate control should be adjusted in relation to the actual fuel quality and amount being burnt at any given time. The sulphur percentage is a good indicator in relation to wear, and an oil dosage proportional to the sulphur level will give the best overall cylinder condition.

The following two criteria determine the control:

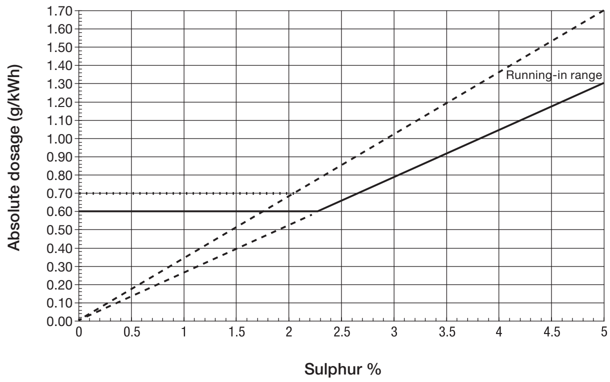
- The cylinder oil dosage shall be proportional to the sulphur percentage in the fuel
- The cylinder oil dosage shall be proportional to the engine load (i.e. the amount of fuel entering the cylinders).

The implementation of the above two criteria will lead to an optimal cylinder oil dosage, proportional to the amount of sulphur entering the cylinders.

Safe and very lubricating-economical control after running-in is obtained with a basic setting according to the formula:

Basic lubricating oil setting = 0,26 g/kWh x S%

with a minimum setting of 0,60 g/kWh, i.e. the setting should be kept constant from about 2.3% sulphur and downwards.

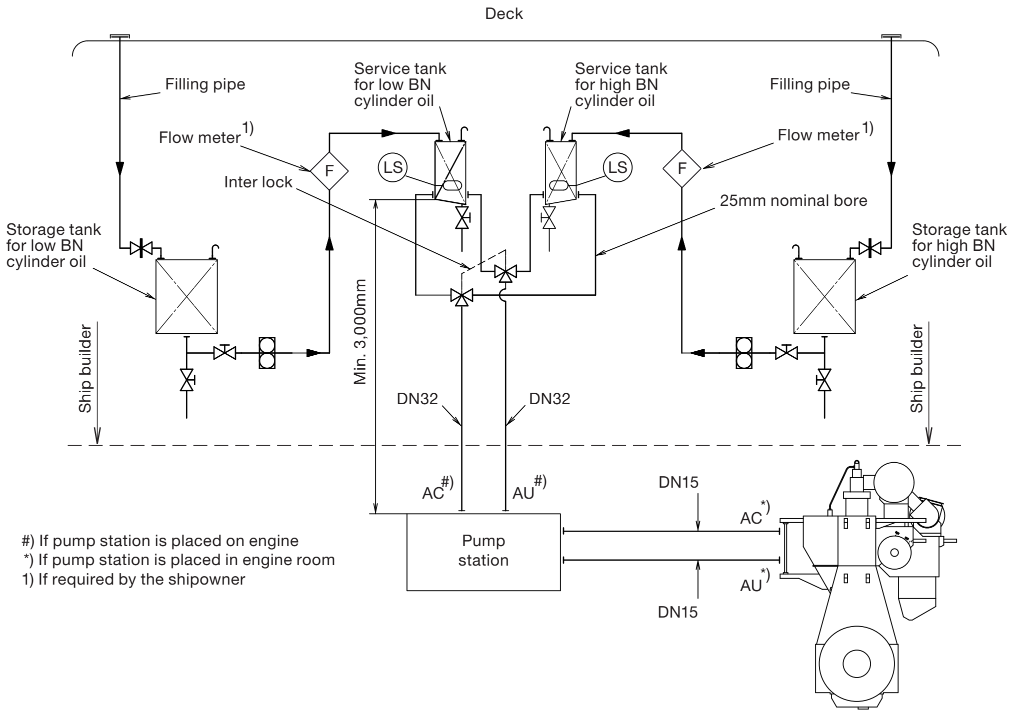


178 59 49-4.0

Fig 9.02.01: Cylinder lubricating oil dosage with Alpha ACC at nominal MCR (BN 70 cylinder oil)

Due to the sulphur dependency, the average cylinder oil dosages rely on the sulphur distribution in worldwide fuel bunkers. Based on deliveries all over the world, the resulting yearly specific cylinder oil dosage is close to 0.7 g/kWh.

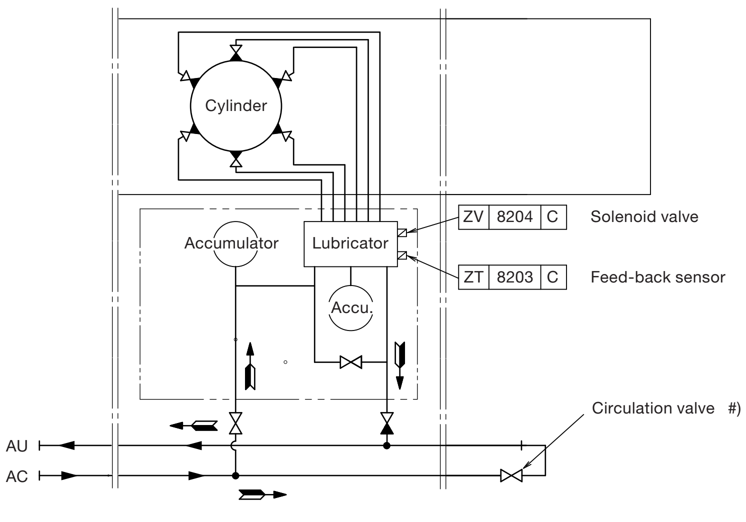
Pump Station and MAN B&W Alpha Cylinder Lubricators on Engine



The letters refer to list of 'Counterflanges'
The item No. refer to 'Guidance values Automation'

078 78 46-0.0.0c

Fig. 9.02.02: Cylinder lubricating oil supply system for two different BN oils



The letters refer to list of 'Counterflanges'
The item No. refer to 'Guidance values Automation'

#) In case of COLD engine room conditions, open the valve to circulate and heat up the cylinder oil. The valve is then to be closed before starting.

121 36 61-8.4.0c

Fig. 9.02.03: MAN B&W Alpha cylinder lubricators with piping and instrumentation on engine

Lubricator control system

The external electrical system must be capable of providing the MCU and BCU with an un-interruptible supply of 24 Volt DC power.

The MAN B&W Alpha Cylinder Lubricator System is equipped with the following (Normally Closed) alarms:

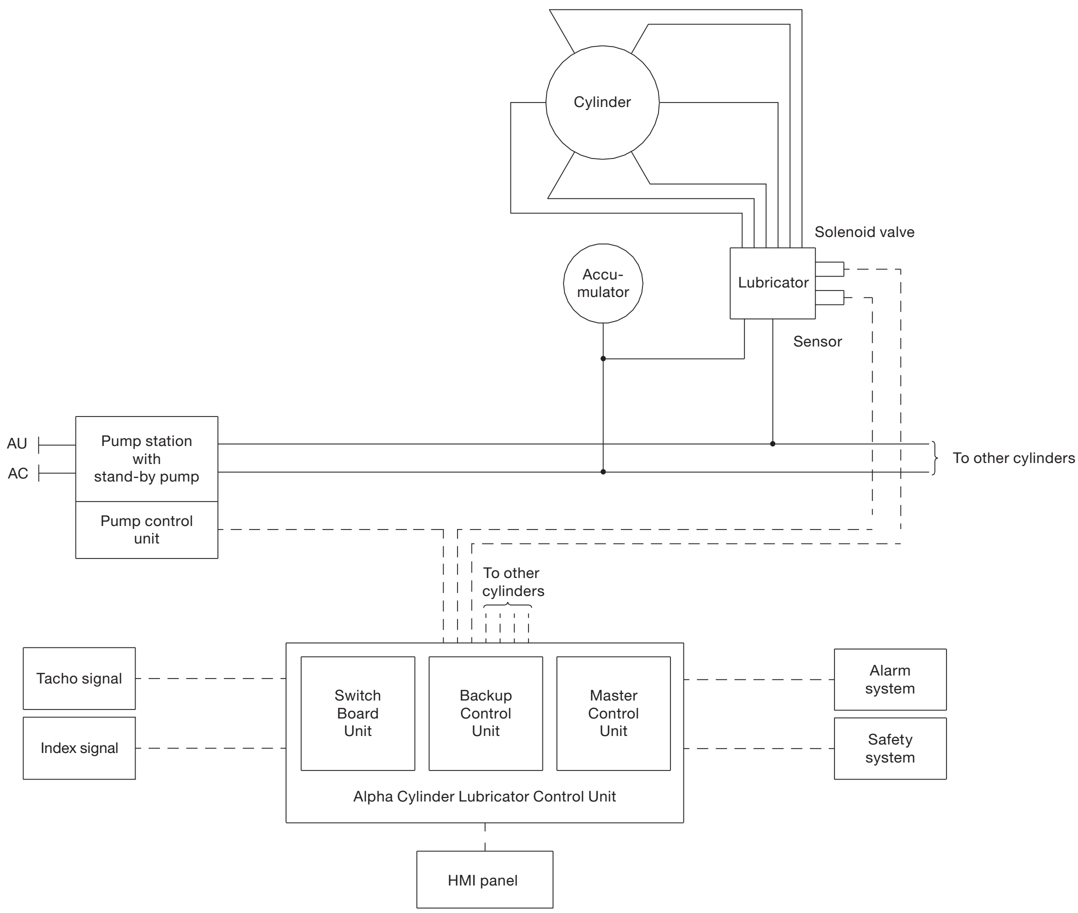
- MCU fail
- MCU power fail
- MCU common alarm
- BCU in control
- BCU fail
- BCU power fail

and slow down (Normally Open) for:

- Electronic cylinder lubricator system

The system has a connection for coupling it to a computer system or a Display Unit (HMI panel) so that engine speed, fuel index, injection frequency, alarms, etc. can be monitored.

The HMI panel for mounting in Engine Control Room (option: 4 42 660) or on the engine (option: 4 42 160) can be delivered separately.



For the actual number of cylinder lubrication points on the specific engine see Fig. 9.02.03

178 47 13-9.3

Fig. 9.02.04: Control of the MAN B&W Alpha Cylinder Lubrication System, one lubricator per cylinder

Wiring Diagram

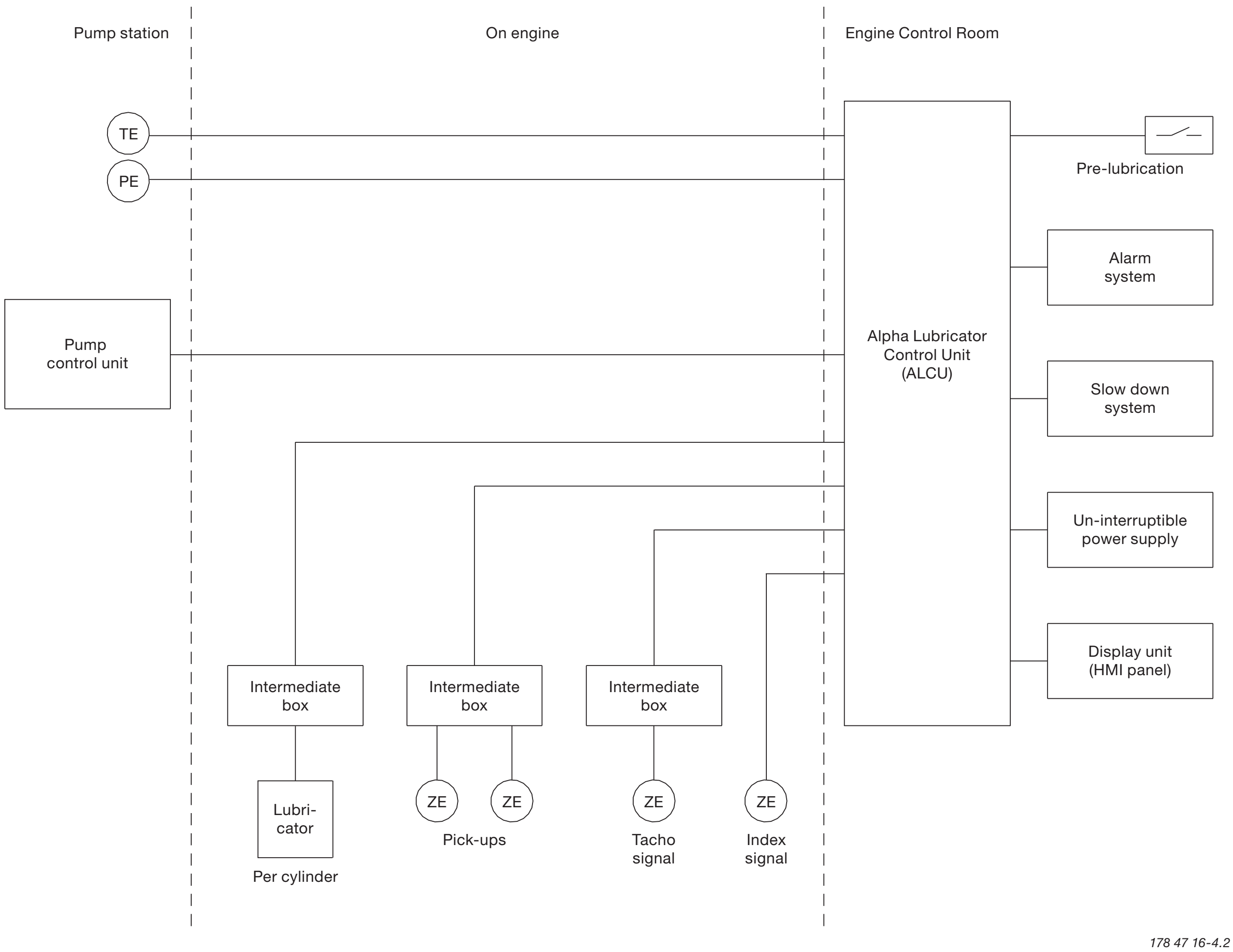


Fig. 9.02.05: Wiring diagram for MAN B&W Alpha Cylinder Lubrication System, one lubricators per cylinder

Mechanical Cylinder Lubricators

Mechanical cylinder lubricator(s), can be mounted on the fore end of the engine, the size of which will decide the number of lubricators needed. If driven by the engine in sync with the crankshaft movement, the lubricators could deliver timed injection of the cylinder lubrication oil.

The lubricator(s) should have a built-in capability for adjustment of the oil quantity and be provided with a sight glass for each lubricating point.

The lubricators should be fitted with:

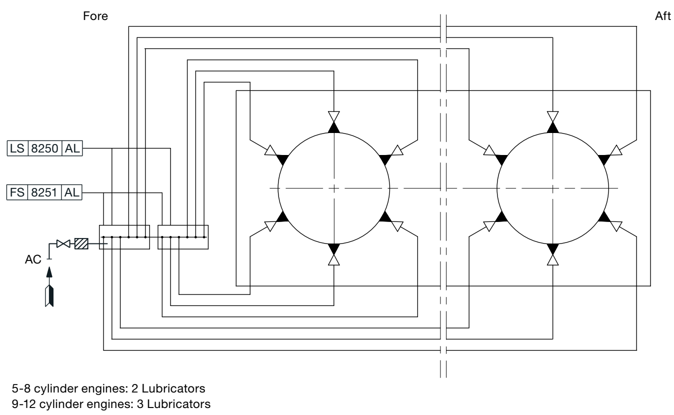
- Electric heating coils
- Low flow and low level alarms.

In the 'Engine Speed Dependent' design, the lubricator pumps a fixed amount of oil to the cylinders for each engine revolution.

Mainly for plants with controllable pitch propeller, the lubricators could, alternatively, be fitted with a mechanical lubrication system which controls the dosage in proportion to the Mean Effective Pressure (MEP).

An 'Engine Speed Dependent' as well as a 'MEP Dependent' mechanical lubricator could be equipped with a 'Load Change Dependent' system, by which the cylinder feed oil rate is automatically increased during starting, manoeuvring and, preferably, during sudden load changes, see Fig. 9.03.02.

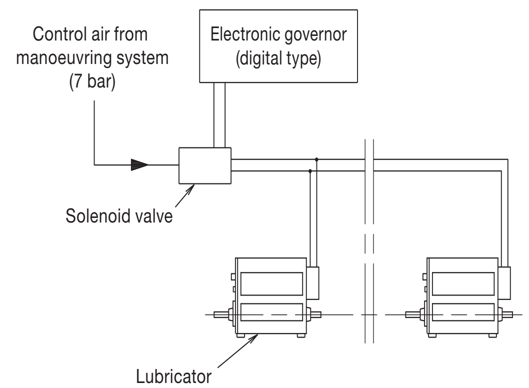
In that case, the signal for the 'Load Change Dependent' system comes from the electronic governor.



The letters refer to list of 'Counterflanges'
The piping is delivered with and fitted onto the engine

178 57 71-8.0

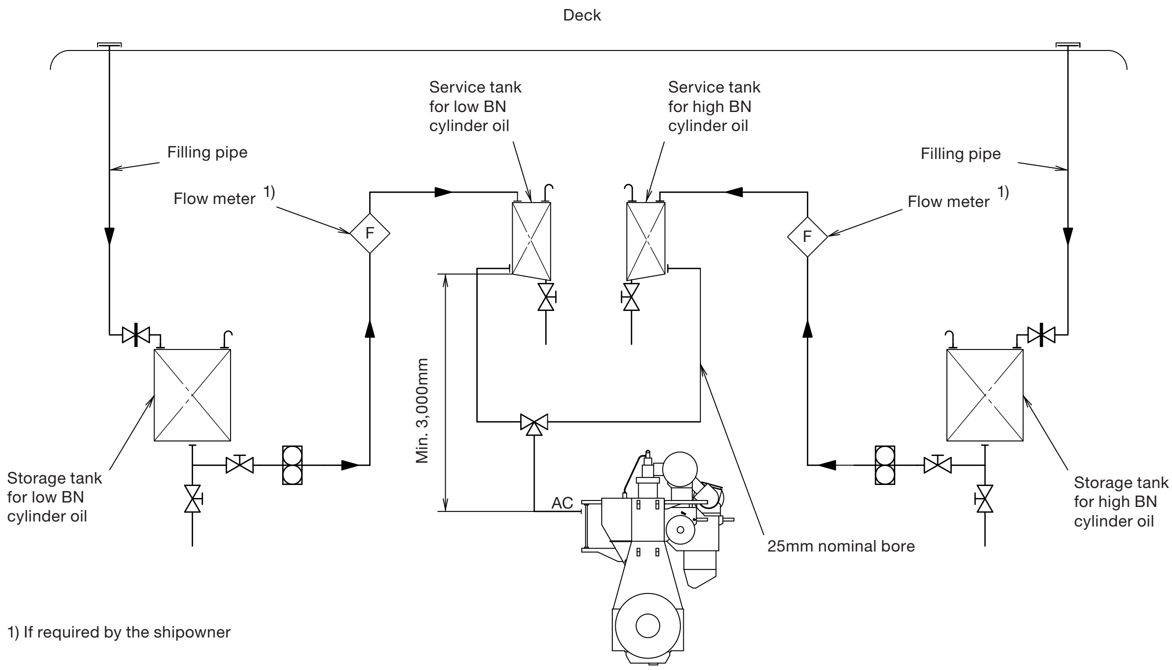
Fig 9.03.01: Piping and instrumentation for a mechanical cylinder lubricator



178 59 50-4.0

Fig 9.03.02: Load change dependent mechanical lubricator

Cylinder Lubricating Oil Supply System



The letters refer to list of 'Counterflanges'

078 78 45-9.0.0

Fig. 9.03.03: Cylinder lubricating oil supply system for two different BN cylinder oils, for mechanical lubricators

Piston Rod Stuffing Box Drain Oil

10

Stuffing Box Drain Oil System

For engines running on heavy fuel, it is important that the oil drained from the piston rod stuffing boxes is not led directly into the system oil, as the oil drained from the stuffing box is mixed with sludge from the scavenge air space.

The performance of the piston rod stuffing box on the engines has proved to be very efficient, primarily because the hardened piston rod allows a higher scraper ring pressure.

The amount of drain oil from the stuffing boxes is about 5 - 10 litres/24 hours per cylinder during normal service. In the running-in period, it can be higher.

The relatively small amount of drain oil is led to the general oily waste drain tank or is burnt in the incinerator, Fig. 10.01.01.

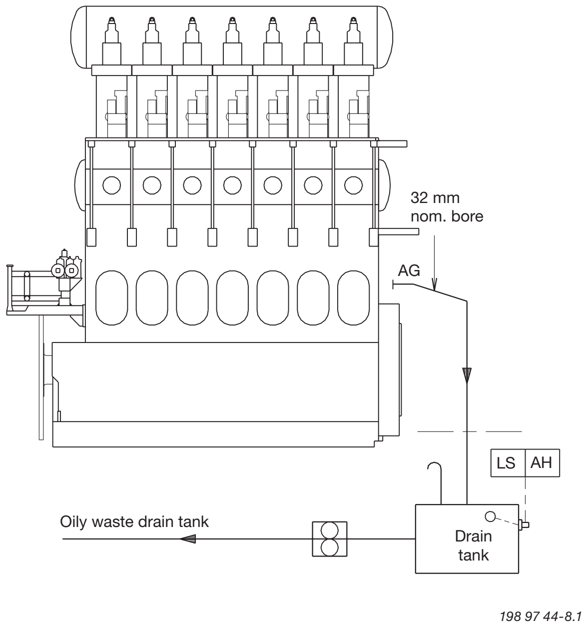


Fig. 10.01.01: Stuffing box drain oil system

Central Cooling Water System

11

Central Cooling Water System

The water cooling can be arranged in several configurations, the most common system choice being a Central cooling water system.

Advantages of the central cooling system:

- Only one heat exchanger cooled by seawater, and thus, only one exchanger to be overhauled
- All other heat exchangers are freshwater cooled and can, therefore, be made of a less expensive material
- Few non-corrosive pipes to be installed
- Reduced maintenance of coolers and components
- Increased heat utilisation.

Disadvantages of the central cooling system:

- Three sets of cooling water pumps (seawater, central water and jacket water.
- Higher first cost.

For information on the alternative Seawater Cooling System, see Chapter 12.

An arrangement common for the main engine and MAN Diesel auxiliary engines is available on request.

For further information about common cooling water system for main engines and auxiliary engines please refer to our publication:

Uni-concept Auxiliary Systems for Two-stroke Main

The publication is available at www.mandiesel.com under ‘Quicklinks’ → ‘Technical Papers’

Central Cooling Water System

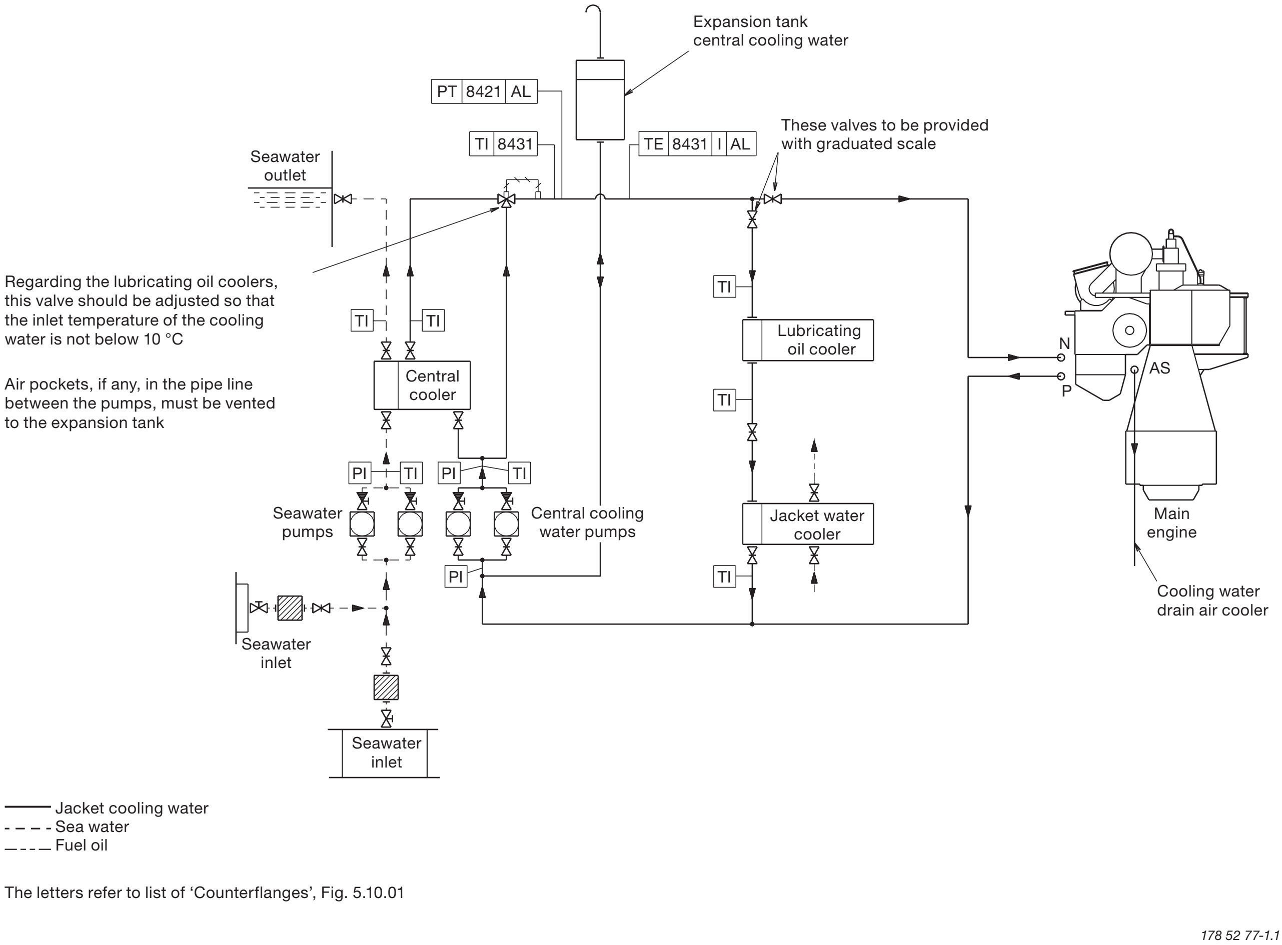


Fig. 11.02.01: Central cooling water system

The central cooling water system is characterised by having only one heat exchanger cooled by seawater, and by the other coolers, including the jacket water cooler, being cooled by central cooling water.

In order to prevent too high a scavenge air temperature, the cooling water design temperature in the central cooling water system is normally 36 °C, corresponding to a maximum seawater temperature of 32 °C.

Our recommendation of keeping the cooling water inlet temperature to the main engine scavenge air cooler as low as possible also applies to the central cooling system. This means that the temperature control valve in the central cooling water circuit is to be set to minimum 10 °C, whereby the temperature follows the outboard seawater temperature when central cooling water temperature exceeds 10 °C.

For external pipe connections, we prescribe the following maximum water velocities:

Jacket water .... 3.0 m/s
Central cooling water .... 3.0 m/s
Seawater .... 3.0 m/s

Components for Central Cooling Water System

Seawater cooling pumps

The pumps are to be of the centrifugal type.

Seawater flow .... see 'List of capacities'
Pump head ....2.5 bar
Test pressure .... according to class rules
Working temperature, normal ....0-32 °C
Working temperature .... maximum 50 °C

The capacity is to be within a tolerance of 0% to +10%.

The differential pressure of the pumps is to be determined on the basis of the total actual pressure drop across the cooling water system.

Central cooler

The cooler is to be of the shell and tube or plate heat exchanger type, made of seawater resistant material.

Heat dissipation .... see 'List of capacities'
Central cooling water flow ...... see 'List of capacities'
Central cooling water temperature, outlet .... 36 °C
Pressure drop on central cooling side .... max. 0.2 bar
Seawater flow .... see 'List of capacities'
Seawater temperature, inlet .... 32 °C
Pressure drop on
seawater side .... maximum 0.2 bar

The pressure drop may be larger, depending on the actual cooler design.

The heat dissipation and the seawater flow figures are based on MCR output at tropical conditions, i.e. a seawater temperature of 32 °C and an ambient air temperature of 45 °C.

Overload running at tropical conditions will slightly increase the temperature level in the cooling system, and will also slightly influence the engine performance.

Central cooling water pumps

The pumps are to be of the centrifugal type.

Central cooling water flow .... see 'List of capacities'
Pump head ....2.5 bar
Delivery pressure .... depends on location of expansion tank
Test pressure .... according to class rules
Working temperature .... 80 °C
Design temperature .... 100 °C

The flow capacity is to be within a tolerance of 0% to +10%.

The list of capacities covers the main engine only. The differential pressure provided by the pumps is to be determined on the basis of the total actual pressure drop across the cooling water system.

Central cooling water thermostatic valve

The low temperature cooling system is to be equipped with a three-way valve, mounted as a mixing valve, which by-passes all or part of the fresh water around the central cooler.

The sensor is to be located at the outlet pipe from the thermostatic valve and is set so as to keep a temperature level of minimum 10 °C.

Jacket water system

Due to the central cooler the cooling water inlet temperature is about 4 °C higher for for this system compared to the seawater cooling system. The input data are therefore different for the scavenge air cooler, the lube oil cooler and the jacket water cooler.

The heat dissipation and the central cooling water flow figures are based on an MCR output at tropical conditions, i.e. a maximum seawater temperature of 32 °C and an ambient air temperature of 45 °C.

Jacket water cooling pump

The pumps are to be of the centrifugal type.
Jacket water flow .... see 'List of capacities'
Pump head .... 3.0 bar
Delivery pressure .... depends on location of expansion tank
Test pressure.................... according to class rules
Working temperature .... 80 °C
Design temperature .... 100 °C

The flow capacity is to be within a tolerance of 0% to +10%.

The stated of capacities cover the main engine only. The pump head of the pumps is to be determined on the basis of the total actual pressure drop across the cooling water system.

Scavenge air cooler

The scavenge air cooler is an integrated part of the main engine.

Heat dissipation .... see 'List of capacities'
Central cooling water flow .... see 'List of capacities'
Central cooling temperature, inlet .... 36 °C
Pressure drop on FW-LT water side .... approx. 0.5 bar

Lubricating oil cooler

See chapter 8 'Lubricating Oil'.

Jacket water cooler

The cooler is to be of the shell and tube or plate heat exchanger type.

Heat dissipation .... see 'List of capacities'
Jacket water flow .... see 'List of capacities'
Jacket water temperature, inlet .... 80 °C
Pressure drop on jacket water side ... max. 0.2 bar
Central cooling water flow .... see 'List of capacities'
Central cooling water temperature, inlet .... approx. 42 °C
Pressure drop on Central cooling water side .... max. 0.2 bar

The other data for the jacket cooling water system can be found in chapter 12.

For further information about a common cooling water system for main engines and MAN Diesel auxiliary engines, please refer to our publication:

Uni-concept Auxiliary Systems for Two-stroke Main

The publication is available at www.mandiesel.com under 'Quicklinks' → 'Technical Papers'

Seawater Cooling System

12

Seawater Systems

The water cooling can be arranged in several configurations, the most simple system choices being seawater and central cooling water system:

- A **seawater cooling system** and a jacket cooling water system

- The advantages of the seawater cooling system are mainly related to first cost, viz:

- Only two sets of cooling water pumps (seawater and jacket water)

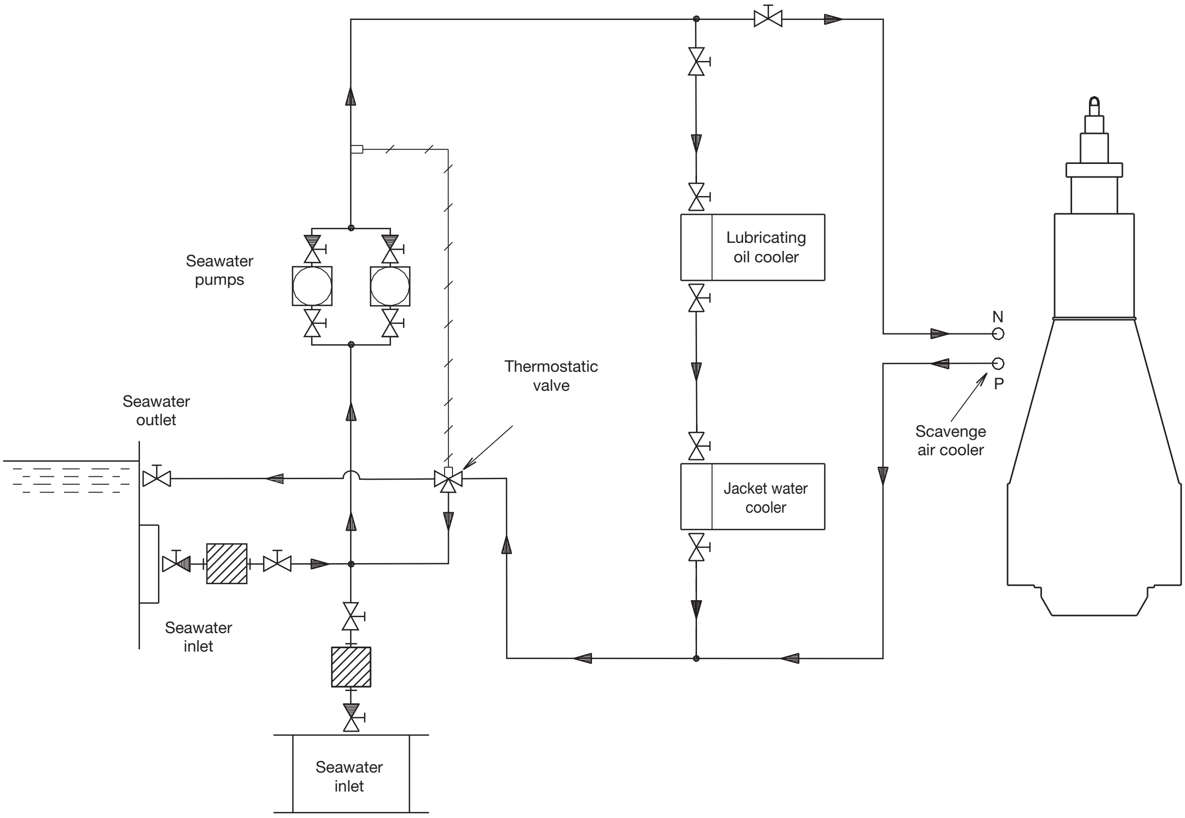
- Simple installation with few piping systems.

Whereas the disadvantages are:

- Seawater to all coolers and thereby higher maintenance cost

- Expensive seawater piping of non-corrosive materials such as galvanised steel pipes or Cu-Ni pipes.

Seawater Cooling System



The letters refer to list of 'Counterflanges'

Fig. 12.02.01: Seawater cooling system

The seawater cooling system is used for cooling, the main engine lubricating oil cooler, the jacket water cooler and the scavenge air cooler, see Fig. 12.02.01.

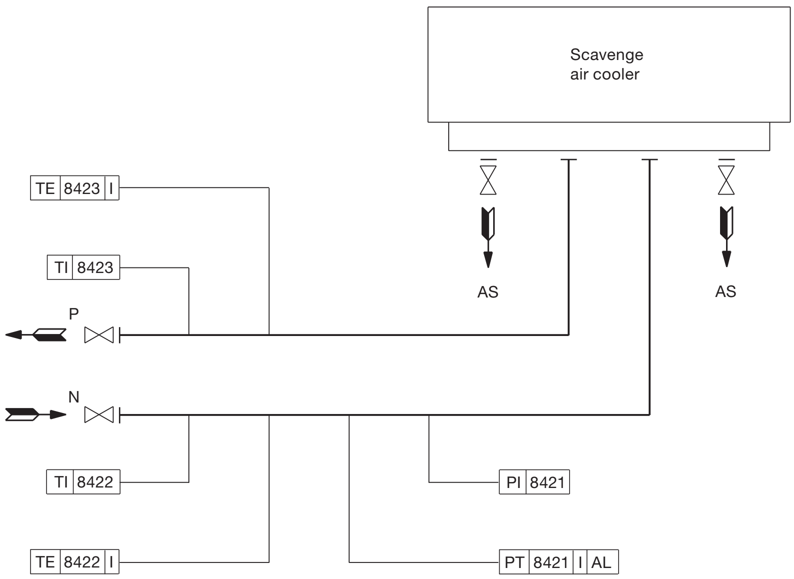
The lubricating oil cooler for a PTO step-up gear should be connected in parallel with the other coolers. The capacity of the seawater pump is based on the outlet temperature of the seawater being maximum 50 °C after passing through the coolers – with an inlet temperature of maximum 32 °C (tropical conditions), i.e. a maximum temperature increase of 18 °C.

The valves located in the system fitted to adjust the distribution of cooling water flow are to be provided with graduated scales.

The inter-related positioning of the coolers in the system serves to achieve:

- The lowest possible cooling water inlet temperature to the lubricating oil cooler in order to obtain the cheapest cooler. On the other hand, in order to prevent the lubricating oil from stiffening in cold services, the inlet cooling water temperature should not be lower than 10 °C
- The lowest possible cooling water inlet temperature to the scavenge air cooler, in order to keep the fuel oil consumption as low as possible.

Seawater Cooling Pipes



178 50 38-7.0

The letters refer to list of ‘Counterflanges’
The item No. refer to ‘Guidance values automation’

Fig. 12.03.01: Seawater cooling pipes for engines with one turbochargers

Components for Seawater Cooling System

Seawater cooling pump

The pumps are to be of the centrifugal type.

Seawater flow .... see 'List of capacities'
Pump head .... 2.5 bar
Test pressure .... according to class rule
Working temperature .... maximum 50 °C

The capacity must be fulfilled with a tolerance of between 0% to +10% and covers the cooling of the main engine only.

Lubricating oil cooler

See chapter 8 'Lubricating Oil'.

Jacket water cooler

The cooler is to be of the shell and tube or plate heat exchanger type, made of seawater resistant material.

Heat dissipation .... see 'List of capacities'
Jacket water flow .... see 'List of capacities'
Jacket water temperature, inlet .... 80 °C
Pressure drop
on jacket water side .... maximum 0.2 bar
Seawater flow .... see 'List of capacities'
Seawater temperature, inlet .... 38 °C
Pressure drop on
seawater side .... maximum 0.2 bar

The heat dissipation and the seawater flow are based on an MCR output at tropical conditions, i.e. seawater temperature of 32 °C and an ambient air temperature of 45 °C.

Scavenge air cooler

The scavenge air cooler is an integrated part of the main engine.

Heat dissipation .... see 'List of capacities'
Seawater flow .... see 'List of capacities'
Seawater temperature,
for seawater cooling inlet, max. .... 32 °C
Pressure drop on
cooling water side .... between 0.1 and 0.5 bar

The heat dissipation and the seawater flow are based on an MCR output at tropical conditions, i.e. seawater temperature of 32 °C and an ambient air temperature of 45 °C.

Seawater thermostatic valve

The temperature control valve is a three-way valve which can recirculate all or part of the seawater to the pump's suction side. The sensor is to be located at the seawater inlet to the lubricating oil cooler, and the temperature level must be a minimum of +10 °C.

Seawater flow .... see 'List of capacities'
Temperature range,
adjustable within .... +5 to +32 °C

Jacket Cooling Water System

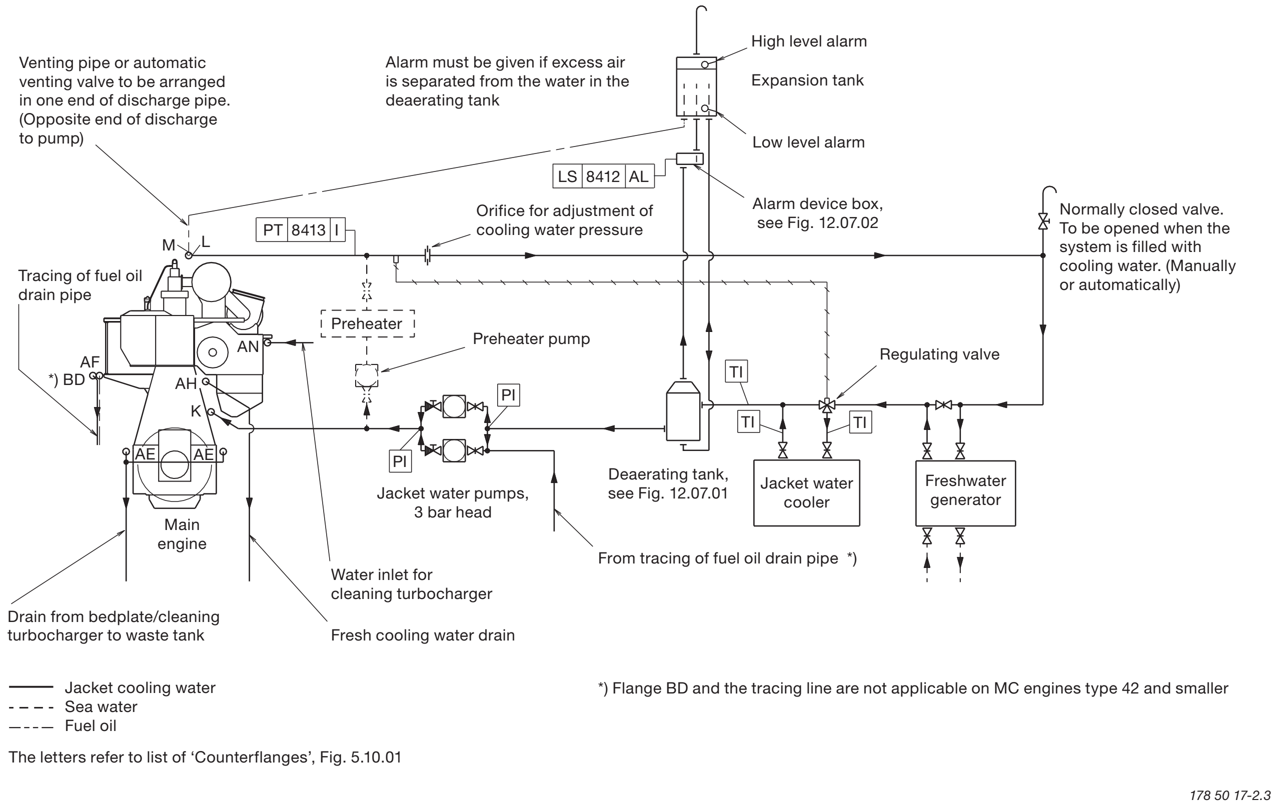


Fig. 12.05.01: Jacket cooling water system

The jacket cooling water system is used for cooling the cylinder liners, cylinder covers and exhaust valves of the main engine and heating of the fuel oil drain pipes, see Fig. 12.05.01.

The jacket water pump) draws water from the jacket water cooler outlet and delivers it to the engine.

At the inlet to the jacket water cooler there is a thermostatically controlled regulating valve, with a sensor at the engine cooling water outlet, which keeps the main engine cooling water outlet at a temperature of 80 °C.

The engine jacket water must be carefully treated, maintained and monitored so as to avoid corrosion, corrosion fatigue, cavitation and scale formation. It is recommended to install a preheater if preheating is not available from the auxiliary engines jacket cooling water system.

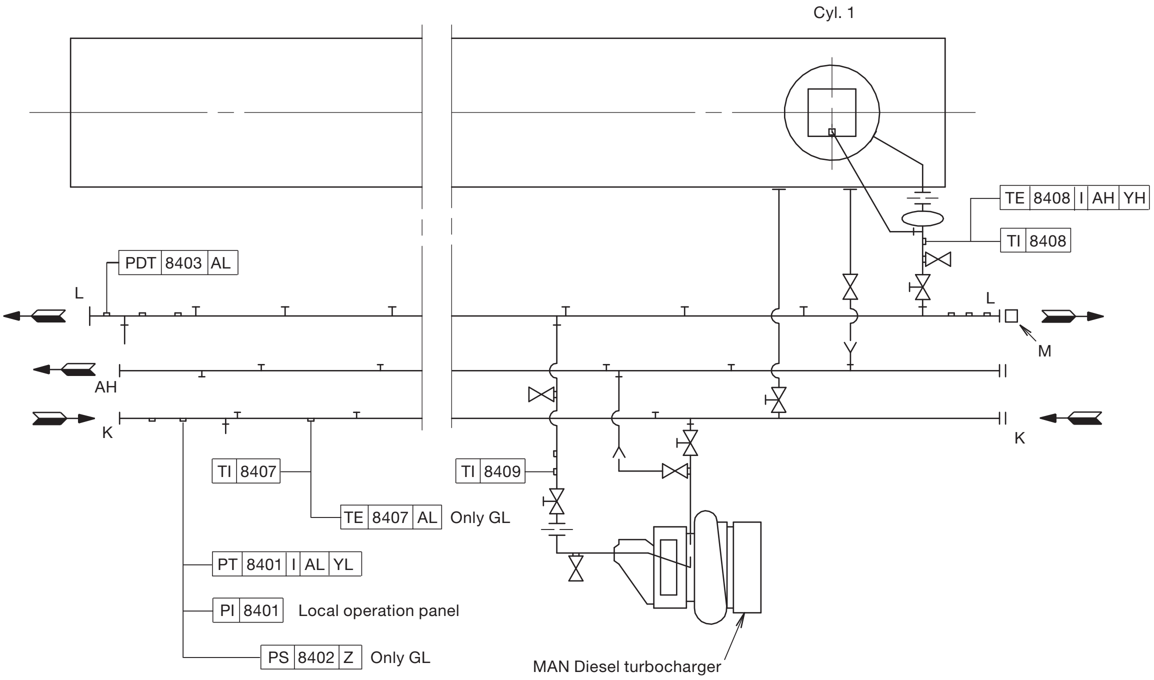
The venting pipe in the expansion tank should end just below the lowest water level, and the expansion tank must be located at least 5 m above the engine cooling water outlet pipe.

The freshwater generator, if installed, may be connected to the seawater system if the generator does not have a separate cooling water pump. The generator must be coupled in and out slowly over a period of at least 3 minutes.

For external pipe connections, we prescribe the following maximum water velocities:

Jacket water .... 3.0 m/s
Seawater .... 3.0 m/s

Jacket Cooling Water Pipes



178 57 93-4 .1

The letters refer to list of 'Counterflanges'
The item No. refer to 'Guidance values automation'

Fig. 12.06.01: Jacket cooling water pipes for engines with MAN Diesel turbochargers, type TCA, and ABB turbochargers, type TPL

Components for Jacket Cooling Water System

Jacket water cooling pump

The pumps are to be of the centrifugal type.

Jacket water flow ....see 'List of capacities'
Pump head ....3.0 bar
Delivery pressure ....depends on position of expansion tank
Test pressure...................... according to class rule
Working temperature, ... 80 °C, max. 100 °C
The capacity must be met at a tolerance of 0% to +10%.

The stated capacities cover the main engine only. The pump head of the pumps is to be determined based on the total actual pressure drop across the cooling water system.

Freshwater generator

If a generator is installed in the ship for production of freshwater by utilising the heat in the jacket water cooling system it should be noted that the actual available heat in the jacket water system is lower than indicated by the heat dissipation figures given in the 'List of capacities.' This is because the latter figures are used for dimensioning the jacket water cooler and hence incorporate a safety margin which can be needed when the engine is operating under conditions such as, e.g. overload. Normally, this margin is 10% at nominal MCR.

The calculation of the heat actually available at specified MCR for a derated diesel engine is stated in chapter 6 'List of capacities'.

For illustration of installation of fresh water generator see Fig. 12.05.01.

Jacket water thermostatic valve

The temperature control system is equipped with a three-way valve mounted as a diverting valve, which by-pass all or part of the jacket water around the jacket water cooler.

The sensor is to be located at the outlet from the main engine, and the temperature level must be adjustable in the range of 70-90 °C.

Jacket water preheater

When a preheater, see Fig. 12.05.01, is installed in the jacket cooling water system, its water flow, and thus the preheater pump capacity, should be about 10% of the jacket water main pump capacity.

Based on experience, it is recommended that the pressure drop across the preheater should be approx. 0.2 bar. The preheater pump and main pump should be electrically interlocked to avoid the risk of simultaneous operation.

The preheater capacity depends on the required preheating time and the required temperature increase of the engine jacket water. The temperature and time relations are shown in Fig. 12.08.01.

In general, a temperature increase of about 35 °C (from 15 °C to 50 °C) is required, and a preheating time of 12 hours requires a preheater capacity of about 1% of the engine`s nominal MCR power.

Deaerating tank

Design and dimensions of the deaerating tank are shown in Fig. 12.07.01 'Deaerating tank' and the corresponding alarm device is shown in Fig. 12.07.02 'Deaerating tank, alarm device'.

Expansion tank

The total expansion tank volume has to be approximate 10% of the total jacket cooling water amount in the system.

Fresh water treatment

The MAN Diesel recommendations for treatment of the jacket water/freshwater are available on request.

Deaerating tank

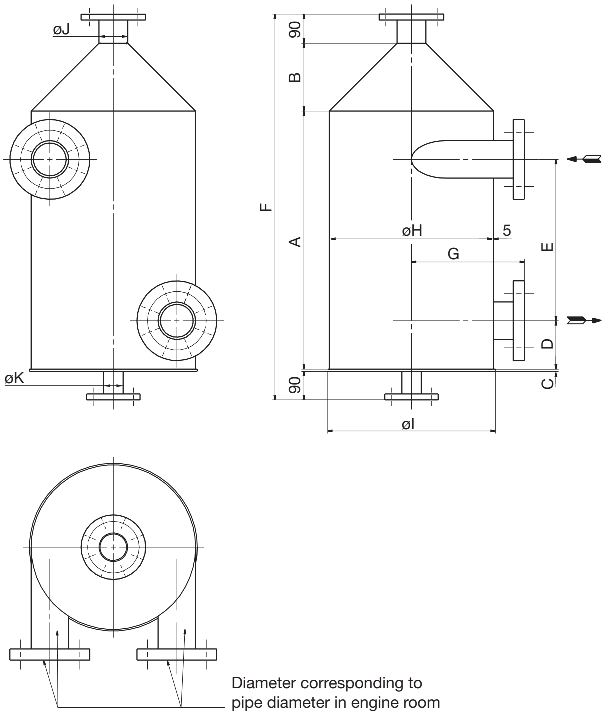


Fig. 12.07.01: Deaerating tank, option: 4 46 640

Deaerating tank dimensions	
Tank size	0.05 m^3
Max. jacket water capacity	120 m^3/h
	Dimensions in mm
Max. nominal diameter	125
A	600
B	125
C	5
D	150
E	300
F	910
G	250
øH	300
øI	320
øJ	ND 50
øK	ND 32

ND: Nominal diameter

Working pressure is according to actual piping arrangement.

In order not to impede the rotation of water, the pipe connection must end flush with the tank, so that no internal edges are protruding.

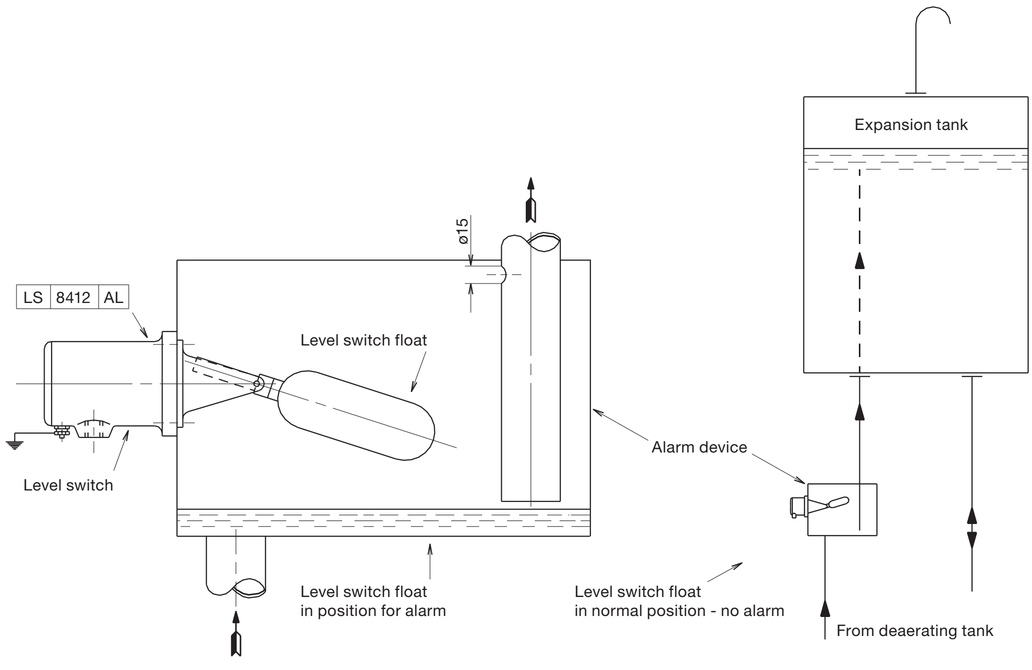


Fig. 12.07.02: Deaerating tank, alarm device, option: 4 46 645

Temperature at Start of Engine

In order to protect the engine, some minimum temperature restrictions have to be considered before starting the engine and, in order to avoid corrosive attacks on the cylinder liners during starting.

Normal start of engine

Normally, a minimum engine jacket water temperature of 50 °C is recommended before the engine is started and run up gradually to 90% of specified MCR speed.

For running between 90% and 100% of specified MCR speed, it is recommended that the load be increased slowly – i.e. over a period of 30 minutes.

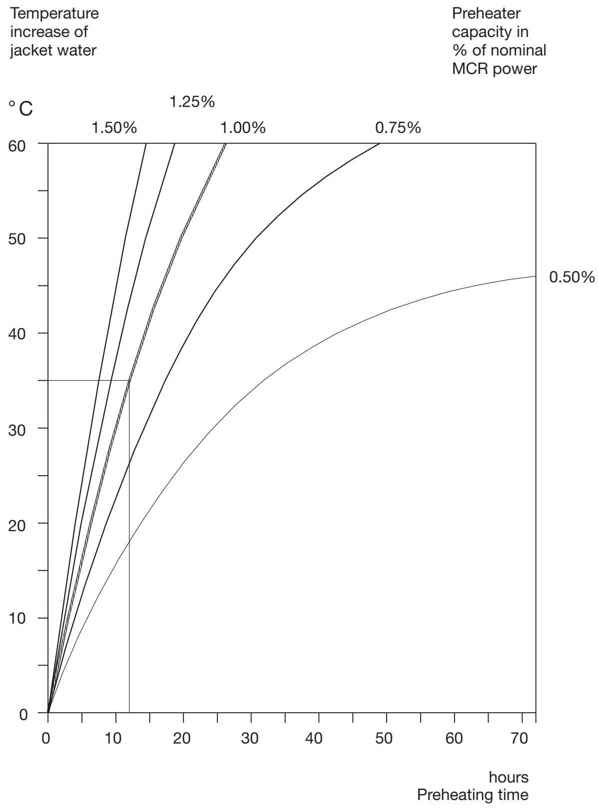
Start of cold engine

In exceptional circumstances where it is not possible to comply with the above-mentioned recommendation, a minimum of 20 °C can be accepted before the engine is started and run up slowly to 90% of specified MCR speed.

However, before exceeding 90% specified MCR speed, a minimum engine temperature of 50 °C should be obtained and, increased slowly – i.e. over a period of at least 30 minutes.

The time period required for increasing the jacket water temperature from 20 °C to 50 °C will depend on the amount of water in the jacket cooling water system, and the engine load.

Note:
The above considerations are based on the assumption that the engine has already been well run-in.



178 16 63-1.0

Fig. 12.08.01: Jacket water preheater

Preheating of diesel engine

Preheating during standstill periods

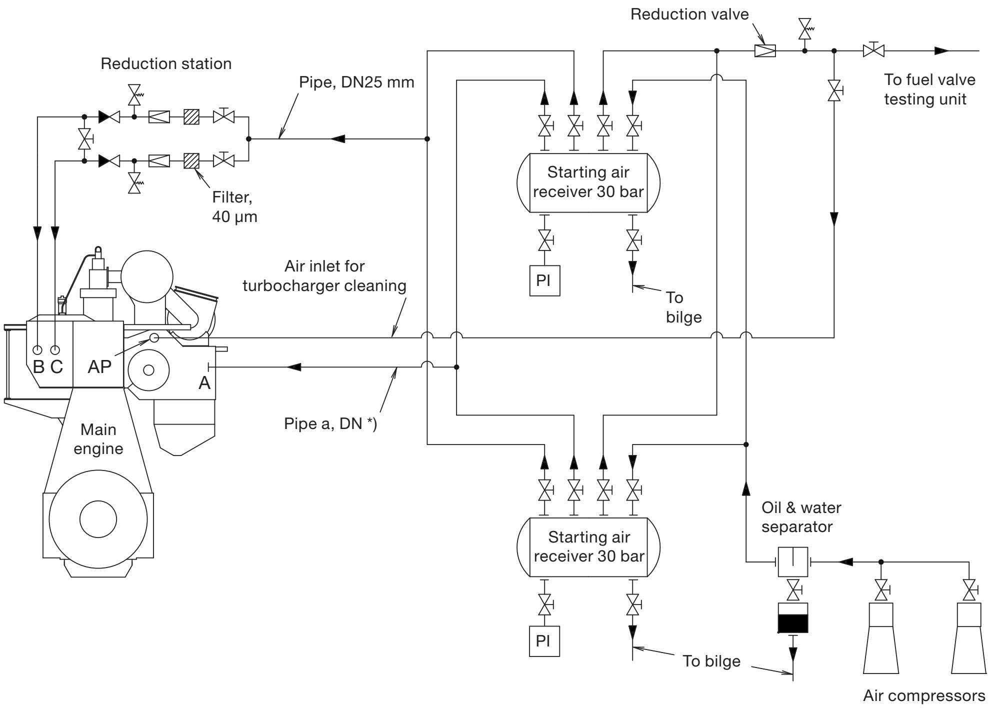
During short stays in port (i.e. less than 4-5 days), it is recommended that the engine is kept preheated, the purpose being to prevent temperature variation in the engine structure and corresponding variation in thermal expansions and possible leakages.

The jacket cooling water outlet temperature should be kept as high as possible and should – before starting-up – be increased to at least 50 °C, either by means of cooling water from the auxiliary engines, or by means of a built-in preheater in the jacket cooling water system, or a combination.

Starting and Control Air

13

Starting and Control Air Systems



The letters refer to list of ‘Counterflanges’
*) Pipe a nominal dimension: DN100 mm

079 61 01-7.1.0

Fig. 13.01.01: Starting and control air systems

The starting air of 30 bar is supplied by the starting air compressors to the starting air receivers and from these to the main engine inlet ‘A’.

Through a reduction station, filtered compressed air at 7 bar is supplied to the engine as:

- Control air for manoeuvring system and for exhaust valve air springs, through engine inle**t** ‘B’
- Safety air for emergency stop, through inlet ‘C’.

Through a reduction valve, compressed air is supplied at 10 bar to ‘AP’ for turbocharger cleaning (soft blast), and a minor volume used for the fuel valve testing unit.

Please note that the air consumption for control air, safety air, turbocharger cleaning and for fuel valve testing unit are momentary requirements of the consumers.

The components of the starting and control air systems are further desribed in Section 13.02.

For information about a common starting air system for main engines and MAN Diesel auxiliary engines, please refer to our publication:

Uni-concept Auxiliary Systems for Two-stroke Main

The publication is available at www.mandiesel.com under ‘Quicklinks’ → ‘Technical Papers’

Components for Starting Air System

Starting air compressors

The starting air compressors are to be of the water-cooled, two-stage type with intercooling.

More than two compressors may be installed to supply the total capacity stated.

Air intake quantity:
Reversible engine,
for 12 starts .... see 'List of capacities'
Non-reversible engine,
for 6 starts .... see 'List of capacities'
Delivery pressure .... 30 bar

Starting air receivers

The starting air receivers shall be provided with man holes and flanges for pipe connections.

The volume of the two receivers is:
Reversible engine,
for 12 starts .... see 'List of capacities' *
Non-reversible engine,
for 6 starts .... see 'List of capacities' *
Working pressure .... 30 bar
Test pressure .... according to class rule

* The volume stated is at 25 °C and 1,000 mbar

Reduction station for control and safety air

In normal operating, each of the two lines supplies one engine inlet. During maintenance, three isolating valves in the reduction station allow one of the two lines to be shut down while the other line supplies both engine inlets, see Fig. 13.01.01.

Reduction .... from 30-10 bar to 7 bar
(Tolerance ±10%)

Flow rate, free air .... 2,100 Normal liters/min
equal to 0.035 m^3/s
Filter, fineness .... 40 μm

Reduction valve for turbocharger cleaning etc

Reduction .... from 30-10 bar to 7 bar
(Tolerance ±10%)

Flow rate, free air .... 2,600 Normal liters/min
equal to 0.043 m^3/s

The consumption of compressed air for control air, exhaust valve air springs and safety air as well as air for turbocharger cleaning and fuel valve testing is covered by the capacities stated for air receivers and compressors in the list of capacities.

Starting and control air pipes

The piping delivered with and fitted onto the main engine is shown in the following figures in Section 13.03:

Fig. 13.03.01 Starting air pipes
Fig. 13.03.02 Air spring pipes, exhaust valves

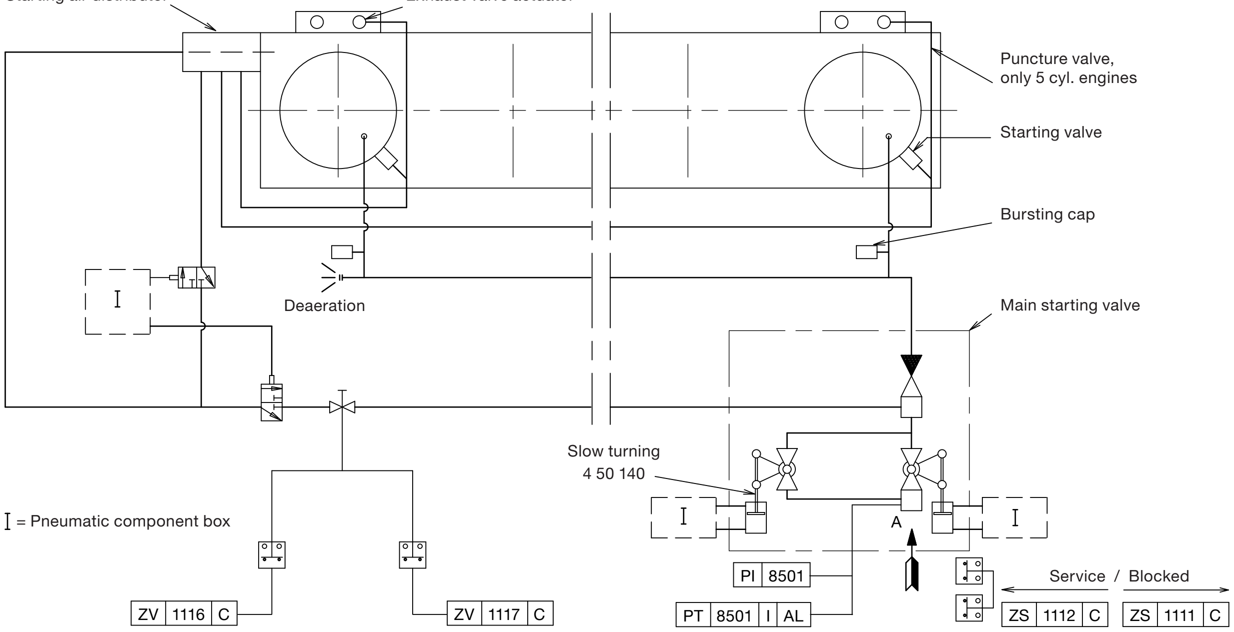
Turning gear

The turning wheel has cylindrical teeth and is fitted to the thrust shaft. The turning wheel is driven by a pinion on the terminal shaft of the turning gear, which is mounted on the bedplate.

Engagement and disengagement of the turning gear is effected by displacing the pinion and terminal shaft axially. To prevent the main engine from starting when the turning gear is engaged, the turning gear is equipped with a safety arrangement which interlocks with the starting air system.

The turning gear is driven by an electric motor with a built-in gear and brake. Key specifications of the electric motor and brake are stated in Section 13.04.

Starting and Control Air Pipes



The letters refer to list of ‘Counterflanges’
The item Nos. refer to ‘Guidance values automation’
The piping is delivered with and fitted onto the engine

317 18 10-9.0.0

Fig. 13.03.01a: Starting air pipes, reversible engine

The starting air pipes, Fig. 13.03.01a and b, contain a main starting valve (a ball valve with actuator), a non-return valve, starting air distributor and starting valves.

The main starting valve is combined with the manoeuvring system, which controls the start of the engine. Slow turning before start of engine is an option: 4 50 140 and is recommended by MAN Diesel, see section 16.01.

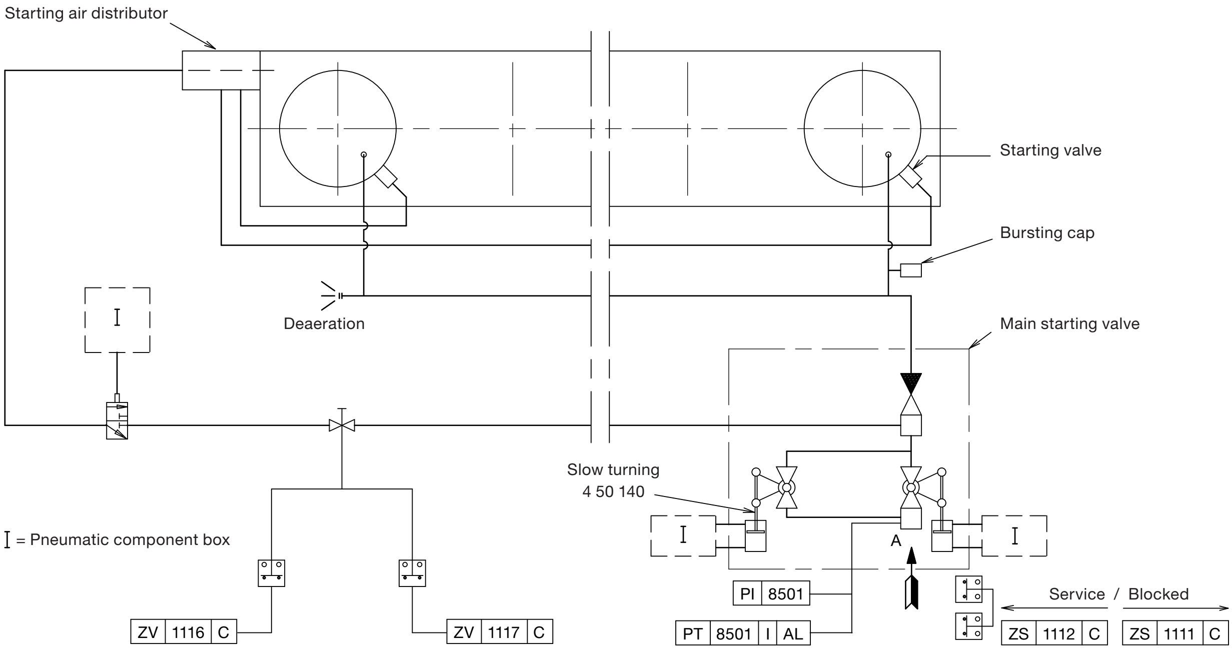
The starting air distributor regulates the supply of control air to the starting valves in accordance with the correct firing sequence.

Please note that the air consumption for control air, turbocharger cleaning, sealing air for exhaust valve and for fuel valve testing unit are momentary requirements of the consumers.

For information about a common starting air system for main engines and auxiliary engines, please refer to the Engine Selection Guide or to our publication:

Uni-concept Auxiliary Systems for Two-stroke Main

The publication is available at www.mandiesel.com under ‘Quicklinks’ → ‘Technical Papers’



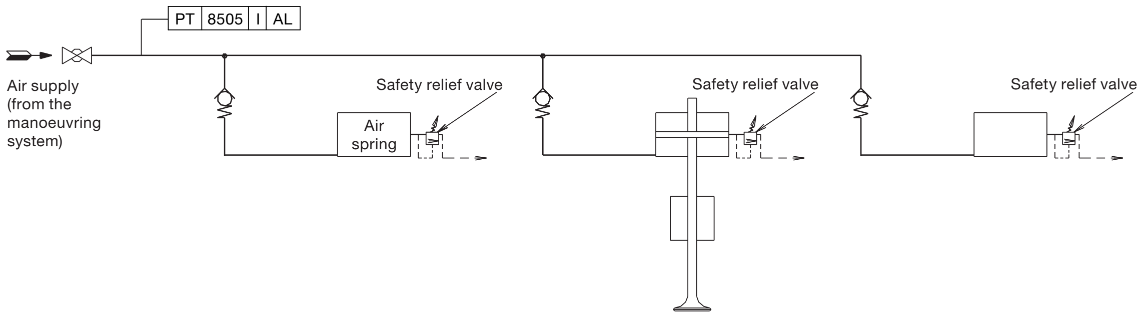
The letters refer to list of ‘Counterflanges’. The item Nos. refer to ‘Guidance values automation’
The piping is delivered with and fitted onto the engine

317 18 20-5.0.0

Fig. 13.03.01b: Starting air pipes, non-reversible engine

Exhaust Valve Air Spring and Sealing Air Pipes

The exhaust valve is opened hydraulically, and the closing force is provided by an ‘air spring’ which leaves the valve spindle free to rotate. The compressed air is taken from the manoeuvring air system.



The item Nos. refer to ‘Guidance values automation’
The piping is delivered with and fitted onto the engine

121 36 87-1.1.0b

Fig. 13.03.02: Air spring and sealing air pipes for exhaust valves

Electric Motor for Turning Gear

MAN Diesel delivers a turning gear with built-in disc brake, option 40 80 101. Two basic executions are available for power supply frequencies of 60 and 50 Hz respectively. Nominal power and current consumption of the motors are listed below.

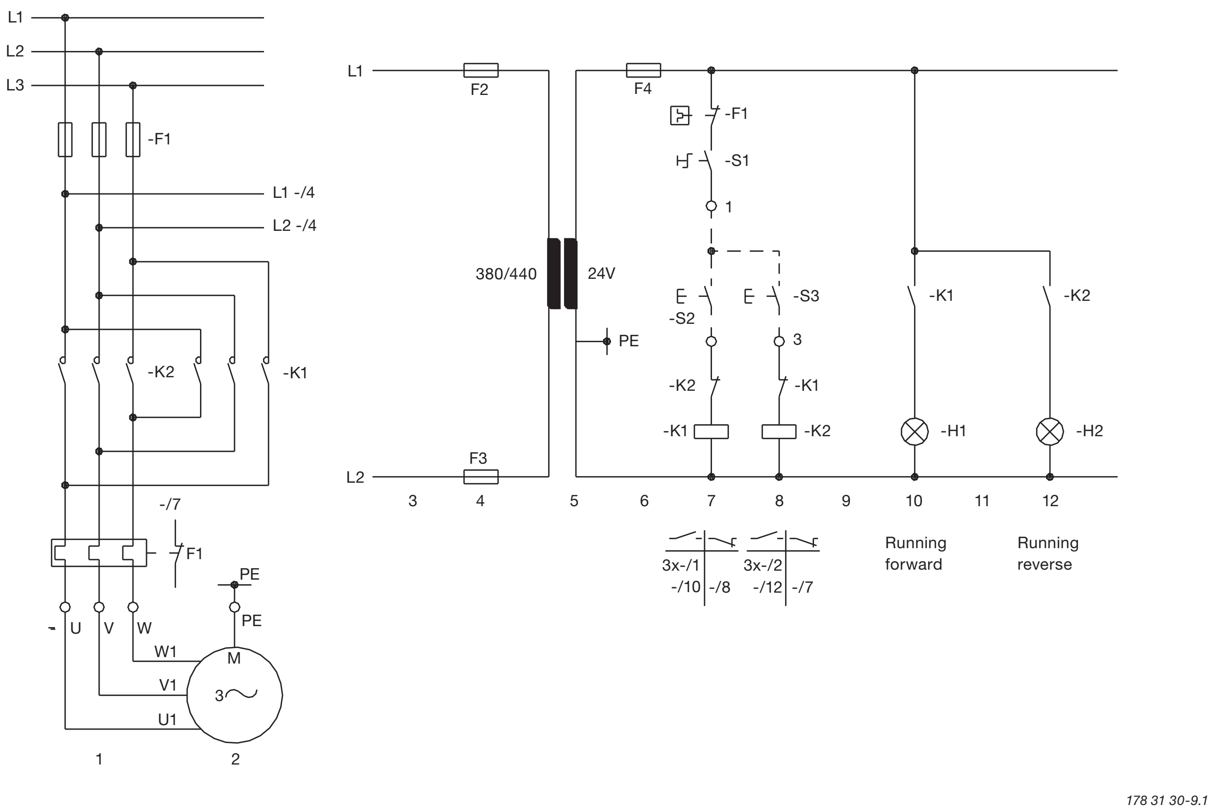
Turning gear with electric motor of other protection or insulation classes can be ordered, option 40 80 103. Information about the alternative executions is available on request.

Electric motor and brake, voltage............3 x 440 V
Electric motor and brake, frequency ....60 Hz
Protection, electric motor / brake....... IP 55 / IP 54
Insulation class ....F

Number of cylinders	Electric motor	
	Nominal power, kW	Normal current, A
5-8	2.6	5.0

Electric motor and brake, voltage............3 x 380 V
Electric motor and brake, frequency ....50 Hz
Protection, electric motor / brake....... IP 55 / IP 54
Insulation class ....F

Number of cylinders	Electric motor	
	Nominal power, kW	Normal current, A
5-8	2.2	5.0



178 31 30-9.1

Fig. 13.04.01: Electric motor for turning gear, option: 40 80 101

Scavenge Air

14

Scavenge Air System

Scavenge air is supplied to the engine by one turbocharger located on either the aft end of the engine, option: 4 59 121, or on the exhaust side, option: 4 59 123.

The compressor of the turbocharger draws air from the engine room, through an air filter, and the compressed air is cooled by the scavenge air cooler. The scavenge air cooler is provided with a water mist catcher, which prevents condensated water from being carried with the air into the scavenge air receiver and to the combustion chamber.

The scavenge air system (see Figs. 14.01.01 and 14.02.01) is an integrated part of the main engine.

The engine power figures and the data in the list of capacities are based on MCR at tropical conditions, i.e. a seawater temperature of 32 °C, or freshwater temperature of 36 °C, and an ambient air inlet temperature of 45 °C.

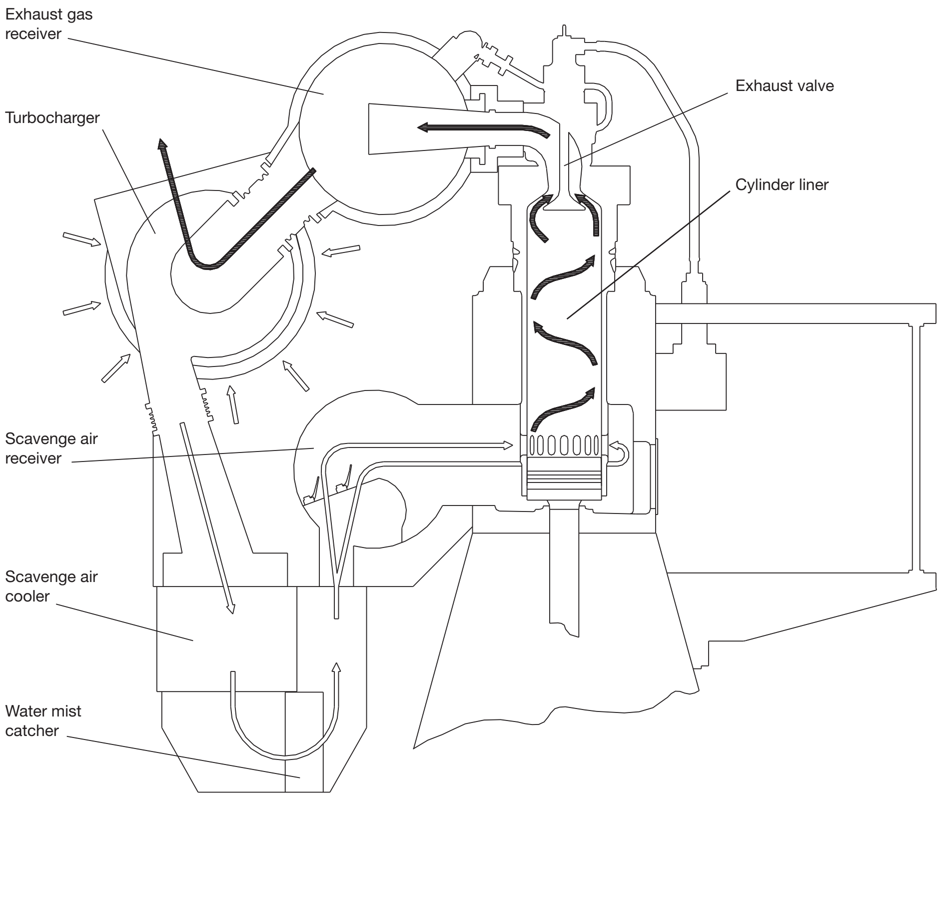


Fig. 14.01.01: Scavenge Air System

Auxiliary Blowers

The engine is provided with a minimum of two electrically driven auxiliary blowers, the actual number depending on the number of cylinders as well as the turbocharger make and amount. Between the scavenge air cooler and the scavenge air receiver, non-return valves are fitted which close automatically when the auxiliary blowers start supplying the scavenge air.

The auxiliary blowers start operating consecutively before the engine is started and will ensure complete scavenging of the cylinders in the starting phase, thus providing the best conditions for a safe start.

During operation of the engine, the auxiliary blowers will start automatically whenever the engine load is reduced to about 30-40%, and will continue operating until the load again exceeds approximately 40-50%.

Emergency running

If one of the auxiliary blowers is out of function, the other auxiliary blower will function in the system, without any manual adjustment of the valves being necessary.

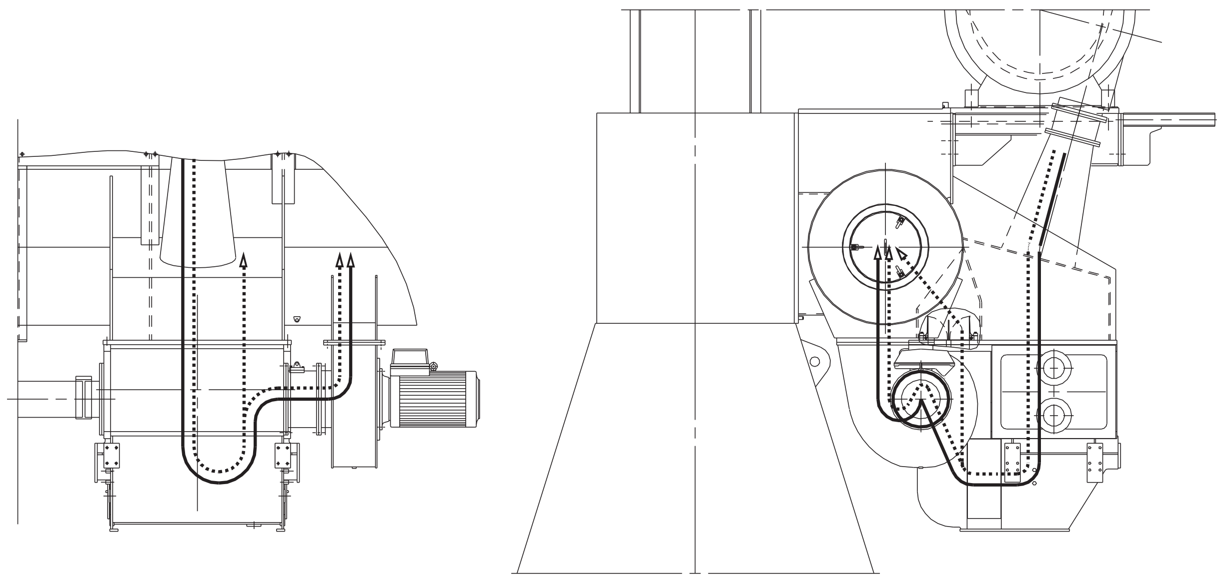
Scavenge Air Cooler requirements

The data for the scavenge air cooler is specified in the description of the cooling water system chosen.

For further information, please refer to our publication titled:

Influence of Ambient Temperature Conditions

The publication is available at: www.mandiesel.com under 'Quicklinks' → 'Technical Papers'.



Running with auxiliary blower

Running with turbocharger

178 44 70-5.1

Fig. 14.02.01: Auxiliary blowers for scavenge air system

Control of the Auxiliary Blowers

The auxiliary blowers are fitted onto the main engine and controlled by a system comprising:

1 pc Control Panel
1 pc Starter Panel per Auxiliary Blower
2 pc Pressure Switches

Referring to the diagram of the auxiliary blower control system, Fig. 14.02.02:

- The Control Panel controls the run/stop signals to all Auxiliary Blower Starter Panels. The Control Panel consists of an operation panel and a terminal row interconnected by a 1,200 mm long wire harness.
- The Auxiliary Blower Starter Panels control and protect the Auxiliary Blowers, one panel with starter per blower. The physical layout and choice of components has to be decided by the manufacturer.
- The pressure switch ‘P’ controls the run/stop signals, while pressure switch ‘B’ is part of the auxiliary blower alarm circuit.

The control panel is yard’s supply. It can be ordered as an option: 4 55 650.

The starter panels with starters for the auxiliary blower motors are not included, they can be ordered as an option: 4 55 653. Heaters for the blower motors are available as an option: 4 55 155.

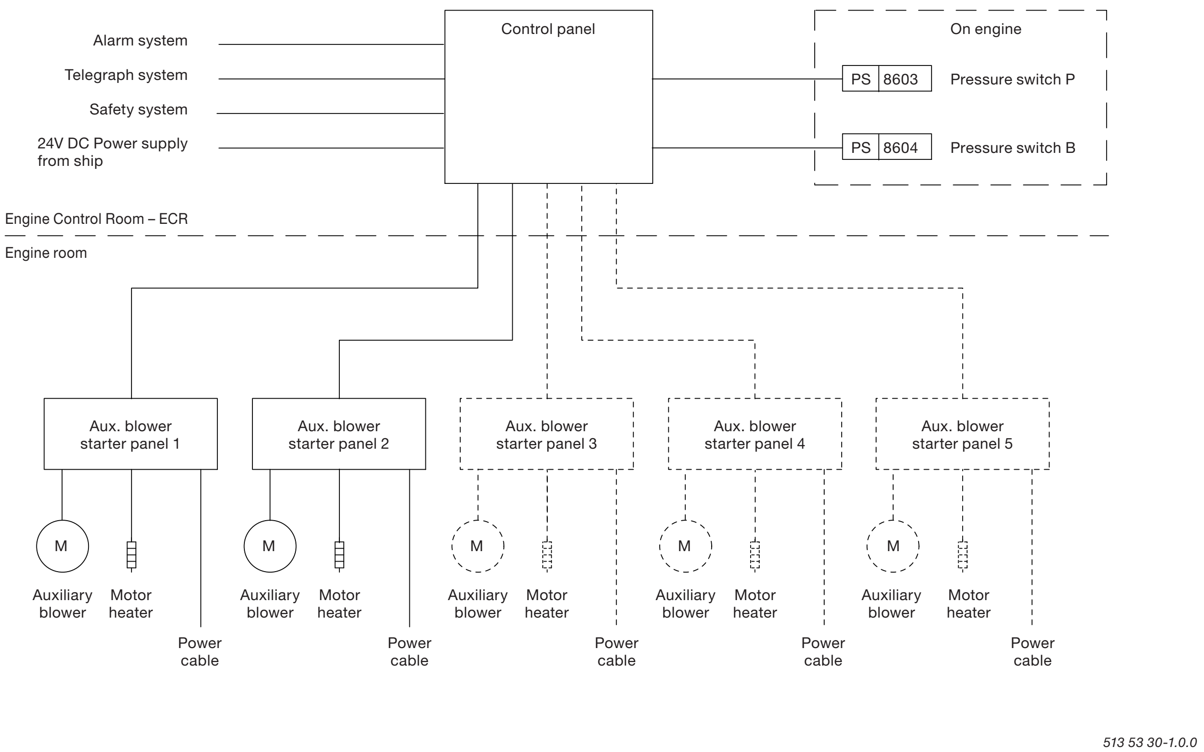


Fig. 14.02.02: Diagram of auxiliary blower control system

Operation Panel for the Auxiliary Blowers

On the operation panel, three control modes are available to run/stop the blowers:

- AUTO – Run/stop is automatically controlled by scavenge air pressure
- MANUAL – Start of all blowers in sequence at intervals of 6 sec
- OFF – The auxiliary blowers are stopped after a set period of time, 30 sec for instance.

The operation panel and terminal row have to be mounted in the Engine Control Room Manoeuvring Console, see section 16.01.

The control panel for the auxiliary blowers including the operation panel, wiring harness and terminal row is shown in Fig. 14.02.03.

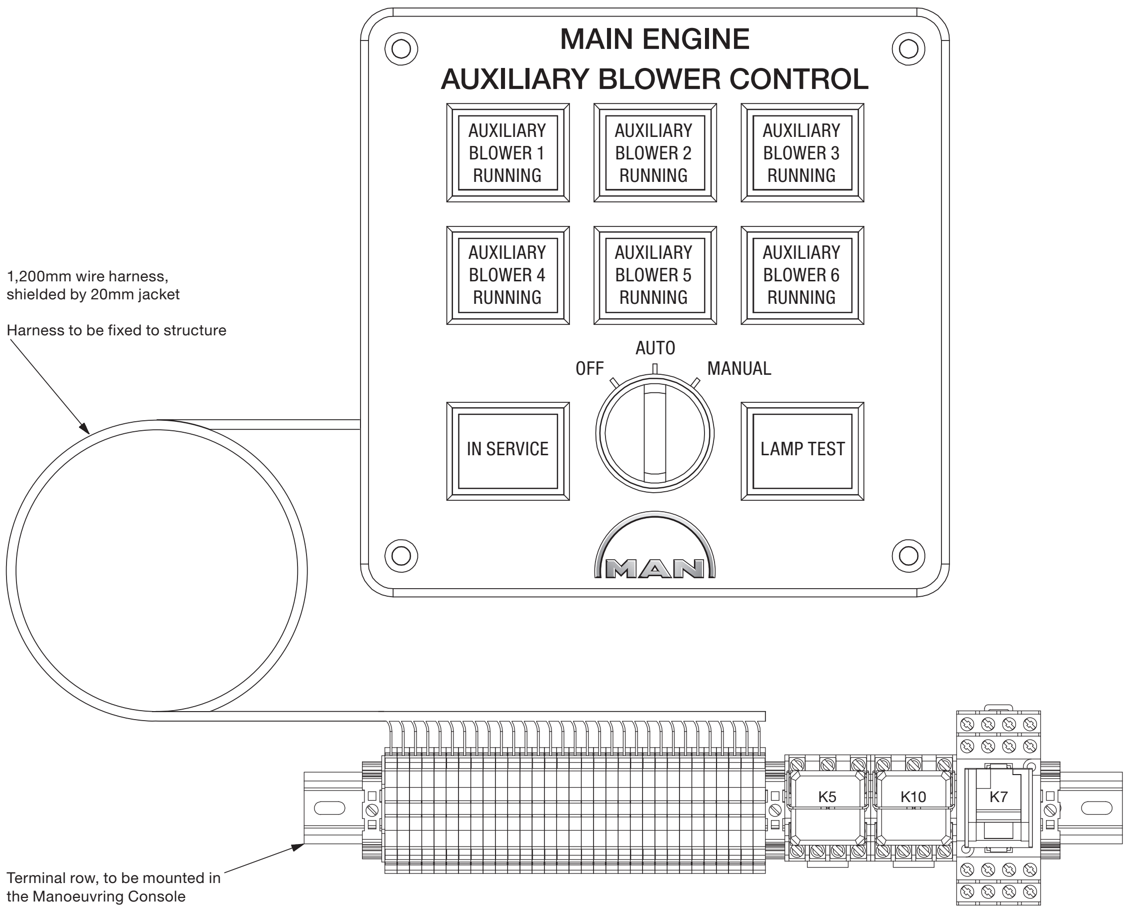
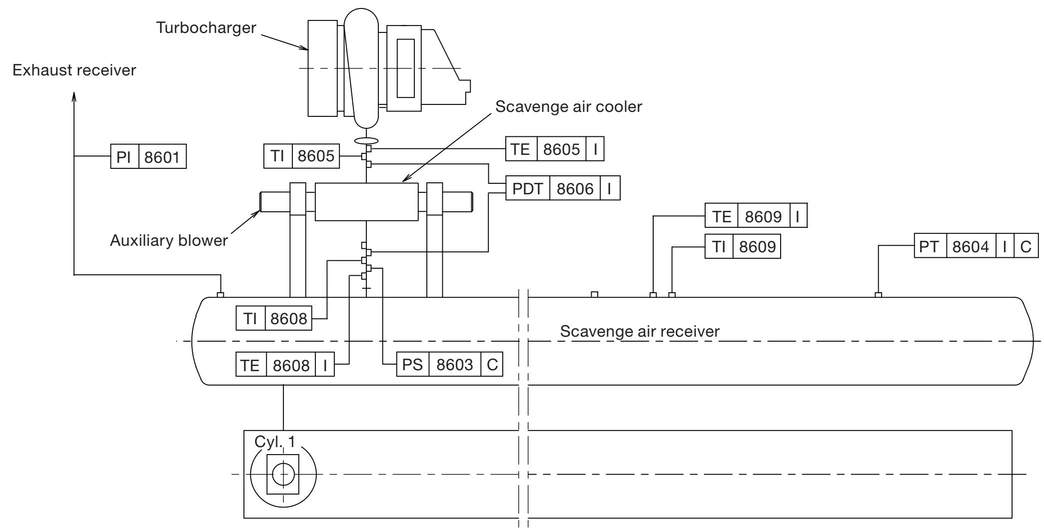


Fig. 14.02.03: Control panel including operation panel, wiring harness and terminal row, option: 4 55 650

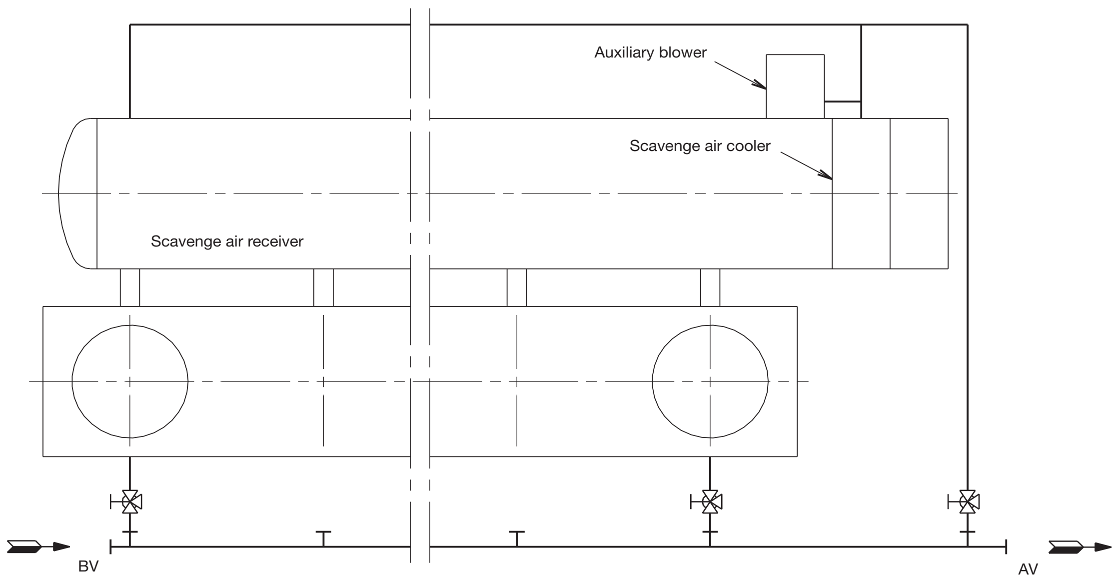
Scavenge Air Pipes



317 18 13-4.0.0

The item No. refer to 'Guidance Values Automation'

Fig. 14.03.01: Scavenge air pipes, turbocharger located on exhaust side.
(Diagram of scavenge air pipes for turbocharger located on aft end is available on request)



172 61 42-0.4.0

The letters refer to list of 'Counterflanges'

Fig. 14.03.02: Scavenge air space, drain pipes

Electric Motor for Auxiliary Blower

The number of auxiliary blowers in a propulsion plant may vary depending on the actual amount of turbochargers as well as space requirements.

For typical engine configurations, the required power of the auxiliary blowers as well as the installed size of the electric motors are listed in Table 14.04.01a and b.

Number of cylinders	Number of auxiliary blowers	Required power/blower kW	Installed power/blower kW
5	2	30	35
6		34	35
7		40	43
8		48	54

The installed power of the electric motors are based on a voltage supply of 3x440V at 60Hz.

The electric motors are delivered with and fitted onto the engine.

Table 14.04.01a: Electric motor for auxiliary blower, engine with turbocharger located on aft end

Number of cylinders	Number of auxiliary blowers	Required power/blower kW	Installed power/blower kW
5	2	33	35
6		42	43
7		47	54
8		52	54

The installed power of the electric motors are based on a voltage supply of 3x440V at 60Hz.

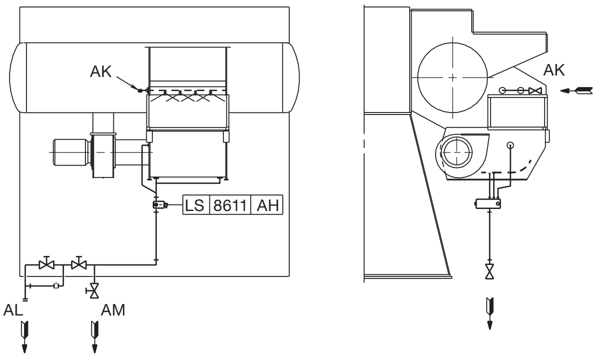
The electric motors are delivered with and fitted onto the engine.

Table 14.04.01b: Electric motor for auxiliary blower, engine with turbocharger located on exhaust side

Scavenge Air Cooler Cleaning System

The air side of the scavenge air cooler can be cleaned by injecting a grease dissolving media through 'AK' to a spray pipe arrangement fitted to the air chamber above the air cooler element.

Sludge is drained through 'AL' to the bilge tank and the polluted grease dissolvent returns from 'AM' through a filter, to the chemical cleaning tank. The cleaning must be carried out while the engine is at standstill. The piping delivered with and fitted on the engine is shown in Fig 14.05.01 'Air cooler cleaning pipes'.

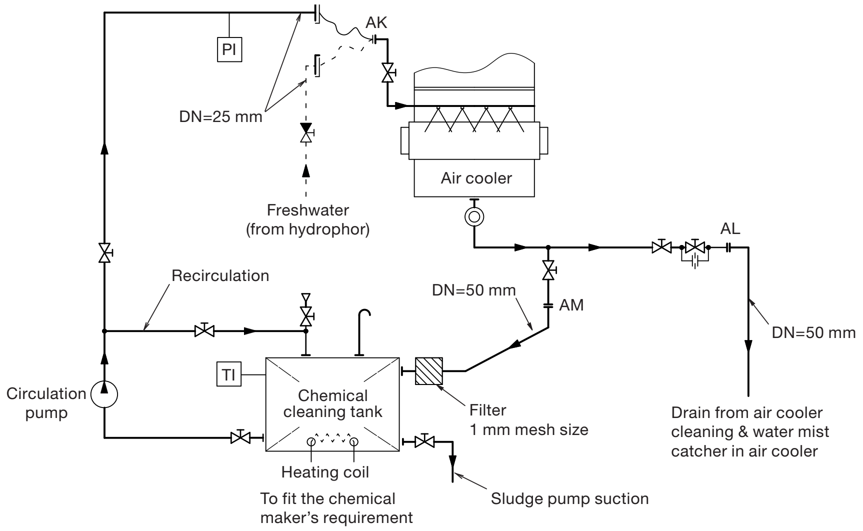


The letters refer to list of 'Counterflanges'
The item no refer to 'Guidance values automation'

178 59 17-1.0

Fig. 14.05.01: Air cooler cleaning pipes, shown on engine with turbocharger located on exhaust side

Air cooler cleaning unit, option: 4 55 665



	No. of cyl.
	5-9
Chemical tank capacity	0.3 m^3
Circulation pump capacity at 3 bar	1 m^3/h

The letters refer to list of 'Counterflanges'

079 61 05-4.1.0c

Fig. 14.05.02: Air cooler cleaning system

Scavenge Air Box Drain System

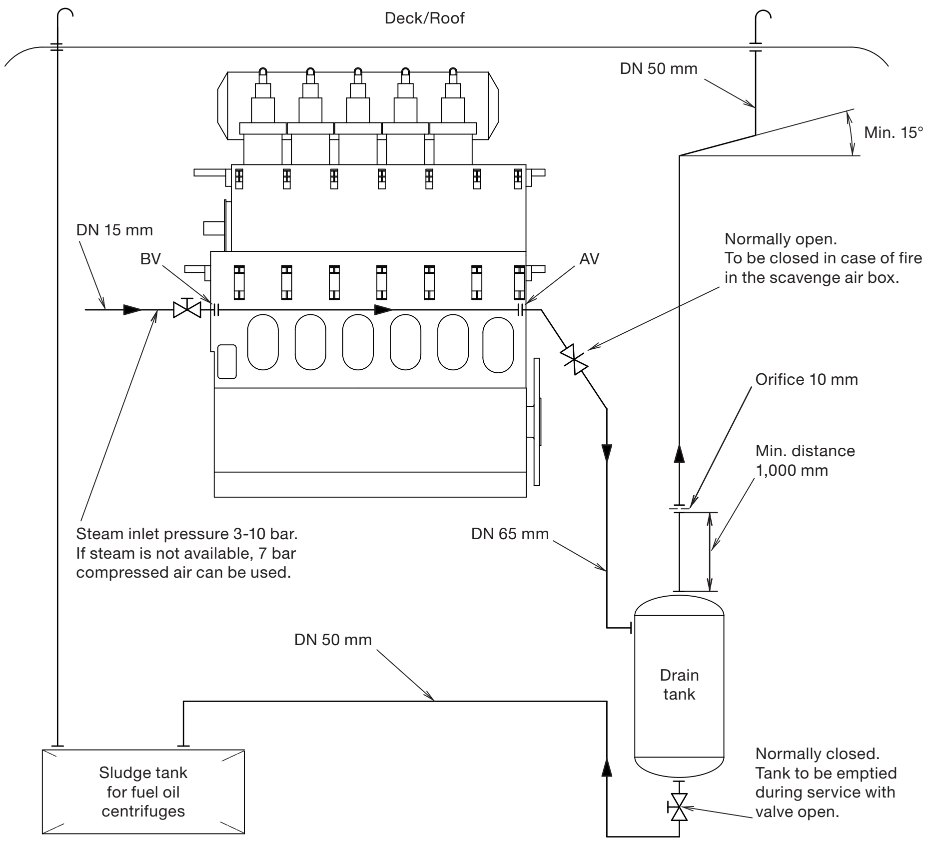
The scavenge air box is continuously drained through 'AV' to a small pressurised drain tank, from where the sludge is led to the sludge tank. Steam can be applied through 'BV', if required, to facilitate the draining. See Fig. 14.06.01.

The continuous drain from the scavenge air box must not be directly connected to the sludge tank owing to the scavenge air pressure. The pressurised drain tank must be designed to withstand full scavenge air pressure and, if steam is applied, to withstand the steam pressure available.

Drain from water mist catcher

The drain line for the air cooler system is, during running, used as a permanent drain from the air cooler water mist catcher. The water is led through an orifice to prevent major losses of scavenge air. The system is equipped with a drain box with a level switch, indicating any excessive water level.

The system delivered with and fitted on the engine is shown in Fig. 14.03.02 Scavenge air space, drain pipes.



	No. of cylinders	
	5-6	7-8
Drain tank capacity	0.4 m³	0.7 m³

The letters refer to list of 'Counterflanges'

079 61 03-0.2.0

Fig. 14.06.01: Scavenge air box drain system

Fire Extinguishing System for Scavenge Air Space

Fire in the scavenge air space can be extinguished by steam, this being the basic solution, or, optionally, by water mist or CO_2.

The external system, pipe and flange connections are shown in Fig. 14.07.01 and the piping fitted onto the engine in Fig. 14.07.02.

In the Extent of Delivery, the fire extinguishing system for scavenge air space is selected by the fire extinguishing agent:

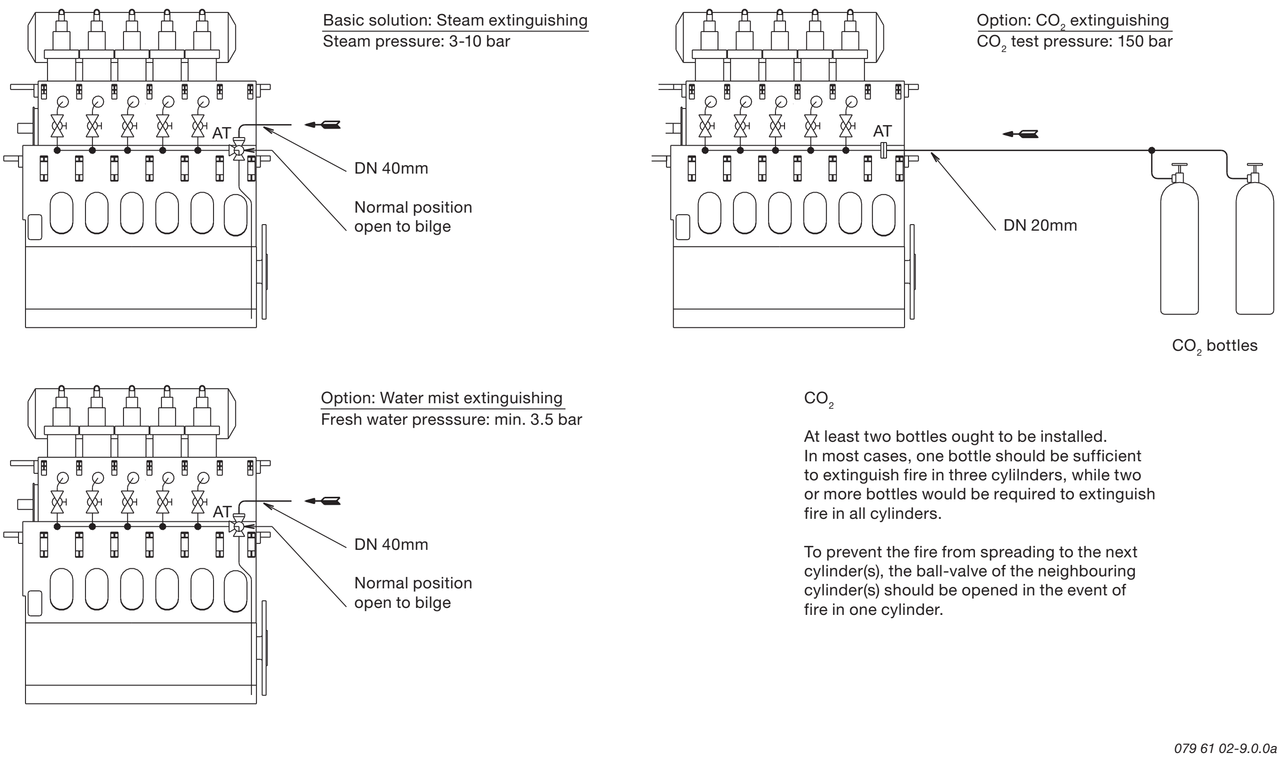
- basic solution: 4 55 140 Steam
- option: 4 55 142 Water mist
- option: 4 55 143 CO_2

The key specifications of the fire extinguishing agents are:

Steam fire extinguishing for scavenge air space
Steam pressure: 3-10 bar
Steam quantity, approx.: 2.2 kg/cyl.

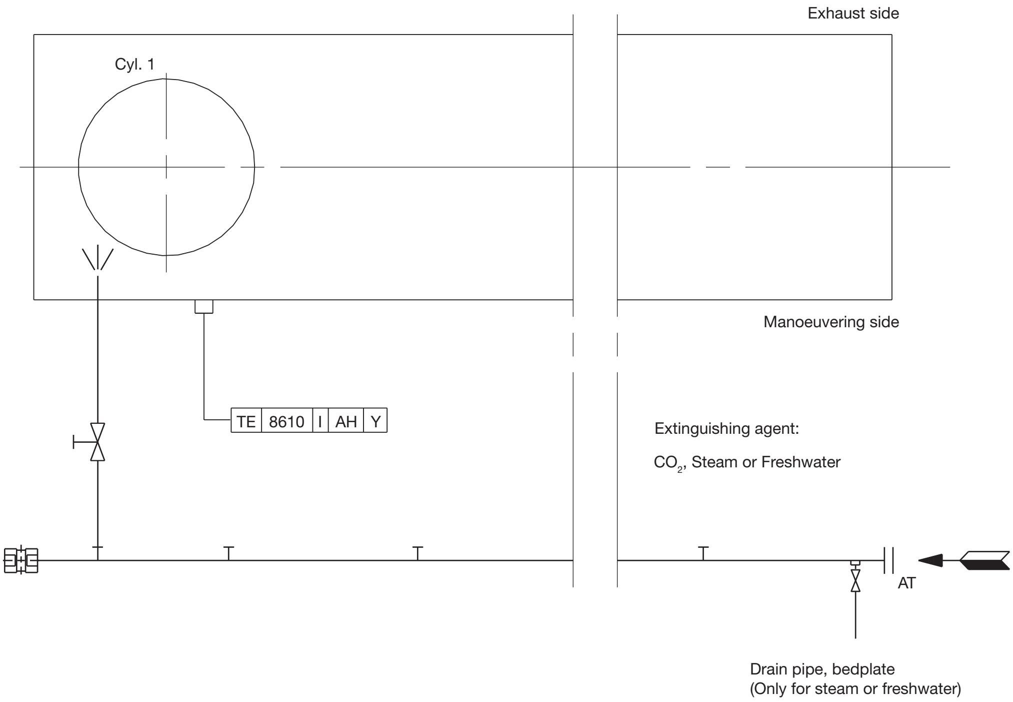
Water mist fire extinguishing for scavenge air space
Freshwater pressure: min. 3.5 bar
Freshwater quantity, approx.: 1.7 kg/cyl.

CO_2 fire extinguishing for scavenge air space
CO_2 test pressure: 150 bar
CO_2 quantity, approx.: 4.3 kg/cyl.



The letters refer to list of 'Counterflanges'

Fig. 14.07.01: Fire extinguishing system for scavenge air space



126 40 81-0.6.0a

The letters refer to list of 'Counterflanges'

Fig. 14.07.02: Fire extinguishing pipes in scavenge air space

Exhaust Gas

15

Exhaust Gas System

The exhaust gas is led from the cylinders to the exhaust gas receiver where the fluctuating pressures from the cylinders are equalised and from where the gas is led further on to the turbocharger at a constant pressure. See fig. 15.01.01.

Compensators are fitted between the exhaust valve housings and the exhaust gas receiver and between the receiver and the turbocharger. A protective grating is placed between the exhaust gas receiver and the turbocharger. The turbocharger is fitted with a pick-up for monitoring and remote indication of the turbocharger speed.

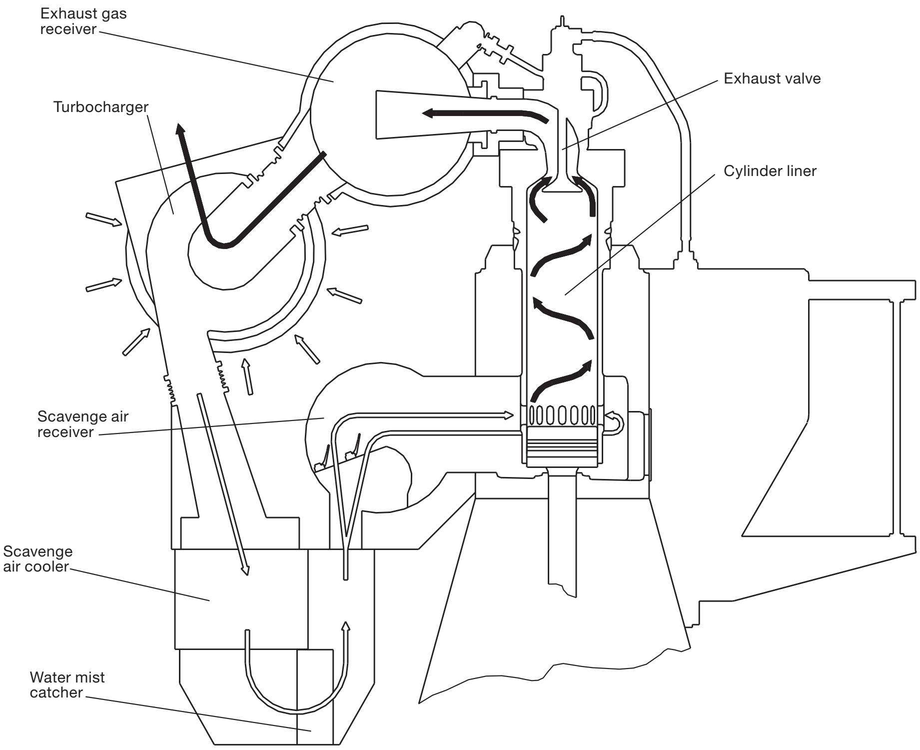
The exhaust gas receiver and the exhaust pipes are provided with insulation, covered by steel plating.

Turbocharger arrangement and cleaning systems

The turbocharger can either be located on the aft end of the engine, option: 4 59 121, or on the exhaust side of the engine, option: 4 59 123.

The engine is designed for the installation of the MAN Diesel turbocharger types TCA (4 59 101), ABB turbocharger type TPL (4 59 102), or MHI turbocharger type MET (4 59 103).

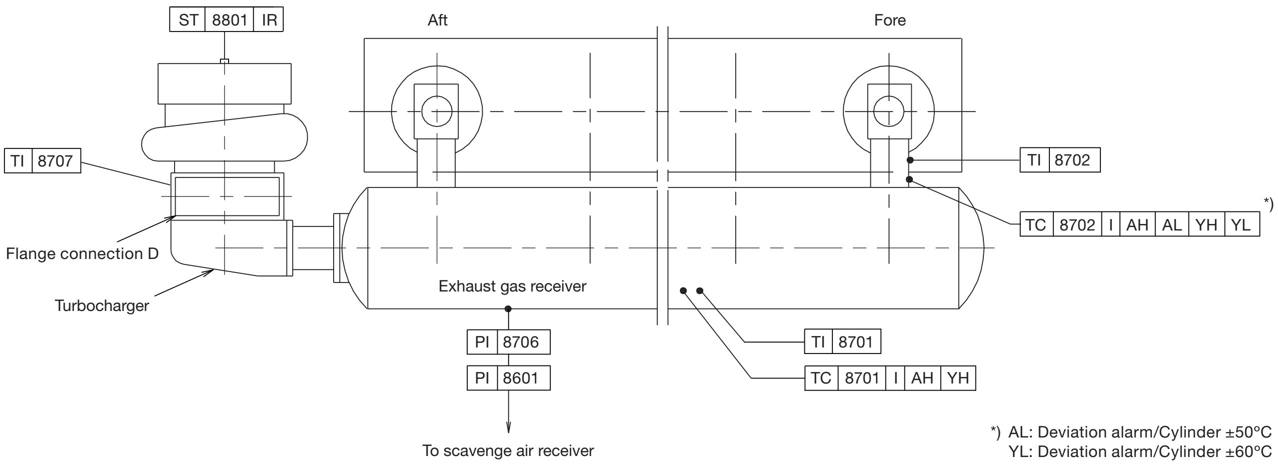
All makes of turbochargers are fitted with an arrangement for water washing of the compressor side, and soft blast cleaning of the turbine side, see Figs. 15.02.02, 15.02.03 and 15.02.04. Washing of the turbine side is only applicable on MAN Diesel and ABB turbochargers.



178 07 27-4.1

Fig. 15.01.01: Exhaust gas system on engine

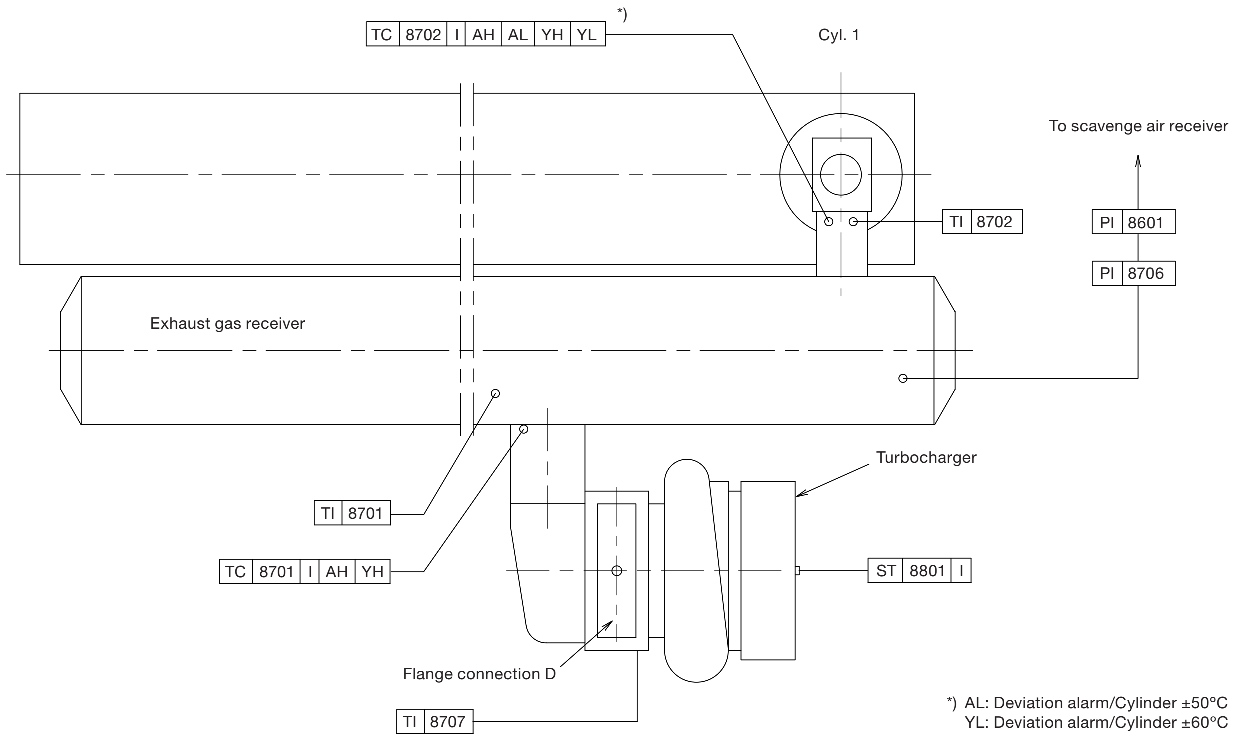
Exhaust Gas Pipes



The letters refer to 'List of flanges'
The position numbers refer to 'List of instruments'
The piping is delivered with and fitted onto the engine

178 38 69-2.2

Fig.15.02.01a: Exhaust gas pipes, with turbocharger located on aft end of engine, option 4 59 121



The letters refer to list of 'Counterflanges'
The item no. refer to 'Guidance Values Automation'

121 15 27-9.2.0

Fig. 15.02.01b: Exhaust gas pipes, with turbocharger located on exhaust side of engine, option 4 59 123

Cleaning Systems

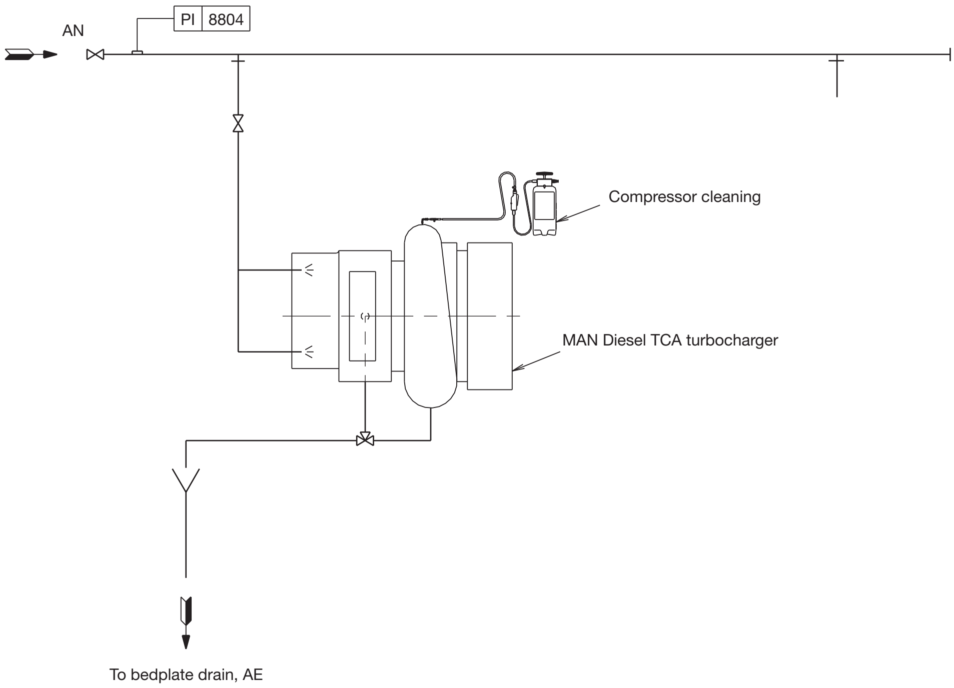


Fig. 15.02.02: MAN Diesel TCA turbocharger, water washing of turbine side

Cleaning Systems

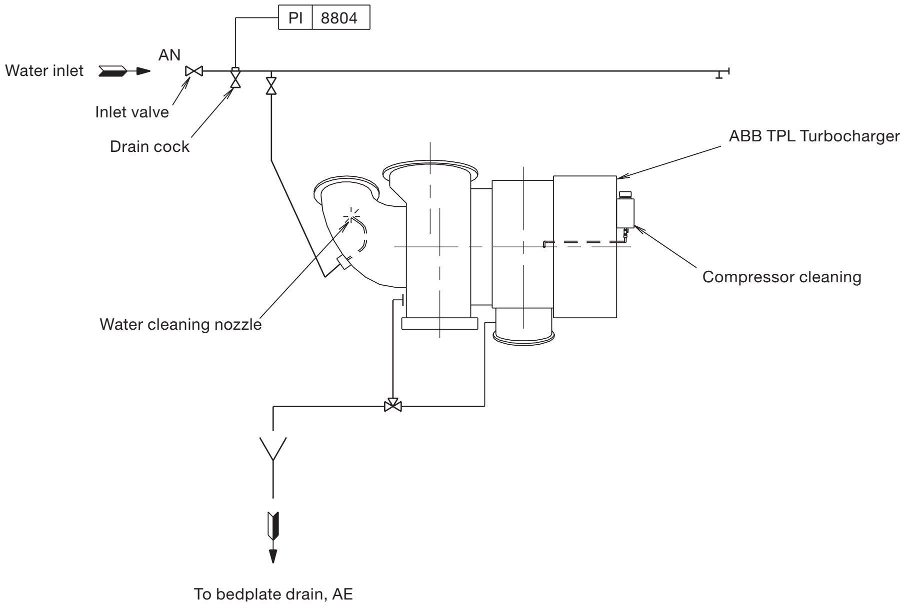


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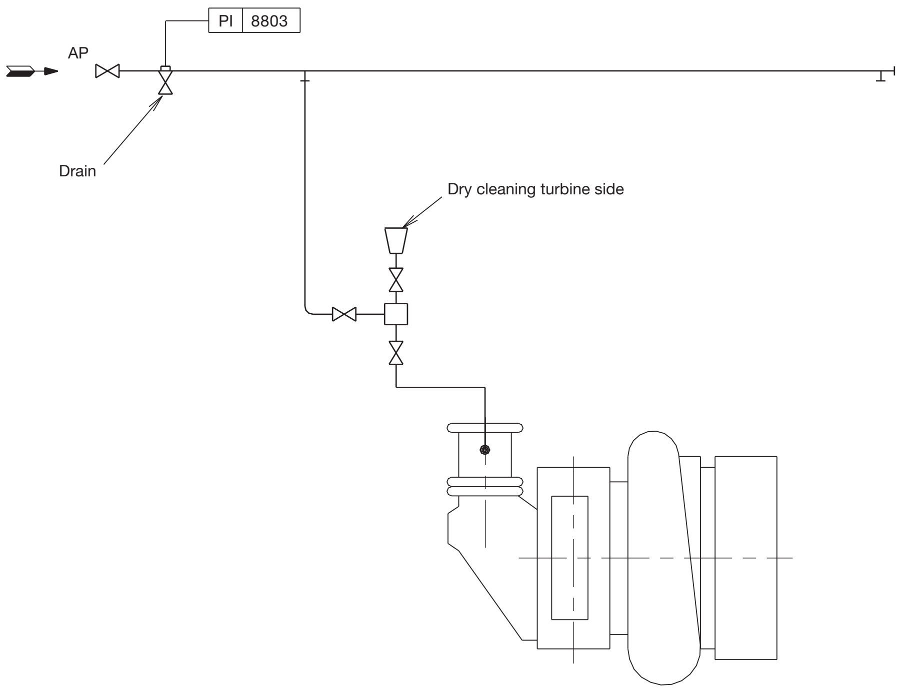
Fig. 15.02.03: Water washing of turbine and compressor sides for ABB, TPL turbochargers



126 40 93-0.2.0

Fig. 15.02.04: Soft blast cleaning of turbine side

Exhaust Gas System for Main Engine

At the specified MCR of the engine, the total back-pressure in the exhaust gas system after the turbocharger (as indicated by the static pressure measured in the piping after the turbocharger) must not exceed 350 mm WC (0.035 bar).

In order to have a back-pressure margin for the final system, it is recommended at the design stage to initially use a value of about 300 mm WC (0.030 bar).

The actual back-pressure in the exhaust gas system at specified MCR depends on the gas velocity, i.e. it is proportional to the square of the exhaust gas velocity, and hence inversely proportional to the pipe diameter to the 4th power. It has by now become normal practice in order to avoid too much pressure loss in the pipings to have an exhaust gas velocity at specified MCR of about 35 m/sec, but not higher than 50 m/sec.

For dimensioning of the external exhaust pipe connections, see the exhaust pipe diameters for 35 m/sec, 40 m/sec, 45 m/sec and 50 m/sec respectively, shown in Table 15.07.02.

As long as the total back-pressure of the exhaust gas system (incorporating all resistance losses from pipes and components) complies with the above-mentioned requirements, the pressure losses across each component may be chosen independently, see proposed measuring points (M) in Fig. 15.05.01. The general design guidelines for each component, described below, can be used for guidance purposes at the initial project stage.

Exhaust gas piping system for main engine

The exhaust gas piping system conveys the gas from the outlet of the turbocharger(s) to the atmosphere.

The exhaust piping is shown schematically in Fig. 15.04.01.

The exhaust system for the main engine comprises:

- Exhaust gas pipes
- Exhaust gas boiler
- Silencer
- Spark arrester (if needed)
- Expansion joints (compensators)
- Pipe bracings.

In connection with dimensioning the exhaust gas piping system, the following parameters must be observed:

- Exhaust gas flow rate
- Exhaust gas temperature at turbocharger outlet
- Maximum pressure drop through exhaust gas system
- Maximum noise level at gas outlet to atmosphere
- Maximum force from exhaust piping on turbocharger(s)
- Sufficient axial and lateral elongation ability of expansion joints
- Utilisation of the heat energy of the exhaust gas.

Items that are to be calculated or read from tables are:

- Exhaust gas mass flow rate, temperature and maximum back pressure at turbocharger gas outlet
- Diameter of exhaust gas pipes
- Utilisation of the exhaust gas energy
- Attenuation of noise from the exhaust pipe outlet
- Pressure drop across the exhaust gas system
- Expansion joints.

Components of the Exhaust Gas System

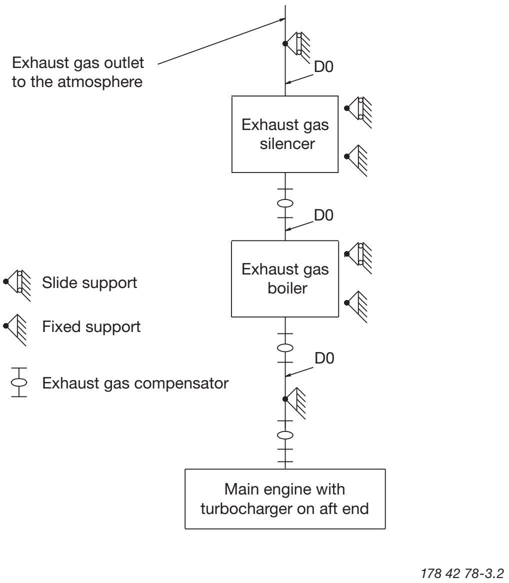


Fig. 15.04.01a: Exhaust gas system, one turbocharger

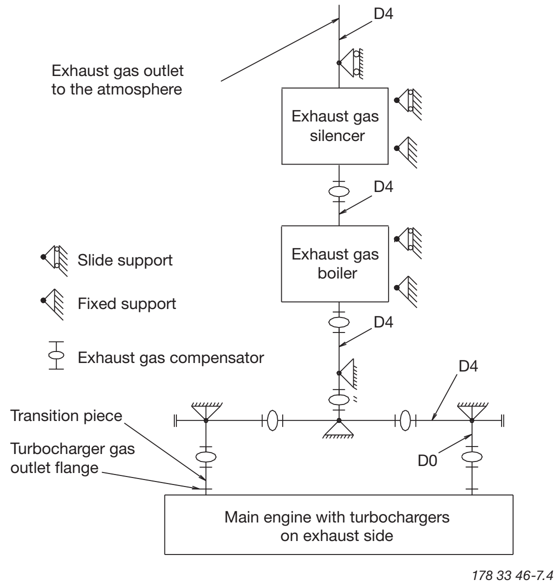


Fig. 15.04.01b: Exhaust gas system, two or more TCs

Exhaust gas compensator after turbocharger

When dimensioning the compensator (option: 4 60 610) for the expansion joint on the turbocharger gas outlet transition piece (option: 4 60 601) the exhaust gas piece and components, are to be so arranged that the thermal expansions are absorbed by expansion joints. The heat expansion of the pipes and the components is to be calculated based on a temperature increase from 20 °C to 250 °C. The max. expected vertical, transversal and longitudinal heat expansion of the engine measured at the top of the exhaust gas transition piece of the turbocharger outlet are indicated in Fig. 15.06.01 and Table 15.06.02 as DA, DB and DC.

The movements stated are related to the engine seating, for DC, however, to the engine centre. The figures indicate the axial and the lateral movements related to the orientation of the expansion joints.

The expansion joints are to be chosen with an elasticity that limits the forces and the moments of the exhaust gas outlet flange of the turbocharger as stated for each of the turbocharger makers in Table 15.06.04. The orientation of the maximum permissible forces and moments on the gas outlet flange of the turbocharger is shown in Fig. 15.06.03.

Exhaust gas boiler

Engine plants are usually designed for utilisation of the heat energy of the exhaust gas for steam production or for heating the thermal oil system. The exhaust gas passes an exhaust gas boiler which is usually placed near the engine top or in the funnel.

It should be noted that the exhaust gas temperature and flow rate are influenced by the ambient conditions, for which reason this should be considered when the exhaust gas boiler is planned. At specified MCR, the maximum recommended pressure loss across the exhaust gas boiler is normally 150 mm WC.

This pressure loss depends on the pressure losses in the rest of the system as mentioned above. Therefore, if an exhaust gas silencer/spark arrester is not installed, the acceptable pressure loss across the boiler may be somewhat higher than the max. of 150 mm WC, whereas, if an exhaust gas silencer/spark arrester is installed, it may be necessary to reduce the maximum pressure loss.

The above mentioned pressure loss across the exhaust gas boiler must include the pressure losses from the inlet and outlet transition pieces.

Exhaust gas silencer

The typical octave band sound pressure levels from the diesel engine's exhaust gas system – at a distance of one meter from the top of the exhaust gas uptake – are shown in Fig.15.04.02.

The need for an exhaust gas silencer can be decided based on the requirement of a maximum permissible noise level at a specific position.

The exhaust gas noise data is valid for an exhaust gas system without boiler and silencer, etc.

The noise level is at nominal MCR at a distance of one metre from the exhaust gas pipe outlet edge at an angle of 30° to the gas flow direction.

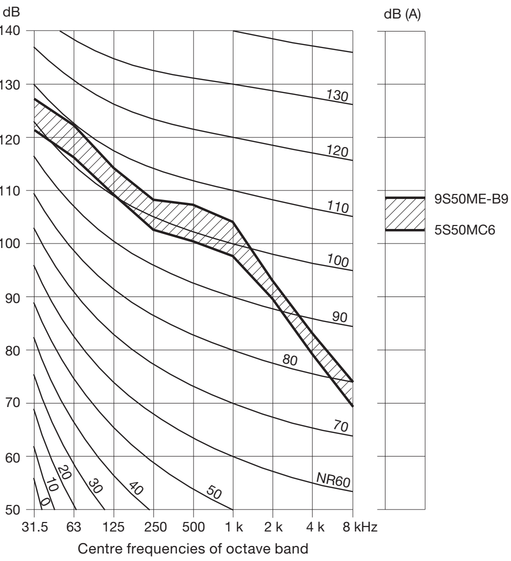
For each doubling of the distance, the noise level will be reduced by about 6 dB (far-field law).

When the noise level at the exhaust gas outlet to the atmosphere needs to be silenced, a silencer can be placed in the exhaust gas piping system after the exhaust gas boiler.

The exhaust gas silencer is usually of the absorption type and is dimensioned for a gas velocity of approximately 35 m/s through the central tube of the silencer.

An exhaust gas silencer can be designed based on the required damping of noise from the exhaust gas given on the graph.

In the event that an exhaust gas silencer is required – this depends on the actual noise level requirement on the bridge wing, which is normally maximum 60-70 dB(A) – a simple flow silencer of the absorption type is recommended. Depending on the manufacturer, this type of silencer normally has a pressure loss of around 20 mm WC at specified MCR.



178 59 42-1.0

Fig. 15.04.02: ISO's NR curves and typical sound pressure levels from the engine's exhaust gas system. The noise levels at nominal MCR and a distance of 1 metre from the edge of the exhaust gas pipe opening at an angle of 30 degrees to the gas flow and valid for an exhaust gas system – without boiler and silencer, etc. Data for a specific engine and cylinder no. is available on request.

Spark arrester

To prevent sparks from the exhaust gas being spread over deck houses, a spark arrester can be fitted as the last component in the exhaust gas system.

It should be noted that a spark arrester contributes with a considerable pressure drop, which is often a disadvantage.

It is recommended that the combined pressure loss across the silencer and/or spark arrester should not be allowed to exceed 100 mm WC at specified MCR. This depends, of course, on the pressure loss in the remaining part of the system, thus if no exhaust gas boiler is installed, 200 mm WC might be allowed.

Calculation of Exhaust Gas Back-Pressure

The exhaust gas back pressure after the turbocharger(s) depends on the total pressure drop in the exhaust gas piping system.

The components, exhaust gas boiler, silencer, and spark arrester, if fitted, usually contribute with a major part of the dynamic pressure drop through the entire exhaust gas piping system.

The components mentioned are to be specified so that the sum of the dynamic pressure drop through the different components should, if possible, approach 200 mm WC at an exhaust gas flow volume corresponding to the specified MCR at tropical ambient conditions. Then there will be a pressure drop of 100 mm WC for distribution among the remaining piping system.

Fig. 15.05.01 shows some guidelines regarding resistance coefficients and back-pressure loss calculations which can be used, if the maker's data for back-pressure is not available at an early stage of the project.

The pressure loss calculations have to be based on the actual exhaust gas amount and temperature valid for specified MCR. Some general formulas and definitions are given in the following.

Exhaust gas data

M: exhaust gas amount at specified MCR in kg/sec.
T: exhaust gas temperature at specified MCR in °C

Please note that the actual exhaust gas temperature is different before and after the boiler. The exhaust gas data valid after the turbocharger may be found in Chapter 6.

Mass density of exhaust gas (ρ)

$$\rho \cong 1.293 \times \frac{273}{273 + T} \times 1.015 \text{ in kg/m}^3$$

The factor 1.015 refers to the average back-pressure of 150 mm WC (0.015 bar) in the exhaust gas system.

Exhaust gas velocity (v)

In a pipe with diameter D the exhaust gas velocity is:

$$v = \frac{M}{\rho} \times \frac{4}{\pi \times D^2} \text{ in m/s}$$

Pressure losses in pipes (Δp)

For a pipe element, like a bend etc., with the resistance coefficient ζ, the corresponding pressure loss is:

$$\Delta p = \zeta \times ½ \rho v^2 \times \frac{1}{9.81} \text{ in mm WC}$$

where the expression after ζ is the dynamic pressure of the flow in the pipe.

The friction losses in the straight pipes may, as a guidance, be estimated as :

1 mm WC per 1 diameter length

whereas the positive influence of the up-draught in the vertical pipe is normally negligible.

Pressure losses across components (Δp)

The pressure loss Δp across silencer, exhaust gas boiler, spark arrester, rain water trap, etc., to be measured/ stated as shown in Fig. 15.05.01 (at specified MCR) is normally given by the relevant manufacturer.

Total back-pressure (Δp_M)

The total back-pressure, measured/stated as the static pressure in the pipe after the turbocharger, is then:

$$\Delta p_M = \Sigma \Delta p$$

where Δp incorporates all pipe elements and components etc. as described:

Δp_M has to be lower than 350 mm WC.

(At design stage it is recommended to use max. 300 mm WC in order to have some margin for fouling).

Measuring Back Pressure

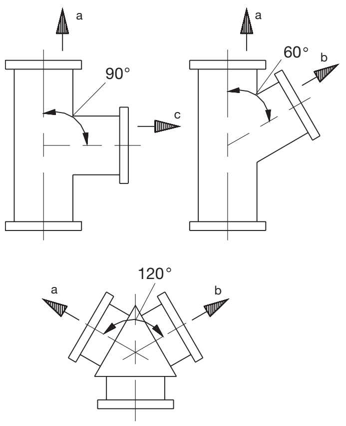
At any given position in the exhaust gas system, the total pressure of the flow can be divided into dynamic pressure (referring to the gas velocity) and static pressure (referring to the wall pressure, where the gas velocity is zero).

At a given total pressure of the gas flow, the combination of dynamic and static pressure may change, depending on the actual gas velocity. The measurements, in principle, give an indication of the wall pressure, i.e., the static pressure of the gas flow.

It is, therefore, very important that the back pressure measuring points are located on a straight part of the exhaust gas pipe, and at some distance from an ‘obstruction‘, i.e. at a point where the gas flow, and thereby also the static pressure, is stable. Taking measurements, for example, in a transition piece, may lead to an unreliable measurement of the static pressure.

In consideration of the above, therefore, the total back pressure of the system has to be measured after the turbocharger in the circular pipe and not in the transition piece. The same considerations apply to the measuring points before and after the exhaust gas boiler, etc.

Pressure losses and coefficients of resistance in exhaust pipes



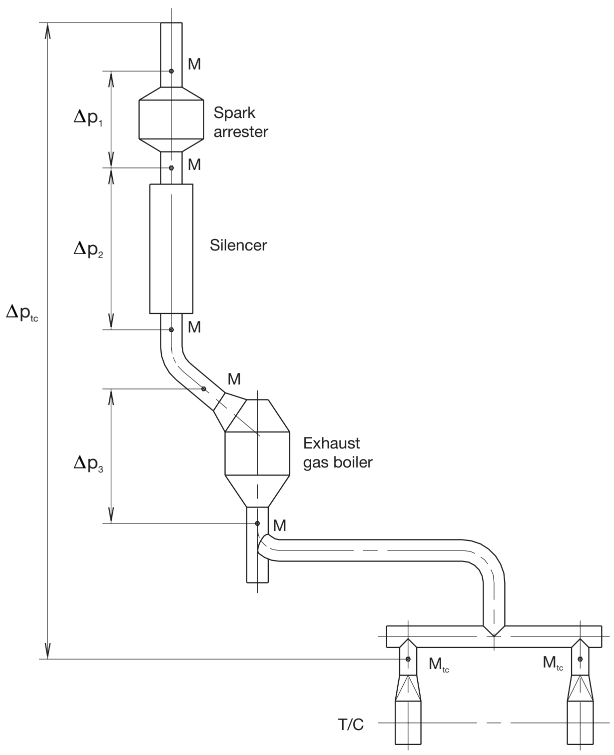
Change-over valves

Change-over valve of type with constant cross section

ζa = 0.6 to 1.2
ζb = 1.0 to 1.5
ζc = 1.5 to 2.0

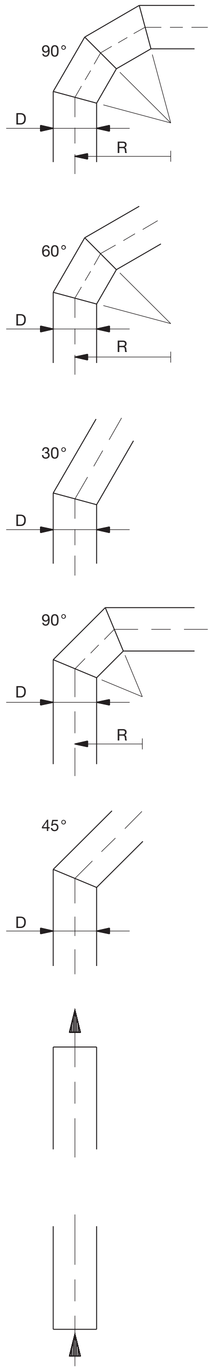
Change-over valve of type with volume

$\zeta a = \zeta b$ = about 2.0



M: Measuring points

178 32 09-1.0



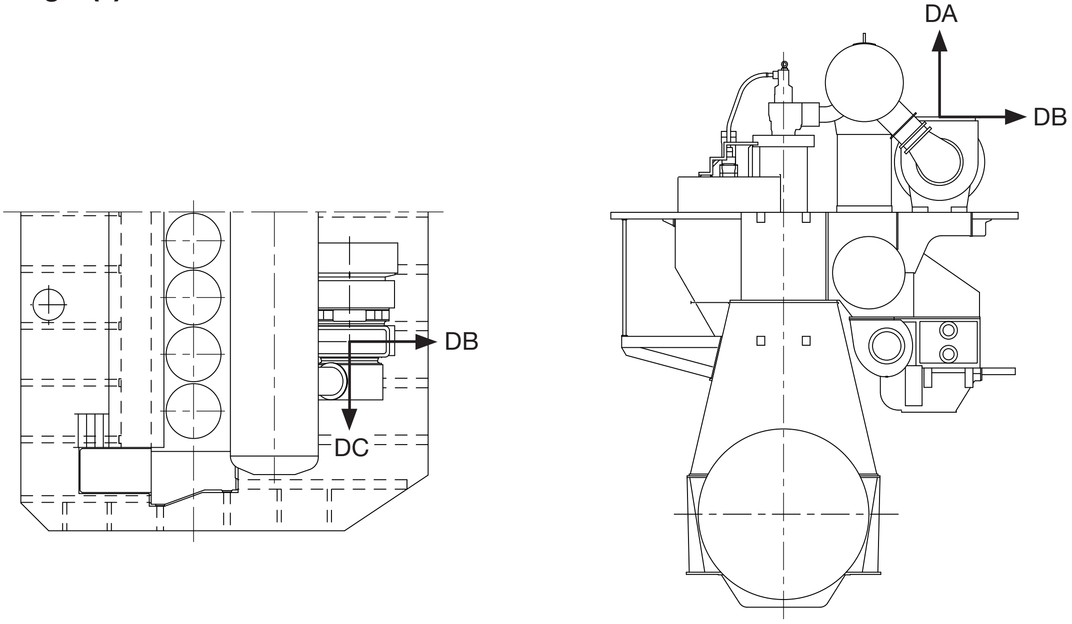
R = D	ζ = 0.28
R = 1.5D	ζ = 0.20
R = 2D	ζ = 0.17
R = D	ζ = 0.16
R = 1.5D	ζ = 0.12
R = 2D	ζ = 0.11
	ζ = 0.05
R = D	ζ = 0.45
R = 1.5D	ζ = 0.35
R = 2D	ζ = 0.30
	ζ = 0.14
Outlet from top of exhaust gas uptake	ζ = 1.00
Inlet (from turbocharger)	ζ = – 1.00

178 06 85-3.0

Fig. 15.05.01: Pressure losses and coefficients of resistance in exhaust pipes

Forces and Moments at Turbocharger

Turbocharger(s) located on exhaust side



DA: Max. movement of the turbocharger flange in the vertical direction
DB: Max. movement of the turbocharger flange in the transversal direction
DC: Max. movement of the turbocharger flange in the longitudinal direction

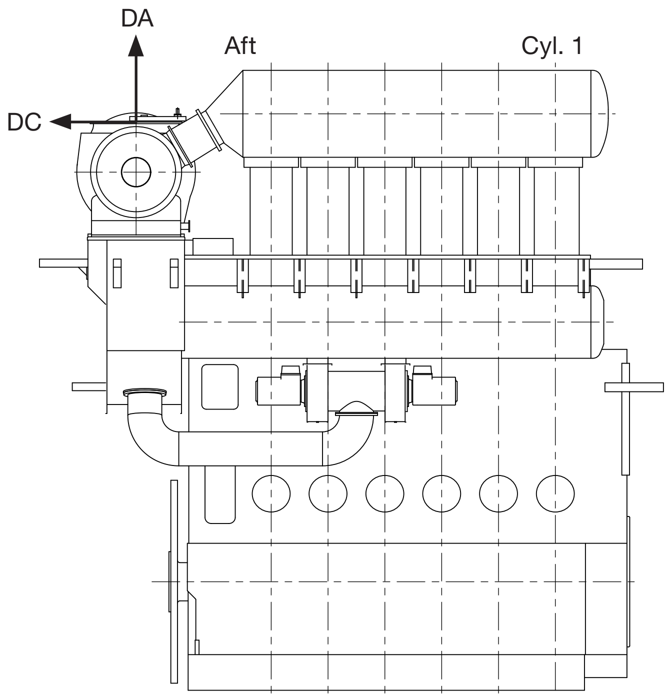
078 87 11-1.0.0b

Fig. 15.06.01a: Vectors of thermal expansion at the turbocharger exhaust gas outlet flange, TC on exhaust side

No. of cylinders		5-8		5	6	7	8
Turbocharger Make	Type	DA mm	DB mm	DC mm	DC mm	DC mm	DC mm
MAN Diesel	TCA55	7.1	1.2	1.1	1.3	1.5	1.7
	TCA66	7.4	1.2	1.1	1.3	1.5	1.7
	TCA77	8.6	1.2	1.1	1.3	1.5	1.7
	NA48	7.0	1.2	1.1	1.3	1.5	1.7
	NA57	7.4	1.1	1.1	1.3	1.5	1.7
ABB	TPL73	6.2	1.2	1.1	1.3	1.5	1.7
	TPL77	6.8	1.2	1.1	1.3	1.5	1.7
	TPL80	7.4	1.1	1.1	1.3	1.5	1.7
MHI	MET53	6.5	1.2	1.1	1.3	1.5	1.7
	MET66	7.3	1.2	1.1	1.3	1.5	1.7

Table 15.06.02a: Max. expected movements of the exhaust gas flange resulting from thermal expansion, TC on exhaust side

One turbocharger located on aft end



DA: Max. movement of the turbocharger flange in the vertical direction
DC: Max. movement of the turbocharger flange in the longitudinal direction

078 87 11-1.0.0a

Fig. 15.06.01b: Vectors of thermal expansion at the turbocharger exhaust gas outlet flange, TC on aft end

No. of cylinders		**5-8**	**5**	**6**	**7**	**8**
Turbocharger Make	**Type**	**DA mm**	**DC mm**	**DC mm**	**DC mm**	**DC mm**
MAN Diesel	TCA55	7.1	2.5	2.7	2.8	3.0
	TCA66	7.4	2.5	2.7	2.8	3.0
	TCA77	8.6	2.9	3.1	3.3	3.5
	NA48	7.0	2.5	2.7	2.9	3.1
	NA57	7.4	2.9	3.1	3.3	3.5
	NA70	8.8	3.3	3.5	3.7	3.9
ABB	TPL73	6.2	2.3	2.4	2.6	2.8
	TPL77	6.8	2.5	2.7	2.8	3.0
	TPL80	7.4	2.7	2.9	3.1	3.2
MHI	MET53	6.5	2.5	2.7	2.8	3.0
	MET66	7.3	2.8	3.0	3.2	3.3

Table 15.06.02b: Max. expected movements of the exhaust gas flange resulting from thermal expansion, TC on aft end

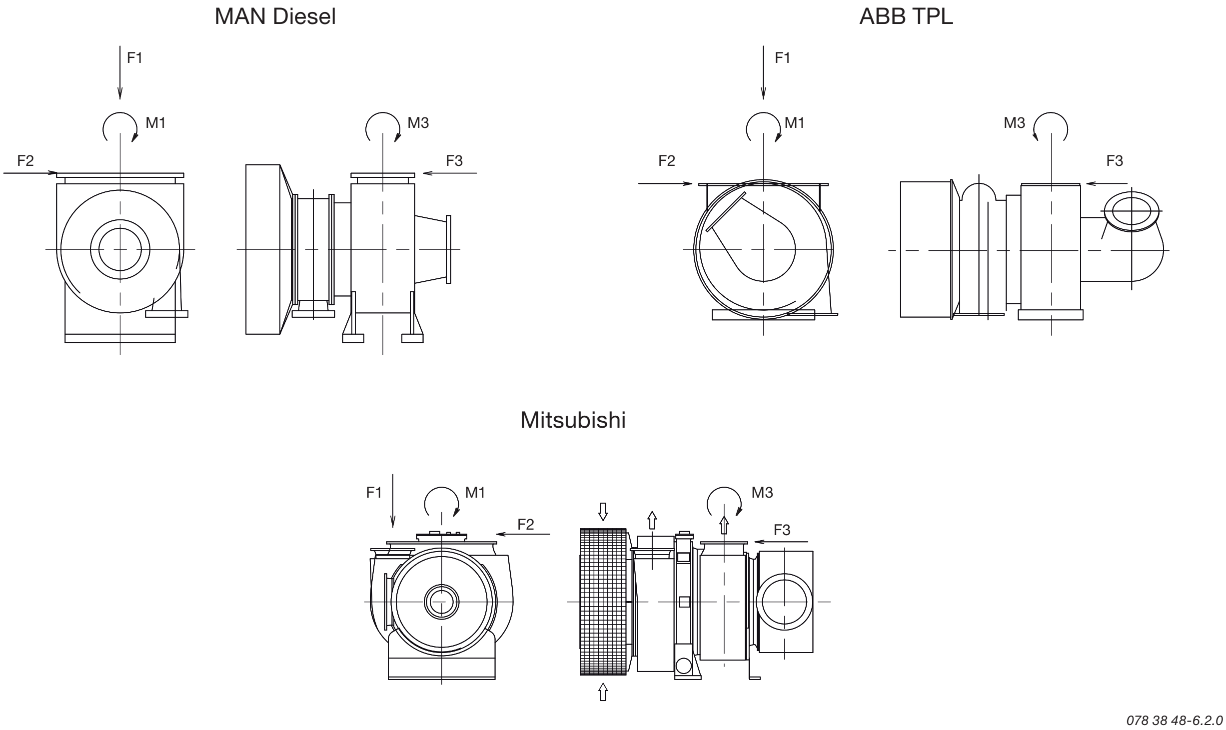


Fig. 15.06.03: Forces and moments on the turbochargers' exhaust gas outlet flange

Table 15.06.04 indicates the maximum permissible forces (F1, F2 and F3) and moments (M1 and M3), on the exhaust gas outlet flange of the turbocharger(s). Reference is made to Fig. 15.06.03.

Turbocharger Make	Turbocharger Type	M1 Nm	M3 Nm	F1 N	F2 N	F3 N
MAN Diesel	TCA55	3,400	6,900	9,100	9,100	4,500
	TCA66	3,700	7,500	9,900	9,900	4,900
	TCA77	4,100	8,200	10,900	10,900	5,400
	NA48	3,600	2,400	6,000	6,000	2,400
	NA57	4,300	3,000	7,000	7,000	3,000
	NA70	5,300	3,500	8,800	8,800	3,500
ABB	TPL73	5,500	5,500	9,500	9,000	9,000
	TPL77	7,700	7,700	11,500	10,000	10,000
	TPL80	11,000	11,000	15,000	13,000	13,000
MHI	MET53	4,900	2,500	7,300	2,600	2,300
	MET66	6,800	3,400	9,300	3,200	3,000

Table 15.06.04: The max. permissible forces and moments on the turbocharger's gas outlet flanges

Diameter of Exhaust Gas Pipes

The exhaust gas pipe diameters listed in Table 15.07.02 are based on the exhaust gas flow capacity according to ISO ambient conditions and an exhaust gas temperature of 250 °C.

The exhaust gas velocities and mass flow listed apply to collector pipe D4. The table also lists the diameters of the corresponding exhaust gas pipes D0 for various numbers of turbochargers installed.

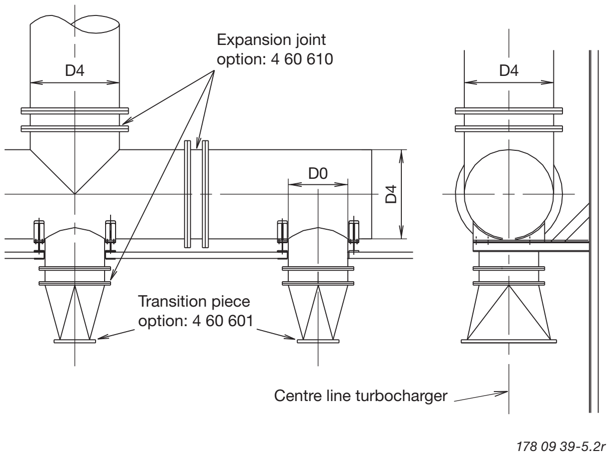


Fig. 15.07.01a: Exhaust pipe system, with turbocharger located on exhaust side of engine, option: 4 59 123

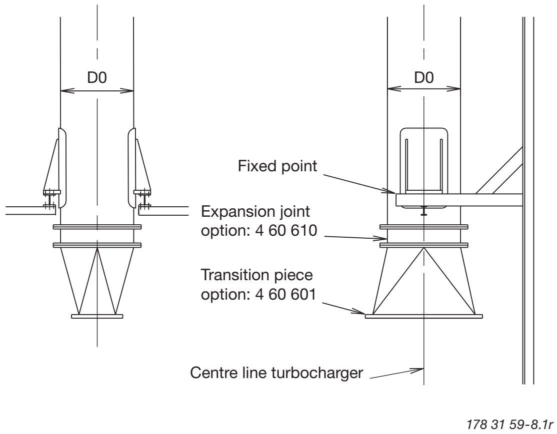


Fig. 15.07.01b: Exhaust pipe system, with single turbocharger located on aft end of engine, option: 4 59 121

Gas velocity				Exhaust gas pipe diameters		
35 m/s	40 m/s	45 m/s	50 m/s	D0		D4
Gas mass flow				1 T/C	2 T/C	
kg/s	kg/s	kg/s	kg/s	[DN]	[DN]	[DN]
13.4	15.3	17.2	19.1	850	600	850
15.0	17.2	19.3	21.5	900	650	900
16.7	19.1	21.5	23.9	950	650	950
18.6	21.2	23.9	26.5	1,000	700	1,000
20.5	23.4	26.3	29.2	1,050	750	1,050
22.4	25.7	28.9	32.1	1,100	800	1,100
24.5	28.0	31.5	35.1	1,150	800	1,150
26.7	30.5	34.3	38.2	1,200	850	1,200
31.4	35.8	40.3	44.8	1,300	900	1,300

Table 15.07.02: Exhaust gas pipe diameters and exhaust gas mass flow at various velocities

Engine Control System

16

Engine Control System

The engine is provided with a pneumatic/electric manoeuvring and fuel oil regulating system, which transmits orders from the separate manoeuvring consoles to the engine.

By means of the regulating system it is possible to start, stop, reverse the engine and control the engine speed. The speed setting device on the manoeuvring consoles gives a speed setting signal to the governor, dependent on the desired number of rpm.

At shut-down, the fuel injection is stopped by activating the puncture valves in the fuel pumps, independent of the speed position of the speed setting device.

The layout of the Engine Control System is shown in Fig. 16.01.01 and a diagram of the pneumatic manoeuvring system in Fig. 16.01.02a and b.

Manoeuvring Consoles

The Engine Control System for the MC / MC-C engine is prepared for conventional remote control, having an interface to the Bridge Control (BC) system and the Engine Side Console (ESC).

The main Engine Control Room (ECR) manoeuvring console is to be located in the engine control room. The console with buttons, lamps, etc. recommended by MAN Diesel is shown in Fig. 16.01.07. Components for remote control for a typical installation with bridge control is shown in Fig. 16.01.05.

The layout of the Engine Side Console and instrument panel is shown in Fig. 16.01.06a, b and c. The console and an electronic speed setting device, the governor, are located on the manoeuvring side of the engine.

In the event of breakdown of the normal pneumatic/electric manoeuvring system, the engine can be operated from the Engine Side Console.

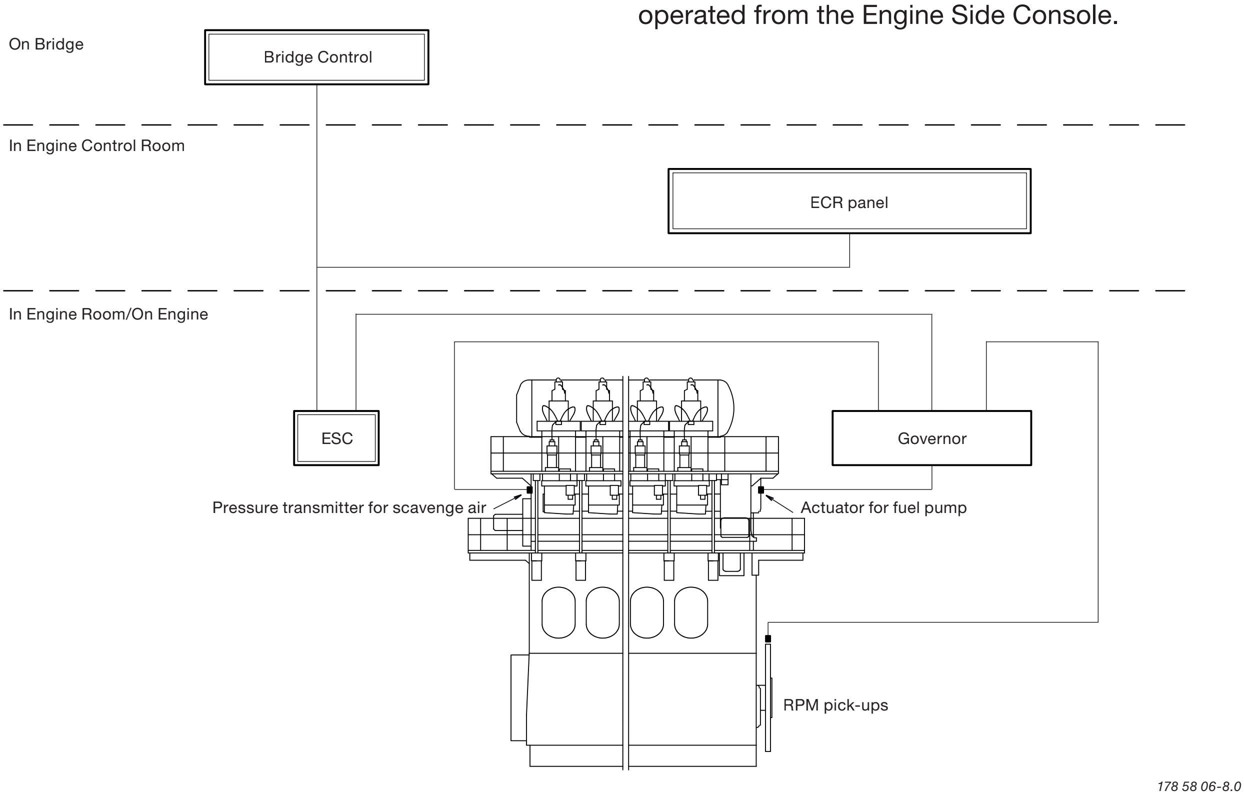


Fig. 16.01.01: Engine Control System Layout

Diagram of manoeuvring system

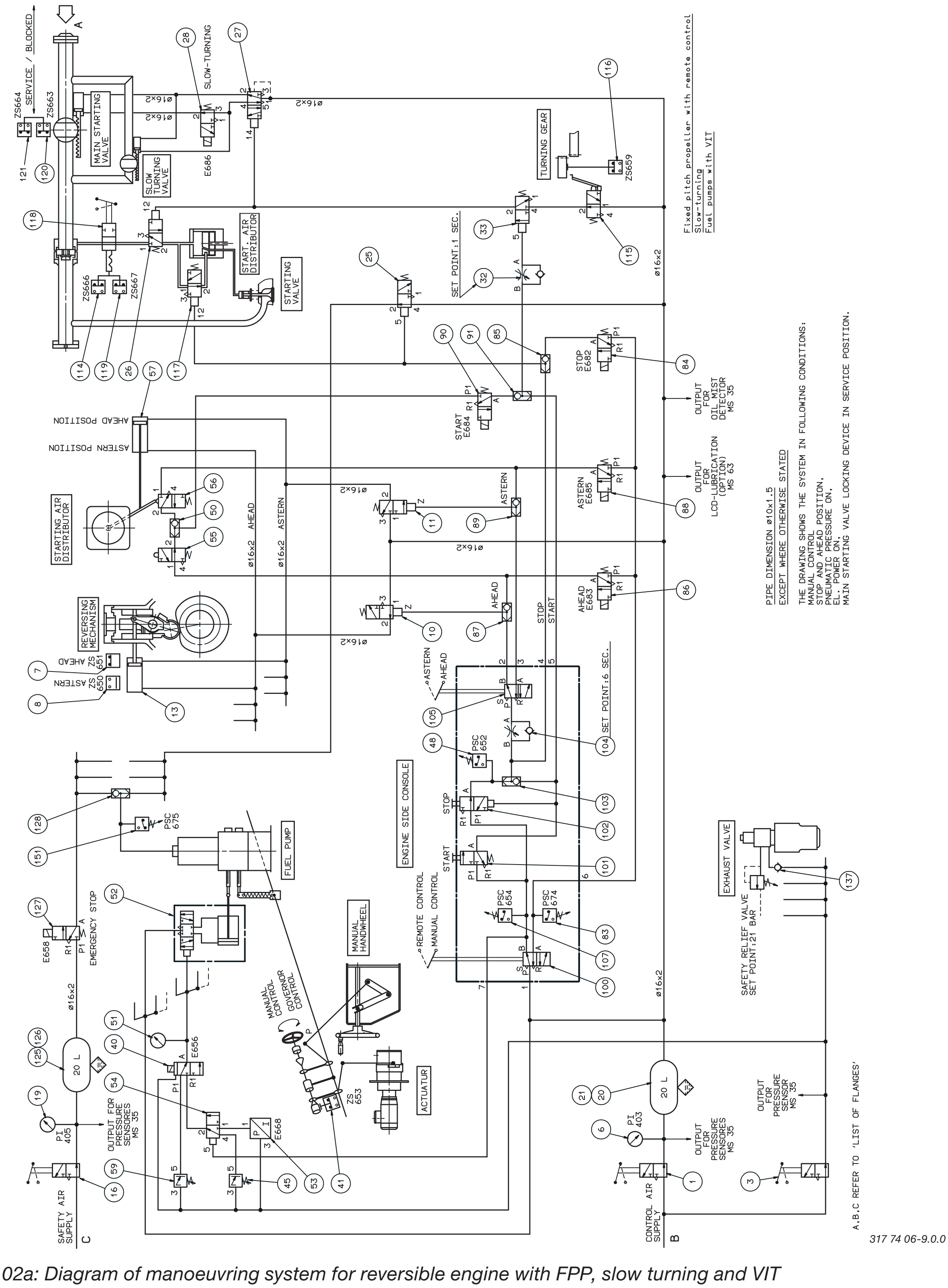


Fig. 16.01.02a: Diagram of manoeuvring system for reversible engine with FPP, slow turning and VIT (Basic for S/K98-80MC/MC-C, optional on S/L70-60 & S50MC-C)

Diagram of manoeuvring system

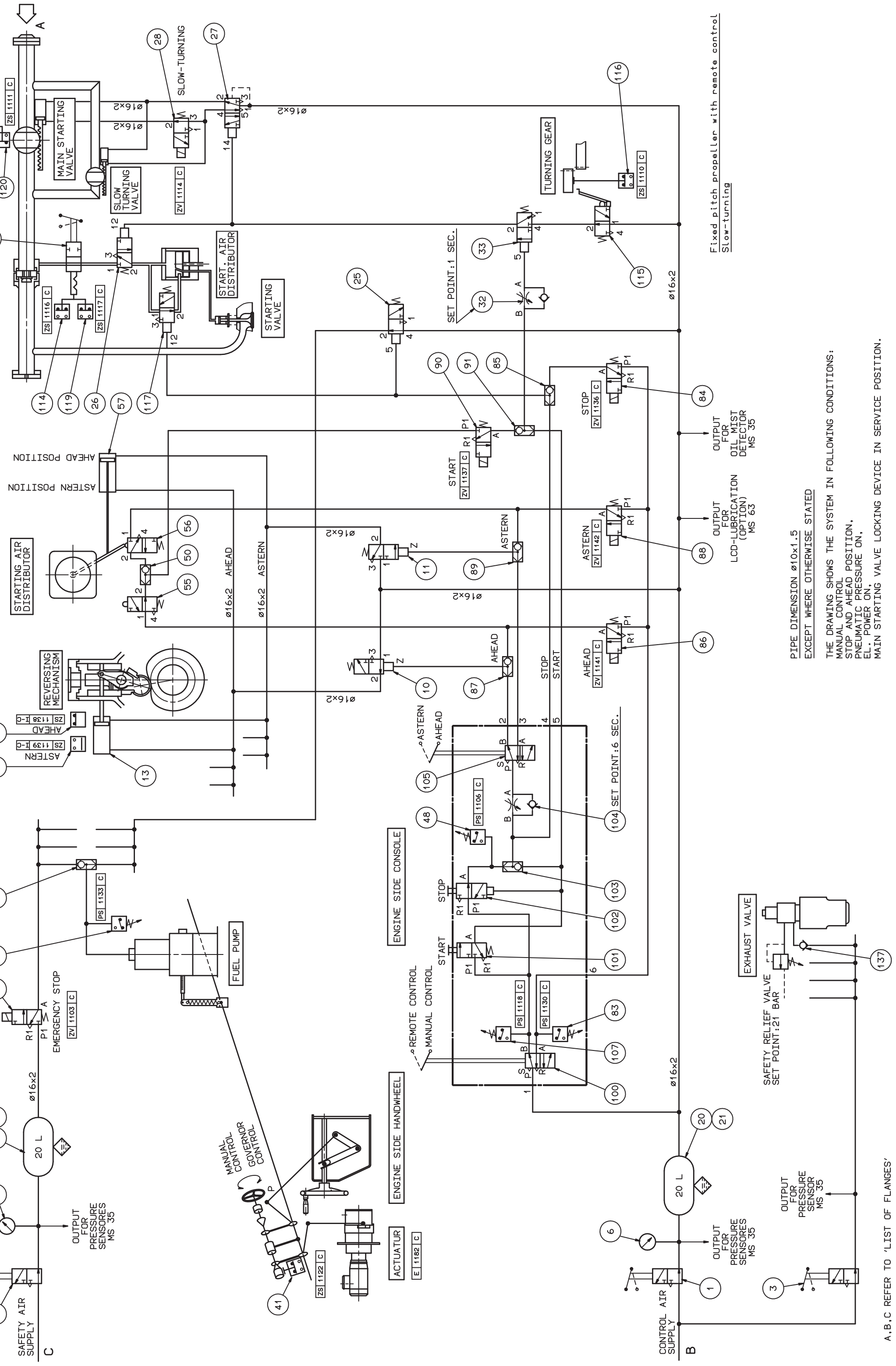


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Fig. 16.01.02b: Diagram of manoeuvring system for reversible engine with FPP and slow turning, no VIT (Basic for S/L70-60 & 35MC/MC-C as well as S50-26MC/MC-C)

Manoeuvring System on Engine

The basic manoeuvring diagram is applicable for reversible engines, i.e. those with Fixed Pitch Propeller (FPP), and shown in Fig. 16.01.02a and b.

The lever on the Engine Side Console can be set to either Manual or Remote position, see Fig. 16.01.06a, b and c.

In the Manual position the engine is controlled from the Engine Side Console by the push buttons START, STOP, and the AHEAD/ASTERN. The speed is set by the 'Manual speed setting' by the handwheel.

In the 'Remote' position all signals to the engine are electronic, the START, STOP, AHEAD and ASTERN signals activate the solenoid valves ZV 1137 C, ZV 1136 C, ZV 1141 C and ZV 1142 C respectively, shown in Figs. 16.01.02 and 16.01.05, and the speed setting signal via the electronic governor and the actuator E 1182 C.

The electrical signal comes from the remote control system, i.e. the Bridge Control (BC) console, or from the Engine Control Room (ECR) console.

Shut down system

The engine is stopped by activating the puncture valve located in the fuel pump either at normal stopping or at shut down by activating solenoid valve ZV 1103 C, see Fig. 16.01.02a and b.

Slow turning

The standard manoeuvring system does not feature slow turning before starting, but for Unattended Machinery Spaces (UMS) we strongly recommend the addition of the slow turning device shown in Fig. 16.01.02a and b as well as Fig. 16.01.03, option: 4 50 140.

The slow turning valve diverts the starting air to partially bypass the main starting valve. During slow turning the engine will rotate so slowly that, In the event that liquids have accumulated on the piston top, the engine will stop before any harm occurs.

Low load operation

For operation at low load, a cylinder cut-out system is provided on engine types 98, 90 and 80, option: 4 65 255.

Control System for Plants with CPP
– applicable for engine types 70-26 only

Where a controllable pitch propeller is installed the control system is to be designed in such a way that the operational requirements for the whole plant are fulfilled.

Special attention should be paid to the actual operation mode, e.g. combinator curve with/without constant frequency shaft generator or constant engine speed with a power take off.

The following requirements have to be fulfilled:

- The control system is to be equipped with a load control function limiting the maximum torque (fuel pump index) in relation to the engine speed, in order to prevent the engine from being loaded beyond the limits of the load diagram
- The control system must ensure that the engine load does not increase at a quicker rate than permitted by the scavenge air pressure
- Load changes have to take place in such a way that the governor can keep the engine speed within the required range.

Please contact the engine builder to get specific data.

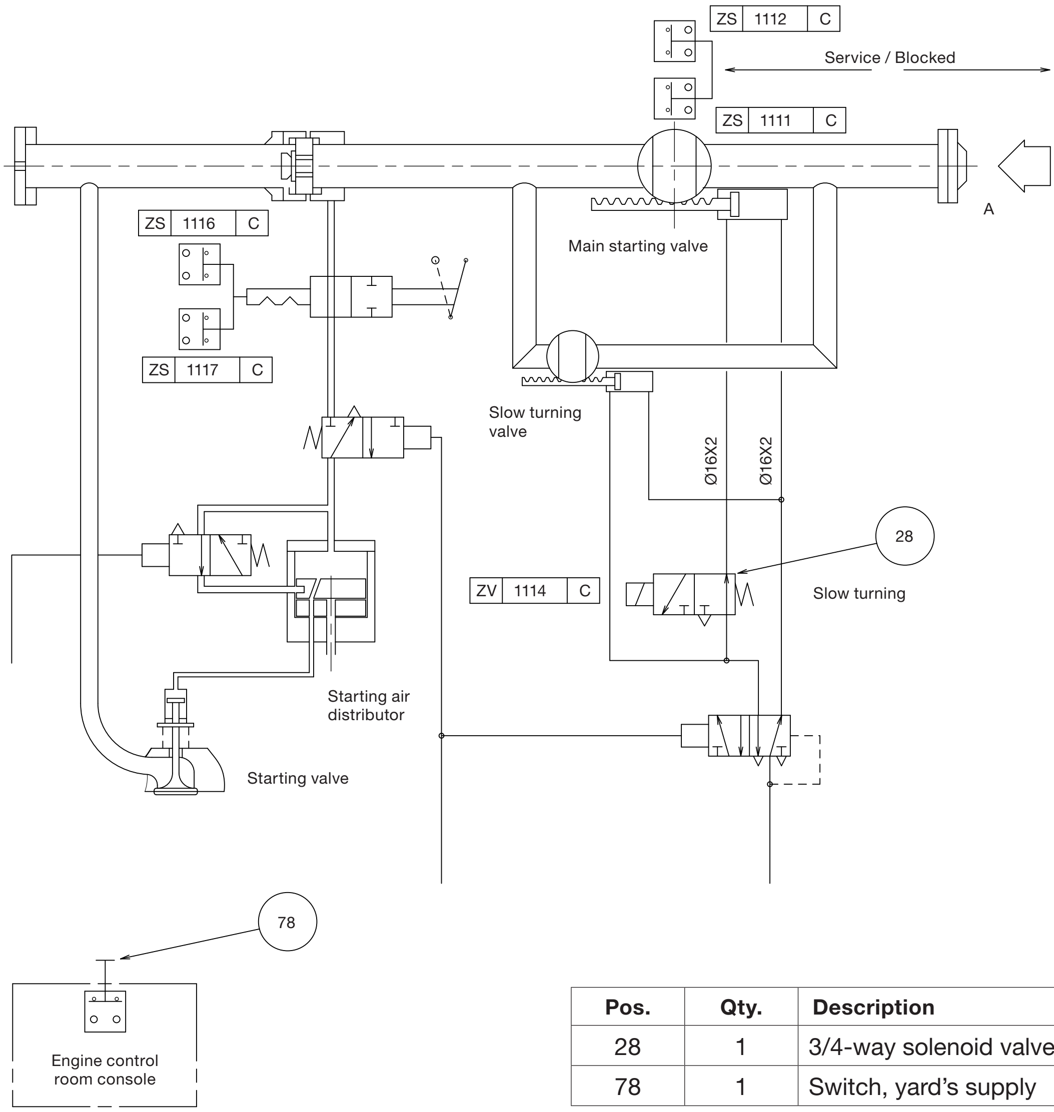
Sequence Diagram

MAN Diesel's requirements for the control system are indicated graphically in Fig. 16.01.08a, b and c, 'Sequence diagram'.

The diagram shows the functions as well as the delays which must be considered in respect to starting 'Ahead' and starting 'Astern', as well as for the activation of the slow down and shut down functions.

On the right of the diagram, a situation is shown where the order 'Astern' is over-ridden by an 'Ahead' order – the engine immediately starts 'Ahead' if the engine speed is above the specified starting level.

Starting Air System



Pos.	Qty.	Description
28	1	3/4-way solenoid valve
78	1	Switch, yard's supply

Additional components for slow turning are the slow turning valve in bypass and position nos. 28 and 78
The item No. refers to 'Guidance values 'automation'
The letter refers to list of 'Counterflanges'
The piping is delivered with and fitted onto the engine

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Fig. 16.01.03: Starting air system, with slow turning, option: 4 50 140

Governor parts and mode of operation

The engine is, as standard, provided with an electronic/mechanical type of fuel pump actuator of a make approved by MAN Diesel.

The speed setting of the actuator is determined by an electronic signal from the electronic governor of a make approved by MAN Diesel. The actuator shaft is connected to the fuel regulating shaft by means of a mechanical linkage.

When selecting the governor, the complexity of the installation has to be considered. We normally distinguish between ‘conventional’ and ‘advanced’ marine installations.

The governor consists of the following elements:

- Actuator
- Revolution transmitter (pick-ups)
- Electronic governor panel
- Power supply unit
- Pressure transmitter for scavenge air.

The actuator, revolution transmitter and the pressure transmitter are mounted on the engine.

The electronic governors must be tailor-made, and the specific layout of the system must be mutually agreed upon by the customer, the governor supplier and the engine builder.

It should be noted that the shut down system, the governor and the remote control system must be compatible if an integrated solution is to be obtained.

The minimum speed is 20-25% of the engines nominal speed when an electronic governor is applied.

Governor for ‘Conventional’ plants

A typical example of a ‘conventional’ marine installation is:

- An engine directly coupled to a fixed pitch propeller.

With a view to such an installations, the engine is, as standard, equipped with a ‘conventional’ electronic governor with actuator of a make approved by MAN Diesel, e.g.:

4 65 170 Woodward

4 65 172 Lyngsø Marine A/S

4 65 174 Kongsberg Maritime Ship Systems A/S

4 65 175 NABCO Ltd.

4 65 177 Siemens.

Governor for ‘Advanced’ plants

For more ‘advanced’ marine installations, such as, for example:

- Plants with flexible coupling in the shafting system
- Geared installations
- Plants with disengageable clutch for disconnecting the propeller
- Plants with shaft generator with great requirement for frequency accuracy.

The electronic governors have to be tailor-made, and the specific layout of the system has to be mutually agreed upon by the customer, the governor supplier and the engine builder.

It should be noted that the shut down system, the governor and the remote control system must be compatible if an integrated solution is to be obtained.

Governor and remote control components

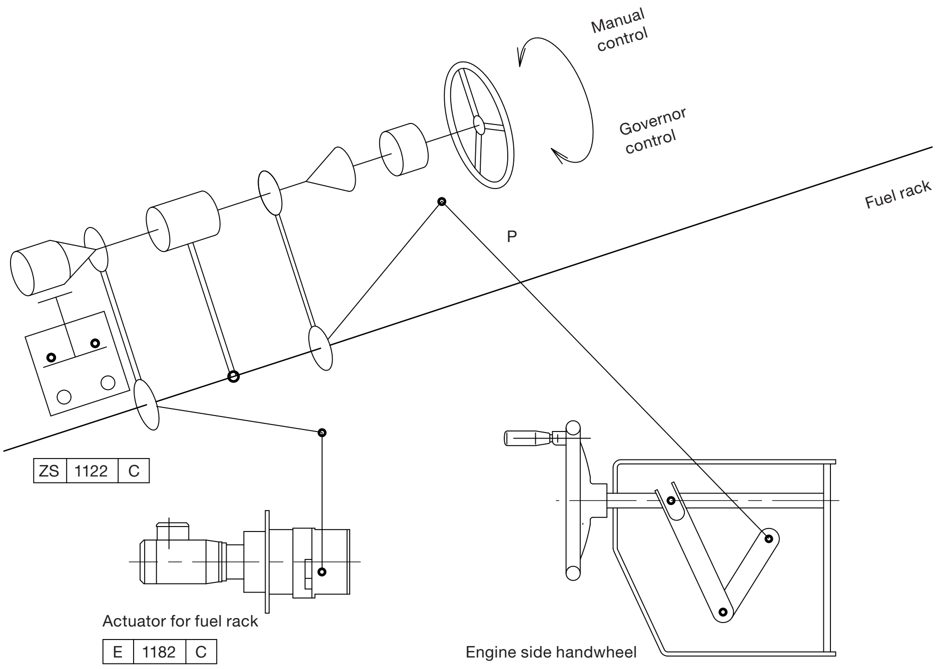

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Fig. 16.01.04: Electronic governor

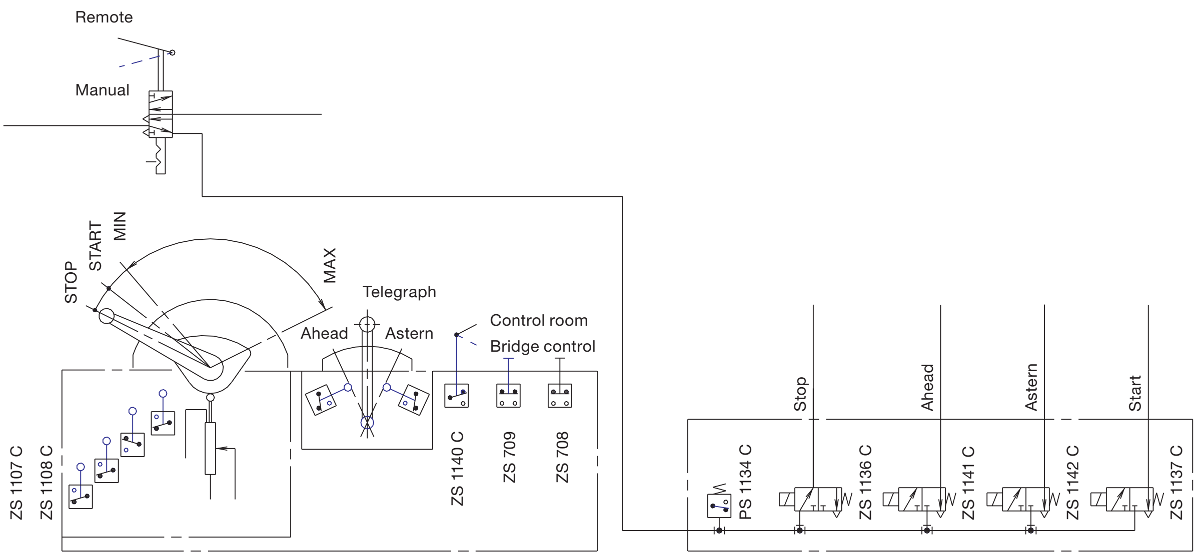

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Fig. 16.01.05: Components for remote control of reversible engine with FPP with bridge control

Engine Side Control Console with diagram

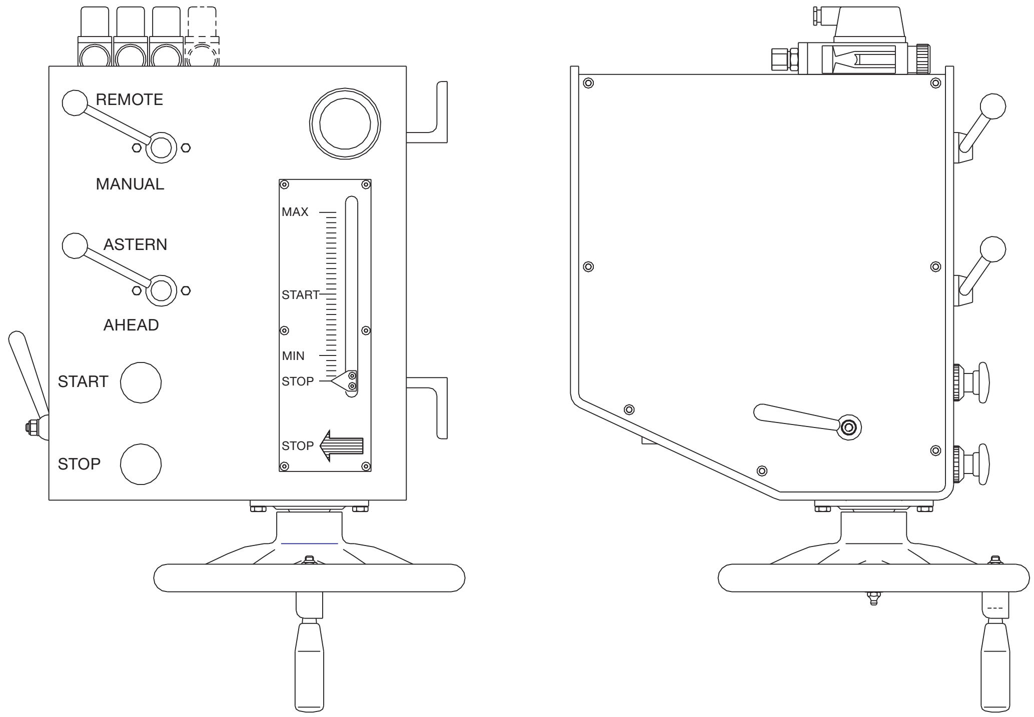


Fig. 16.01.06a: Engine Side Control console, for reversible engine

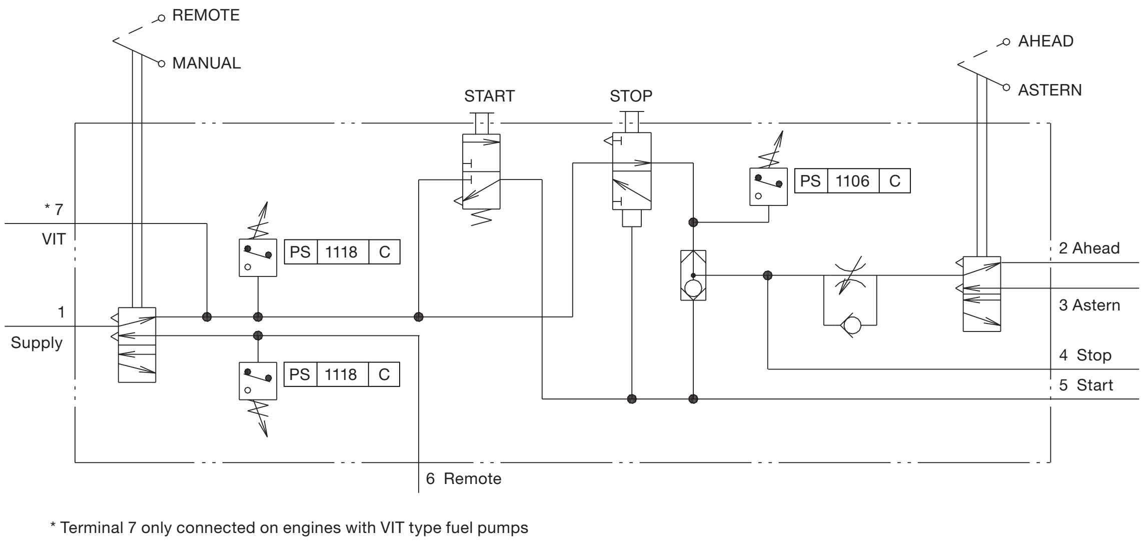
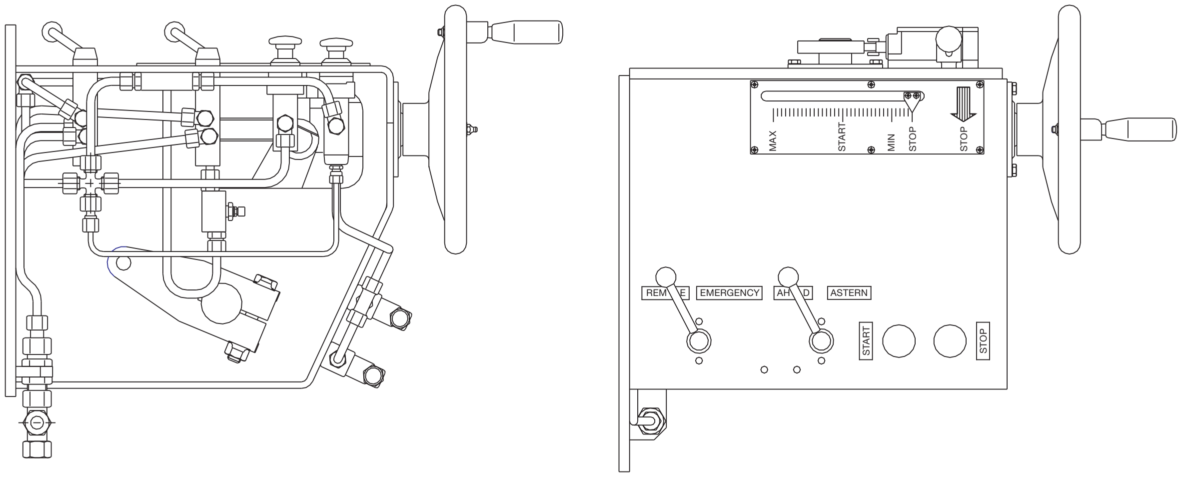


Fig. 16.01.06b: Diagram of Engine Side Control console

Engine Side Control Console and Instrument Panel



Components included for:

Fixed pitch propeller:

- Remote control – manual engine side control
- Ahead – Astern handle
- Start button
- Stop button

The instrument panel includes:

For reversible engine:

- Tachometer for engine
- Indication for engine side control
- Indication for control room control (remote)
- Indication for bridge control (remote)
- Indication for ‘Ahead’
- Indication for ‘Astern’
- Indication for auxiliary blower running
- Indication and buzzer for wrong way alarm
- Indication for turning gear engaged
- Indication for ‘Shut down’
- Push button for canceling ‘Shut down’, with indication

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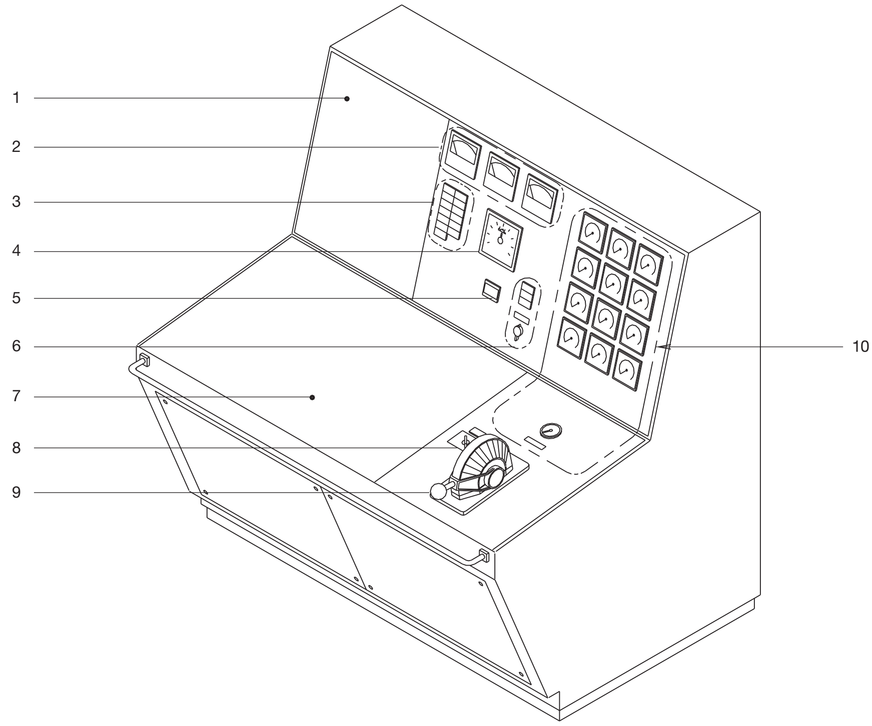
Fig. 16.01.06c: Engine Side Control console and instrument panel

Engine Control Room Console



1 Free space for mounting of safety panel
  Engine builder's supply
2 Tachometer(s) for turbocharger(s)
3 Indication lamps for:
  - Ahead
  - Astern
  - Engine Side Control
  - Control Room Control
  - Wrong way alarm
  - Turning gear engaged
  - Main starting valve in service
  - Main starting valve in blocked mode
  - Remote control
  - Shut down
  - (Spare)
  - Lamp test
4 Tachometer for main engine
5 Revolution counter
6 Switch and lamps for auxiliary blowers
7 Free spares for mounting of bridge control equipment for main engine
8 Switch and lamp for cancelling of limiters for governor
9 Engine control handle, option: 4 65 625 from engine maker
* 10 Pressure gauges for:
  - Scavenge air
  - Lubricating oil, main engine
  - Cooling oil, main engine
  - Jacket cooling water
  - Sea cooling water
  - Lubricating oil, camshaft
  - Fuel oil before filter
  - Fuel oil after filter
  - Starting air
  - Control air supply
* 10 Thermometer:
  - Jacket cooling water
  - Lubricating oil water

Note: If an axial vibration monitor is ordered (option: 4 31 116) the manoeuvring console has to be extended by a remote alarm/slow down indication lamp.

* These instruments have to be ordered as option: 4 75 645 and the corresponding analogue sensors on the engine as option: 4 75 128.

Fig. 16.01.07: Instruments and pneumatic components for Engine Control Room console, yard's supply

Sequence diagram for engines with Fixed Pitch Propeller

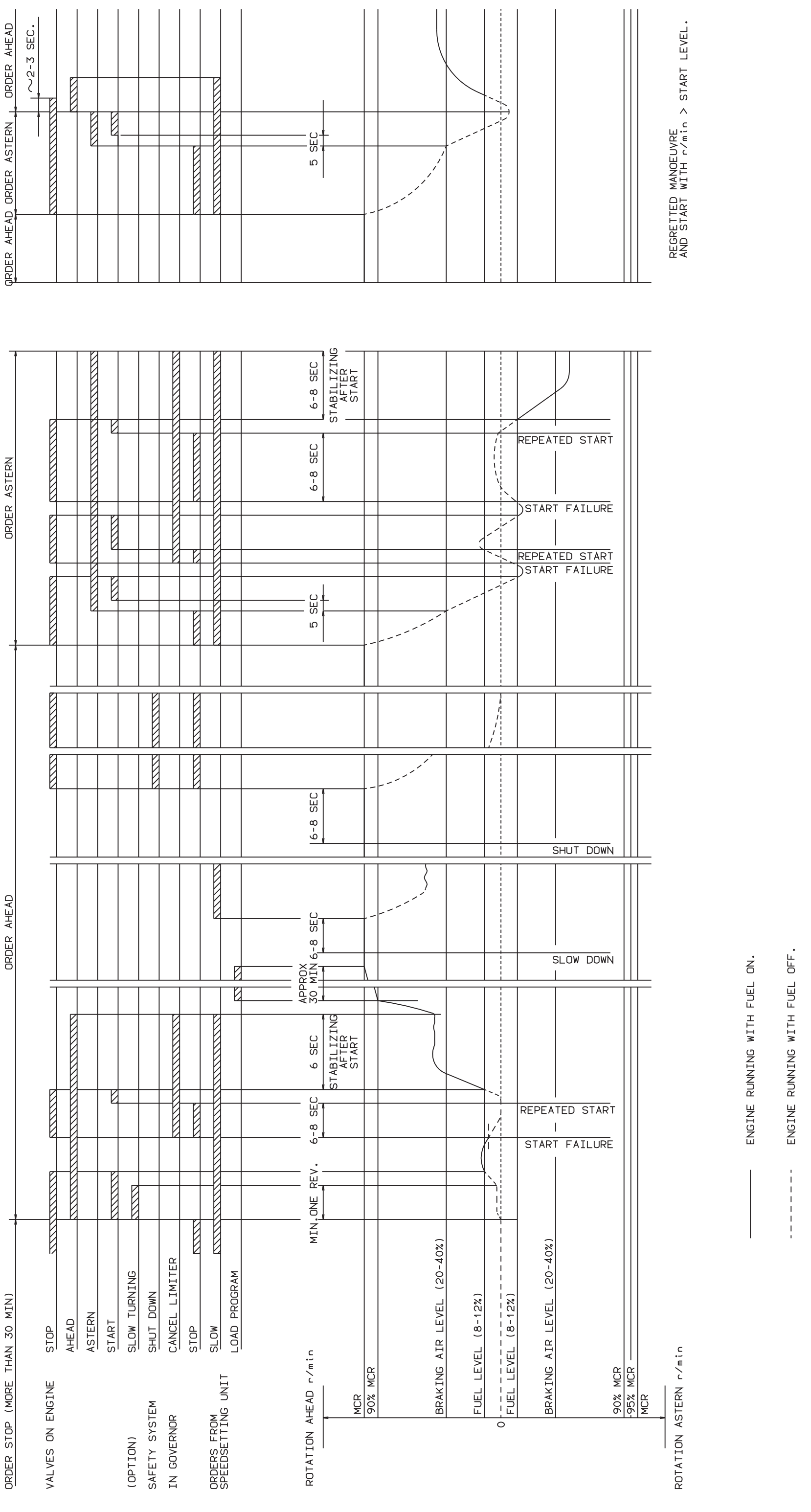


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Fig. 16.01.08a: Sequence diagram for fixed pitch propeller, MC/MC-C types 50-26

Controllable Pitch Propeller

This section is available on request

Engine Control System Interface to Surrounding Systems

To support the navigator, the vessels are equipped with a ship control system, which includes subsystems to supervise and protect the main propulsion engine.

The monitoring systems and instrumentation are explained in detail in Chapter 18.

Alarm system

The alarm system has no direct effect on the Engine Control System (ECS). The alarm alerts the operator of an abnormal condition.

The alarm system is an independent system, in general covering more than the main engine itself, and its task is to monitor the service condition and to activate the alarms if a normal service limit is exceeded.

The signals from the alarm sensors can be used for the slow down function as well as for remote indication.

Slow down system

The engine safety system is an independent system with its respective sensors on the main engine, fulfilling the requirements of the respective classification society and MAN Diesel.

Safety system

The engine safety system is an independent system with its respective sensors on the main engine, fulfilling the requirements of the respective classification society and MAN Diesel.

If a critical value is reached for one of the measuring points, the input signal from the safety system must cause either a cancellable or a non-cancellable shut down signal to the ECS.

The safety system is included as standard in the extent of delivery.

Telegraph system

The telegraph system is an independent system.

This system enables the navigator to transfer the commands of engine speed and direction of rotation from the Bridge, the engine control room or the Engine Side Console (ESC).

Remote Control system

The remote control system normally has two alternative control stations:

- the Bridge Control console
- the Engine Control Room console

The remote control system is to be delivered by an approved supplier.

Power Management system

The system handles the supply of electrical power onboard, i.e. the starting and stopping of the generating sets as well as the activation / deactivation of the main engine Shaft Generator (SG), if fitted.

The normal function involves starting, synchronising, phasing-in, transfer of electrical load and stopping of the generators based on the electrical load of the grid on board.

The activation / deactivation of the SG is to be done within the engine speed range which fulfils the specified limits of the electrical frequency.

Auxiliary equipment system

The input signals for 'Auxiliary system ready' are given partly based on the status for:

• fuel oil system
• lube oil system
• cooling water systems

and partly from the ECS itself:

• turning gear disengaged
• main starting valve 'open'
• control air valve for sealing air 'open'
• control air valve for air spring 'open'
• auxiliary blowers running
• hydraulic power supply ready.

Engine monitoring

In order to assist the engineer in runnning the diesel engine at its optimum performance, a MAN Diesel's PMI system, type PT/S off-line or on-line could be applied as an option.

The MAN Diesel's PMI system, type PT/S off-line monitors engine parameters such as:

• cylinder pressure
• fuel oil injection pressure
• scavenge air pressure
• engine speed.

This and other engine monitoring systems are further explained in Chapter 18 in this Project Guide.

Instrumentation

Chapter 18 includes lists of instrumentation for:

• The CoCos-EDS on-line system
• The class requirements and MAN Diesel's requirements for alarms, slow down and shut down for Unattended Machinery Spaces.

Vibration Aspects

17

Vibration Aspects

The vibration characteristics of the two-stroke low speed diesel engines can for practical purposes be split up into four categories, and if the adequate countermeasures are considered from the early project stage, the influence of the excitation sources can be minimised or fully compensated.

In general, the marine diesel engine may influence the hull with the following:

- External unbalanced moments
  These can be classified as unbalanced 1st and 2nd order external moments, which need to be considered only for certain cylinder numbers
- Guide force moments
- Axial vibrations in the shaft system
- Torsional vibrations in the shaft system.

The external unbalanced moments and guide force moments are illustrated in Fig. 17.01.01.

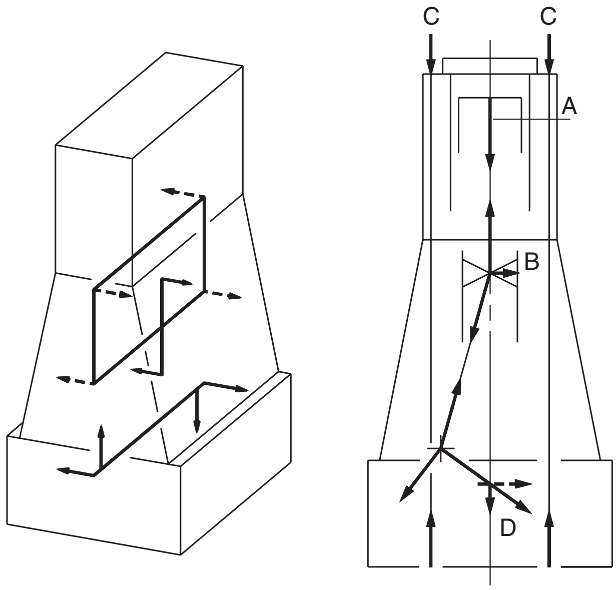
In the following, a brief description is given of their origin and of the proper countermeasures needed to render them harmless.

External unbalanced moments

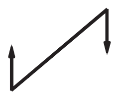
The inertia forces originating from the unbalanced rotating and reciprocating masses of the engine create unbalanced external moments although the external forces are zero.

Of these moments, the 1st order (one cycle per revolution) and the 2nd order (two cycles per revolution) need to be considered for engines with a low number of cylinders. On 7-cylinder engines, also the 4th order external moment may have to be examined. The inertia forces on engines with more than 6 cylinders tend, more or less, to neutralise themselves.

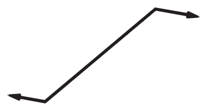
Countermeasures have to be taken if hull resonance occurs in the operating speed range, and if the vibration level leads to higher accelerations and/or velocities than the guidance values given by international standards or recommendations (for instance related to special agreement between shipowner and shipyard). The natural frequency of the hull depends on the hull's rigidity and distribution of masses, whereas the vibration level at resonance depends mainly on the magnitude of the external moment and the engine's position in relation to the vibration nodes of the ship.



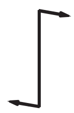
A – Combustion pressure
B – Guide force
C – Staybolt force
D – Main bearing force



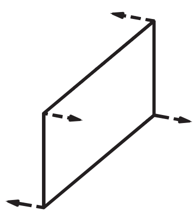
1st order moment vertical 1 cycle/rev.
2nd order moment, vertical 2 cycle/rev.



1st order moment, horizontal
1 cycle/rev.



Guide force moment,
H transverse Z cycles/rev.
Z is 1 or 2 times number of cylinder



Guide force moment,
X transverse Z cycles/rev.
Z = 1, 2…12

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Fig. 17.01.01: External unbalanced moments and guide force moments

2nd Order Moments on 5 or 6-cylinder Engines

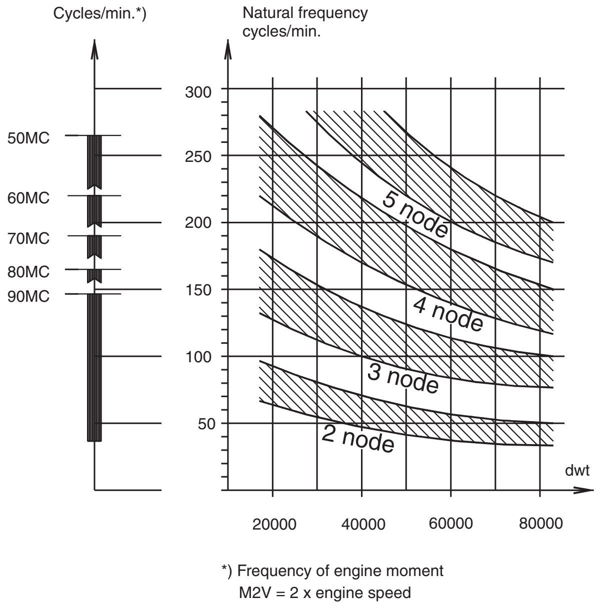

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Fig. 17.02.01: Statistics of vertical hull vibrations in tankers and bulk carriers

The 2nd order moment acts only in the vertical direction. Precautions need only to be considered for 5 and 6-cylinder engines in general.

Resonance with the 2nd order moment may occur in the event of hull vibrations with more than 3 nodes. Contrary to the calculation of natural frequency with 2 and 3 nodes, the calculation of the 4 and 5-node natural frequencies for the hull is a rather comprehensive procedure and often not very accurate, despite advanced calculation methods.

A 2nd order moment compensator comprises two counter-rotating masses running at twice the engine speed. 2nd order moment compensators are not included in the basic extent of delivery.

Several solutions are available to cope with the 2nd order moment, as shown in Fig. 17.03.02, out of which the most cost efficient one can be chosen in the individual case, e.g.:

1) No compensators, if considered unnecessary on the basis of natural frequency, nodal point and size of the 2nd order moment.

2) A compensator mounted on the aft end of the engine, driven by the main chain drive, option: 4 31 203 (types 46 and larger).

3) A compensator mounted on the fore end, driven from the crankshaft through a separate chain drive, options: 4 31 213 (types 46 and larger)

4) Compensators on both aft and fore ends, driven from the crankshaft by the main chain drive and a separate chain drive respectively, options 4 31 203 and 4 31 213.

As standard, the compensators reduce the external 2nd order moment to a level as for a 7-cylinder engine or less.

Briefly speaking, solution 1) is applicable if the node is located far from the engine, or the engine is positioned more or less between nodes. Solution 2) or 3) should be considered where one of the engine ends is positioned in a node or close to it, since a compensator is inefficient in a node or close to it and therefore superfluous. Solution 4) should be considered if the engine is positioned over the node.

A decision regarding the vibrational aspects and the possible use of compensators must be taken at the contract stage. If no experience is available from sister ships, which would be the best basis for deciding whether compensators are necessary or not, it is advisable to make calculations to determine which of the solutions should be applied.

Experience with our two-stroke slow speed engines has shown that propulsion plants with small bore engines (engines smaller than 46 types) are less sensitive regarding hull vibrations exited by 2nd order moments than the larger bore engines. Therefore, these engines do not have engine driven 2nd order moment compensators.

Preparation for compensators

If compensator(s) are initially omitted, the engine can be delivered prepared for compensators to be fitted on engine fore end later on, but the decision to prepare or not must be taken at the contract stage, options: 4 31 212 (types 46 and larger). Measurements taken during the sea trial, or later in service and with fully loaded ship, will be able to show if compensator(s) have to be fitted at all.

If no calculations are available at the contract stage, we advise to make preparations for the fitting of a compensator in the steering compartment.

Electric Driven Moment Compensator

If it is decided not to use chain driven moment compensators and, furthermore, not to prepare the main engine for compensators to be fitted later, another solution can be used, if annoying vibrations should occur: An **electrically driven moment compensator** synchronised to the correct phase relative to the external force or moment can neutralise the excitation.

This type of compensator needs an extra seating fitted, preferably, in the steering gear room where vibratory deflections are largest and the effect of the compensator will therefore be greatest.

The electrically driven compensator will not give rise to distorting stresses in the hull, but it is more expensive than the engine-mounted compensators 2), 3) and 4). It does, however, offer several advantages over the engine mounted solutions:

When placed in the steering gear room, the compensator is not as sensitive to the positioning of the node as the compensators 2) and 3).

The decision whether or not to install compensators can be taken at a much later stage of a project, since no special version of the engine structure has to be ordered for the installation.

No preparation for a later installation nor an extra chain drive for the compensator on the fore end of the engine is required. This saves the cost of such preparation, often left unused.

Compensators could be retrofit, even on ships in service, and also be applied to engines with a higher number of cylinders than is normally considered relevant, if found necessary.

The compensator only needs to be active at speeds critical for the hull girder vibration. Thus, it may be activated or deactivated at specified speeds automatically or manually.

Combinations with and without moment compensators are not required in torsional and axial vibration calculations, since the electrically driven moment compensator is not part of the mass-elastic system of the crankshaft.

Furthermore, by using the compensator as a vibration exciter a ship's vibration pattern can easily be identified without having the engine running, e.g. on newbuildings at an advanced stage of construction. If it is verified that a ship does not need the compensator, it can be removed and reused on another ship.

It is a condition for the application of the rotating force moment compensator that no annoying longitudinal hull girder vibration modes are excited. Based on our present knowledge, and confirmed by actual vibration measurements onboard a ship, we do not expect such problems.

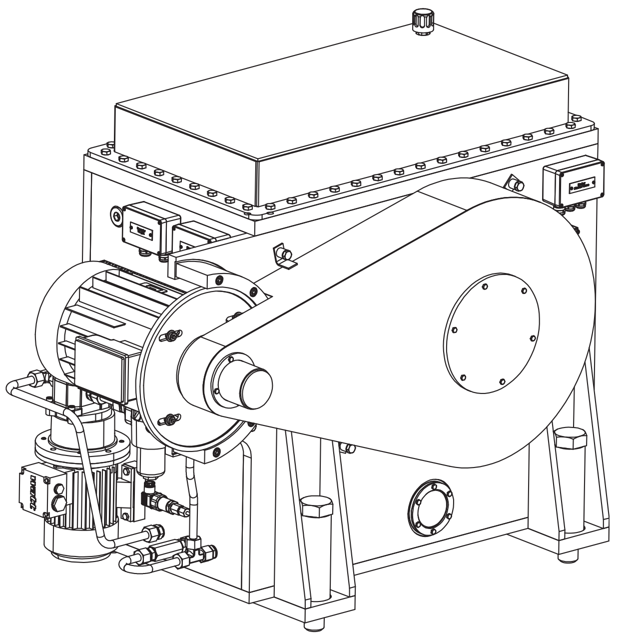

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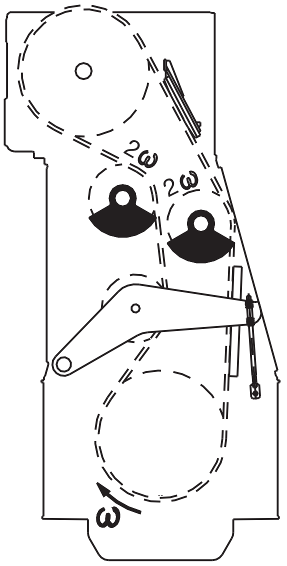
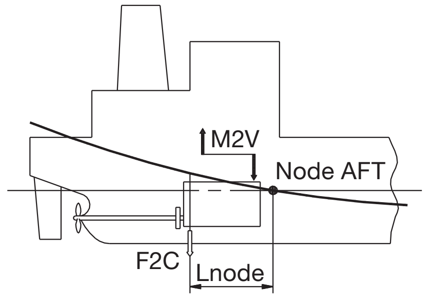
Fig. 17.03.01: MAN B&W 1st or 2nd order electrically driven moment compensator, separately mounted, option: 4 31 605.

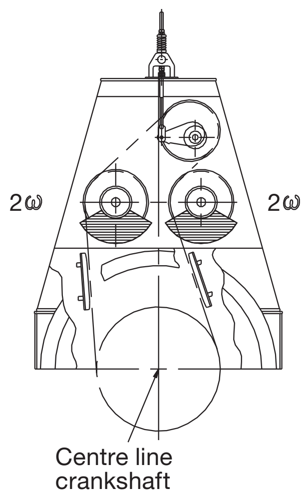
Moment compensator
Aft end, option: 4 31 203



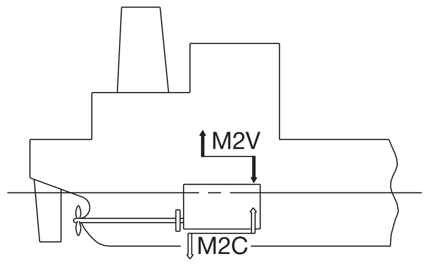
Compensating moment
F2C x Lnode
outbalances M2V



Moment compensator
Fore end, option: 4 31 213

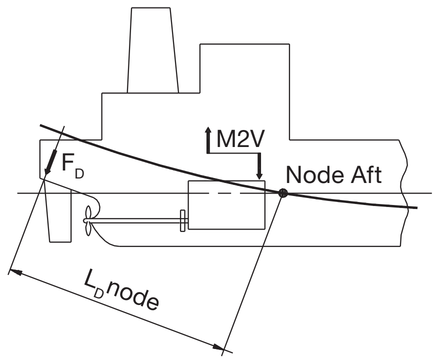


Moment from compensator
M2C reduces M2V



Electric driven moment compensator

Compensating moment
F_D x Lnode
outbalances M2V



3 and 4-node vertical hull girder mode

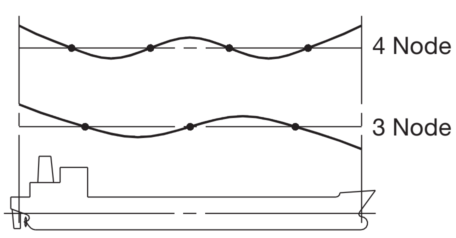


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Fig. 17.03.02: Compensation of 2nd order vertical external moments

Power Related Unbalance

To evaluate if there is a risk that 1st and 2nd order external moments will excite disturbing hull vibrations, the concept Power Related Unbalance (PRU) can be used as a guidance, see Table 17.04.01 below.

$$PRU = \frac{\text{External moment}}{\text{Engine power}} \text{ Nm/kW}$$

With the PRU-value, stating the external moment relative to the engine power, it is possible to give an estimate of the risk of hull vibrations for a specific engine.

Based on service experience from a great number of large ships with engines of different types and cylinder numbers, the PRU-values have been classified in four groups as follows:

PRU Nm/kW	Need for compensator
0 - 60	Not relevant
60 - 120	Unlikely
120 - 220	Likely
220 -	Most likely

S50MC6 – 1,430 kW/cyl at 127 r/min

	5 cyl.	6 cyl.	7 cyl.	8 cyl.	9 cyl.	10 cyl.	11 cyl.	12 cyl.	14 cyl.
PRU acc. to 1st order, Nm/kW	15,3	0,0	6,5	19,1	N.a.	N.a.	N.a.	N.a.	N.a.
PRU acc. to 2nd order, Nm/kW	155,2	90,1	22,4	0,0	N.a.	N.a.	N.a.	N.a.	N.a.

Based on external moments in layout point L_1
N.a. Not applicable

Table 17.04.01: Power Related Unbalance (PRU) values in Nm/kW

Calculation of External Moments

In the table at the end of this chapter, the external moments (M_1) are stated at the speed (n_1) and MCR rating in point L_1 of the layout diagram. For other speeds (n_A), the corresponding external moments (M_A) are calculated by means of the formula:

$$M_A = M_1 \times \left\{\frac{n_A}{n_1}\right\}^2 \text{ kNm}$$

(The tolerance on the calculated values is 2.5%).

Guide Force Moments

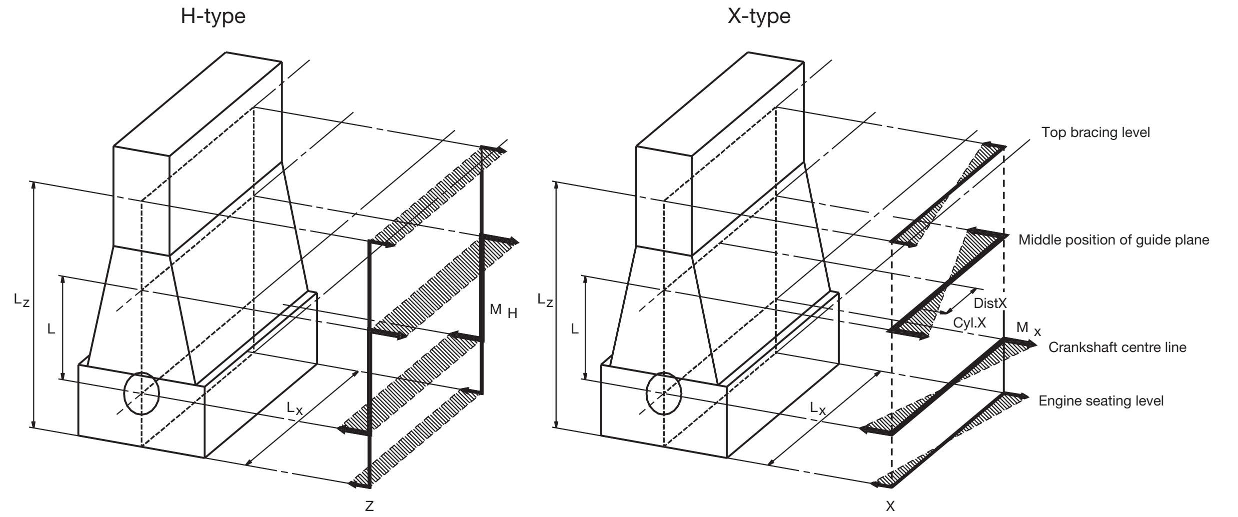


Fig. 17.05.01: H-type and X-type guide force moments

The so-called guide force moments are caused by the transverse reaction forces acting on the crossheads due to the connecting rod/cranskahft mechanism. These moments may excite engine vibrations, moving the engine top athwartships and causing a rocking (excited by H-moment) or twisting (excited by X-moment) movement of the engine as illustrated in the above figure.

The guide force moments corresponding to the MCR rating (L_1) are stated in Table 17.07.01.

Top bracing

The guide force moments are harmless except when resonance vibrations occur in the engine/double bottom system.

As this system is very difficult to calculate with the necessary accuracy MAN Diesel strongly recommend, as standard, that top bracing is installed between the engine's upper platform brackets and the casing side.

The vibration level on the engine when installed in the vessel must comply with MAN Diesel vibration units as stated in Fig. 17.05.02.

We recommend using the hydraulic top bracing which allow adjustment to the loading conditions of the ship. Mechanical top bracings with stiff connections are available on request.

With both types of top bracing above-mentioned natural frequency will increase to a level where resonance will occur above the normal engine speed. Details of the top bracings are shown in Chapter 05.

Definition of Guide Force Moments

Over the years it has been discussed how to define the guide force moments. Especially now that complete FEM-models are made to predict hull/engine interaction, the propeller definition of these moments has become increasingly important.

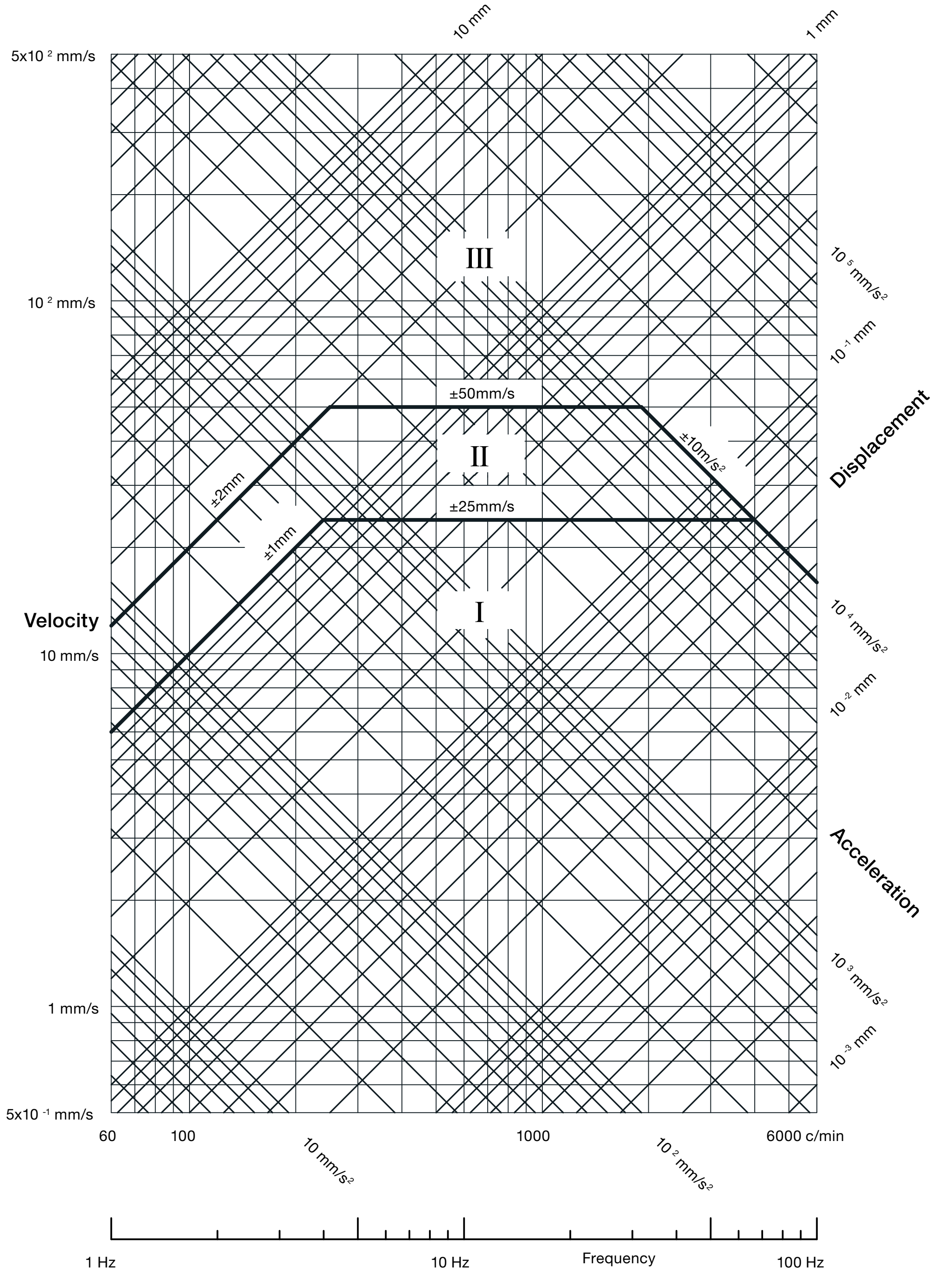
H-type Guide Force Moment (M_H)

Each cylinder unit produces a force couple consisting of:

1. A force at crankshaft level.

2. Another force at crosshead guide level. The position of the force changes over one revolution as the guide shoe reciprocates on the guide.

Limits valid for single order harmonics



Zone 1: Acceptable
Zone 2: Vibration will not damage the main engine, however, under adverse conditions, annoying/harmful vibration responses may appear in the connected structures
Zone 3: Not acceptable

078 81 27-6.0

Fig.17.05.02: Vibration limits

As the deflection shape for the H-type is equal for each cylinder the N^{th} order H-type guide force moment for an N-cylinder engine with regular firing order is:

$N \times M_{H(\text{one cylinder})}$

For modelling purposes the size of the forces in the force couple is:

Force = M_H/L [kN]

where L is the distance between crankshaft level and the middle position of the crosshead guide (i.e. the length of the connecting rod.)

As the interaction between engine and hull is at the engine seating and the top bracing positions, this force couple may alternatively be applied in those positions with a vertical distance of (L_Z). Then the force can be calculated as:

$\text{Force}_Z = M_H/L_Z$ [kN]

Any other vertical distance may be applied, so as to accomodate the actual hull (FEM) model.

The force couple may be distributed at any number of points in the longitudinal direction. A reasonable way of dividing the couple is by the number of top bracing and then applying the forces at those points.

$\text{Force}_{Z,\text{ one point}} = \text{Force}_{Z,\text{ total}}/N_{\text{top bracing, total}}$ [kN]

X-type Guide Force Moment (M_X)

The X-type guide force moment is calculated based on the same force couple as described above. However as the deflection shape is twisting the engine each cylinder unit does not contribute with an equal amount. The centre units do not contribute very much whereas the units at each end contributes much.

A so-called 'Bi-moment' can be calculated (Fig. 17.05.02):

'Bi-moment' = Σ [force-couple(cyl.X) x distX] in kNm^2

The X-type guide force moment is then defined as:

M_X = 'Bi-Moment'/L [kNm]

For modelling purpose the size of the four (4) forces can be calculated:

Force = M_X/L_X [kN]

where:

L_X is the horizontal length between 'force points'

Similar to the situation for the H-type guide force moment, the forces may be applied in positions suitable for the FEM model of the hull. Thus the forces may be referred to another vertical level L_Z above crankshaft centre line. These forces can be calculated as follows:

$$\text{Force}_{Z,\text{ one point}} = \frac{M_x \times L}{L \times L} \text{ [kN]}$$

In order to calculate the forces it is necessary to know the lengths of the connecting rods = L, which are:

Engine Type	L in mm
K98MC6/7	3,220
K98MC-C6/7	3,090
S90MC-C7/8	3,270
K90MC-C6	3,159
S80MC6	3,504
S80MC-C7/8	3,280
K80MC-C6	2,920
S70MC6	3,066
S70MC-C7/8	2,870
L70MC-C7/8	2,660
S60MC6	2,628
S60MC-C7/8	2,460
L60MC-C7/8	2,280

Engine Type	L in mm
S50MC6	2,190
S50MC-C7/8	2,050
S46MC-C7/8	1,980
S42MC7	2,025
S35MC7	1,600
L35MC6	1,260
S26MC6	1,125

Axial Vibrations

When the crank throw is loaded by the gas pressure through the connecting rod mechanism, the arms of the crank throw deflect in the axial direction of the crankshaft, exciting axial vibrations. Through the thrust bearing, the system is connected to the ship's hull.

Generally, only zero-node axial vibrations are of interest. Thus the effect of the additional bending stresses in the crankshaft and possible vibrations of the ship`s structure due to the reaction force in the thrust bearing are to be considered.

An axial damper is fitted as standard on all engines, minimising the effects of the axial vibrations (4 31 111).

Torsional Vibrations

The reciprocating and rotating masses of the engine including the crankshaft, the thrust shaft, the intermediate shaft(s), the propeller shaft and the propeller are for calculation purposes considered as a system of rotating masses (inertias) interconnected by torsional springs. The gas pressure of the engine acts through the connecting rod mechanism with a varying torque on each crank throw, exciting torsional vibration in the system with different frequencies.

In general, only torsional vibrations with one and two nodes need to be considered. The main critical order, causing the largest extra stresses in the shaft line, is normally the vibration with order equal to the number of cylinders, i.e., six cycles per revolution on a six cylinder engine. This resonance is positioned at the engine speed corresponding to the natural torsional frequency divided by the number of cylinders.

The torsional vibration conditions may, for certain installations require a torsional vibration damper, option: 4 31 105.

Based on our statistics, this need **may arise** for the following types of installation:
- Plants with controllable pitch propeller
- Plants with unusual shafting layout and for special owner/yard requirements
- Plants with 8-cylinder engines.

The so-called QPT (Quick Passage of a barred speed range Technique), is an alternative to a torsional vibration damper, on a plant equipped with a controllable pitch propeller. The QPT could be implemented in the governor in order to limit the vibratory stresses during the passage of the barred speed range.

The application of the QPT, option: 4 31 108, has to be decided by the engine maker and MAN Diesel based on final torsional vibration calculations.

Six-cylinder engines, require special attention. On account of the heavy excitation, the natural frequency of the system with one-node vibration should be situated away from the normal operating speed range, to avoid its effect. This can be achieved by changing the masses and/or the stiffness of the system so as to give a much higher, or much lower, natural frequency, called undercritical or overcritical running, respectively.

Owing to the very large variety of possible shafting arrangements that may be used in combination with a specific engine, only detailed torsional vibration calculations of the specific plant can determine whether or not a torsional vibration damper is necessary.

Undercritical running

The natural frequency of the one-node vibration is so adjusted that resonance with the main critical order occurs about 35-45% above the engine speed at specified MCR.

Such undercritical conditions can be realised by choosing a rigid shaft system, leading to a relatively high natural frequency.

The characteristics of an undercritical system are normally:
- Relatively short shafting system
- Probably no tuning wheel
- Turning wheel with relatively low inertia
- Large diameters of shafting, enabling the use of shafting material with a moderate ultimate tensile strength, but requiring careful shaft alignment, (due to relatively high bending stiffness)
- Without barred speed range

Critical Running

When running undercritical, significant varying torque at MCR conditions of about 100-150% of the mean torque is to be expected.

This torque (propeller torsional amplitude) induces a significant varying propeller thrust which, under adverse conditions, might excite annoying longitudinal vibrations on engine/double bottom and/or deck house.

The yard should be aware of this and ensure that the complete aft body structure of the ship, including the double bottom in the engine room, is designed to be able to cope with the described phenomena.

Overcritical running

The natural frequency of the one-node vibration is so adjusted that resonance with the main critical order occurs about 30-70% below the engine speed at specified MCR. Such overcritical conditions can be realised by choosing an elastic shaft system, leading to a relatively low natural frequency.

The characteristics of overcritical conditions are:

- Tuning wheel may be necessary on crankshaft fore end
- Turning wheel with relatively high inertia
- Shafts with relatively small diameters, requiring shafting material with a relatively high ultimate tensile strength
- With barred speed range (EoD 4 07 015) of about ±10% with respect to the critical engine speed.

Torsional vibrations in overcritical conditions may, in special cases, have to be eliminated by the use of a torsional vibration damper.

Overcritical layout is normally applied for engines with more than four cylinders.

Please note:
We do not include any tuning wheel or torsional vibration damper in the standard scope of supply, as the proper countermeasure has to be found after torsional vibration calculations for the specific plant, and after the decision has been taken if and where a barred speed range might be acceptable.

For further information about vibration aspects, please refer to our publications:

An Introduction to Vibration Aspects

Vibration Characteristics of Two-stroke Engines

The publications are available at
www.mandiesel.com under
‘Quicklinks’ → ‘Technical Papers’

External Forces and Moments, S50MC6 Layout point L_1 - SFOC

No of cylinder :	5	6	7	8
Firing type :	1-4-3-2-5	1-5-3-4-2-6	1-7-2-5-4-3-6	1-8-3-4-7-2-5-6

External forces [kN] :				
1. Order : Horizontal	0	0	0	0
1. Order : Vertical	0	0	0	0
2. Order : Vertical	0	0	0	0
4. Order : Vertical	0	0	0	0
6. Order : Vertical	0	4	0	0
External moments [kNm] :				
1. Order : Horizontal a)	109	0	65	218
1. Order : Vertical a)	109	0	65	218
2. Order : Vertical	1.109 c)	772 c)	224	0
4. Order : Vertical	5	41	115	47
6. Order : Vertical	0	0	0	0
Guide force H-moments in [kNm] :				
1 x No. of cyl.	579	421	317	219
2 x No. of cyl.	47	18	23	22
3 x No. of cyl.	15	-	-	-
Guide force X-moments in [kNm] :				
1. Order :	67	0	40	134
2. Order :	81	57	16	0
3. Order :	110	200	218	280
4. Order :	25	189	537	218
5. Order :	0	0	47	594
6. Order :	13	0	8	0
7. Order :	92	0	0	16
8. Order :	55	39	3	0
9. Order :	3	55	6	5
10. Order :	0	13	38	0
11. Order :	1	0	21	27
12. Order :	6	0	1	5
13. Order :	6	0	0	15
14. Order :	1	5	0	0
15. Order :	0	11	0	1
16. Order :	1	4	1	0

a) 1st order moments are, as standard, balanced so as to obtain equal values for horizontal and vertical moments for all cylinder numbers.

c) 5 and 6-cylinder engines can be fitted with 2nd order moment compensators on the aft and fore end, reducing the 2nd order external moment.

Table 17.07.01

Monitoring Systems and Instrumentation

18

Monitoring Systems and Instrumentation

Engine monitoring and instrumentation can be enhanced by Man Diesel's PMI system for measuring cylinder pressure and by the CoCoS-EDS (Computer Controlled Surveillance – Engine Diagnostics System) for engine performance evaluation. Both of which have been in service since 1994.

The monitoring system measures the main parameters of the engine and makes an evaluation of the general engine condition, indicating the measures to be taken. This ensures that the engine performance is kept within the prescribed limits throughout the engines lifetime.

In its basic design the MC engine instrumentation consists of:

• Engine Control System
• Shut-down sensors, option: 4 75 124

The optional extras are:

• CoCoS system
  type EDS on-line, option: 4 09 660

• PMI system type PT/S off-line, option: 4 75 208

• PMI system type on-line, option: 4 75 215

As most engines are sold for Unattended Machinery Spaces (UMS), the following option is normally included:

• Sensors for alarm, slow down and remote indication according to the classification society's and MAN Diesel's requirements for UMS, option: 4 75 127, see Section 18.04.

Sensors for CoCoS can be ordered, if required, as option: 4 75 129. They are listed in Section 18.03.

All instruments are identified by a combination of symbols and a position number as shown in Section 18.07.

PMI System

As an option on the MC engines, the mechanical indicator system can be supported by a pressure analyser system for measurement of the cylinder combustion pressure.

Monitoring of cylinder pressures allows for:
- optimising the engine performance
- optimising the fuel economy
- minimising engine load
- minimising operating cost through condition based maintenance
- complying with emission requirements

Measurements

The cylinder pressure is measured by a high performance piezo-electric pressure transducer, mounted on the indicator valve.

The engine speed signal is obtained from an angle encoder mounted on crankshaft fore end. Alternatively the signal could be obtained from an optical sensor reading a zebra tape bonded to the engine shaft.

The PMI system data is automatically compensated for crankshaft deflection from the torque generated at different loads.

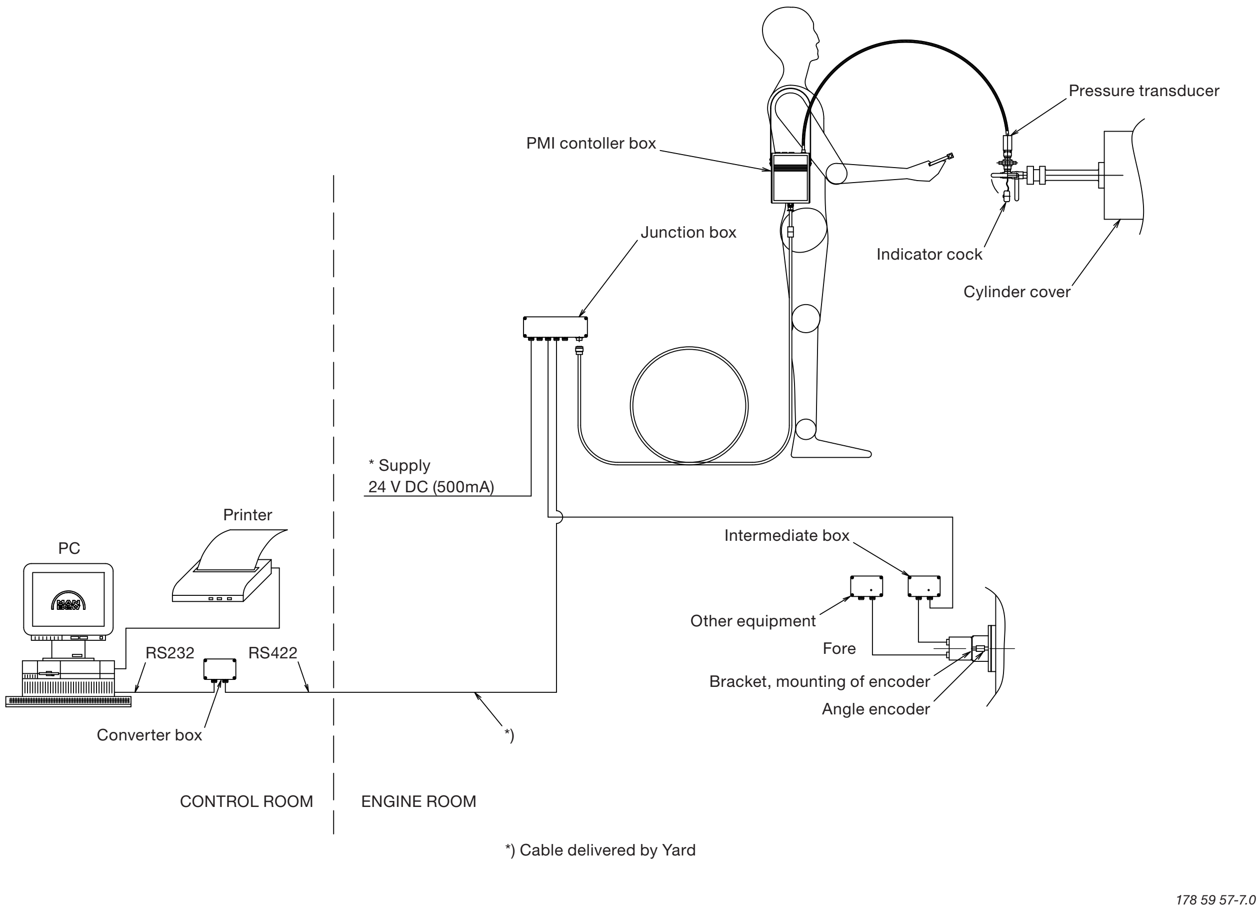


Fig. 18.02.01: PMI type PT/S off-line, option: 4 75 208

PMI System, Off-line and On-line Versions

The PMI system is available in two versions, PT/S off-line and on-line, see Fig. 18.02.01 and 02.

The basic functions of the two different versions are:

- PT/S off-line version, option 4 75 208:
  The manually operated single transducer is moved from one cylinder to another in order to complete measurements on all cylinders.

- On-line version, option 4 75 215:
  Fixed mounted pressure transducing sensor on each cylinder for continuous measurements, analysis and adjustments.

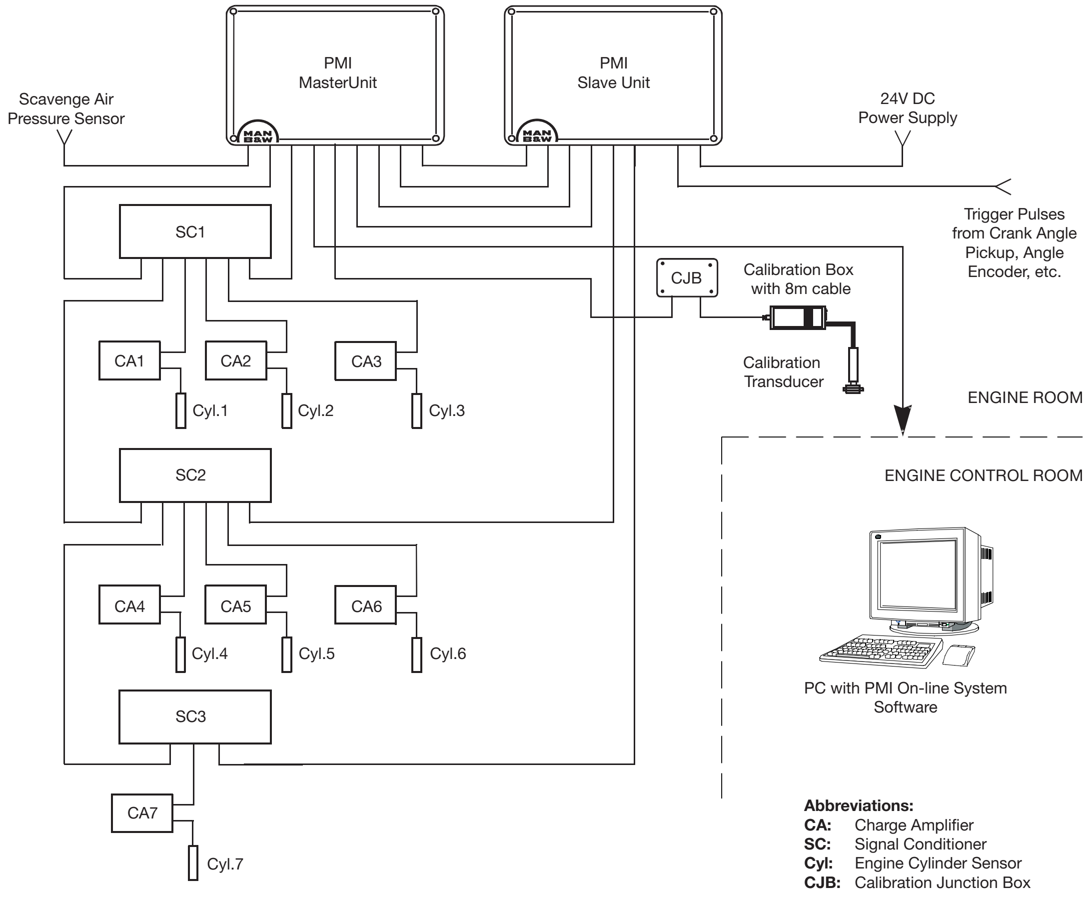


Fig. 18.02.02: PMI type on-line, option: 4 75 215

CoCoS-EDS

The **C**omputer **C**ontrolled **S**urveillance system is the family name of the software application products from the MAN Diesel group.

In order to obtain an easier, more versatile and continuous diagnostics system, the Engine Control System and the PMI System is recommended extended by the CoCoS-EDS products.

CoCoS-EDS features

The CoCoS-EDS, option: 4 09 660, allows for engine condition monitoring through surveillance of operating states and behaviour of diesel engines.

Primary features are:

- Data and trend logging
- Engine performance monitoring, analysis and reporting
- Troubleshooting and diagnostics.

The CoCoS-EDS assists the operator effectively in maintaining the main as well as the auxiliary engines in optimal operating condition.

With CoCoS-EDS, early intervention as well as preventive maintenance, the engine operators are able to reduce the risk of damages and failures. CoCoS-EDS further allow for easier troubleshooting in case of unusual engine behaviour.

Connectivity

In order to obtain an easier, more versatile and continuous diagnostics system, the CoCoS-EDS is recommended extended by interfaces to the PMI system and the plant's alarm and monitoring system.

Table 18.03.01 lists the sensors required to enable online diagnostics for CoCoS-EDS, option: 4 75 129.

CoCoS-EDS Sensor List

Required sensors for online engine performance analysis, option: 4 75 129.
All pressure gauges measuring relative pressure, except PE 8802 Ambient pressure.

Sensor	Parameter name	No. sen-sors	Recommended range	Type	Remark
	Fuel oil system data				
PE 8001	Inlet pressure	1	0 - 10 bar		
TE 8005	Inlet temperature	1	0 - 200 °C		
	Cooling water system				
PE 8421	Pressure air cooler inlet	A/C	0 - 4 bar		
TE 8422	Temperature air cooler inlet	1	0 - 100 °C	PT 100	
TE 8423	Temperature air cooler outlet	A/C	0 - 100 °C	PT 100	
PDE 8424	dP cooling water across air cooler	A/C	0 - 800 mbar		
	Scavenging air system				
PE 8601	Scavenge air receiver pressure	Rec.	0 - 4 bar		
TE 8605	Scavenge air cooler air inlet temperature	A/C	0 - 200 °C	PT 100	
PDE 8606	dP air across scavenge air cooler	A/C	0 - 100 mbar		
PDE 8607	dP air across T/C air intake filter	T/C	0 - 100 mbar		
TE 8608	Scavenge air cooler air outlet temperature	A/C	0 - 100 °C	PT 100	Optional if one T/C
TE 8609	Scavenge air receiver temperature	Rec.	0 - 100 °C	PT 100	
TE 8612	T/C air intake temperature	T/C	0 - 100 °C	PT 100	
	Exhaust gas system				
TE 8701	Exhaust gas temperature at turbine inlet	T/C	0 - 600 °C	NiCrNi	
TE 8702	Exhaust gas temperature after exhaust valve	Cyl.	0 - 600 °C	NiCrNi	
PE 8706	Exhaust gas receiver pressure	Rec.	0 - 4 bar		
TE 8707	Exhaust gas temperature at turbine outlet	T/C	0 - 600 °C	NiCrNi	
PE 8708	Turbine back presssure	T/C	0 - 100 mbar		
	General data				
SE 8801	Turbocharger speed	T/C			
PE 8802	Ambient pressure	1	900 - 1100 mbar		Absolute !
SE 4020	Engine speed	1			
ZE 3003	Governor index (absolute)	1			
	Power take off/in from main engine shaft (PTO/PTI)	1			With option installed
XC1401	Mean Indicated Pressure MIP	Cyl.			1)
XC1402	Maximum Pressure Pmax	Cyl.			1)
XC1403	Compression Pressure Pcomp	Cyl.			1)
–	PMI online engine speed	Cyl.	rpm		1)

1): In case of MAN Diesel PMI system - signal from PMI system. Other MIP systems - signal from manual input

Table 18.03.01 CoCoS-EDS Sensor list

Alarm – Slow Down and Shut Down System

The shut down system must be electrically separated from other systems by using independent sensors, or sensors common for the alarm system but with galvanically separated electrical circuits, i.e. one sensor with two sets of electrically independent terminals. The list of sensors are shown in Table 18.04.04.

Attended Machinery Space (AMS)

The basic safety system for a MAN Diesel engine is designed for Attended Machinery Space and comprises the temperature sensors and pressure sensors that are specified in the ‘MAN Diesel’ column for shut down in Table 18.04.04.

These sensors are included in the basic scope of supply (option: 4 75 124) and are also included for UMS.

Unattended Machinery Space (UMS)

In the ‘Extent of Delivery’ an asterisk (*) marks items normally required for plants designed for UMS including the sensors for alarm and slow down, option: 4 75 127, but not those for shut down.

The shut down and slow down panels can be ordered as options: 4 75 610, 4 75 614 or 4 75 615 whereas the alarm panel is yard’s supply, as it normally includes several other alarms than those for the main engine.

For practical reasons, the sensors for the engine itself are normally delivered from the engine supplier, so they can be wired to terminal boxes on the engine.

The number and position of the terminal boxes depends on the degree of dismantling specified in the Dispatch Pattern for the transportation of the engine based on the lifting capacities available at the engine maker and at the yard.

Alarm, slow down and remote indication sensors

The International Association of Classification Societies (IACS) indicates that a common sensor can be used for alarm, slow down and remote indication.

A general view of the alarm, slow down and shut down systems is shown in Fig. 18.04.01.

Tables 18.04.02 and 18.04.03 show the requirements by MAN Diesel for alarm and slow down and for UMS by the classification societies (Class), as well as IACS’ recommendations.

The number of sensors to be applied to a specific plant for UMS is the sum of requirements of the classification society, the Buyer and MAN Diesel.

If further analogue sensors are required, they can be ordered as option: 4 75 128.

The slow down functions are designed to safeguard the engine components against overloading during normal service conditions and to keep the ship manoeuvrable if fault conditions occur.

The slow down sequence must be adapted to the actual plant parameters, such as for FPP or CPP, engine with or without shaft generator, and to the required operating mode.

General outline of the electrical system

The figure shows the concept approved by all classification societies.

The shut down panel and slow down panel can be combined for some makers.

The classification societies permit having common sensors for slow down, alarm and remote indication.

One common power supply might be used, instead of the three indicated, provided that the systems are equipped with separate fuses.

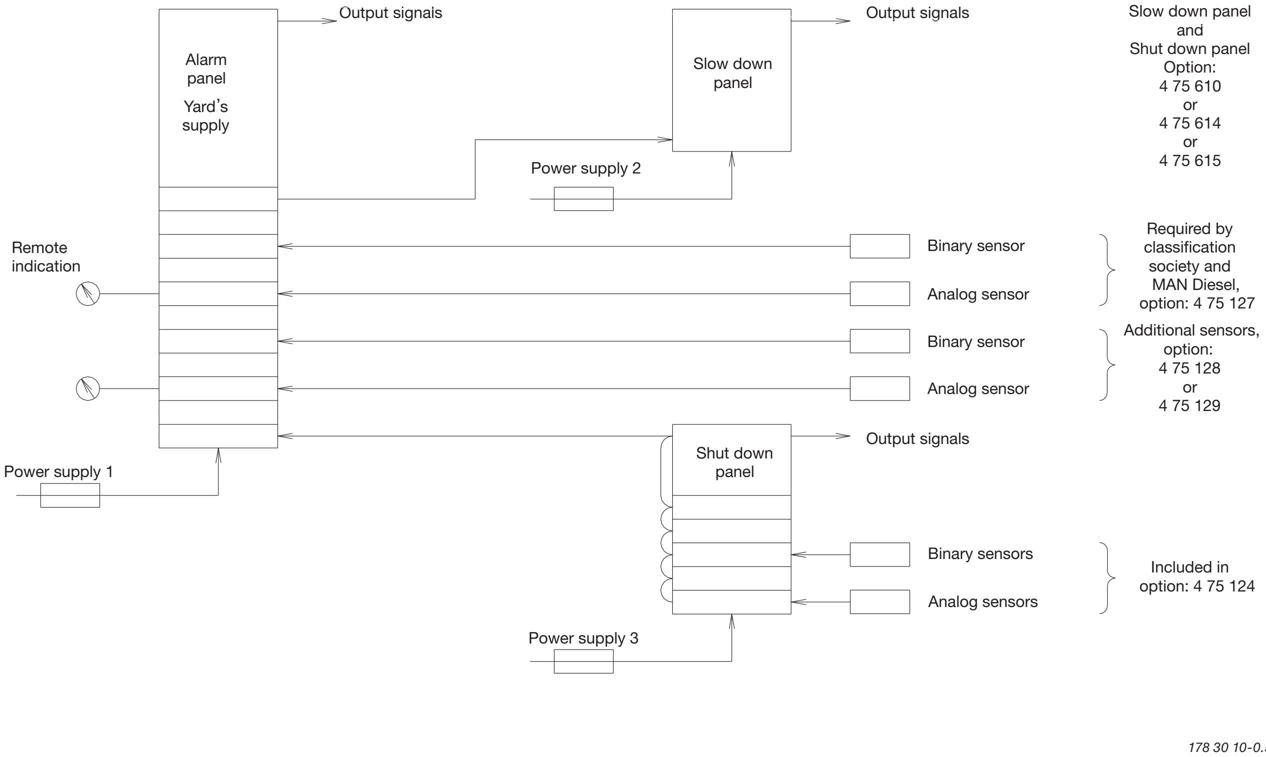


Fig. 18.04.01: Panels and sensors for alarm and safety systems

Alarms for UMS – Class and MAN Diesel requirements

ABS	BV	CCS	DNV	GL	KR	LR	NK	RINA	RS	IACS	MAN Diesel	Sensor and function	Point of location
													Fuel oil
1	1	1	1	1	1	1	1	1	1	1	1	PT 8001 AL	Fuel oil, inlet engine
1	1	1	1	1	1	1	1	1	1	1	1	LS 8006 AH	Leakage from high pressure pipes
													Lubricating oil
1	1	1	1	1	1	1		1	1	1	1	PT 8103 AL	Lubricating oil inlet to turbocharger/turbocharger
1	1	1	1	1	1	1	1	1	1	1	1	TE 8106 AH	Thrust bearing segment
1	1	1	1	1	1	1	1	1	1	1	1	PT 8108 AL	Lubricating oil inlet to main engine
1	1	1	1	1	1	1	1	1	1	1	1	TE 8112 AH	Lubricating oil inlet to main engine
1	1	1	1	1	1		1	1	1	1	1	TE 8113 AH	Piston cooling oil outlet/cylinder
1	1	1	1	1	1		1	1	1	1	1	FS 8114 AL	Piston cooling oil outlet/cylinder
1	1	1		1	1	1		1	1	1	1	TE 8117 AH	Turbocharger lubricating oil outlet from turbocharger/turbocharger 2)
											1	TE 8123 AH	Main bearing oil outlet temperature/main bearing (Only MC types 42-26)
											1	XC 8126 AH	Bearing wear (K98MC6/7 and all MC-C)
											1	XS 8150 AH	Water in lubricating oil (All MC/MC-C except S80-50MC6)
											1	XS 8150 AH	Water in lubricating oil – too high (All MC/MC-C except S80-50MC6)

1 Indicates that the sensor is required.
The sensors in the MAN Diesel column are included for Unattended Machinery Spaces (UMS), option: 4 75 127, subject to class requirements and will be finally specified in the Guidance Values Automation for the specific engine plant.
The sensor identification codes and functions are listed in Table 18.07.01.
The tables are liable to change without notice, and are subject to latest class requirements.

2) For turbochargers with slide bearings only

Table 18.04.02a: Alarm functions for UMS

Alarms for UMS – Class and MAN Diesel requirements

ABS	BV	CCS	DNV	GL	KR	LR	NK	RINA	RS	IACS	MAN Diesel	Sensor and function	Point of location
													Cooling water
1	1	1	1	1	1	1	1	1	1	1	1	PT 8401 AL	Jacket cooling water inlet
											1	PDS/PDT 8403 AL	Jacket cooling water across engine; to be calculated in alarm system from sensor no. 8402 and 8413
				1							1	TE 8407 AL	Jacket cooling water inlet
1	1	1	1	1	1	1	1	1	1	1	1	TE 8408 AH	Jacket cooling water outlet, cylinder
											1	PT 8413 I	Jacket cooling water outlet, common pipe
1	1	1		1	1	1	1	1	1	1	1	PT 8421 AL	Cooling water inlet air cooler
				1							1	TE 8422 AH	Cooling water inlet air cooler/air cooler
													Compressed air
1	1	1		1	1	1	1	1	1	1	1	PT 8501 AL	Starting air inlet to main starting valve
1	1	1	1	1	1	1	1	1+	1	1	1	PT 8503 AL	Control air inlet and finished with engine
			1								1	PT 8505 AL	Air inlet to air cylinder for exhaust valve
													Scavenge air
				1					1		1	PS 8604 AL	Scavenge air, auxiliary blower, failure
	1	1		1			1÷				1	TE 8609 AH	Scavenge air receiver
1	1	1	1	1	1	1	1	1	1	1	1	TE 8610 AH	Scavenge air box – fire alarm, cylinder/cylinder
1	1	1		1	1	1	1	1	1	1	1	LS 8611 AH	Water mist catcher – water level

1 Indicates that the sensor is required.
The sensors in the MAN Diesel column are included for Unattended Machinery Spaces (UMS), option: 4 75 127, subject to class requirements and will be finally specified in the Guidance Values Automation for the specific engine plant.
The sensor identification codes and functions are listed in Table 18.07.01.
The tables are liable to change without notice, and are subject to latest class requirements.

Select one of the alternatives
\+ Alarm for high pressure, too
÷ Alarm for low pressure, too

Table 18.04.02b: Alarm functions for UMS

Alarms for UMS – Class and MAN Diesel requirements

ABS	BV	CCS	DNV	GL	KR	LR	NK	RINA	RS	IACS	MAN Diesel	Sensor and function	Point of location
													Exhaust gas
1	1	1	1	1	1	(1)	1	1	1	1	1	TC 8701 AH	Exhaust gas before turbocharger/turbocharger
1	1		1		1	1	1	1	1	1	1	TC 8702 AH	Exhaust gas after exhaust valve, cylinder/cylinder
1	1	1	1	1	1	1	1	1	1	1		TC 8707 AH	Exhaust gas outlet turbocharger/turbocharger (Yard's supply)
													Miscellaneous
			1									ZT 8801 AH	Turbocharger overspeed
			1									WT 8805 AH	Vibration of turbocharger
											1	WT 8812 AH	Axial vibration monitor 2)
1	1		1	1	1	1	1	1	1	1	1	XS 8813 AH	Oil mist in crankcase/cylinder
	1										1	XS 8814 AL	Oil mist detector failure
											1	XC 8816 I	Shaftline earthing device

1 Indicates that the sensor is required.
The sensors in the MAN Diesel column are included for Unattended Machinery Spaces (UMS), option: 4 75 127, subject to class requirements and will be finally specified in the Guidance Values Automation for the specific engine plant.
The sensor identification codes and functions are listed in Table 18.07.01.
The tables are liable to change without notice, and are subject to latest class requirements.

(1) May be combined with TC 8702 AH where turbocharger is mounted directly on the exhaust manifold.

2) Required for: K-MC-C6/7 and K98MC6/7 engines with 11 and 14 cylinders.
S-MC-C7/8 and L-MC-C7/8 engines with 5 and 6 cylinders.
(For 9-12 cylinder S42MC7, L35MC6, and S26MC6 data is available on request).

Alarm for overheating of main, crank and crosshead bearings, option: 4 75 134.

Table 18.04.02c: Alarm functions for UMS

Slow down for UMS – Class and MAN Diesel requirements

ABS	BV	CCS	DNV	GL	KR	LR	NK	RINA	RS	IACS	MAN Diesel	Sensor and function	Point of location
1	1	1	1	1	1	1	1	1	1	1	1	TE 8106 YH	Thrust bearing segment
1	1	1	1*	1	1	1	1	1	1	1	1	PT 8108 YL	Lubricating oil inlet to main engine
				1		1						TE 8112 YH	Lubricating oil inlet to main engine
1	1	1	1	1	1		1	1	1	1	1	TE 8113 YH	Piston cooling oil outlet/cylinder
1	1	1	1	1	1		1	1	1	1	1	FS 8114 YL	Piston cooling oil outlet/cylinder
											1	TE 8123 YH	Main bearing oil outlet temperature/main bearing (Only MC types 42-26)
											1	XC 8126 YH	Bearing wear (K98MC6/7 and all MC-C)
1	1	1	1		1	1	1	1	1	1	1	PT 8401 YL	Jacket cooling water inlet
1	1	1	1	1	1	1	1	1	1	1	1	TE 8408 YH	Jacket cooling water outlet, cylinder/cylinder
	1	1					1					TE 8609 YH	Scavenge air receiver
1	1	1	1	1	1	1	1	1	1	1	1	TE 8610 YH	Scavenge air box fire-alarm, cylinder/cylinder
		1	1						1			TC 8701 YH	Exhaust gas before turbocharger/turbocharger
1	1		1	1	1	1	1	1	1	1	1	TC 8702 YH	Exhaust gas after exhaust valve, cylinder/cylinder
			1	1								TC 8702 YH	Exhaust gas after exhaust valve, cylinder/cylinder, deviation from average
											1	WT 8812 YH	Axial vibration monitor 2)
1	1		1*		1	1	1	1	1	1	1	XS 8813 YH	Oil mist in crankcase/cylinder

1 Indicates that the sensor is required.
The sensors in the MAN Diesel column are included for Unattended Machinery Spaces (UMS), option: 4 75 127, subject to class requirements and will be finally specified in the Guidance Values Automation for the specific engine plant.
The sensor identification codes and functions are listed in Table 18.07.01.
The tables are liable to change without notice, and are subject to latest class requirements.

2) Required for: K-MC-C6/7 and K98MC6/7 engines with 11 and 14 cylinders.
S-MC-C7/8 and L-MC-C7/8 engines with 5 and 6 cylinders.
(For 9-12 cylinder S42MC7, L35MC6, and S26MC6 data is available on request).

Select one of the alternatives

* Or shut down

Or alarm for low flow

* Or shut down

Or alarm for overheating of main, crank and crosshead bearings, option: 4 75 134.
See also Table 18.04.04: Shut down functions for AMS and UMS

Table 18.04.03: Slow down functions for UMS

Shut down for AMS and UMS – Class and MAN Diesel requirements

ABS	BV	CCS	DNV	GL	KR	LR	NK	RINA	RS	IACS	MAN Diesel	Sensor and function	Point of location
1	1	1	1*	1	1	1	1	1	1	1	1	PS/PT 8109 Z	Lubricating oil inlet to main engine and thrust bearing
1	1	1	1*	1	1	1	1	1	1	1	1	ZT 4020 Z	Engine overspeed, incorporated in Engine Control System
1	1	1			1			1	1	1	1	TE/TS 8107 Z	Thrust bearing segment
				1								PS/PT 8402 Z	Jacket cooling water inlet
			*	1								XS 8813 Z	Oil mist in crankcase/cylinder

1 Indicates that the sensor is required.
The sensors in the MAN Diesel column are included for Unattended Machinery Spaces (UMS), option: 4 75 127, subject to class requirements and will be finally specified in the Guidance Values Automation for the specific engine plant.
The sensor identification codes and functions are listed in Table 18.07.01.
The tables are liable to change without notice, and are subject to latest class requirements.

Or alarm for overheating of main, crank and crosshead bearings, option: 4 75 134.
See also Table 18.04.03: Slow down functions for UMS

* Or slow down

International Association of Classification Societies

The members of the International Association of Classification Societies, IACS, have agreed that the stated sensors are their common recommendation, apart from each class' requirements.

The members of IACS are:
ABS American Bureau of Shipping
BV Bureau Veritas
CCS China Classification Society
DNV Det Norske Veritas
GL Germanischer Lloyd
KR Korean Register
LR Lloyd's Register
NK Nippon Kaiji Kyokai
RINA Registro Italiano Navale
RS Russian Maritime Register of Shipping

and the assosiated member is:
IRS Indian Register of Shipping

Table 18.04.04: Shut down functions for AMS and UMS, option: 4 75 124

Local Instruments

The basic local instrumentation on the engine, options: 4 70 120 comprises thermometers, pressure gauges and other indicators located on the piping or mounted on panels on the engine. The tables 18.05.01a, b and c list those as well as sensors for slow down, alarm and remote indication, option: 4 75 127.

Local instruments	Remote sensors	Point of location
Thermometer, stem type	**Temperature element/switch**	
		Fuel oil
TI 8005	TE 8005	Fuel oil, inlet engine
		Lubricating oil
TI 8106	TE 8106	Thrust bearing segment
	TE/TS 8107	Thrust bearing segment
TI 8112	TE 8112	Lubricating oil inlet to main engine
TI 8113	TE 8113	Piston cooling oil outlet/cylinder
TI 8117	TE 8117	Lubricating oil outlet from turbocharger/turbocharger (depends on turbocharger design)
	TE 8123	Main bearing oil outlet temperature/main bearing (Only engine types 42-26)
		Cylinder lubricating oil
	TE 8202	Cylinder lubricating oil inlet (Alpha cylinder lubricator)
		High temperature cooling water, jacket cooling water
TI 8407	TE 8407	Jacket cooling water inlet
TI 8408	TE 8408	Jacket cooling water outlet, cylinder/cylinder
TI 8409	TE 8409	Jacket cooling water outlet/turbocharger
		Low temperature cooling water, seawater or freshwater for central cooling
TI 8422	TE 8422	Cooling water inlet, air cooler
TI 8423	TE 8423	Cooling water outlet, air cooler/air cooler
		Scavenge air
TI 8605	TE 8605	Scavenge air before air cooler/air cooler
TI 8608	TE 8608	Scavenge air after air cooler/air cooler
TI 8609	TE 8609	Scavenge air receiver
	TE 8610	Scavenge air box – fire alarm, cylinder/cylinder
Thermometer, stem type	**Thermo couple**	
		Exhaust gas
TI 8701	TC 8701	Exhaust gas before turbocharger/turbocharger
TI 8702	TC 8702	Exhaust gas after exhaust valve, cylinder/cylinder
	TC 8704	Exhaust gas inlet exhaust gas receiver
TI 8707	TC 8707	Exhaust gas outlet turbocharger

Table 18.05.01a: Local thermometers on engine, option 4 70 120, and remote indication sensors, option: 4 75 127

Local instruments	Remote sensors	Point of location
Pressure gauge (manometer)	**Pressure transmitter/switch**	
		Fuel oil
PI 8001	PT 8001	Fuel oil, inlet engine
	PT 8007	Fuel pump roller guide gear activated (Only engine types 98-80)
		Lubricating oil
PI 8103	PT 8103	Lubricating oil inlet to turbocharger/turbocharger
PI 8108	PT 8108	Lubricating oil inlet to main engine
	PS/PT 8109	Lubricating oil inlet to main engine and thrust bearing
		Cylinder lubrication
	PT 8201	Cylinder lubrication oil inlet pressure (Alpha lubricator)
	PDI 8206	Pressure drop across filter
		High temperature jacket cooling water, jacket cooling water
PI 8401	PT 8401	Jacket cooling water inlet
	PS/PT 8402	Jacket cooling water inlet (Only Germanischer Lloyd)
	PDS/PDT 8403 I	Jacket cooling water across engine
	PT 8413	Jacket cooling water outlet, common pipe
		Low temperature cooling water, seawater or freshwater for central cooling
PI 8421	PT 8421	Cooling water inlet, air cooler
		Compressed air
PI 8501	PT 8501 I	Starting air inlet to main starting valve
PI 8503	PT 8503 I	Control air inlet
PI 8504	PT 8504	Safety air inlet
	PT 8505	Air inlet to air cylinder for exhaust valve
		Scavenge air
PI 8601	PT 8601	Scavenge air receiver (PI 8601 instrument same as PI 8706)
	PS 8604	Scavenge air receiver, auxiliary blower failure
PDI 8606		Pressure drop of air across cooler/air cooler
PI 8613	PT 8613	Pressure compressor scroll housing/turbocharger (NA type)
PDI 8614	PDT 8614	Pressure drop across compressor scroll housing/turbocharger (NA type)
		Exhaust gas
PI 8706		Exhaust gas receiver/Exhaust gas outlet turbocharger
		Miscellaneous functions
PI 8803		Air inlet for dry cleaning of turbocharger
PI 8804		Water inlet for cleaning of turbocharger

Table 18.05.01b: Local pressure gauges on engine, option: 4 70 120, and remote indication sensors, option: 4 75 127

Local instruments	Remote sensors	Point of location
Other indicators	**Other transmitters/ switches**	
		Fuel oil
	LS 8006	Leakage from high pressure pipes
		Lubricating oil
	FS 8114	Piston cooling oil outlet/cylinder
	XC 8126	Bearing wear (K98MC6/7 and all MC-C)
	XS 8150	Water in lubricating oil (All MC/MC-C except S80-50MC6)
		Cylinder lube oil
	LS 8208	Level switch
	LS 8250	Cylinder lubricators (built-in switches)/lubricator (Mechanical lubricator)
	XC 8220	MCU common alarm (Alpha cylinder lubrication system)
	XC 8221	BCU in control (Alpha cylinder lubrication system)
	XC 8222	MCU failure (Alpha cylinder lubrication system)
	XC 8223	BCU failure (Alpha cylinder lubrication system)
	XC 8224	MCU power fail (Alpha cylinder lubrication system)
	XC 8226	BCU power fail (Alpha cylinder lubrication system)
	FS 8251	Cylinder lubricators (built-in switches)/lubricator (Mechanical lubricator)
		Scavenge air
	LS 8611	Water mist catcher – water level
		Miscellaneous functions
	ST 8801 I	Turbocharger speed/turbocharger
WI 8812	WT 8812	Axial vibration monitor (For certain engines only, see note in Table 18.04.04) (WI 8812 instrument is part of the transmitter WT 8812)
	XS 8813	Oil mist in crankcase/cylinder
	XS 8814	Oil mist detector failure
	XC 8816	Shaftline earthing device

Table 18.05.01c: Other indicators on engine, option: 4 70 120, and remote indication sensors, option: 4 75 127

Other Alarm Functions

Drain box for fuel oil leakage alarm

Any leakage from the fuel oil high pressure pipes of any cylinder is drained to a common drain box fitted with a level alarm. This is included for both AMS and UMS.

Bearing Condition Monitoring

Based on our experience we decided in 1990 that all plants, whether constructed for Attended Machinery Space (AMS) or for Unattended Machinery Space (UMS), must include an oil mist detector specified by MAN Diesel. Since then an Oil Mist Detector (OMD) and optionally some extent of Bearing Temperature Monitoring (BTM) equipment have made up the warning arrangements for prevention of crankcase explosions on two-stroke engines. Both warning systems are approved by the classification societies.

In order to achieve a response to damage faster than possible with Oil Mist Detection and Bearing Temperature Monitoring alone we introduce Bearing Wear Monitoring (BWM) systems. By monitoring the actual bearing wear continuously, mechanical damage to the crank-train bearings (main-, crank- and crosshead bearings) can be predicted in time to react and avoid damaging the journal and bearing housing.

If the oil supply to a main bearing fails, the bearing temperature will rise and in such a case a Bearing Temperature Monitoring system will trigger an alarm before wear actually takes place. For that reason the ultimate protection against severe bearing damage and the optimum way of providing early warning, is a combined bearing wear and temperature monitoring system.

For all types of error situations detected by the different bearing condition monitoring systems applies that in addition to damaging the components, in extreme cases, a risk of a crankcase explosion exists.

Oil Mist Detector

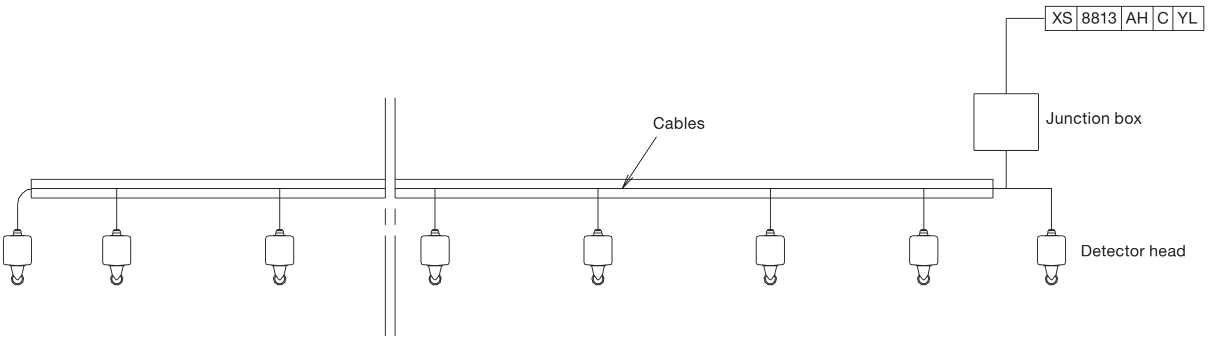
The oil mist detector system constantly measures samples of the atmosphere in the crankcase compartments and registers the results on an optical measuring track, where the opacity (degree of haziness) is compared with the opacity of the atmospheric air. If an increased difference is recorded, a slow down is activated (a shut down in case of Germanische Lloyd).

Furthermore, for shop trials only MAN Diesel requires that the oil mist detector is connected to the shut down system.

The EoD lists three alternative oil mist detectors:

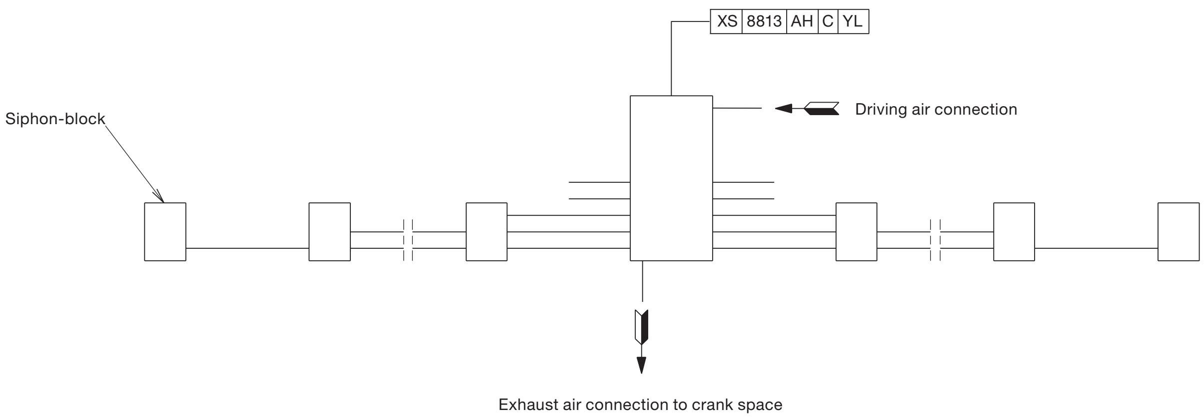
4 75 161	Oil mist detector Graviner MK6. Make: Kidde Fire Protection
4 75 163	Oil mist detector Visatron VN 215/93. Make: Schaller
4 75 165	Oil mist detector QMI Make: Quality Monitoring Instruments Ltd

Diagrams for two of them are shown in Figs. 18.06.01a and 18.06.01b.



178 49 80-9.2

Fig. 18.06.01a: Oil mist detector pipes on engine, type Graviner MK6 from Kidde Fire Protection (EoD: 4 75 161)



178 49 81-0.2

Fig. 18.06.01b: Oil mist detector pipes on engine, type Visatron VN215/93 from Schaller (EoD: 4 75 163)

Bearing Wear Monitoring System

The Bearing Wear Monitoring (BWM) system monitors all three principal crank-train bearings using two proximity sensors forward/aft per cylinder unit and placed inside the frame box.

Targeting the guide shoe bottom ends continuously, the sensors measure the distance to the crosshead in Bottom Dead Center (BDC). Signals are computed and digitally presented to computer hardware, from which a useable and easily interpretable interface is presented to the user.

The measuring precision is more than adequate to obtain an alarm well before steel-to-steel contact in the bearings occur. Also the long-term stability of the measurements has shown to be excellent.

In fact, BWM is expected to provide long-term wear data at better precision and reliability than the manual vertical clearance measurements normally performed by the crew during regular service checks.

For the above reasons, we consider unscheduled open-up inspections of the crank-train bearings to be superfluous, given BWM has been installed.

Two BWM 'high wear' alarm levels including deviation alarm apply. The first level of the high wear / deviation alarm is indicated in the alarm panel only while the second level also activates a slow down.

The Extent of Delivery lists four Bearing Wear Monitoring options of which the two systems from Dr. E. Horn and Kongsberg could also include Bearing Temperature Monitoring:

4 75 142	Bearing Wear Monitoring System XTS-W. Make: AMOT
4 75 143	Bearing Wear Monitoring System BDMS. Make: Dr. E. Horn
4 75 144	Bearing Wear Monitoring System PS-10. Make: Kongsberg
4 75 147	Bearing Wear Monitoring System OPEN-predictor. Make: Rovsing

K98MC6/7 and all MC-C engines are as standard specified with Bearing Wear Monitoring for which any of the mentioned options could be chosen.

Water In Oil Monitoring System

In case the oil system becomes contaminated with an amount of water exceeding our limit of 0.2% (0.5% for short periods), acute corrosive wear of the crosshead bearing overlayer may occur. The higher the water content, the faster the wear rate.

To prevent water from accumulating in the lube oil and, thereby, causing damage to the bearings, the oil should be monitored manually or automatically by means of a Water In Oil (WIO) monitoring system connected to the engine alarm and monitoring system. In case of water contamination the source should be found and the equipment inspected and repaired accordingly.

The WIO system should trigger an alarm when the water content exceeds 0.3%, and preferably again when exceeding 0.5% measured as absolute water content.

Some WIO systems measure water activity, ie the relative availability of water in a substance expressed in aw on a scale from 0 to 1. Here, '0' indicates oil totally free of water and '1' oil fully saturated by water. The correlation to absolute water content in normal running as well as alarm condition is as follows:

Engine condition	Abs. water content, %	Water activity, wa
Normal running	0 - 0.2	0 - 0.7
Low alarm level	0.3	0.8
High alarm level	0.5	1.0

K98MC6/7, S42MC7, S35MC7, L35MC6 and S26MC6 as well as all MC-C engines are as standard specified with Water In Oil monitoring system.

Please note: Corrosion of the overlayer is a potential problem only for crosshead bearings, because only crosshead bearings are designed with an overlayer. Main and crankpin bearings may also suffer irreparable damage from water contamination, but the damage mechanism would be different and not as acute.

Bearing Temperature Monitoring System

The Bearing Temperature Monitoring (BTM) system continuously monitors the temperature of the bearing. Some systems measure the temperature on the backside of the bearing shell directly, other systems detect it by sampling a small part of the return oil from each bearing in the crankcase.

In case a specified temperature is recorded, either a bearing shell/housing temperature or bearing oil outlet temperature alarm is triggered.

In main bearings, the shell/housing temperature or the oil outlet temperature is monitored depending on how the temperature sensor of the BTM system, option: 4 75 133, is installed.

In crankpin and crosshead bearings, the shell/housing temperature or the oil outlet temperature is monitored depending on which BTM system is installed, options: 4 75 134 or 4 75 135.

For shell/housing temperature in main, crankpin and crosshead bearings two high temperature alarm levels apply. The first level alarm is indicated in the alarm panel while the second level activates a slow down.

For oil outlet temperature in main, crankpin and crosshead bearings two high temperature alarm levels including deviation alarm apply. The first level of the high temperature / deviation alarm is indicated in the alarm panel while the second level activates a slow down.

In the Extent of Delivery, there are three options:

4 75 133	Temperature sensors fitted to main bearings
4 75 134	Temperature sensors fitted to main bearings, crankpin bearings, crosshead bearings and for moment compensator, if any
4 75 135	Temperature sensors fitted to main bearings, crankpin bearings and crosshead bearings

S42MC7, S35MC7, L35MC6 and S26MC6 engines are as standard specified with option 4 75 133.

Control Devices

The control devices mainly include a position switch (ZS) or a position transmitter (ZT) and solenoid valves (ZV) which are listed in Table 18.06.02 below. The sensor identification codes are listed in Table 18.07.01.

Sensor id. code	Point of location
	Manoeuvring system
ZV 1103	Solenoid valve for engine emergency stop
XS/PS 1106	Reset shut down at emergency
ZS 1109-A/B C	Turning gear – disengaged
ZS 1110-A/B C	Turning gear – engaged
ZS 1111-A/B C	Main starting valve – blocked
ZS 1112-A/B C	Main starting valve – in service
ZV 1114 C	Slow turning valve
ZS 1116-A/B C	Start air distribution system in service
ZS 1117-A/B C	Start air distribution system, blocked
PS 1118	Manoeuvring system in Emergency Control
ZV 1121-A/B C	Activate main starting valves - open
ZS 1122	Switch at change-over mechanism - change safety system reset between local telegraph and engine side console
XC 1126	I/P converter for VIT control (Only engines with VIT)
ZV 1127	Solenoid valve for control of VIT system in stop or Astern funktionl (Only engines with VIT)
PS 1133	Cancel of tacho alarm from safety system when Stop is ordered
PS 1134	Gives signal when »Bridge control«
ZV 1136	Remote stop solenoid valve
ZV 1137	Remote start solenoid valve
ZS 1138	Reversing cylinder Ahead position
ZS 1139	Reversing cylinder Astern position
ZV 1141	Solenoid valve for rev.cyl activation, direktion Ahead, during remote control
ZV 1142	Solenoid valve for rev.cyl activation, direktion Astern, during remote control
PT 1149	Pilot pressure to actuator for V.I.T. system (Only engines with VIT)
E 1180	Electric motor, auxiliary blower
E 1181	Electric motor, turning gear
E 1182	Actuator for electronic governor
	Fuel oil
ZV 8020 C	Fuel oil cut-off at engine inlet (shut down), Germanischer Lloyd only
	Cylinder lube oil
ZT 8203 C	Confirm cylinder lubricator piston movement, cyl/cy
ZV 8204	Activate cylinder lubricator, cyl/cyl
	Scavenge air
PS 8603 C	Scavenge air receiver, auxiliary blower control

Table 18.06.02: Control devices on engine

Identification of instruments

The measuring instruments are identified by a combination of letters and a position number:

Measured variables
First letters:

DS	Density switch
DT	Density transmitter
FT	Flow transmitter
FS	Flow switch
GT	Gauging transmitter (Index, load)
LI	Level indication, local
LS	Level switch
LT	Level transmitter
PDI	Pressure difference indication, local
PDS	Pressure difference switch
PDT	Pressure difference transmitter
PI	Pressure indication, local
PS	Pressure switch
PT	Pressure transmitter
ST	Speed transmitter
TC	Thermo couple (NiCr-Ni)
TE	Temperature element (Pt 100)
TI	Temperature indication, local
TS	Temperature switch
VS	Viscosity switch
VT	Viscosity transmitter
WI	Vibration indication, local
WS	Vibration switch
WT	Vibration transmitter
XC	Unclassified control
XS	Unclassified switch
XT	Unclassified transmitter
ZS	Position switch
ZT	Position transmitter (proximity switch)
ZV	Position valve (solenoid valve)

Location of measuring point
Ident. number:

11xx	Manoeuvring system
12xx	Hydraulic power supply system
14xx	Combustion pressure supervision
20xx	ECS to/from safety system
21xx	ECS to/from remote control system
22xx	ECS to/from alarm system
30xx	ECS miscellaneous input/output
40xx	Tacho/crankshaft position system
41xx	Engine cylinder components
50xx	VOC, supply system
51xx	VOC, sealing oil system
52xx	VOC, control oil system
53xx	VOC, other related systems
54xx	VOC, engine related components
80xx	Fuel oil system
81xx	Lubricating oil system
82xx	Cylinder lube oil system
83xx	Stuffing box drain system
84xx	Cooling water systems
85xx	Compressed air systems
86xx	Scavenge air system
87xx	Exhaust gas system
88xx	Miscellaneous functions
90xx	Project specific functions
xxxx-A	Alternative redundant sensors
xxxx-1	Cylinder/turbocharger numbers

ECS: Engine Control System
VOC: Volatile Organic Compound

Functions
Secondary letters:

A	Alarm
AH	Alarm, high
AL	Alarm, low
C	Control
H	High
I	Indication
L	Low
R	Recording
S	Switching
X	Unclassified function
Y	Slow down
Z	Shut down

Repeated signals

Signals which are repeated for example for each cylinder or turbocharger are provided with a suffix number indicating the location, ‘1’ for cylinder 1 etc.

If redundant sensors are applied for the same measuring point, the suffix is a letter: A, B, C etc.

Examples:
TI 8005 indicates a local temperature indication (thermometer) in the fuel oil system.

ZS 1112-A C and ZS 1112-B C indicate that there are two position switches in the manoeuvring system, A and B for control of the main starting air valve position.

PT 8501 I AL Y indicates a pressure transmitter located in the control air supply for remote indication, alarm for low pressure and slow down for low pressure.

Table 18.07.01: Identification of instruments

Dispatch Pattern, Testing, Spares and Tools

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Dispatch Pattern, Testing, Spares and Tools

Painting of Main Engine

The painting specification, Section 19.02, indicates the minimum requirements regarding the quality and the dry film thickness of the coats of, as well as the standard colours applied on MAN B&W engines built in accordance with the 'Copenhagen' standard.

Paints according to builder's standard may be used provided they at least fulfil the requirements stated.

Dispatch Pattern

The dispatch patterns are divided into two classes, see Section 19.03:

A: Short distance transportation and short term storage
B: Overseas or long distance transportation or long term storage.

Short distance transportation *(A)* is limited by a duration of a few days from delivery ex works until installation, or a distance of approximately 1,000 km and short term storage.

The duration from engine delivery until installation must not exceed 8 weeks.

Dismantling of the engine is limited as much as possible.

Overseas or long distance transportation or long term storage require a class B dispatch pattern.

The duration from engine delivery until installation is assumed to be between 8 weeks and maximum 6 months.

Dismantling is effected to a certain degree with the aim of reducing the transportation volume of the individual units to a suitable extent.

Note:
Long term preservation and seaworthy packing are always to be used for class B.

Furthermore, the dispatch patterns are divided into several degrees of dismantling in which '1' comprises the complete or almost complete engine. Other degrees of dismantling can be agreed upon in each case.

When determining the degree of dismantling, consideration should be given to the lifting capacities and number of crane hooks available at the engine maker and, in particular, at the yard (purchaser).

The approximate masses of the sections appear in Section 19.04. The masses can vary up to 10% depending on the design and options chosen.

Lifting tools and lifting instructions are required for all levels of dispatch pattern. The lifting tools (4 12 110 or 4 12 111), are to be specified when ordering and it should be agreed whether the tools are to be returned to the engine maker (4 12 120) or not (4 12 121).

MAN Diesel's recommendations for preservation of disassembled/ assembled engines are available on request.

Furthermore, it must be considered whether a drying machine, option 4 12 601, is to be installed during the transportation and/or storage period.

Shop trials/Delivery Test

Before leaving the engine maker's works, the engine is to be carefully tested on diesel oil in the presence of representatives of the yard, the shipowner and the classification society.

The shop trial test is to be carried out in accordance with the requirements of the relevant classification society, however a minimum as stated in Section 19.05.

MAN Diesel's recommendations for shop trial, quay trial and sea trial are available on request.

An additional test is required for measuring the NO_x emissions, for plants with FPP or CPP, EoD 4 06 060a or 4 06 060b respectively.

Spare Parts

List of spares, unrestricted service

The tendency today is for the classification societies to change their rules such that required spare parts are changed into recommended spare parts.

MAN Diesel, however, has decided to keep a set of spare parts included in the basic extent of delivery (4 87 601) covering the requirements and recommendations of the major classification societies, see Section 19.06.

This amount is to be considered as minimum safety stock for emergency situations.

Additional spare parts recommended by MAN Diesel

The above-mentioned set of spare parts can be extended with the 'Additional Spare Parts Recommended by MAN Diesel' (option: 4 87 603), which facilitates maintenance because, in that case, all the components such as gaskets, sealings, etc. required for an overhaul will be readily available, see Section 19.07.

Wearing parts

The consumable spare parts for a certain period are not included in the above mentioned sets, but can be ordered for the first 1, 2, up to 10 years' service of a new engine (option: 4 87 629), a service year being assumed to be 6,000 running hours.

The wearing parts supposed to be required, based on our service experience, are divided into 14 groups, see Table A in Section 19.08, each group including the components stated in Tables B.

Large spare parts, dimensions and masses

The approximate dimensions and masses of the larger spare parts are indicated in Section 19.09. A complete list will be delivered by the engine maker.

Tools

List of standard tools

The engine is delivered with the necessary special tools for overhauling purposes. The extent, dimensions and masses of the main tools is stated in Section 19.10. A complete list will be delivered by the engine maker.

Tool Panels

Most of the tools are arranged on steel plate panels (EoD 4 88 660) see Section 19.11 'Tool Panels'.

It is recommended to place the panels close to the location where the overhaul is to be carried out.

Specification for painting of main engine

Components to be painted before shipment from workshop	**Type of paint**	No. of coats/ Total dry film thickness μm	**Colour:** RAL 840HR DIN 6164 MUNSELL
Component/surfaces, inside engine, exposed to oil and air			
1. Unmachined surfaces all over. However cast type crankthrows, main bearing cap, crosshead bearing cap, crankpin bearing cap, pipes inside crankcase and chainwheel need not to be painted but the cast surface must be cleaned of sand and scales and kept free of rust.	Engine alkyd primer, weather resistant Oil and acid resistant alkyd paint. Temperature resistant to minimum 80 °C.	2/80 1/30	**Free** **White:** RAL 9010 DIN N:0:0.5 MUNSELL N-9.5
Components, outside engine			
2. Engine body, pipes, gallery, brackets etc. Delivery standard is in a primed and finally painted condition, unless otherwise stated in the contract.	Engine alkyd primer, weather resistant. Final alkyd paint resistant to salt water and oil, option: 4 81 103.	2/80 1/30	**Free** **Light green:** RAL 6019 DIN 23:2:2 MUNSELL10GY 8/4
Heat affected components:			
3. Supports for exhaust receiver Scavenge air-pipe outside. Air cooler housing inside and outside.	Paint, heat resistant to minimum 200 °C.	2/60	**Alu:** RAL 9006 DIN N:0:2 MUNSELL N-7.5
Components affected by water and cleaning agents			
4. Scavenge air cooler box inside.	protection of the components exposed to moderately to severely corrosive environment and abrasion.	2/75	**Free**
5. Gallery plates topside.	Engine alkyd primer, weather resistant.	2/80	**Free**
6. Purchased equipment and instruments painted in makers colour are acceptable unless otherwise stated in the contract.			
Tools			
Unmachined surfaces all over on handtools and lifting tools. Purchased equipment painted in makers colour is acceptable, unless otherwise stated in the contract/drawing.	Oil resistant paint.	2/60	**Orange red:** RAL 2004 DIN:6:7:2 MUNSELL N-7.5r 6/12
Tool panels	Oil resistant paint.	2/60	**Light grey:** RAL 7038 DIN:24:1:2 MUNSELL N-7.5

Note: All paints are to be of good quality. Paints according to builder's standard may be used provided they at least fulfil the above requirements.
The data stated are only to be considered as guidelines. Preparation, number of coats, film thickness per coat, etc. have to be in accordance with the paint manufacturer's specifications.

178 30 20-7.4

Fig. 19.02.01: Painting of main engine: 4 81 101, 4 81 102 or 4 81 103

Dispatch Pattern

The relevant engine supplier is responsible for the actual execution and delivery extent. As differences may appear in the individual suppliers' extent and dispatch variants.

Class A (option 4 12 020):
Short distance transportation limited by duration of transportation time within a few days or a distance of approximately 1000 km and short term storage.
Duration from engine delivery to installation must not exceed eight weeks.
Dismantling must be limited.

Class B (option 4 12 030):
Overseas and other long distance transportation, as well as long-term storage.
Dismantling is effected to reduce the transport volume to a suitable extent.
Long-term preservation and seaworthy packing must always be used.

Classes A + B comprise the following basic variants:

A1 + B1 (option 4 12 021 + 4 12 031)
- Engine complete

A2 + B2 (option 4 12 022 + 4 12 032)
- Top section including cylinder frame complete, cylinder covers complete, scavenge air receiver including cooler box and cooler insert, turbocharger(s), camshaft, piston rods complete and galleries with pipes.
- Bottom section including bedplate complete, frame box complete, connecting rods, turning gear, crankshaft complete and galleries.
- Remaining parts, stay bolts, chains, etc.

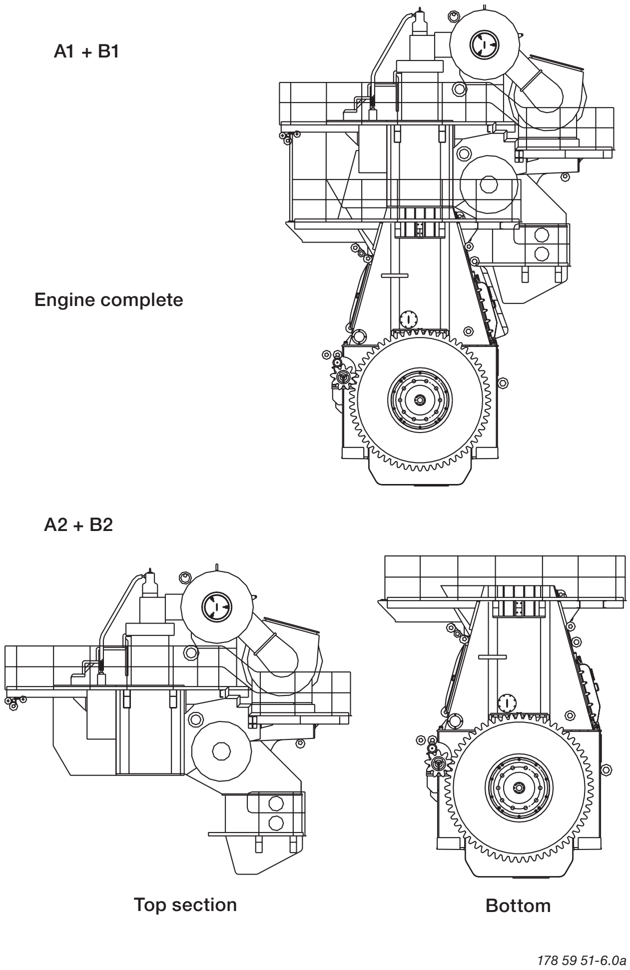
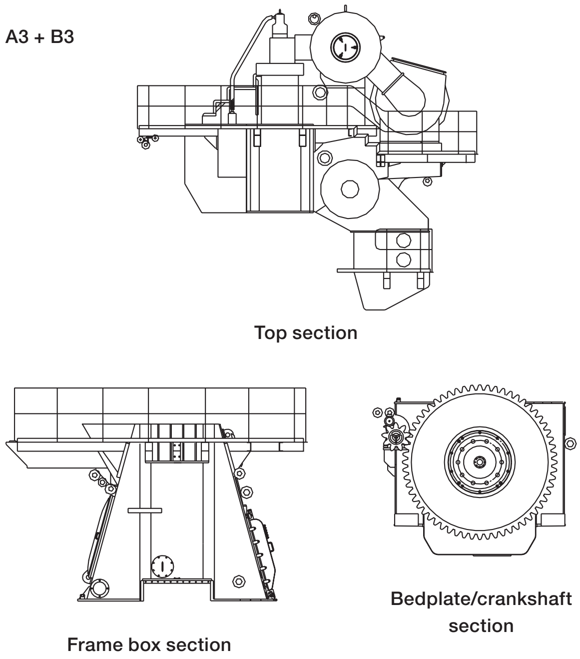


Fig. 19.03.01a : Dispatch pattern, engine with turbocharger on exhaust side (4 59 122)

A3 + B3 (option 4 12 023 + 4 12 033)

- Top section including cylinder frame complete, cylinder covers complete, scavenge air receiver including cooler box and cooler insert, turbocharger(s), camshaft, piston rods complete and galleries with pipes.
- Frame box section including frame box complete, chain drive connecting rods and galleries.
- Bedplate/crankshaft section including bedplate complete, crankshaft complete with wheels and turning gear.
- Remaining parts, stay bolts, chains, etc.



178 59 51-6.0b

178 59 52-8.0

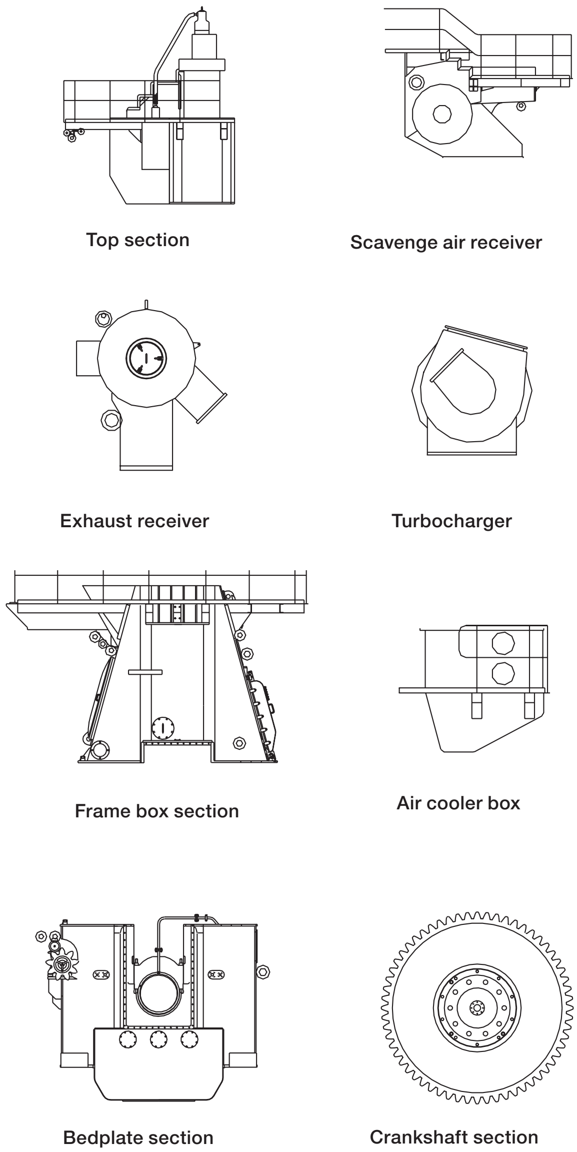
Fig. 19.03.01b: Dispatch pattern, engine with turbocharger on exhaust side (4 59 122)

A4 + B4 (option 4 12 024 + 4 12 034)

- Top section including cylinder frame complete, cylinder covers complete, camshaft, piston rods complete and galleries with pipes on camshaft side.
- Exhaust receiver with pipes.
- Scavenge air receiver with galleries and pipes.
- Turbocharger.
- Air cooler box with cooler insert.
- Frame box section including frame box complete, chain drive, connecting rods and galleries.
- Crankshaft with wheels.
- Bedplate with pipes and turning gear.
- Remaining parts, stay bolts, chains, etc.

Note!
The engine supplier is responsible for the necessary lifting tools and lifting instructions for transportation purpose to the yard.

The delivery extent of tools, ownership and lending/lease conditions are to be stated in the contract. Furthermore, it must be stated whether a dehumidifier is to be installed during the transportation and/or storage period.



178 59 52-8.0c

Fig. 19.03.01c: Dispatch pattern, engine with turbocharger on exhaust side (4 59 122)

Dispatch Pattern

The relevant engine supplier is responsible for the actual execution and delivery extent. As differences may appear in the individual suppliers' extent and dispatch variants.

Class A (option 4 12 020):
Short distance transportation limited by duration of transportation time within a few days or a distance of approximately 1000 km and short term storage.
Duration from engine delivery to installation must not exceed eight weeks.
Dismantling must be limited.

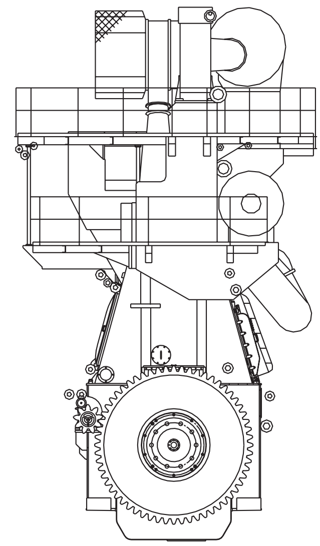
Class B (option 4 12 030):
Overseas and other long distance transportation, as well as long-term storage.
Dismantling is effected to reduce the transport volume to a suitable extent.
Long-term preservation and seaworthy packing must always be used.

Classes A + B comprise the following Basic Variants

A1 + B1 (option 4 12 021 + 4 12 031)
- Engine Complete

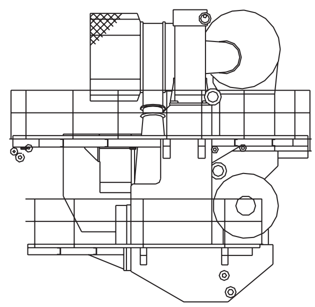
A2 + B2 (option 4 12 022 + 4 12 032)
- Top section including cylinder frame complete, cylinder covers complete, scavenge air receiver including cooler box and cooler insert, turbocharger(s), camshaft, piston rods complete and galleries with pipes.
- Bottom section including bedplate complete, frame box complete, connecting rods, turning gear, crankshaft complete and galleries.
- Remaining parts, stay bolts, chains, suction pipe, etc.

A1 + B1

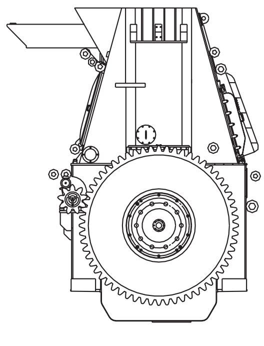


Engine complete

A2 + B2



Topsection



Bottom section

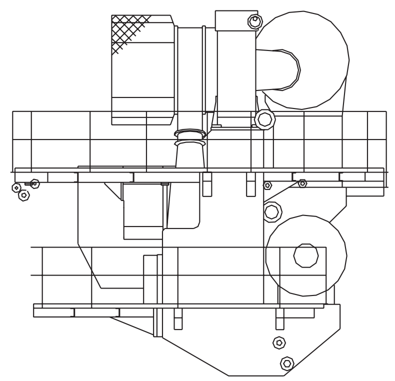
178 47 33-1.0a

Fig. 19.03.02a: Dispatch pattern, engine with turbocharger on on aft end (4 59 121)

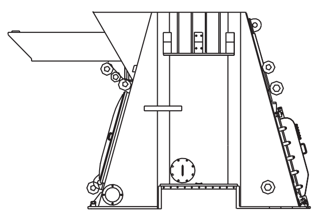
A3 + B3 (option 4 12 023 + 4 12 033)

- Top section including cylinder frame complete, cylinder covers complete, scavenge air receiver including cooler box and cooler insert, turbocharger(s), camshaft, piston rods complete and galleries with pipes.
- Frame box section including frame box complete, chain drive, connecting rods and galleries.
- Bedplate/crankshaft section including bedplate complete, crankshaft complete with wheels and turning gear.
- Remaining parts, stay bolts, chains, suction pipe, etc.

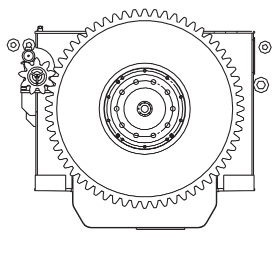
A3 + B3



Top section



Framebox section



Bedplate/crankshaft section

178 47 33-1.0b

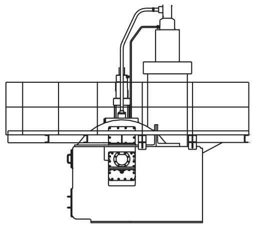
Fig. 19.03.02b: Dispatch pattern, engine with turbocharger on on aft end (4 59 121)

A4 + B4 (option 4 12 024 + 4 12 034)

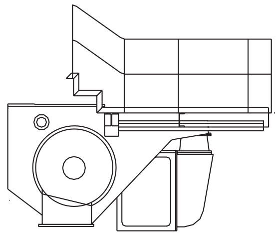
- Top section including cylinder frame complete, cylinder covers complete, camshaft, piston rods complete and galleries with pipes on camshaft side.
- Exhaust receiver with pipes.
- Scavenge air receiver with galleries and pipes, without air cooler box.
- Turbocharger.
- Air cooler box with galleries.
- Air cooler insert.
- Frame box section including frame box complete, chain drive, connecting rods and galleries.
- Crankshaft with wheels.
- Bedplate with pipes and turning gear.
- Remaining parts, stay bolts, chains, suction pipe, auxiliary blower, etc.

Note!
The engine supplier is responsible for the necessary lifting tools and lifting instructions for transportation purpose to the yard.

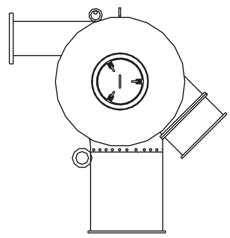
The delivery extent of tools, ownership and lending/lease conditions are to be stated in the contract.
Furthermore, it must be stated whether a dehumidifier is to be installed during the transportation and/or storage period.



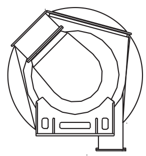
Top section



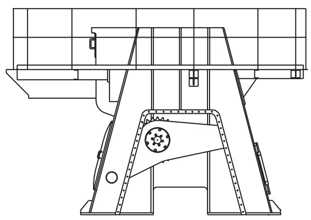
Scavenge air receiver



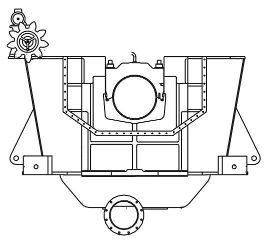
Exhaust receiver



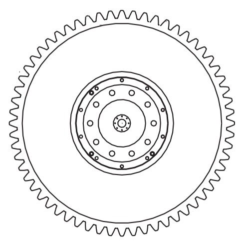
Turbocharger



Frame box section



Bedplate section



Crankshaft section

178 47 33-1.0c

Fig. 19.03.02c: Dispatch pattern, engine with turbocharger on on aft end (4 59 121)

Dispatch pattern, list of masses and dimensions

Pattern	Section	5 cylinders		6 cylinders		7 cylinders		8 cylinders			
		Mass	Length	Mass	Length	Mass	Length	Mass	Length	Height	Width
		in t	in m	in t	in m	in t	in m	in t	in m	in m	in m
A1+B1	Engine complete	**202.1**	**8.7**	**232.0**	**9.6**	**255.9**	**10.5**	**287.9**	**11.4**	**9.3**	**5.5**
A2+B2	Top section	77.0	8.7	91.5	9.6	102.9	10.5	118.4	11.4	5.0	5.5
	Bottom section	114.9	8.3	129.5	9.2	141.3	10.1	157.1	11.0	5.6	4.9
	Remaining parts	10.2		10.9		11.6		12.4			
A3+B3	Top section	77.0	8.7	91.5	9.6	102.9	10.5	118.4	11.4	5.0	5.5
	Frame box section	46.3	8.1	52.9	9.0	55.0	9.9	61.6	10.8	3.0	4.9
	Bedplate/Crankshaft	68.6	6.8	76.6	7.7	86.4	8.5	95.5	9.4	2.8	3.3
	Remaining parts	10.2		10.9		11.6		12.4			
A4+B4	Top section	52.4	6.6	61.8	7.5	71.3	8.4	80.8	9.3	4.3	3.6
	Exhaust receiver	5.5	5.5	6.2	6.4	6.8	7.3	7.5	8.2	2.2	2.2
	Scavenge air receiver	5.9	6.6	7.5	7.5	8.8	8.4	10.0	9.3	3.0	2.0
	Turbocharger - each	3.7		5.1		5.1		9.8			
	Air cooler - insert	1.8		3.2		3.2		2.5			
	Air cooler box	6.4	2.0	6.4	2.0	6.4	2.0	6.4		3.4	5.5
	Frame box section	46.7	6.2	53.3	7.1	55.3	8.0	61.8	2.0	3.0	4.6
	Crankshaft	35.0	6.5	39.1	7.4	46.7	8.3	52.0	9.2	2.4	2.4
	Bedplate	33.1	6.3	37.0	7.2	39.2	8.1	43.1	9.0	2.7	3.3
	Remaining parts	11.7		12.4		13.1		14.0			

The weights stated are for standard engines with semi-built crankshaft with forged throws, crosshead guides integrated in the frame box, and MAN Diesel turbocharger. The final weights are to be confirmed by the engine supplier, as variations in major engine components due to the use of local standards (plate thickness etc.), size of tuning wheel, type of turbocharger and the choice of cast/welded or forged component designs may increase the total weight by up to 10 %. All masses and dimensions in the dispatch pattern are therefore approximate and do not include packing and lifting tools.

Note: Some engines are equipped with moment compensator and/or turning wheel. However, the weights for these components are not included in dispatch pattern.

Table 19.04.01: Dispatch pattern, list of masses and dimensions: Engine with turbocharger located on aft end (4 59 123)

Pattern	Section	5 cylinders		6 cylinders		7 cylinders		8 cylinders			
		Mass in t	Length in m	Mass in t	Length in m	Mass in t	Length in m	Mass in t	Length in m	Height in m	Width in m
A1+B1	Engine complete	**200.1**	**8.3**	**230.9**	**9.2**	**254.9**	**10.0**	**288.3**	**10.9**	**9.0**	**7.1**
A2+B2	Top section	76.9	7.1	91.5	8.0	103.0	8.9	119.9	9.8	6.0	7.1
	Bottom section	115.1	8.3	129.7	9.2	141.6	10.0	157.4	10.9	5.6	6.0
	Remaining parts	8.8		9.5		10.2		11.0			
A3+B3	Top section	76.9	7.1	91.6	8.0	103.0	8.9	119.9	9.8	6.0	7.1
	Frame box section	46.5	8.3	53.1	9.2	55.2	10.0	61.9	10.9	3.0	6.0
	Bedplate/Crankshaft	68.6	6.8	76.6	7.7	86.4	8.5	95.5	9.4	2.8	3.3
	Remaining parts	8.8		9.5		10.2		11.0			
A4+B4	Top section	53.8	7.1	53.3	8.0	72.7	8.9	82.4	9.8	4.3	3.6
	Exhaust receiver	5.2	5.5	5.9	6.4	6.5	7.3	7.5	8.2	2.2	2.2
	Scavenge air receiver	12.0	6.2	13.8	7.1	15.2	8.0	18.7	8.9	3.0	3.6
	Turbocharger - each	3.7		5.1		5.1		7.4			
	Air cooler - insert	1.8		3.2		3.2		3.6			
	Frame box section	46.8	8.3	53.5	9.2	55.6	10.0	62.2	10.9	3.0	4.6
	Crankshaft	35.0	6.5	39.1	7.4	46.7	8.3	52.0	9.2	2.4	2.4
	Bedplate	33.1	6.3	37.0	7.2	39.2	8.1	43.1	9.0	2.7	3.3
	Remaining parts	9.3		10.0		10.7		11.4			

The weights stated are for standard engines with semi-built crankshaft with forged throws, crosshead guides integrated in the frame box, and MAN Diesel turbocharger. The final weights are to be confirmed by the engine supplier, as variations in major engine components due to the use of local standards (plate thickness etc.), size of tuning wheel, type of turbocharger and the choice of cast/welded or forged component designs may increase the total weight by up to 10 %. All masses and dimensions in the dispatch pattern are therefore approximate and do not include packing and lifting tools.

*Note: Some engines are equipped with moment compensator and/or turning wheel.
However, the weights for these components are not included in dispatch pattern.*

Table 19.04.02: Dispatch pattern, list of masses and dimensions: Engine with turbocharger located on exhaust side, (4 59 123)

Shop test

Minimum delivery test: 4 14 001

- Starting and manoeuvring test at no load
- Load test
  Engine to be started and run up to 50% of Specified MCR (M) in 1 hour

Followed by:

- 0.50 hour running at 25% of specified MCR
- 0.50 hour running at 50% of specified MCR
- 0.50 hour running at 75% of specified MCR
- 1.00 hour running at 100% of specified MCR
- 0.50 hour running at 110% of specified MCR

Only for Germanischer Lloyd:

- 0.75 hour running at 110% of specified MCR

Governor tests, etc:

- Governor test
- Minimum speed test
- Overspeed test
- Shut down test
- Starting and reversing test
- Turning gear blocking device test
- Start, stop and reversing from the Local Opera-ting Panel (LOP)

Before leaving the factory, the engine is to be carefully tested on diesel oil in the presence of representatives of Yard, Shipowner, Classification Society, and MAN Diesel.

At each load change, all temperature and pressure levels etc. should stabilise before taking new engine load readings.

Fuel oil analysis is to be presented.
All tests are to be carried out on diesel or gas oil.

Fig. 9.05.01: Shop trial running/delivery test: 4 14 001

EIAPP certificate

An additional test may be required for obtaining the 'Engine Prevention' Certificate, which states that the engine complies with IMO NO_x emission limitations 4 06 060.

An additional test is to be performed for: 'Individual Engines' and for 'Parent Engines' if the group certificate is not available - to be checked at MAN Diesel.

'Member Engines' to existing 'Parent Engines' do not need an additional test.

The tests, if required, are:
E3, marine engine, propeller law for FPP 4 06 060a
or
E2, marine engine, constant speed for CPP
4 06 060b.

List of Spare Parts, Unrestricted Service

Spare parts are **requested** by the following Classes only: GL, KR, NK and RS, while just **recommended** by: ABS, DNV and LR, but neither requested nor recommended by: BV, CCS and RINA.

Cylinder cover, plate 901 and others

1	Cylinder cover with fuel, exhaust and starting valves, indicator valve and sealing rings (disassembled).
½ set	Studs for 1 cylinder cover

Piston, plate 902

1	Piston complete (with cooling pipe), piston rod, piston rings and stuffing box, studs and nuts
1 set	Piston rings for 1 cylinder

Cylinder liner, plate 903

1	Cylinder liner inclusive of sealing rings and gaskets.

Cylinder lubricator, plate 903 [1])

	Standard Spare parts
1 set	Spares for MAN B&W Alpha lubricator for 1 cyl.
1	Lubricator
2	Feed back sensor, complete
1	Suction filter element for pump station
1	Pressure filter element for pump station
1	Complete sets of O-rings for lubricator (depending on No. of lubricating per. cylinder)
6	3A, 3 pcs. 12A ceramic or sand filled fuses 6.3 x 32 mm, for MCU, BCU & SBU
2	LED's for visual feed back indication
or	
1 set	LED's for visual feed back indication

Connecting rod, and crosshead bearing, plate 904

1	Telescopic pipe with bushing for 1 cylinder
1	Crankpin bearing shells in 2/2 with studs and nuts
1	Crosshead bearing shell lower part with studs and nuts
2	Thrust piece

Main bearing and thrust block, plate 905

1 set	Thrust pads for one face of each size, if different for 'ahead' and 'astern'

Chain drive, plate 906 [1])

1	Of each type of bearings for camshaft at chain drive, chain tightener and intermediate shaft
6	Camshaft chain links. Only for ABS, DNV, LR, NK and RS
1	Mechanically driven cylinder lubricator drive: 6 chain links or gear wheels
1	Guide ring 2/2 for camshaft bearing

Starting valve, plate 907

1	Starting valve, complete

Exhaust valve, plate 908

2	Exhaust valves complete. 1 only for GL)
1	Pressure pipe for exhaust valve pipe

Fuel pump, plate 909

1	Fuel pump barrel, complete with plunger
1	High-pressure pipe, each type
1	Suction and puncture valve, complete

Fuel valve, plate 909

2	Fuel valves per cylinder for all cylinders on one engine, and a sufficient number of valve parts, excluding the body, to form with those fitted on each cylinder for a complete engine set for BV, CCS, GL, KR, LR, NK, RINA, RS and IACS
2	Fuel valves per cylinder for half the number of cylinders on one engine, and a sufficient number of valve parts, excluding the body, to form with those fitted on each cylinder for a complete engine set for ABS
1 set	Fuel valves for all cylinders on one engine for DNV

Turbocharger, plate 910

1	Set of maker's standard spare parts
1 a)	Spare rotor for one turbocharger, including: compressor wheel, rotor shaft with turbine blades and partition wall, if any

Scavenge air blower, plate 910

1 set a)	Rotor, rotor shaft, gear wheel or equivalent working parts
1 set	Bearings for electric motor
1 set	Bearings for blower wheel
1	Belt, if applied
1 set	Packing for blower wheel

Bedplate, plate 912

1	Main bearing shell in 2/2 of each size
1 set	Studs and nuts for 1 main bearing

[1]) MD required spare parts.

a) Only required for RS. To be ordered separately as option: 4 87 660 for other classification societies.

Please note: Plate number refers to Instruction Book, Vol. III containing plates with spare parts.

Fig. 19.06.01: List of spare parts, unrestricted service: 4 87 601

Additional Spares

For easier maintenance and increased security in operation

Beyond class requirements

Cylinder cover, section 90101

4	Studs for exhaust valve
4	Nuts for exhaust valve
½ set	O-rings for cooling jacket
1	Cooling jacket
½ set	Sealing between cyl.cover and liner
4	Spring housings for fuel valv

Hydraulic tool for cylinder cover, section 90161

1 set	Hydraulic hoses with protection hose complete with couplings
8 pcs	O-rings with backup rings, upper
8 pcs	O-rings with backup rings, lower

Piston and piston rod, section 90201

1 box	Locking wire, L=63 m
5	Piston rings of each kind
2	D-rings for piston skirt
2	D-rings for piston rod

Piston rod stuffing box, section 90205

15	Self locking nuts
5	O-rings
5	Top scraper rings
15	Pack sealing rings
10	Cover sealing rings
120	Lamellas for scraper rings
30	Springs for top scraper and sealing rings
20	Springs for scraper rings

Cylinder frame, section 90301

½ set	Studs for cylinder cover for one cyl.
1	Bushing

Cylinder liner and cooling jacket, section 90302

1	Cooling jacket of each kind
4	Non return valves
1 set	O-rings for one cylinder liner
½ set	Gaskets for cooling water connection
½ set	O-rings for cooling water pipes
1 set	Cooling water pipes between liner and cover for one cylinder

Cylinder Lubricating Oil System, section 90306

1 set	Spares for MAN B&W Alpha lubricating oil system for 1cyl.
1	Lubricator
2	Feed back sensor, complete
1	Complete sets of O-rings for lubricator (depending on No. of lubricating nozzles per. cylinder)

Connecting rod and crosshead, section 90401

1	Telescopic pipe
2	Thrust piece

HPS Hydaulic Power Supply, section 906

1	Delivery pump
1	Start up pump
1	Pressure relief valve
1	Pumps short cutting valve
1 set	Check valve Cartridge (3 pcs)

Engine Control System, section 906

1 set	Fuses for MPC, TSA, CNR
1	Segment for triggerring

HCU Hydraulic Cylinder Unit, section **906**

1 set	Packings

Main starting valve, section 90702

1	Repair kit for main actuator
1	Repair kit for main ball valve
1	*) Repair kit for actuator, slow turning
1	*) Repair kit for ball valve, slow turning

*) if fitted

Starting valve, section 90704

2	Locking plates
2	Piston
2	Spring
2	Bushing
1 set	O-ring
1	Valve spindle

Note:
Section numbers refers to Instruction Book, Vol. III containing plates with spareparts

Fig. 19.07.01a: Additional spare parts beyond class requirements or recommendation, for easier maintenance and increased availability, option: 4 87 603

Exhaust valve, section 90801

1 Exhaust valve spindle
1 Exhaust valve seat
½ set O-ring exhaust valve/cylinder cover
4 Piston rings
½ set Guide rings
½ set Sealing rings
½ set Safety valves
1 set Gaskets and O-rings for safety valve
1 Piston complete
1 Damper piston
1 set O-rings and sealings between air piston and exhaust valve housing/spindle
1 Liner for spindle guide
1 set Gaskets and O-rings for cool.w.conn.
1 Conical ring in 2/2
1 set O-rings for spindle/air piston
1 set Non-return valve

Exhaust valve, section 908

1 Sealing oil unit

Exhaust valve actuator, section 90805

1 Hydraulic exhaust valve actuator complete for 1 cylinder
1 Electronic exhaust valve control valve

Cooling water outlet, section 90810

2 Ball valve
1 Butterfly valve
1 Compensator
1 set Gaskets for butterfly valve and compensator

Fuel injection system, section 90901

1 Fuel oil pressure booster complete, for 1 cyl.
1 Hydraulic cylinder unit
1 set Gaskets and sealings
1 Electronic fuel injection cotrol valve

Fuel valve, section 90910

1 set Fuel nozzles
1 set O-rings for fuel valve
3 Spindle guides, complete
½ set Springs
½ set Discs, +30 bar
3 Thrust spindles
3 Non return valve (if mounted)

Fuel oil high pressure pipes, section 90913

1 High pressure pipe, from fuel oil pressure booster to fuel valve
1 High pressure pipe from actuator to exhaust valve
1 set O-rings for high pressure pipes

Overflow valve, section 90915

1 Overflow valve, complete
1 O-rings of each kind

Turbocharger, section 91000

1 Spare rotor, complete with bearings
1 Spare part set for turbocharger

Scavenge air receiver, section 91001

2 Non-return valves complete
1 Compensator

Exhaust pipes and receiver, section 91003

1 Compensator between TC and receiver
2 Compensator between exhaust valve and receiver
1 set Gaskets for each compensator

Air cooler, section 91005

16 Iron blocks (Corrosion blocks)

Safety valve, section 91101

1 set Gasket for safety valve
2 Safety valve, complete

Arrangement of safety cap, section 91104

1 set Bursting disc

Engine Lubricating System, section 912

1 set 10 μ filter

Note:
Section numbers refers to Instruction Book, Vol. III containing plates with spareparts

Fig. 19.07.01b: Additional spare parts beyond class requirements or recommendation, for easier maintenance and increased availability, option: 4 87 603

Wearing Parts

Table A

Group No.	Section	Qty.	Descriptions
1	90101	50%	O-rings and gaskets for 1 cylinder
2		25%	Spring housing, complete for 1 cylinder
3	90161	50%	O-ring W / Back-up ring for 1 cylinder
4		50%	Hose with union for 1 cylinder
5	90201	1 Box	Locking wire 1,0MM L=63
		100%	Piston rings for 1 cylinder
		100%	O-rings for 1 cylinder
6	90205	100%	O-rings for 1 cylinder
		100%	Lamella rings 3/3 for 1 cylinder
		50%	Top scraper rings 4/4 for 1 cylinder
		50%	Pack Sealing rings 4/4 for 1 cylinder
		50%	Cover Sealing rings 4/4 for 1 cylinder
		50%	Springs of each kind for 1 cylinder
7	90302	50%	O-rings / Sealing rings for Cylinder liner
		100%	O-rings, Packings and Gaskets for cooling water connections
8		1Pcs	Cylinder liner
		1Pcs	Piston cleaning ring (if Mounted)
9	90610	50%	Bearing Shells and Guide Disc for 1 Engine
10	90612	100%	Packings and Gaskets for 1 Engine
		25%	Indicator valves for 1 Engine
11	90615-25	25%	Pull-rods for 1 Engine
12	90702	50%	Repair Kit for each type of valve for 1 Engine
13	90704	100%	O-rings, Packings and Gaskets for 1 Engine
14	90801	25%	Exhaust valve spindle for 1 Engine
		25%	Exhaust valve W-bottom piece for 1 Engine
15		100%	Piston rings for exhaust valve air piston and oil piston for 1 Engine
		100%	O-rings for water connections for 1 Engine
		100%	Gasket for cooling for water connections for 1 Engine
		100%	O-rings for oil connections for 1 Engine
		1 Pcs	Spindle guide
		2 Pcs	Air sealing ring
		50%	Guide sealing rings
		100%	O-rings for bottom piece for 1 Engine
17	90901	25%	Plunger and barrel for fuel pump for 1 Engine
		50%	Suction valve complete / puncture valve,complete for 1 Cylinder
		100%	Sealing rings, O-rings and Gaskets for 1 cylinder
18	90910	50%	Fuel valve nozzle for 1 cylinder
		25%	Spindle guide complete and non-return valve for 1 cylinder
		200%	O-rings for 1 cylinder
19	91000	1	Slide bearing for turbocharger for 1 engine (roller bearings)
		1	Guide bearing for turbocharger for 1 engine (roller bearings)
20	91000	1	Slide bearing for turbocharger for 1 engine (slide bearings)
		1	Guide bearing for turbocharger for 1 engine (slide bearings)

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Table 19.08.01a: Wearing parts, option 4 87 629

The wearing parts are divided into 20 groups, each including the components stated in table A.

The average expected consumption of wearing parts is stated in tables B for 1, 2, 3... 10 years' service of a new engine, a service year being assumed to be of 6000 hours.

In order to find the expected consumption for a 6 cylinder engine during the first 18000 hours' service, the extent stated for each group in table A is to be multiplied by the figures stated in the table B (see the arrow), for the cylinder No. and service hours in question.

Table B

Group No.	Service hours	0-6000					0-12000				
		Number of cylinders									
	Description	4	5	6	7	8	4	5	6	7	8
1	O-rings and gaskets	4	5	6	7	8	8	10	12	14	16
2	Spring housing	0	0	0	0	0	4	5	6	7	8
3	O-ring W / Back-up ring	4	5	6	7	8	8	10	12	14	16
4	Hose with union	0	0	0	0	0	0	0	0	0	0
5	Set of piston rings	0	0	0	0	0	4	5	6	7	8
6	St. box, lamella / sealing rings	0	0	0	0	0	4	5	6	7	8
7	O-rings / Sealing rings Cyl. liner	0	0	0	0	0	4	5	6	7	8
8	Cylinder liners	0	0	0	0	0	0	0	0	0	0
9	Bearing Shells and Guide Disc	0	0	0	0	0	0	0	0	0	0
10	Packings and Gaskets	4	5	6	7	8	8	10	12	14	16
11	Pull-rods	0	0	0	0	0	0	0	0	0	0
12	Repair Kit for each type of valve	0	0	0	0	0	4	5	6	7	8
13	O-rings, Packings and Gaskets	4	5	6	7	8	8	10	12	14	16
14	Exhaust valve spindles / bottom pieces	0	0	0	0	0	0	0	0	0	0
15	Exhaust valve guide bushings	0	0	0	0	0	4	5	6	7	8
	O-rings for exhaust valve	4	5	6	7	8	8	10	12	14	16
17	Fuel pump plungers	0	0	0	0	0	0	0	0	0	0
	Suction/puncture valves , Sealing rings and Gaskets	0	0	0	0	0	4	5	6	7	8
18	Fuel valve guides and nozzles	0	0	0	0	0	4	5	6	7	8
19	Set bearings per TC (roller bearings)	0	0	0	0	0	0	0	0	0	0
20	Set bearings per TC (slide bearings)	0	0	0	0	0	0	0	0	0	0

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Table 19.08.01b: Wearing parts, option 4 87 629

Table B

Group No.	Service hours	0-18000					0-24000				
		Number of cylinders									
	Description	**4**	**5**	**6**	**7**	**8**	**4**	**5**	**6**	**7**	**8**
1	O-rings and gaskets	12	15	18	21	24	16	20	24	28	32
2	Spring housing	4	5	6	7	8	4	5	6	7	8
3	O-ring W / Back-up ring	12	15	18	21	24	16	20	24	28	32
4	Hose with union	4	5	6	7	8	4	5	6	7	8
5	Set of piston rings	4	5	6	7	8	8	10	12	14	16
6	St. box, lamella / sealing rings	4	5	6	7	8	8	10	12	14	16
7	O-rings / Sealing rings Cyl. liner	4	5	6	7	8	8	10	12	14	16
8	Cylinder liners	0	0	0	0	0	0	0	0	0	0
9	Bearing Shells and Guide Disc	0	0	0	0	0	4	5	6	7	8
10	Packings and Gaskets	12	15	18	21	24	16	20	24	28	32
11	Pull-rods	4	5	6	7	8	4	5	6	7	8
12	Repair Kit for each type of valve	4	5	6	7	8	8	10	12	14	16
13	O-rings, Packings and Gaskets	12	15	18	21	24	16	20	24	28	32
14	Exhaust valve spindles / bottom pieces	4	5	6	7	8	4	5	6	7	8
15	Exhaust valve guide bushings	4	5	6	7	8	8	10	12	14	16
	O-rings for exhaust valve	12	15	18	21	24	16	20	24	28	32
17	Fuel pump plungers	0	0	0	0	0	0	0	0	0	0
	Suction/puncture valves , Sealing rings and Gaskets	4	5	6	7	8	8	10	12	14	16
18	Fuel valve guides and nozzles	4	5	6	7	8	8	10	12	14	16
19	Set bearings per TC (roller bearings)	1	1	1	1	1	2	2	2	2	2
20	Set bearings per TC (slide bearings)	0	0	0	0	0	1	1	1	1	1

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Table 19.08.01c: Wearing parts, option 4 87 629

Table B

Group No.	Service hours	0-30000					0-36000				
		Number of cylinders									
	Description	**4**	**5**	**6**	**7**	**8**	**4**	**5**	**6**	**7**	**8**
1	O-rings and gaskets	20	25	30	35	40	24	30	36	42	48
2	Spring housing	8	5	6	7	8	4	5	6	7	8
3	O-ring W / Back-up ring	20	25	30	35	40	24	30	36	42	48
4	Hose with union	4	5	6	7	8	8	10	12	14	16
5	Set of piston rings	12	15	18	21	24	16	20	24	28	32
6	St. box, lamella / sealing rings	8	10	12	14	16	12	15	18	21	24
7	O-rings / Sealing rings Cyl. liner	4	5	6	7	8	8	10	12	14	16
8	Cylinder liners	0	0	0	0	0	0	0	0	0	0
9	Bearing Shells and Guide Disc	4	5	6	7	8	8	10	12	14	16
10	Packings and Gaskets	20	25	30	35	40	24	30	36	42	48
11	Pull-rods	4	5	6	7	8	4	5	6	7	8
12	Repair Kit for each type of valve	12	15	18	21	24	16	20	24	28	32
13	O-rings, Packings and Gaskets	20	25	30	35	40	24	30	36	42	48
14	Exhaust valve spindles / bottom pieces	4	5	6	7	8	8	10	12	14	16
15	Exhaust valve guide bushings	8	10	12	14	16	16	20	24	28	32
	O-rings for exhaust valve	20	25	30	35	40	24	30	36	42	48
17	Fuel pump plungers	0	0	0	0	0	4	5	6	7	8
	Suction/puncture valves , Sealing rings and Gaskets	8	10	12	14	16	12	15	18	21	24
18	Fuel valve guides and nozzles	16	20	24	28	32	16	20	24	28	32
19	Set bearings per TC (roller bearings)	2	2	2	2	2	3	3	3	3	3
20	Set bearings per TC (slide bearings)	1	1	1	1	1	1	1	1	1	1

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Table 19.08.01d: Wearing parts, option 4 87 629

Table B

Group No.	Service hours	0-42000					0-48000				
		Number of cylinders									
	Description	**4**	**5**	**6**	**7**	**8**	**4**	**5**	**6**	**7**	**8**
1	O-rings and gaskets	28	35	42	49	56	32	40	48	56	64
2	Spring housing	4	5	6	7	8	4	5	6	7	8
3	O-ring W / Back-up ring	28	35	42	49	56	32	40	48	56	64
4	Hose with union	4	5	6	7	8	8	10	12	14	16
5	Set of piston rings	12	15	18	21	24	16	20	24	28	32
6	St. box, lamella / sealing rings	12	15	18	21	24	16	20	24	28	32
7	O-rings / Sealing rings Cyl. liner	8	10	12	14	16	16	20	24	28	32
8	Cylinder liners	0	0	0	0	0	0	0	0	0	0
9	Bearing Shells and Guide Disc	4	5	6	7	8	8	10	12	14	16
10	Packings and Gaskets	28	35	42	49	56	32	40	48	56	64
11	Pull-rods	4	5	6	7	8	4	5	6	7	8
12	Repair Kit for each type of valve	12	15	18	21	24	16	20	24	28	32
13	O-rings, Packings and Gaskets	28	35	42	49	56	32	40	48	56	64
14	Exhaust valve spindles / bottom pieces	4	5	6	7	8	8	10	12	14	16
15	Exhaust valve guide bushings	8	10	12	14	16	16	20	24	28	32
	O-rings for exhaust valve	28	35	42	49	56	32	40	48	56	64
17	Fuel pump plungers	4	5	6	7	8	4	5	6	7	8
	Suction/puncture valves , Sealing rings and Gaskets	12	15	18	21	24	16	20	24	28	32
18	Fuel valve guides and nozzles	20	25	30	35	40	20	25	30	35	40
19	Set bearings per TC (roller bearings)	3	3	3	3	3	4	4	4	4	4
20	Set bearings per TC (slide bearings)	1	1	1	1	1	2	2	2	2	2

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Table 19.08.01e: Wearing parts, option 4 87 629

Table B

Group No.	Service hours	0-54000					0-60000				
		Number of cylinders									
	Description	**4**	**5**	**6**	**7**	**8**	**4**	**5**	**6**	**7**	**8**
1	O-rings and gaskets	36	45	54	63	72	40	50	60	70	80
2	Spring housing	4	5	6	7	8	4	5	6	7	8
3	O-ring W / Back-up ring	36	45	54	63	72	40	50	60	70	80
4	Hose with union	4	5	6	7	8	8	10	12	14	16
5	Set of piston rings	16	20	24	28	32	16	20	24	28	32
6	St. box, lamella / sealing rings	12	15	18	21	24	16	20	24	28	32
7	O-rings / Sealing rings Cyl. liner	4	5	6	7	8	8	10	12	14	16
8	Cylinder liners	0	0	0	0	0	0	0	0	0	0
9	Bearing Shells and Guide Disc	4	5	6	7	8	8	10	12	14	16
10	Packings and Gaskets	28	35	42	49	56	32	40	48	56	64
11	Pull-rods	4	5	6	7	8	4	5	6	7	8
12	Repair Kit for each type of valve	12	15	18	21	24	16	20	24	28	32
13	O-rings, Packings and Gaskets	36	45	54	63	72	40	50	60	70	80
14	Exhaust valve spindles / bottom pieces	4	5	6	7	8	8	10	12	14	16
15	Exhaust valve guide bushings	8	10	12	14	16	16	20	24	28	32
	O-rings for exhaust valve	36	45	54	63	72	40	50	60	70	80
17	Fuel pump plungers	4	5	6	7	8	4	5	6	7	8
	Suction/puncture valves , Sealing rings and Gaskets	12	15	18	21	24	12	15	18	21	24
18	Fuel valve guides and nozzles	12	15	18	21	24	12	15	18	21	24
19	Set bearings per TC (roller bearings)	4	4	4	4	4	5	5	5	5	5
20	Set bearings per TC (slide bearings)	2	2	2	2	2	2	2	2	2	2

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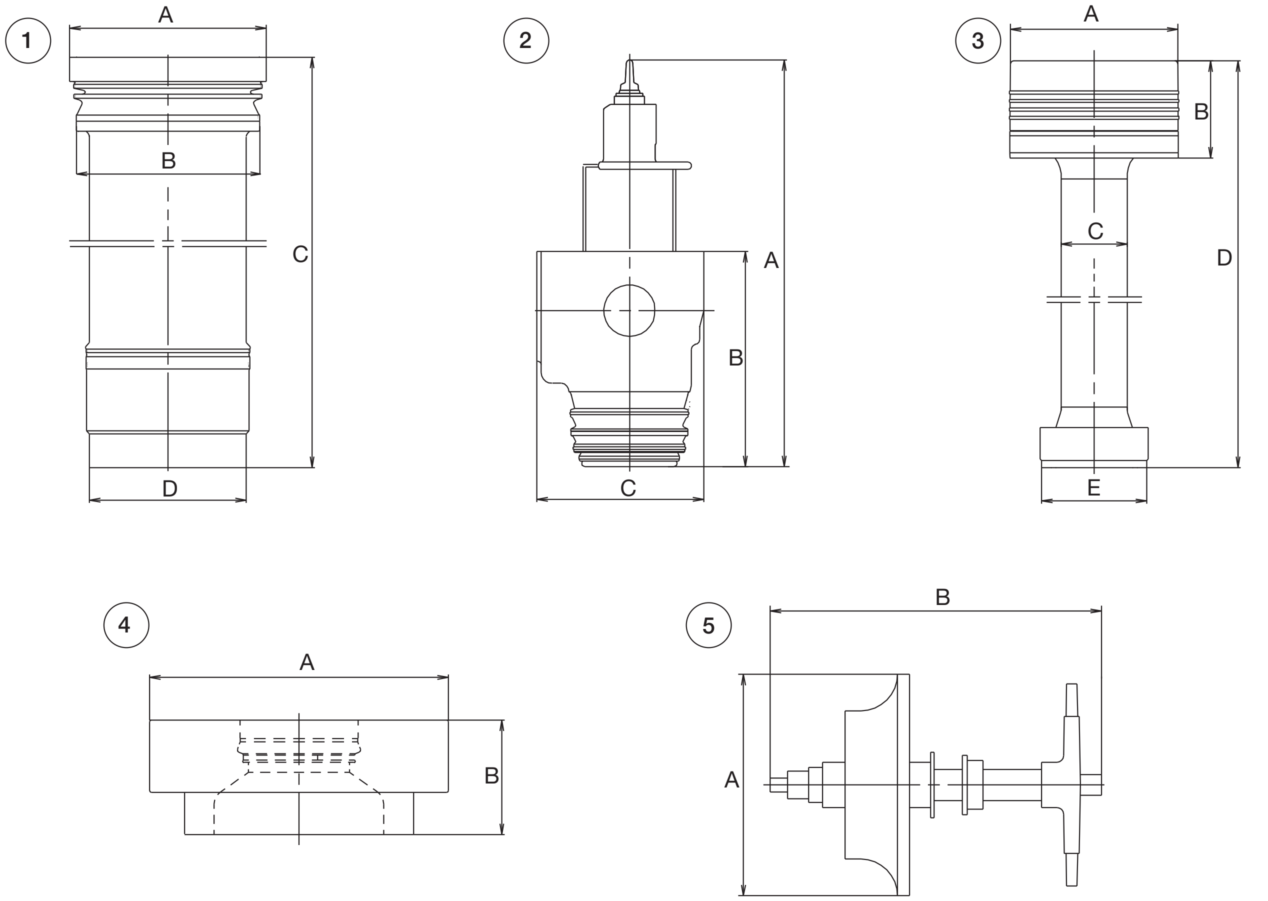
Table 19.08.01f: Wearing parts, option 4 87 629

Large spare parts, dimensions and masses



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Pos	Sec. Description	Mass	Dimensions (mm)				
		(kg)	A	B	C	D	E
1	Cylinder liner, incl. cooling jacket	1,541	ø660	ø680	2,093	ø590	
2	Exhaust valve	449	1,310	655	494		
3	Piston complete, with piston rod	872	ø500	349	ø195	2,662	320
4	Cylinder cover, incl. valves	1,163	ø903	413			
5	Rotor for turbocharger, TCA 55-20/21	130	ø530	990			
5	Rotor for turbocharger, TCA 66-20/21	220	ø630	1,170			
5	Rotor for turbocharger, TCA 77-20/21	360	ø750	1,360			
5	Rotor for turbocharger, TPL73-B12	115	ø507	963			
5	Rotor for turbocharger, TPL77-B11	190	ø580	1,136			
5	Rotor for turbocharger, TPL77-B12	190	ø602	1,136			
5	Rotor for turbocharger, MET53MA	190	ø586	1,035			
5	Rotor for turbocharger, MET60MA	240	ø652	1,188			
5	Rotor for turbocharger, MET66MA	330	ø730	1,271			

Fig. 19.09.01: Large spare parts, dimensions and masses

List of Standard Tools for Maintenance

This section is available on request

Tool Panels

This section is available on request

Project Suppport and Documentation

20

Project Support and Documentation

The selection of the ideal propulsion plant for a specific newbuilding is a comprehensive task. However, as this selection is a key factor for the profitability of the ship, it is of the utmost importance for the end-user that the right choice is made.

MAN Diesel is able to provide a wide variety of support for the shipping and shipbuilding industries all over the world.

The knowledge accumulated over many decades by MAN Diesel covering such fields as the selection of the best propulsion machinery, optimisation of the engine installation, choice and suitability of a Power Take Off for a specific project, vibration aspects, environmental control etc., is available to shipowners, shipbuilders and ship designers alike.

Part of this information can be found in the following documentation:

- Installation drawings
- CEAS - Engine room dimensioning
- Project Guides
- Extent of Delivery (EOD)
- Technical papers

The publications are available at:
www.mandiesel.com → 'Marine' → 'Low Speed'

Engine Selection Guides

The 'Engine Selection Guides' are intended as a tool to provide assistance at the very initial stage of the project work. The guides give a general view of the MAN B&W two-stroke Programme for MC as well as for ME engines and include information on the following subjects:

- Engine data
- Engine layout and load diagrams
  specific fuel oil consumption
- Turbocharger choice
- Electricity production, including power take off
- Installation aspects
- Auxiliary systems
- Vibration aspects.

After selecting the engine type on the basis of this general information, and after making sure that the engine fits into the ship's design, then a more detailed project can be carried out based on the 'Project Guide' for the specific engine type selected.

Project Guides

For each engine type of MC or ME design a 'Project Guide' has been prepared, describing the general technical features of that specific engine type, and also including some optional features and equipment.

The information is general, and some deviations may appear in a final engine documentation, depending on the content specified in the contract and on the individual licensee supplying the engine. The Project Guides comprise an extension of the general information in the Engine Selection Guide, as well as specific information on such subjects as:

- Engine Design
- Engine Layout and Load Diagrams, SFOC
- Turbocharger Choice & Exhaust Gas By-pass
- Electricity Production
- Installation Aspects
- List of Capacities: Pumps, Coolers & Exhaust Gas
- Fuel Oil
- Lubricating Oil
- Cylinder Lubrication
- Piston Rod Stuffing Box Drain Oil
- Central Cooling Water System
- Seawater Cooling
- Starting and Control Air
- Scavenge Air
- Exhaust Gas
- Engine Control System
- Vibration Aspects
- Monitoring Systems and Instrumentation
- Dispatch Pattern, Testing, Spares and Tools
- Project Support and Documentation

Computerised Engine Application System

Further customised information can be obtained from MAN Diesel as project support and, for this purpose, we have developed a 'Computerised Engine Application System', by means of which specific calculations can be made during the project stage, such as:

- Estimation of ship's dimensions
- Propeller calculation and power prediction
- Selection of main engine
- Main engines comparison
- Layout/load diagrams of engine
- Maintenance and spare parts costs of the engine
- Total economy – comparison of engine rooms
- Steam and electrical power – ships' requirement
- Auxiliary machinery capacities for derated engine
- Fuel and lube oil consumption – exhaust gas data
- Heat dissipation of engine
- Utilisation of exhaust gas heat
- Water condensation separation in air coolers
- Noise – engine room, exhaust gas, structure borne
- Preheating of diesel engine
- Utilisation of jacket cooling water heat, fresh water production
- Starting air system
- Exhaust gas back pressure
- Engine room data: pumps, coolers, tanks.

For further information, please refer to www.mandiesel.com under 'Marine' → 'Low speed' → 'CEAS Engine Room Dimensions'.

Extent of Delivery

The 'Extent of Delivery' (EoD) sheets have been compiled in order to facilitate communication between owner, consultants, yard and engine maker during the project stage, regarding the scope of supply and the alternatives (options) available for MAN B&W two-stroke engines.

We provide four different EoDs:

EoD 98 - 50 MC Type Engine
EoD 46 - 26 MC Type Engines
EoD 108 - 50 ME Type Engines
EoD 50 - 35 ME-B Type Engines

These publications are available at:
www.mandiesel.com
under 'Marine' → 'Low speed' →
'Project Guides and Extent of Delivery (EOD)'

Content of Extent of Delivery

The 'Extent of Delivery' includes a list of the basic items and the options of the main engine and auxiliary equipment and, it is divided into the systems and volumes stated below:

General information

4 00 xxx	General information
4 02 xxx	Rating
4 03 xxx	Direction of rotation
4 06 xxx	Rules and regulations
4 07 xxx	Calculation of torsional and axial vibrations
4 09 xxx	Documentation
4 11 xxx	Voltage on board for eletrical consumers
4 12 xxx	Dismantling, packing and shipping of engine
4 14 xxx	Testing of diesel engine
4 17 xxx	Supervisors and advisory work
4 20 xxx	Propeller
4 21 xxx	Propeller hub
4 22 xxx	Stern tube
4 23 xxx	Propeller shaft
4 24 xxx	Intermediate shaft
4 25 xxx	Propeller shaftline
4 26 xxx	Propeller, miscellaneous

Diesel engine

4 30 xxx	Diesel engine
4 31 xxx	Vibrations and balancing
4 35 xxx	Fuel oil piping
4 40 xxx	Lubricating oil and control oil piping
4 42 xxx	Cylinder lubricating oil piping
4 43 xxx	Piston rod stuffing box drain piping
4 45 xxx	Low temperature cooling water piping
4 46 xxx	Jacket cooling water piping
4 50 xxx	Starting and control air piping
4 54 xxx	Scavenge air cooler
4 55 xxx	Scavenge air piping
4 59 xxx	Turbocharger
4 60 xxx	Exhaust gas piping
4 65 xxx	Engine control system
4 70 xxx	Local instrumentation
4 75 xxx	Monitoring, safety, alarm and remote indication
4 78 xxx	Electrical wiring on engine

Miscellaneous

4 80 xxx	Miscellaneous
4 81 xxx	Painting
4 82 xxx	Engine seating
4 83 xxx	Galleries
4 85 xxx	Power Take Off
4 87 xxx	Spare parts
4 88 xxx	Tools

Remote control system

4 95 xxx	Bridge control system

Description of the 'Extent of Delivery'

The 'Extent of Delivery' (EoD) is the basis for specifying the scope of supply for a specific order.

The list consists of 'Basic' and 'Optional' items.

The 'Basic' items define the simplest engine, designed for attended machinery space (AMS), without taking into consideration any specific requirements from the classification society, the yard or the owner.

The 'Options' are extra items that can be alternatives to the 'Basic' or additional items available to fulfil the requirements/functions for a specific project.

We base our first quotations on a 'mostly required' scope of supply, which is the so called 'Copenhagen Standard EoD', which are marked with an asterisk *.

This includes:

- Items for Unattended Machinery Space
- Minimum of alarm sensors recommended by the classification societies and MAN Diesel
- Moment compensator for certain numbers of cylinders
- MAN Diesel turbochargers
- The basic Engine Control System
- CoCoS-EDS online
- Spare parts either required or recommended by the classification societies and MAN Diesel
- Tools required or recommended by the classification societies and MAN Diesel.

The filled-in EoD is often used as an integral part of the final contract.

Installation Documentation

When a final contract is signed, a complete set of documentation, in the following called 'Installation Documentation', will be supplied to the buyer by the engine maker.

The 'Installation Documentation' is normally divided into the 'A' and 'B' volumes mentioned in the 'Extent of Delivery' under items:

4 09 602 Volume 'A':
Mainly comprises general guiding system drawings for the engine room

4 09 603 Volume 'B':
Mainly comprises specific drawings for the main engine itself

Most of the documentation in volume 'A' are similar to those contained in the respective Project Guides, but the Installation Documentation will only cover the order-relevant designs. These will be forwarded within 4 weeks from order.

The engine layout drawings in volume 'B' will, in each case, be customised according to the buyer's requirements and the engine manufacturer's production facilities. The documentation will be forwarded, as soon as it is ready, normally within 3-6 months from order.

As MAN Diesel and most of our licensees are using computerised drawings UniGraphics, Cadam and TIFF format, the documentation forwarded will normally be in size A4 or A3. The maximum size available is A1.

The drawings of volume 'A' are available on CD ROM.

The following list is intended to show an example of such a set of Installation Documentation, but the extent may vary from order to order.

Engine-relevant documentation

Main Section 901 Engine data
External forces and moments
Guide force moments
Water and oil in engine
Centre of gravity
Basic symbols for piping
Instrument symbols for piping
Balancing

Main Section 915 Engine connections
Scaled engine outline
Engine outline
List of flanges/counterflanges
Engine pipe connections
Gallery outline

Main Section 921 Engine instrumentation
List of instruments
Connections for electric components
Guidance values for automation

Main Section 923 Engine Control System
Engine Control System, description
Engine Control System, diagrams
Pneumatic system
Speed correlation to telegraph
List of components
Sequence diagram

Main Section 924 Oil mist detector
Oil mist detector

Main Section 925 Control equipment for auxiliary blower
Electric wiring diagram
Auxiliary blower
Starter for electric motors

Main Section 932 Shaft line
Crankshaft driving end
Fitted bolts

Main Section 934 Turning gear
Turning gear arrangement
Turning gear, control system
Turning gear, with motor

Main Section 936 Spare parts
List of spare parts

Main Section 939 Engine paint
Specification of paint

Main Section 940 Gaskets, sealings, O-rings
Instructions
Packings
Gaskets, sealings, O-rings

Main Section 950 Engine pipe diagrams
Engine pipe diagrams
Bedplate drain pipes
Instrument symbols for piping
Basic symbols for piping
Lube oil, cooling oil and hydraulic oil piping
Cylinder lube oil pipes
Stuffing box drain pipes
Cooling water pipes, air cooler
Jacket water cooling pipes
Fuel oil drain pipes
Fuel oil pipes
Control air pipes
Starting air pipes
Turbocharger cleaning pipe
Scavenge air space, drain pipes
Scavenge air pipes
Air cooler cleaning pipes
Exhaust gas pipes
Steam extinguishing, in scav.box
Oil mist detector pipes
Pressure gauge pipes

Engine room-relevant documentation

Main Section 901 Engine data
List of capacities
Basic symbols for piping
Instrument symbols for piping

Main Section 902 Lube and cooling oil
Lube oil bottom tank
Lubricating oil filter
Crankcase venting
Lubricating and hydraulic oil system
Lube oil outlet

Main Section 904 Cylinder lubrication
Cylinder lube oil system

Main Section 905 Piston rod stuffing box
Stuffing box drain oil cleaning system

Main Section 906 Seawater cooling
Seawater cooling system

Main Section 907 Jacket water cooling
Jacket water cooling system
Deaerating tank
Deaerating tank, alarm device

Main Section 909 Central cooling system
Central cooling water system
Deaerating tank
Deaerating tank, alarm device

Main Section 910 Fuel oil system
Fuel oil heating chart
Fuel oil system
Fuel oil venting box
Fuel oil filter

Main Section 911 Compressed air
Starting air system

Main Section 912 Scavenge air
Scavenge air drain system

Main Section 913 Air cooler cleaning
Air cooler cleaning system

Main Section 914 Exhaust gas
Exhaust pipes, bracing
Exhaust pipe system, dimensions

Main Section 917 Engine room crane
Engine room crane capacity, overhauling space

Main Section 918 Torsiograph arrangement
Torsiograph arrangement

Main Section 919 Shaft earthing device
Earthing device

Main Section 920 Fire extinguishing in scavenge air space
Fire extinguishing in scavenge air space

Main Section 921 Instrumentation
Axial vibration monitor

Main Section 926 Engine seating
Profile of engine seating
Epoxy chocks
Alignment screws

Main Section 927 Holding-down bolts
Holding-down bolt
Round nut
Distance pipe
Spherical washer
Spherical nut
Assembly of holding-down bolt
Protecting cap
Arrangement of holding-down bolts

Main Section 928 Supporting chocks
Supporting chocks
Securing of supporting chocks

Main Section 929 Side chocks
Side chocks
Liner for side chocks, starboard
Liner for side chocks, port side

Main Section 930 End chocks
Stud for end chock bolt
End chock
Round nut
Spherical washer, concave
Spherical washer, convex
Assembly of end chock bolt
Liner for end chock
Protecting cap

Main Section 931 Top bracing of engine
Top bracing outline
Top bracing arrangement
Friction-materials
Top bracing instructions
Top bracing forces
Top bracing tension data

Main Section 932 Shaft line
Static thrust shaft load
Fitted bolt

Main Section 933 Power Take-Off
List of capacities
PTO/RCF arrangement, if fitted

Main Section 936 Spare parts dimensions
Connecting rod studs
Cooling jacket
Crankpin bearing shell
Crosshead bearing
Cylinder cover stud
Cylinder cover
Cylinder liner
Exhaust valve
Exhaust valve bottom piece
Exhaust valve spindle
Exhaust valve studs
Fuel valve
Main bearing shell
Main bearing studs
Piston complete
Starting valve
Telescope pipe
Thrust block segment
Turbocharger rotor

Main Section 940 Gaskets, sealings, O-rings
Gaskets, sealings, O-rings

Main Section 949 Material sheets
MAN B&W Standard Sheets Nos:

- S19R
- S45R
- S25Cr1
- S34Cr1R
- C4

Engine production and installation-relevant documentation

Main Section 935 Main engine production records, engine installation drawings
Installation of engine on board
Dispatch pattern 1, or
Dispatch pattern 2
Check of alignment and bearing clearances
Optical instrument or laser
Reference sag line for piano wire
Alignment of bedplate
Piano wire measurement of bedplate
Check of twist of bedplate
Crankshaft alignment reading
Bearing clearances
Check of reciprocating parts
Production schedule
Inspection after shop trials
Dispatch pattern, outline
Preservation instructions

Main Section 941 Shop trials
Shop trials, delivery test
Shop trial report

Main Section 942 Quay trial and sea trial
Stuffing box drain cleaning
Fuel oil preheating chart
Flushing of lube oil system
Freshwater system treatment
Freshwater system preheating
Quay trial and sea trial
Adjustment of control air system
Adjustment of fuel pump
Heavy fuel operation
Guidance values – automation

Main Section 945 Flushing procedures
Lubricating oil system cleaning instruction

Tools

Main Section 926 Engine seating
Hydraulic jack for holding down bolts
Hydraulic jack for end chock bolts

Main Section 937 Engine tools
List of tools
Outline dimensions, main tools

Main Section 938 Tool panel
Tool panels

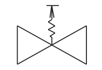
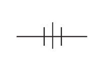
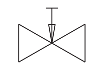
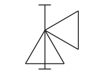
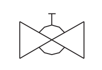
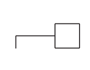
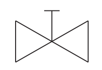
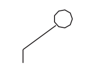
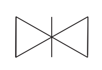
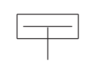
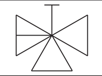
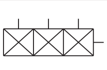
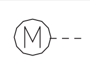
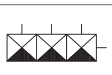
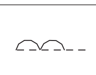
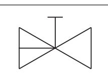
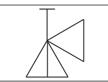
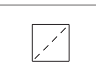
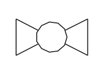
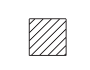
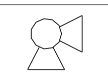
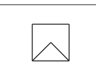
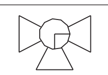
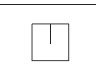
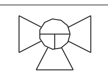
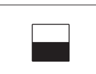
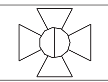
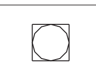
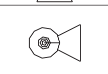
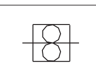
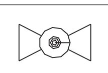
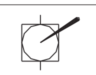
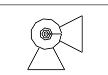
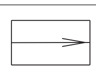
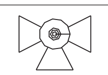
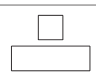
Auxiliary equipment
980 Fuel oil supply unit, if ordered
990 Exhaust silencer, if ordered
995 Other auxiliary equipment

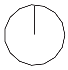
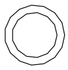
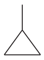
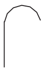
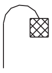
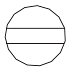
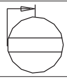
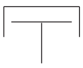
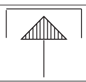
Appendix

A

Symbols for Piping

No.	Symbol	Symbol designation	No.	Symbol	Symbol designation
1	**General conventional symbols**		2.14		Spectacle flange
1.1		Pipe	2.15		Bulkhead fitting water tight, flange
1.2		Pipe with indication of direction of flow	2.16		Bulkhead crossing, non-watertight
1.3		Valves, gate valves, cocks and flaps	2.17		Pipe going upwards
1.4		Appliances	2.18		Pipe going downwards
1.5		Indicating and measuring instruments	2.19		Orifice
2	**Pipes and pipe joints**		**3**	**Valves, gate valves, cocks and flaps**	
2.1		Crossing pipes, not connected	3.1		Valve, straight through
2.2		Crossing pipes, connected	3.2		Valves, angle
2.3		Tee pipe	3.3		Valves, three way
2.4		Flexible pipe	3.4		Non-return valve (flap), straight
2.5		Expansion pipe (corrugated) general	3.5		Non-return valve (flap), angle
2.6		Joint, screwed	3.6		Non-return valve (flap), straight, screw down
2.7		Joint, flanged	3.7		Non-return valve (flap), angle, screw down
2.8		Joint, sleeve	3.8		Flap, straight through
2.9		Joint, quick-releasing	3.9		Flap, angle
2.10		Expansion joint with gland	3.10		Reduction valve
2.11		Expansion pipe	3.11		Safety valve
2.12		Cap nut	3.12		Angle safety valve
2.13		Blank flange	3.13		Self-closing valve

No.	Symbol	Symbol designation	No.	Symbol	Symbol designation
3.14		Quick-opening valve	**4**	**Control and regulation parts**	
3.15		Quick-closing valve	4.1		Hand-operated
3.16		Regulating valve	4.2		Remote control
3.17		Kingston valve	4.3		Spring
3.18		Ballvalve (cock)	4.4		Mass
3.19		Butterfly valve	4.5		Float
3.20		Gate valve	4.6		Piston
3.21		Double-seated changeover valve	4.7		Membrane
3.22		Suction valve chest	4.8		Electric motor
3.23		Suction valve chest with non-return valves	4.9		Electro-magnetic
3.24		Double-seated changeover valve, straight	**5**	**Appliances**	
3.25		Double-seated changeover valve, angle	5.1		Mudbox
3.26		Cock, straight through	5.2		Filter or strainer
3.27		Cock, angle	5.3		Magnetic filter
3.28		Cock, three-way, L-port in plug	5.4		Separator
3.29		Cock, three-way, T-port in plug	5.5		Steam trap
3.30		Cock, four-way, straight through in plug	5.6		Centrifugal pump
3.31		Cock with bottom connection	5.7		Gear or screw pump
3.32		Cock, straight through, with bottom conn.	5.8		Hand pump (bucket)
3.33		Cock, angle, with bottom connection	5.9		Ejector
3.34		Cock, three-way, with bottom connection	5.10		Various accessories (text to be added)

No.	Symbol	Symbol designation	No.	Symbol	Symbol designation
5.11		Piston pump	**7**	**Indicating instruments with ordinary symbol designations**	
6	**Fittings**		7.1		Sight flow indicator
6.1		Funnel	7.2		Observation glass
6.2		Bell-mounted pipe end	7.3		Level indicator
6.3		Air pipe	7.4		Distance level indicator
6.4		Air pipe with net	7.5		Counter (indicate function)
6.5		Air pipe with cover	7.6		Recorder
6.6		Air pipe with cover and net			
6.7		Air pipe with pressure vacuum valve			
6.8		Air pipe with pressure vacuum valve with net			
6.9		Deck fittings for sounding or filling pipe			
6.10		Short sounding pipe with selfclosing cock			
6.11		Stop for sounding rod			

The symbols used are in accordance with ISO/R 538-1967, except symbol No. 2.19

178 30 61-4.1

Fig. A.01.01: Symbols for piping