S60MC Mk 6 Project Guide

Two-stroke Engines

This book describes the general technical features of the S60MC engine including some optional features and/or equipment.

As differences may appear in the individual suppliers' Extent of Delivery, please contact the relevant engine supplier for a confirmation of the actual execution and extent of delivery.

A "List of Updates" will be updated continuously. The "S60MC Project Guide" and "List of Updates" are also available at the Internet address: www.manbw.dk, under the section "Library".

This Project Guide is also available on a CD-ROM together with the List of Updates.

5th Edition
June 2000

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These drawings can be downloaded from our website at www.manbw.dk, choose headings 'Products', 'Marine Power', 'Two-stroke Engines', 'S60MC', and 'Installation Drawings for S60MC'.

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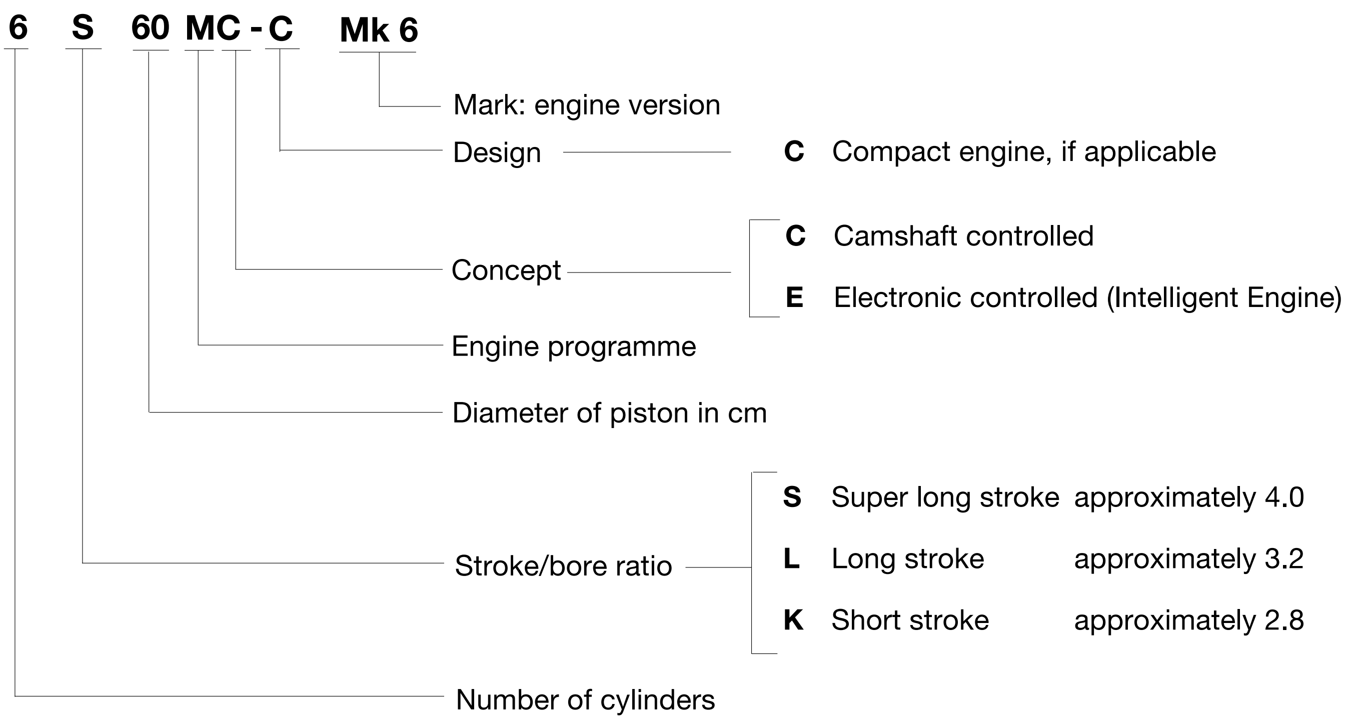
Engine Design 1

The engine types of the MC programme are identified by the following letters and figures:

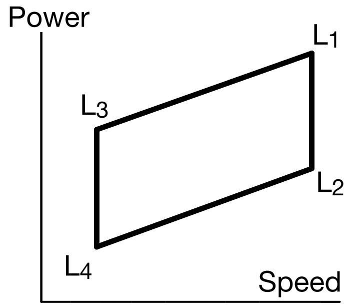


178 34 41-3.2

Fig. 1.01: Engine type designation

Power, Speed and SFOC

S60MC Mk 6
Bore: 600 mm
Stroke: 2292 mm



Power and speed

Layout	Engine speed	Mean effective pressure	Power **kW** BHP				
			Number of cylinders				
	r/min	bar	4	5	6	7	8
L_1	105	18.0	**8160** 11120	**10200** 13900	**12240** 16680	**14280** 19460	**16320** 22240
L_2	105	11.5	**5240** 7120	**6550** 8900	**7860** 10680	**9170** 12460	**10480** 14240
L_3	79	18.0	**6120** 8320	**7650** 10400	**9180** 12480	**10710** 14560	**12240** 16640
L_4	79	11.5	**3920** 5320	**4900** 6650	**5880** 7980	**6860** 9310	**7840** 10640

Fuel and lubricating oil consumption

	Specific fuel oil consumption **g/kWh** g/BHPh				Lubricating oil consumption	
At load Layout point	**With high efficiency turbocharger**		With conventional turbocharger		System oil Approximate kg/cyl. 24 hours	Cylinder oil **g/kWh** g/BHPh
	100%	80%	100%	80%		
L_1	**170** 125	**167** 123	**173** 127	**170** 125	**5 - 6.5**	**0.95 - 1.5** 0.7 - 1.1
L_2	**158** 116	**156** 115	**160** 118	**159** 117		
L_3	**170** 125	**167** 123	**173** 127	**170** 125		
L_4	**158** 116	**156** 115	**160** 118	**159** 117		

175 88 37-2.0

Fig. 1.02: Fuel and lubricating oil consumption

Engine Power Range and Fuel Consumption

Engine Power

The table contains data regarding the engine power, speed and specific fuel oil consumption of the engine.

Engine power is specified in both BHP and kW, in rounded figures, for each cylinder number and layout points L_1, L_2, L_3 and L_4:

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. The mean effective pressure is:

	L_1 - L_3	L_2 - L_4
bar	18.0	11.5
kp/cm^2	18.3	11.7

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, i.e.:

Blower inlet temperature . . . . 45 °C
Blower inlet pressure. . . . . 1000 mbar
Seawater temperature . . . . 32 °C

Specific fuel oil consumption (SFOC)

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

ISO 3046/1-1986:
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 the following pages.

High efficiency/conventional turbochargers

The engine is in its basis design made with a high efficiency turbocharger in order to obtain the lowest possible Specific Fuel Oil Consumption (SFOC).

The amount of air required for the combustion can however be adjusted to provide a higher exhaust gas temperature, if this is needed for exhaust gas boiler by applying “conventional” turbocharger, - see section 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 periodes and under special conditions, feed rates of up to 1.5 times the stated values should be used.

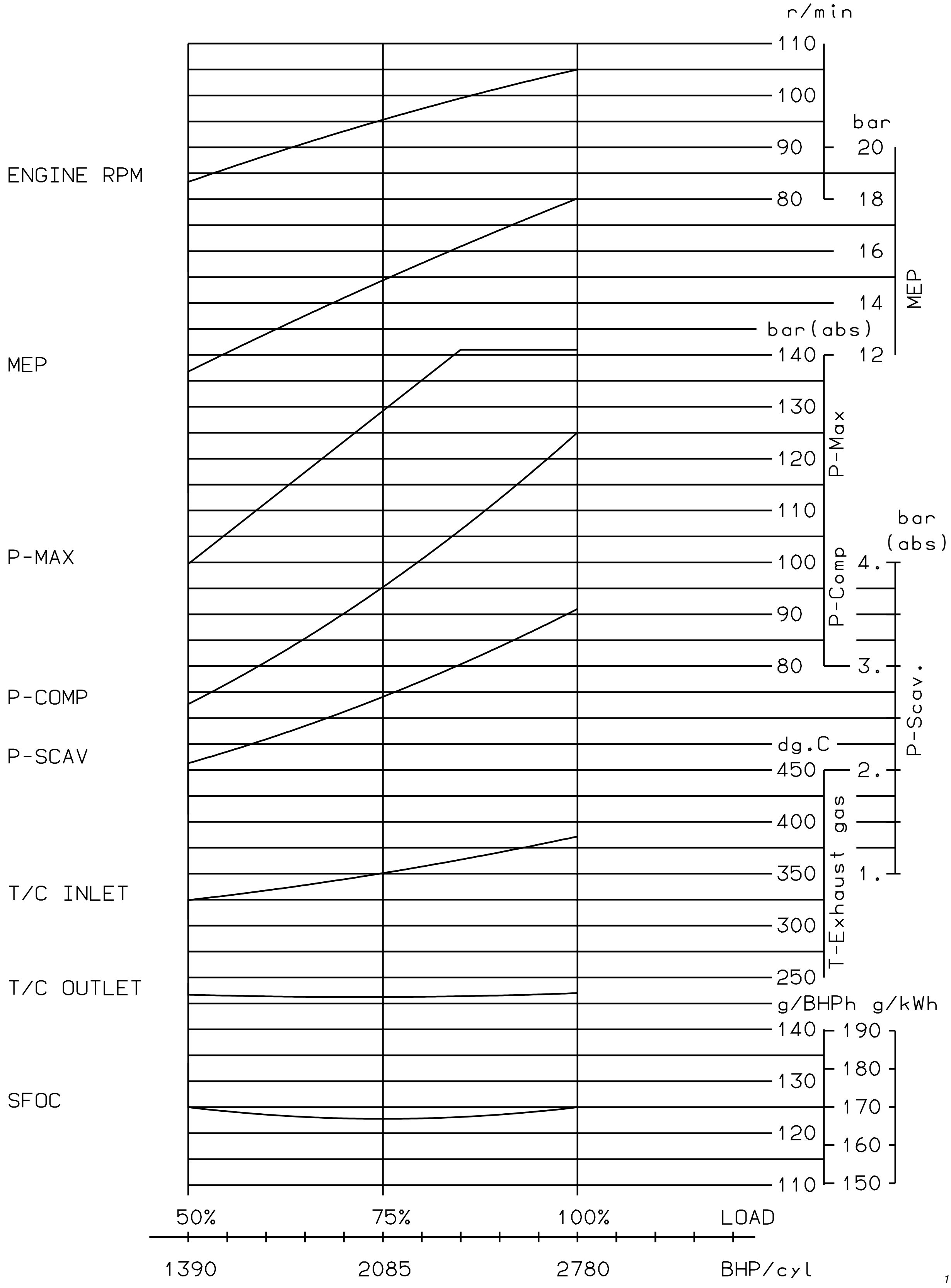


Fig. 1.03: Performance curves.

Description of Engine

The engines built by our licensees are in accordance with MAN B&W drawings and standards. In a few cases, some local standards may be applied; however, all spare parts are interchangeable with MAN B&W designed parts. Some other components can differ from MAN B&W's design because of 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 any options mentioned.

Bedplate and Main Bearing

The bedplate is divded into sections of suitable size, in accordance with the production facilities available. It consists of high, welded, longitudinal girders and welded cross girders with cast steel bearing supports.

For fitting to the engine seating, long, elastic holding-down bolts, and hydraulic tightening tools, can be supplied as an option: 4 82 602 and 4 82 630, respectively.

The bedplate is made without taper if mounted on epoxy chocks (4 82 102), or with taper 1:100, if mounted on cast iron chocks, option 4 82 101.

The oil pan, which is integrated in the bedplate, collects the return oil from the forced lubricating and cooling oil system. The oil outlets from the oil pan are normally vertical (4 40 101) and are provided with gratings.

Horizontal outlets at both ends can be arranged as an option: 4 40 102, to be confirmed by the engine maker.

The main bearings consist of thick walled steel shells lined with white metal. The bottom shell can, by means of special tools, and hydraulic tools for lifting the crankshaft, be rotated out and in. The shells are kept in position by a bearing cap and are fixed by long, elastic studs, with nuts tightened by hydraulic tools. The chain drive is integreated with the thrust bearing in the aft end of the engine.

Thrust Bearing

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 cast iron with white metal. The thrust shaft is thus an integrated part of the crankshaft.

The propeller thrust is transferred through the thrust collar, the segments, and the bedplate, to the engine seating and end chocks.

The thrust bearing is lubricated by the engine's main lubricating oil system.

Turning Gear and Turning Wheel

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.

The turning gear is driven by an electric motor with built-in gear and chain drive with brake. The electric motor is provided with insulation class B and enclosure IP44. The turning gear is equipped with a blocking device that 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.

A control device for turning gear, consisting of starter and manual remote control box, with 15 metres of cable, can be ordered as an option: 4 80 601.

Frame Box

The frame box is of welded design and is divided into sections of suitable size, determined by the production facilities available. On the exhaust side, it is provided with relief valves for each cylinder while, on the camhaft side, it is provided with a large hinged door for each cylinder.

The crosshead guides are welded or bolted to the frame box, depending on the production facilties available.

For each cylinder, a slotted pipe for collecting part of the cooling oil outlet from the piston for visual control and flow alarm is bolted into the frame box.

The frame box is connected to the bedplate with bolts. The stay bolts are normally made in one part and are tightened hydraulically with the use of jacks. Staybolts in two parts are also available as an option: 4 30 132, if the dismantling height is restricted.

Cylinder Frame, Cylinder Liner and Stuffing Box

The cylinder frame units are of cast iron. Together with the cylinder liners they form the scavenge air space and the cooling water space. At the chain drive, the upper part of the chain wheel frame is fitted. On the camshaft side of the engine, the cylinder frame units are provided with covers for cleaning the scavenge air space and for inspection of the scavenge ports.

On the camshaft side of the engine, the cylinder frame units are provided with access covers for cleaning the scavenge air space and for inspection through the scavenge ports.

The roller guide housings, the mechanical lubricators, and the gallery brackets are bolted onto the cylinder frame units. Furthermore, the outer part of the telescopic pipe is fitted for the supply of piston cooling oil and lubricating oil.

A piston rod stuffing box for each cylinder unit is fitted at the bottom of the cylinder frame. The stuffing box is provided with Heco sealing rings for scavenge air, and with oil scraper rings to prevent oil from entering the scavenge air space.

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 of the slim type and just below a short cooling jacket is fitted. The cylinder liner has scavenge ports and drilled holes for cylinder lubrication.

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 fuel valves, safety valve, starting valve and indicator valve.

Exhaust Valve and Valve Gear

The exhaust valve consists of a housing with gas channel and spindle guide. The housing is water cooled and made of cast iron. Between the cylinder cover and the housing there is a bottom piece.

The bottom piece is made with hardened face for the spindle seat, and is water cooled on its outer surface.

The valve spindle is of the Nimonic type and is provided with a small vane wheel on which the exhaust gas acts during operation, thus making the spindle rotate slightly.

The hydraulic system consists of an actuator, activated by a cam on the camshaft, a high-pressure pipe, and an oil cylinder for the exhaust valve spindle mounted on top of the housing. The hydraulic system opens the exhaust valve, while the closing force is provided by an air spring. The closing of the exhaust valve is damped by means of an oil cushion on top of the spindle.

Air sealing of the exhaust valve spindle guide is provided.

Fuel Valves, Starting Valve, Safety Valve and Indicator Valve

Each cylinder cover is equipped with two fuel valves, one starting valve, one safety valve, and one indicator valve. The opening of the fuel valves is controlled by the fuel oil high pressure created by the fuel pumps, and the valve is closed by a spring.

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

The starting valve is opened by control air from the starting air distributor and is closed by a spring.

The safety valve is spring-loaded.

Indicator Drive

In its basic execution, the engine is not fitted with an indicator drive, which is an option: 4 30 141.

The indicator drive consists of a cam fitted on the camshaft and a spring-loaded spindle with roller which moves up and down, corresponding to 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 mounted on the indicator valve.

Crankshaft

The crankshaft is of the semi-built type made from forged steel throws or, for some cylinder numbers, from cast steel throws with cold rolled fillets.

The crankshaft is built integral with the thrust shaft and is, on the aft end, provided with a flange for the turning wheel and for coupling to the intermediate shaft. At the fore end, the crankshaft is provided with a flange for a moment compensator chain wheel and for a tuning wheel, in the even that these are to be installed.

Coupling bolts and nuts for joining the crankshaft together with the intermediate shaft are not normally supplied. These can be ordered as an option: 4 30 602.

Axial Vibration Damper

The engine is fitted with an axial vibration damper (4 31 111), which is 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 journal, and the housing is fixed to the main bearing support. A mechanical device for check of the functioning of the vibration damper is fitted.

On 5-cylinder engines an electronic axial vibration monitor is provided (4 31 117).

Connecting Rod

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

The crosshead and crankpin bearing caps are secured to the connecting rod by studs and nuts which are tightened by 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. Lub. oil is supplied through ducts in the crosshead and connecting rod.

Piston, Piston Rod and Crosshead

The piston consists of a piston crown and piston skirt. The piston crown is made of heat-resistant steel and has four ring grooves which are hard-chrome plated on both the upper and lower surfaces of the grooves. The piston crown is with “high topland”, i.e. the distance between the piston top and the upper piston ring has been increased.

The upper piston ring is a CPR type (Controlled Pressure Relief) whereas the other three piston rings are with an oblique cut. The uppermost piston ring is higher than the lower ones. The piston skirt is of cast iron and provided with bronze bands.

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 studs. The piston rod has a central bore which, in conjunction with a cooling oil pipe, forms the inlet and outlet for cooling oil.

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

A bracket for oil inlet from the telescopic pipe and another for oil outlet to a slotted pipe are mounted on the crosshead.

Fuel 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 plunger of nitrated steel. In order to prevent fuel oil from being mixed with the lubricating oil, the pump actuator is provided with a sealing arrangement.

The pump is activated by the fuel cam, and the volume injected is controlled by turning the plunger by means of a toothed rack connected to the regulating mechanism.

The fuel pumps incorporate Variable injection Timing (VIT) for optimised fuel economy at part load. The VIT principle uses the fuel regulating shaft position as the controlling parameter.

Adjustment of the pump lead is effected by a threaded connection, operated by a toothed rack.

The roller guide housing is provided with a manual lifting device (4 35 130) which, during turning of the engine, can lift the roller guide free of the cam.

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

The fuel oil high-pressure pipes are equipped with protective hoses and are neither heated nor insulated.

Camshaft and Cams

The camshaft consists of a number of sections. Each section consists of a shaft piece with exhaust cams, fuel cams, indicator cams and coupling parts.

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

The cam for indicator drive can be adjusted mechanically. The coupling parts are shrunk on to the shaft and can be adjusted and dismantled hydraulically.

The camshaft bearings consist of one lower half shell mounted in a bearing support which is attached to the roller guide housing by means of hydraulically tightened studs.

Chain Drive

The camshaft is driven from the crankshaft by a chain drive. The engines are equipped with a mechanical chain tightener (4 30 145), but they can be fitted with a hydraulic chain tightener, option: 4 30 146. The long free lengths of chain are supported by guidebars. The cylinder lubricators are driven by a separate chain from the crankshaft.

Reversing

Reversing of the engine takes place 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 reversible.

2nd order Moment Compensators

These are relevant only for 4, 5 or 6-cylinder engines, and can be mounted either on the aft end or on both fore end and aft end. In special cases only a compensator on the fore end is necessary.

The aft-end compensator consists of balance weights built into the camshaft chain drive, option: 4 31 203.

The fore-end compensator consists of balance weights driven from the fore end of the crankshaft, option: 4 31 213.

Tuning Wheel/Torsional Vibration Damper

A tuning wheel, option: 4 31 101 or torsional vibration damper, option: 4 31 105 is to be ordered separately based upon the final torsional vibration calculations. All shaft and propeller data are to be forwarded by the yard to the engine builder, see section 7.

For plants with a CP propeller or with PTO, the engine will normally need a torsional vibration damper.

Governor

The engine is to be provided with an electronic/mechanical governor of a make approved by MAN B&W Diesel A/S, see section 6.11.

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.

Cylinder Lubricators

The standard mechanical cylinder lubricators, one per cylinder, are both speed dependent (4 42 111) and load change dependent (4 42 120). They are controlled by the engine revolutions, and are mounted on the roller guide housings, and interconnected with shaft pieces. The mechanical lubricators have a “built-in” capability to adjust the oil quantity. They are of the “Sight Feed Lubricator” type and are provided with a sight glass for each lubricating point. The oil is led to the lubricator through a pipe system from an elevated tank (Yard’s supply).

Once adjusted, the mechanical lubricators will basically have a cylinder oil feed rate proportional to the engine revolutions. No-flow and level alarm devices are included. The Load Change Dependent system will automatically increase the oil feed rate in case of a sudden change in engine load, for instance during manoeuvring or rough sea conditions.

The mechanical lubricators are equipped with electric heating of cylinder lubricator.

As an alternative to the speed dependent lubricator, a speed and mean effective pressure (MEP) dependent mechanical lubricator can be fitted, option: 4 42 113 which is frequently used on plants with controllable pitch propeller.

The electronic Alpha cylinder lubrication system is an alternative (option: 4 42 105) to the mechanical.

Manoeuvring System (prepared for Bridge Control)

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

The regulating system makes it possible to start, stop, and reverse the engine and to control the engine speed. The speed control handle on the manoeuvring console gives a speed-setting signal to the governor, dependent on the desired number of revolutions. At a shut down function, the fuel injection is stopped by activating the puncture valves in the fuel pumps, independent of the speed control handle’s position.

Reversing is effected by moving the telegraph handle from 'Ahead' to 'Astern' and by moving the speed control handle from the 'Stop' to the 'Start' position. Control air then moves the starting air distributor and, through an air cylinder, the displaceable roller in the driving mechanism for the fuel pump, to the “Astern” position.

The engine is provided with a side mounted emergency control console and instrument panel.

Gallery Arrangement

The engine is provided with gallery brackets, stanchions, railings and platforms (exclusive of ladders). The brackets are placed at such a height that the best possible overhauling and inspection conditions are achieved. Some main pipes of the engine are suspended from the gallery brackets.

The upper gallery brackets on each end of the engine are provided with lifting holes for dismantling the auxiliary blowers, and the upper gallery platform on the camshaft side is provided with overhauling holes for the piston. The number of holes depends on the number of cylinders.

The engine is prepared for top bracings on the exhaust side (4 83 110), or on the camshaft side, option 4 83 111.

Scavenge Air System

The air intake to the turbocharger takes place direct from the engine room through the intake silencer of the turbocharger. 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. The charging air pipe between the turbocharger and the air cooler is provided with a compensator and is heat insulated on the outside. See section 6.09.

Exhaust Turbocharger

The engine can be fitted with MAN B&W (4 59 101) ABB (4 59 102) or Mitsubishi (4 59 103) turbochargers arranged on the exhaust side of the engine (4 59 122).

S60MC engines with one turbocharger can be fitted with the turbocharger on the aft end of the engines, option: 4 59 124.

The turbocharger is provided with:

a) Equipment for water washing of the compressor side

b) Equipment for dry cleaning of the turbine side and water washing

Water washing on the turbine side is, however, not available for the Mitsubishi turbochargers.

The gas outlet can be 15°/30°/45°/60°/75°/90° from vertical, away from the engine. See any of options 4 59 301-309. The turbocharger is equipped with an electronic tacho system with pick-ups, converter and indicator for mounting in the engine control room.

Scavenge Air Cooler

The engine is fitted with air cooler(s) of the monoblock type (one per tuurbocharger) for a conventional seawater cooling system designed for a pressure of up to 2.0-2.5 bar working pressure (4 54 130), or for central cooling with freshwater of maximum 4.5 bar working pressure, option: 4 54 132. The air cooler is so designed that the difference between the scavenge air temperature and the water inlet temperature (at the optimising point) can be kept at a maximum of 12°C.

a) The end covers are of coated cast iron 4 54 150, or alternatively of bronze, option: 4 54 151.

b) The cooler is provided with equipment for a cleaning of:

   Air side:
   Standard showering sytem
   (Cleaning pump unit including tank and filter to be of yard's supply)

   Water side:
   Cleaning brush

Cleaning is to take place only when the engine is stopped.

A water mist catcher of the through-flow type is located in the air chamber after the air cooler.

Exhaust Gas System

From the exhaust valves, the gas is led to the exhaust gas receiver where the fluctuating pressure from the individual cylinders is equalised, and the total volume of gas led further on to the turbocharger at a constant pressure. After the turbocharger, the gas is led to the external exhaust pipe system, which is yard's supply.

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

For quick assembling and disassembling of the joints between the exhaust gas receiver and the exhaust valves, clamping bands are used. The exhaust gas receiver and exhasut pipes are provided with insulation, covered by galvanized steel plating.

There is a protective grating between the exhaust gas receiver and the turbocharger. See also section 6.10.

Auxiliary Blower

The engine is provided with two electrically-driven blowers (4 55 150). 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.

Both auxiliary blowers will start operating before the engine is started and will ensure sufficient scavenge air pressure to obtain a safe start.

During operation of the engine, both auxiliary blowers will start automatically each time the engine load is reduced to about 30-40%, and they will continue operating until the load again exceeds approximately 40-50%.

In cases where one of the auxiliary blowers is out of service, the other auxiliary blower will automatically compensate without any manual readjustment of the valves, thus avoiding any engine load reduction. This is achieved by the automatically working non-return valves in the pressure side of the blowers.

The electric motors are of the totally enclosed, fan cooled, single speed type, with insulation min. class B and enclosure minimum IP44.

The electrical control panel and starters for two auxiliary blowers can be delivered as an option: 4 55 650.

Piping Arrangements

The engine is delivered with piping arrangements for:

Fuel oil
Heating of fuel oil pipes
Lubricating and piston cooling oil pipes
Cylinder lubricating oil
Lubricating of turbocharger
Sea cooling water
Jacket cooling water
Cleaning of scavenge air cooler
Cleaning of turbocharger
Fire extinguishing for scavenge air space
Starting air
Control air
Safety air
Air spring pipe - exhaust valve
Exhaust valve - air spring
Oil mist detector

All arrangements are made of steel piping, except for the control air, safety air and steam heating of fuel pipes which are made of copper. The pipes for sea cooling water to the air cooler are of:

Galvanised steel . . . . 4 45 130, or
Thick-walled, galvanised steel, option 4 45 131, or
Aluminium brass, ... option 4 45 132, or
Copper nickel, ... option 4 45 133

In the case of central cooling, the pipes for freshwater to the air cooler are of steel.

The pipes are provided with sockets for local instruments, alarm and safety equipment and, furthermore, with a number of sockets for supplementary signal equipment and supplementary remote instruments.

The inlet and return fuel oil pipes (except branch pipes) are heated with:

Steam tracing . . . . 4 35 110, or
Electrical tracing . . . . option: 4 35 111, or
Thermal oil tracing . . . . option: 4 35 112

The fuel oil drain pipe is heated by fresh cooling water.

The above heating pipes are normally delivered without insulation, (4 35 120). If the engine is to be transported as one unit, insulation can be mounted as an option: 4 35 121.

The engine's external pipe connections are in accordance with DIN and ISO standards:

- Sealed, without counterflanges in one end, and with blank counterflanges and bolts in the other end of the piping (4 30 201), or
- With blank counterflanges and bolts in both ends of the piping, option: 4 30 202, or
- With drilled counterflanges and bolts, option: 4 30 203

A fire extinguishing system for the scavenge air box will be provided, based on:

Steam . . . . 4 55 140, or
Water mist . . . . option: 4 55 142, or
CO_2 (excluding bottles). . . . . option: 4 55 143

Starting Air Pipes

The starting air system comprises a main starting valve, a non-return valve, a bursting disc for the branch pipe to each cylinder, a starting air distributor, and a starting valve on each cylinder. The main starting valve is connected with the manoeuvring system, which controls the start of the engine. See also section 6.08.

A slow turning valve with actuator can be ordered as an option: 4 50 140.

The starting air distributor regulates the supply of control air to the starting valves so that they supply the engine cylinders with starting air in the correct firing order.

The starting air distributor has one set of starting cams for 'Ahead' and one set for 'Astern', as well as one control valve for each cylinder.

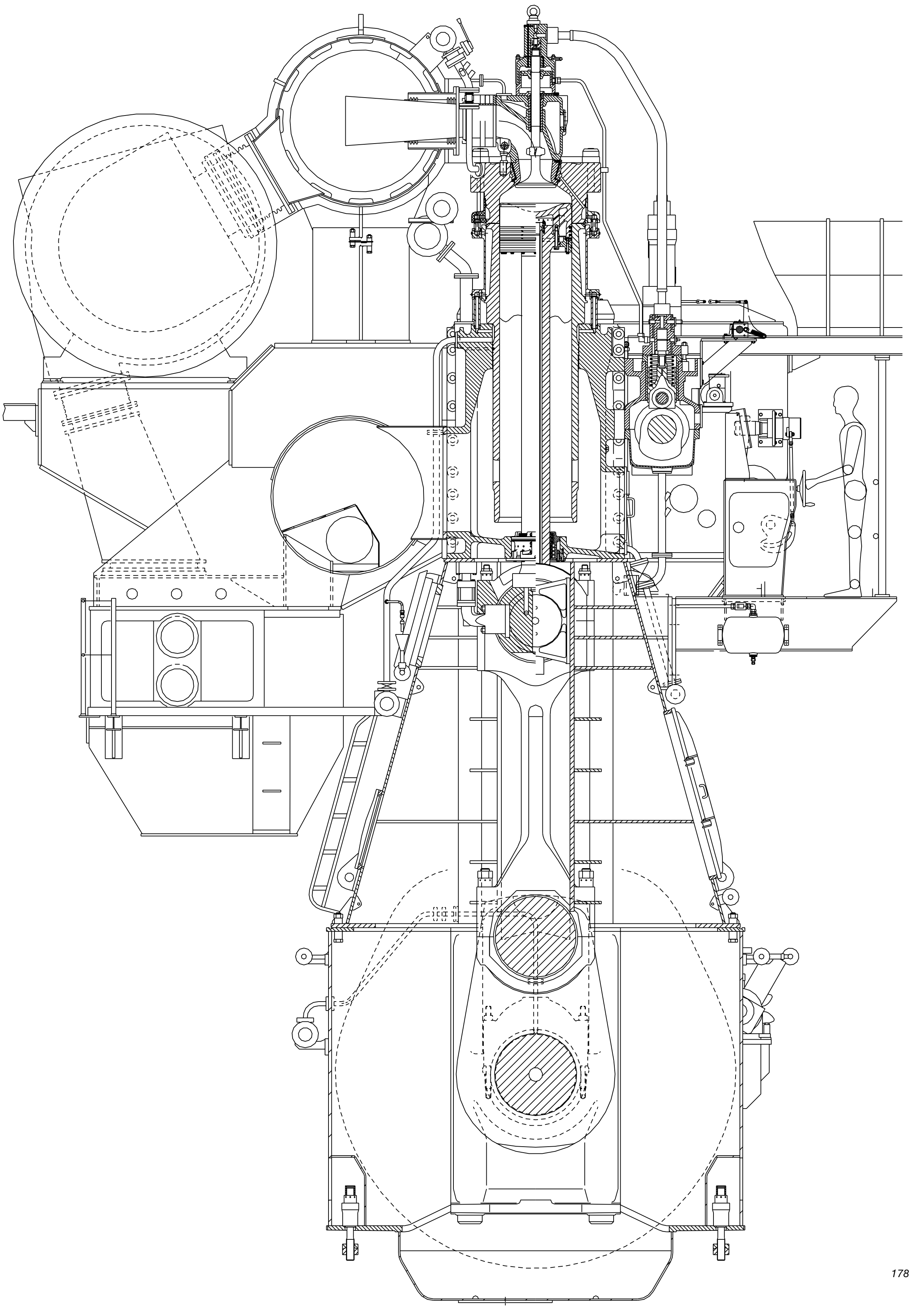


Fig. 1.04: Engine cross section

Engine Layout and Load Diagrams, SFOC 2

2 Engine Layout and Load Diagrams

Introduction

The effective brake power "P_b" 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:

$P_b = c \times p_e \times n$

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

$P_b = c \times n^1$ (for constant mep)

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

$P_b = c \times n^3$ (propeller law)

Thus, for the above examples, the brake power P_b may be expressed as a power function of the speed "n" to the power of "i", i.e.:

$P_b = c \times n^i$

Fig. 2.01a shows the relationship for the linear functions, y = ax + b, using linear scales.

The power functions $P_b = c \times n^i$, see Fig. 2.01b, will be linear functions when using logarithmic scales.

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

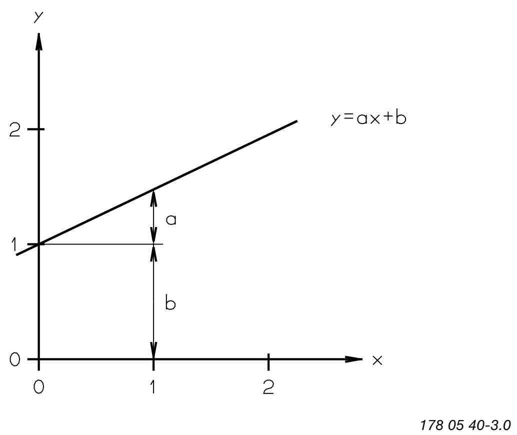


Fig. 2.01a: Straight lines in linear scales

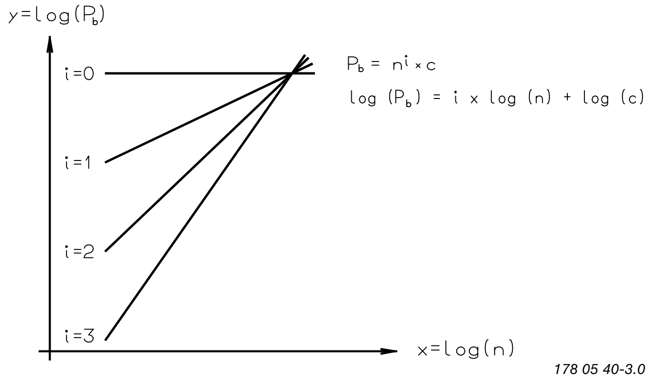


Fig. 2.01b: Power function curves in logarithmic scales

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, making 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:

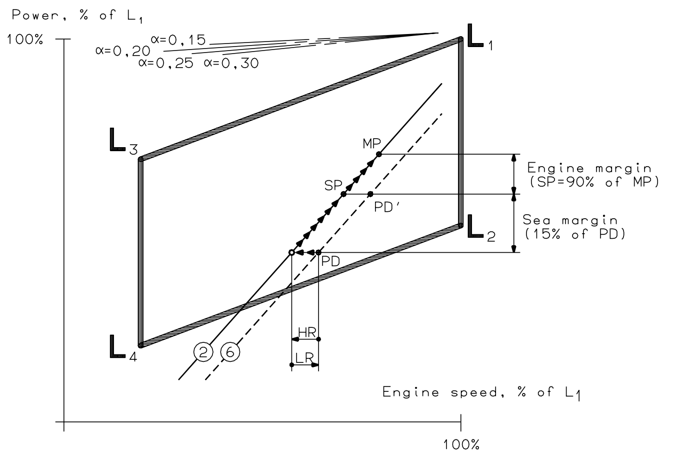
$P_b = c \times n^3$, in which:

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

Propeller design point

Normally, estimations 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 Fig. 2.02. 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.

Fouled hull



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

178 05 41-5.3

Fig. 2.02: Ship propulsion running points and engine layout

When the ship has sailed for some time, the hull and propeller become fouled and the hull's resistance will increase. Consequently, the ship 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 fouling after sea trial, therefore, will involve a relatively higher resistance and thereby a heavier running propeller.

Sea margin and heavy propeller

If, at the same time the weather is bad, with head winds, the ship's resistance may increase compared to operating at calm weather conditions.

When determining the necessary engine power, it is therefore 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 speed considering the influence of a heavy running propeller for operating at large extra ship resistance, it is recommended - compared to the clean hull and calm weather propeller curve 6 - to choose a heavier propeller curve 2 for engine layout, and the propeller curve for clean hull and calm weather in curve 6 will be said to represent a "light running" (LR) propeller.

Compared to the heavy engine layout curve 2 we recommend to use 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% 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% 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.

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 and, – 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.

Constant ship speed lines

The constant ship speed lines α, are shown at the very top of Fig. 2.02, indicating the power required at various propeller speeds in order to keep the same ship speed, provided that the optimum propeller diameter with an optimum pitch/diameter vatio is used at any given speed taking into consideration the total propulsion efficiency.

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, see Fig. 2.02. The L_1 point refers to the engine's nominal maximum continuous rating.

Within the layout area there is full freedom to select the engine's specified MCR point M which suits the demand of propeller power and speed for the ship.

On the horizontal axis the engine speed and on the vertical axis the engine power are shown in 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 at which the engine is normally assumed to operate, 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 placed on line 1 of the load diagram, 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 93.5% 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 provided that the MCR power is not higher than the L_1 power.

Load Diagram

Definitions

The load diagram, Fig. 2.03, 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 ship's specification.

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, provided the torsional vibration conditions permit.

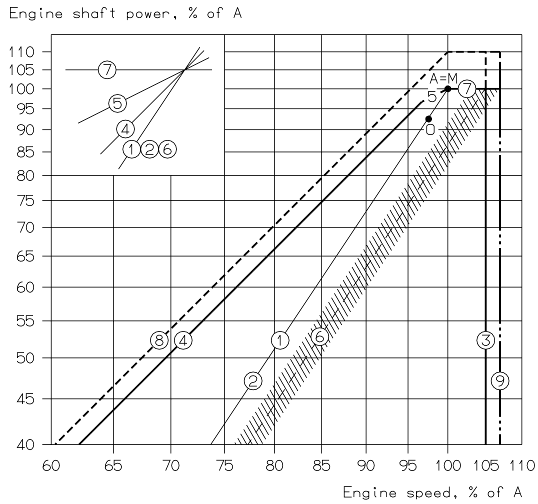
The overspeed set-point is 109% of the speed in A, however, it may be moved to 109% *of the nominal speed* in L_1, provided that torsional vibration conditions permit.

Running above 100% of the nominal L_1 speed at a load lower than about 65% specified MCR is, however, to 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. 2.03: 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 ship's speed.

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) has 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 of the engine, change of the fuel valve nozzles, adjusting of the cylinder liner cooling, as well as rematching of 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.

Examples of the use of the Load Diagram

In the following are some examples 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 shaft generator coupled to a fixed pitch propeller.

In example 2 are diagrams for the same configuration, here with the optimising point to the left of the heavy running propeller curve (2) obtaining an extra engine margin for heavy running.

As for example 1, example 3 shows the same layout for an engine with fixed pitch propeller (example 1), but with a shaft generator.

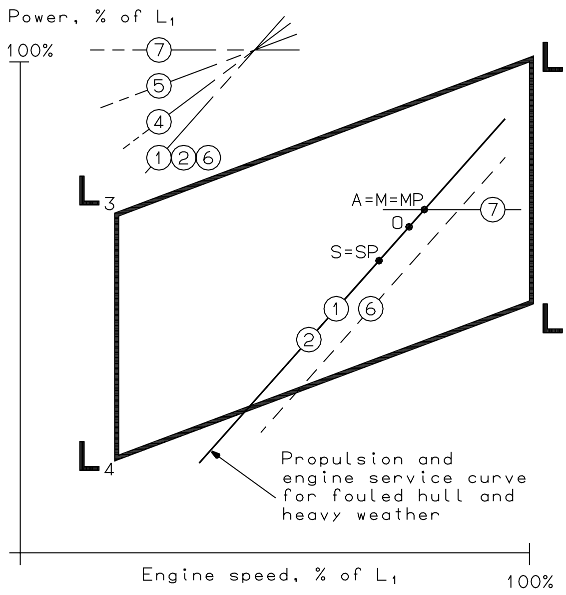
Example 4 shows a special case with a shaft generator. In this case the shaft generator is cut off, and the GenSets used when the engine runs at specified MCR. This makes it possible to choose a smaller engine with a lower power output.

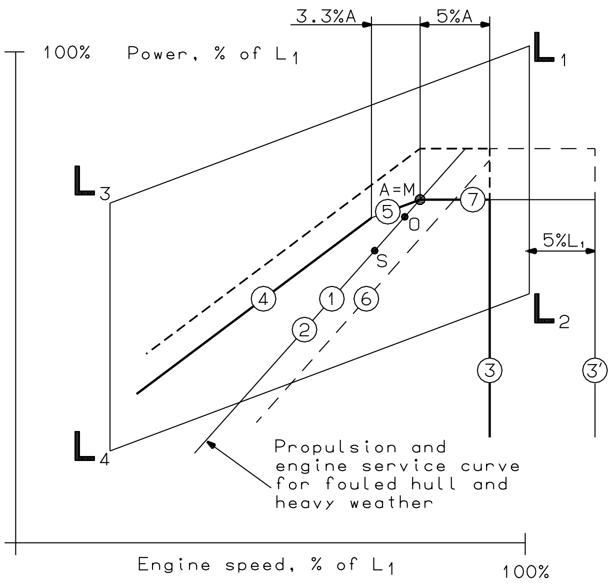
Example 5 shows diagrams for an engine coupled to a controllable pitch propeller, with or without a shaft generator, (constant speed or combinator curve operation).

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 project, the layout diagram shown in Fig. 2.10 may be used for construction of the actual load diagram.

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





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

Fig. 2.04a: Example 1, Layout diagram for normal running conditions, engine with FPP, without shaft generator

Point A of 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

178 05 44-0.6

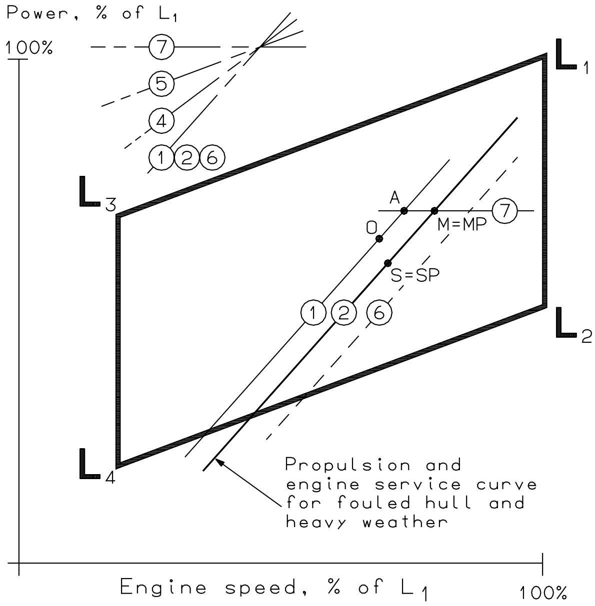
Fig. 2.04b: Example 1, Load diagram for normal running conditions, engine with FPP, without shaft generator

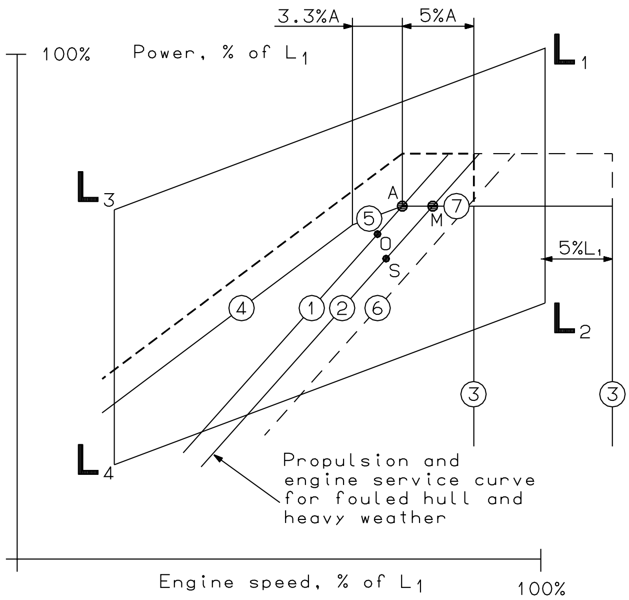
For engines with VIT, the optimising point O and its propeller curve 1 will normally be selected on the engine service curve 2, see the lower diagram of Fig. 2.04a.

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 Fig. 2.04b 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.

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





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 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

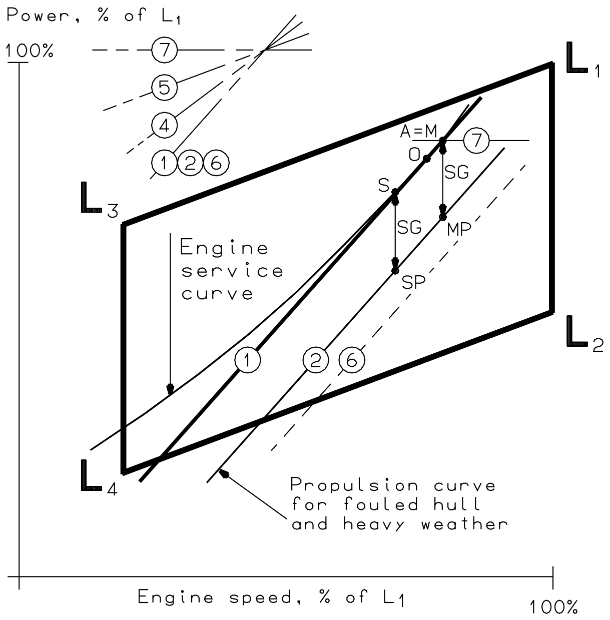
178 05 46-4.6

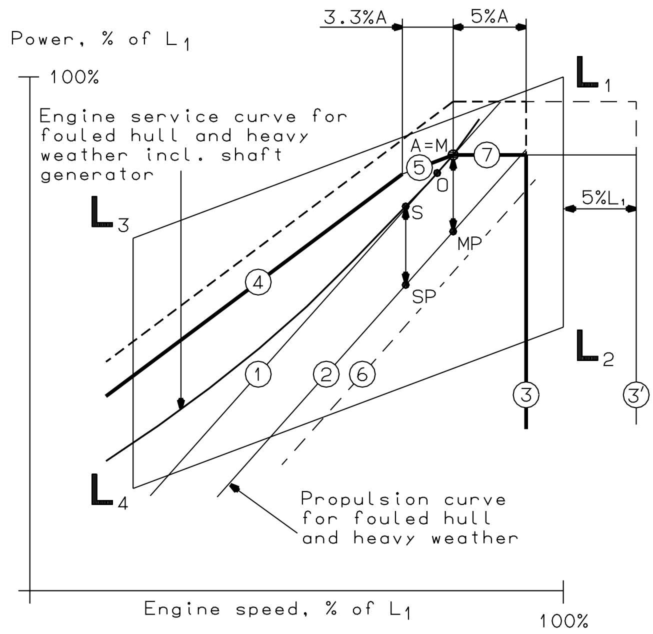
Fig. 2.05a: Example 2, Layout diagram for special running conditions, engine with FPP, without shaft generator

Fig. 2.05b: Example 1, Load diagram for special running conditions, engine with FPP, without shaft generator

A similar example 2 is shown in Fig. 2.05. In this case, the optimising point O has been selected more to the left than in example 1, obtaining an extra engine margin for heavy running operation in heavy weather conditions. In principle, the light running margin has been increased for this case.

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





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

Point A of 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

178 05 48-8.6

Fig. 2.06a: Example 3, Layout diagram for normal running conditions, engine with FPP, without shaft generator

Fig. 2.06b: Example 3, Load diagram for normal running conditions, engine with FPP, with shaft generator

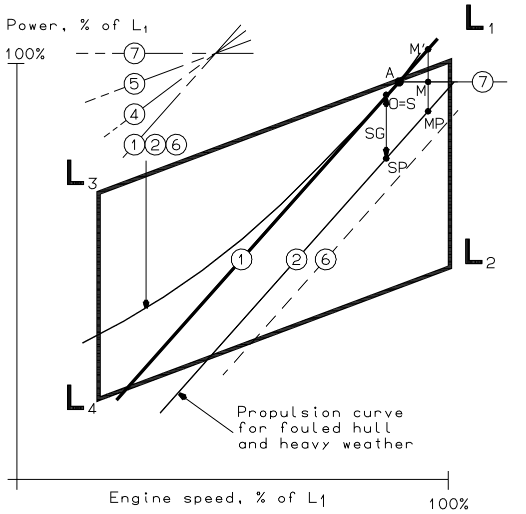
In example 3 a shaft generator (SG) is installed, and therefore the service power of the engine also has to incorporate the extra shaft power required for the shaft generator's electrical power production.

In Fig. 2.06a, 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.

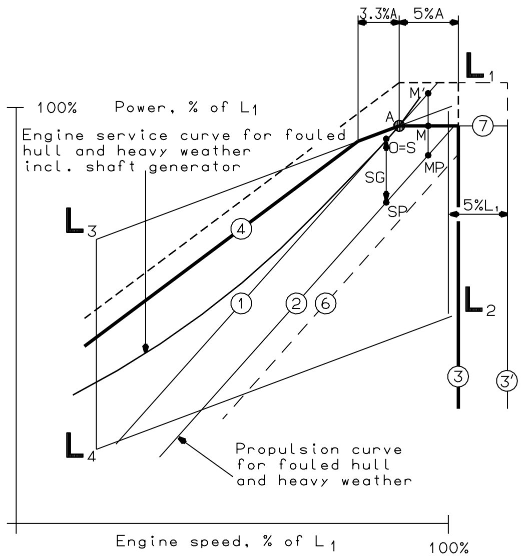
Point A is then found in the same way as in example 1, and the load diagram can be drawn as shown in Fig. 2.06b.

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



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

Fig. 2.07a: Example 4. Layout diagram for special running conditions, engine with FPP, with shaft generator



Point A of 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. (A = O if the engine is without VIT) and with MP's speed.

178 06 35-1.6

Fig. 2.07b: Example 4. Load diagram for special running conditions, engine with FPP, with shaft generator

Example 4:

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, see Fig. 2.07a.

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

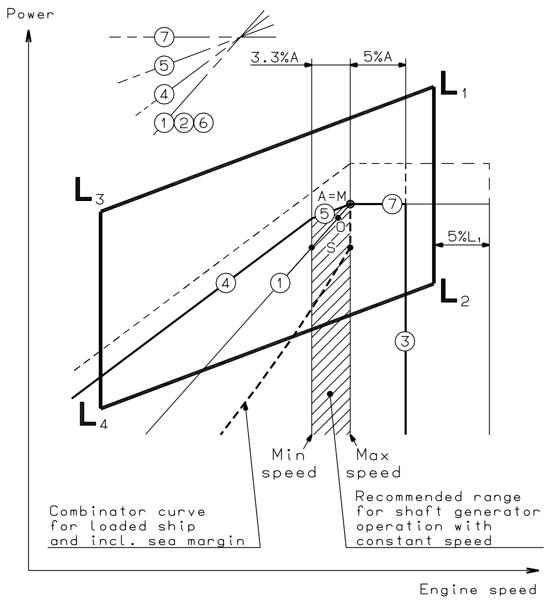
One solution could be to choose a larger diesel engine with an extra cylinder, but another and cheaper solution is to reduce the electrical power production of the shaft generator when running in the upper propulsion power range.

In choosing the latter solution, the required specified MCR power can be reduced from point M' to point M as shown in Fig. 2.07a. 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.

Point A, having the highest possible power, is then found at the intersection of line L_1-L_3 with line 1, see Fig. 2.07a, and the corresponding load diagram is drawn in Fig. 2.07b. Point M is found on line 7 at MP's speed.

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



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

178 06 36-3.4

Fig. 2.08: Example 5: Engine with Controllable Pitch Propeller (CPP), with or without shaft generator

Layout diagram - without shaft generator

If a controllable pitch propeller (CPP) is applied, the combinator curve (of the propeller) will normally be selected for loaded ship including sea margin.

The combinator curve may for a given propeller speed 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 as shown in Fig. 2.08 to obtain an increased operation margin of the diesel engine in heavy weather to the limit indicated by curves 4 and 5.

Layout diagram - with shaft generator

The hatched area in Fig. 2.08 shows the recommended speed range between 100% and 96.7% of the specified MCR speed for an engine with 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 for engines with VIT may 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 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 may 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 constant speed with a CP propeller.

Example 6: Engines with VIT fuel pumps running at constant speed with controllable pitch propeller (CPP)

Fig. 2.09a 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. 2.09a 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. 2.09b: Constant speed curve through M, **wrong position** *of optimising point O*

If the engine has been service-optimised in 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. 2.09c: 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 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 applied lower constant engine speed.

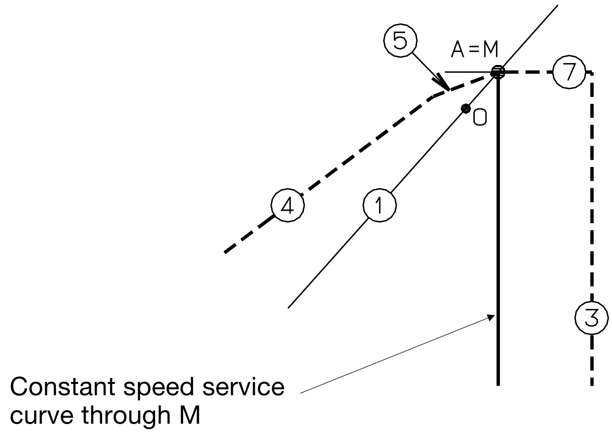


Fig. 2.09a: Normal procedure

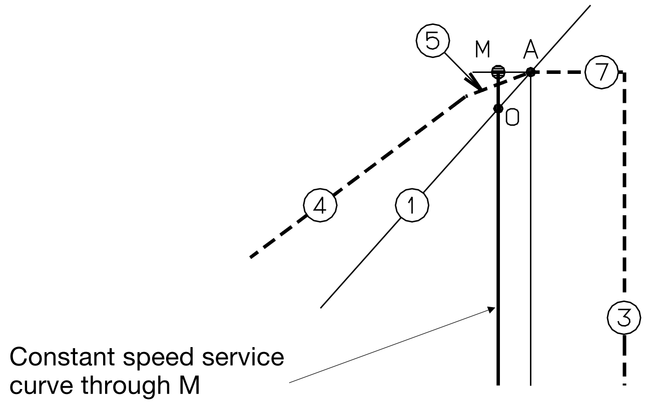


Fig. 2.09b: Wrong procedure

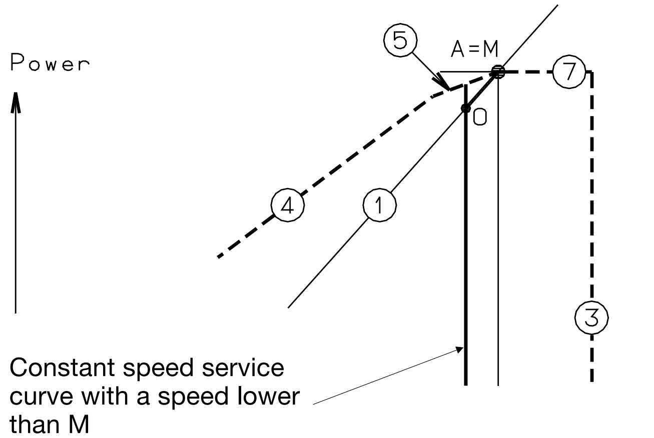
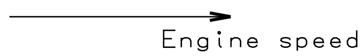


Fig. 2.09c: Recommended procedure



Logarithmic scales

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

178 19 69-9.0

Fig. 2.09: Running at constant speed with CPP

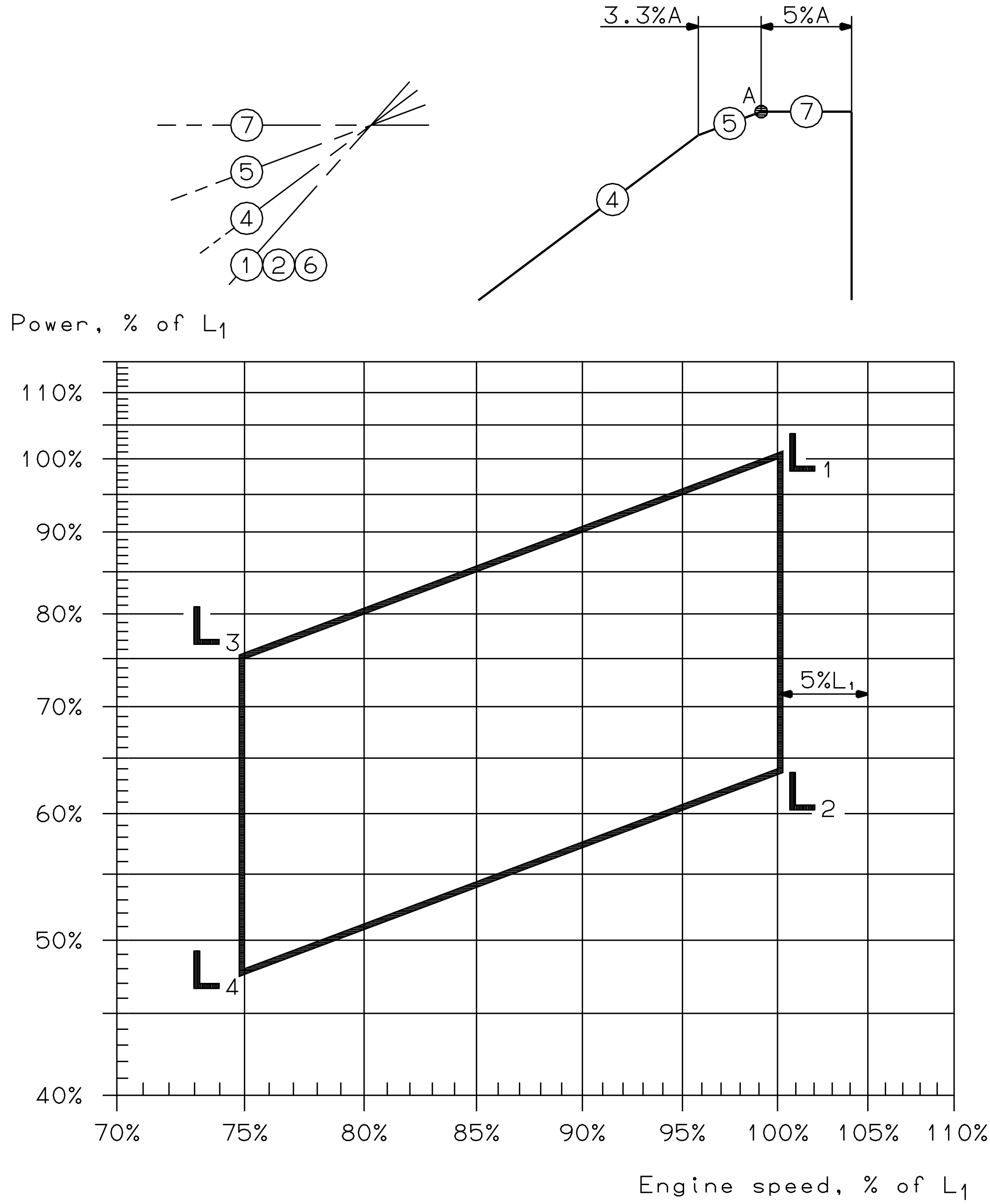


Fig. 2.10 contains a layout diagram that can be used for construction of the load diagram for an actual project, using the %-figures stated and the inclinations of the lines.

178 06 86-5.1

Fig. 2.10: Diagram for actual project

Specific Fuel Oil Consumption

High efficiency/conventional turbochargers

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.

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 up to 2 g/BHPh.

So this engine is available in two versions with respect to the SFOC, see Fig. 2.11.

- (A) With high efficiency turbocharger, (4 59 104)
- (B) With conventional turbocharger, option: 4 59 107

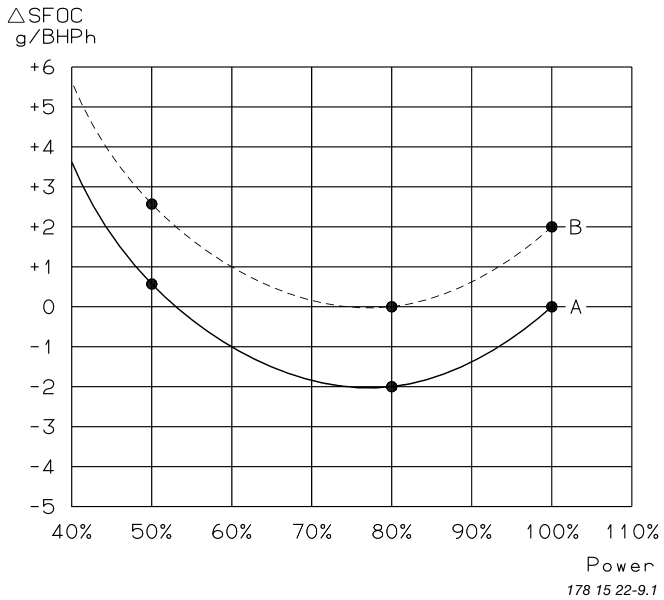


Fig. 2.11: Example of part load SFOC curves for the two engine versions

The calculation of the expected specific fuel oil consumption (SFOC) can be carried out by means of Fig. 2.12 for fixed pitch propeller and 2.13 for controllable pitch propeller, constant speed. Throughout the whole load area the SFOC of the engine depends on where the optimising point O is chosen.

SFOC at reference conditions

The SFOC is based on the reference ambient conditions stated in ISO 3046/1-1986:

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 10,200 kcal/kg (42,700 kJ/kg).

For lower calorific values and for ambient conditions that are different from the ISO reference conditions, the SFOC will be adjusted according to the conversion factors in the below table provided that the maximum combustion pressure (P_{max}) is adjusted to the nominal value (left column), or if the P_{max} is not re-adjusted to the nominal value (right column).

		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 1 °C increase of the scavenge air coolant temperature, a corresponding 1 °C increase of the scavenge air temperature will occur and involves an SFOC increase of 0.06% if P_{max} is adjusted.

SFOC guarantee

The SFOC guarantee refers to the above ISO reference conditions and lower calorific value, and is guaranteed for the power-speed combination in which the engine is optimised (O) and fulfilling the IMO NO_x emission limitations.

The SFOC guarantee is given with a margin of 5%.

As SFOC and NO_x are interrelated paramaters, an engine offered without fulfilling the IMO NO_x limitations only has a tolerance of 3% of the SFOC.

VIT fuel pumps

This engine type is fitted with fuel pumps with Variable Injection Timing (VIT).

Engines with VIT fuel pumps can be part-load optimised between 85-100% (normally at 93.5%) of the specified MCR.

To facilitate the graphic calculation of SFOC we use the same diagram 1 for guidance in both cases, the location of the optimising point is the only difference.

The exact SFOC calculated by our computer program will in the part load area from approx. 60-95% give a slightly improved SFOC compared to engines optimised at the specified MCR (M).

Examples of graphic calculation of SFOC

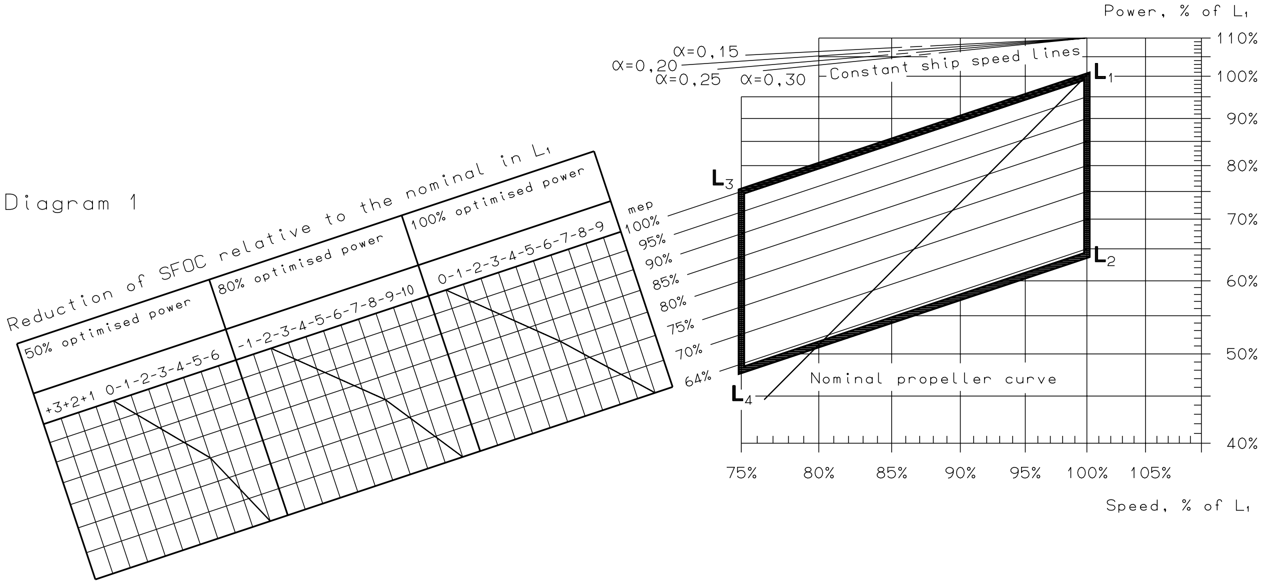
Diagram 1 in figs. 2.12 and 2.13 valid for fixed pitch propeller and constant speed, respectively, shows the reduction in SFOC, relative to the SFOC at nominal rated MCR L_1.

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

The optimising point O is drawn into the above-mentioned Diagram 1. A straight line along the constant mep curves (parallel to L_1-L_3) is drawn through the optimising point O. The line intersections of the solid lines and the oblique lines indicate the reduction in specific fuel oil consumption at 100%, 80% and 50% of the optimised power, related to the SFOC stated for the nominal MCR (L_1) rating at the actually available engine version.

The SFOC curve for an engine with conventional turbocharger is identical to that for an engine with high efficiency turbocharger, but located at 2 g/BHPh higher level.

In Fig. 2.14 an example of the calculated SFOC curves are shown on Diagram 2, valid for two alternative engine ratings: O_1 = 100% M and O_2 = 85%M.

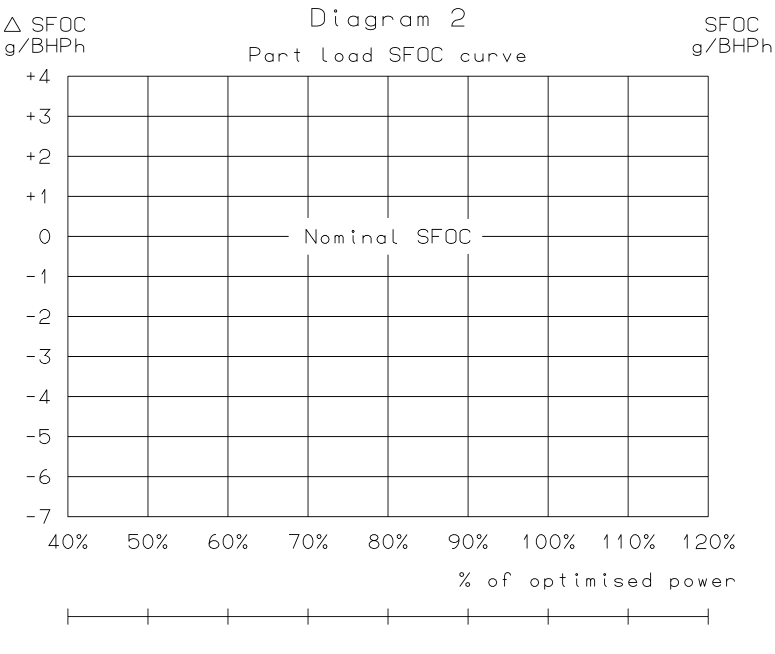


178 15 92-3.0

Data at nominal MCR (L_1): S60MC		
100% Power:		BHP
100% Speed:	105	r/min
High efficiency turbocharger:	125	g/BHPh
Conventional turbocharger:	127	g/BHPh

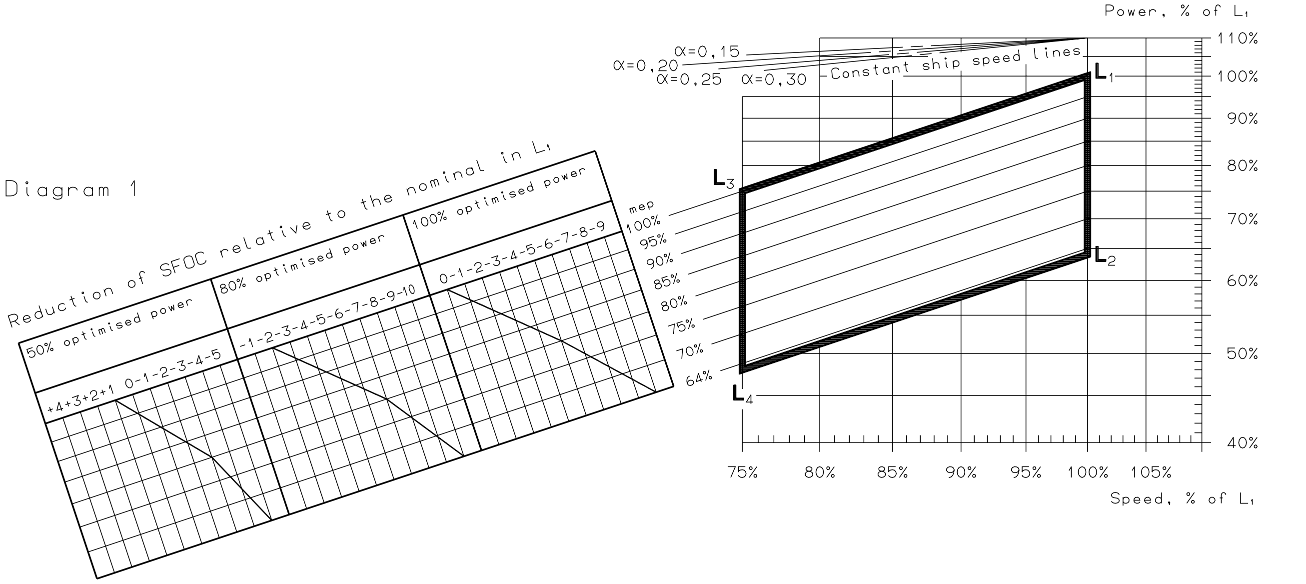
Data of optimising point (O)	
Power: 100% of (O)	BHP
Speed: 100% of (O)	r/min
SFOC found:	g/BHPh

178 43 64-0.0



178 43 63-9.0

Fig. 2.12: SFOC for engine with fixed pitch propeller

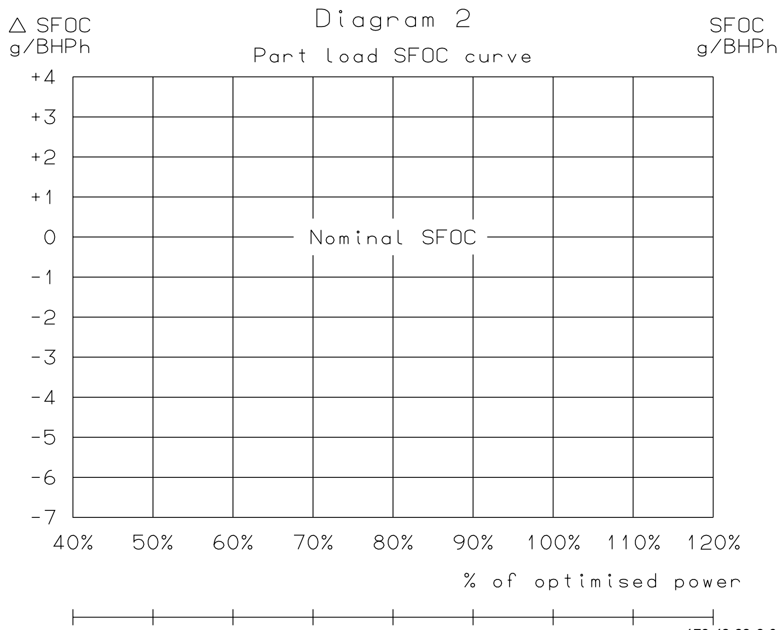


178 15 91-1.0

Data at nominal MCR (L_1): S60MC		
100% Power:		BHP
100% Speed:	105	r/min
High efficiency turbocharger:	125	g/BHPh
Conventional turbocharger:	127	g/BHPh

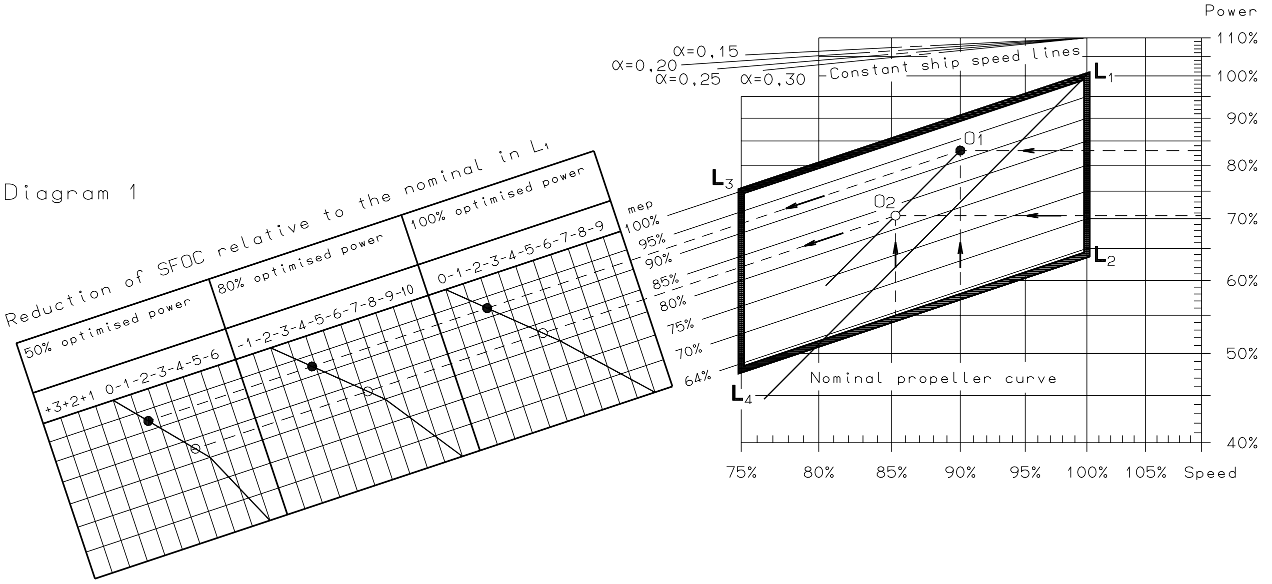
Data of optimising point (O)	
Power: 100% of (O)	BHP
Speed: 100% of (O)	r/min
SFOC found:	g/BHPh

178 43 64-0.0



178 43 63-9.0

Fig. 2.13: SFOC for engine with constant speed

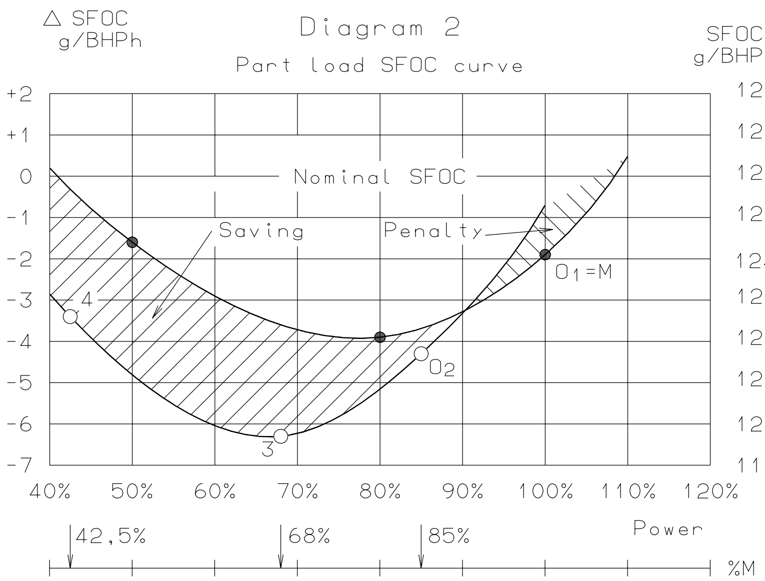


178 15 88-8.0

Data at nominal MCR (L_1): 6S60MC	
100% Power: 100% Speed: High efficiency turbocharger:	16,680 BHP 105 r/min 125 g/BHPh

Data of optimising point (O)	O_1	O_2
Power: 100% of O Speed: 100% of O SFOC found:	13,845 BHP 94.5 r/min 123.1 g/BHPh	11,760 BHP 89.5 r/min 120.7 g/BHPh

178 39 37-5.0



O_1: Optimised in M
O_2: Optimised at 85% of power M
Point 3: is 80% of O_2 = 0.80 x 85% of M = 68% M
Point 4: is 50% of O_2 = 0.50 x 85% of M = 42.5% M

178 31 79-0.0

Fig. 2.14: Example of SFOC for 6S60MC with fixed pitch propeller, high efficiency turbocharger

Fuel Consumption at an Arbitrary Load

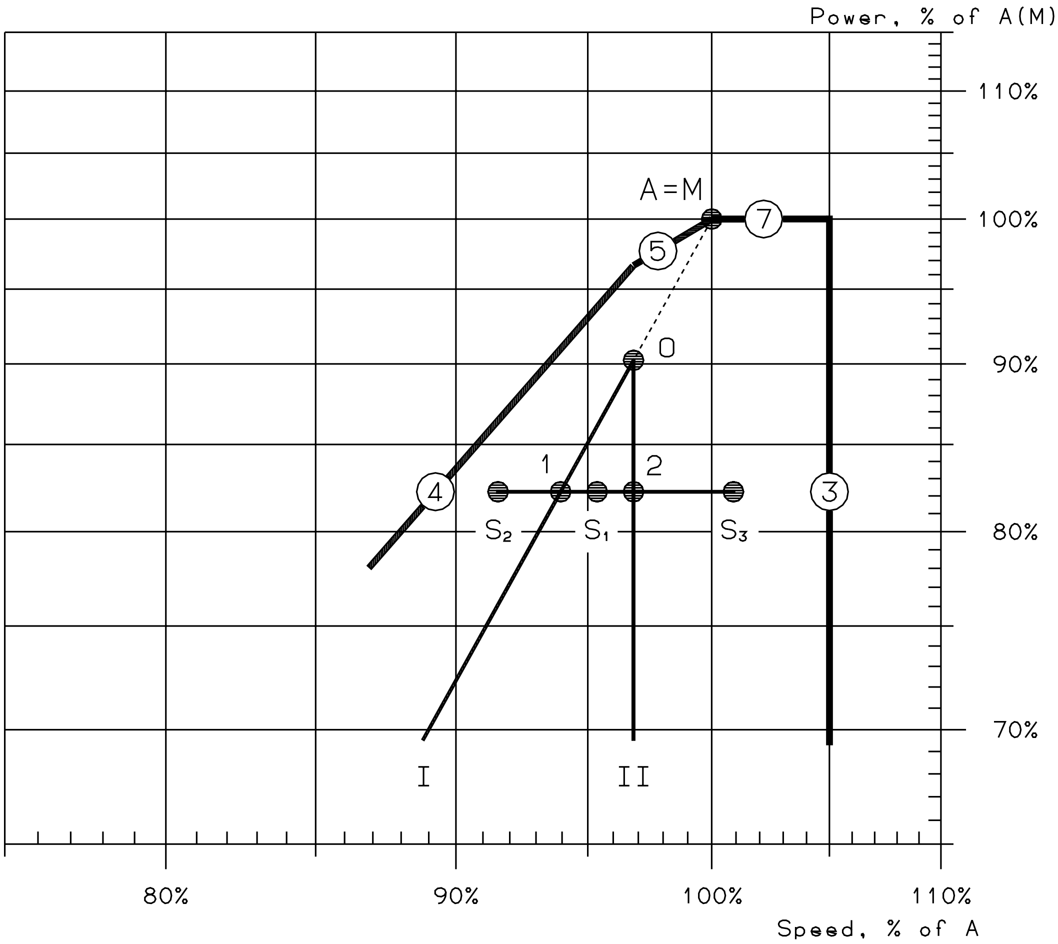
Once the engine has been optimised in point O, shown on this Fig., the specific fuel oil consumption in an arbitrary point S_1, S_2 or S_3 can be estimated based on the SFOC in points “1" and ”2".

These SFOC values can be calculated by using the graphs in Fig. 2.12 for the fixed pitch propeller curve I and Fig. 2.13 for the constant speed curve II, obtaining the SFOC in points 1 and 2, respectively.

Then 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, to 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 figure. 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.



178 05 32-0.1

Fig. 2.15: SFOC at an arbitrary load

Emission Control

All MC engines are delivered so as to comply with the IMO speed dependent NO_X limit, measured according to ISO 8178 Test Cycles E2/E3 for Heavy Duty Diesel Engines.

IMO NO_X limits, i. e. 0-30% NO_X reduction

The primary method of NO_X control, i.e. engine adjustment and component modification to affect the engine combustion process directly, enables reductions of up to 30% to be achieved.

The Specific Fuel Oil Consumption (SFOC) and the NO_X are interrelated parameters, and an engine offered with a guaranteed SFOC and also guaranteed to comply with the IMO NO_X limitation will be subject to a 5% fuel consumption tolerance.

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 the steam and cavitation. It may be necessary to modify some of the engine components such as the fuel pumps, camshaft, and the engine control system.

Up to 95-98% NO_X reduction

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.

Plants designed according to this method have been in service since 1990 on four 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.

More detailed information can be found in our publications:

- P. 331 Emissions Control, Two-stroke Low-speed Engines
- P. 333 How to deal with Emission Control.

Turbocharger Choice 3

3. Turbocharger Choice

Turbocharger Types

The MC engines are designed for the application of either MAN B&W, ABB or Mitsubishi (MHI) turbochargers, and are matched to comply with the IMO speed dependent NO_X limitations, measured according to ISO 8178 Test Cycles E2/E3 for Heavy Duty Diesel Engines.

The turbocharger choice is made with a view to obtaining the lowest possible Specific Fuel Oil Consumption (SFOC) values, i.e. with the nominal MCR and the high efficiency turbochargers stated in Fig. 3.01a.

The amount of air required for the combustion can, however be adjusted to provide a higher exhaust gas temperature, if this is needed for the exhaust gas boiler. In this case the conventional turbochargers are to be applied, see Fig. 3.01b. The SFOC is then about 2 g/BHPh higher, see section 2.

For other layout points than L_1, the size of turbocharger may be different, depending on the point at which the engine is to to be optimised, see the following layout diagrams.

Figs. 3.02 and 3.06 show the approximate limits for application of the MAN B&W turbochargers, Figs. 3.03, 3.04, 3.07 and 3.08 for ABB types TPL and VTR, respectively, and Figs. 3.05 and 3.09 for MHI turbochargers.

In order to clean the turbine blades and the nozzle ring assembly during operation, the exhaust gas inlet to the turbocharger(s) is provided with a dry cleaning system using nut shells and a water washing system.

As standard, the engine is equipped with one turbocharger located on the aft end (4 59 124).

The engine can, as an option: 4 59 123, be supplied with the turbocharger located on the exhaust side.

Two turbochargers can optionally be applied, if this is desirable due to space requirements, or for other reasons, option: 4 59 113.

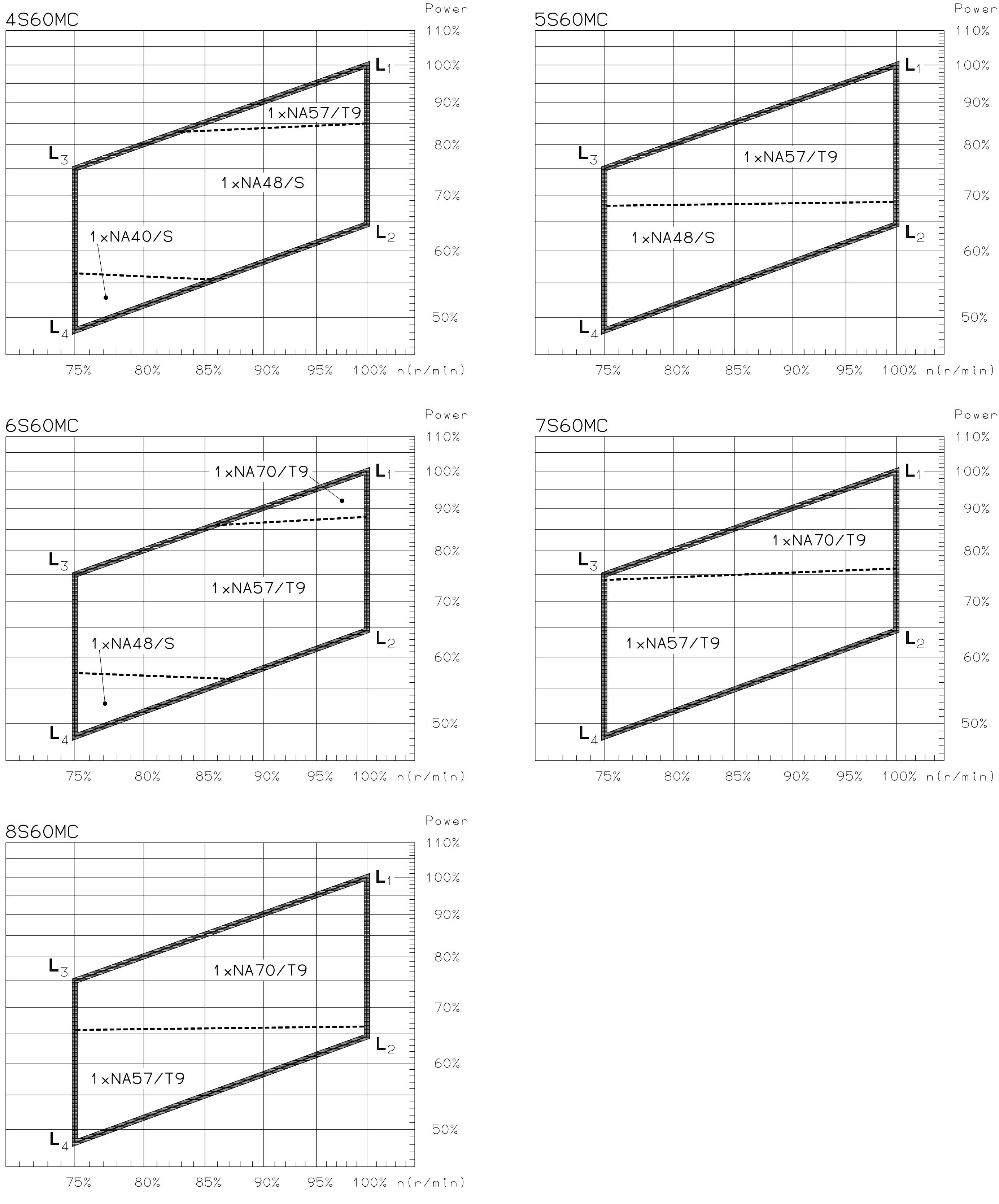
Cyl.	MAN B&W	ABB	ABB	MHI
4	1 x NA57/T9	1 x TPL77-B11	1 x VTR564D	1 x MET53SE
5	1 x NA57/T9	1 x TPL80-B11	1 x VTR714D	1 x MET66SE
6	1 x NA70/T9	1 x TPL80-B12	1 x VTR714D	1 x MET66SE
7	1 x NA70/T9	1 x TPL85-B11	1 x VTR714D	1 x MET71SE
8	1 x NA70/T9	1 x TPL85-B11	2 x VTR564D	1 x MET83SE

Fig. 3.01a: High efficiency turbochargers

Cyl.	MAN B&W	ABB	ABB	MHI
4	1 x NA48/S	1 x TPL77-B11	1 x VTR564D	1 x MET53SE
5	1 x NA57/T9	1 x TPL77-B12	1 x VTR564D	1 x MET66SE
6	1 x NA57/T9	1 x TPL80-B11	1 x VTR714D	1 x MET66SE
7	1 x NA70/T9	1 x TPL80-B12	1 x VTR714D	1 x MET66SE
8	1 x NA70/T9	1 x TPL85-B11	1 x VTR714D	1 x MET71SE

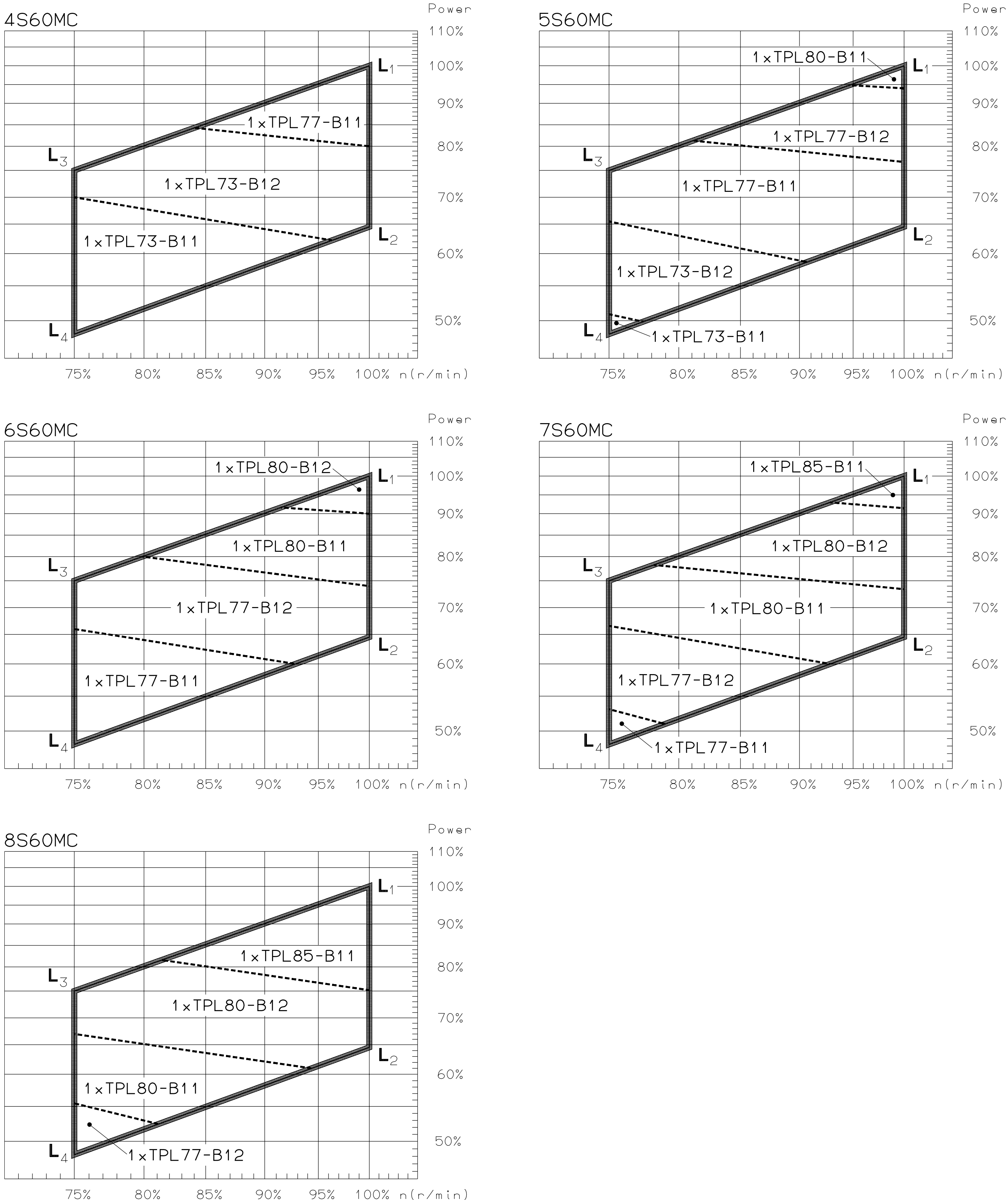
178 45 97-6.0

Fig. 3.01b: Conventional turbochargers, option: 4 59 107



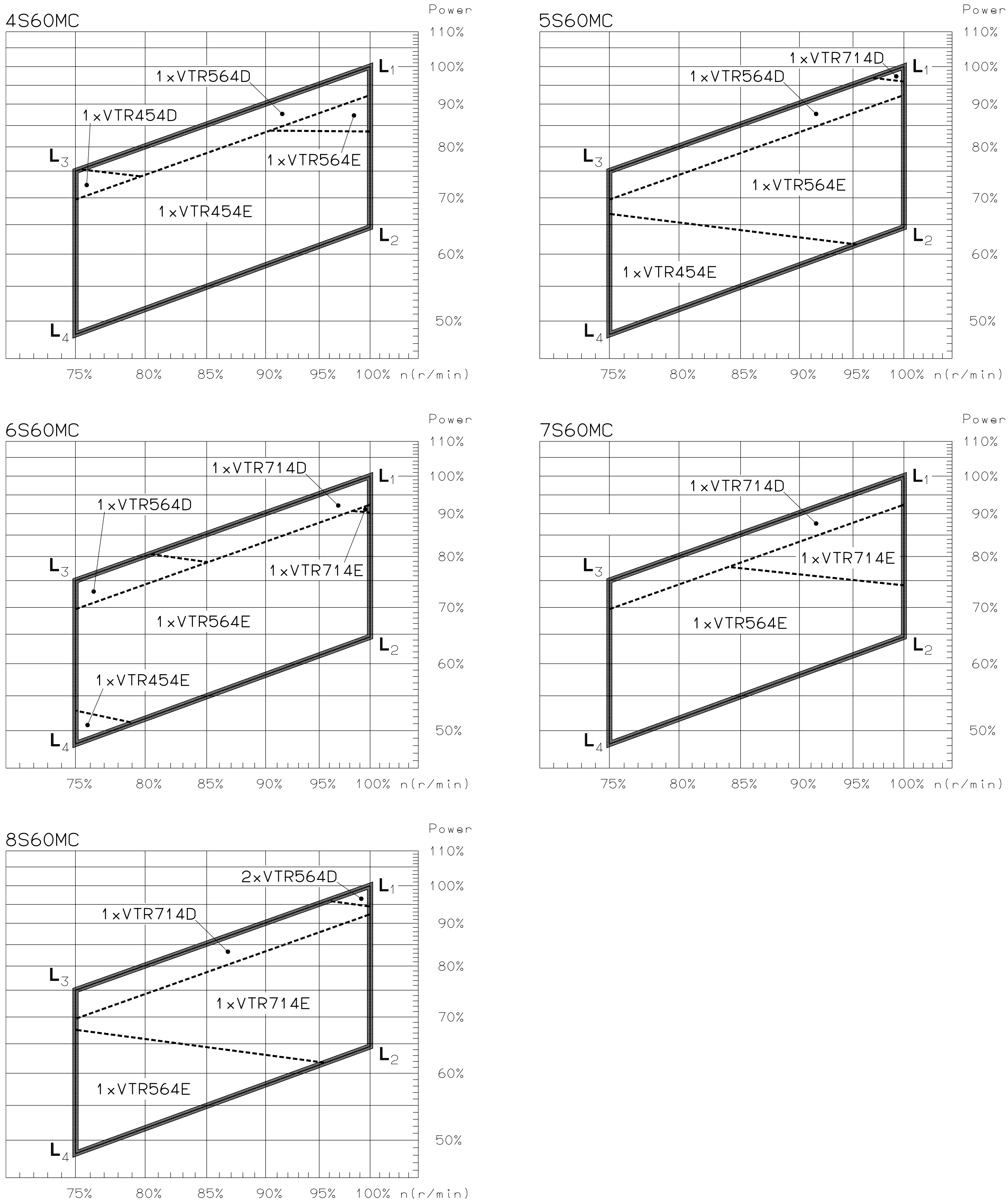
178 20 27-5.0

Fig. 3.02: Choice of high efficiency turbochargers, make MAN B&W



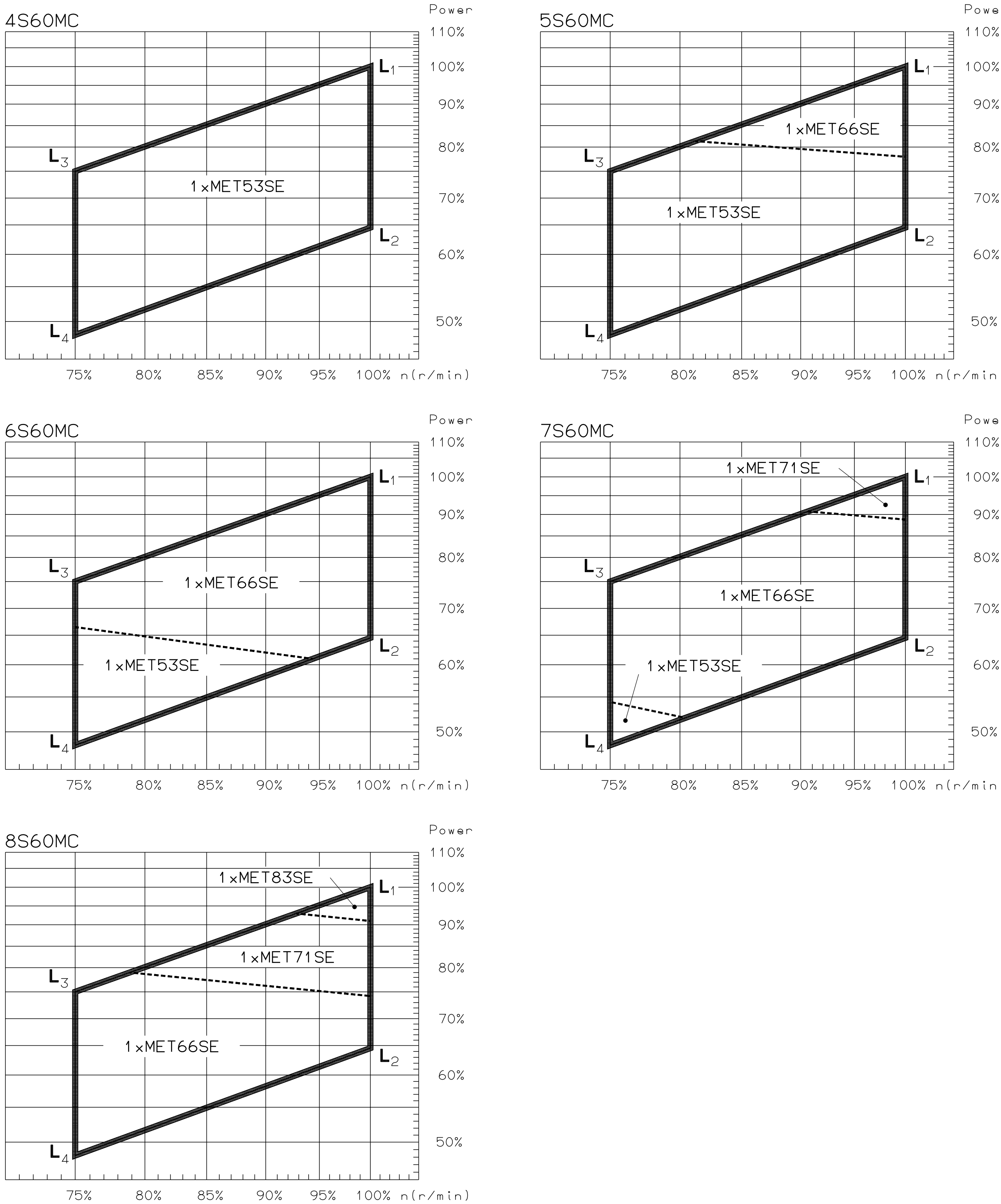
178 20 28-7.0

Fig. 3.03: Choice of high efficiency turbochargers, make ABB turbochargers, type TPL



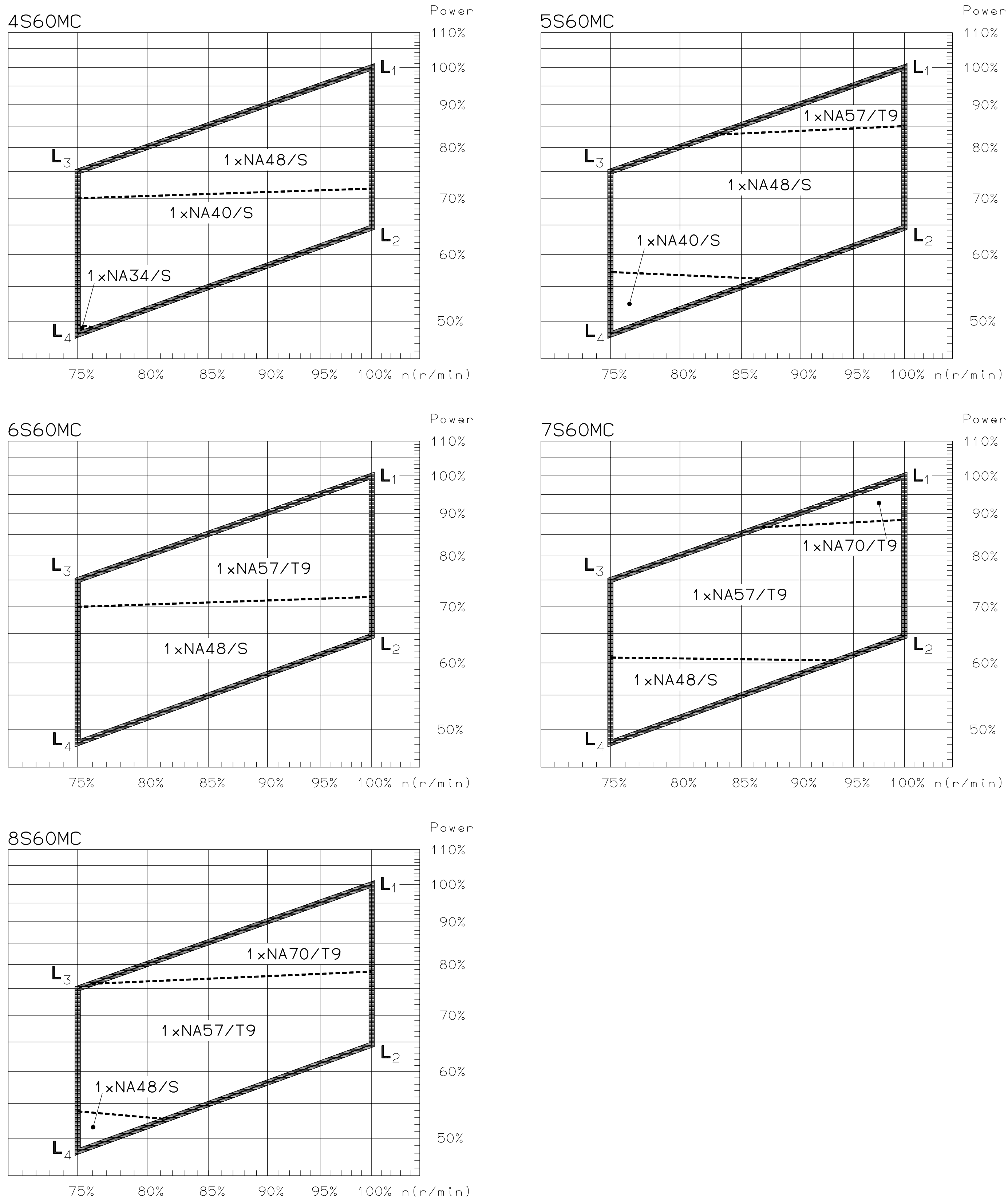
178 20 29-9.0

Fig. 3.04: Choice of high efficiency turbochargers, make ABB, type VTR



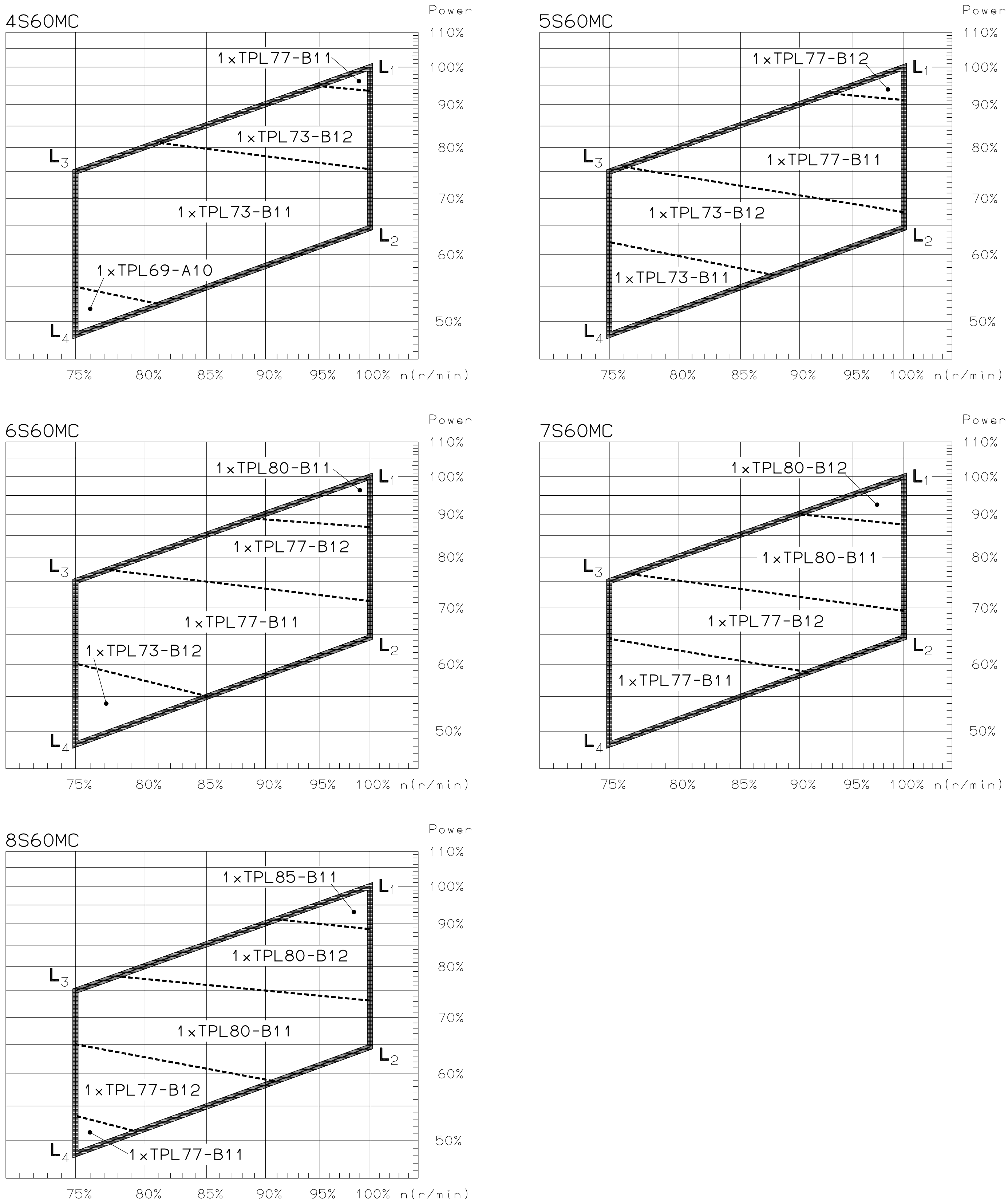
178 20 30-9.0

Fig. 3.05: Choice of high efficiency turbochargers, make MHI



178 20 31-0.0

Fig. 3.06: Choice of conventional turbochargers, make MAN B&W



178 20 32-2.0

Fig. 3.07: Choice of conventional turbochargers, make ABB, type TPL

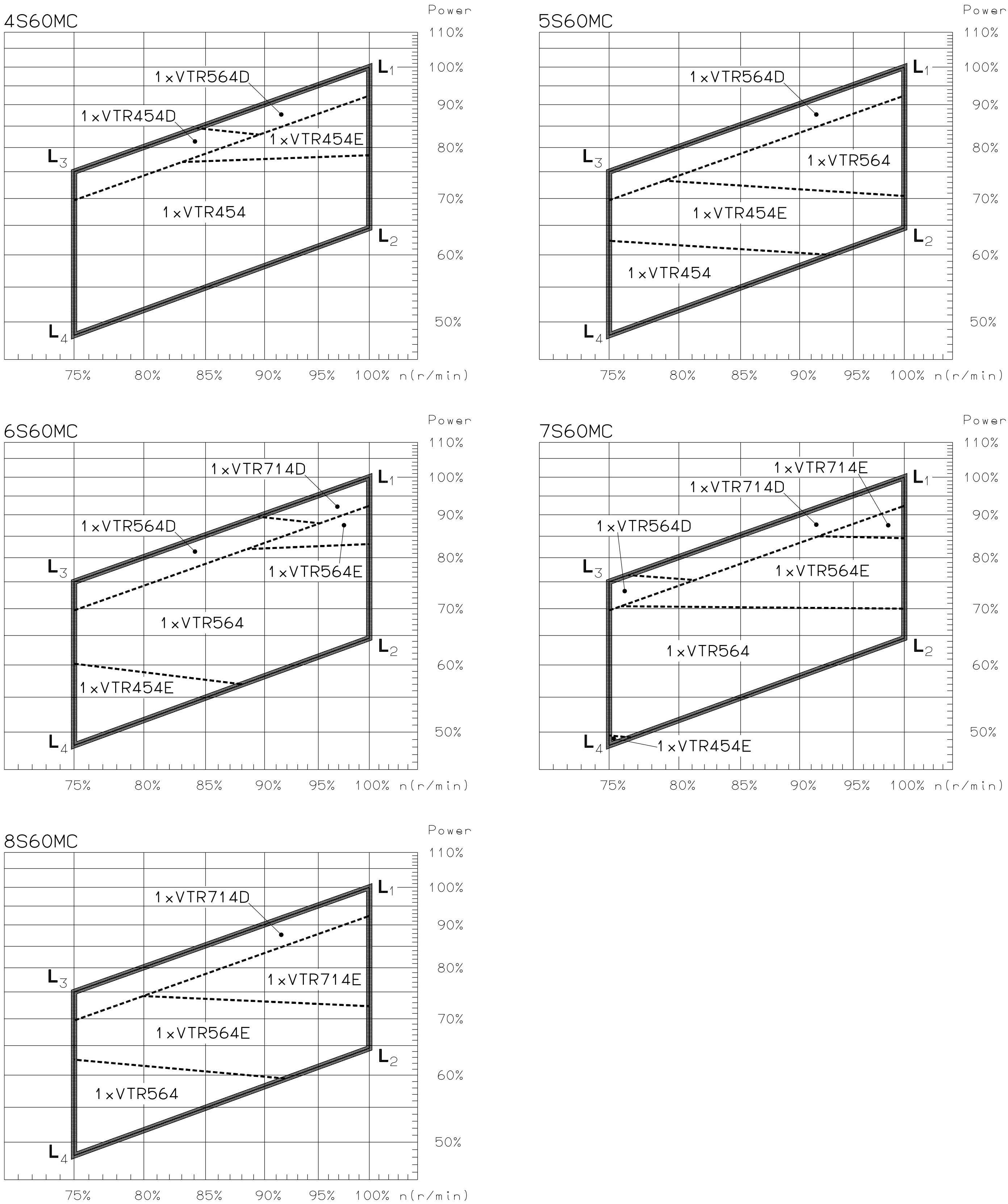


Fig. 3.08: Choice of conventional turbochargers, make ABB, type VTR

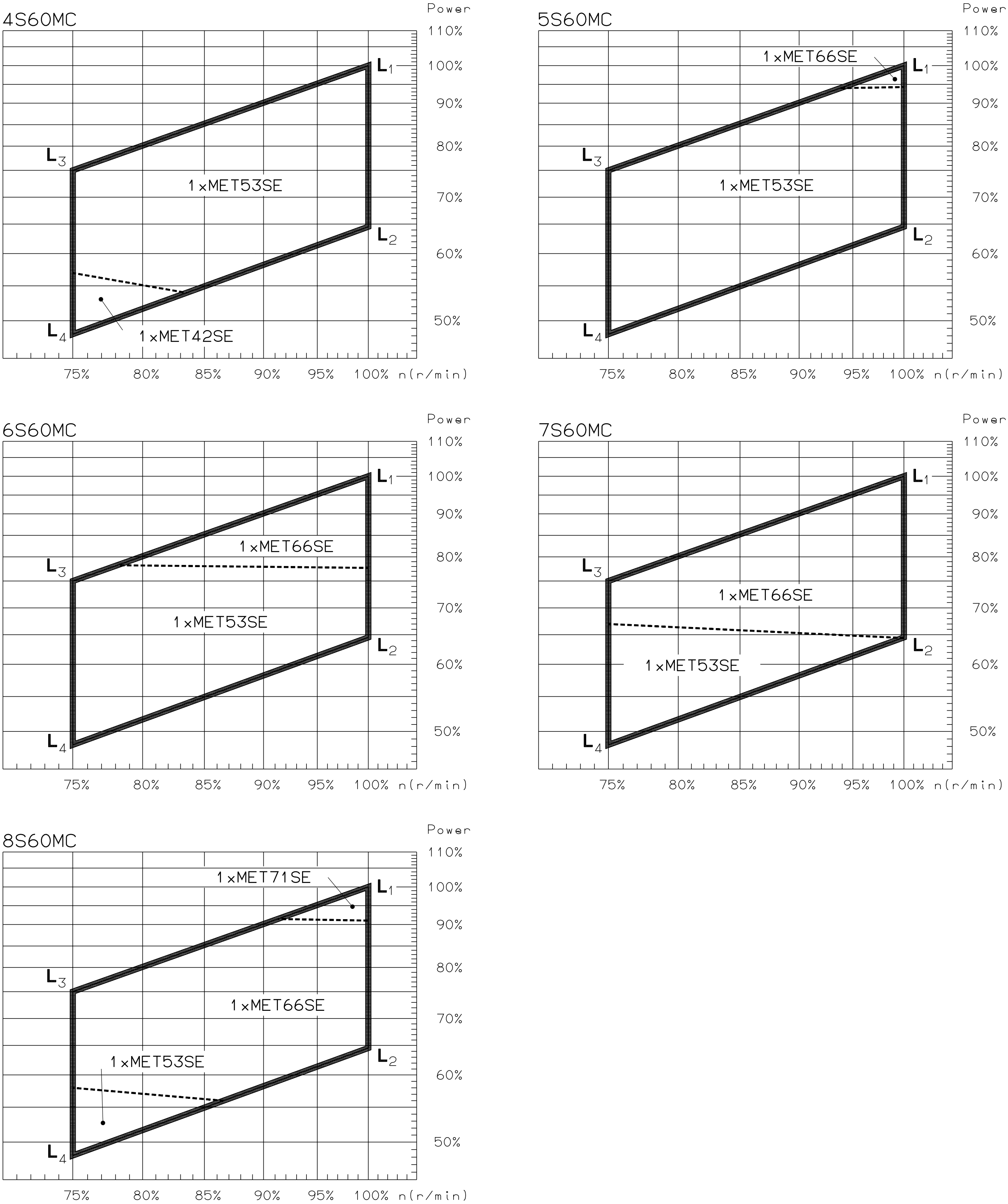


Fig. 3.09: Choice of conventional turbochargers, make MHI

Cut-Off or By-Pass of Exhaust Gas

The exhaust gas can be cut-off or by-passed the turbochargers using either of the following four systems.

Turbocharger cut-out system
Option: 4 60 110

This system, Fig. 3.10, is to be investigated case by case as its application depends on the layout of the turbocharger(s), can be profitably to introduce on engines with **two turbochargers** if the engine is to operate for long periods at low loads of about 50% of the optimised power or below.

The advantages are:

- Reduced SFOC if one turbocharger is cut-out
- Reduced heat load on essential engine components, due to increased scavenge air pressure. This results in less maintenance and lower spare parts requirements
- The increased scavenge air pressure permits running without auxiliary blowers down to 20-30% of specified MCR, instead of 30-40%, thus saving electrical power.

The saving in SFOC at 50% of optimised power is about 1-2 g/BHPh, while larger savings in SFOC are obtainable at lower loads.

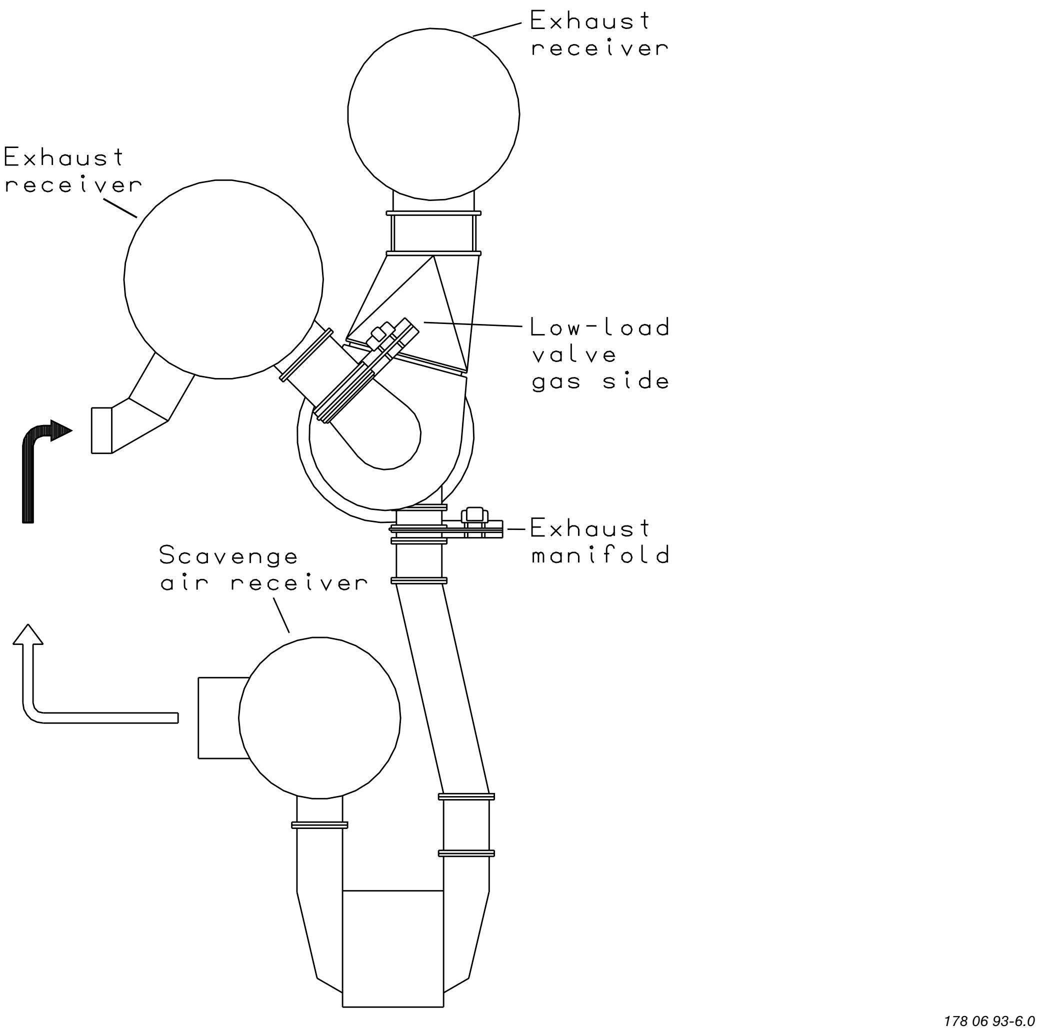


Fig. 3.10: Position of turbocharger cut-out valves

Valve for partical by-pass
Option: 4 60 117

Valve for partical by-pass of the exhaust gas round the high efficiency turbocharger(s), Fig. 3.11, can be used in order to obtain improved SFOC at part loads. For engine loads above 50% of optimised power, the turbocharger allows part of the exhaust gas to be by-passed round the turbocharger, giving an increased exhaust temperature to the exhaust gas boiler.

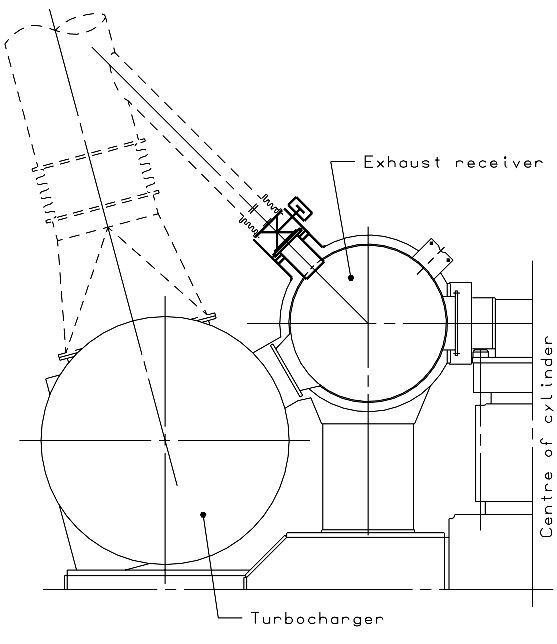
At loads below 50% of optimised power, the by-pass closes automatically and the turbocharger works under improved conditions with high efficiency. Furthermore, the limit for activating the auxiliary blowers decreases correspondingly.

Total by-pass for emergency running
Option: 4 60 119

By-pass of the total amount of exhaust gas round the turbocharger, Fig. 3.12, is only used for emergency running in case of turbocharger failure.

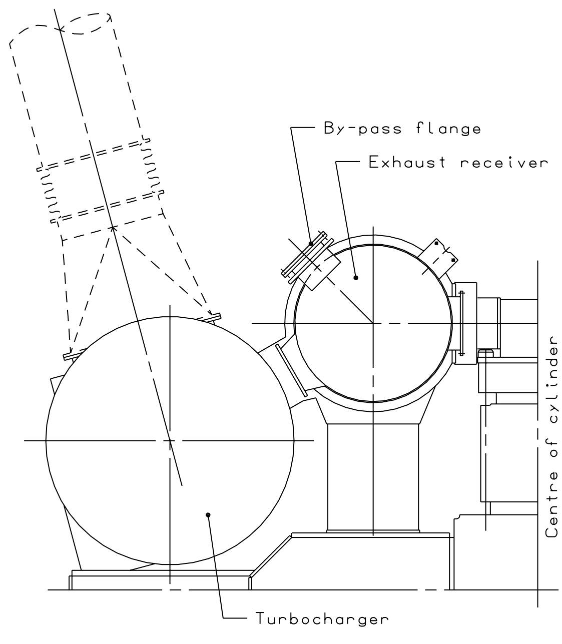
This enables the engine to run at a higher load than with a locked rotor under emergency conditions. The engine's exhaust gas receiver will in this case be fitted with a by-pass flange of the same diameter as the inlet pipe to the turbocharger. The emergency pipe is the yard's delivery.

178 44 67-1.0



178 06 69-8.0

Fig. 3.11: Valve for partical by-pass



178 06 72-1.1

Fig. 3.12: Total by-pass of exhaust for emergency running

Electricity Production 4

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 based on an economical evaluation of first cost, operating costs, and the demand of 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 B&W.

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 (PTO)

With a generator coupled to a Power Take Off (PTO) from the main engine, the electricity can be produced based on the main engine's low SFOC and use of heavy fuel oil. Several standardised PTO systems are available, see Fig. 4.01 and the designations on Fig. 4.02:

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.

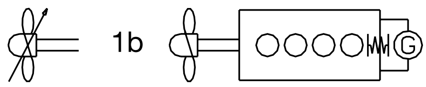
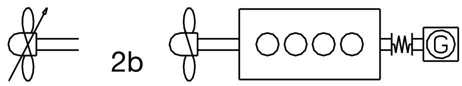
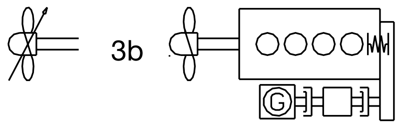
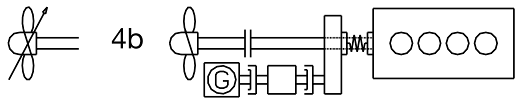
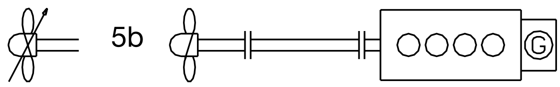
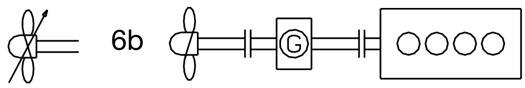
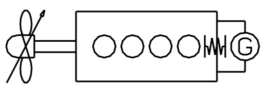
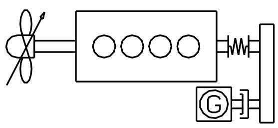
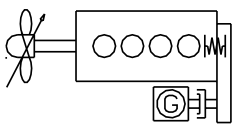
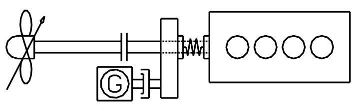
BW II:
A free-standing gear mounted on the tank top and connected to the fore end of the diesel engine, with a vertical or horizontal generator.

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.

On this type of engine, special attention has to be paid to the space requirements for the BWIII system if the turbocharger is located on the exhaust side.

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 type designated BW III/RCF 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

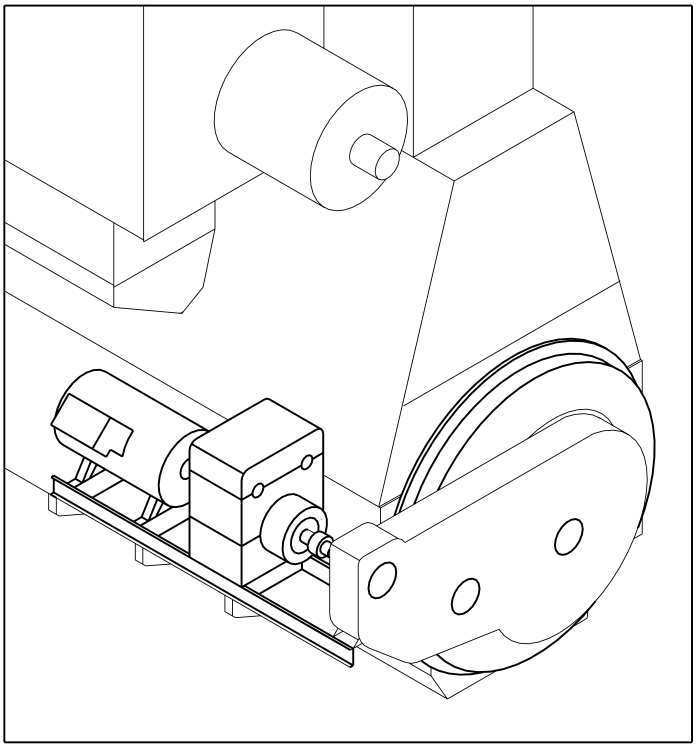
178 19 66-3.1

Fig. 4.01: Types of PTO

For further information please refer to our publication:

P. 364 “Shaft Generators
Power Take Off
from the Main Engine”

Which is also available at the Internet address:
www.manbw.dk under “Libraries”.



Power take off:
BW III S60/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

Engine type on which it is applied

Layout of PTO: See Fig. 4.01

Make: MAN B&W

Fig. 4.02: Designation of PTO

178 47 47-5.0

PTO/RCF

Side mounted generator, BWIII/RCF
(Fig. 4.01, 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. 4.03.

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. 4.03 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

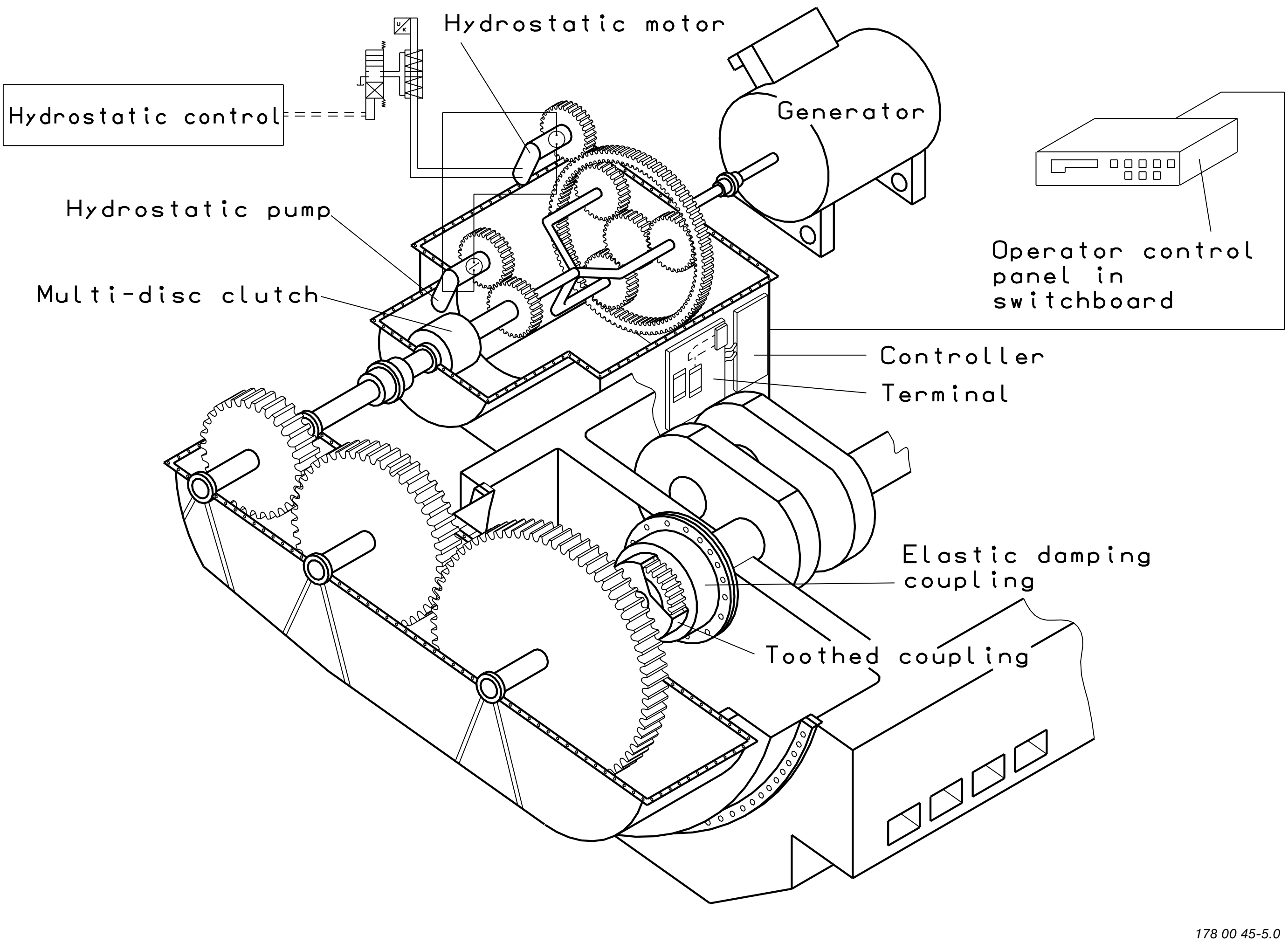


Fig. 4.03: Power Take Off with Renk constant frequency gear: BW III/RCF, option: 4 85 253

female part of the toothed coupling can be moved forward, thus disconnecting the two parts of the toothed coupling.

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 satisfactory 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. 4.04 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	1056	845	940	752
74 M1-4	1271	1017	1137	909
74 M2-4	1432	1146	1280	1024
74 L1-4	1651	1321	1468	1174
74 L2-4	1924	1539	1709	1368
86 K1-4	1942	1554	1844	1475
86 M1-4	2345	1876	2148	1718
86 L2-4	2792	2234	2542	2033
99 K1-4	3222	2578	2989	2391

178 34 89-3.1

In the case that a larger generator is required, please contact MAN B&W Diesel A/S.

If a main engine speed other than the nominal is required as a basis for the PTO operation, this must be taken into consideration when determining the ratio of the crankshaft gear. However, this 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 adding 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.

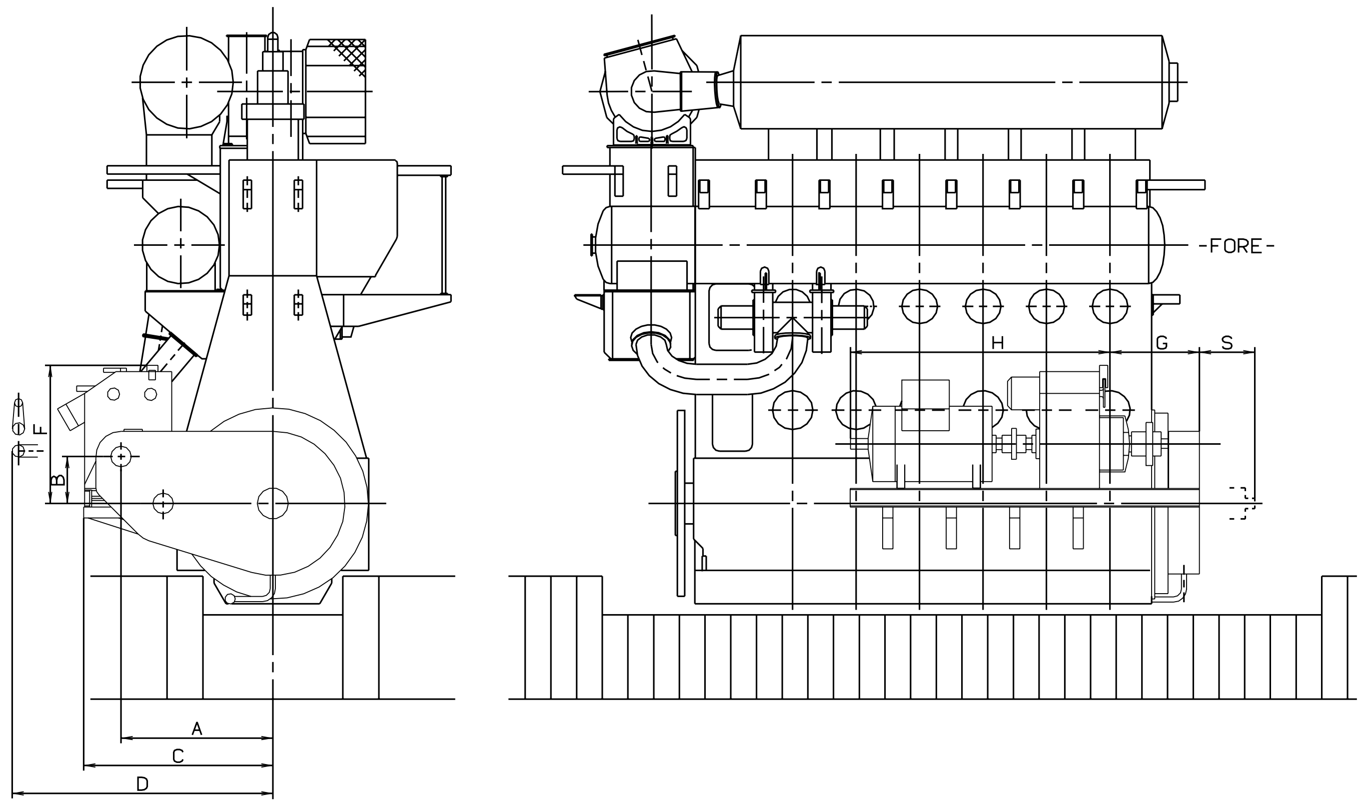
3. Wiring between the generator and the operator control panel in the switch-board.

4. An external permanent lubricating oil filling-up connection can be established in connection with the RCF unit. The system is shown in Fig. 4.07 “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. 4.06).

The necessary preparations to be made on the engine are specified in Figs. 4.05a and 4.05b.

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. 4.06.



178 05 11-7.0

	kW Generator			
	700 kW	1200 kw	1800 kW	2600 kw
A	2684	2684	2824	2824
B	632	632	632	632
C	3344	3344	3624	3624
D	3740	3740	4020	4020
F	1682	1802	1922	2032
G	2364	2364	2724	2724
H	2134	2636	3021	4341
S	390	450	530	620
	System mass (kg) with generator:			
	23750	27500	39100	52550
	System mass (kg) without generator:			
	21750	24850	34800	47350

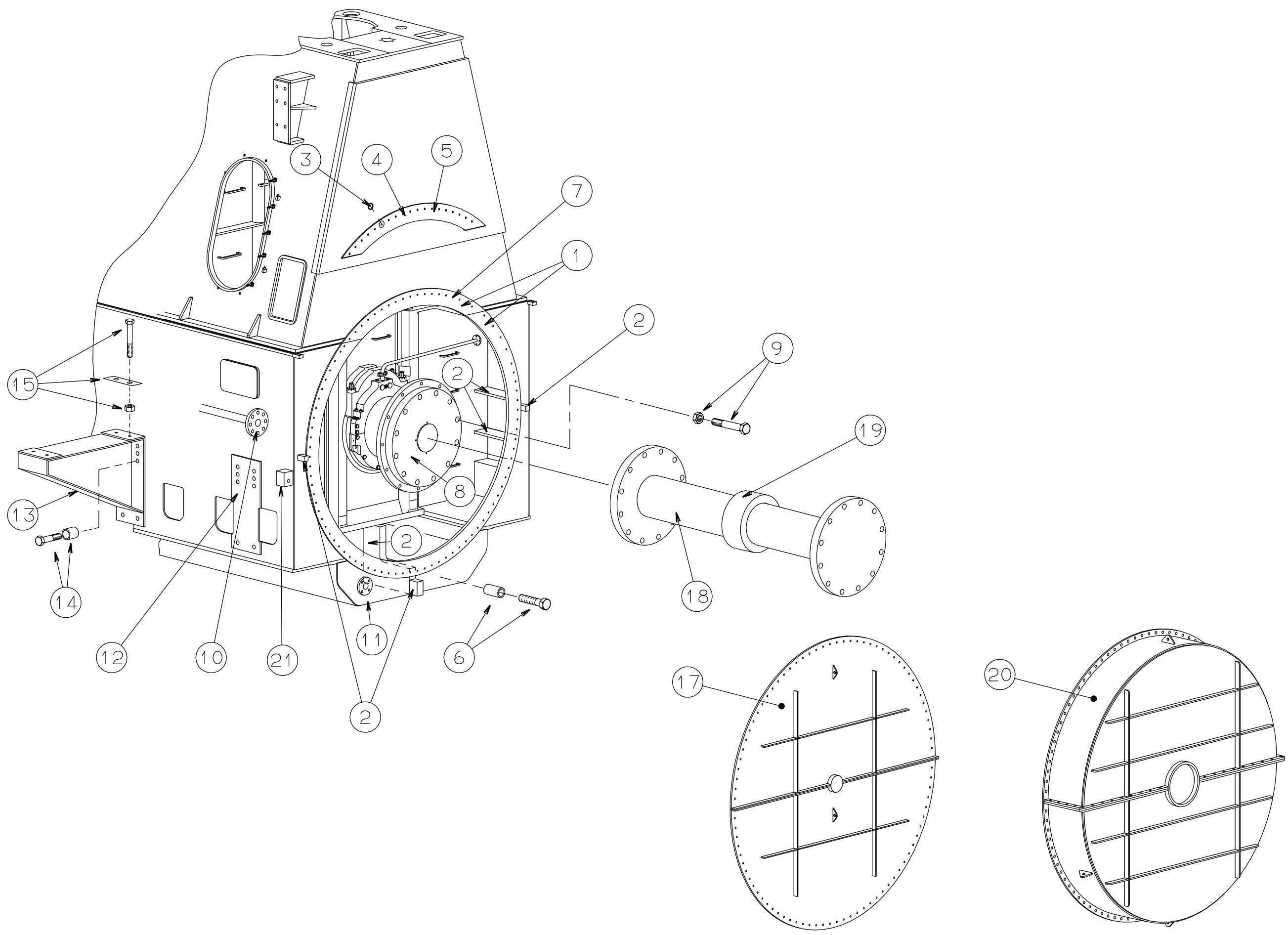
The stated kW, which is at generator terminals, is available between 70% and 100% of the engine speed at specified MCR.

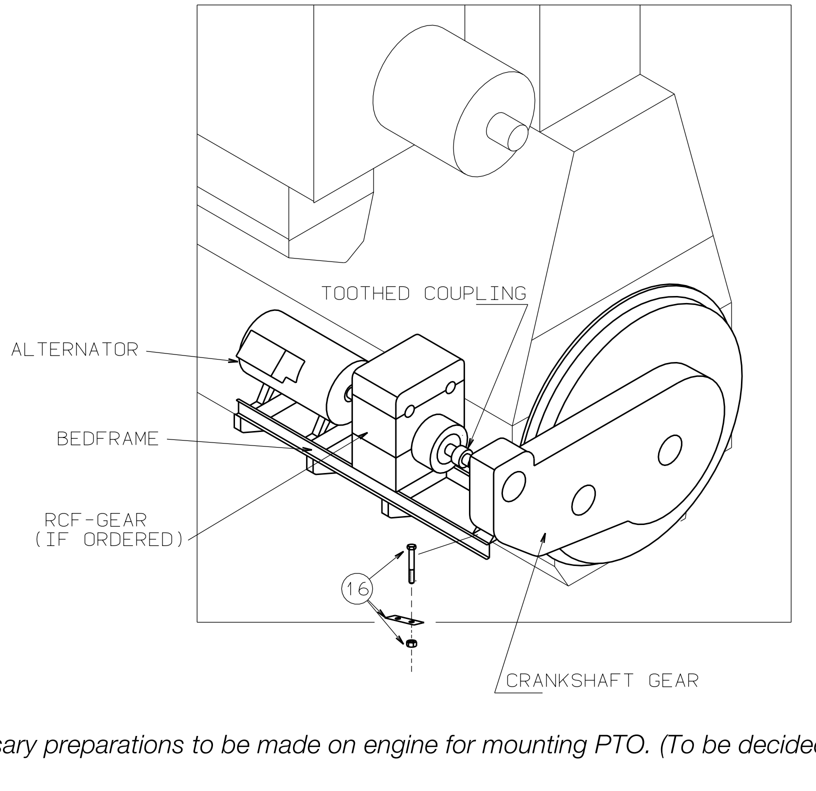
Space requirements for the 2600kW generator has to be investigated case by case

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

178 88 34-7.0

Fig. 4.04: Space requirement for side mounted generator PTO/RCF type BWIII S60/RCF





178 40 42-8.0

Fig. 4.05a: Necessary preparations to be made on engine for mounting PTO. (To be decided when ordering the engine)

Pos. 1 Special face on bedplate and frame box

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

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

Pos. 4 Rubber gasket placed on frame box part of face

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

Pos. 6 Distance tubes and long bolts

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

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

Pos. 9 Studs and nuts for crankshaft flange

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

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

Pos. 12 Face for brackets

Pos. 13 Brackets

Pos. 14 Studs for mounting the brackets

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

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

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

Pos. 18 Intermediate shaft between crankshaft and PTO

Pos. 19 Oil sealing for intermediate shaft

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

Pos. 21 Plug box for electronic measuring instrument for check of condition of axial vibration damper

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

A: Preparations to be carried out by engine builder

B: Parts supplied by PTO-maker

C: See text of pos. no.

178 33 84-9.0

Fig. 4.05b: Necessary preparations to be made on engine for mounting PTO. (To be decided when ordering the engine)

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	1200	1800	2600
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	1200	1800	2600
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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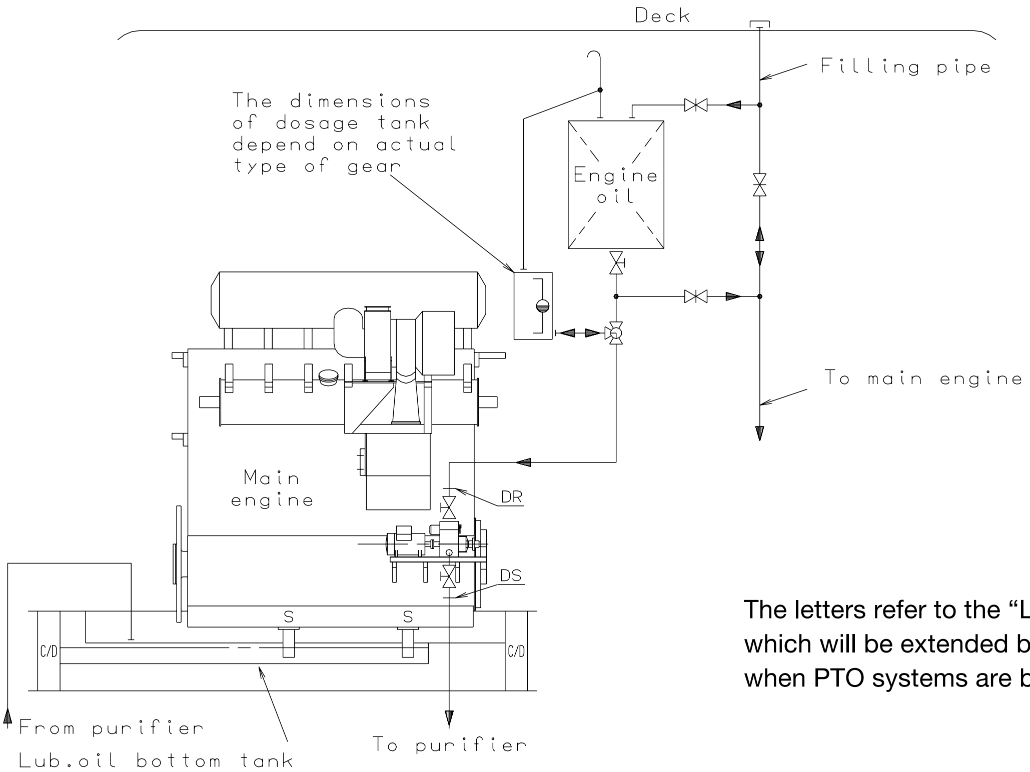
Fig. 4.06: Necessary capacities for PTO/RCF, BW III/RCF system



The letters refer to the “List of flanges”, which will be extended by the engine builder, when PTO systems are built on the main engine

178 06 47-1.0

Fig. 4.07: Lubricating oil system for RCF gear

DMG/CFE Generators
Option: 4 85 259

Fig. 4.01 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. 4.08 and 4.09.

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

The DMG/CFE system has been developed in cooperation with the German generator manufacturers Siemens and AEG, but similar types of generators can be supplied by others, e.g. Fuji, Nishishiba and Shinko 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. 4.09), 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.

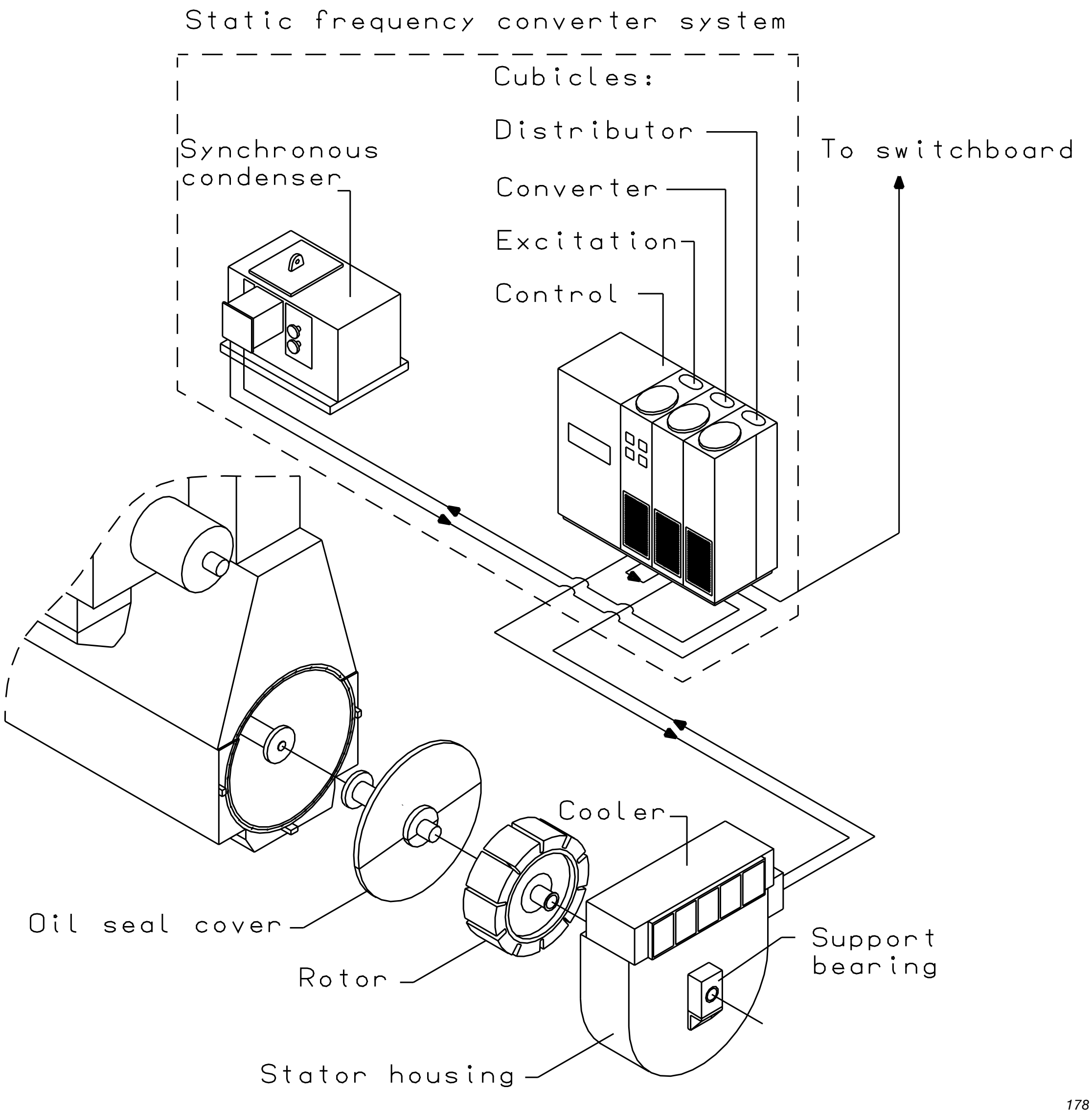


Fig. 4.08: Standard engine, with direct mounted generator (DMG/CFE)

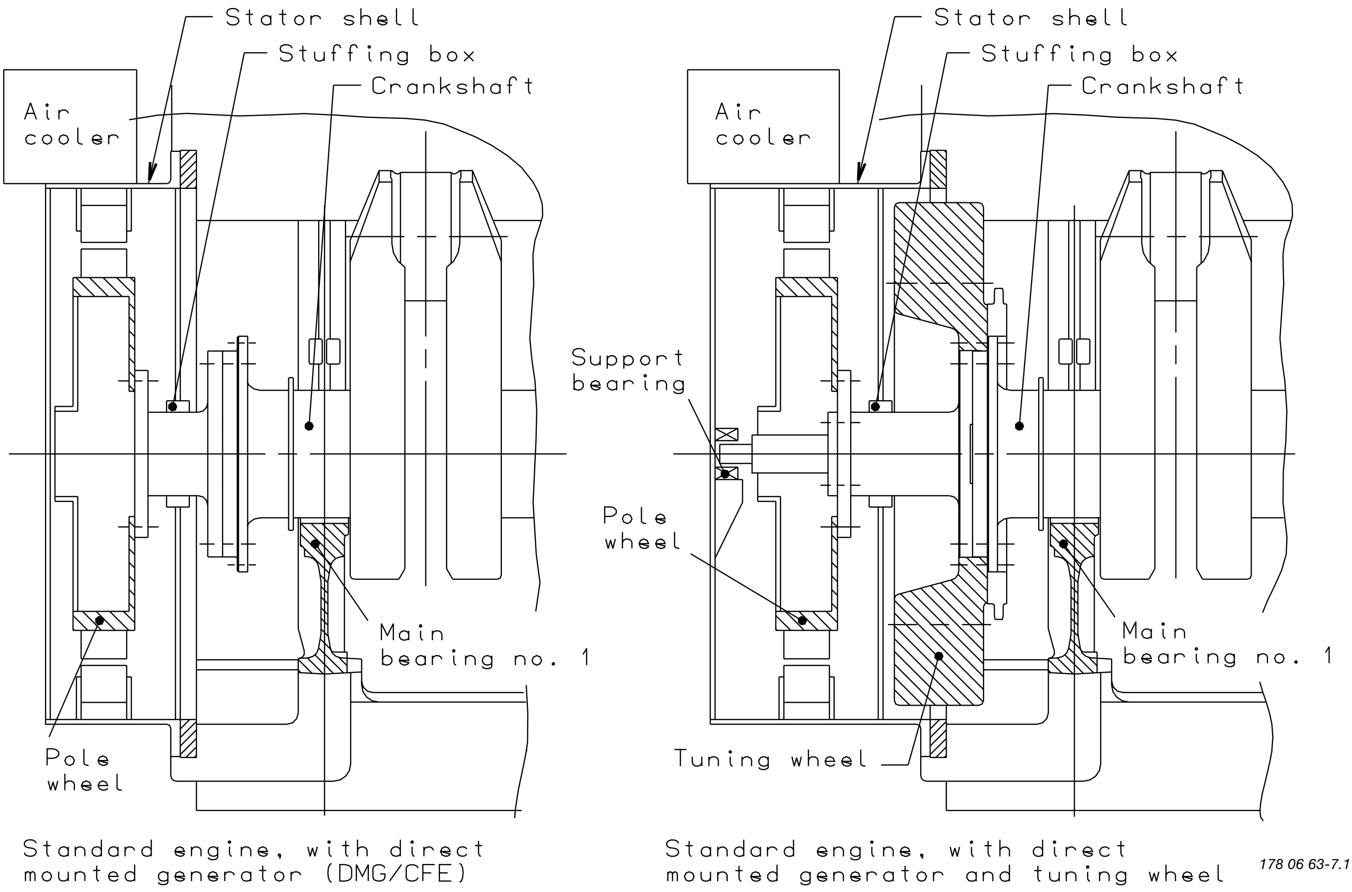


Fig. 4.09: Standard engine, with direct mounted generator and tuning wheel

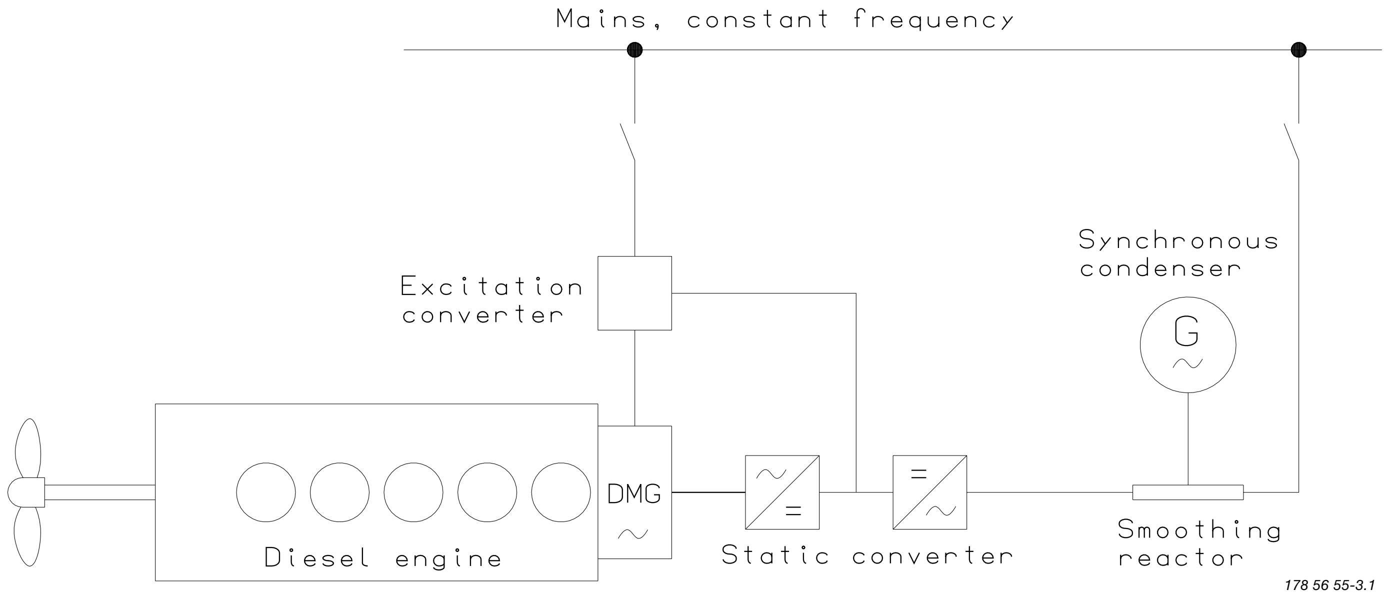


Fig. 4.10: Diagram of DMG/CFE with static converter

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. 4.09.

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 in 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. 4.10) 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 inclusive of 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. 4.05a and 4.05b.

Power Take Off/Gear Constant Ratio, PTO type: BW II/GCR

The system Fig. 4.01 alternative 8 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 and, by virtue of its short and compact design, it requires a minimum of installation space, see Fig. 4.11. 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 BW II/GCR cannot, as standard, be mechanically disconnected from the main engine, but a hydraulically activated clutch, including hydraulic pump, control valve and control panel, can be fitted as an option.

PTO type: BW IV/GCR Power Take Off/Gear Constant Ratio

The shaft generator system, type BW IV/GCR, installed in the shaft line (Fig. 4.01 alternative 10) 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 flexible coupling integrated in the shaft line.

The main engine needs no special preparation for mounting this type of PTO system if it is 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 combinator mode. This will, however, also require an additional Renk Constant Frequency gear (Fig. 4.01 alternative 4) or additional electrical equipment

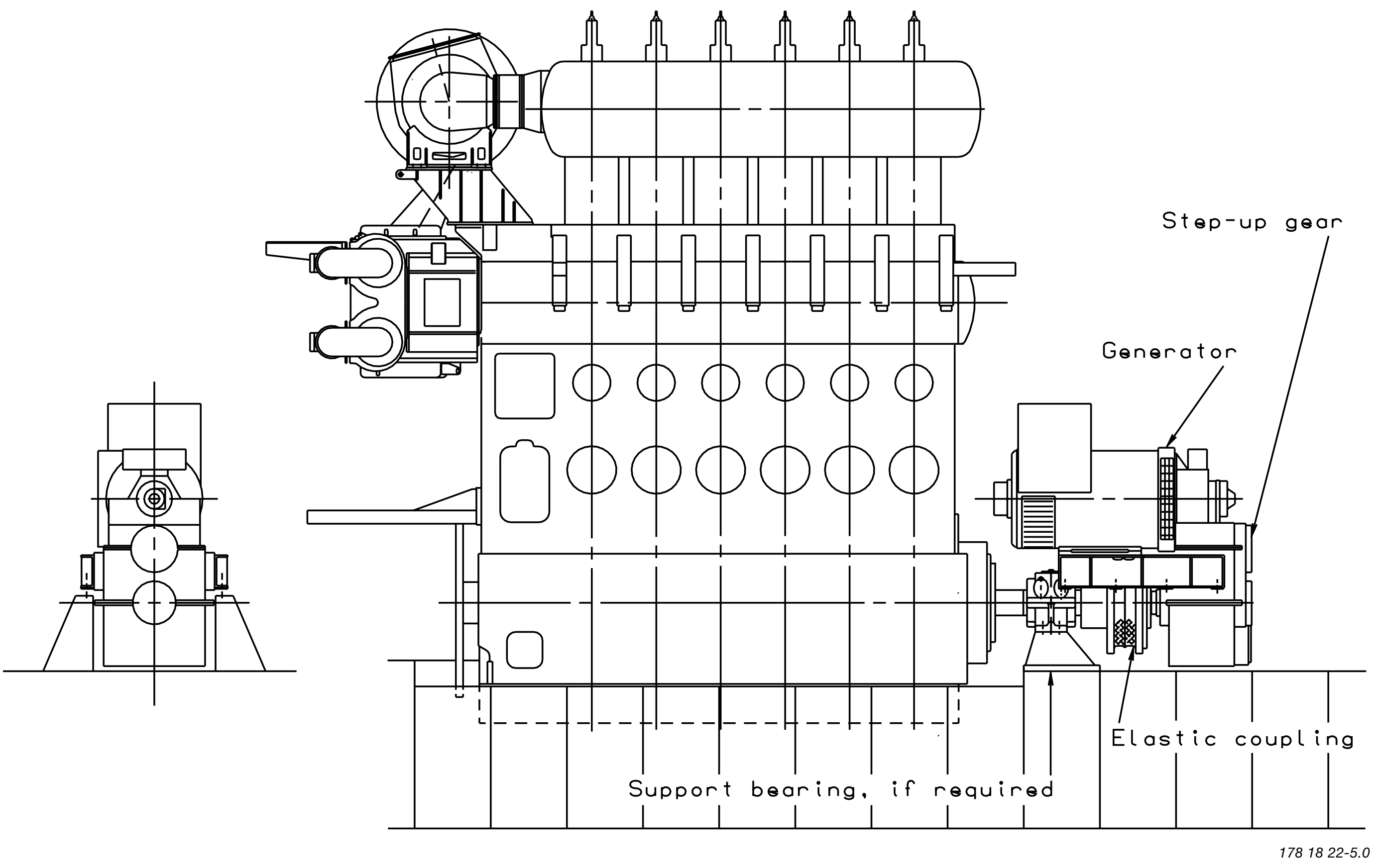


Fig. 4.11: Power Take Off (PTO) BW II/GCR

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. 4.12.

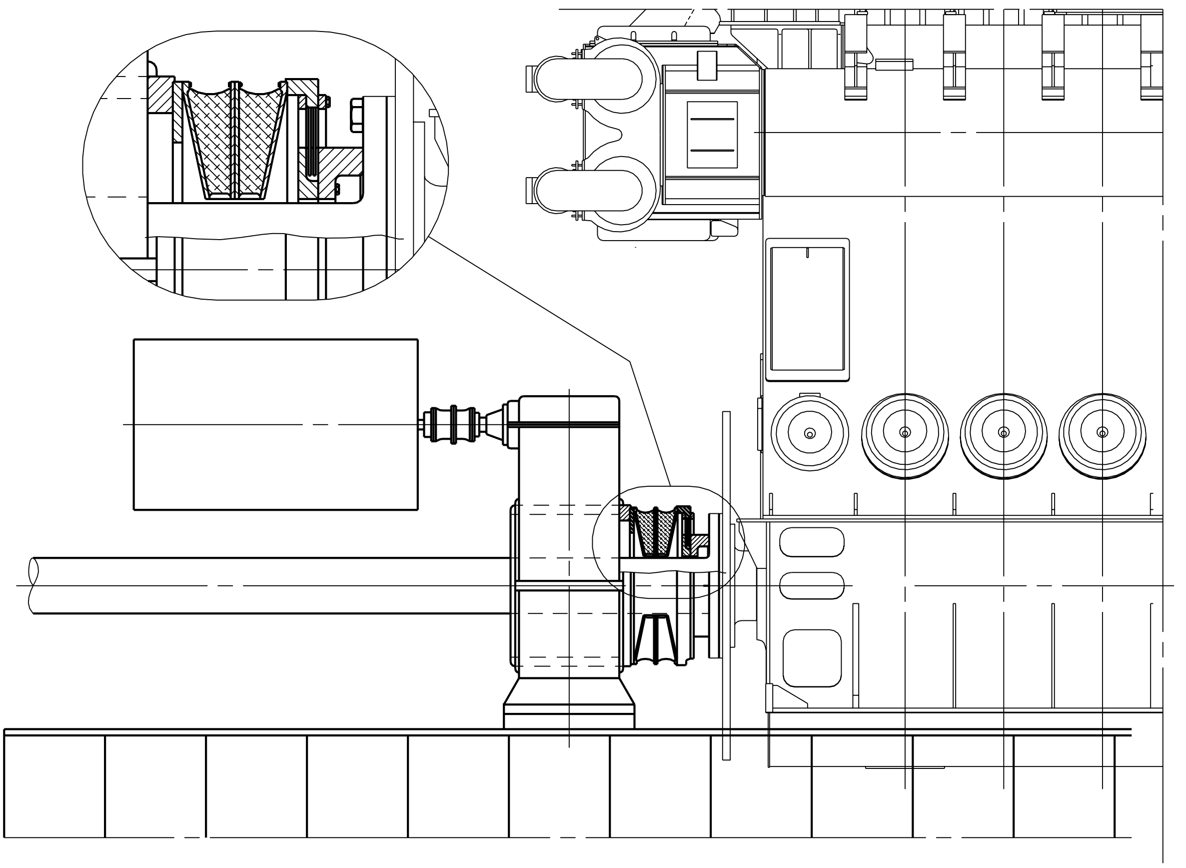
Generator step-up gear and flexible coupling integrated in the shaft line

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 electricity 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.



178 18 25-0.0

Fig. 4.12: 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 B&W 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 conical bolt clutch (CB-Clutch) 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 4.13.

The CB-Clutch is operated by hydraulic oil pressure which is supplied by the power pack used to control the CP-propeller.

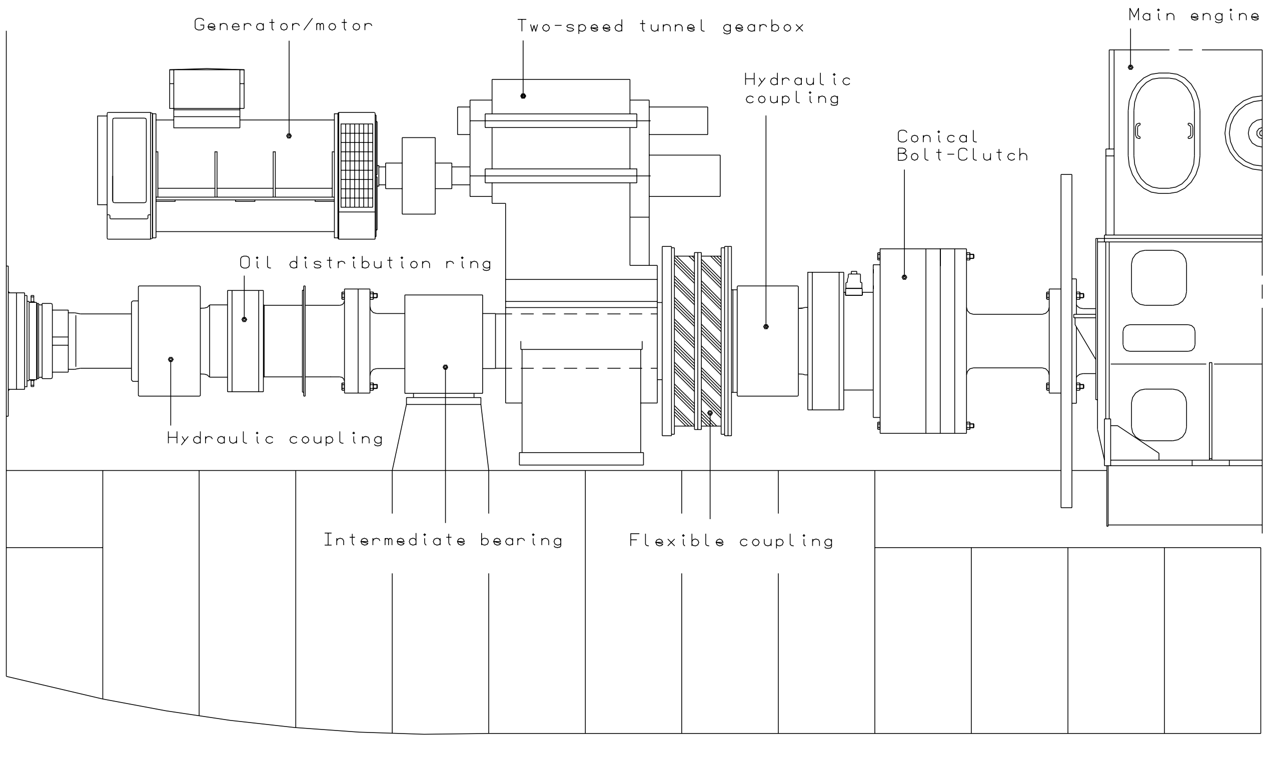
A thrust bearing, which transfers the auxiliary propulsion propeller thrust to the engine thrust bearing when the clutch is disengaged, is built into the CB-Clutch. When the clutch is engaged, the thrust is transferred statically to the engine thrust bearing through the thrust bearing built into the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



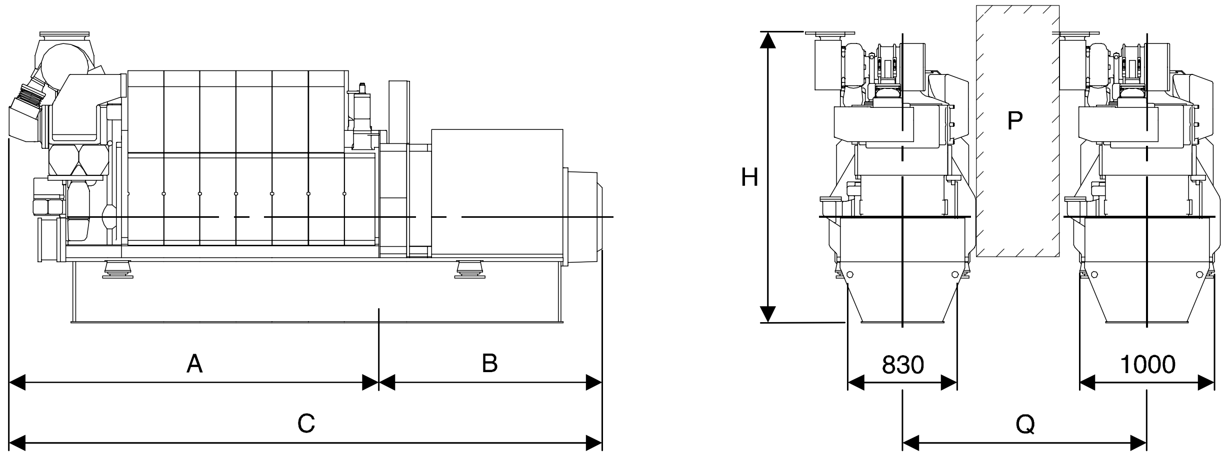
178 47 02-0.0

Fig. 4.13: Auxiliary propulsion system

L16/24 Holeby GenSet Data

Bore: 160 mm Stroke: 240 mm

	Power lay-out			
	1200 r/min	60 Hz	1000 r/min	50 Hz
	Eng. kW	Gen. kW	Eng. kW	Gen. kW
5L16/24	500	475	450	430
6L16/24	600	570	540	515
7L16/24	700	665	630	600
8L16/24	800	760	720	680
9L16/24	900	855	810	770



Cyl. no	A (mm)	* B (mm)	* C (mm)	H (mm)	**Dry weight GenSet (t)
5 (1000 rpm)	2751	1400	4151	2226	9.5
5 (1200 rpm)	2751	1400	4151	2226	9.5
6 (1000 rpm)	3026	1490	4516	2226	10.5
6 (1200 rpm)	3026	1490	4516	2226	10.5
7 (1000 rpm)	3301	1585	4886	2226	11.4
7 (1200 rpm)	3301	1585	4886	2266	11.4
8 (1000 rpm)	3576	1680	5256	2266	12.4
8 (1200 rpm)	3576	1680	5256	2266	12.4
9 (1000 rpm)	3851	1680	5531	2266	13.1
9 (1200 rpm)	3851	1680	5531	2266	13.1

178 33 87-4.3

P Free passage between the engines, width 600 mm and height 2000 mm.
Q Min. distance between engines: 1800 mm.

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

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

Fig. 4.14a: Power and outline of L16/24

L16/24 Holeby GenSet Data

Max. continuous rating at		Cyl.	5	6	7	8	9
1000/1200 r/min		Engine kW	450/500	540/600	630/700	720/800	810/900
1000/1200 r/min	50-60 Hz	Gen. kW	430/475	515/570	600/665	680/760	770/855
ENGINE DRIVEN PUMPS							
HT cooling water pump**	(2.0/3.2 bar)	m^3/h	10.9/13.1	12.7/15.2	14.5/17.4	16.3/19.5	18.1/21.6
LT cooling water pump**	(1.7/3.0 bar)	m^3/h	15.7/17.3	18.9/20.7	22.0/24.2	25.1/27.7	28.3/31.1
Lubricating oil	(3-5.0 bar)	m^3/h	21/25	23/27	24/29	26/31	28/33
EXTERNAL PUMPS							
Fuel oil feed pump	(4 bar)	m^3/h	0.14/0.15	0.16/0.18	0.19/0.21	0.22/0.24	0.24/0.27
Fuel booster pump	(8 bar)	m^3/h	0.41/0.45	0.49/0.54	0.57/0.63	0.65/0.72	0.73/0.81
COOLING CAPACITIES							
Lubricating oil		kW	79/85	95/102	110/161	126/136	142/153
Charge air LT		kW	43/50	51/60	60/63	68/80	77/90
*Flow LT at 36°C inlet and 44°C outlet engine		m^3/h	13.1/14.6	15.7/17.5	18.4/24.2	21.0/23.3	23.6/26.2
Jacket cooling		kW	107/125	129/150	150/152	171/200	193/225
Charge air HT		kW	107/114	129/137	150/146	171/182	193/205
*Flow HT at 36°C inlet and 80°C outlet engine		m^3/h	4.2/4.7	5.0/5.6	5.9/5.8	6.7/7.5	7.6/8.4
GAS DATA							
Exhaust gas flow		kg/h	3321/3675	3985/4410	4649/4701	5314/5880	5978/6615
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	3231/3575	3877/4290	4523/4561	5170/5720	5816/6435
STARTING AIR SYSTEM							
Air consumption per start		Nm^3	0.19	0.23	0.27	0.31	0.35
HEAT RADIATION							
Engine		kW	11/12	13/15	15/17	17/20	19/22
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 HT water is fixed to 80°C, and 44°C for LT water. At different inlet temperatures 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 change to (80-36)/(80-25)*100 = 80% of the original flow. If the temperature rises above 36°C, then the LT outlet will rise accordingly.

** Max. permission inlet pressure 2.0 bar.

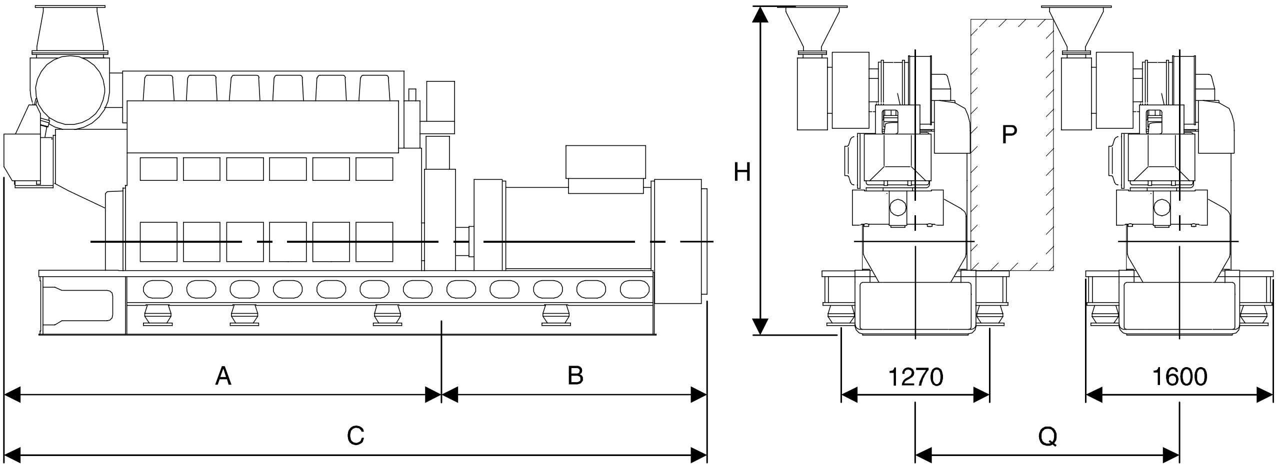
178 33 88-6.0

Fig. 4.14b: List of capacities for L16/24

L23/30H Holeby GenSet Data

Bore: 225 mm Stroke: 300 mm

	Power lay-out					
	720 r/min	60Hz	750 r/min	50Hz	900 r/min	60Hz
	Eng. kW	Gen. kW	Eng. kW	Gen. kW	Eng. kW	Gen. kW
5L23/30H	650	615	675	645		
6L23/30H	780	740	810	770	960	910
7L23/30H	910	865	945	900	1120	1060
8L23/30H	1040	990	1080	1025	1280	1215



Cyl. no	A (mm)	* B (mm)	* C (mm)	H (mm)	**Dry weight GenSet (t)
5 (720 rpm)	3369	2155	5524	2383	18.0
5 (750 rpm)	3369	2155	5524	2383	17.6
6 (720 rpm)	3738	2265	6004	2383	19.7
6 (750 rpm)	3738	2265	6004	2383	19.7
6 (900 rpm)	3738	2265	6004	2815	21.0
7 (720 rpm)	4109	2395	6504	2815	21.4
7 (750 rpm)	4109	2395	6504	2815	21.4
7 (900 rpm)	4109	2395	6504	2815	22.8
8 (720 rpm)	4475	2480	6959	2815	23.5
8 (750 rpm)	4475	2480	6959	2815	22.9
8 (900 rpm)	4475	2340	6815	2815	24.5

178 34 53-3.1

P Free passage between the engines, width 600 mm and height 2000 mm.
Q Min. distance between engines: 2250 mm.

* Depending on alternator
** Weight included a standard alternator, make A. van Kaick

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

Fig. 4.15a: Power and outline of L23/30H

L23/30H Holeby GenSet Data

Max. continuous rating at		Cyl.	5	6	7	8
720/750 r/min		Engine kW	650/675	780/810	910/945	1040/1080
900 r/min		Engine kW		960	1120	1280
720/750 r/min	60/50 Hz	Gen. kW	615/645	740/770	865/900	990/1025
900 r/min	60 Hz	Gen. kW		910	1060	1215
ENGINE-DRIVEN PUMPS		**720, 750/900 r/min**				
Fuel oil feed pump	(5.5-7.5 bar)	m^3/h	1.0/1.3	1.0/1.3	1.0/1.3	1.0/1.3
LT cooling water pump	(1-2.5 bar)	m^3/h	55/69	55/69	55/69	55/69
HT cooling water pump	(1-2.5 bar)	m^3/h	36/45	36/45	36/45	36/45
Lub. oil main pump	(3-5/3.5-5 bar)	m^3/h	16/20	16/20	20/20	20/20
SEPARATE PUMPS						
Fuel oil feed pump***	(4-10 bar)	m^3/h	0.19	0.23/0.29	0.27/0.34	0.30/0.39
LT cooling water pump*	(1-2.5 bar)	m^3/h	35/44	42/52	48/61	55/70
LT cooling water pump**	(1-2.5 bar)	m^3/h	48/56	54/63	60/71	73/85
HT cooling water pump	(1-2.5 bar)	m^3/h	20/25	24/30	28/35	32/40
Lub. oil stand-by pump	(3-5/3.5-5 bar)	m^3/h	14/16	15/17	16/18	17/19
COOLING CAPACITIES						
LUBRICATING OIL						
Heat dissipation		kW	69/97	84/117	98/137	112/158
LT cooling water quantity*		m^3/h	5.3/6.2	6.4/7.5	7.5/8.8	8.5/10.1
SW LT cooling water quantity**		m^3/h	18	18	18	25
Lub. oil temp. inlet cooler		°C	67	67	67	67
LT cooling water temp. inlet cooler		°C	36	36	36	36
CHARGE AIR						
Heat dissipation		kW	251/310	299/369	348/428	395/487
LT cooling water quantity		m^3/h	30/38	36/46	42/53	48/61
LT cooling water inlet cooler		°C	36	36	36	36
JACKET COOLING						
Heat dissipation		kW	182/198	219/239	257/281	294/323
HT cooling water quantity		m^3/h	20/25	24/30	28/35	32/40
HT cooling water temp. inlet cooler		°C	77	77	77	77
GAS DATA						
Exhaust gas flow		kg/h	5510/6980	6620/8370	7720/9770	8820/11160
Exhaust gas temp.		°C	310/325	310/325	310/325	310/325
Max. allowable back. press.		bar	0.025	0.025	0.025	0.025
Air consumption		kg/h	5364/6732	6444/8100	7524/9432	8604/10800
STARTING AIR SYSTEM						
Air consumption per start		Nm^3	0.30	0.35	0.40	0.45
HEAT RADIATION						
Engine		kW	21/26	25/32	29/37	34/42
Generator		kW	(See separate data from generator maker)			

Please note that for the 750 r/min engine the heat dissipation, capacities of gas and engine-driven pumps are 4% higher than stated at the 720 r/min engine. If LT cooling is sea water, the LT inlet is 32° C instead of 36°C.

These data are 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 no 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.

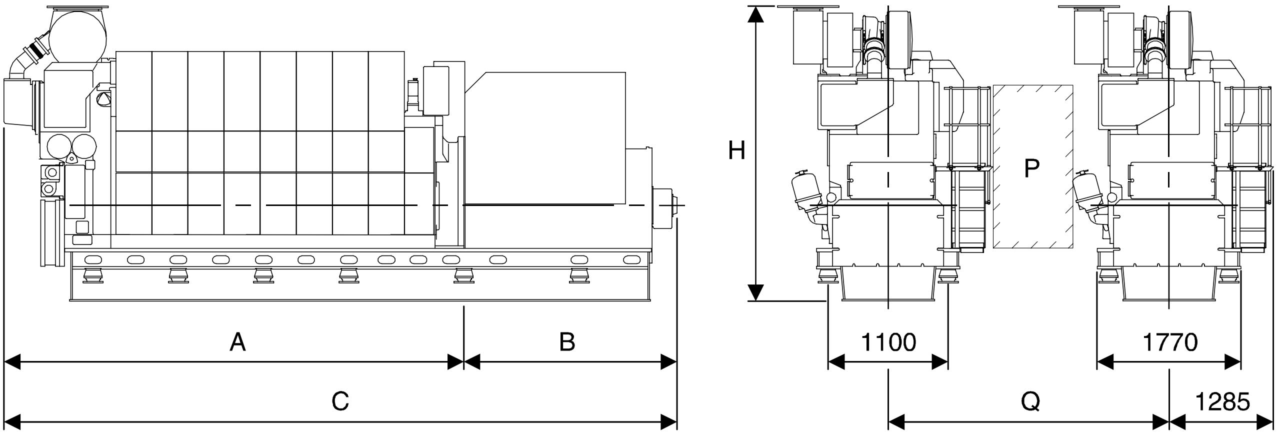
178 34 54-5.1

Fig. 4.15b: List of capacities for L23/30H

L27/38 Holeby GenSet Data

Bore: 270 mm Stroke: 380 mm

	Power lay-out			
	720 r/min	60Hz	750 r/min	50Hz
	Eng. kW	Gen. kW	Eng. kW	Gen. kW
5L27/38	1500	1425	1600	1520
6L27/38	1800	1710	1920	1825
7L27/38	2100	1995	2240	2130
8L27/38	2400	2280	2560	2430
9L27/38	2700	2565	2880	2735



Cyl. no	A (mm)	* B (mm)	* C (mm)	H (mm)	**Dry weight GenSet (t)
5 (720 rpm)	4346	2486	6832	3705	42.0
5 (750 rpm)	4346	2486	6832	3705	42.3
6 (720 rpm)	4791	2766	7557	3705	45.8
6 (750 rpm)	4791	2766	7557	3717	46.1
7 (720 rpm)	5236	2766	8002	3717	52.1
7 (750 rpm)	5236	2766	8002	3717	52.1
8 (720 rpm)	5681	2986	8667	3797	56.5
8 (750 rpm)	5681	2986	8667	3797	58.3
9 (720 rpm)	6126	2986	9112	3797	61.8
9 (750 rpm)	6126	2986	9112	3797	63.9

178 33 89-8.1

P Free passage between the engines, width 600 mm and height 2000 mm.
Q Min. distance between engines: 3000 mm. (without gallery) and 3400 mm. (with gallery)

* Depending on alternator
** Weight included a standard alternator

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

Fig. 4.16a: Power and outline of L27/38

L27/38 Holeby GenSet Data

Max. continuous rating at		Cyl.	5	6	7	8	9
720/750 r/min		Engine kW	1500/1600	1800/1920	2100/2240	2400/2560	2700/2880
720/750 r/min	60/50 Hz	Gen. kW	1425/1520	1710/1825	1995/2130	2280/2430	2565/2735
ENGINE DRIVEN PUMPS							
HT cooling water pump	(1-2.5 bar)	m^3/h	36/39	44/46	51/54	58/62	65/70
LT cooling water pump	(1-2.5 bar)	m^3/h	36/39	44/46	51/54	58/62	65/70
Lubricating oil pump	(4.5-5.5 bar)	m^3/h	30/32	36/38	42/45	48/51	54/58
EXTERNAL PUMPS							
Fuel oil feed pump	(4 bar)	m^3/h	0.45/0.48	0.54/0.58	0.63/0.67	0.72/0.77	0.81/0.86
Fuel booster pump	(8 bar)	m^3/h	1.35/1.44	1.62/1.73	1.89/2.02	2.16/2.30	2.43/2.59
COOLING CAPACITIES							
Lubricating oil		kW	264/282	317/338	370/395	423/451	476/508
Charge air LT		kW	150/160	180/192	210/224	240/256	270/288
*Flow LT at 36°C inlet and 44°C outlet		m^3/h	35.8/38.2	42.9/45.8	50.1/53.4	57.2/61.1	64.4/68.7
Jacket cooling		kW	264/282	317/338	370/395	423/451	476/508
Charge air HT		kW	299/319	359/383	419/447	479/511	539/575
*Flow HT at 36°C inlet and 80°C outlet		m^3/h	11.1/11.8	13.3/14.2	15.5/16.5	17.7/18.9	19.9/21.2
GAS DATA							
Exhaust gas flow		kg/h	11310/12064	13572/14476	15834/16889	18096/19302	20358/21715
Exhaust gas temp.		°C	350	350	350	350	350
Max. allowable back press.		bar	0.025	0.025	0.025	0.025	0.025
Air consumption		kg/h	11010/11744	13212/14093	15414/16442	17616/18790	19818/21139
STARTING AIR SYSTEM							
Air consumption per start		Nm^3	1.78	1.82	1.86	1.90	1.94
HEAT RADIATION							
Engine		kW	54/57	64/69	75/80	86/92	97/103
Generator		kW	(see separate data from the generator maker)				

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

* The outlet temperature of the HT water is fixed to 80°C, and 44°C for 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)/(44-25)*100 = 53% of the original flow.

The HT flow will change to (80-36)/(80-25)*100 = 80% of the original flow.

** Max. permission inlet pressure 2.0 bar.

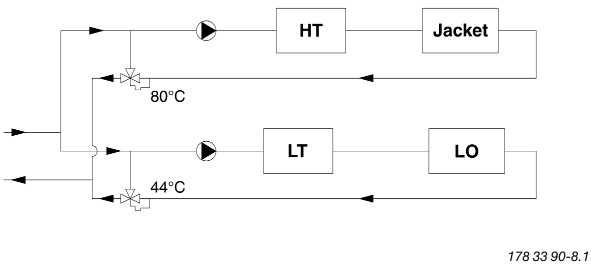
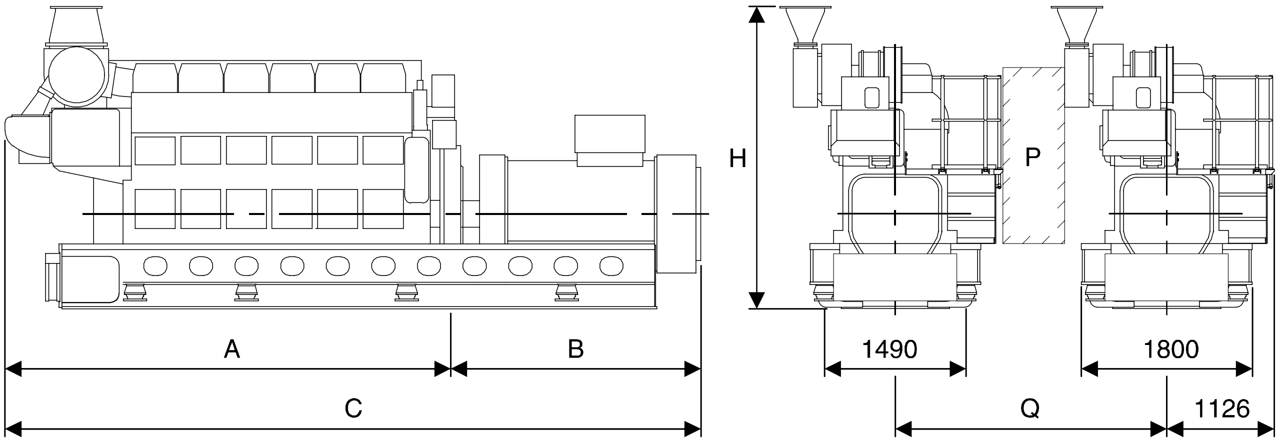


Fig. 4.16b: List of capacities for L27/38

L28/32H Holeby GenSet Data

Bore: 280 mm Stroke: 320 mm

	Power lay-out			
	720 r/min	60Hz	750 r/min	50Hz
	Eng. kW	Gen. kW	Eng. kW	Gen. kW
5L28/32H	1050	1000	1100	1045
6L28/32H	1260	1200	1320	1255
7L28/32H	1470	1400	1540	1465
8L28/32H	1680	1600	1760	1670
9L28/32H	1890	1800	1980	1880



Cyl. no	A (mm)	* B (mm)	* C (mm)	H (mm)	**Dry weight GenSet (t)
5 (720 rpm)	4279	2400	6679	3184	32.6
5 (750 rpm)	4279	2400	6679	3184	32.3
6 (720 rpm)	4759	2510	7269	3184	36.3
6 (750 rpm)	4759	2510	7269	3184	36.3
7 (720 rpm)	5499	2680	8179	3374	39.4
7 (750 rpm)	5499	2680	8179	3374	39.4
8 (720 rpm)	5979	2770	8749	3374	40.7
8 (750 rpm)	5979	2770	8749	3374	40.6
9 (720 rpm)	6199	2690	8889	3534	47.1
9 (750 rpm)	6199	2690	8889	3534	47.1

178 33 92-1.3

P Free passage between the engines, width 600 mm and height 2000 mm.
Q Min. distance between engines: 2655 mm. (without gallery) and 2850 mm. (with gallery)

* Depending on alternator
** Weight included a standard alternator, make A. van Kaick

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

Fig. 4.17a: Power and outline of L28/32H

L28/32H Holeby GenSet Data

Max. continuous rating at		Cyl.	5	6	7	8	9
720/750 r/min		Engine kW	1050/1100	1260/1320	1470/1540	1680/1760	1890/1980
720/750 r/min	60/50 Hz	Gen. kW	1000/1045	1200/1255	1400/1465	1600/1670	1800/1880
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
LT cooling water pump	(1-2.5 bar)	m^3/h	45	60	75	75	75
HT cooling water pump	(1-2.5 bar)	m^3/h	45	45	60	60	60
Lub. oil main pump	(3-5 bar)	m^3/h	24	24	33	33	33
SEPARATE PUMPS							
Fuel oil feed pump***	(4-10 bar)	m^3/h	0.31	0.36	0.43	0.49	0.55
LT cooling water pump*	(1-2.5 bar)	m^3/h	45	54	65	77	89
LT cooling water pump**	(1-2.5 bar)	m^3/h	65	73	95	105	115
HT cooling water pump	(1-2.5 bar)	m^3/h	37	45	50	55	60
Lub. oil stand-by pump	(3-5 bar)	m^3/h	22	23	25	27	28
COOLING CAPACITIES							
LUBRICATING OIL							
Heat dissipation		kW	105	127	149	172	194
LT cooling water quantity*		m^3/h	7.8	9.4	11.0	12.7	14.4
SW LT cooling water quantity**		m^3/h	28	28	40	40	40
Lub. oil temp. inlet cooler		°C	67	67	67	67	67
LT cooling water temp. inlet cooler		°C	36	36	36	36	36
CHARGE AIR							
Heat dissipation		kW	393	467	541	614	687
LT cooling water quantity		m^3/h	37	45	55	65	75
LT cooling water inlet cooler		°C	36	36	36	36	36
JACKET COOLING							
Heat dissipation		kW	264	320	375	432	489
HT cooling water quantity		m^3/h	37	45	50	55	60
HT cooling water temp. inlet cooler		°C	77	77	77	77	77
GAS DATA							
Exhaust gas flow		kg/h	9260	11110	12970	14820	16670
Exhaust gas temp.		°C	305	305	305	305	305
Max. allowable back. press.		bar	0.025	0.025	0.025	0.025	0.025
Air consumption		kg/h	9036	10872	12672	14472	16308
STARTING AIR SYSTEM							
Air consumption per start		Nm^3	0.7	0.8	0.9	1.0	1.1
HEAT RADIATION							
Engine		kW	26	32	38	44	50
Generator		kW	(See separate data from generator maker)				

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

These data are 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 no 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.

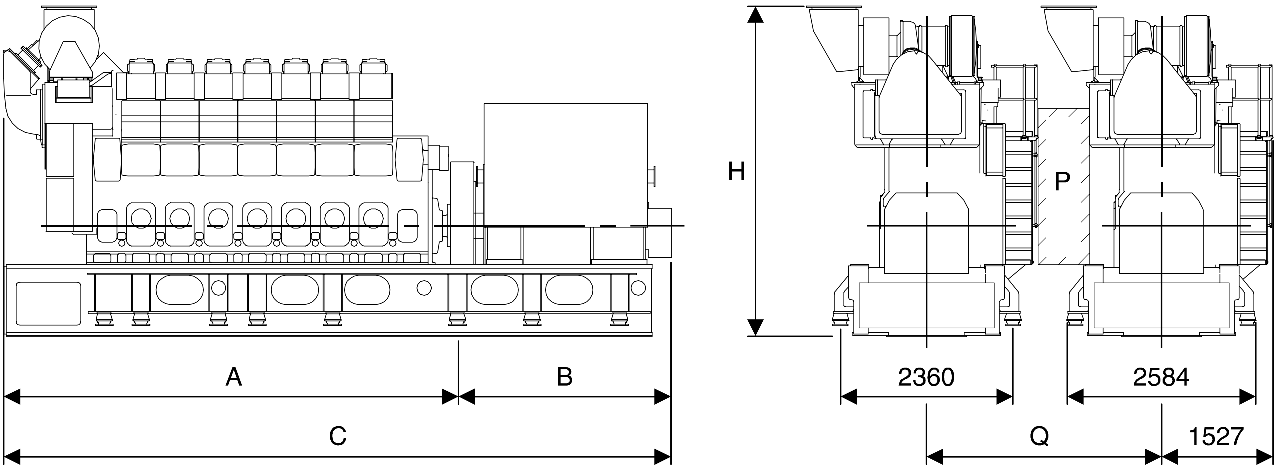
178 33 93-3.1

Fig. 4.17b: List of capacities for L28/32H

L32/40 Holeby GenSet Data

Bore: 320 mm Stroke: 400 mm

	Power lay-out			
	720 r/min	60Hz	750 r/min	50Hz
	Eng. kW	Gen. kW	Eng. kW	Gen. kW
5L32/40	2290	2185	2290	2185
6L32/40	2750	2625	2750	2625
7L32/40	3205	3060	3205	3060
8L32/40	3665	3500	3665	3500
9L32/40	4120	3935	4120	3935



Cyl. no	A (mm)	* B (mm)	* C (mm)	H (mm)	**Dry weight GenSet (t)
6 (720 rpm)	6340	3415	9755	4510	75.0
6 (750 rpm)	6340	3415	9755	4510	75.0
7 (720 rpm)	6870	3415	10285	4510	79.0
7 (750 rpm)	6870	3415	10285	4510	79.0
8 (720 rpm)	7400	3635	11035	4780	87.0
8 (750 rpm)	7400	3635	11035	4780	87.0
9 (720 rpm)	7930	3635	11565	4780	91.0
9 (750 rpm)	7930	3635	11565	4780	91.0

P Free passage between the engines, width 600 mm and height 2000 mm.
Q Min. distance between engines: 2835 mm. (without gallery) and 3220 mm. (with gallery)

178 34 55-7.2

* Depending on alternator
** Weight included an alternator, Type B16, Make Siemens

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

Fig. 4.18a: Power and outline of L32/40

L32/40 Holeby GenSet Data

480 kW/Cyl. - two stage air cooler

Max. continuous rating at		Cyl.	6	7	8	9
720 r/min		Engine kW	2880	3360	3840	4320
720 r/min	60 Hz	Gen. kW	2750	3210	3665	4125
ENGINE-DRIVEN PUMPS						
LT cooling water pump	(3 bar)	m^3/h	36	42	48	54
HT cooling water pump	(3 bar)	m^3/h	36	42	48	54
Lub. oil main pump	(8 bar)	m^3/h	75	88	100	113
SEPARATE PUMPS						
Fuel oil feed pump	(4 bar)	m^3/h	0.9	1.0	1.2	1.3
Fuel oil booster pump	(8 bar)	m^3/h	2.6	3.0	3.5	3.9
Lub. oil stand-by pump	(8 bar)	m^3/h	75	88	100	113
Prelubricating oil pump	(8 bar)	m^3/h	19	22	26	29
LT cooling water pump	(3 bar)	m^3/h	36	42	48	54
HT cooling water pump	(3 bar)	m^3/h	36	42	48	54
COOLING CAPACITIES						
LT charge air		kW	303	354	405	455
Lubricating oil		kW	394	460	526	591
Flow LT at 36° C		m^3/h	36	42	48	54
HT charge air		kW	801	934	1067	1201
Jacket cooling		kW	367	428	489	550
Flow HT 80° C outlet engine		m^3/h	36	42	48	54
GAS DATA						
Exhaust gas flow		kg/h	22480	26227	29974	33720
Exhaust gas temp.		°C	360	360	360	360
Max. allowable back. press.		bar	0.025	0.025	0.025	0.025
Air consumption		kg/h	21956	25615	29275	32934
STARTING AIR SYSTEM						
Air consumption per start		Nm^3	0.97	1.13	1.29	1.45
HEAT RADIATION						
Engine		kW	137	160	183	206
Generator		kW	(See separate data from generator maker)			

The stated heat balances are based on 100% load and tropical condition, the flows are based on ISO ambient condition.

178 34 56-9.1

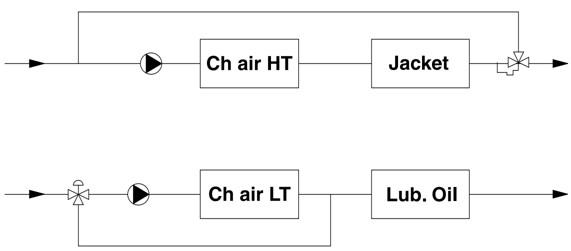


Fig. 4.18b: List of capacities for L32/40

Installation Aspects 5

5 Installation Aspects

The figures shown in this chapter are intended as an aid at the project stage. The data is subject to change without notice, and binding data is to be given by the engine builder in the “Installation Documentation” mentioned in section 10.

Please note that the newest version of most of the drawings of this section can be downloaded from our website on www.manbw.dk under 'Products', 'Marine Power', 'Two-stroke Engines' where you then choose the engine type.

Space Requirements for the Engine

The space requirements stated in Fig. 5.01 are valid for engines rated at nominal MCR (L_1).

Additional space needed for engines equipped with PTO is stated in section 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.

Overhaul of Engine

The overhaul heights stated from the centre of the crankshaft to the crane hook are for vertical or tilted lift, see note F in Fig. 5.01.

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. 5.02 and 5.03.

Please note that the height given by using a double-jib crane is from the centre of the crankshaft to the lower edge of the deck beam, see note E in Fig. 5.01.

Only a 2 x 1.6 tons double-jib crane can be used for the S60MC engine as this crane has been individually designed for the engine.

The capacity of a normal engine room crane has to be minimum 3.2 tons.

For the recommended area to be covered by the engine room crane and regarding crane for dismatling the turbochargers, see figs. 5.01e and 5.01f.

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.

Engine Outline

The total length of the engine at the crankshaft level depends on the equipment fitted on the fore end of the engine, such as adjustable counterweights, tuning wheel, moment compensators and PTO which are shown as alternatives in Figs. 5.04, 5.05 and 5.06.

Engine Masses and Centre of Gravity

The partial and total engine masses appear from section 9, “Dispatch Pattern”, to which the masses of water and oil in the engine, Fig. 5.08, are to be added. The centre of gravity is shown in Fig. 5.07, including the water and oil in the engine, but without moment compensators or PTO.

Gallery Outline

Fig. 5.09,5.10 and 5.11 show the gallery outline for engines with high efficiency turbochargers and rated at nominal MCR (L1).

Engine Pipe Connections

The position of the external pipe connections on the engine are stated in Figs. 5.12,and 5.13 and the corresponding lists of counterflanges for pipes and turbocharger in Figs. 5.14 and 5.15, respectively.

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 Seating and Arrangement of Holding Down Bolts

The dimensions of the seating stated in Figs. 5.16 and 5.17 are for guidance only.

The engine is basically mounted on epoxy chocks 4 82 102 in which case the underside of the bed-plate's lower flanges has no taper.

The epoxy types approved by MAN B&W Diesel A/S are:

"Chockfast Orange PR 610 TCF"
from ITW Philadelphia Resins Corporation, USA, and
"Epocast 36"
from H.A. Springer – Kiel, Germany

The engine may alternatively, be mounted on cast iron chocks (solid chocks 4 82 101), in which case the underside of the bedplate's lower flanges is with taper 1:100.

Top Bracing

The so-called guide force moments are caused by the transverse reaction forces acting on the crossheads due to the connecting rod/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 (or piston skirt in the case of a trunk engine), and together they form a guide force moment.

The 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.

For engines with fewer than seven cylinders, this guide force moment tends to rock the engine in transverse direction, and for engines with seven cylinders or more, it tends to twist the engine. Both forms are shown in section 7 dealing with vibrations. The guide force moments are harmless to the engine, however, they may 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 B&W Diesel recommend that a 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, then we have no objection to the top bracing being dismounted and the rest of the series produced without top bracing.

It is our experience that especially a seven-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 top bracing increases the natural frequency of the above-mentioned vibrating system.

The top bracing is normally placed on the exhaust side of the engine (4 83 110), but it can alternatively be placed on the camshaft side, option: 4 83 111, see Figs 5.18, and 5.19.

The top bracing is to be made by the shipyard in accordance with MAN B&W instructions.

Mechanical top bracing

The mechanical top bracing, option: 4 83 112 shown in Figs. 5.18 and 5.19 comprises stiff connections (links) with friction plates.

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

Force per bracing . . . . ±93 kN
Maximum horizontal deflection at the
link's points of attachment to the hull. . . . 0.25 mm
Minimum horizontal rigidity in MN/m. . . . . . 140 kN

Hydraulic top bracing

They hydraulic trop bracings are available in two designs:

with pump station, option 4 83 122, or
without pump station, option 4 83 123

See Figs. 5.21, and 5.22.

The hydraulically adjustable top bracing is an alternative to our standard top bracing and is intended for application in vessels where hull deflection is foreseen to exceed the usual level.

Similar to our standard mechanical top bracing, this hydraulically adjustable top bracing is intended for one side mounting, either the exhaust side (alternative 1), or the camshaft side (alternative 2).

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

It should be noted that only two hydraulic cylinders are to be installed for engines with 4 to 7 cylinders and four hydraulic cylinders are to be installed for engines with 8 cylinders.

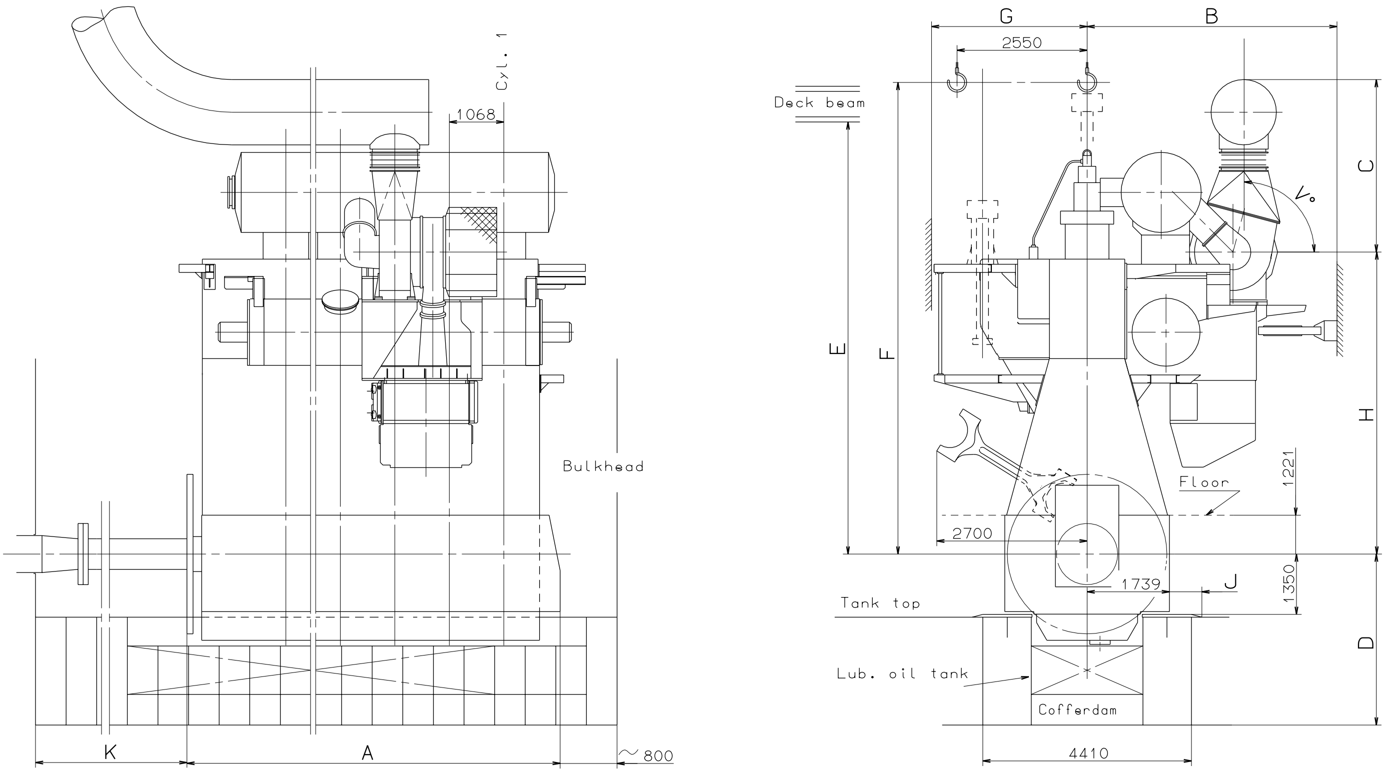
Earthing Device

In some cases, it has been found that the difference in the electrical potential between the hull and the propeller shaft (due to the propeller being immersed in seawater) has caused spark erosion on the main bearings and journals of the engine.

A potential difference of less than 80 mV is harmless to the main bearings so, in order to reduce the potential between the crankshaft and the engine structure (hull), and thus prevent spark erosion, we recommend the installation of a highly efficient earthing device.

The sketch Fig. 5.25 shows the layout of such an earthing device, i.e. a brush arrangement which is able to keep the potential difference below 50 mV.

We also recommend the installation of a shaft-hull mV-meter so that the potential, and thus the correct functioning of the device, can be checked.



Normal centreline distance for twin engine installation: minimum 6250/5350 mm (5350 mm for common gallery for starboard and port design engines).

Please note that there must be a free space (100 x 80) at the outer part of the bedplate-frame box connection reqired for alignment of the engine on board by laser/piano wire, etc.

The dimensions given in the table are in mm and are for guidance only.

If dimensions cannot be fulfilled, please contact MAN B&W Diesel A/S or our local representative.

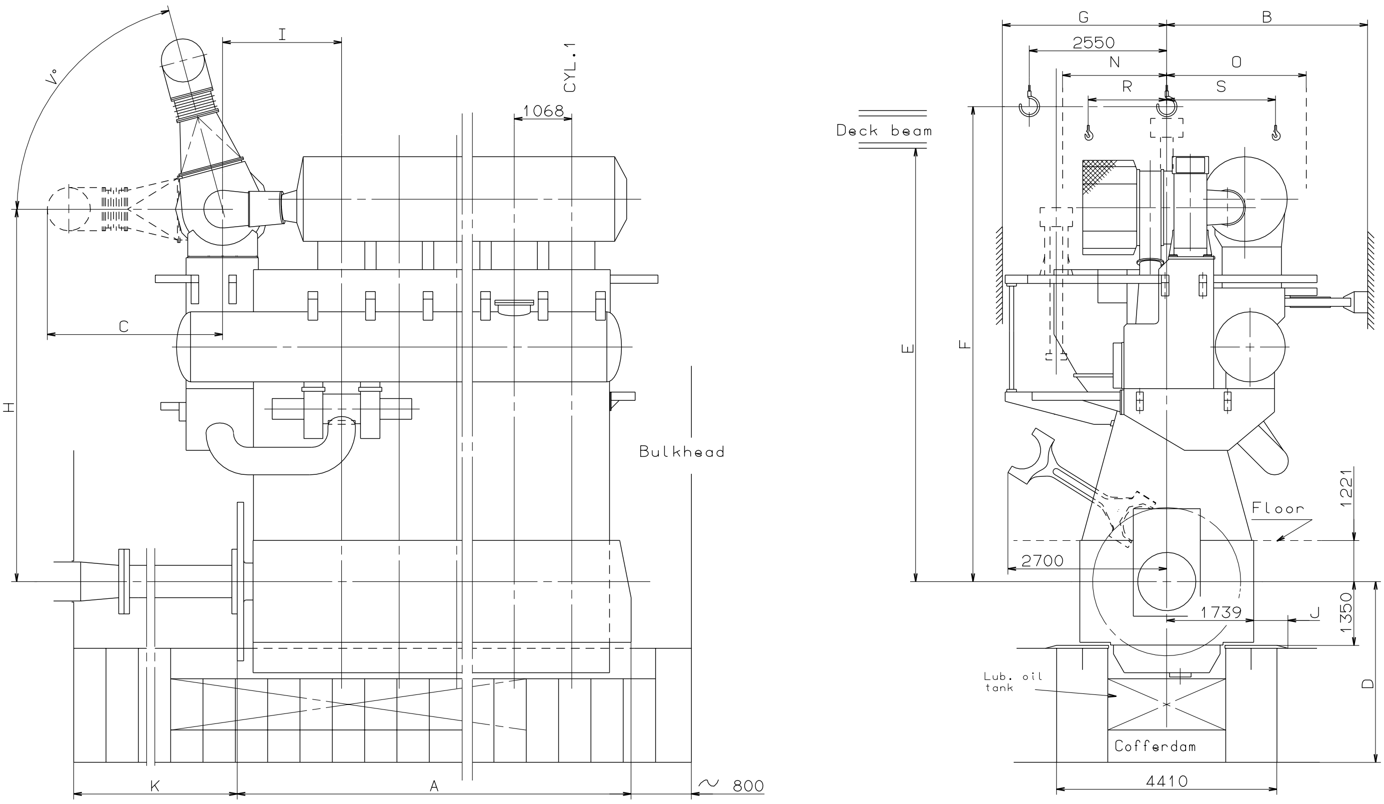
178 47 54-6.0

Fig. 5.01a: Space requirement for the engine, turbocharger on exhaust side (4 59 122)

Cyl. No.		4	5	6	7	8		
A	min.	6587	7655	8723	9791	10859	Fore end: A minimum shows basic engine A maximum shows engine with built on tuning wheel For PTO: See corresponding space requirement	
	max.	6942	8010	9078	10146	11214		
B		4710	4710	5260	5260	5260	MAN B&W turbocharger	The required space to the engine room casing includes top bracing
		4720	4720	5260	5260	5260	ABB turbocharger	
		-	-	-	-	-	MHI turbocharger	
C		3247	3547	3825	4025	4330	MAN B&W turbocharger	Dimensions according to turbocharger choice at nominal MCR
		3074	3374	3632	3832	4137	ABB turbocharger	
		-	-	-	-	-	MHI turbocharger	
D		3470	3555	3650	3680	3750	The dimension includes a cofferdam of 600 mm and must fulfil minimum height to tanktop according to classification rules	
E		9550					The distance from crankshaft centreline to lower edge of deck beam, when using MAN B&W Double-Jib Crane	
F		10500					Vertical lift of piston, one cylinder cover stud removed	
		9700					Tilted lift of piston, one cylinder cover stud removed	
G		3400					See top bracing arrangement, if top bracing fitted on camshaft side	
H		6764	6764	6935	6935	6935	MAN B&W turbocharger	Dimensions according to turbocharger choice at nominal MCR
		6520	6520	6897	6897	6897	ABB turbocharger	
		-	-	-	-	-	MHI turbocharger	
J		490					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	
V		15°, 30°, 45°, 60°, 75°, 90°					Max. 30° when engine room has min. headroom above the turbocharger	

178 47 54-6.0

Fig. 5.01b: Space requirement for the engine, turbocharger on exhaust side (4 59 122)



Normal minimum centreline distance for twin engine installation: 6250/5350 mm (5350 mm for common gallery for starboard and port design engines).

Please note that there must be a free space (100 x 80) at the outer part of the bedplate-frame box connection reqired for alignment of the engine on board by laser/piano wire, etc.

The dimensions given in the table are in mm and are for guidance only.

If dimensions cannot be fulfilled, please contact MAN B&W Diesel A/S or our local representative.

178 47 55-8.0

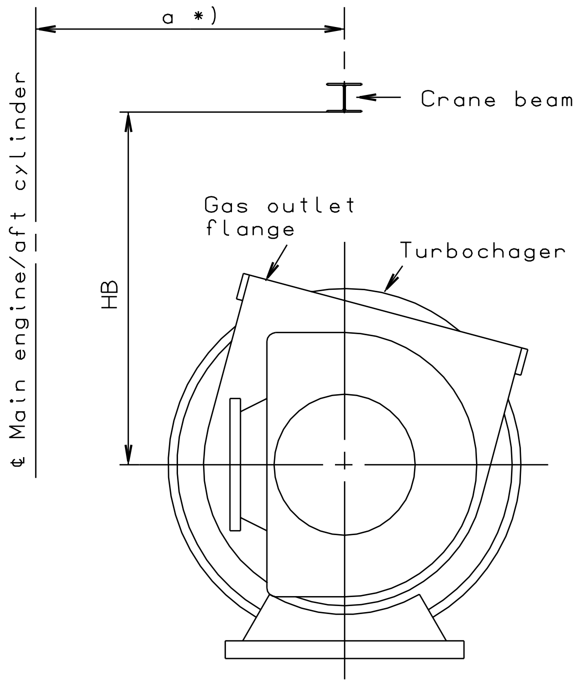
Fig. 5.01c: Space requirement for the engine, turbocharger on aft end, option: 4 59 124

Cyl. No.		4	5	6	7	8		
A	min.	6587	7655	8723	9791	10859	Fore end: A minimum shows basic engine A maximum shows engine with built on tuning wheel	
	max.	6942	8010	9078	10146	11214	For PTO: See corresponding space requirement	
B		3150					MAN B&W, ABB and MHI turbochargers	The required space to the engine room casing includes top bracing
C		3650	4062	4385	4660	5040	MAN B&W turbocharger	Dimensions according to turbocharger choice at nominal MCR
		3471	3883	4185	4460	4840	ABB turbocharger	
		-	-	-	-	-	MHI turbocharger	
D		3470	3555	3650	3680	3750	The dimension includes a cofferdam of 600 mm and must fulfil minimum height to tanktop according to classification rules	
E		9550					The distance from crankshaft centreline to lower edge of deck beam, when using MAN B&W Double-Jib Crane	
F		10500					Vertical lift of piston, one cylinder cover stud removed	
		9700					Tilted lift of piston, one cylinder cover stud removed	
G		3400 1)					See top bracing arrangement, if top bracing fitted on camshaft side	
H		7776	7776	7932	7932	7932	MAN B&W turbocharger	Dimensions according to turbocharger choice at nominal MCR
		7746	7746	7841	7841	7841	ABB turbocharger	
		-	-	-	-	-	MHI turbocharger	
I		2532	2532	2644	2644	2644	MAN B&W turbocharger	Dimensions according to turbocharger choice at nominal MCR
		2550	2550	2736	2736	2736	ABB turbocharger	
		-	-	-	-	-	MHI turbocharger	
J		490					Space for tightening control of holding down bolts	
N		2029					The distances cover required space and hook travelling width for turbocharger NA70/T9	
O		2148						
R		1602						
S		2088						
V		0°, 15°, 30°, 45°, 60°, 75°, 90°					Max. 15° when engine room has min. headroom above the turbocharger	

1) Space for air cooler element overhaul: 3400 mm

178 47 55-8.0

Fig. 5.01d: Space requirement for the engine, turbocharger on aft end, option: 4 59 124



178 32 20-8.0

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.

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

The crane beam is used for lifting the following components:

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

The sketch shows a turbocharger and a crane beam that can lift the components mentioned.

The crane beam(s) is/are to be located 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).

Fig. 5.01e: Crane beams for overhaul of turbocharger

MAN B&W turbocharger related figures

		Type NA		
		48	57	70
W	kg	1000	2000	3000
HB	mm	1700	1800	2300

ABB turbocharger related figures

		Type VTR		
		454	564	714
W	kg	1000	2000	3000
HB	mm	1400	1700	2200

		Type TPL			
		73	77	80	85
W	kg	1000	1000	1500	2200
HB	mm	800	900	1000	1200

MHI turbocharger related figures

		Type MET			
		53SD 53SE	66SD 66SE	71SD 71SE	83SD 83SE
W	kg	1500	3000	4000	6000
HB	mm	1500	1800	~2000	2200

The table indicates the position of the crane beam(s) in the vertical level related to the centre of the turbocharger(s).

The crane beam location in horizontal direction

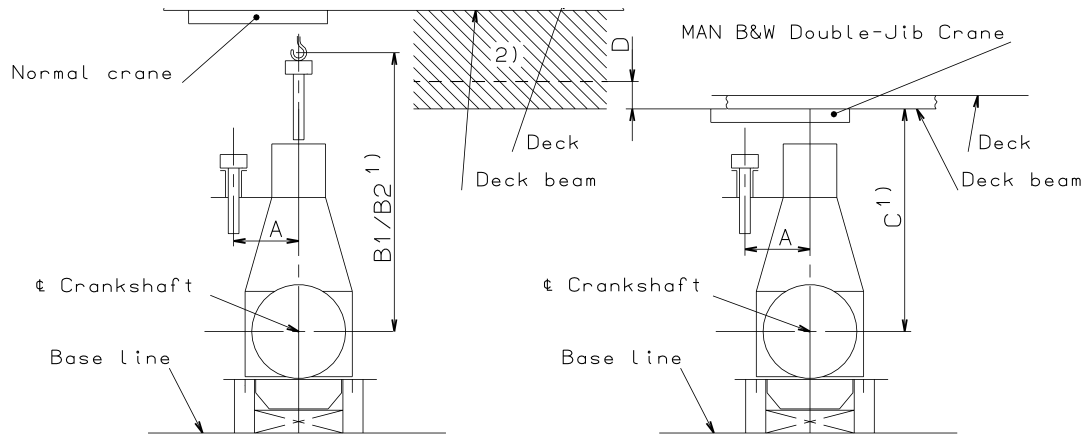
*) Engines with the turbocharger(s) located on the exhaust side.
The letter ‘a’ indicates the distance between vertical centrelines of the engine and the turbocharger(s).

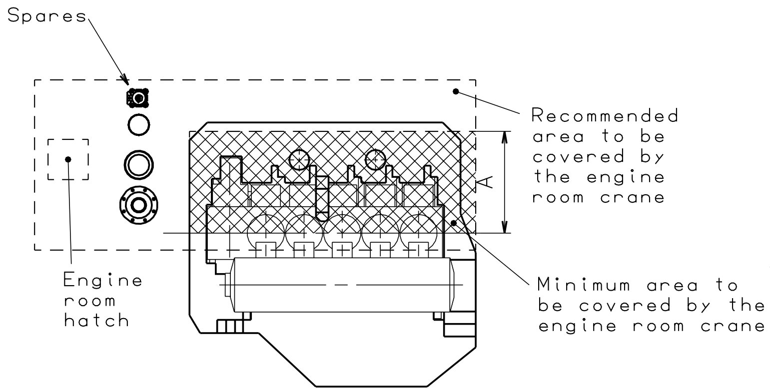
*) Engines with the turbocharger located on the aft end of engine.
The letter ‘a’ indicates the distance between vertical centrelines of the aft cylinder and the turbocharger.
The figures ‘a’ are stated on the ‘Engine Outline’ drawing

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 is indicated in the table for the various turbocharger makes. The crane beam shall be dimensioned for lifting the weight ‘W’ with a deflection of some 5 mm only.

178 88 48-0.0





1) With minimum overhauling height (B1, B2, C), one cylinder cover stud has to be dismounted, to allow the stuffing box, mounted around the piston rod, to pass between the remaining studs.

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

178 34 30-5.1

Weight in kg inclusive lifting tools			Crane capacity in tons		Crane operating width in mm	Normal crane	MAN B&W double jib crane	
						Height to crane hook in mm (vertical lift of piston/tilted lift of piston)	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/B2 Minimum height from centreline crankshaft to centreline crane hook	C Minimum height from centreline crankshaft to underside deck beam	D Additional height required for removal of exhaust valve without removing of any exhaust valve stud
2550	2875	1525	3.2	2 x 1.6	2550	10500/9825	9550	600

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.

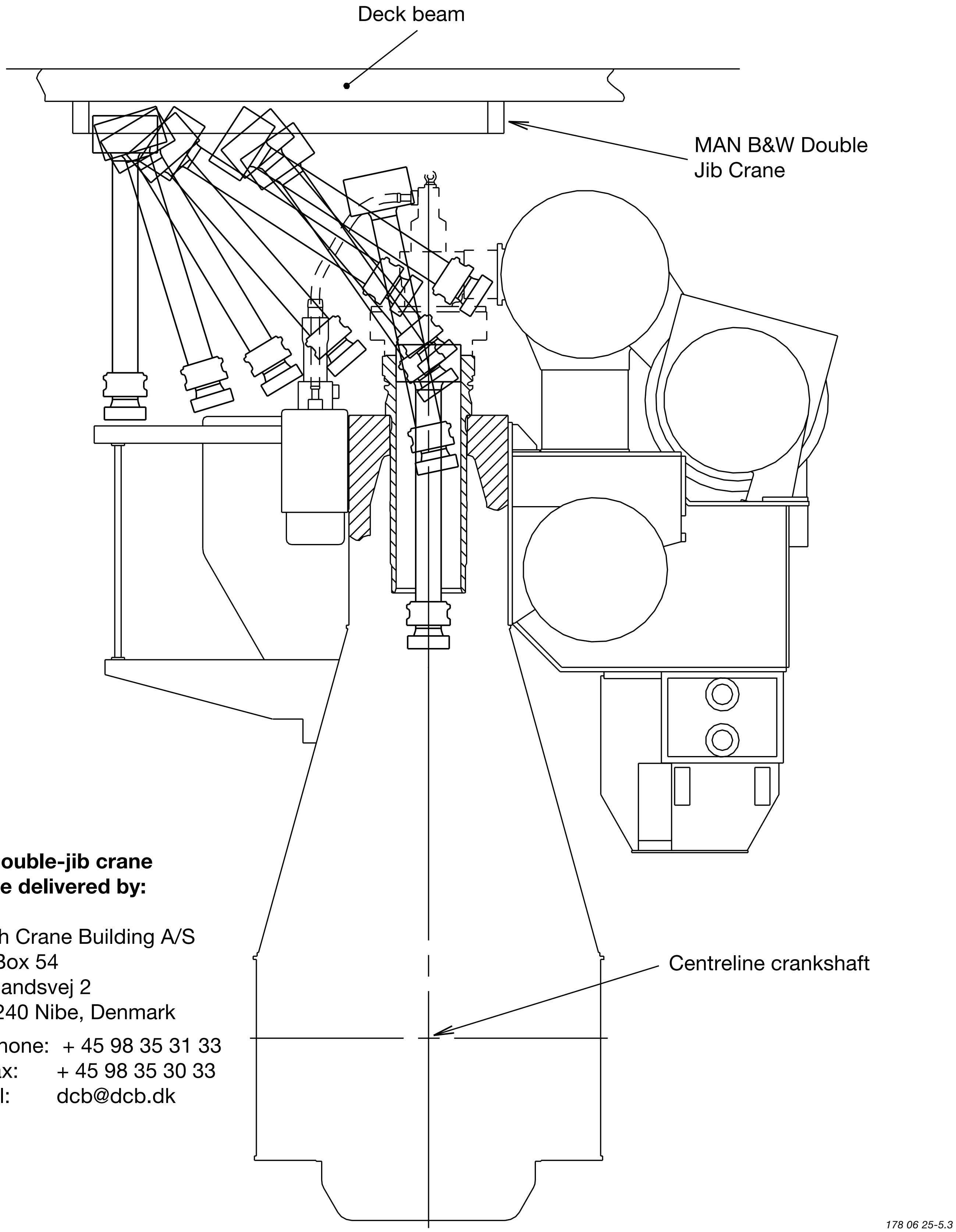
It is furthermore recommended that the engine room crane can be used for transport of heavy spare parts from the engine room hatch to the spare part stores and to the engine. See example on this drawing.

The crane hook should at least be able to reach down to a level corresponding to the centreline 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 Fig. 5.01e with information about the required lifting capacity for overhaul of turbocharger(s).

178 88 50-2.0

Fig. 5.01f: Engine room crane

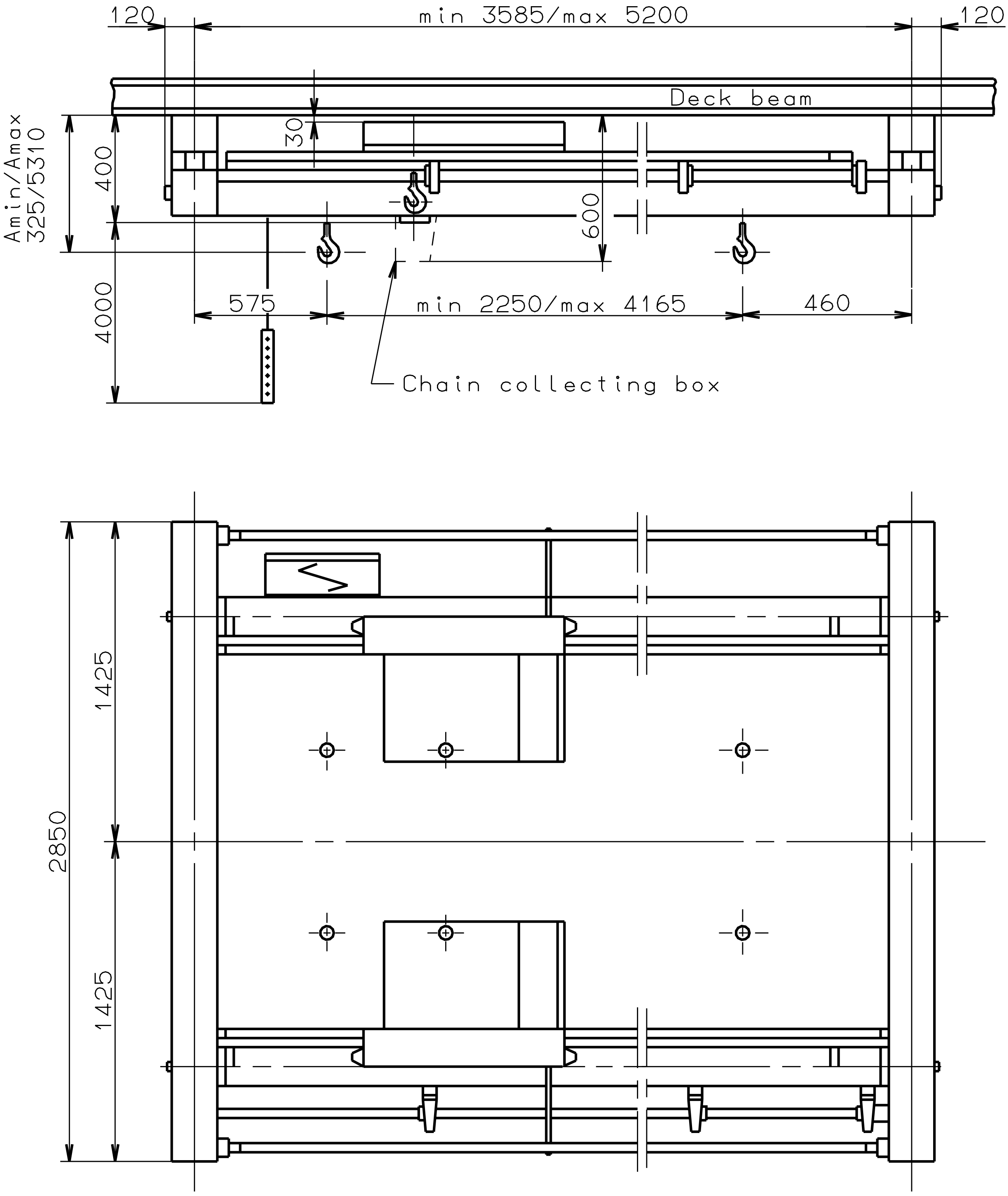


The double-jib crane can be delivered by:

Danish Crane Building A/S
P.O. Box 54
Østerlandsvej 2
DK-9240 Nibe, Denmark

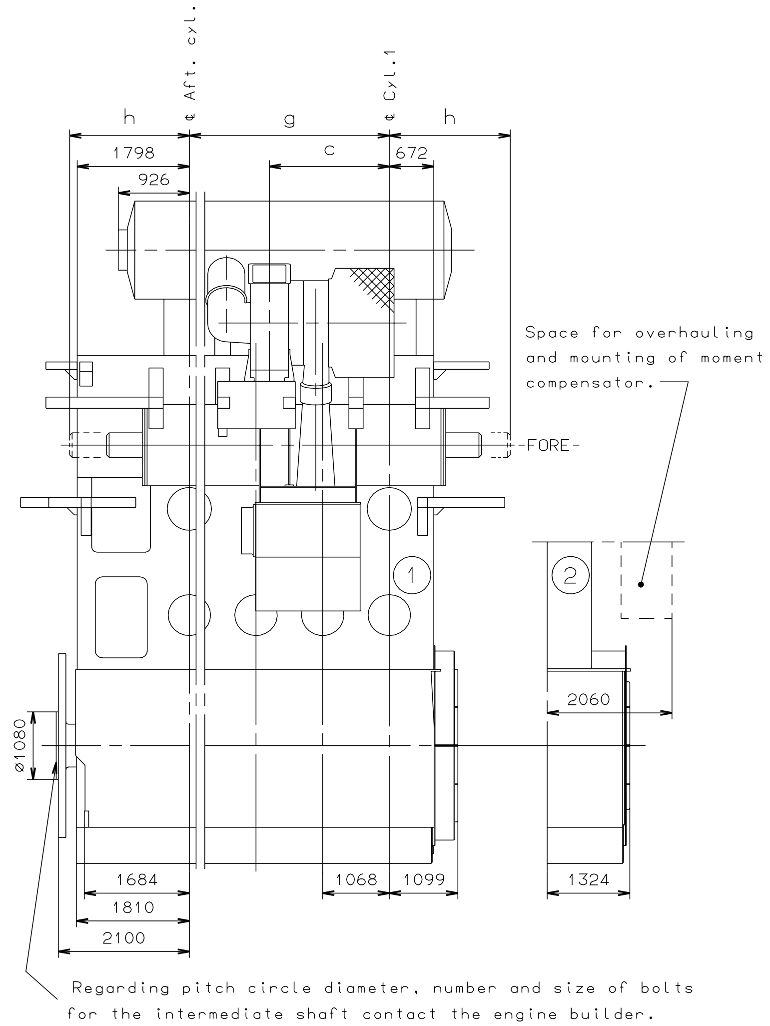
Telephone: + 45 98 35 31 33
Telefax: + 45 98 35 30 33
E-mail: dcb@dcb.dk

Fig. 5.02a: Overhaul with double-jib crane



178 47 59-5.0

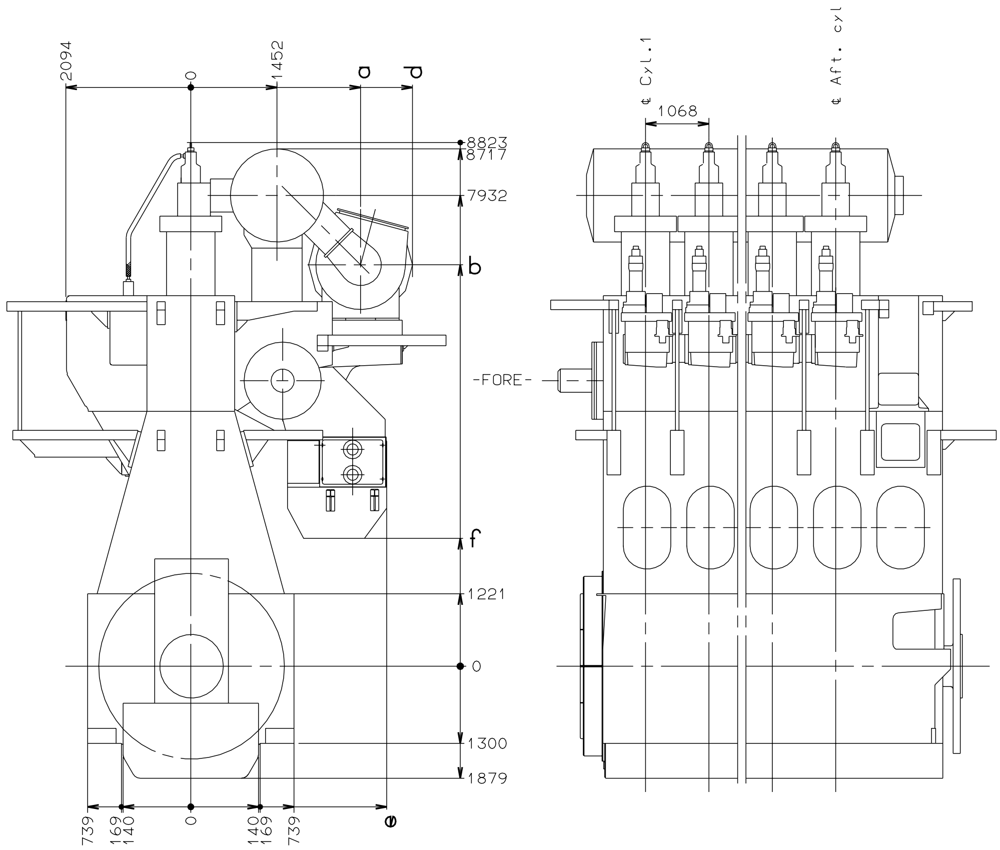
Fig. 5.03: MAN B&W Double-Jib Crane 2 x 1.6 t, option: 4 88 701



Types of fore end	Typical for cylinder No.	Space demand valid for
1	5-6-7-8	Design without moment compensator
2	4-5-6	Design, with built-on 2nd order moment compensator

178 31 84-8.1

Fig. 5.04a: Engine outline, with one turbocharger located on exhaust side



	Turbocharger type		a	b	c	d
MAN B&W	NA48		2850	6562	1946	3597
	NA48/S		2850	6562	1894	3680
	NA57/T8	4-7 cyl.	2860	6764	1922	3740
		8 cyl.			2990	
	NA57/T9	4-7 cyl.	2860	6764	1922	3740
		8 cyl.			2990	
	NA70/T8		3179	6935	2898	3720
	NA70/T9		3179	6935	2898	4339
ABB	VTR454		2750	6634	2105	3437
	VTR454E/D		2750	6634	2101	3437
	VTR564	4-7 cyl.	2864	6520	1906	3720
		8 cyl.			2974	
	VTR564E/D	4-7 cyl.	2864	6520	1903	3720
		8 cyl.			2971	
	VTR714	6 cyl.	3245	6897	1855	4340
		7-8 cyl.			2923	
	VTR714E/D	6 cyl.	3245	6897	1850	4340
		7-8 cyl.			2918	
	TPL 80		2912	6472	2040	3732
MHI	MET66	4-7 cyl.	2835	6545	2013	4300
		8 cyl.			3081	
	MET 71SE		3000	6630	3097	3898
	MET83	4-7 cyl.	3283	6875	2114	4357
		8 cyl.			3182	

Air cooler type*	e	f
LKM-B/C	3702	1983
LKM-E/D	3292	2183
LKM-K/L	3087	2183

Cyl. No.	g	h
4	3204	2066
5	4272	2066
6	5340	2153
7	6408	2178
8	7476	2251

Please note:
The dimensions are in mm and subject to revision without notice.

For platform dimensions see “Gallery outline”.

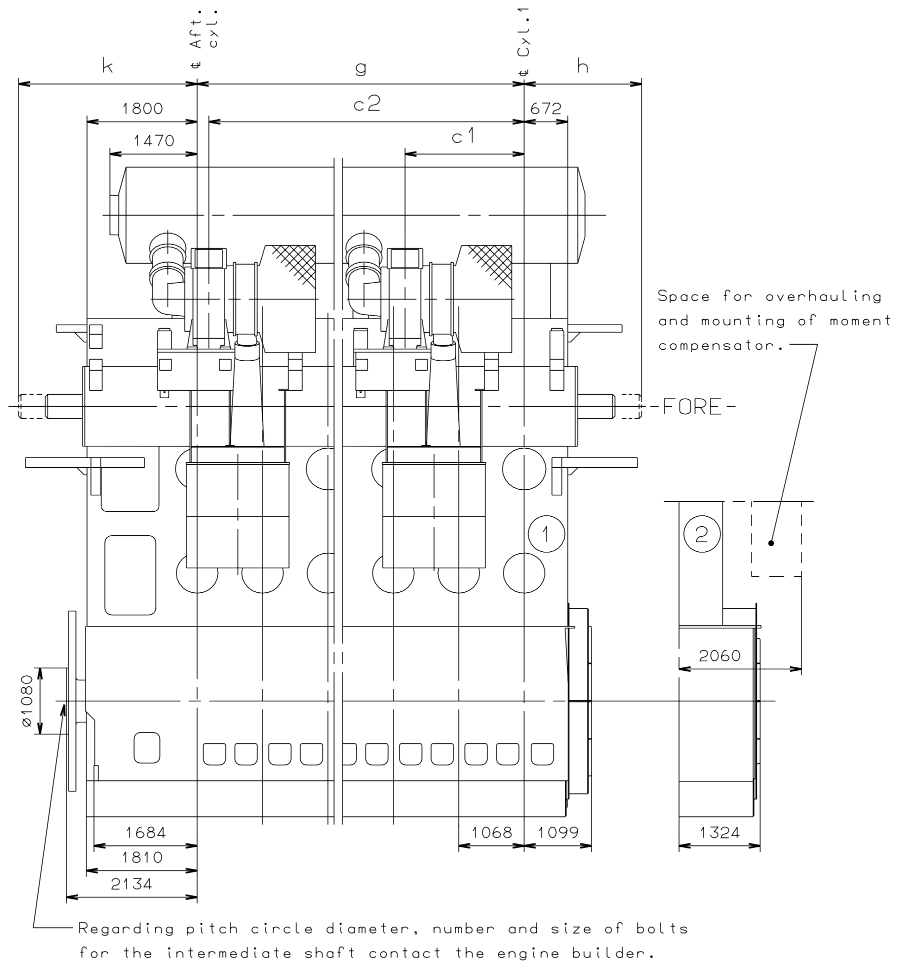
If the air cooler is prepared for Waste Heat Recovery, the dimension “f” is to be reduced by 490 mm.

The dimension “h” is based upon ABB motors.

* The air cooler type depends on the engine’s optimisnig point and on whether a separator or central cooling water is used.

1783184-8.1

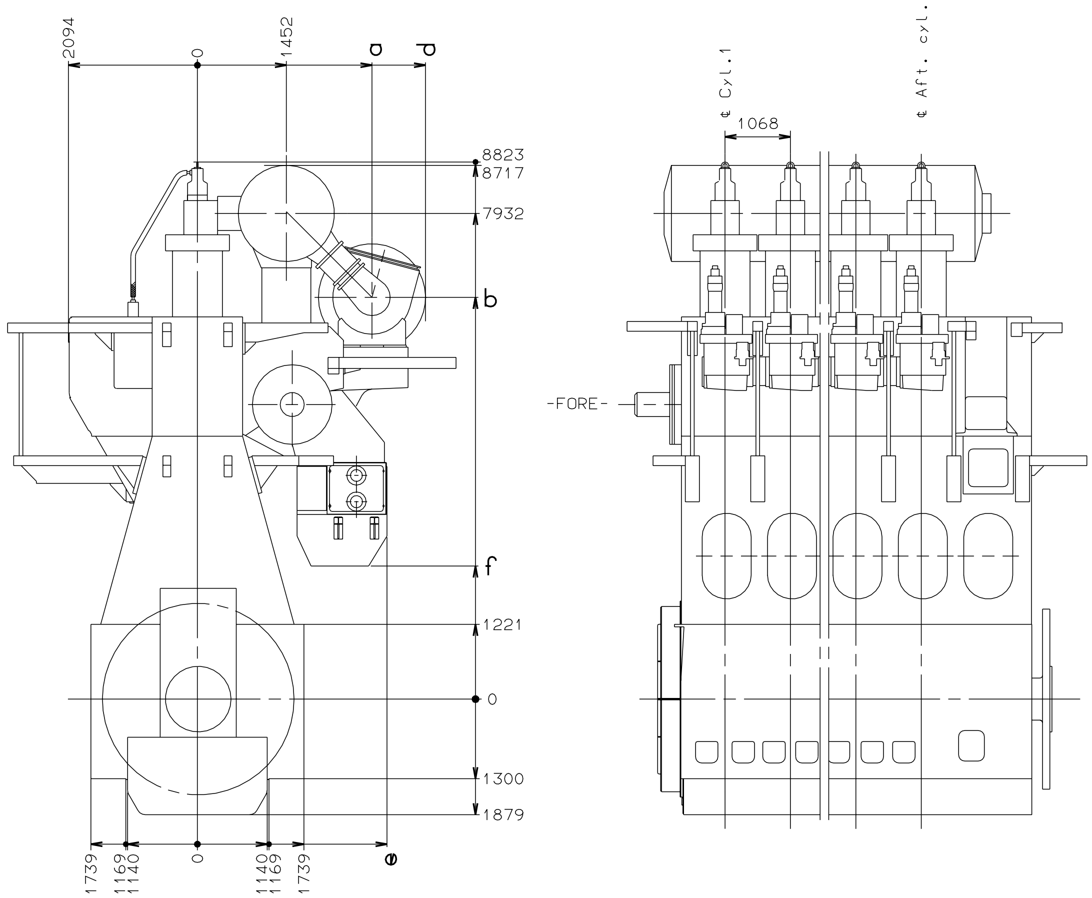
Fig. 5.04b: Engine outline, with one turbocharger located on exhaust side



Types of fore end	Typical for cylinder No.	Space demand valid for
1	5-6-7-8	Design without moment compensator
2	4-5-6	Design with built on 2nd order moment compensator

178 31 86-1.1

Fig. 5.05a: Engine outline, with two turbochargers located on exhaust side, option 4 59 113



	Turbocharger type		a	b	c1	c2	d
MAN B&W	NA40/T8	6 cyl.	2722	6662	2090	5294	3482
		7 cyl.				6362	
	NA40/S	6 cyl.	2722	6662	1945	5149	3357
		7 cyl.				6217	
	NA48/T8	6 cyl.	2850	6562	1946	5150	3597
		7-8 cyl.				6218	
	NA48/S	6 cyl.	2850	6562	1894	5098	3680
		7-8 cyl.				6166	
	NA57/T8		2860	6764	1922	6194	3740
	NA57/T9		2860	6764	1922	6194	3740
ABB	TPL 77	6 cyl.	2750	6634	1900	5107	3475
		7-8 cyl.				5175	
	VTR454	6 cyl.	2750	6634	2105	5309	3437
		7-8 cyl.				6377	
	VTR454E	6 cyl.	2750	6634	2101	5305	3437
		7-8 cyl.				6373	
	VTR564		2864	6520	1906	6178	3720
	VTR564E		2864	6520	1903	6175	3720
MHI	MET53SE/SD	6-7 cyl.	2735	6649	1980	5184	3456
		8 cyl.				6252	

Air cooler type*	e	f
LKM-B/C	3702	1983
LKM-E/D	3292	2183
LKM-K/L	3087	2183

Cyl. No.	g	h	k
6	5340	2153	3153
7	6408	2178	3178
8	7476	2251	2251

Please note:
The dimensions are in mm and subject to revision without notice.

For platform dimensions see “Gallery outline”.

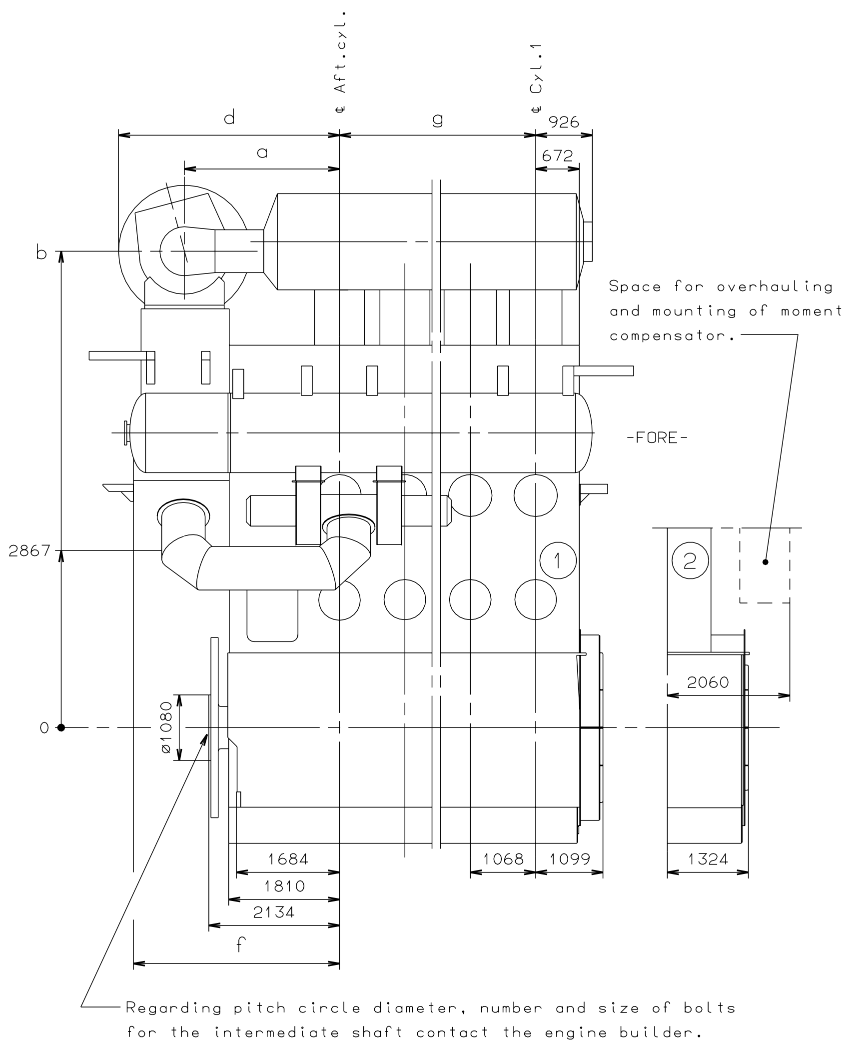
If the air cooler is prepared for Waste Heat Recovery, the dimension “f” is to be reduced by 490 mm.

The dimension “h” is based upon ABB motors.

* The air cooler type depends on the engine’s optimisnig point and on whether a separator or central cooling water is used.

178 31 86-1.1

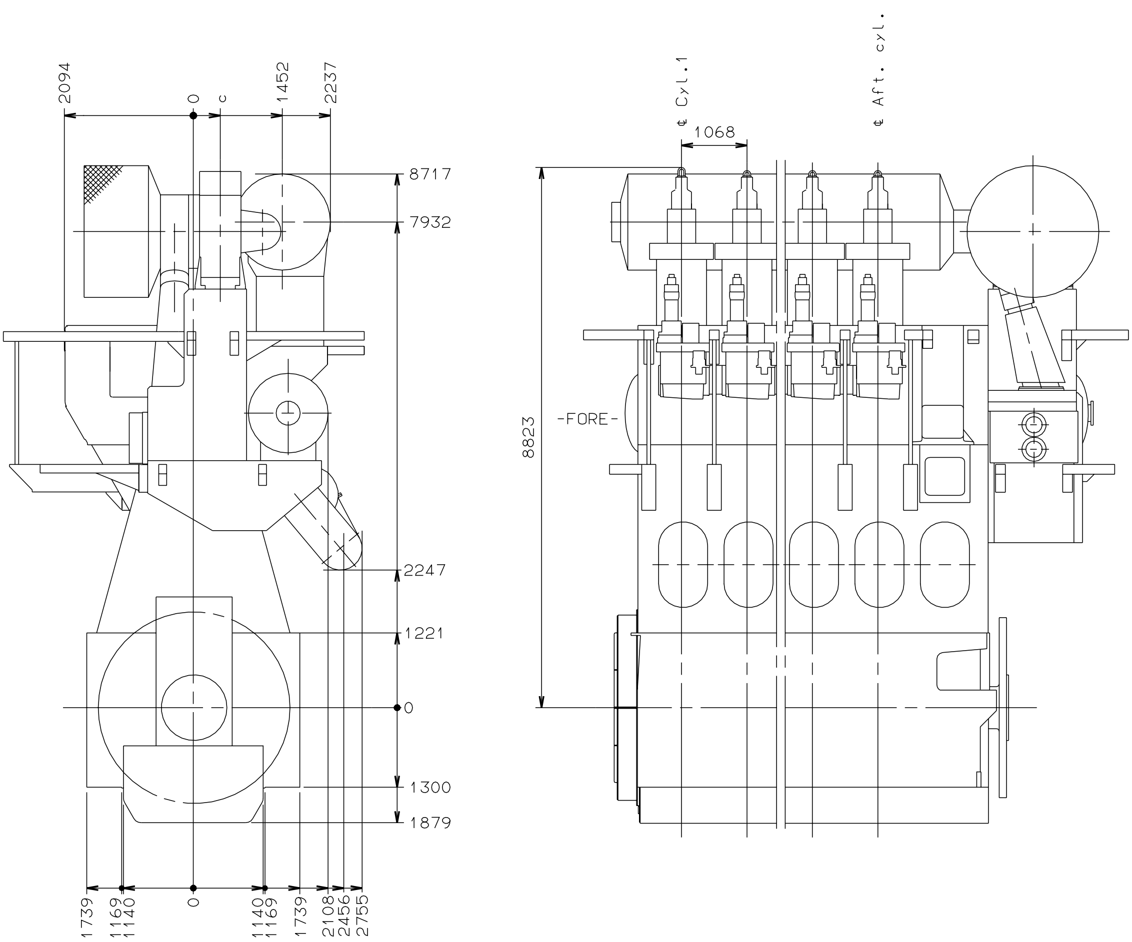
Fig.5.05b: Engine outline, with two turbochargers located on exhaust side, option 4 59 113



Types of fore end	Typical for cylinder No.	Space demand valid for
1	5-6-7-8	Design without moment compensator
2	4-5-6	Design with built on 2nd order moment compensator

178 31 87-3.1

Fig. 5.06a: Engine outline, with one turbocharger located on aft end of engine, option 4 59 124



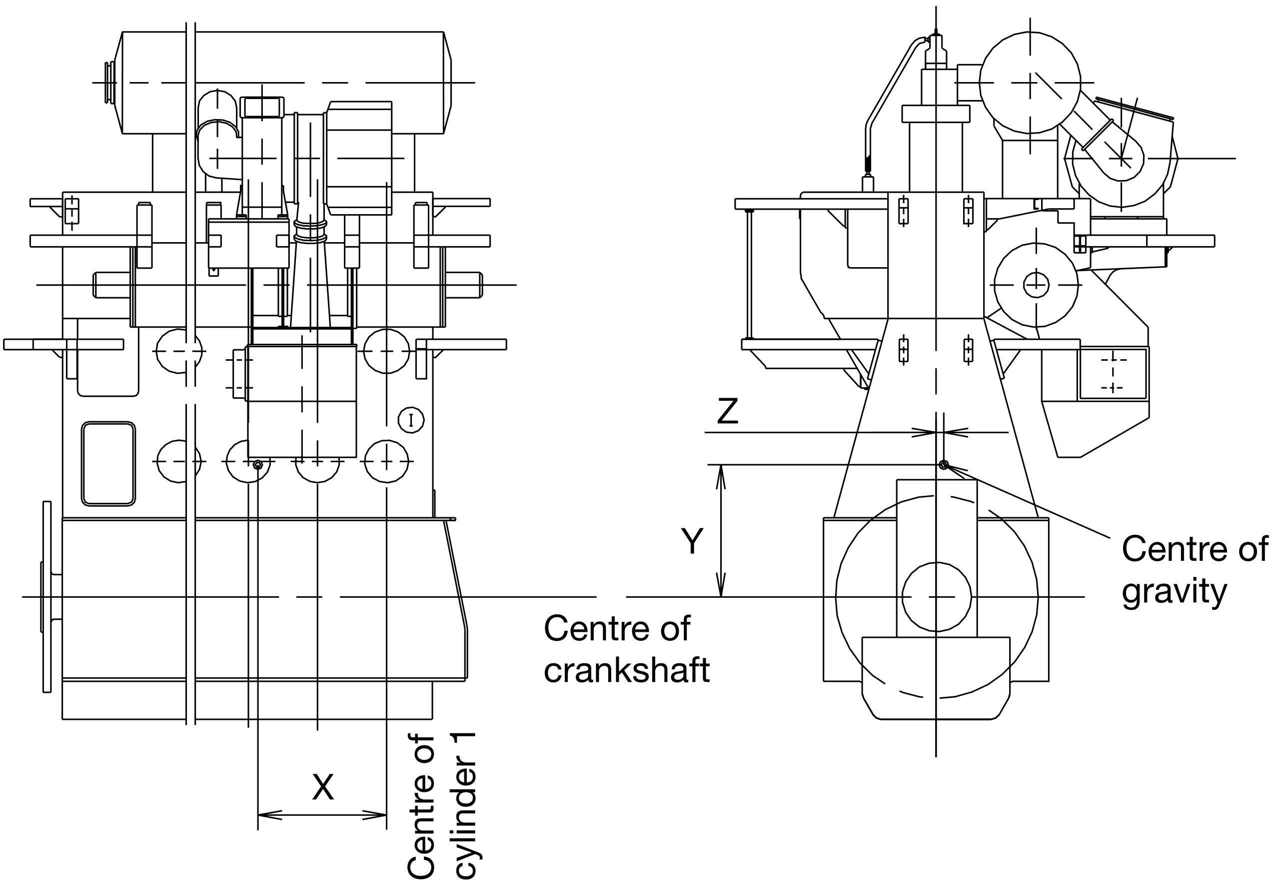
	Turbocharger type	a	b	c	d
MAN B&W	NA48/T8	2372	7826	485	3119
	NA48/S	2532	7776	468	3362
	NA57/T8	2532	7776	440	3412
	NA57/T9	2532	7776	440	3412
	NA70/T8	2644	7932	368	3720
	NA70/T9	2644	7932	368	3720
ABB	VTR454	2372	7746	402	3059
	VTR454E	2372	7746	398	3059
	VTR564	2550	7746	380	3406
	VTR564E	2550	7746	377	3406
	VTR714	2736	7841	300	3831
	VTR714E	2736	7841	295	3831
MHI	MET53SE/SD	2447	7746	457	3168
	MET66SE/SD	2533	7747	342	3460
	MET83SE/SD	2825	7932	607	2896

Cyl. No.	g
4	3204
5	4272
6	5340
7	6408
8	7476

Please note:
The dimensions are in mm and subject to revision without notice
For platform dimensions see “Gallery outline”

178 31 87-3.1

Fig. 5.06b: Engine outline, with one turbocharger located on aft end of engine, option 4 59 124



The Masses are stated in “Dispatch Pattern” in section 9.

For engines with one turbocharger

No. of cylinders	4	5	6	7	8
Distance X mm	2040	2530	2530	3080	4300
Distance Y mm	2750	3820	2820	2820	2860
Distance Z mm	90	90	110	110	115

All dimensions are approximate

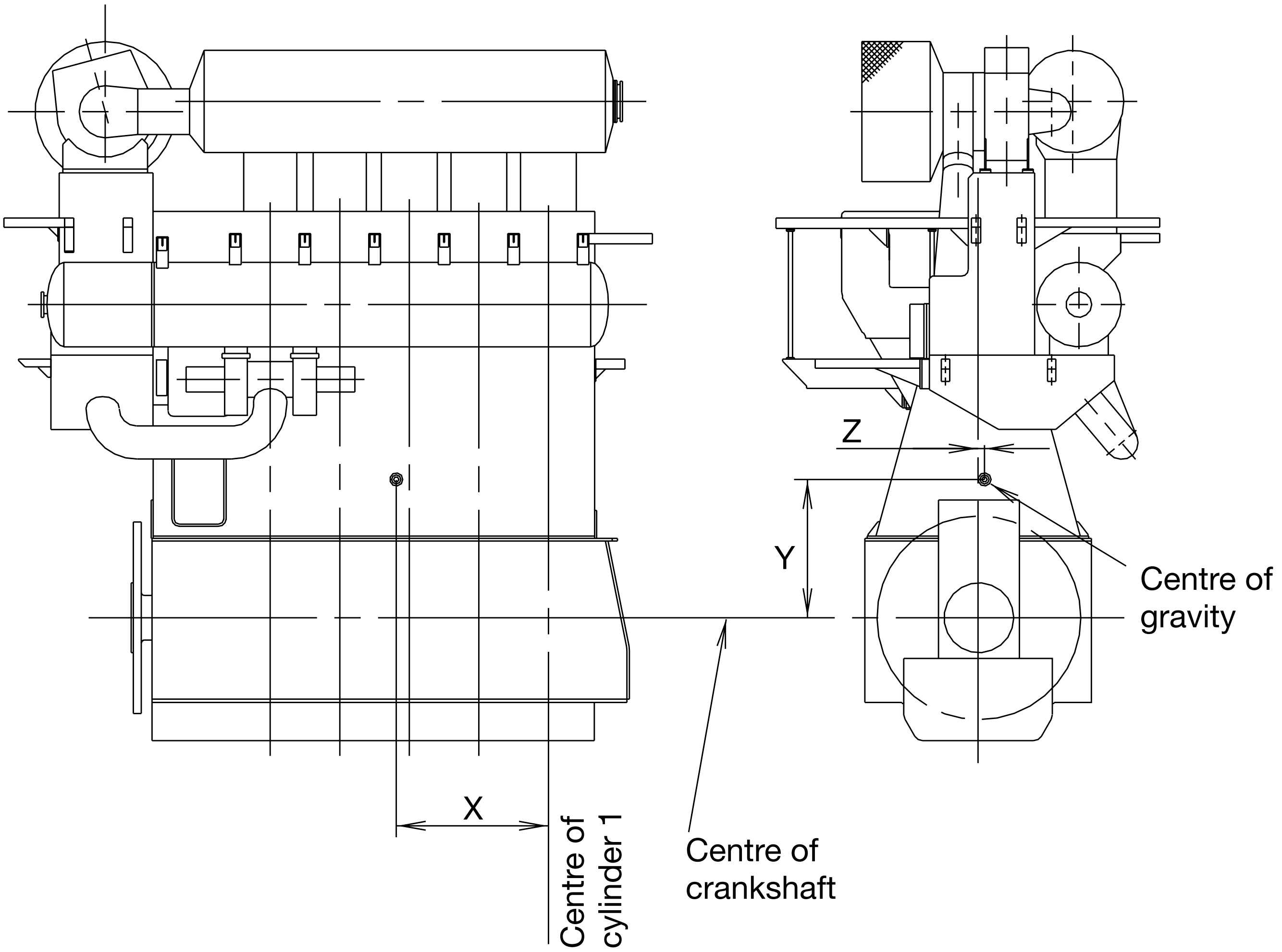
For engines with two turbocharger

No. of cylinders	4	5	6	7	8
Distance X mm	-	-	3340	3700	4360
Distance Y mm	-	-	2810	2790	2860
Distance Z mm	-	-	200	115	95

All dimensions are approximate

178 32 14-9.1

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



The Masses are stated in “Dispatch Pattern” in section 9.

For engines with one turbocharger

No. of cylinders	4	5	6	7	8
Distance X mm	2270	2780	3360	3910	4580
Distance Y mm	2780	2820	2850	2820	2830
Distance Z mm	10	10	10	15	15

All dimensions are approximate

1783213-7.0

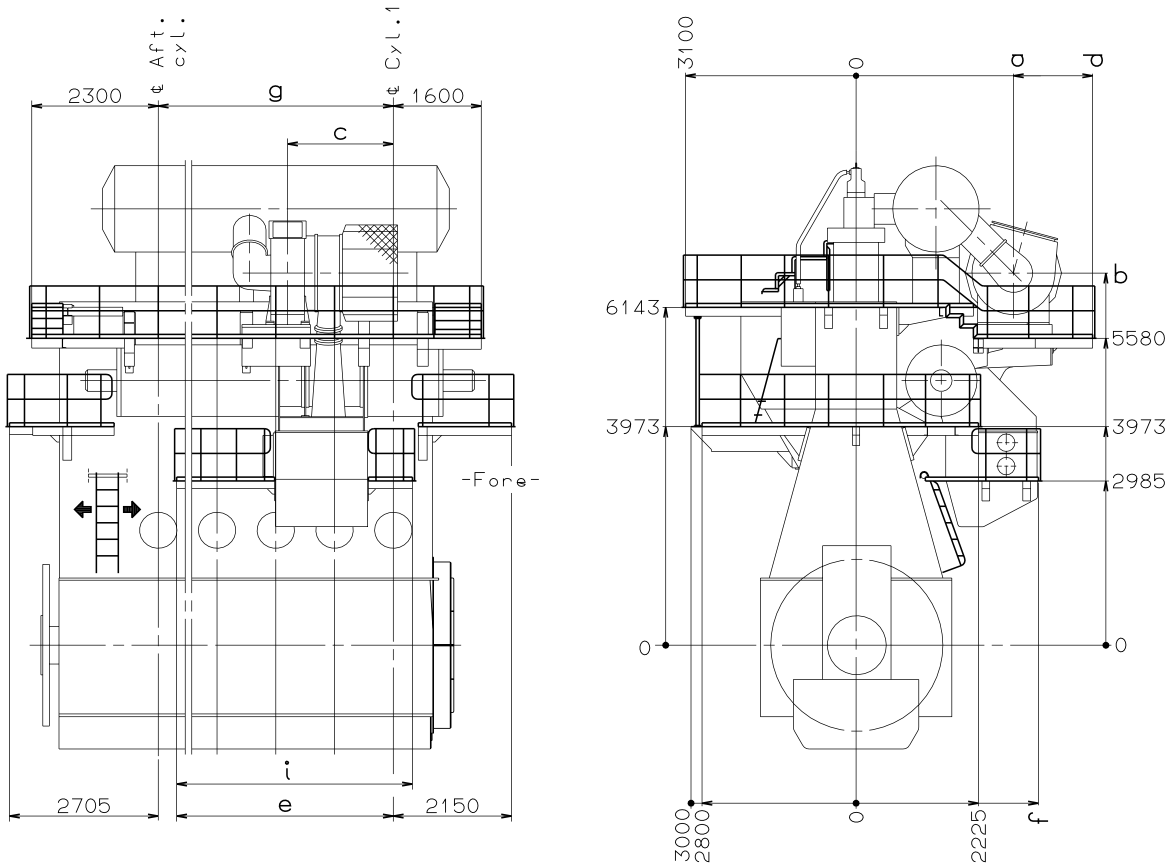
Fig. 5.07b: Centre of gravity, turbocharger located on aft end of engine, option 4 59 124

No. of cylinders	Mass of water and oil in engine in service					
	Mass of water			Mass of oil in		
	Freshwater kg	Seawater kg	Total kg	Engine system kg	Oil pan * kg	Total kg
4	550	300	850	440	480	920
5	740	300	1040	630	690	1320
6	860	430	1290	750	940	2690
7	990	430	1420	1010	860	1870
8	1140	430	1570	1140	1090	2230

*The stated values are only valid for horizontal engine

178 88 98-2.0

Fig. 5.08: Water and oil in engine



	Turbocharger type		a	b	c	d
MAN B&W	NA48		2850	6562	1946	4200
	NA57	5 cyl. / 6 cyl.	2860	6764	1922	4300
	NA70		3179	6935	2898	4850
ABB	VTR454		2750	6634	2105	4000
	VTR454E/D		2750	6634	2101	4000
	VTR564		2864	6520	1906	4300
	VTR564E/D		2864	6520	1903	4300
	VTR714	6 cyl.	3245	6897	1855	4850
		7-8 cyl.			2923	
	VTR714E/D	6 cyl.	3245	6897	1850	4850
		7-8 cyl.			2918	
	TPL80		2912	6472	2040	4300
MHI	MET66	4-7 cyl.	2835	6545	2013	4500
		8 cyl.			3081	
	MET71SE		3000	6630	3097	4500
	MET83	4-7 cyl.	3283	6875	2114	4850
		8 cyl.			3182	

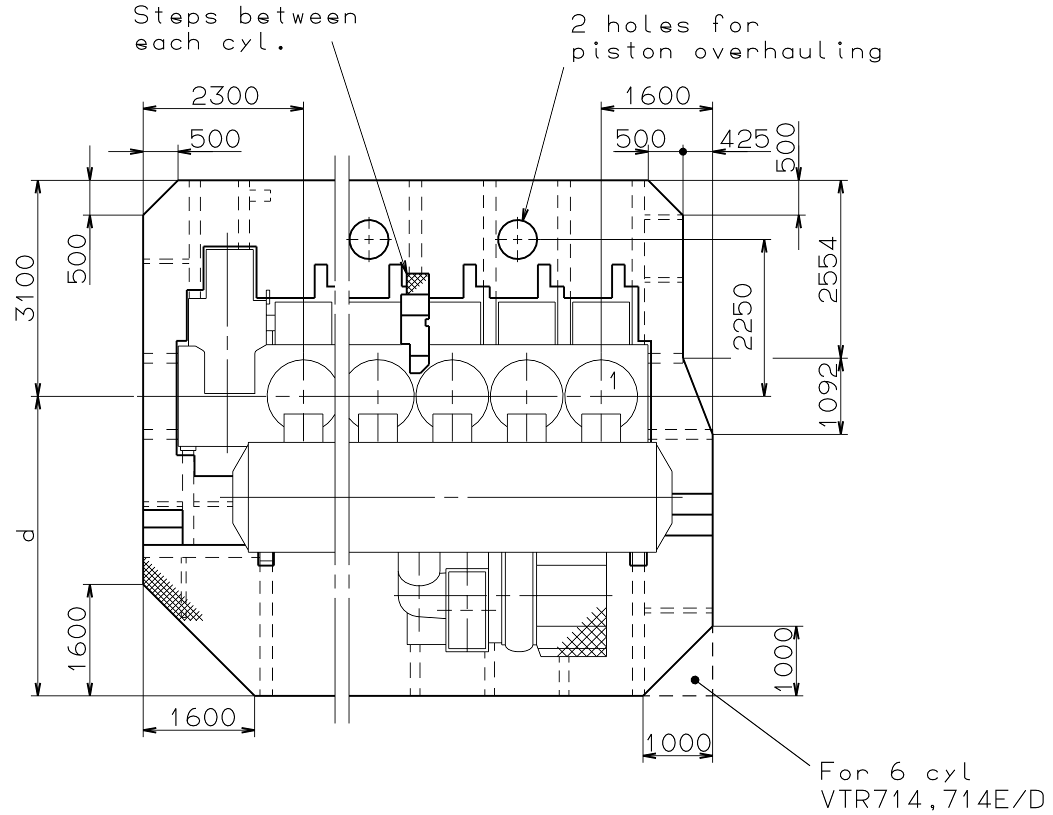
Cyl. No.	g
4	3204
5	4272
6	5340
7	6408
8	7476

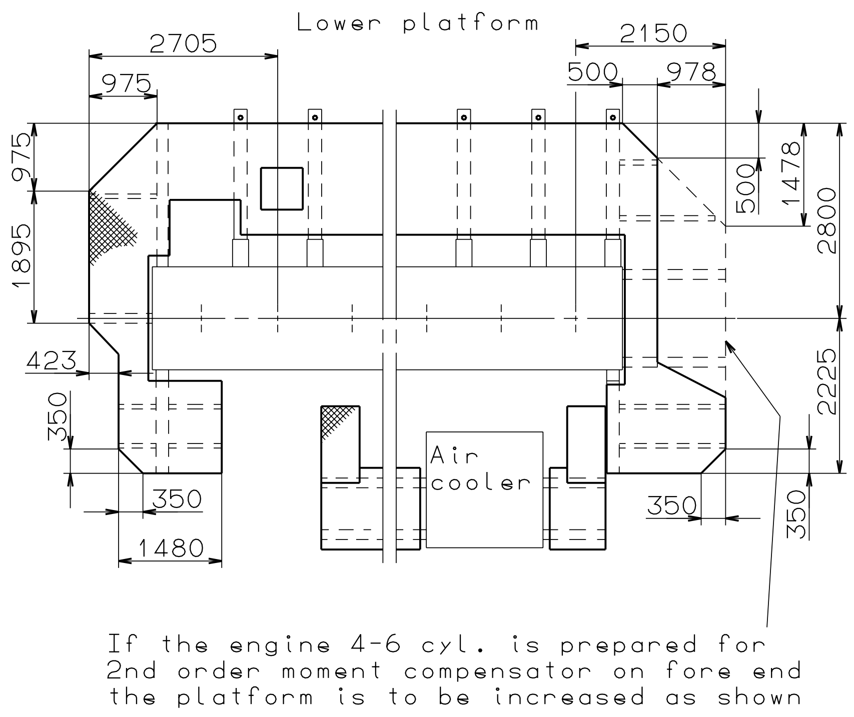
Air cooler type		e	f	i
5,6 cyl.	LKM-E	4076	3292	4504
6 cyl.	LKM-D	4727	3292	4827
6 cyl.	LKM-C	4076	3702	4504
6,7, 8 cyl.	LKM-B	5069	3702	4827

Please note:
The dimensions are in mm and subject to revision without notice.
For engine dimensions see “Engine outline”.

178 31 93-2.1

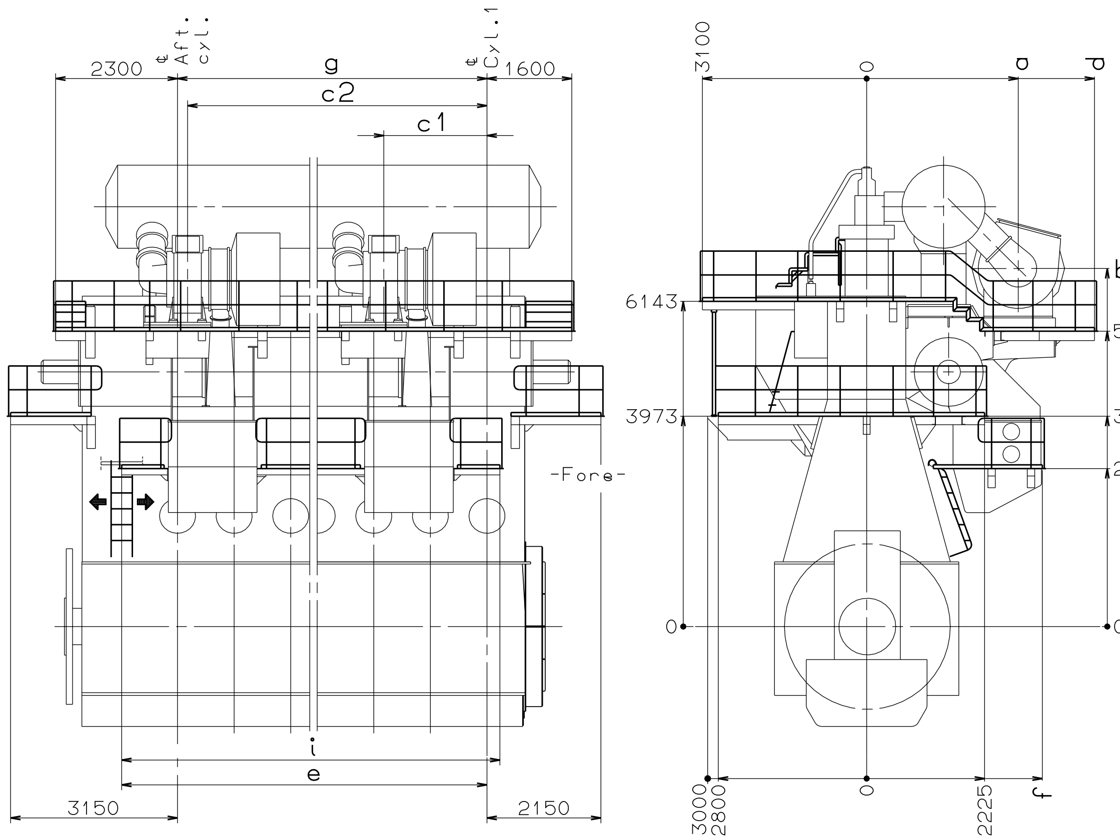
Fig.5.09a: Gallery outline, with one turbocharger located on exhaust side





178 31 93-2.1

Fig. 5.09b: Gallery outline, with one turbocharger located on exhaust side



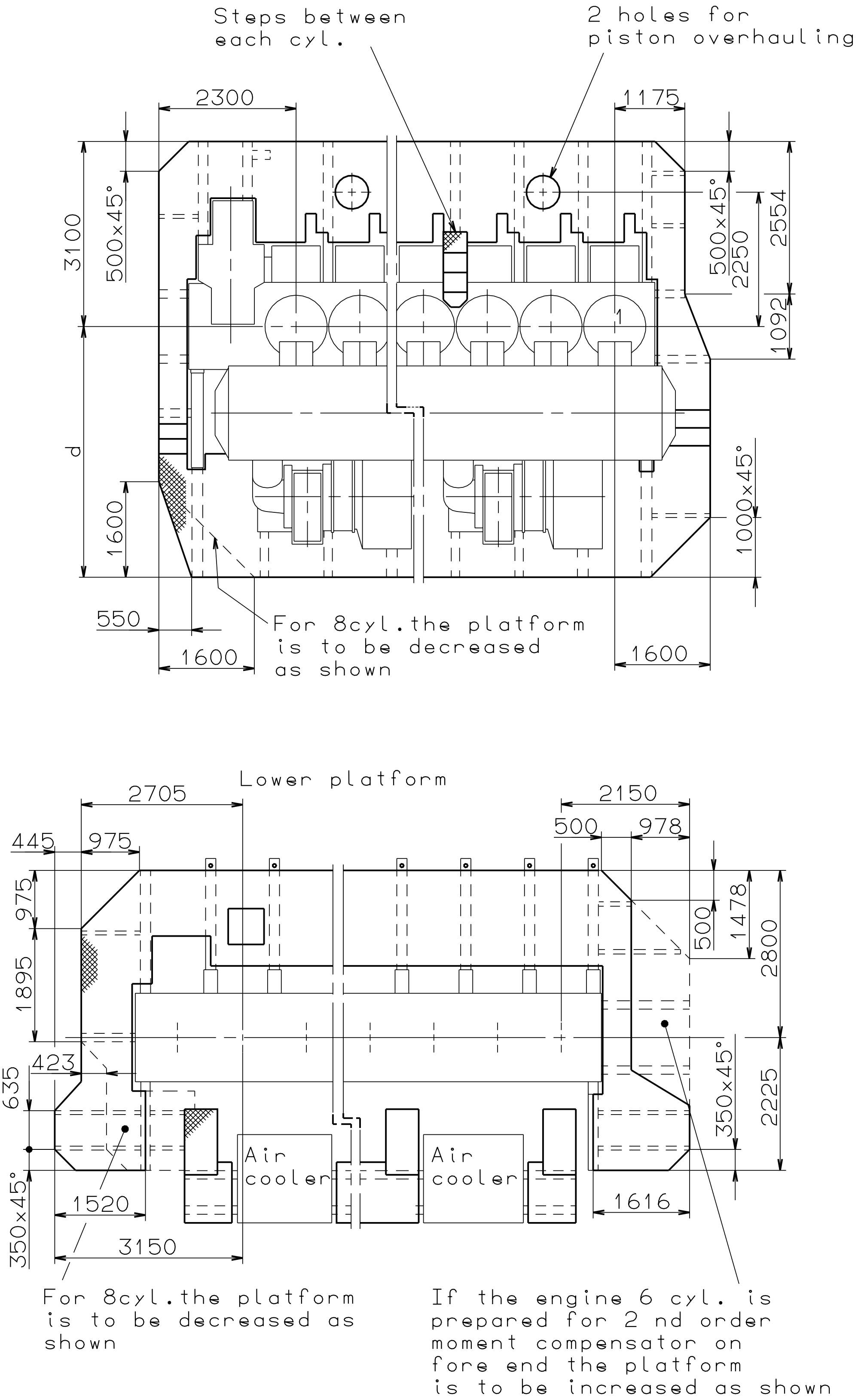
	Turbocharger type		a	b	c1	c2	d	e	f	i
MAN B&W	NA40	6 cyl.	2722	6662	2090	5294	4000	6635	3106	6895
		7 cyl.				6362		7478		7738
	NA40/S	6 cyl.	2722	6662	1945	5149	4000	6635	3106	6895
		7 cyl.				6217		7478		7738
	NA48	6 cyl.	2850	6562	1946	5150	4200	6635	3106	6895
		7-8 cyl.				6218		7478		7738
	NA48/S	7-8 cyl.	2850	6562	1894	6166	4300	7478	3106	7738
	NA57	8 cyl.	2860	6764	1922	6194	4300	7478	3106	7738
ABB	TPL77	6 cyl.	2750	6634	1900	5107	4075	6635	3106	6895
		7-8 cyl.				6175		7478		7738
	VTR454	6 cyl.	2750	6634	2105	5309	4000	6635	3106	6895
		7 cyl.				6377		7478		7738
	VTR454E		2750	6634	2101	6373	4100	7478	3106	7738
	VTR564	7-8 cyl.	2864	6520	1906	6178	4300	7478	3106	7738
	VTR564D/E	7-8 cyl.	2864	6520	1903	6175	4300	7478	3106	7738
MHI	MET53SE/SD	6-7 cyl.	2735	6649	1980	5184	4100	6635	3106	6895
		8 cyl.				6252		7478		7738

Cyl. No.	g
6	5340
7	6408
8	7476

Please note:
The dimensions are in mm and subject to revision without notice.
For engine dimensions see “Engine outline”.

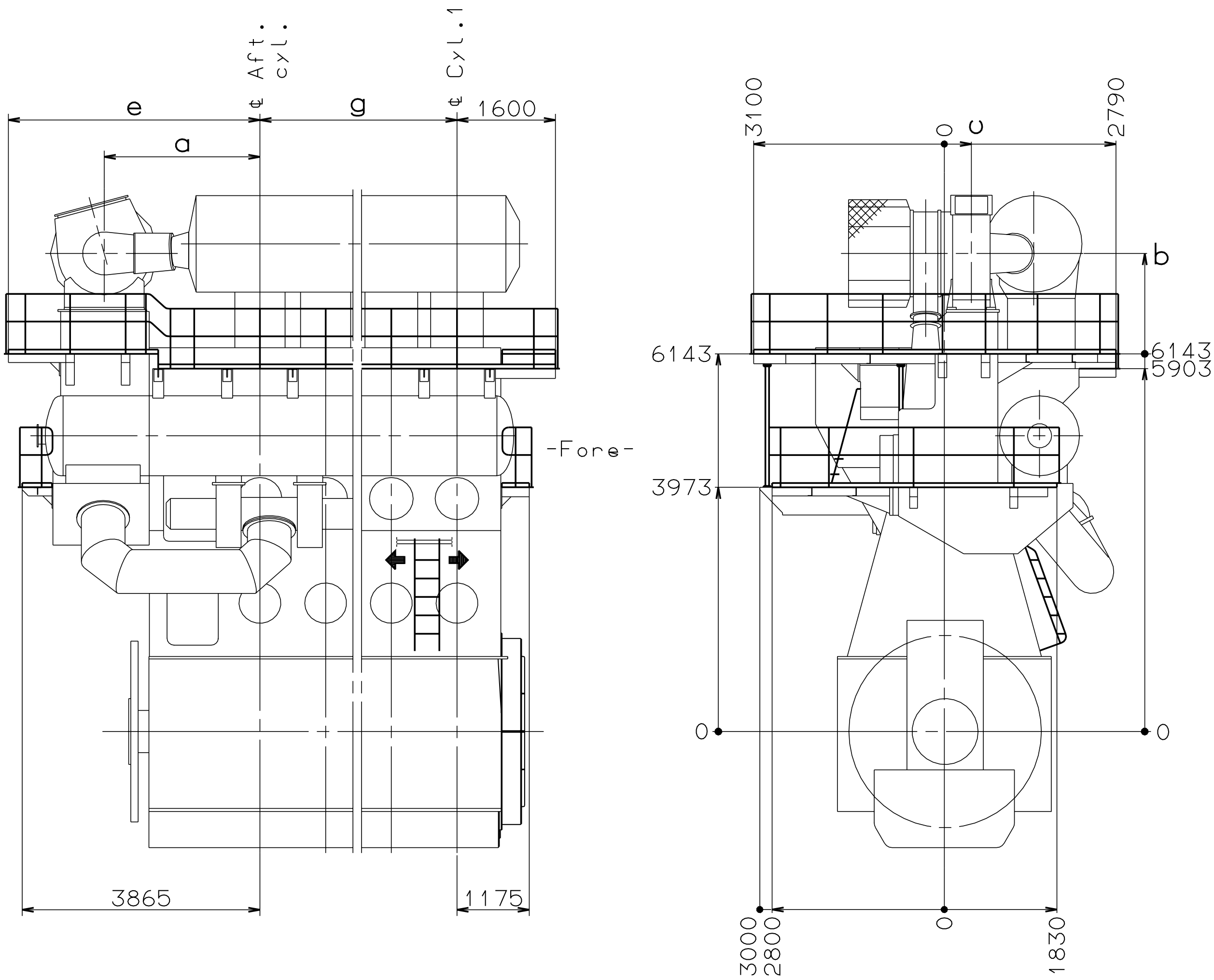
178 31 94-4.1

Fig.5.10a: Gallery outline, with two turbocharger located on exhaust side, option 4 59 112



178 31 94-4.1

Fig.5.10b: Gallery outline, with two turbochargers located on exhaust side, option 4 59 112



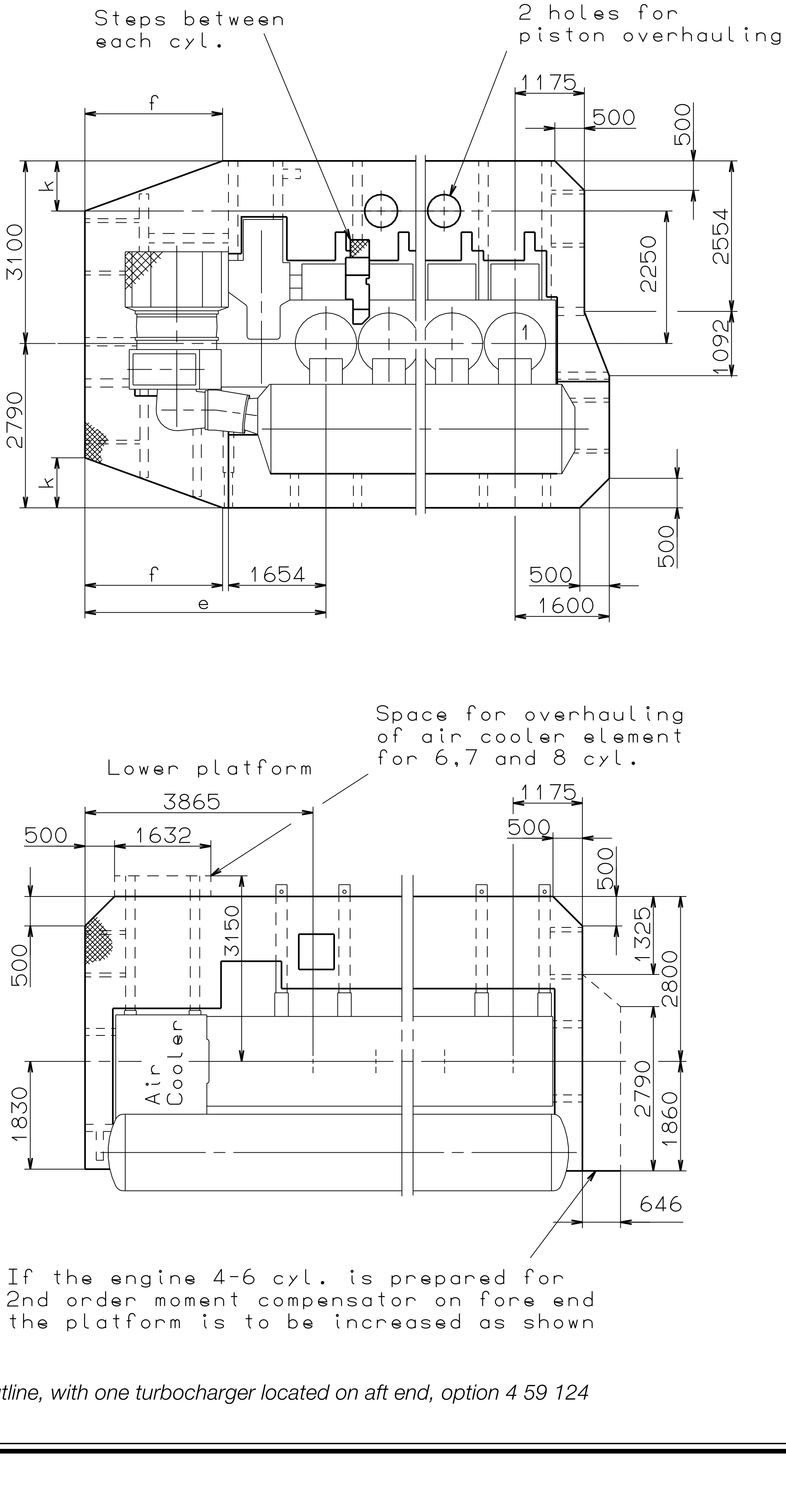
	Turbocharger type	a	b	c	e	f	k
MAN B&W	NA48	2372	7826	485	3730	1866	850
	NA57	2532	7776	440	4090	2336	850
	NA70	2644	7932	368	4400	1200	500
ABB	VTR 454	2372	7746	402	3730	1866	850
	VTR564	2550	7746	380	4090	336	850
	VTR564E	2550	7746	377	4090	2336	850
	VTR714	2736	7841	300	4400	1200	500

Cyl. No.	g
4	3204
5	4272
6	5340
7	6408
8	7476

178 31 95-6.1

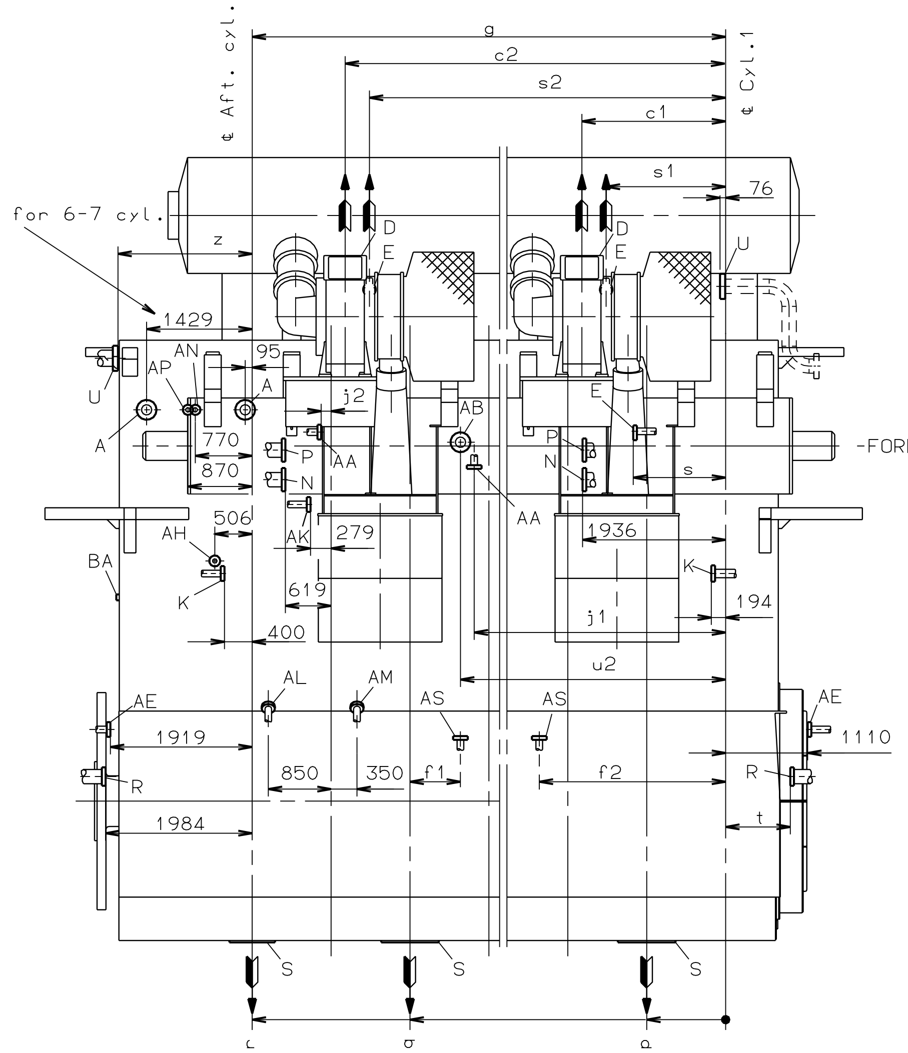
Please note:
The dimensions are in mm and subject to revision without notice.
For engine dimensions see “Engine outline”

Fig.5.11a: Gallery outline, with one turbocharger located on aft end, option 4 59 124



178 31 95-6.1

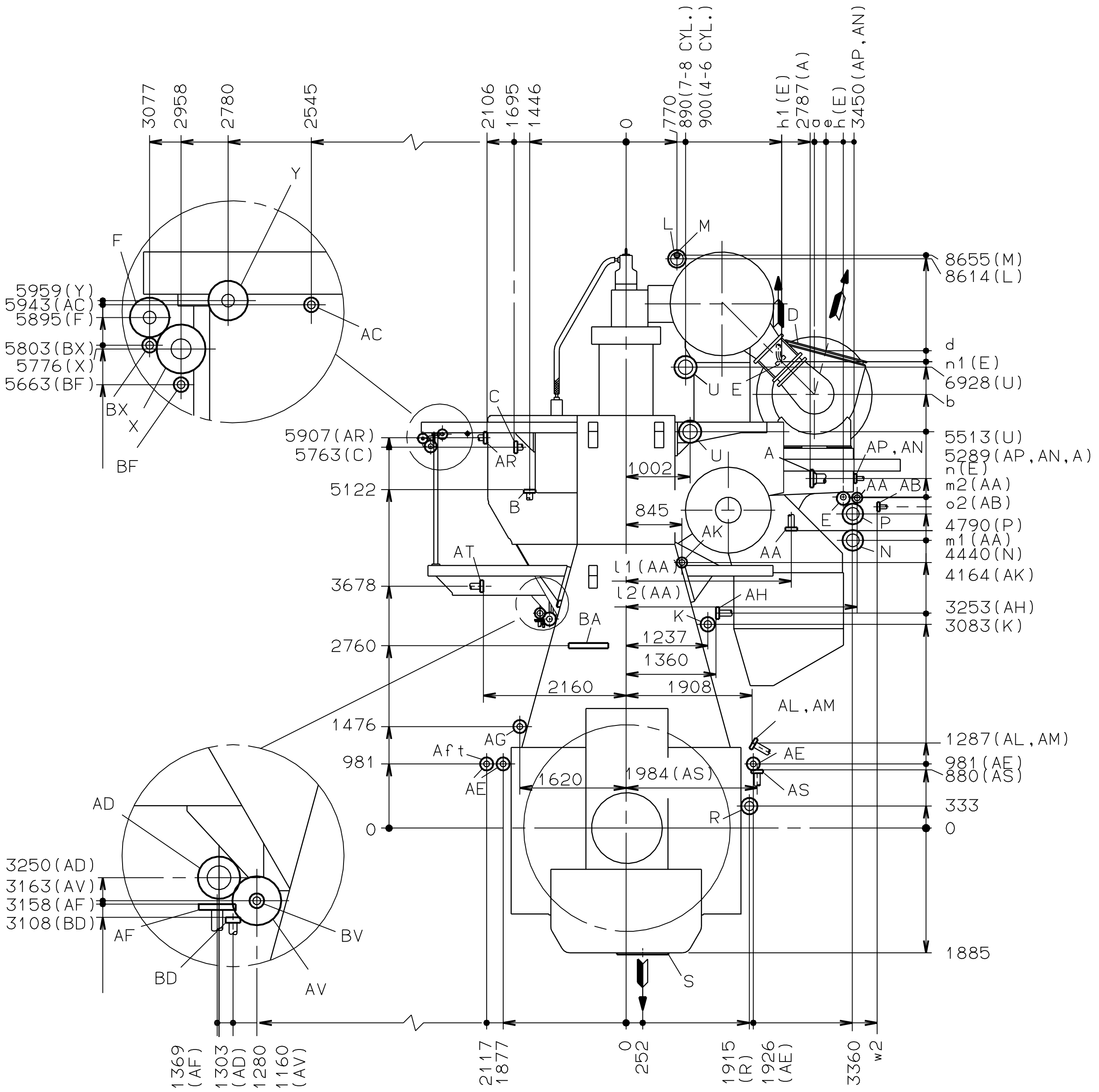
Fig. 5.11b: Gallery outline, with one turbocharger located on aft end, option 4 59 124



Turbocharger type			a	b	c	d	e	z	i	j	v	n	n1	h	h1	s	s1
MAN B&W	NA48		2850	6562	1946	7224	3027	91	243	2770	1725	5053	-	3320	-	1205	-
	NA48/S		2850	6562	1894	7248	3027	91	243	2770	1725	5053	-	3320	-	1205	-
	NA57	4-7 cyl. 8 cyl.	2860	6764	1922 2990	7551	3071	91	243	2770	1725	5027	6990	3288	2076	1182	1396
	NA70		3179	6935	2898	7901	3438	21	330	2800	1950	4844	-	3913	-	2020	-
ABB	VTR454		2750	6634	2105	7122	2881	91	243	2770	1725	-	-	-	-	-	-
	VTR454E/D		2750	6634	2101	7122	2881	91	243	2770	1725						
	VTR564	4-7 cyl. 8 cyl.	2864	6520	1906 2974	7134	3034	91	243	2770	1725	-	-	-	-	-	-
	VTR564E/D	4-7 cyl. 8 cyl.	2864	6520	1903 2971	7134	3034	91	243	2770	1725	-	-	-	-	-	-
	VTR714	6 cyl. 7-8 cyl.	3254	6897	1855 2923	7670	3452	21	330	2800	1950	-	-	-	-	-	-
	VTR714E/D	6 cyl. 7-8 cyl.	3254	6897	1850 2918	7670	3452	21	330	2800	1950	-	-	-	-	-	-
	TPL80		2912	6472	2040	7239	3117	21	243	2770	1725	-	-	-	-	-	-
MHI	MET66	4-7 cyl. 8 cyl.	2835	6545	2013 3081	7231	3019	91	243	2770	1725	-	7061	-	2319	-	1536 2604
	MET71	4-7 cyl. 8 cyl.	3000	6630	3097	7316	3184	91	243	2770	1725	-	7146	-	2484	-	2619
	MET83	4-7 cyl. 8 cyl.	3285	6875	2114 3182	7744	3519	21	330	2800	1950	-	7902	-	3285	-	1479 2547

Fig. 5.12a: Engine pipe connections, with one turbocharger located on exhaust side

178 31 88-8.1



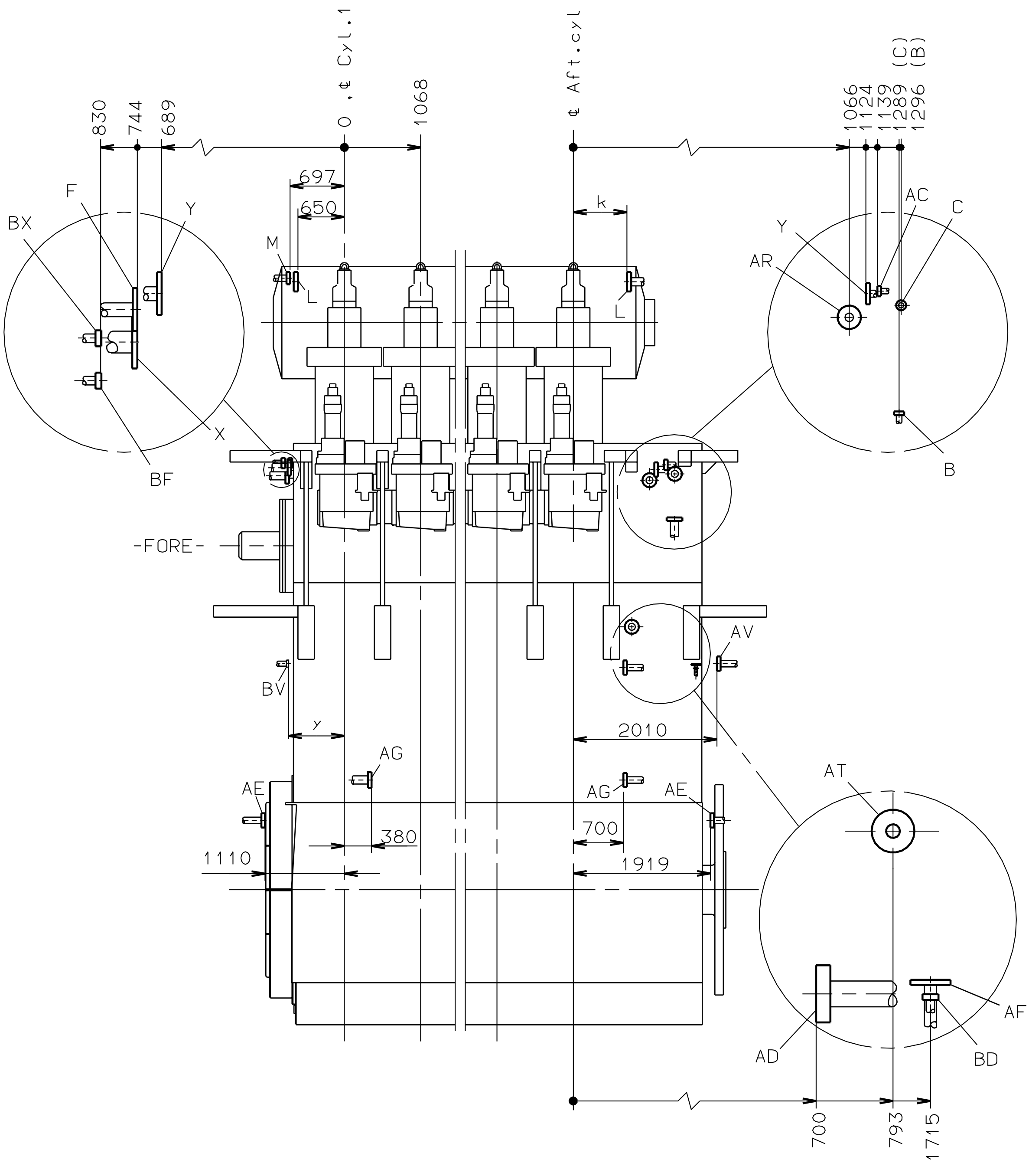
Cyl . No.	g	p	q	r	t	y
4	3204	0	-	3204	1294	1721
5	4272	1068	-	4272	1294	1721
6	5340	1068	-	4272	1294	1721
7	6408	1068	4272	6408	1005	921
8	7476	1068	4272	7476	1005	921

Air coolers		f	k	l	m
5,6 cyl.	LKM-E	2759	3381	3226	3652
6 cyl.	LKM-D	3082	3381	3226	3652
6 cyl.	LKM-C	2815	3803	3239	3639
6,7,8 cyl.	LKM-B	3882	3803	3239	3639

TC type	o1	o2	u1	u2	w1	w2
NA57	381	734	5265	3667	2047	2750
MET66	390	734	7495	3967	2047	2750
MET71	390	134	5495	3967	2047	2750

178 31 88-8.1

Fig. 5.12b: Engine pipe connections, with one turbocharger located on exhaust side



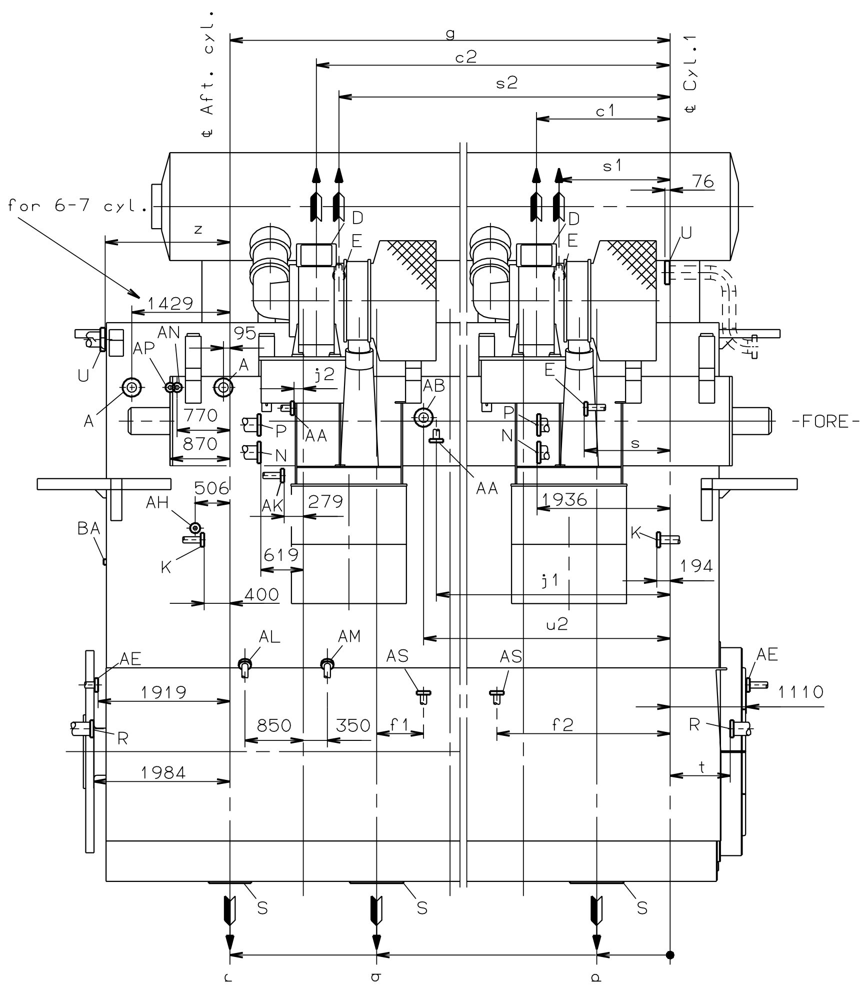
The letters refer to “List of flanges”
Some of the pipes can be connected fore or aft as shown, and the engine builder has to be informed which end to be used

For engine dimensions see “Engine outline” and “Gallery outline”

Connections N and P:
If the air cooler is prepared for Waste Heat Recovery, the dimensions l and m are to be reduced with 490 mm

178 31 88-8.1

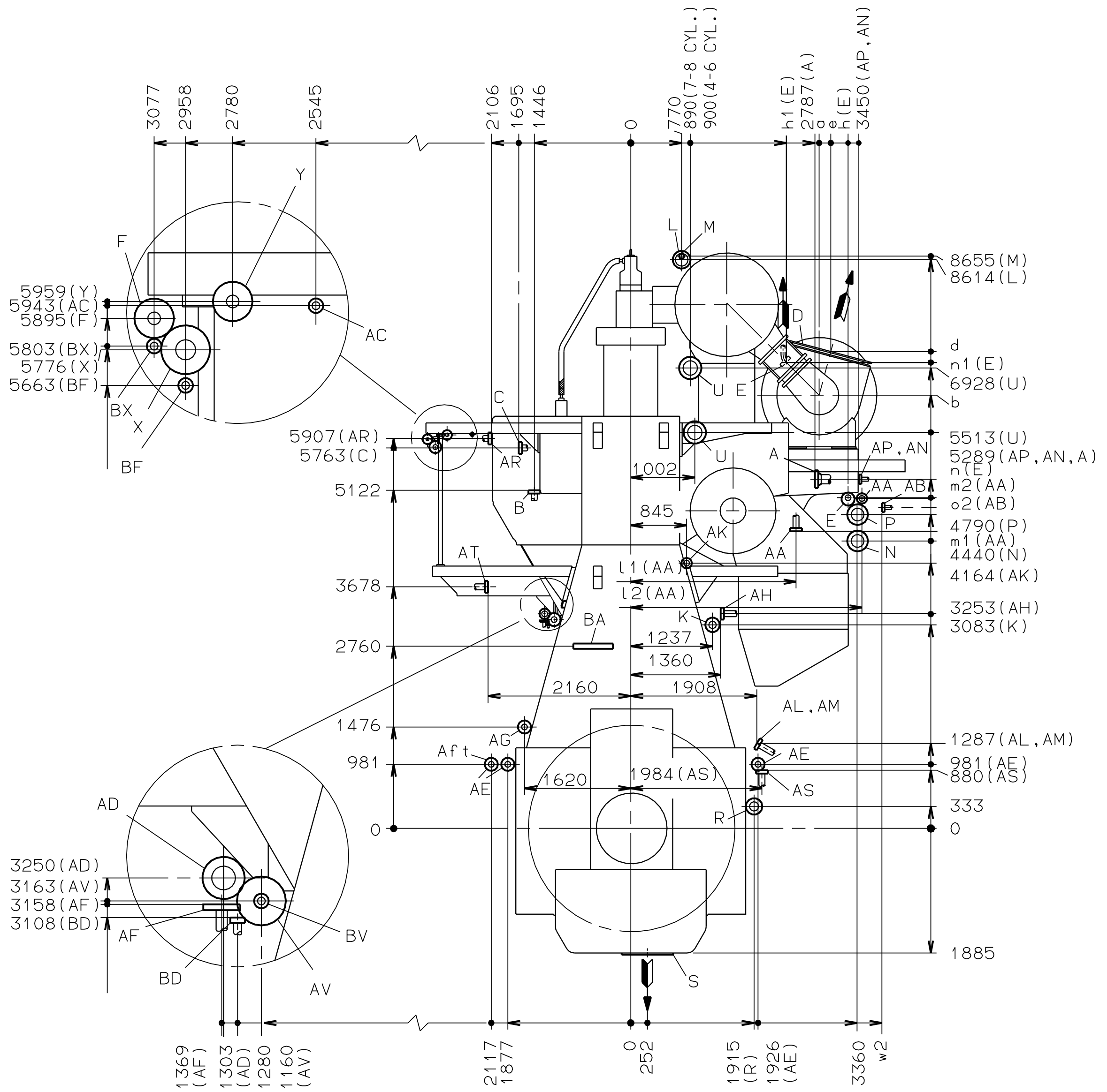
Fig. 5.12c: Engine pipe connections, with one turbocharger located on exhaust side



Turbocharger type			a	b	c1	c2	d	e	f1	f2	n	n1	h	h1	s	s1	s2
MAN B&W	NA40/T8	6 cyl. / 7 cyl.	2722	6662	2090	5294 / 6362	7232	2875	296 / 521	2397	-	-	-	-	-	-	-
	NA40/S	6 cyl. / 7 cyl.	2722	6662	1945	5149 / 6217	7232	2875	296 / 521	2397	5221	-	3095	-	1236	-	-
	NA48/T8	6 cyl.	2850	6562	1946	5150	7224	3027	296	2397	5034	-	3320	-	1211	-	-
		7-8 cyl.	-	-	-	6218	-	-	521	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	688	-	-	-	-	-	-	-	-
	NA48/S	6 cyl. / 7-8 cyl.	2850	6562	1894	5098 / 6166	7224	3027	377	2233	-	7589	-	2025	-	1372	5644
	NA57/T8/T9		2860	6764	1922	6194	7551	3071	682	2522	5027	-	3288	-	1184	-	-
ABB	TPL77	6 cyl. / 7-8 cyl.	2750	6634	1900	5107 / 6175	7295	2927	670	2217						3400 / 3940	
	VTR454	6 cyl. / 7-8 cyl.	2750	6634	2105	5309 / 6377	7122	2881	670	2217	-	-	-	-	-	-	-
	VTR454E	6 cyl / 7-8 cyl.	2750	6634	2101	5305 / 6373	7122	2881	670	2217	-	-	-	-	-	-	-
	VTR564		2864	6520	1906	6178	7134	3034	682	2522	-	-	-	-	-	-	-
	VTR564E		2864	6520	1903	6175	7134	3034	682	2522	-	-	-	-	-	-	-
MHI	MET53/ SE/SD	6-7 cyl. / 8 cyl.	2735	6649	1980	5184 / 6252	7200	2883	518	2522	-	7098	-	2286	-	1595	4799 / 5867

178 31 89-7.1

Fig. 5.13a: Engine pipe connections, with two turbocharger located on exhaust side, (4 59 122)

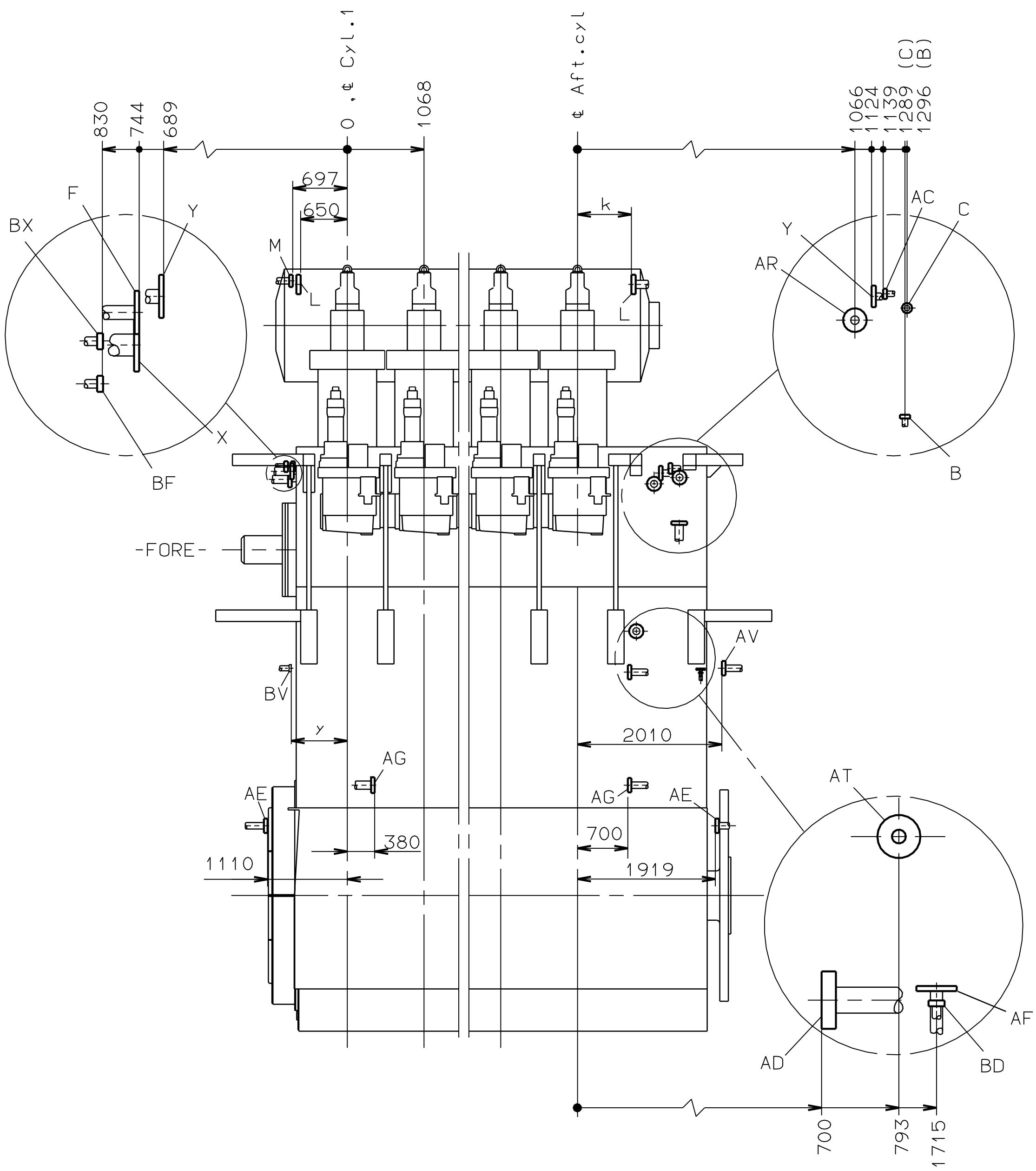


Cyl . No.	g	k	p	q	r	t	y	z
6	5340	1034	1068	-	4272	1254	1721	1817
7	6408	1034	1068	4272	6408	875	921	2370
8	7476	750	1068	4272	7476	875	921	2370

TC type	j1	j2	l1	l2	m1	m2	u1	u2	o2	w2
NA48/S	-	135	-	3498	-	4998	-	3589	4861	3800
TPL77	3406 3940	-	2500	-	4500	-	2039	-	-	-

178 31 89-7.1

Fig. 5.13b: Engine pipe connections, with two turbochargers located on exhaust side, (4 59 122)



The letters refer to "List of flanges"
Some of the pipes can be connected fore or aft as shown and the engine builder has to be informed which end to be used

For engine dimensions see "Engine outline" and "Gallery outline"

178 31 89-7.1

Fig. 5.13c: Engine pipe connections, with two turbochargers located on exhaust side, (4 59 122)

Reference	Cyl. No.	Flange			Bolts		Description
		Diam.	PCD	Thickn.	Diam.	No. off	
A	TC/exh.	270	220	26	M24	8	Starting air inlet
	TC/aft.	Flange for pipe 139.7x6.3					
B	4 - 8	Coupling for 20 mm pipe					Control air inlet
C	4 - 8	Coupling for 16 mm pipe					Safety air inlet
D		See “figures, drawing, page no. 2”					Exhaust gas outlet
E	MET 53	❑125	130	14	M12	4	Venting of lubricating oil discharge pipe for MAN B&W and MHI turbochargers
	MET 66	❑140	145	14	M16	4	
	MET 71	❑140	145	14	M16	4	
	MET83	180	145	14	M16	4	
	NA40	185	145	18	M16	4	
	NA48S/NA57	140	114	14	M12	6	
	NA70	210	170	18	M16	4	
F	4 - 8	150	110	16	M16	4	Fuel oil outlet
K	4 - 6	220	180	20	M16	8	Fresh cooling water inlet
	7 - 8	250	210	22	M16	8	
L	4 - 6	220	180	20	M16	8	Fresh cooling water outlet
	7 - 8	250	210	22	M16	8	
M	4 - 8	Coupling for 30 mm pipe					Cooling water de-aeration
N	4 - 5	285	240	24	M20	8	Cooling water inlet to air cooler
	6 - 8	340	295	24	M20	8	
P	4 - 5	285	240	24	M20	8	Cooling water outlet from air cooler
	6 - 8	340	295	24	M20	8	
R	4 - 8	220	180	20	M16	8	Lubricating oil inlet (system oil)
S	4 - 8	See speciel drawing of oil outlet					System oil outlet to bottom tank
U	4 - 6	340	295	24	M20	8	Cooling oil inlet (system oil)
	7 - 8	395	350	28	M20	12	
X	4 - 8	185	145	18	M16	8	Fuel oil inlet
Y	4 - 8	150	110	16	M16	4	Lubricating oil inlet to camshaft
AA	1xNA57	150	110	18	M16	4	Lubricating oil inlet to MAN B&W, MHI MET and ABB TPL turbochargers
	1xNA70	140	125	20	M16	4	
	2xNA48	165	125	20	M16	4	
	2xNA57	185	145	18	M16	4	
	2xNA70	220	180	22	M16	8	
	2xMET53	165	125	20	M16	4	
	2xMET66	185	145	18	M16	4	
	1xMET66	165	125	20	M16	4	
	1xMET71	165	125	20	M16	4	
	1xMET83	165	125	20	M16	4	
	TPL77,80	140	100	18	M16	4	
AB	1xNA57	185	145	18	M16	4	Lubricating oil outlet to MAN B&W, MHI and ABB TPL turbochargers
	1xNA70	220	180	22	M16	8	
	2xNA48	220	180	22	M16	8	
	2xNA57	220	180	22	M16	8	
	2xNA70	285	240	24	M20	8	
	2xMET53	250	210	22	M16	8	
	2xMET66	285	240	24	M20	8	
	1xMET66	220	180	22	M16	8	
	1xMET171	190	155	14	M16	8	
	1xMET83	250	210	22	M16	8	
	1xTPL77	200	160	20	M16	8	
	1xTPL80	220	180	24	M16	8	

Fig. 5.14a: List of counterflanges, option: 4 30 202

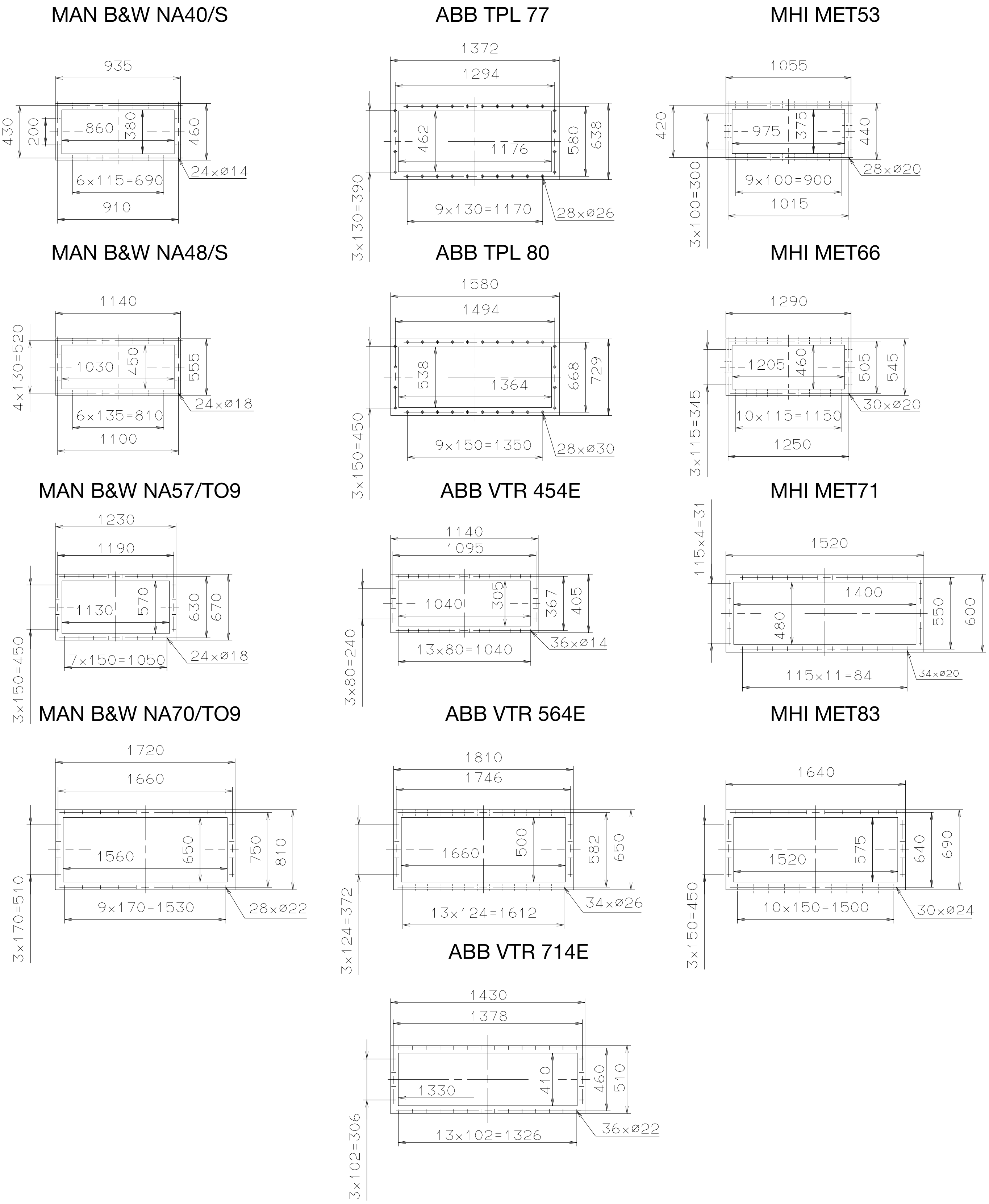
178 31 96-8.2

Reference	Cyl. No.	Flange			Bolts		Description
		Diam.	PCD	Thickn.	Diam.	No. off	
AC	4 - 8	Coupling for 30 mm pipe				8	Lubricating oil inlet to cylinder lubricators
AD	4 - 8	115	85	14	M12	4	Fuel oil return from umbrella sealing
AE	4 - 8	140	100	16	M16	4	Drain from bedplate/cleaning turbocharger
AF	4 - 8	140	100	16	M16	4	Fuel oil to draintank
AG	4 - 8	140	100	16	M16	4	Drain oil from piston rod stuffing boxes
AH	4 - 8	140	100	16	M16	4	Fresh cooling water drain
AK	4 - 8	Coupling for 30 mm pipe					Inlet cleaning air cooler
AL TC aft	4 - 8	140	100	16	M16	4	Outlet air cooler cleaning/water mist catcher
AM TC aft	4 - 8	140	100	16	M16	4	Outlet air cooler to chemical cleaning tank
AL TC exh	4 - 8	165	125	18	M16	4	Outlet air cooler cleaning/water mist catcher
AM TC exh	4 - 8	165	125	18	M16	4	Outlet air cooler to chemical cleaning tank
AN	4 - 8	Coupling for 30 mm pipe					Water inlet for cleaning of turbocharger
AP TC aft	4 - 8	Coupling for 12 mm pipe					Air inlet for dry cleaning of turbocharger
AP TC exh	4 - 8	Coupling for 30 mm pipe					Air inlet for dry cleaning of turbocharger
AR	4 - 8	165	125	18	M16	4	Oil vapour discharge
AS	4 - 8	Coupling for 30 mm pipe					Cooling water drain air cooler
AT	4 - 8	150	110	16	M16	4	Extinguishing of fire in scavenge air box
AV	4 - 8	185	145	18	M16	4	Drain from scavenge air box to closed drain tank
BA	4 - 8	Coupling for 8 mm pipe					Terminal plate for remote instruments
BD	4 - 8	Coupling for 16 mm pipe					Fresh water outlet for heating fuel oil drain pipes
BX	4 - 8	Coupling for 16 mm pipe					Steam inlet for heating fuel oil pipes
BF	4 - 8	Coupling for 16 mm pipe					Steam outlet for heating fuel oil pipes
BV	4 - 8	Coupling for 16 mm pipe					Steam inlet for cleaning drain scavenge air box

The list of flanges will be extended, when PTO system is built onto the engine

178 31 96-8.2

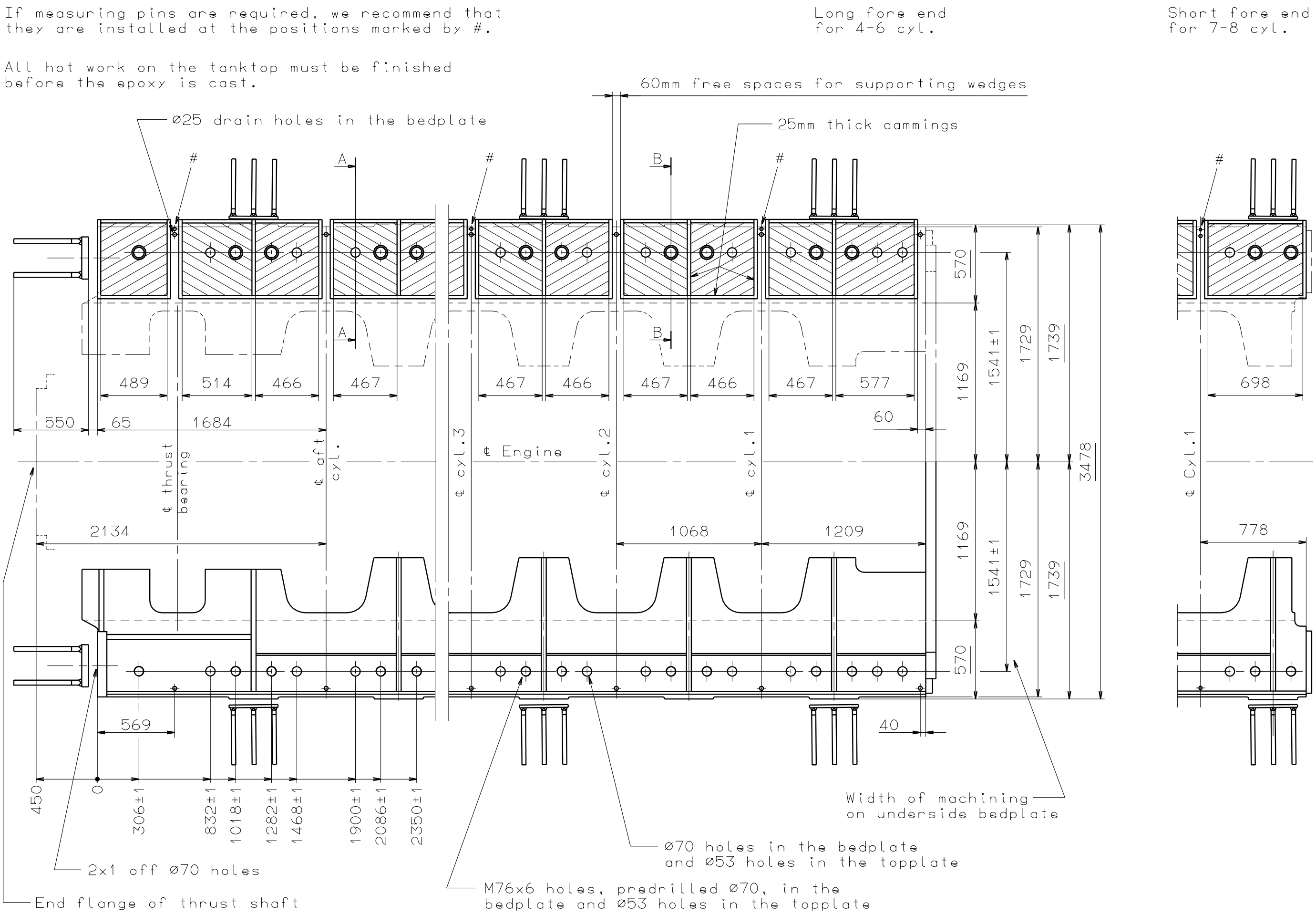
Fig. 5.14b: List of counterflanges, option: 4 30 202

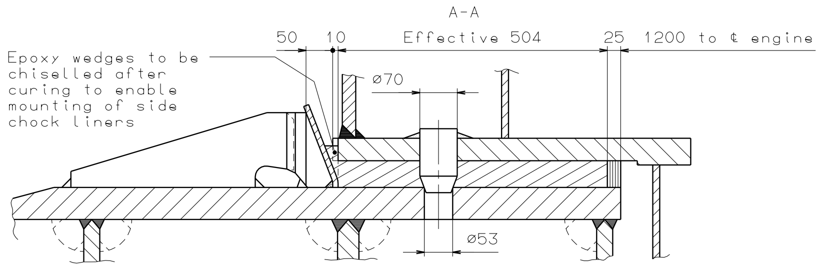


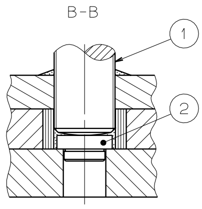
Thickness of flanges: 25 mm (for VTR454 and VTR454E thickness = 20 mm)

178 19 41-1.2

Fig. 5.15: List of counterflanges, turbocharger exhaust outlet (yard's supply)







1: Alignment screw
2: Plug

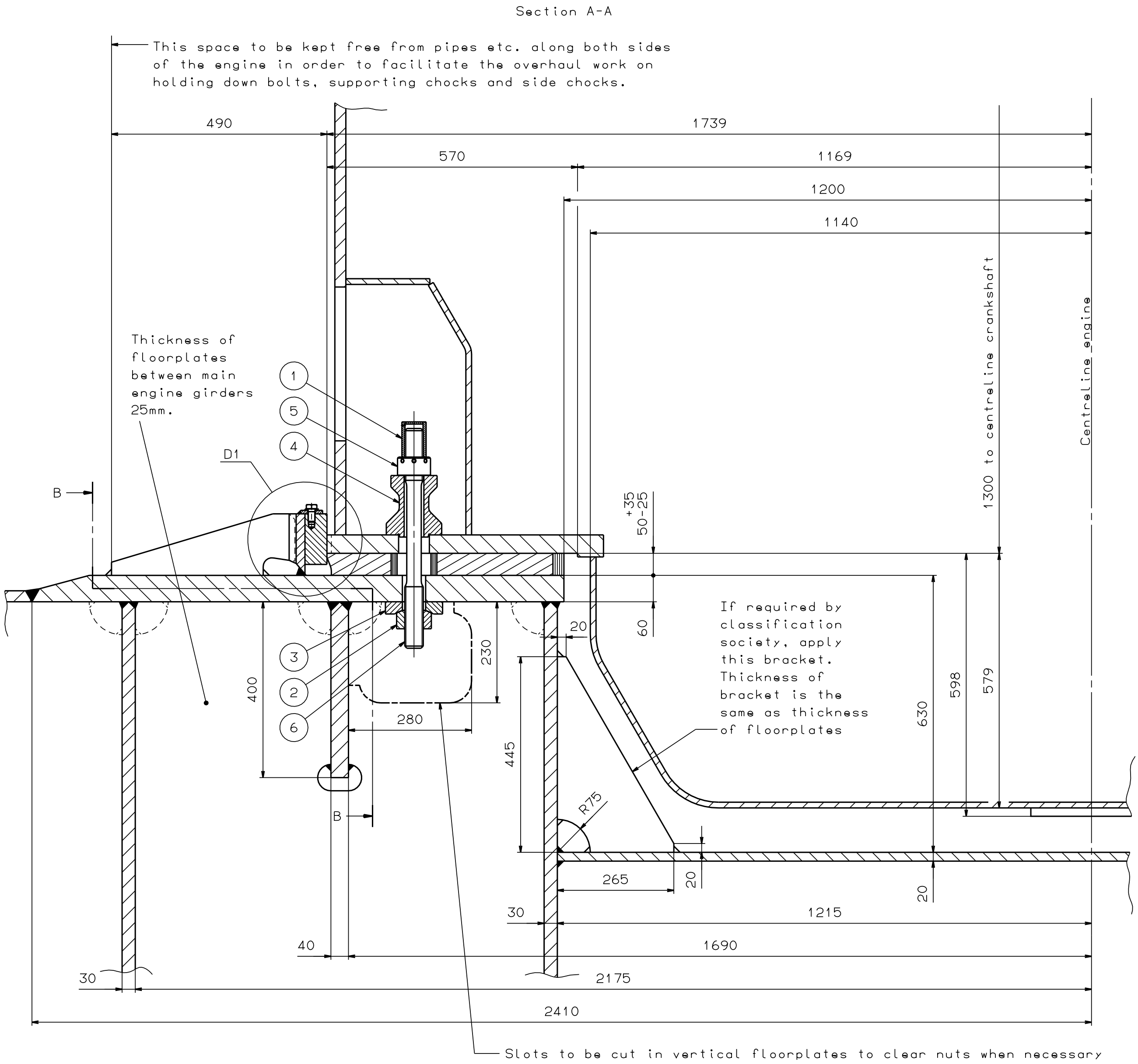
For details of chocks and bolts see special drawings

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 Diesel A/S 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 Diesel A/S drawings of these bolts

178 14 91-6.2

Fig. 5.16: Arrangement of epoxy chocks and holding down bolts

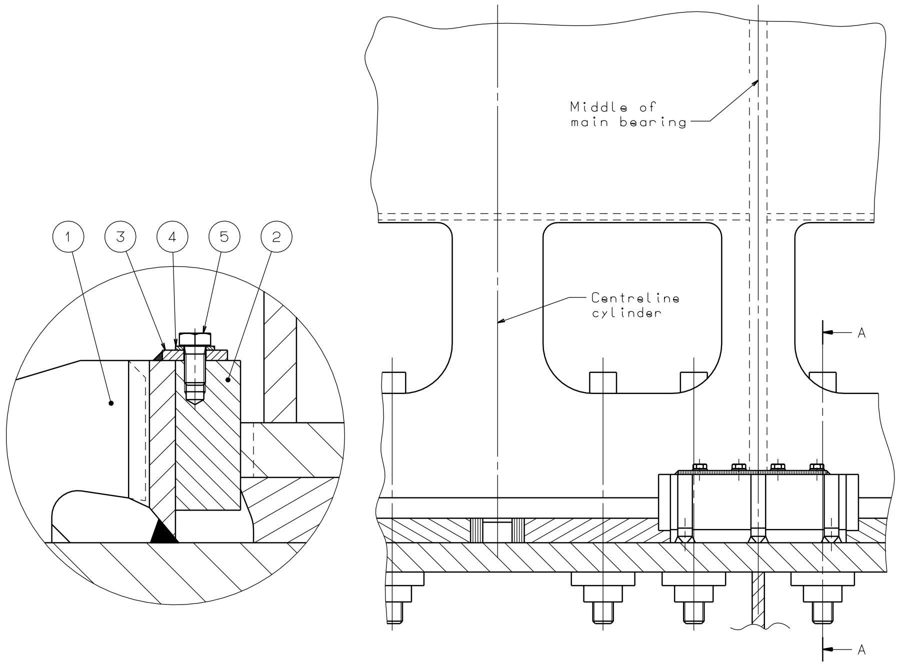


Holding down bolts, option: 4 82 602 includes:

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

178 14 76-2.2

Fig. 5.17a: Profile of engine seating with vertical oil outlets

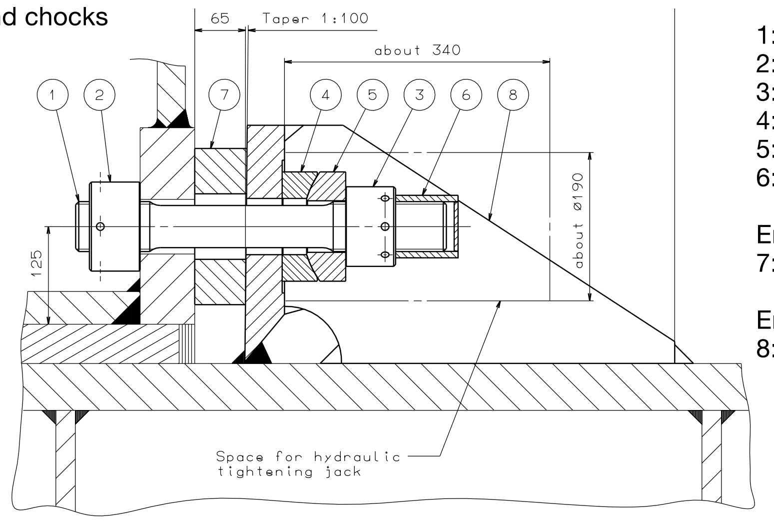


Side chock liners, option: 4 82 620 includes:
2: Liner for side chock
3; Lock plate
4: Washer
5: Screw

Side chock bracket option: 4 82 622 includes:
1: Side chock bracket

Fig. 5.17b: Profile of engine seating, side chocks

End chocks



End chock bolts, option: 4 82 610 includes:

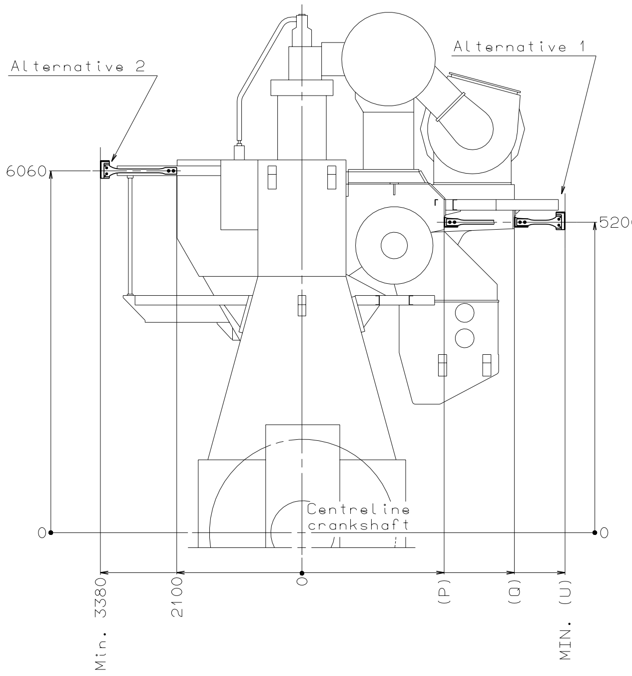
1: Stud for end chock bolt
2: Round nut
3: Round nut
4: Spherical washer
5: Spherical washer
6: Protecting cap

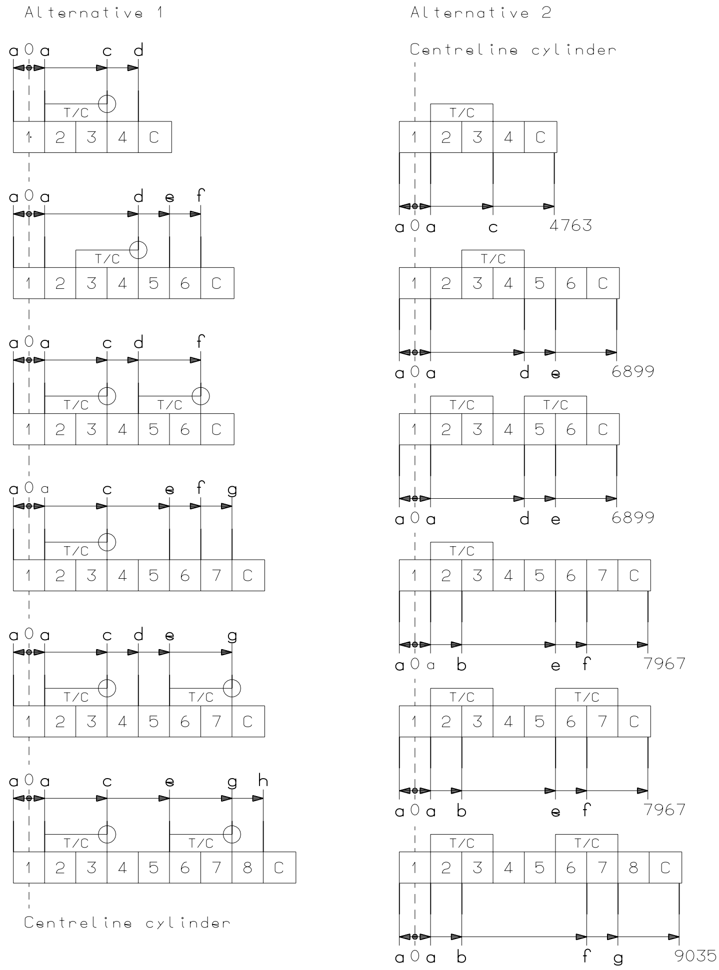
End chock liners, option: 4 82 612 includes:
7: Liner for end chock

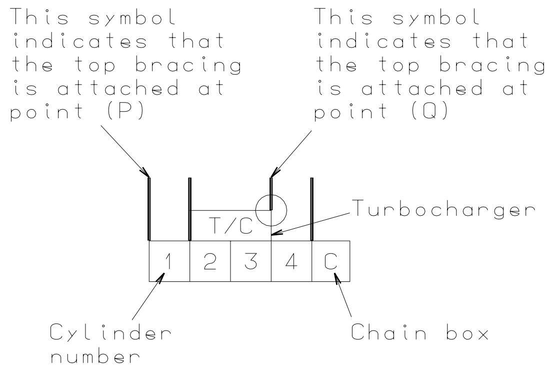
End chock brackets, option: 4 82 614 includes:
8: End chock brackets

178 14 77-4.2

Fig. 5.17c: Profile of engine seating, end chocks







T/C type	P	Q	U
NA40	2385	3202	4052
NA48	2385	3453	4303
NA57	2385	3563	4413
NA70	2550	4034	4884
VTR454/TPL77	2385	3338	4188
VTR564/TPL80	2385	3586	4436
VTR714	2385	4135	4985
MET66	2385	3585	4435
MET83	2385	4185	5035

Top bracing should only be installed on one side, either the exhaust side as show, or on the camshaft side (Please contact MAN B&W for further information).

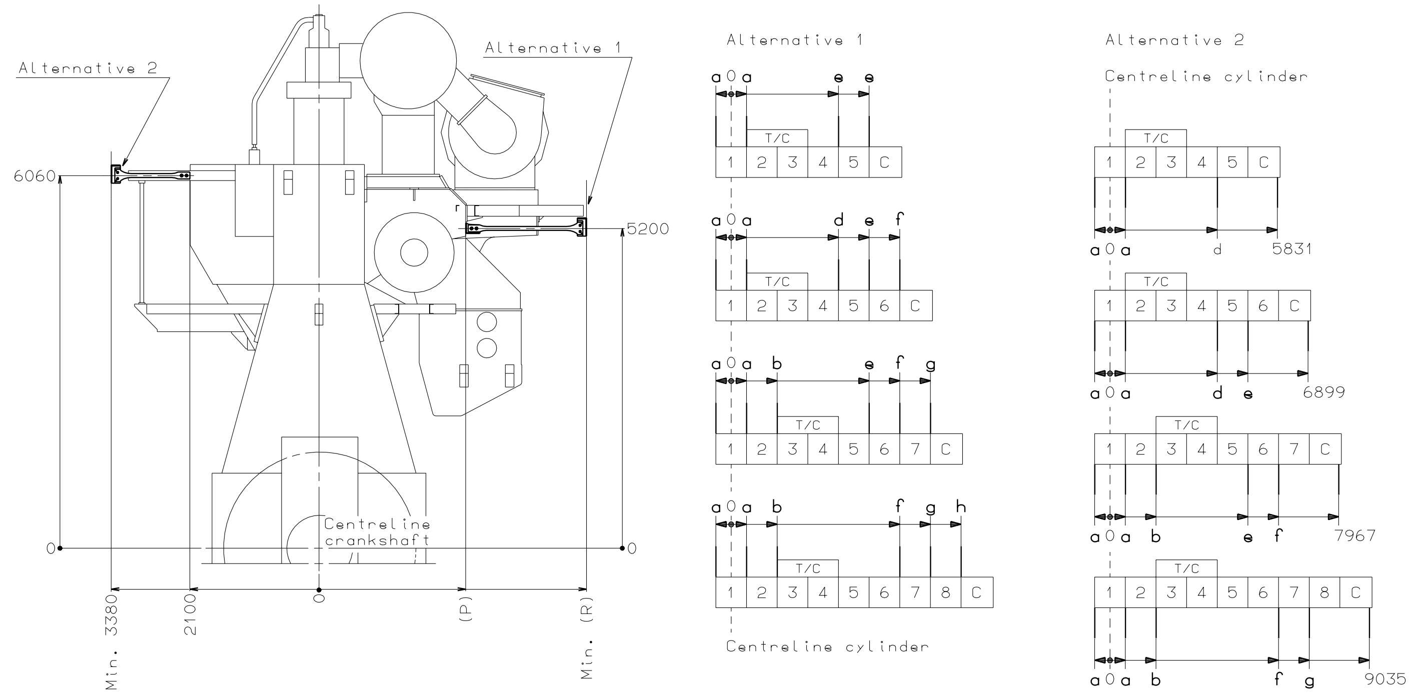
For 4-7 cylinder engines we recommend to prepare the ship for later installation of bracings in positions marked by (x), just in case a trial trip indicates the need for more bracings than recommended here.

Horizontal distance between top bracing fix point and center line of cylinder no. 1.

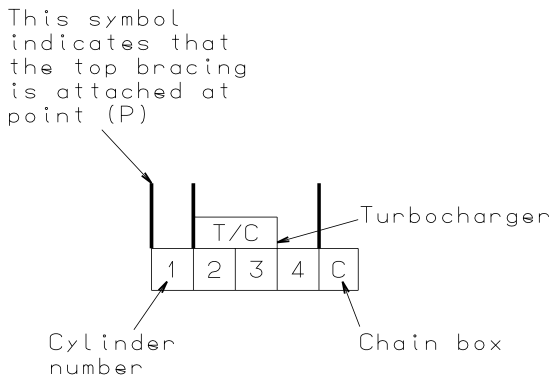
a = 534 e = 4806
b = 1602 f = 5874
c = 2670 g = 6942
d = 3738 h = 8010

178 31 99-3.0

Fig. 5.18a: Mechanical top bracing arrangement, turbocharger located on the exhaust side of the engine, at least one top bracing in alternative 1 is to be attached at point (Q)

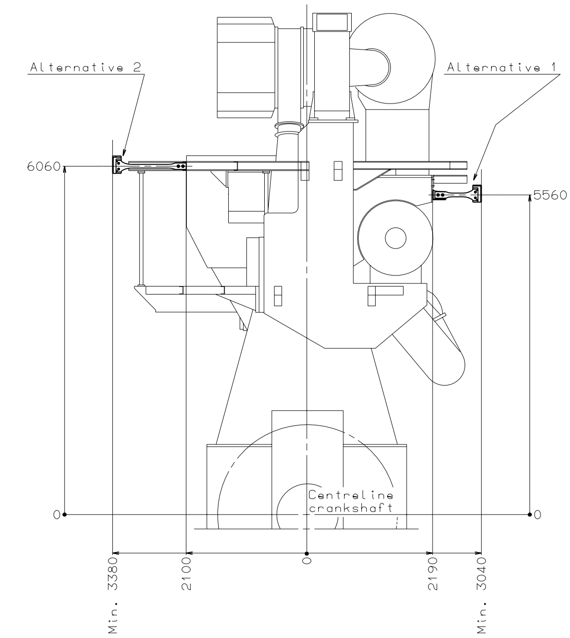


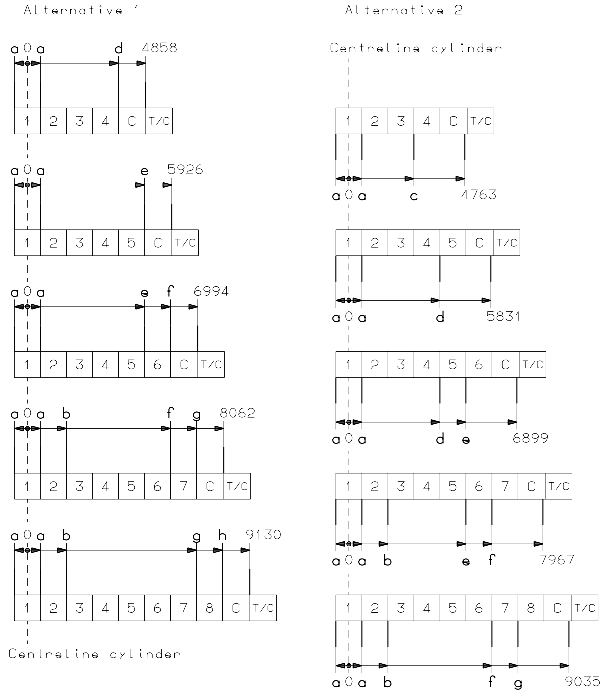
T/C type	P	R
NA40	2385	4350
NA48	2385	4350
NA57	2385	4350
NA70	2550	1900
VTR454/TPL77	2385	4350
VTR564/TPL80	2385	4350
VTR714	2385	4350
MET66	2385	4550
MET83	2385	4900

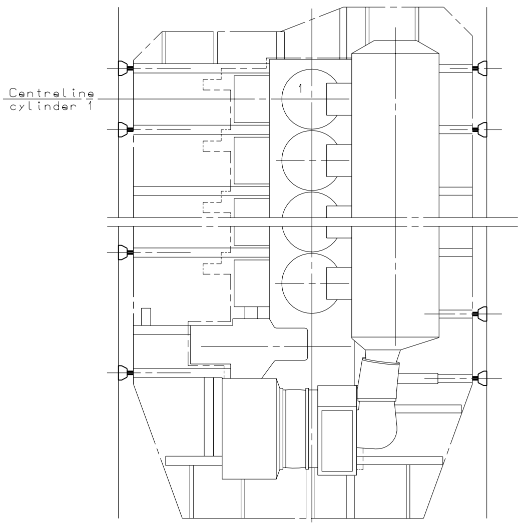


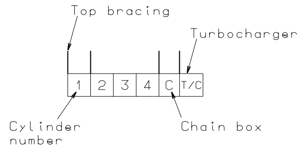
178 14 78-6.1

Fig. 5.18b: Mechanical top bracing arrangement, turbocharger located on the exhaust side of the engine, all top bracings in alternative 1 are to be attached at point (P)









Horizontal distance between top bracing fix point and centre line of cylinder 1:

a = 534	e = 4806
b = 1602	f = 5874
c = 2670	g = 6942
d = 3738	h = 8010

Top bracing should only be installed on one side, either the exhaust side as show, or on the camshaft side
(Please contact MAN B&W for further information).

For 4-7 cylinder engines we recommend to prepare the ship for later installation of bracings in positions marked by (x), just in case a trial trip indicates the need for more bracings than recommended here.

178 14 79-8.1

Fig. 5.19: Mechanical top bracing arrangement, turbocharger located on aft end of engine option: 4 59 124

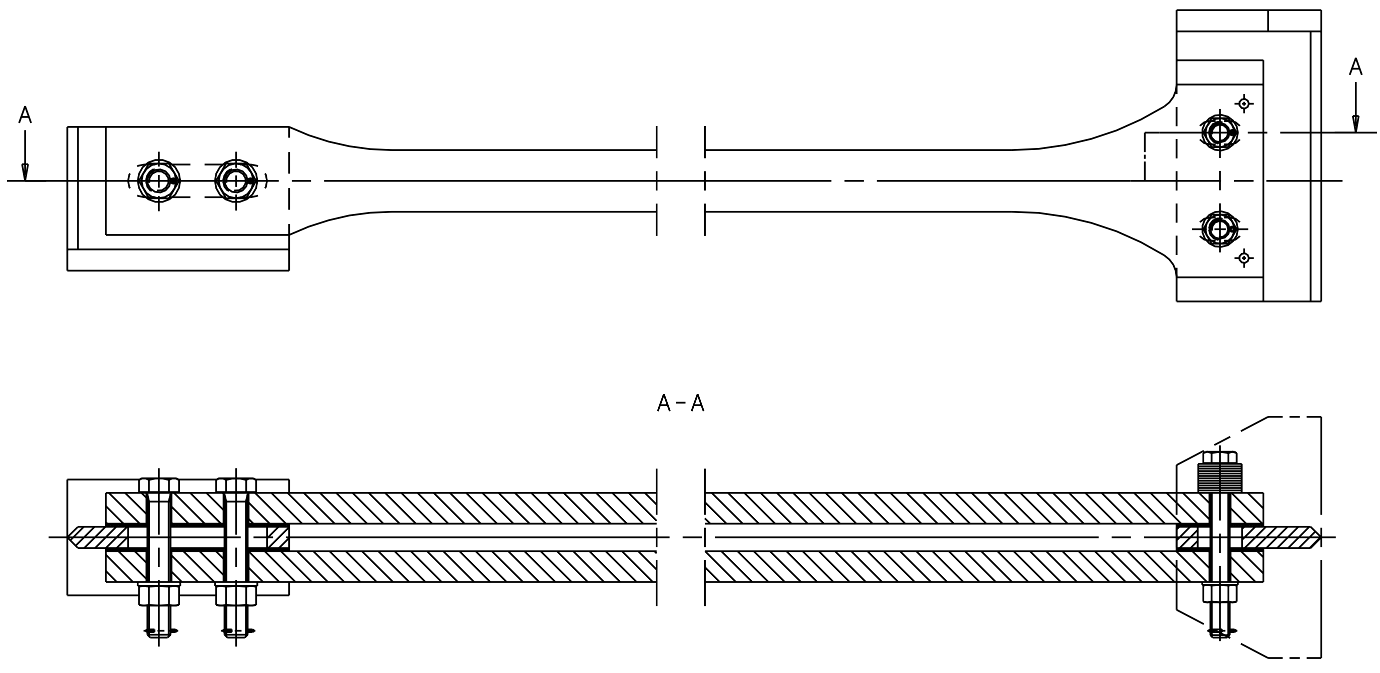
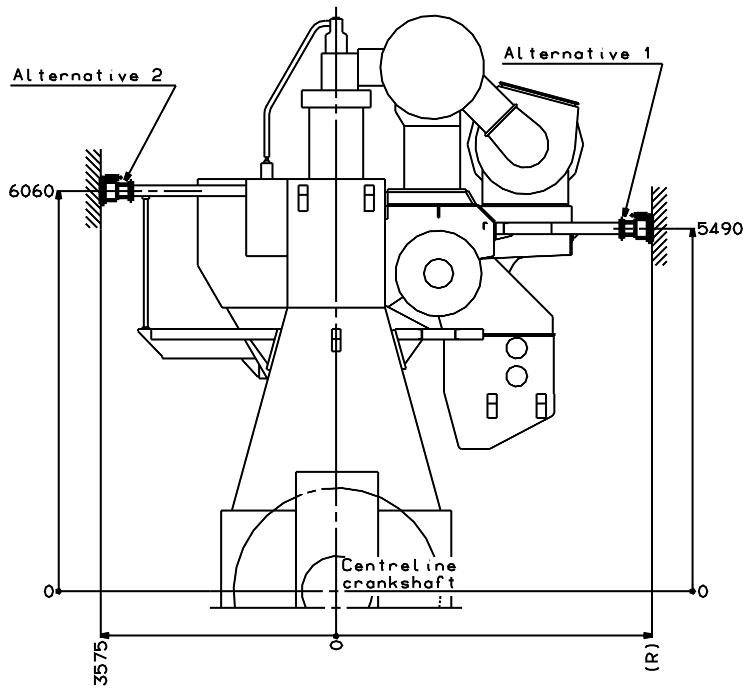
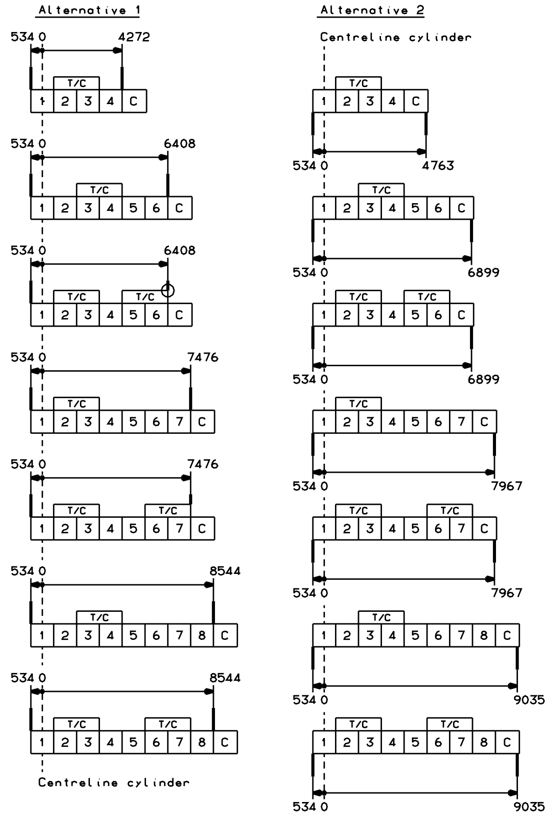


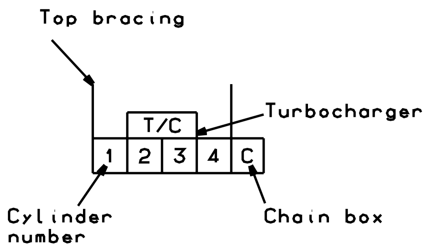
Fig. 5.20c: Mechanical top bracing outline, option: 4 83 112

Top bracing should only be installed on one side, either the exhaust side (alternative 1), or the camshaft side (alternative 2).





TC type	R
NA40	4475
NA40/S	4475
NA48	4675
NA48/S	4775
NA57	4775
NA70	5325
VTR454	4475
VTR454/E	4475
VTR564	4775
VTR564/E	4775
VTR714	5325
VTR714/E	5325
TPL77	4550
TPL80	4775
MET53	4575
MET66	4975
MET71	4975
MET83	5325



178 14 82-1.1

Fig. 5.21: Hydraulic top bracing arrangement, turbocharger located on the exhaust side of the engine

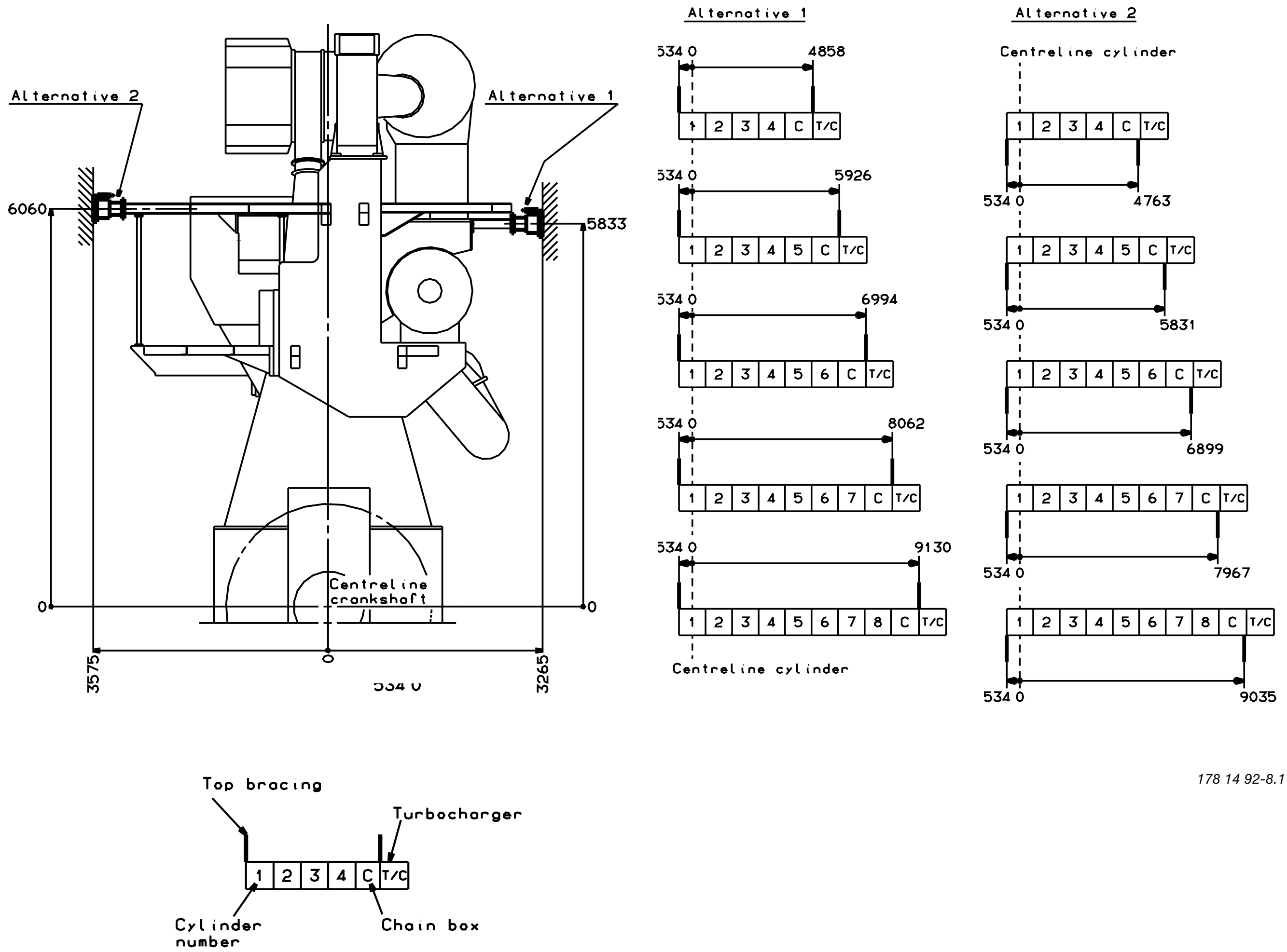
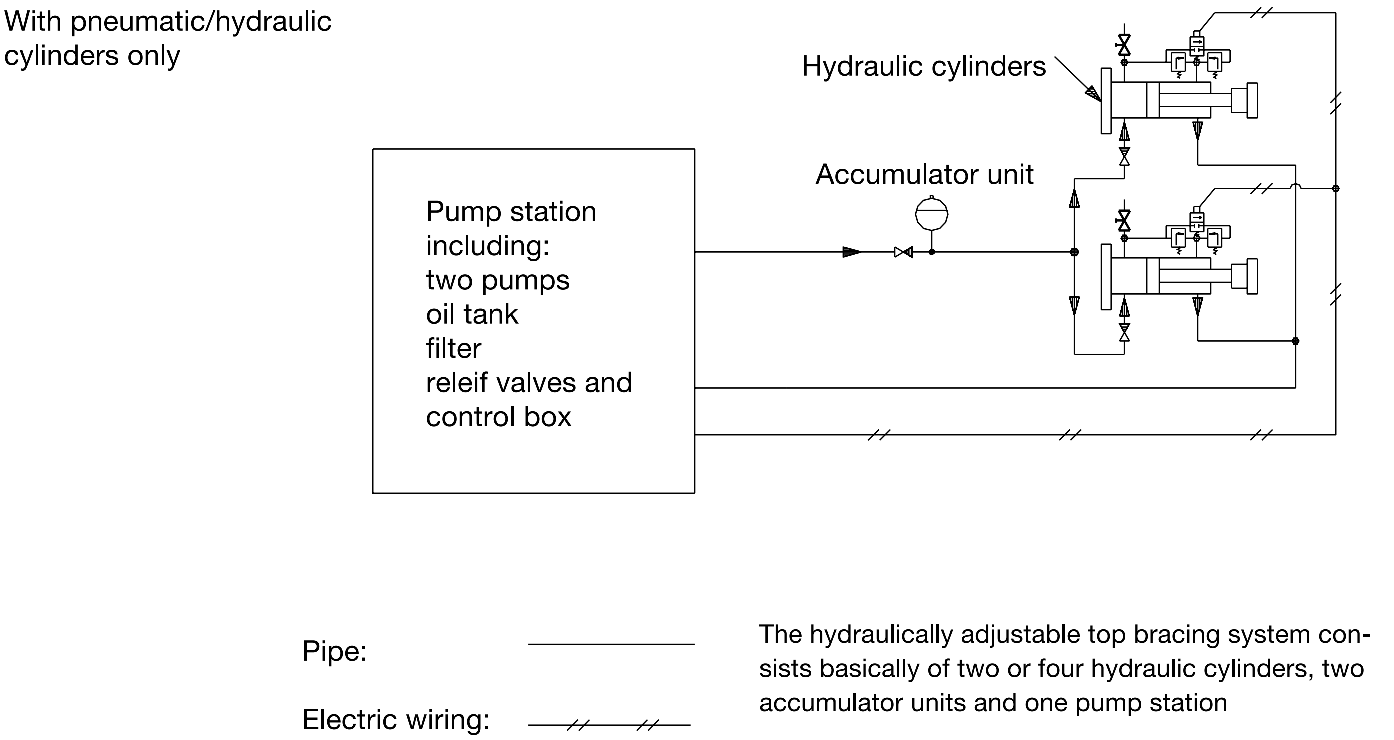


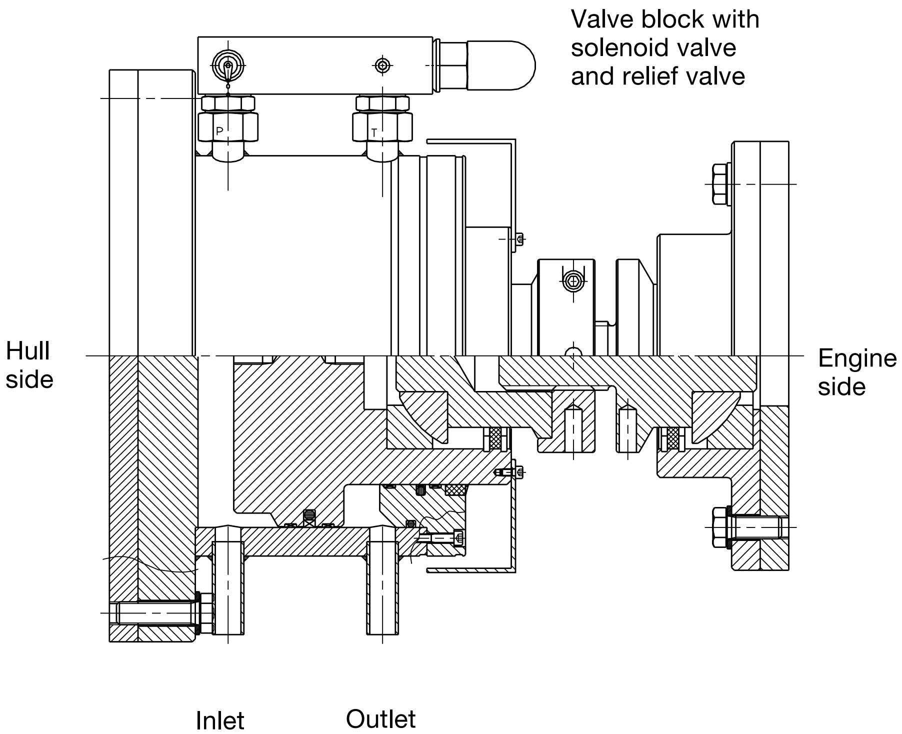
Fig. 5.22: Hydraulic top bracing arrangement, turbocharger located on the aft end of the engine



The hydraulically adjustable top bracing system consists basically of two or four hydraulic cylinders, two accumulator units and one pump station

178 16 68-0.0

Fig. 5.23a: Hydraulic top bracing layout of system with pump station, option: 4 83 122



178 16 47-6.0

Fig. 5.23b: Hydraulic cylinder for option 4 83 122

With pneumatic/hydraulic cylinders only

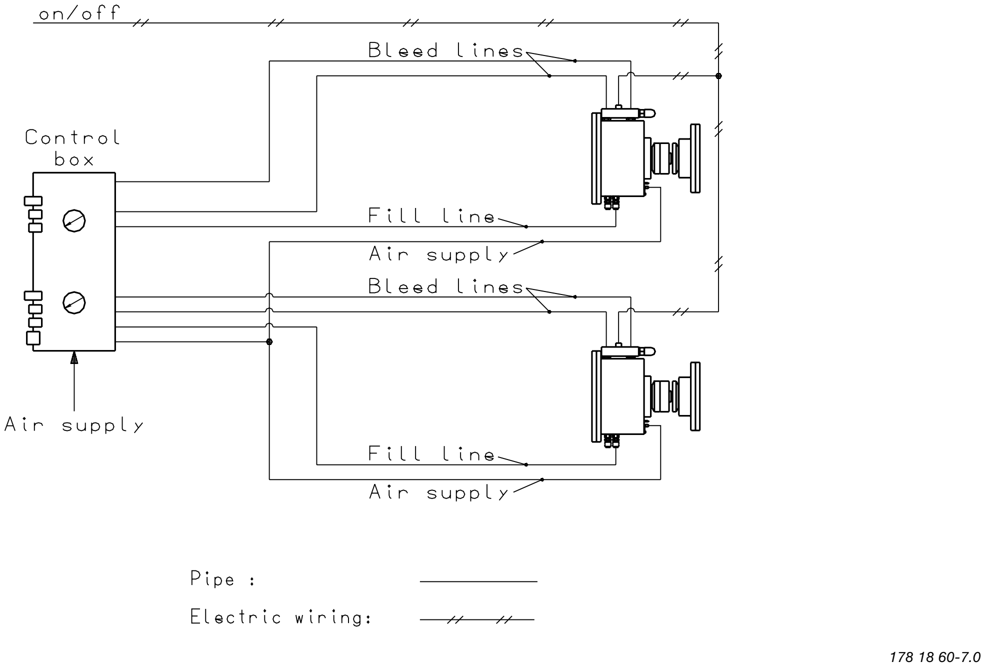


Fig. 5.24a: Hydraulic top bracing layout of system without pump station, option: 4 83 123

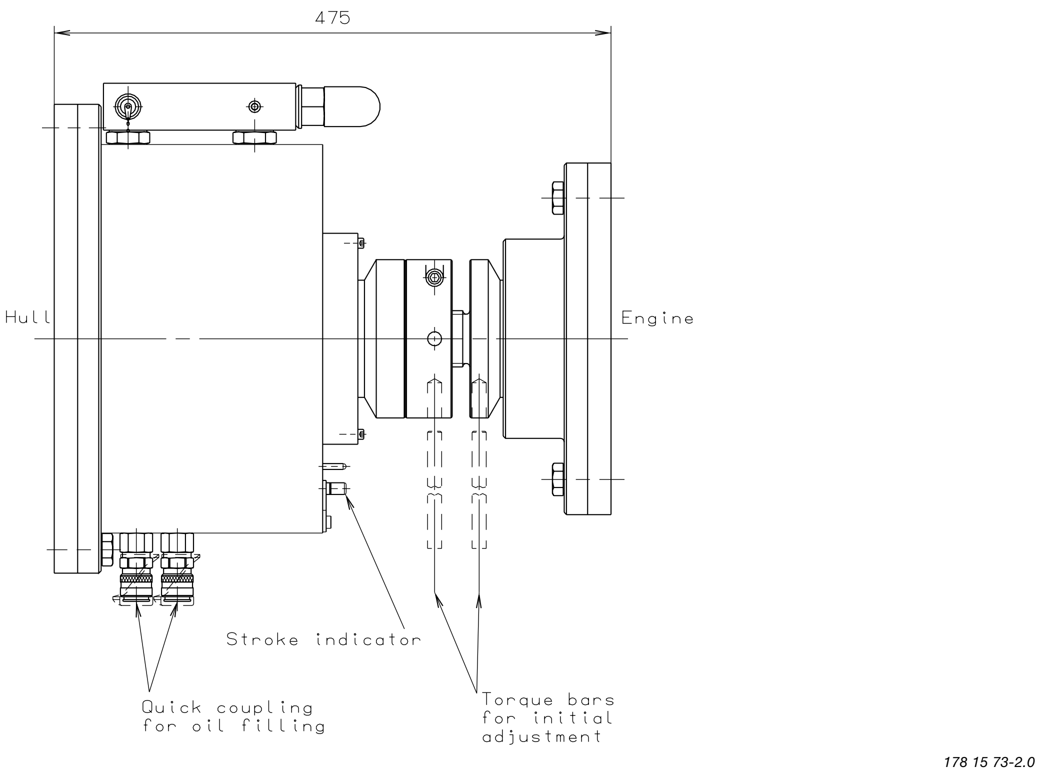
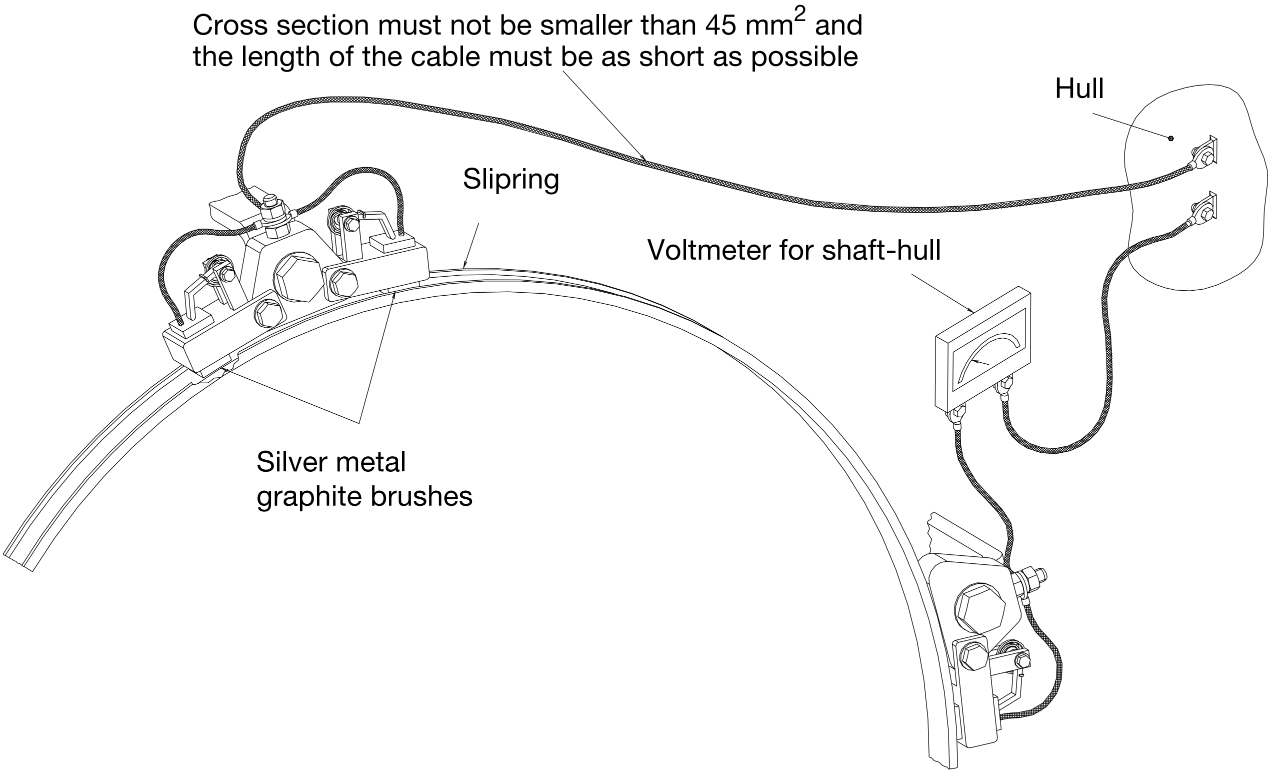
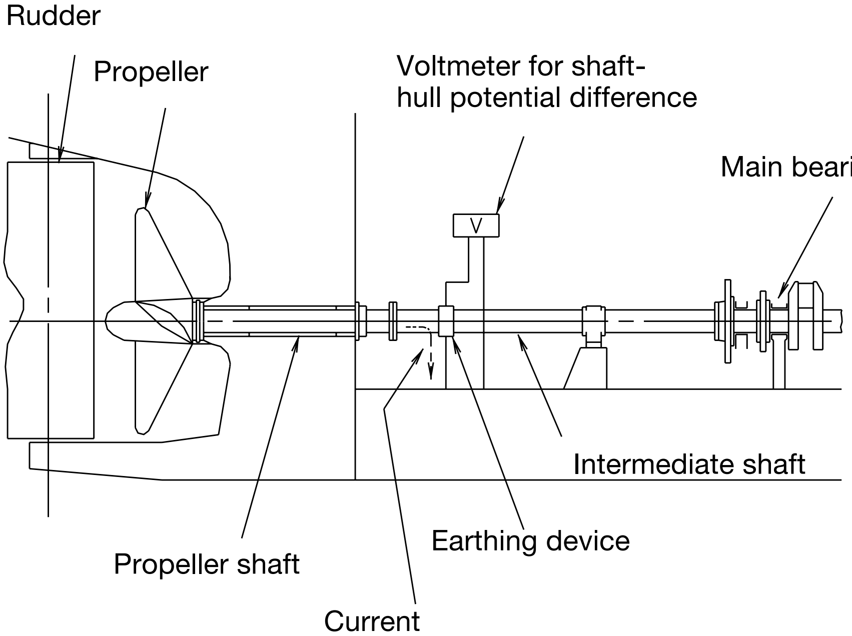


Fig. 5.24b: Hydraulic cylinder for option 4 83 123





178 32 07-8.0

Fig. 5.25: Earthing device, (yard's supply)

Auxiliary Systems 6

6.01. Calculation of Capacities

Engine configurations related to SFOC

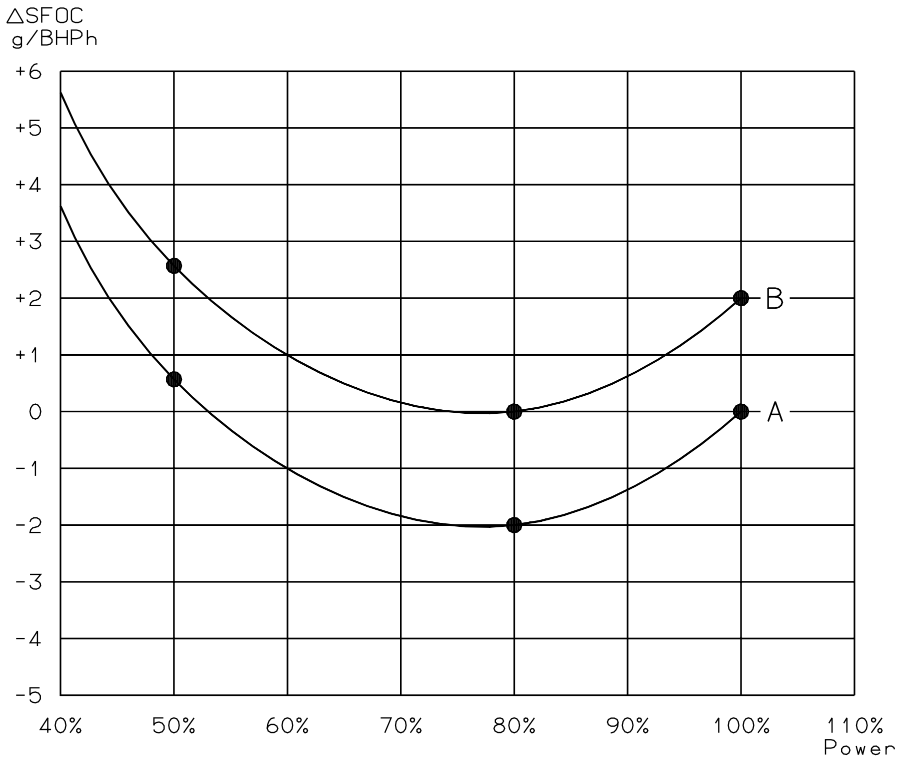
The engine type is available in the following two versions with respect to the efficiency of the turbocharger:

- **A) With high efficiency turbochargers:** which is the basic design and for which the lists of capacities Figs. 6.01.03a and 6.01.03b 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 up to 2 g/BHPh see example on Fig. 6.01.01. The corresponding list of capacities are stated in Figs. 6.01.04a and 6.01.04b.

The Lists of Capacities contain data regarding the necessary capacities of the auxiliary machinery for the main engine only.

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.



178 15 32-5.0

Fig. 6.01.01: Example of part load SFOC curves for the available two engine versions

Cooling Water Systems

The capacities given in the tables are based on tropical ambient reference conditions and refer to engines with a high efficiency/conventional turbocharger running at nominal MCR (L1) for, respectively:

- **Seawater cooling system,** Figs. 6.01.02a, 6.01.03a and 6.01.04a
- **Central cooling water system,** Figs. 6.01.02b, 6.01.03b and 6.01.04b

The capacities for the starting air receivers and the compressors are stated in Fig. 6.01.05

The above two cooling water systems are valid for uni-lubrication, but if a separate camshaft lubricating oil system is required, option 4 40 105, the coresponding list of capacities may be informed by contact to MAN B&W Diesel.

A detailed specification of the various components is given in the description of each system. If a freshwater generator is installed, the water production can be calculated by using the formula stated later in this chapter and the way of calculating the exhaust gas data is also shown later in this chapter. The air consumption is approximately 98% of the calculated exhaust gas amount.

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

The diagrams use the symbols shown in Fig. 6.01.19 "Basic symbols for piping", whereas the symbols for instrumentation accord to the "Symbolic representation of instruments" and the instrumentation list found in section 8.

Heat radiation

The radiation and convection heat losses to the engine room is about 1.3% of the engine nominal power (kW in L_1).

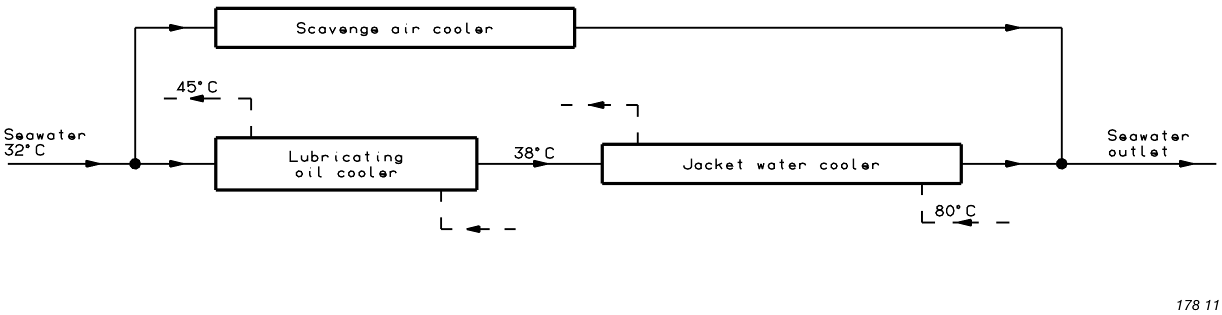


Fig. 6.01.02a: Diagram for seawater cooling

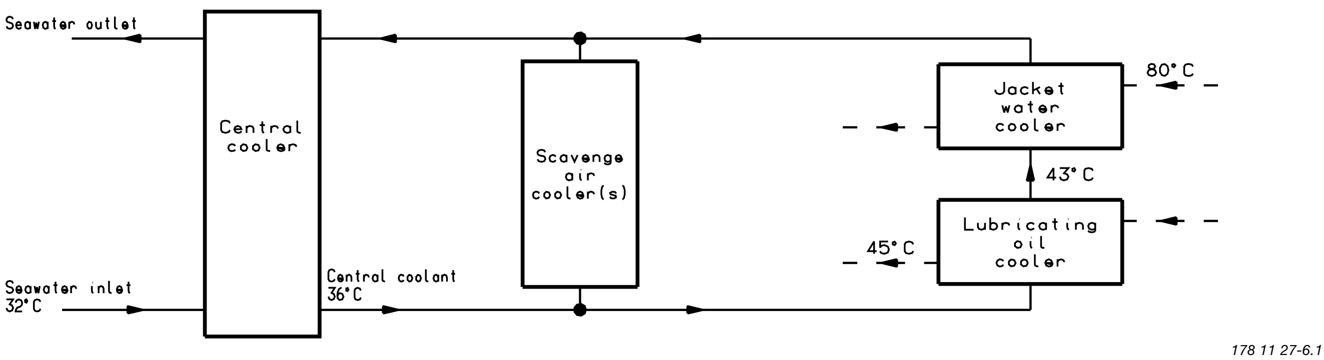


Fig. 6.01.02b: Diagram for central cooling water system

		Cyl.		4	5	6	7	8
	Nominal MCR at 105 r/min	**kW**		**8160**	**10200**	**12240**	**14280**	**16320**
Pumps	Fuel oil circulating pump	m^3/h		4.2	5.3	6.4	7.4	8.5
	Fuel oil supply pump	m^3/h		2.0	2.5	3.1	3.6	4.1
	Jacket cooling water pump	m^3/h	1)	67	82	100	120	135
			2)	62	78	93	110	125
			3)	66	83	98	115	130
			4)	62	78	93	110	125
	Seawater cooling pump*	m^3/h	1)	265	325	395	455	520
			2)	260	325	390	460	520
			3)	260	325	390	455	520
			4)	260	325	390	455	520
	Lubricating oil pump*	m^3/h	1)	175	220	265	310	350
			2)	175	220	265	310	350
			3)	170	210	255	295	340
			4)	180	220	265	310	350
	Booster pump for camshaft	m^3/h		5.2	6.5	7.8	9.1	10.4
Coolers	**Scavenge air cooler** Heat dissipation approx.	kW		3240	4050	4860	5670	6480
	Seawater	m^3/h		172	215	258	301	344
	Lubricating oil cooler Heat dissipation approx.*	kW	1)	640	780	960	1100	1250
			2)	680	850	1000	1200	1340
			3)	580	720	860	1010	1150
			4)	650	790	950	1110	1250
	Lubricating oil*	m^3/h		See above "Main lubricating oil pump"				
	Seawater	m^3/h	1)	93	110	137	154	176
			2)	88	110	132	159	176
			3)	88	110	132	154	176
			4)	88	110	132	154	176
	Jacket water cooler Heat dissipation approx.	kW	1)	1250	1550	1860	2160	2460
			2)	1190	1480	1780	2080	2380
			3)	1250	1580	1880	2170	2500
			4)	1190	1480	1780	2080	2380
	Jacket cooling water	m^3/h		See above "Jacket cooling water pump"				
	Seawater	m^3/h		See above "Seawater quantity" for lube oil cooler				
	Fuel oil heater	kW		110	140	170	195	225
	Exhaust gas flow at 235 °C**	kg/h		77300	96600	115900	135200	154600
	Air consumption of engine	kg/s		21.1	26.3	31.6	36.8	42.1

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

** The exhaust gas amount and temperature must be adjusted according to the actual plant specification

1) Engines with MAN B&W turbochargers
2) Engines with ABB turbochargers, type TPL
3) Engines with ABB turbochargers, type VTR
4) Engines with Mitsubishi turbochargers

178 30 51-8.1

*Fig. 6.03a: List of capacities, S60MC with **high efficiency turbocharger** and **seawater system** stated at the nominal MCR power (L_1) for engines complying with IMO's NO_x emission limitations*

		Cyl.		4	5	6	7	8
	Nominal MCR at 105 r/min	**kW**		**8160**	**10200**	**12240**	**14280**	**16320**
Pumps	Fuel oil circulating pump	m^3/h		4.2	5.3	6.4	7.4	8.5
	Fuel oil supply pump	m^3/h		2.0	2.5	3.1	3.6	4.1
	Jacket cooling water pump	m^3/h	1)	67	82	100	120	135
			2)	62	78	93	110	125
			3)	66	83	98	115	130
			4)	62	78	93	110	125
	Central cooling water pump*	m^3/h	1)	210	265	320	370	420
			2)	210	265	315	370	420
			3)	210	260	315	365	420
			4)	210	260	315	365	415
	Seawater pump*	m^3/h	1)	245	305	365	425	485
			2)	245	305	365	425	485
			3)	240	300	360	420	485
			4)	240	300	360	420	480
	Lubricating oil pump*	m^3/h	1)	175	220	265	310	350
			2)	175	220	265	310	350
			3)	170	210	255	295	340
			4)	180	220	265	310	350
	Booster pump for camshaft	m^3/h		5.2	6.5	7.8	9.1	10.4
Coolers	**Scavenge air cooler** Heat dissipation approx.	kW		3220	4020	4830	5630	6440
	Central cooling water	m^3/h		122	152	183	213	244
	Lubricating oil cooler Heat dissipation approx.*	kW	1)	640	780	960	1100	1250
			2)	680	850	1000	1200	1340
			3)	580	720	860	1010	1150
			4)	650	790	950	1110	1250
	Lubricating oil*	m^3/h		See above "Lubricating oil pump"				
	Central cooling water	m^3/h	1)	88	113	137	157	176
			2)	88	113	132	157	176
			3)	88	108	132	152	176
			4)	88	108	132	152	171
	Jacket water cooler Heat dissipation approx.	kW	1)	1250	1550	1860	2160	2460
			2)	1190	1480	1780	2080	2380
			3)	1250	1580	1880	2170	2500
			4)	1190	1480	1780	2080	2380
	Jacket cooling water	m^3/h		See above "Jacket cooling water"				
	Central cooling water	m^3/h		See above "Central cooling water quantity" for lube oil cooler				
	Central cooler Heat dissipation approx.*	kW	1)	5110	6350	7650	8890	10150
			2)	5090	6350	7610	8910	10160
			3)	5050	6320	7570	8810	10090
			4)	5060	6290	7560	8820	10070
	Central cooling water*	m^3/h		See above "Central cooling water pump"				
	Seawater*	m^3/h		See above "Seawater cooling pump"				
	Fuel oil heater	kW		110	140	170	195	225
	Exhaust gas flow at 235 °C**	kg/h		77300	96600	115900	135200	154600
	Air consumption of engine	kg/s		21.1	26.3	31.6	36.8	42.1

178 30 53-1.1

*Fig. 6.03b: List of capacities, S60MC with **high efficiency turbocharger** and **central cooling system** stated at the nominal MCR power (L_1) for engines complying with IMO's NO_x emission limitations*

		Cyl.		4	5	6	7	8
	Nominal MCR at 105 r/min	kW		8160	10200	12240	14280	16320
Pumps	Fuel oil circulating pump	m^3/h		4.3	5.4	6.4	7.5	8.6
	Fuel oil supply pump	m^3/h		2.1	2.6	3.1	3.6	4.2
	Jacket cooling water pump	m^3/h	1)	62	82	98	120	135
			2)	62	78	93	110	125
			3)	66	81	98	115	130
			4)	62	78	93	110	125
	Seawater cooling pump*	m^3/h	1)	250	315	380	445	510
			2)	255	315	380	440	510
			3)	250	315	375	440	500
			4)	250	315	375	440	500
	Lubricating oil pump*	m^3/h	1)	175	220	265	310	350
			2)	175	220	265	305	355
			3)	170	215	255	300	340
			4)	180	220	265	310	355
	Booster pump for camshaft	m^3/h		5.2	6.5	7.8	9.1	10.4
Coolers	**Scavenge air cooler**							
	Heat dissipation approx.	kW		3070	3830	4600	5370	6130
	Seawater	m^3/h		164	205	246	287	328
	Lubricating oil cooler							
	Heat dissipation approx.*	kW	1)	660	780	920	1100	1250
			2)	680	820	1000	1140	1340
			3)	580	720	860	1010	1150
			4)	650	790	930	1090	1250
	Lubricating oil*	m^3/h		See above "Main lubricating oil pump"				
	Seawater	m^3/h	1)	86	110	134	158	182
			2)	91	110	134	153	182
			3)	86	110	129	153	172
			4)	86	110	129	153	172
	Jacket water cooler							
	Heat dissipation approx.	kW	1)	1190	1550	1850	2160	2460
			2)	1190	1480	1780	2080	2380
			3)	1250	1550	1880	2170	2470
			4)	1190	1480	1780	2080	2380
	Jacket cooling water	m^3/h		See above "Jacket cooling water pump"				
	Seawater	m^3/h		See above "Seawater quantity" for lube oil cooler				
	Fuel oil heater	kW		115	140	170	195	225
	Exhaust gas flow at 255 °C**	kg/h		71400	89300	107100	125000	142800
	Air consumption of engine	kg/s		19.4	24.3	29.1	34	38.8

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

** The exhaust gas amount and temperature must be adjusted according to the actual plant specification

1) Engines with MAN B&W turbochargers
2) Engines with ABB turbochargers, type TPL
3) Engines with ABB turbochargers, type VTR
4) Engines with Mitsubishi turbochargers

178 88 64-6.0

Fig. 6.01.04a: List of capacities, S60MC with ***conventional turbocharger*** *and* ***seawater cooling system,*** *stated at the nominal MCR power (L_1) for engines complying with IMO's NO_x emission limitations*

		Cyl.		4	5	6	7	8
	Nominal MCR at 105 r/min	kW		8160	10200	12240	14280	16320
Pumps	Fuel oil circulating pump	m^3/h		4.3	5.4	6.4	7.5	8.6
	Fuel oil supply pump	m^3/h		2.1	2.6	3.1	3.6	4.2
	Jacket cooling water pump	m^3/h	1)	62	82	98	120	135
			2)	62	78	93	110	125
			3)	66	81	98	115	130
			4)	62	78	93	110	125
	Central cooling water pump*	m^3/h	1)	205	260	310	360	415
			2)	205	255	310	360	415
			3)	205	255	310	360	410
			4)	205	255	305	355	410
	Seawater pump*	m^3/h	1)	235	295	350	410	470
			2)	235	290	350	410	470
			3)	235	290	350	405	465
			4)	235	290	350	405	465
	Lubricating oil pump*	m^3/h	1)	175	220	265	310	350
			2)	175	220	265	305	355
			3)	170	215	255	300	340
			4)	180	220	265	310	355
	Booster pump for camshaft	m^3/h		5.2	6.5	7.8	9.1	10.4
Coolers	**Scavenge air cooler** Heat dissipation approx.	kW		3040	3810	4570	5330	6090
	Central cooling water	m^3/h		118	147	176	206	235
	Lubricating oil cooler Heat dissipation approx.*	kW	1)	660	780	920	1100	1250
			2)	680	820	1000	1140	1340
			3)	580	720	860	1010	1150
			4)	650	790	930	1090	1250
	Lubricating oil*	m^3/h		See above "Lubricating oil pump"				
	Central cooling water	m^3/h	1)	87	113	134	154	180
			2)	87	108	134	154	180
			3)	87	108	134	154	175
			4)	87	108	129	149	175
	Jacket water cooler Heat dissipation approx.	kW	1)	1190	1550	1850	2160	2460
			2)	1190	1480	1780	2080	2380
			3)	1250	1550	1880	2170	2470
			4)	1190	1480	1780	2080	2380
	Jacket cooling water	m^3/h		See above "Jacket cooling water"				
	Central cooling water	m^3/h		See above "Central cooling water quantity" for lube oil cooler				
	Central cooler Heat dissipation approx.*	kW	1)	4890	6140	7340	8590	9800
			2)	4910	6110	7350	8550	9810
			3)	4870	6080	7310	8510	9710
			4)	4880	6080	7280	8500	9720
	Central cooling water*	m^3/h		See above "Central cooling water pump"				
	Seawater*	m^3/h		See above "Seawater cooling pump"				
	Fuel oil heater	kW		115	140	170	195	225
	Exhaust gas flow at 255 °C**	kg/h		71400	89300	107100	125000	142800
	Air consumption of engine	kg/s		19.4	24.3	29.1	34	38.8

178 88 65-8.0

*Fig. 6.01.04b: List of capacities, S60MC with **conventional turbocharger** and **central cooling water system**, stated at the nominal MCR power (L_1) for engines complying with IMO's NO_X emission limitations*

Starting air system: 30 bar (gauge)

Cylinder No.		**4**	**5**	**6**	**7**	**8**
Reversible engine						
Receiver volume (12 starts)	m^3	2 x 4.0	2 x 4.5	2 x 5.0	2 x 5.0	2 x 5.0
Compressor capacity, total	m^3/h	240	270	300	300	300
Non-reversible engine						
Receiver volume (6 starts)	m^3	2 x 2.5	2 x 2.5	2 x 2.5	2 x 2.5	2 x 3.0
Compressor capacity, total	m^3/h	150	150	150	150	180

178 88 70-5.0

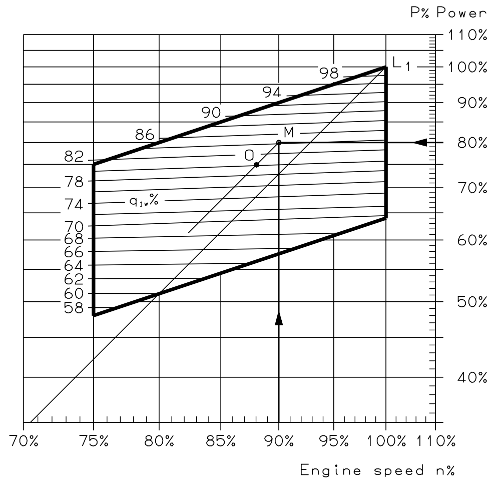
Fig. 6.01.05: Capacities of starting air receivers and compressors for main engine S60MC

Auxiliary System Capacities for Derated Engines

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), see Figs. 6.01.03 and 6.01.04, may also be used if wanted.

Cooler heat dissipations

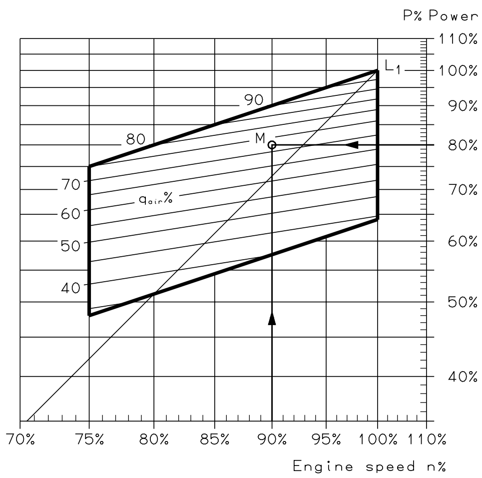
For the specified MCR (M) the diagrams in Figs. 6.01.06, 6.01.07 and 6.01.08 show reduction factors for the corresponding heat dissipations for the coolers, relative to the values stated in the "List of Capacities" valid for nominal MCR (L_1).



$$q_{jw}\% = e^{(-0.0811 \times \ln(n\%) + 0.8072 \times \ln(P\%) + 1.2614)}$$

178 06 56-6.1

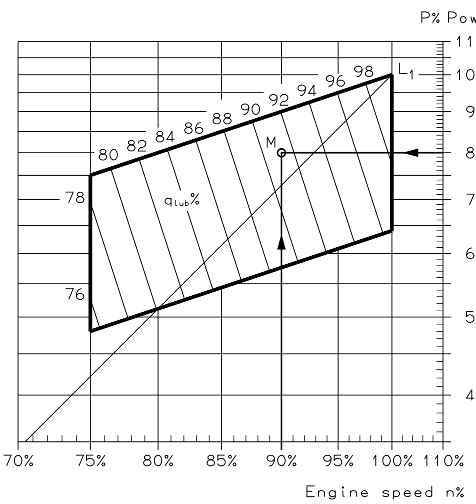
Fig. 6.01.07: Jacket water cooler, heat dissipation q_{jw}% in % of L_1 value



$$q_{air}\% = e^{(-0.8548 \times \ln(n\%) + 1.8321 \times \ln(P\%) + 0.1045)}$$

178 06 55-6.1

Fig. 6.01.06: Scavenge air cooler, heat dissipation q_{air}% in % of L_1 value



$$q_{lub}\% = 67.3009 \times \ln(n\%) + 7.6304 \times \ln(P\%) - 245.0714$$

178 08 07-7.0

Fig. 6.01.08: Lubricating oil cooler, heat dissipation q_{lub}% in % of L_1 value

The percentage power (P%) and speed (n%) of L_1 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", Figs. 6.01.03 and 6.01.04.

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 and the camshaft lubricating oil pump, if fitted, must remain unchanged.

Also, the fuel oil circulating and supply pumps should remain unchanged, and the same applies to the fuel oil preheater.

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

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

The seawater flow capacity for each of the scavenge air, lub. oil and jacket water coolers can be reduced proportionally to the reduced heat dissipations found in Figs. 6.01.06, 6.01.07 and 6.01.08, respectively.

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 lub. 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.

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. °C
Fuel oil supply pump	4	100
Fuel oil circulating pump	10	150
Lubricating oil pump	4	60
Booster pump for exhaust valve actuator lubrication	3	60
Seawater pump	2.5	50
Central cooling water pump	2.5	60
Jacket water pump	3	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

Example 1:

Derated 6S60MC with ***high efficiency*** *MAN B&W turbocharger with fixed pitch propeller and* ***seawater cooling*** *system.*

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}:	12,240 kW = 16,680 BHP	(100.0%)	105.0 r/min	(100.0%)
Specified MCR, (M)	P_M:	9,792 kW = 13,344 BHP	(80.0%)	94.5 r/min	(90.0%)
Optimised power, (O)	P_O:	9,156 kW = 12,477 BHP	(74.8%)	92.4 r/min	(88.0%)

Example 1:

The method of calculating the reduced capacities for point M is shown below.

The values valid for the nominal rated engine are found in the “List of Capacities” Fig. 6.01.03a, and are listed together with the result in Fig. 6.01.09.

Heat dissipation of scavenge air cooler
Fig. 6.01.05 which is approximate indicates a 73% heat dissipation:

4860 x 0.73 = 3548 kW

Heat dissipation of jacket water cooler
Fig. 6.01.07 indicates a 84% heat dissipation:

1860 x 0.84 = 1562 kW

Heat dissipation of lube. oil cooler
Fig. 6.01.08 indicates a 91% heat dissipation:

960 x 0.91 = 874 kW

Seawater pump

Scavenge air cooler:	258 x 0.73 = 188.3 m^3/h
Lubricating oil cooler:	137 x 0.91 = 124.7 m^3/h
Total:	313.0 m^3/h

		Nominal rated engine (L_1) high efficiency MAN B&W turbocharger	**Example 1** Specified MCR (M)
Shaft power at MCR		12,240 kW at 105 r/min	9,792 kW at 94.5 r/min
Pumps:			
Fuel oil circulating pump	m^3/h	6.4	6.4
Fuel oil supply pump	m^3/h	3.1	3.1
Jacket cooling water pump	m^3/h	100	100
Seawater pump	m^3/h	395	313.0
Lubricating oil pump	m^3/h	265	265
Booster pump for camshaft	m^3/h	7.8	7.8
Coolers:			
Scavenge air cooler			
Heat dissipation	kW	4860	3548
Seawater quantity	m^3/h	258	188.3
Lub. oil cooler			
Heat dissipation	kW	960	874
Lubricating oil quantity	m^3/h	265	265
Seawater quantity	m^3/h	137	124.7
Jacket water cooler			
Heat dissipation	kW	1860	1562
Jacket cooling water quantity	m^3/h	100	100
Seawater quantity	m^3/h	137	124.7
Fuel oil preheater:	kW	170	170
Gases at ISO ambient conditions *			
Exhaust gas flow	kg/h	115900	90700
Exhaust gas temperature	°C	235	226
Air consumption	kg/sec.	31.6	24.7
Starting air system: 30 bar (gauge)			
Reversible engine			
Receiver volume (12 starts)	m^3	2 x 5.0	2 x 5.0
Compressor capacity, total	m^3/h	300	300
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
Exhaust gas tolerances: temperature -/+ 15 °C and amount +/- 5%			

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

178 88 73-0.0

Fig. 6.01.09: Example 1 – Capacities of derated 6S60MC with high efficiency MAN B&W turbocharger and seawater cooling 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.

For a derated diesel engine, i.e. an engine having a specified MCR (M) and/or an 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. 6.01.07.

At part load operation, lower than optimised 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. 6.01.10.

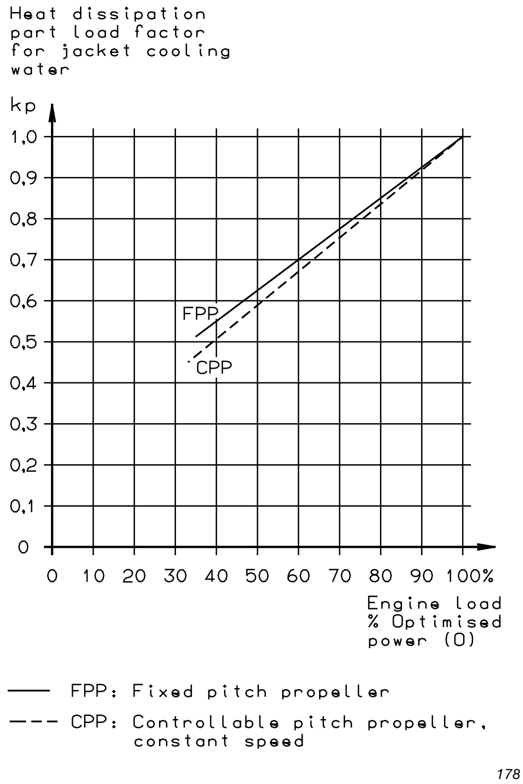


Fig. 6.01.10 Correction factor "kp" for jacket cooling water heat dissipation at part load, relative to heat dissipation at optimised power

With reference to the above, the heat actually available for a derated diesel engine may then be found as follows:

1. Engine power between optimised and specified power.

   For powers between specified MCR (M) and optimised power (O), the diagram Fig. 6.01.07 is to be used, i.e. giving the percentage correction factor "q_{jw}%" and hence

   $$Q_{jw} = Q_{L1} \times \frac{q_{jw\%}}{100} \times 0.9 \qquad (0.87) \qquad [1]$$

2. Engine power lower than optimised power.

   For powers lower than the optimised power, the value Qjw,O found for point O by means of the above equation [1] is to be multiplied by the correction factor kp found in Fig. 6.01.10 and hence

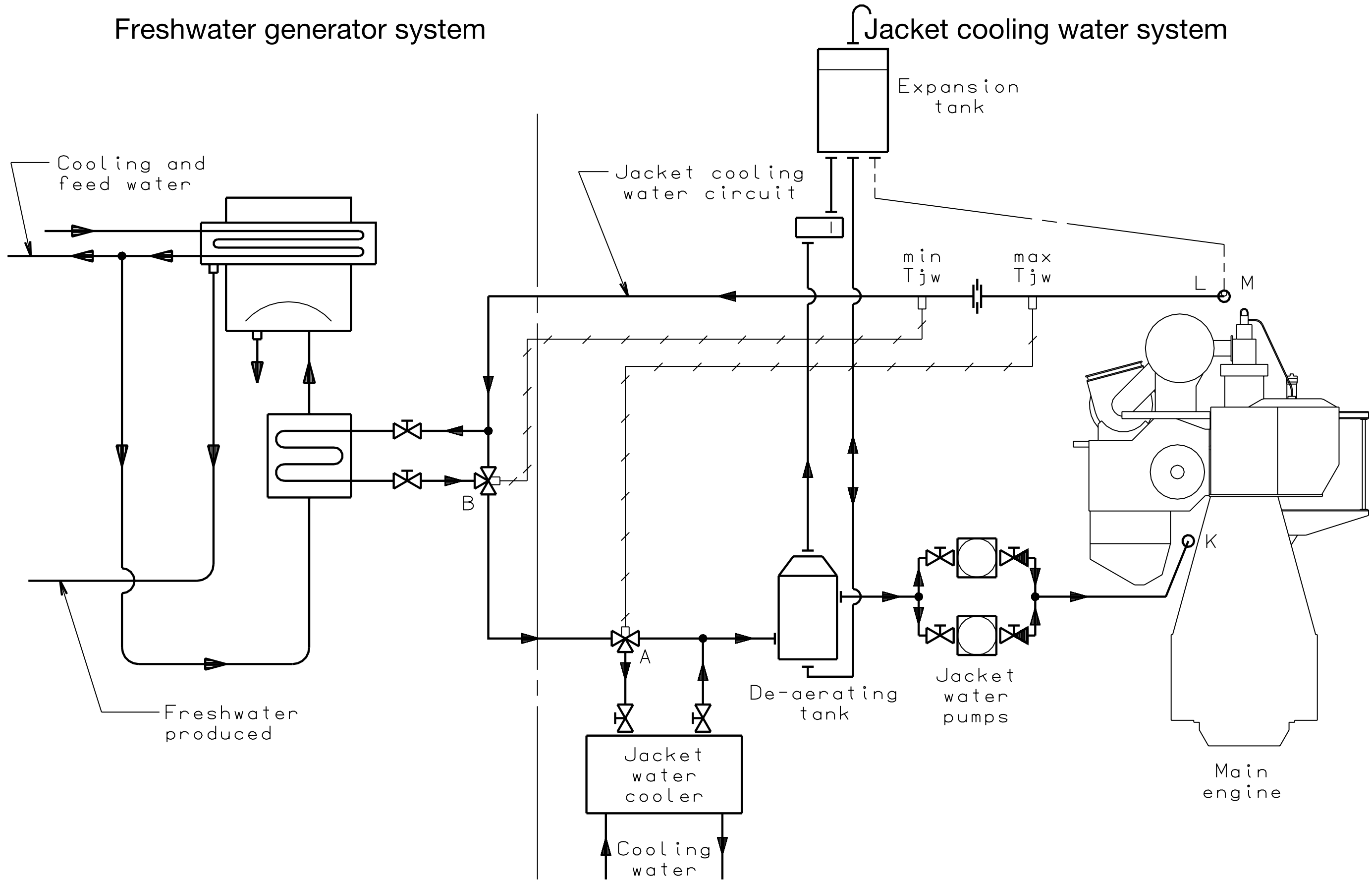
   $$Q_{jw} = Q_{jw,O} \times kp \qquad [2]$$

where

Q_{jw} = jacket water heat dissipation
Q_{L1} = jacket water heat dissipation at nominal MCR (L_1)
q_{jw}% = percentage correction factor from Fig. 6.01.07
$Q_{jw,O}$ = jacket water heat dissipation at optimised power (O), found by means of equation [1]
k_p = correction factor from Fig. 6.01.10
0.9 = factor for overload margin, tropical ambient conditions

The heat dissipation is assumed to be more or less independent of the ambient temperature conditions, yet the overload factor of about 0.87 instead of 0.90 will be more accurate for ambient conditions corresponding to ISO temperatures or lower.

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.



Valve A: ensures that T_{jw} < 80 °C
Valve B: ensures that T_{jw} >80 – 5 °C = 75 °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

178 16 79-9.2

Fig. 6.01.11: Freshwater generators. Jacket cooling water heat recovery flow diagram

Such a temperature control system may consist, e.g., of a special by-pass pipe installed in the jacket cooling water system, see Fig. 6.01.11, 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%.

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.:

$M_{fw} = 0.03 \times Q_{jw}$ t/24h [3]

where M_{fw} is the freshwater production in tons per 24 hours and Q_{jw} is to be stated in kW.

Example 2:

*Freshwater production from a derated 6S60MC with **high efficiency MAN B&W** tubocharger.*

Based on the engine ratings below, and by means of an example, this chapter 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.
6S60MC derated with fixed pitch propeller

Nominal MCR, P_{L1}:	12,240 kW = 16,680 BHP	(100.0%)	105.0 r/min	(100.0%)
Specified MCR, P_M:	9,792 kW = 13,344 BHP	(80.0%)	94.5 r/min	(90.0%)
Optimised power, P_O:	9,156 kW = 12,477 BHP	(74.8%)	92.4 r/min	(88.0%)
Service rating, P_S:	7,320 kW = 9,975 BHP	(59.8%)	85.8 r/min	(81.7%)

Ambient reference condition: 20°C air and 18°C cooling water

The expected available jacket cooling water heat at service rating is found as follows:

Q_{L1} = 1860 kW from "List of Capacities"

$q_{jw}\%$ = 80.0% using 74.8% power and 88.0% speed for the optimising point O in Fig. 6.01.07

By means of equation [1], and using factor 0.87 for actual ambient condition the heat dissipation in the optimising point (O) is found:

$$Q_{jw,O} = Q_{L1} \times \frac{q_{jw\%}}{100} \times 0.87$$

$$= 1860 \times \frac{80.0}{100} \times 0.87 = 1295 \text{ kW}$$

By means of equation [2], the heat dissipation in the service point (S) is found:

$Q_{jw} = Q_{jw,O} \times k_p = 1295 \times 0.85 = 1100$ kW

k_p = 0.85 using $P_{s\%}$ = 80% in Fig. 6.01.10

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]:

$M_{fw} = 0.03 \times Q_{jw} = 0.03 \times 1100 = 33.0$ t/24h

Calculation of 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 optimising point of the engine (point O):

P_O: power in kW (BHP) at optimising point
n_O: speed in r/min at optimising point

b) The ambient conditions, and exhaust gas backpressure:

T_{air}: actual ambient air temperature, in °C
p_{bar}: actual barometric pressure, in mbar
T_{CW}: actual scavenge air coolant temperature, in °C
p_O: exhaust gas back-pressure in mm WC at optimising point

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 (BHP)

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.

M_{exh}: exhaust gas amount in kg/h, to be found
T_{exh}: exhaust gas temperature in °C, to be found

The partial calculations based on the above influencing factors have been summarised in equations [4] and [5], see Fig. 6.01.12.

The partial calculations based on the influencing factors are described in the following:

a) Correction for choice of optimising point
When choosing an optimising point "O" 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 6.01.13 and 6.01.14 the corresponding percentage values (of L_1) for optimised power $P_{O\%}$ and speed $n_{O\%}$.

$m_{o\%}$: specific exhaust gas amount, in % of specific gas amount at nominal MCR (L_1), see Fig. 6.01.13.

ΔT_o: change in exhaust gas temperature after turbocharger relative to the L_1 value, in °C, see Fig. 6.01.14.

$$M_{exh} = M_{L1} \times \frac{P_O}{P_{L1}} \times \frac{m_{O\%}}{100} \times \left(1 + \frac{\Delta M_{amb\%}}{100}\right) \times \left(1 + \frac{\Delta m_{s\%}}{100}\right) \times \frac{P_{S\%}}{100} \quad \text{kg/h} \qquad [4]$$

$$T_{exh} = T_{L1} + \Delta T_o + \Delta T_{amb} + \Delta T_S \quad °C \qquad [5]$$

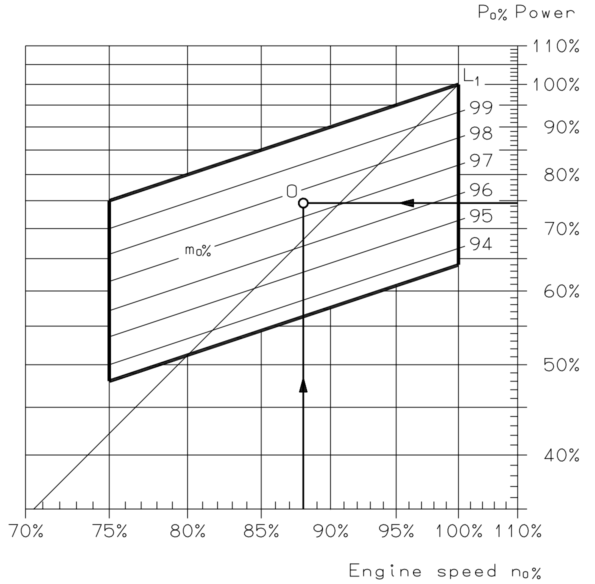
where, according to "List of capacities", i.e. referring to ISO ambient conditions and 300 mm WC back-pressure and optimised in L_1:

M_{L1}: exhaust gas amount in kg/h at nominal MCR (L_1)

T_{L1}: exhaust gas temperatures after turbocharger in °C at nominal MCR (L_1)

178 30 58-0.0

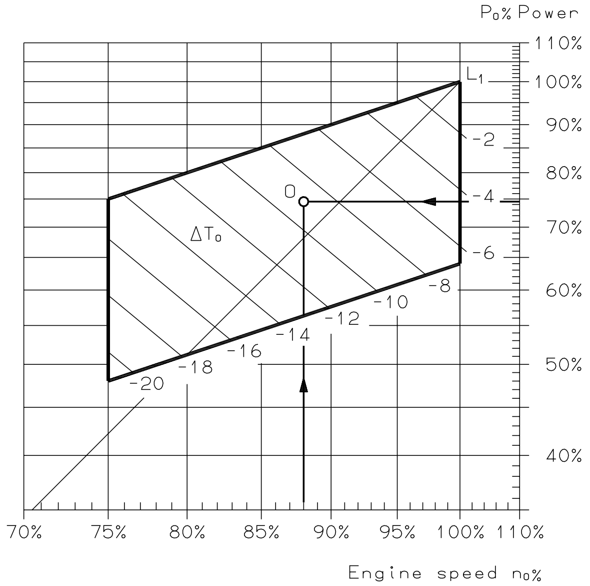
Fig. 6.01.12: Summarising equations for exhaust gas amounts and temperatures



$m_{o\%} = -14.9388 \times \ln(n_{o\%}) + 14.9388 \times \ln(P_{o\%}) + 100$

178 06 59-1.1

Fig. 6.01.13: Specific exhaust gas amount, m_o% in % of L_1 value



$\Delta T_o = 35.5195 \times \ln(n_{o\%}) + 14.9410 \times \ln(P_{o\%}) - 232.3792$ °C

178 06 60-1.1

Fig. 6.01.14: Change of exhaust gas temperature, ΔT_o in °C after turbocharger relative to L_1 value

b) Correction for actual ambient conditions and back-pressure

For ambient conditions other than ISO 3046/1-1986, and back-pressure other than 300 mm WC at optimising point (O), the correction factors stated in the table in Fig. 6.01.15 may be used as a guide, and the corresponding relative change in the exhaust gas data may be found from equations [6] and [7], shown in Fig. 6.01.16.

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 optimising point	+ 100 mm WC	+ 5.0 °C	– 1.1%

178 30 59-2.1

Fig. 6.01.15: Correction of exhaust gas data for ambient conditions and exhaust gas back pressure

$$\Delta M_{amb\%} = -0.41 \times (T_{air} - 25) + 0.03 \times (p_{bar} - 1000) + 0.19 \times (T_{CW} - 25) - 0.011 \times (\ p\ - 300) \quad \% \quad [6]$$

$$T_{amb} = 1.6 \times (T_{air} - 25) - 0.01 \times (p_{bar} - 1000) + 0.1 \times (T_{CW} - 25) + 0.05 \times (\ p\ - 300) \quad °C \quad [7]$$

where the following nomenclature is used:

$M_{amb\%}$: change in exhaust gas amount, in % of amount at ISO conditions

T_{amb}: change in exhaust gas temperature, in °C

The back-pressure at the optimising point can, as an approximation, be calculated by:

$$p_O = p_M \times (P_O/P_M)^2 \quad [8]$$

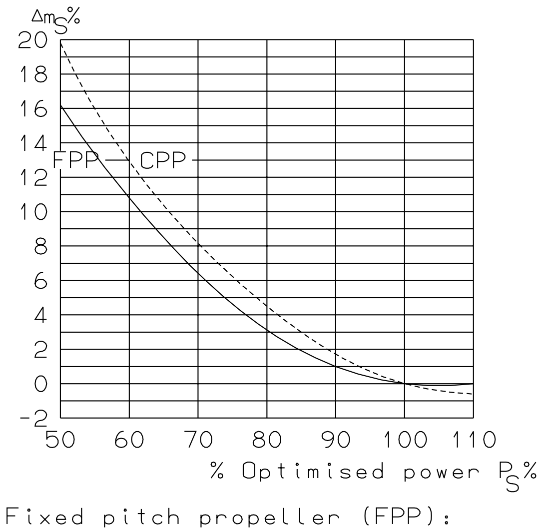
where,

P_M: power in kW (BHP) at specified MCR

p_M: exhaust gas back-pressure prescribed at specified MCR, in mm WC

178 30 60-2.1

Fig. 6.01.16: Exhaust gas correction formula for ambient conditions and exhaust gas back-pressure



Fixed pitch propeller (FPP):

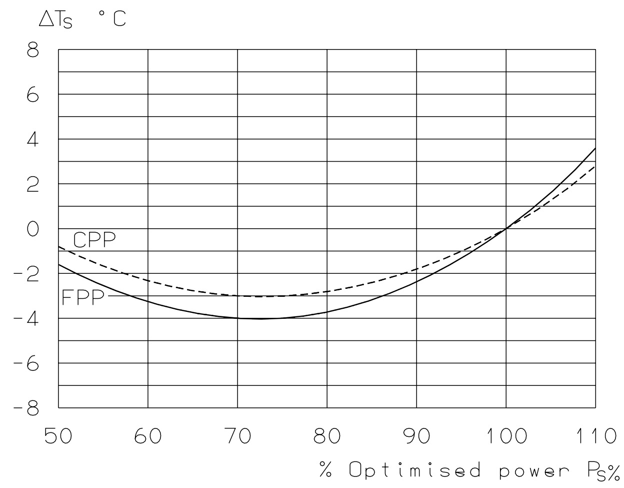
$$\Delta m_{s\%} = 0.0055 \times P_{S\%}^2 - 1.15 \times P_S\% + 60$$

Constant engine speed (CPP):

$$\Delta m_{s\%} = 0.0055 \times P_{S\%}^2 - 1.22 \times P_S\% + 67$$

178 06 74-5.0

Fig. 6.01.17: Change of specific exhaust gas amount, $\Delta m_{S\%}$ in % at part load



Fixed pitch propeller (FPP):

$$\Delta T_S = 0.005 \times P_{S\%}^2 - 0.72 \times P_S\% + 22$$

Constant engine speed (CPP):

$$\Delta T_S = 0.0043 \times P_{S\%}^2 - 0.63 \times P_S\% + 20$$

178 06 73-3.0

Fig. 6.01.18: Change of exhaust gas temperature, ΔT_S in °C at part load

c) Correction for engine load

Figs. 6.01.17 and 6.01.18 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 optimising point, i.e. using as input $P_{S\%} = (P_S/P_O) \times 100\%$:

$m_S\%$: change in *specific* exhaust gas amount, in % of specific amount at optimising point, see Fig. 6.01.17.

T_S: change in exhaust gas temperature, in °C, see Fig. 6.01.18.

Example 3: Expected exhaust gas data for a derated 6S60MC **with high efficiency turbocharger**

6S60MC derated with fixed pitch propeller

Nominal MCR, P_{L1}:	12,240 kW = 16,680 BHP	(100.0%)	105.0 r/min	(100.0%)
Specified MCR, P_M:	9,792 kW = 13,344 BHP	(80.0%)	94.5 r/min	(90.0%)
Optimised power, P_O:	9,156 kW = 12,477 BHP	(74.8%)	92.4 r/min	(88.0%)
Service rating, P_S:	7,320 kW = 9,975 BHP	(59.8%)	85.8 r/min	(81.7%)

Reference conditions:

Air temperature T_{air} . . . . 20 °C
Scavenge air coolant temperature T_{CW} . . . . . 18 °C
Barometric pressure p_{bar} . . . . 1013 mbar
Exhaust gas back-pressure at specified MCR
p_M . . . . 300 mm WC

a) Correction for choice of optimising point:

$$P_O\% = \frac{9156}{12240} \times 100 = 74.8\%$$

$$n_{O\%} = \frac{92.4}{105} \times 100 = 88.0\%$$

By means of Figs. 6.01.13 and 6.01.14:

$m_O\%$ = 97.6 %

T_O = - 8.9 °C

b) Correction for ambient conditions and back-pressure:
The back-pressure at the optimising point is found by means of equation [8]:

$$p_O = 300 \times \left(\frac{9156}{9792}\right)^2 = 262 \text{ mm WC}$$

By means of equations [6] and [7]:

$$M_{amb}\% = -0.41 \times (20-25) - 0.03 \times (1013-1000) + 0.19 \times (18-25) - 0.011 \times (262-300)\ \%$$

$M_{amb}\%$ = + 0.75%

$$T_{amb} = 1.6 \times (20-25) + 0.01 \times (1013-1000) + 0.1 \times (18-25) + 0.05 \times (262-300)\ °C$$

T_{amb} = - 10.5 °C

c) Correction for engine load:
By means of Figs. 6.01.17 and 6.01.18:

$m_{S\%}$ = + 3.2%

T_S = - 3.6 °C

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} = 115900 kg/h

$$M_{exh} = 115900 \times \frac{9156}{12240} \times \frac{97.6}{100} \times \left(1 + \frac{0.75}{100}\right) \times \left(1 + \frac{3.2}{100}\right) \times \frac{80}{100} = 70379 \text{ kg/h}$$

M_{exh} = 70300 kg/h +/- 5%

The exhaust gas temperature:

T_{L1} = 235 °C

T_{exh} = 235 – 8.9 – 10.5 – 3.6 = 212 °C

T_{exh} = 212 °C -/+15 °C

Exhaust gas data at specified MCR (ISO)

At specified MCR (M), the running point may be considered as a service point where:

$$P_{S\%} = \frac{P_M}{P_O} \times 100\% = \frac{9792}{9156} \times 100\% = 106.95\%$$

and for ISO ambient reference conditions, the corresponding calculations will be as follows:

$$M_{exh,M} = 115900 \times \frac{9156}{12240} \times \frac{97.6}{100} \times (1 \quad \frac{0.42}{100}) \times$$

$$(1 \quad \frac{0.1}{100}) \times \frac{106.95}{100} = 90781 \text{ kg/h}$$

$$M_{exh,M} = 90700 \text{ kg/h}$$

$$T_{exh,M} = 235 - 8.9 - 1.9 + 2.2 = 226.4\ °C$$

$$T_{exh,M} = 226\ °C$$

The air consumption will be:

90700 x 0.98 kg/h = 24.7 kg/sec

No.	Symbol	Symbol designation	No.	Symbol	Symbol designation
1	**General conventional symbols**		2.17		Pipe going upwards
1.1		Pipe	2.18		Pipe going downwards
1.2		Pipe with indication of direction of flow	2.19		Orifice
1.3		Valves, gate valves, cocks and flaps	**3**	**Valves, gate valves, cocks and flaps**	
1.4		Appliances	3.1		Valve, straight through
1.5		Indicating and measuring instruments	3.2		Valves, angle
2	**Pipes and pipe joints**		3.3		Valves, three way
2.1		Crossing pipes, not connected	3.4		Non-return valve (flap), straight
2.2		Crossing pipes, connected	3.5		Non-return valve (flap), angle
2.3		Tee pipe	3.6		Non-return valve (flap), straight, screw down
2.4		Flexible pipe	3.7		Non-return valve (flap), angle, screw down
2.5		Expansion pipe (corrugated) general	3.8		Flap, straight through
2.6		Joint, screwed	3.9		Flap, angle
2.7		Joint, flanged	3.10		Reduction valve
2.8		Joint, sleeve	3.11		Safety valve
2.9		Joint, quick-releasing	3.12		Angle safety valve
2.10		Expansion joint with gland	3.13		Self-closing valve
2.11		Expansion pipe	3.14		Quick-opening valve
2.12		Cap nut	3.15		Quick-closing valve
2.13		Blank flange	3.16		Regulating valve
2.14		Spectacle flange	3.17		Kingston valve
2.15		Bulkhead fitting water tight, flange	3.18		Ballvalve (cock)
2.16		Bulkhead crossing, non-watertight			

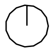
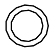
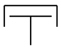
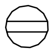
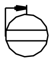
178 30 61-4.1

Fig. 6.01.19a: Basic symbols for piping

No.	Symbol	Symbol designation	No.	Symbol	Symbol designation
3.19		Butterfly valve	4.6		Piston
3.20		Gate valve	4.7		Membrane
3.21		Double-seated changeover valve	4.8		Electric motor
3.22		Suction valve chest	4.9		Electro-magnetic
3.23		Suction valve chest with non-return valves	**5**	**Appliances**	
3.24		Double-seated changeover valve, straight	5.1		Mudbox
3.25		Double-seated changeover valve, angle	5.2		Filter or strainer
3.26		Cock, straight through	5.3		Magnetic filter
3.27		Cock, angle	5.4		Separator
2.28		Cock, three-way, L-port in plug	5.5		Steam trap
3.29		Cock, three-way, T-port in plug	5.6		Centrifugal pump
3.30		Cock, four-way, straight through in plug	5.7		Gear or screw pump
3.31		Cock with bottom connection	5.8		Hand pump (bucket)
3.32		Cock, straight through, with bottom conn.	5.9		Ejector
3.33		Cock, angle, with bottom connection	5.10		Various accessories (text to be added)
3.34		Cock, three-way, with bottom connection	5.11		Piston pump
4	**Control and regulation parts**		**6**	**Fittings**	
4.1		Hand-operated	6.1		Funnel
4.2		Remote control	6.2		Bell-mounted pipe end
4.3		Spring	6.3		Air pipe
4.4		Mass	6.4		Air pipe with net
4.5		Float	6.5		Air pipe with cover

178 30 61-4.1

Fig. 6.01.19b: Basic symbols for piping

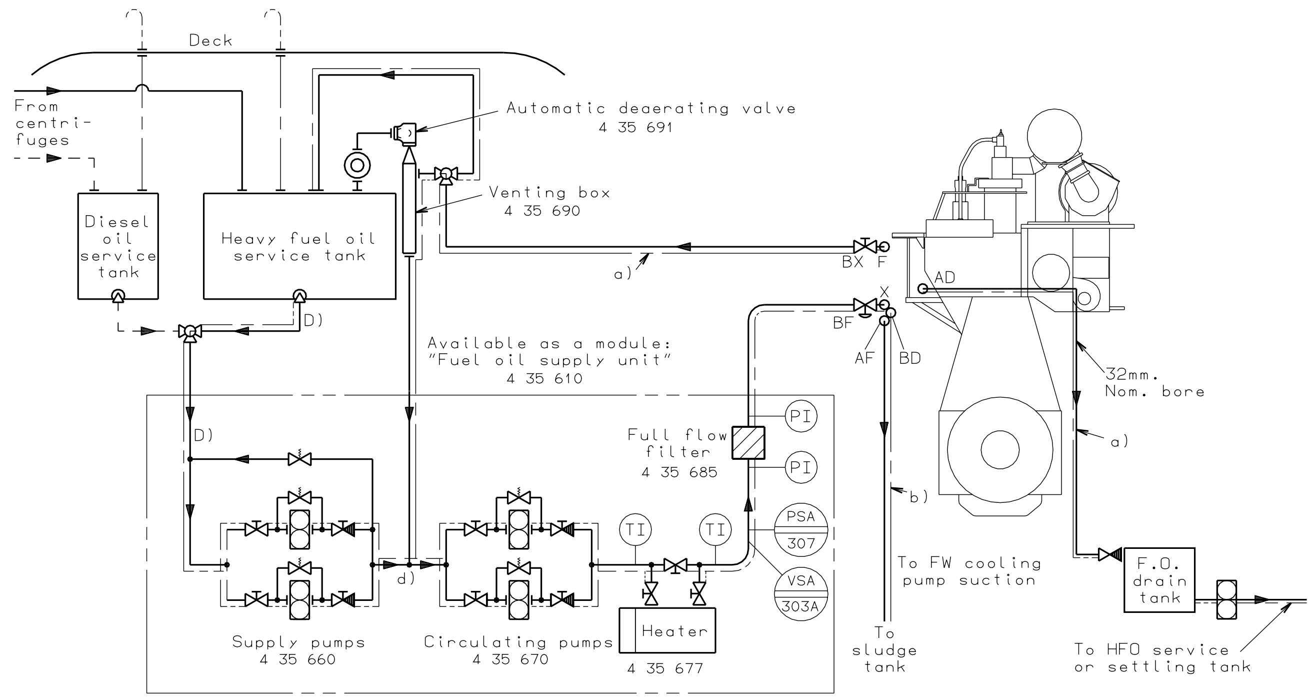
No.	Symbol	Symbol designation	No.	Symbol	Symbol designation
6.6		Air pipe with cover and net	**7**	**Indicating instruments with ordinary symbol designations**	
6.7		Air pipe with pressure vacuum valve	7.1		Sight flow indicator
6.8		Air pipe with pressure vacuum valve with net	7.2		Observation glass
6.9		Deck fittings for sounding or filling pipe	7.3		Level indicator
6.10		Short sounding pipe with selfclosing cock	7.4		Distance level indicator
6.11		Stop for sounding rod	7.5		Counter (indicate function)
			7.6		Recorder

The symbols used are in accordance with ISO/R 538-1967, except symbol No. 2.19

178 30 61-4.1

Fig. 6.01.19c: Basic symbols for piping

6.02 Fuel Oil System



Diesel oil

Heavy fuel oil

Heated pipe with insulation

a) Tracing fuel oil lines of max. 150 °C

b) Tracing drain lines: by jacket cooling water max. 90 °C, min. 50 °C

The letters refer to the "List of flanges"
D shall have min. 50% larger area than d.

Fig. 6.02.01: Fuel oil system

Pressurised Fuel Oil System

The system is so arranged that both diesel oil and heavy fuel oil can be used, see Fig. 6.02.01.

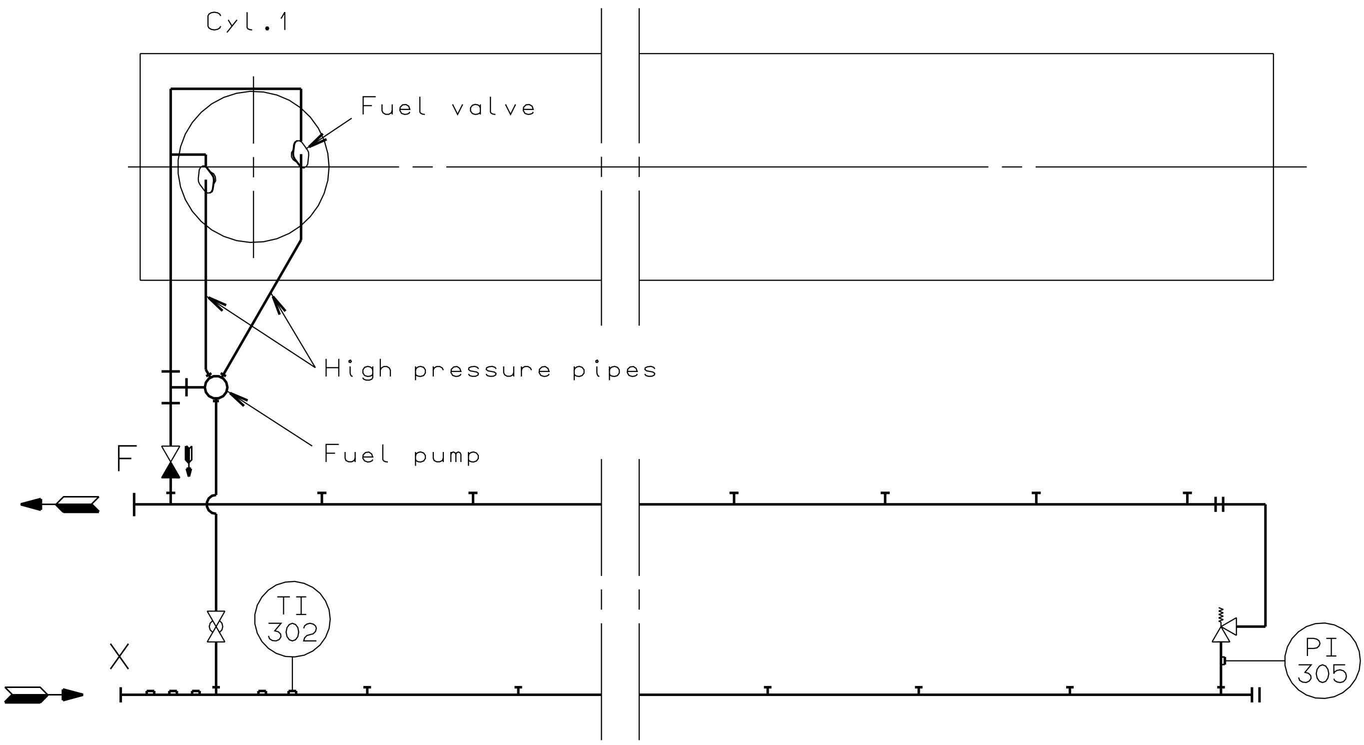
From the service tank the fuel is led to an electrically driven supply pump (4 35 660) by means of which a pressure of approximately 4 bar can be maintained in the low pressure part of the fuel circulating system, thus avoiding gasification of the fuel in the venting box (4 35 690) in the temperature ranges applied.

The venting box is connected to the service tank via an automatic deaerating valve (4 35 691), 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 (4 35 670), which pumps the fuel oil through a heater (4 35 677) and a full flow filter (4 35 685) situated immediately before the inlet to the engine.

To ensure ample filling of the fuel 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, as shown on "Fuel oil pipes", Fig.6.02.02.



The piping is delivered with and fitted onto the engine
The letters refer to the "List of flanges"
The pos. numbers refer to list of standard instruments

178 30 67-5.0

Fig. 6.02.02: Fuel oil pipes and drain pipes

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.

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 deae-rated. This automatic circulation of preheated fuel during engine standstill is the background for our recommendation:

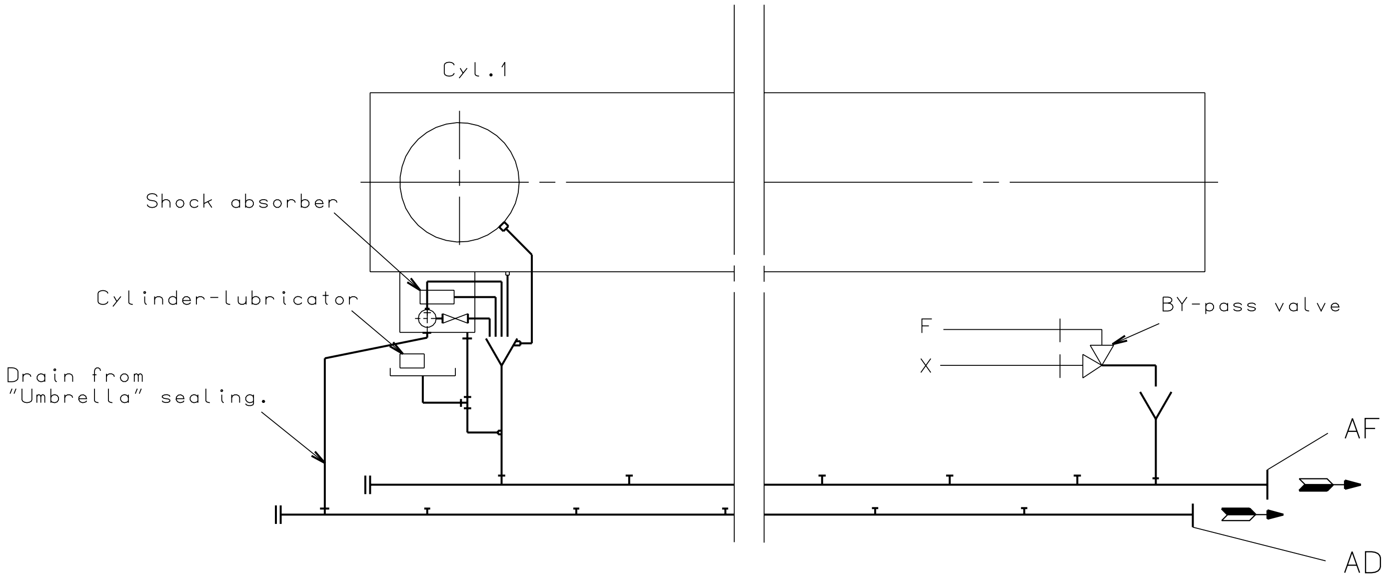
constant operation on heavy fuel

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. Therefore, we strongly advise against the use of diesel oil for operation of the engine – this applies to all loads.

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.
environmental requirements

The built-on overflow valves, if any, at the supply pumps are to be adjusted to 8 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.



178 30 68-7.2

The piping is delivered with and fitted onto the engine
The letters refer to the "List of flanges"
The pos. numbers refer to list of standard instruments

Fig. 6.02.03: Fuel oil drain pipes

The remote controlled quick-closing valve at inlet "X" to the engine (Fig. 6.02.01) is required by MAN B&W in order to be able to stop the engine immediately, especially during quay and sea trials, in the event that the other shut-down systems should fail. This valve is yard's supply and is to be situated as close as possible to the engine. 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 neces- sary 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.

The main purpose of the drain "AF" is to collect oil from the various fuel oil pipes in the fuel oil system, however when the cylinders are overhauled, some inhibited cooling water may be drained to this tank, which means that the oil drained to it is not necessarily pure fuel oil.

The umbrella type fuel oil pumps have an additional external leakage rate of fuel oil which, through "AD". is led back to the HFO setting. The flow rate is approx, 0.6 l/cyl. h.

The 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.

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 Figs. 6.02.01 and 6.02.04.

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.

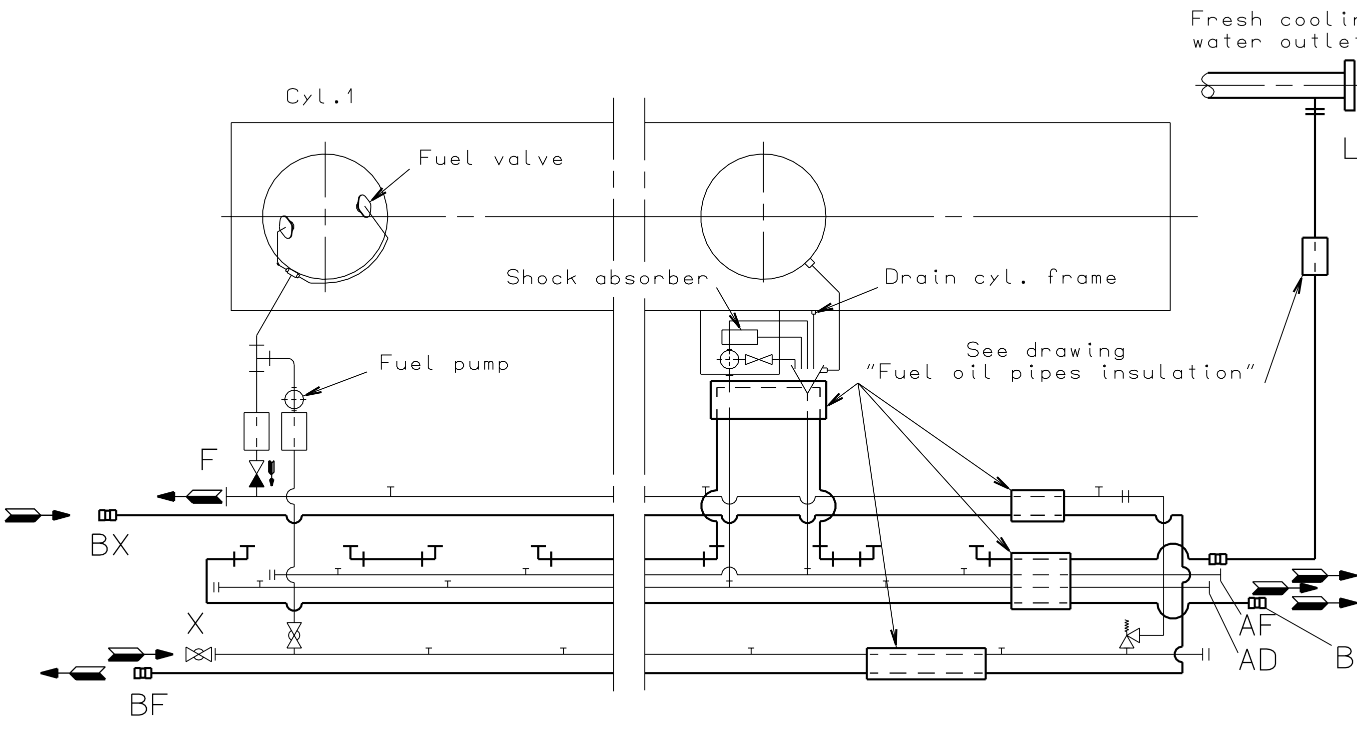
The drain arrangement from the fuel oil system and the cylinder lubricator is shown in Fig. 6.02.03 "Fuel oil drain pipes". As shown in Fig. 6.02.04 "Fuel oil pipes heating" the drain pipes are heated by the jacket cooling water outlet from the main engine, whereas the HFO pipes as basic are heated by steam.

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

For arrangement common for main engine and auxiliary engines from MAN B&W Holeby, please refer to our puplication:

P.240 "Operation on Heavy Residual Fuels MAN B&W Diesel Two-stroke Engines and MAN B&W Diesel Four-stroke Holeby GenSets."



The piping is delivered with and fitted onto the engine
The letters refer to "List of flanges"

Fig. 6.02.04: Fuel oil pipes, steam and jacket water heating: 4 35 110

Fuel oil pipe insulation, option: 4 35 121

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.

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 mats 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 overlap 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.

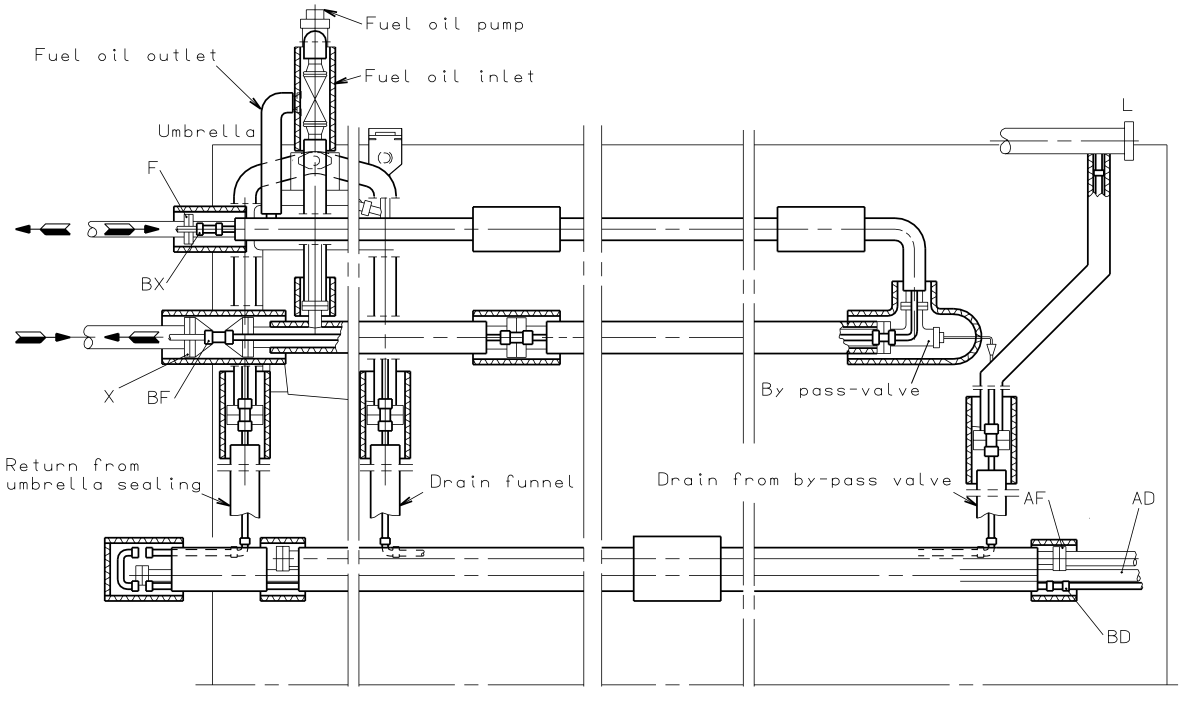


Fig. 6.02.05: Fuel oil pipes heat, insulation, option: 4 35 121

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 (7000 sec. Redwood I at 100 °F) can be used.

For guidance on purchase, reference is made to ISO 8217, British Standard 6843 and to CIMAC recommendations regarding requirements for heavy fuel for diesel engines, third edition 1990, in which the maximum acceptable grades are RMH 55 and K55. 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.

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 slow speed diesel engines.

The data refers to the fuel as supplied i.e. before any on board cleaning.

Property	Units	Value
Density at 15°C	kg/m^3	≤ 991*
Kinematic viscosity at 100 °C at 50 °C	 cSt cSt	 ≥ 55 ≥ 700
Flash point	°C	≥ 60
Pour point	°C	≥ 30
Carbon residue	% mass	≥ 22
Ash	% mass	≥ 0.15
Total sediment after ageing	% mass	≥ 0.10
Water	% volume	≥ 1.0
Sulphur	% mass	≥ 5.0
Vanadium	mg/kg	≥ 600
Aluminum + Silicon	mg/kg	≥ 80

*) May be increased to 1.010 provided adequate cleaning equipment is installed, i.e. modern type of centrifuges.

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.

Components for fuel oil system

(See Fig. 6.02.01)

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 $\leq$ 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:

0.27 l/kWh = 0.20 l/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 (4 35 660)

This is to be of the screw wheel 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
Delivery pressure . . . . 4 bar
Working temperature . . . . 100 °C

The capacity is to be fulfilled with a tolerance of: -0% +15% and shall also be able to cover the back flushing, see "Fuel oil filter".

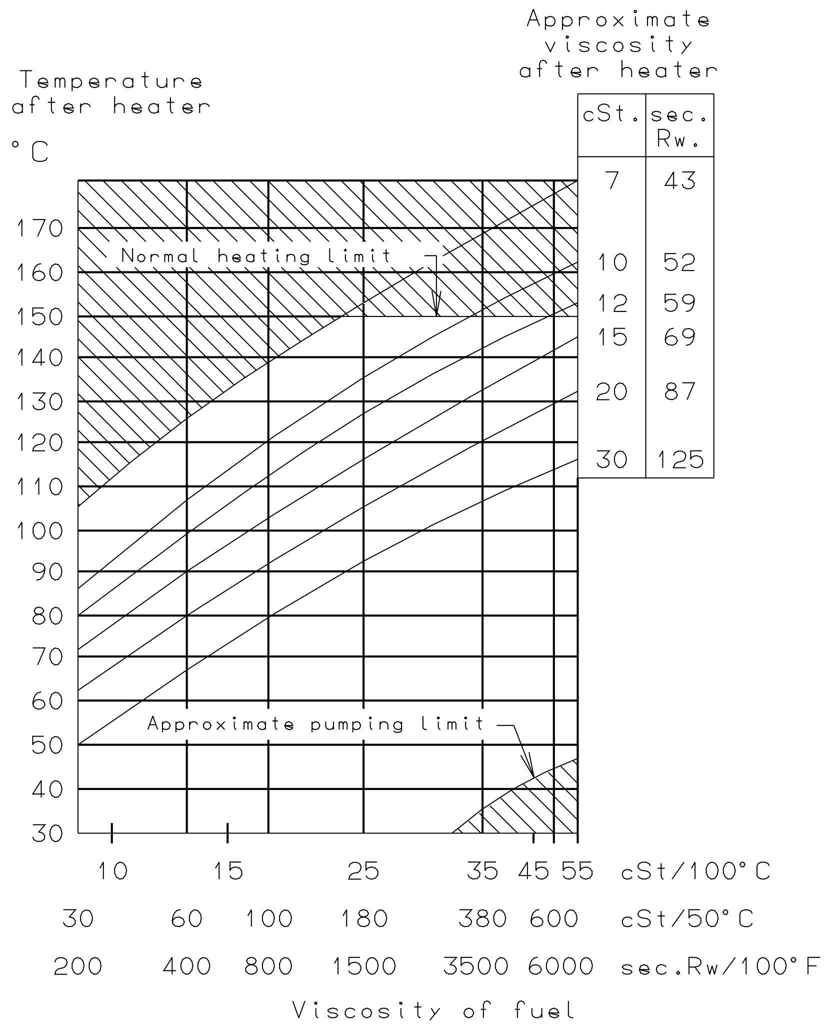
Fuel oil circulating pump (4 35 670)

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 is to be fulfilled with a tolerance of: - 0% + 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.



178 06 28-0.1

Fig. 6.02.06: Fuel oil heating chart

Fuel oil heater (4 35 677)

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
Pump head . . . . 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 (4 35 685)

The filter can be of the manually cleaned duplex type or an automatic filter with a manually cleaned by-pass 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 back-flushing** 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 back-flushing, so that the fuel oil pressure at the inlet to the main engine can be maintained during cleaning.

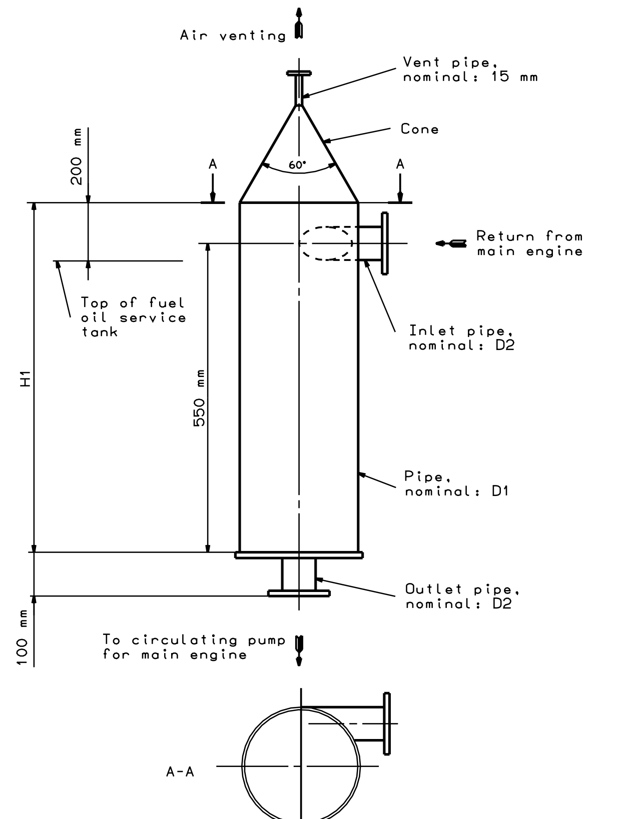
In those cases where an **automatically cleaned filter** is installed, it should be noted that in order to activate the cleaning process, certain makers of filters require a greater oil pressure at the inlet to the filter than the pump pressure specified. Therefore, the pump capacity should be adequate 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 m
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 at . . . . 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.



178 38 39-3.0

	Dimensions in mm		
	D1	D2	H1
4-5 cyl.	200	50	600
6-8 cyl.	400	100	1200

178 89 04-3.0

Fig. 6.02.07: 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 cleaned in accordance with MAN B&W’s recommendations “Flushing of Fuel Oil System” which is available on request.

Fuel oil venting box (4 35 690)

The design is shown on “Fuel oil venting box”, see Fig. 6.02.07.

The systems fitted onto the main engine are shown on:
“Fuel oil pipes"
“Fuel oil drain pipes"
“Fuel oil pipes, steam and jacket water tracing” and
“Fuel oil pipes, insulation”

Modular units

The pressurised fuel oil system is preferable when operating the diesel engine on high viscosity fuels. When using high viscosity fuel requiring a heating temperature above 100 °C, there is a risk of boiling and foaming if an open return pipe is used, especially if moisture is present in the fuel.

The pressurised system can be delivered as a mo-dular unit including wiring, piping, valves and instruments, see Fig. 6.02.08 below.

The fuel oil supply unit is tested and ready for service supply connections.

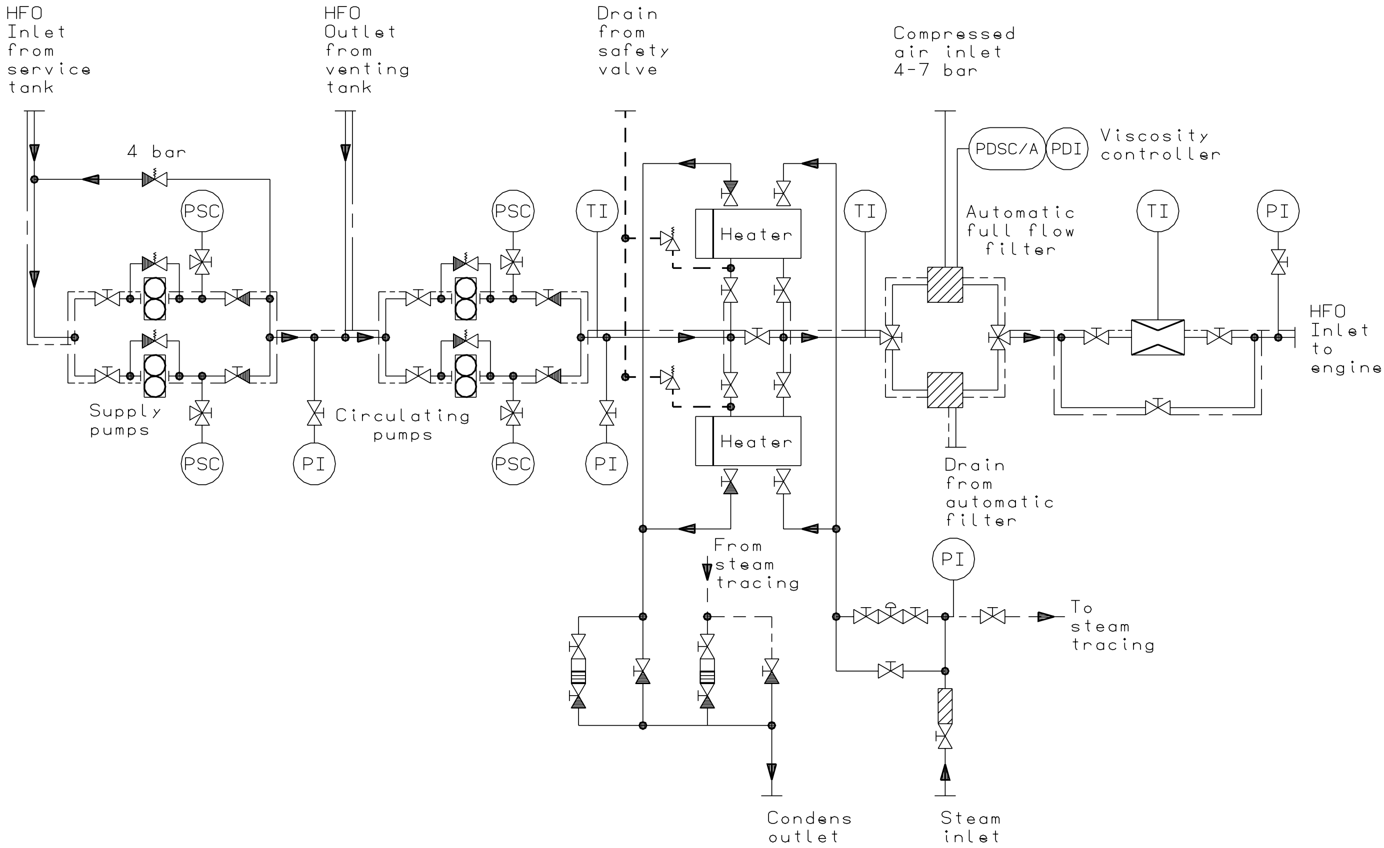
The unit is available in the following sizes:

Engine type	Units	
	60 Hz 3 x 440V	50 Hz 3 x 380V
4S60MC	F - 5.5 - 4.0 - 6	F - 5.4 - 5.2 - 5
5S60MC	F - 5.5 - 4.0 - 6	F - 5.4 - 5.2 - 5
6S60MC	F - 6.4 - 6.2 - 6	F - 8.9 - 5.8 - 5
7S60MC	F - 7.9 - 5.2 - 6	F - 8.9 - 5.8 - 5
8S60MC	F - 9.5 - 5.8 - 6	F - 8.9 - 5.8 - 5

178 89 08-0.0

F – 7.9 – 5.2 – 6

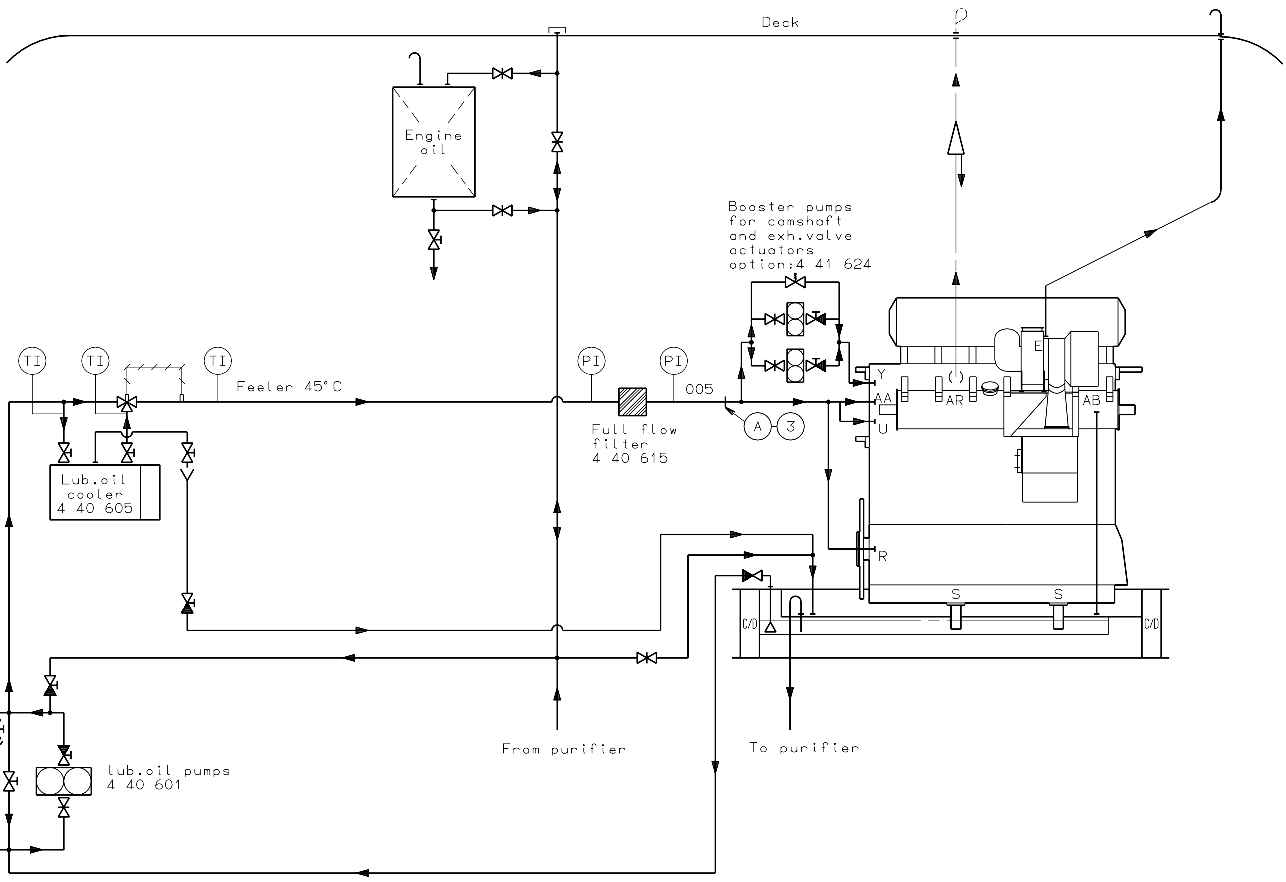
- 5 = 50 Hz, 3 x 380V
  6 = 60 Hz, 3 x 440V
- Capacity of fuel oil supply pump in m^3/h
- Capacity of fuel oil circulating pump in m^3/h
- Fuel oil supply unit



178 30 73-4.0

Fig. 6.02.08 Fuel oil supply unit, MAN B&W Diesel /C.C Jensen, option: 4 35 610

6.03 Uni-lubricating Oil System



The letters refer to "List of flanges"
* Venting for MAN B&W, ABB TPL or Mitsubishi turbochargers only

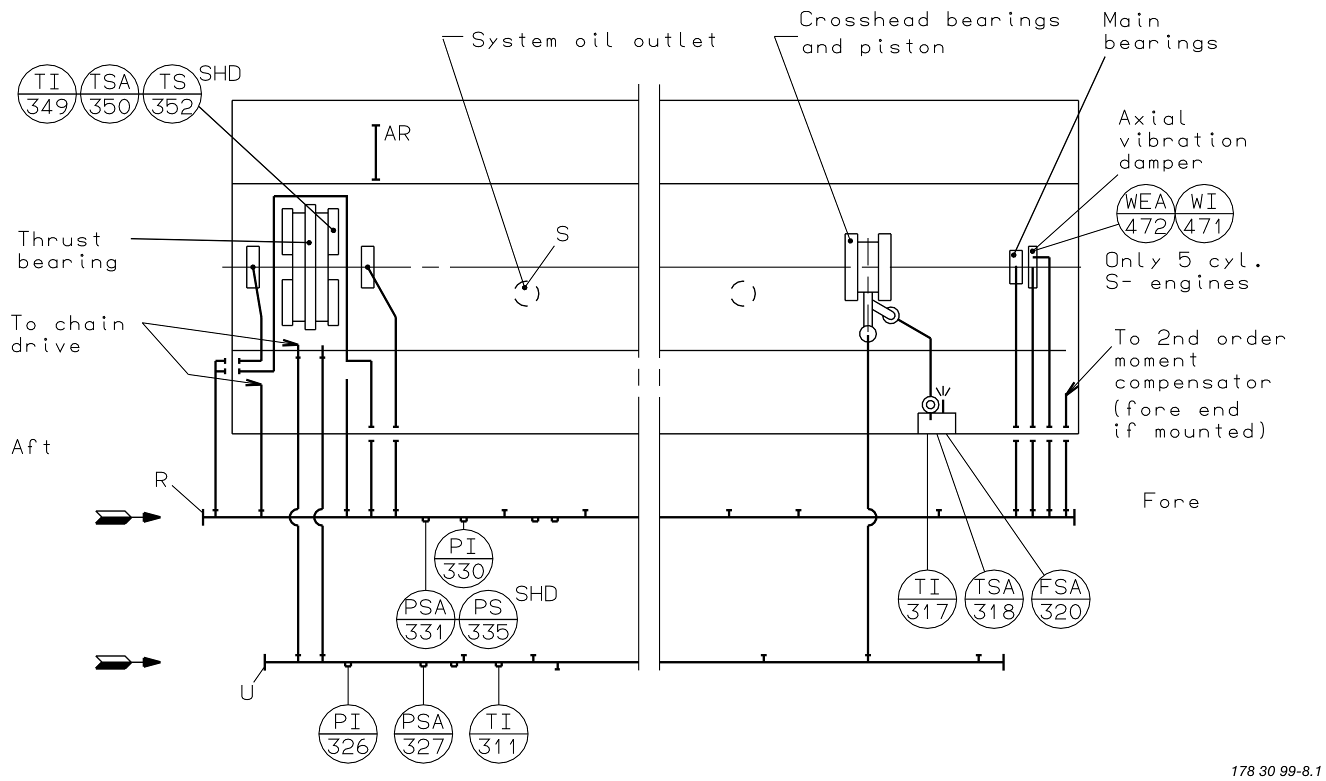
178 15 84-0.2

Fig. 6.03.01: Lubricating and cooling oil system

Since we introduced the so-called "umbrella" type of fuel pump the fuel pump sealing arrangement eliminates the risk of fuel oil penetrating into the camshaft lube oil system, for which reason a separate camshaft lube oil system is no longer necessary. The design with a seperate camshaft lube oil system is however still available as option: 4 40 105.

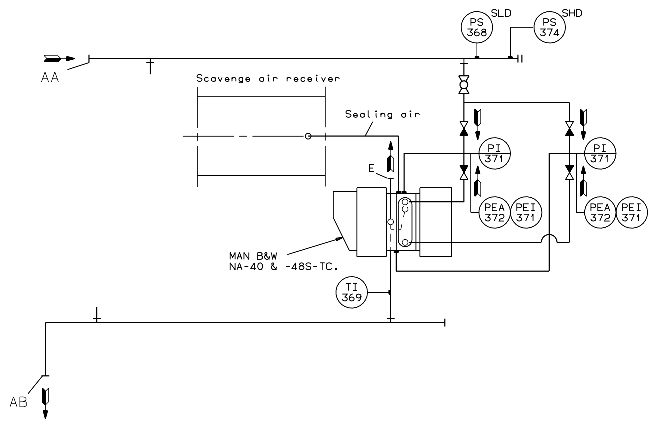
As a consequence the uni-lubricating oil system is now standard, with two small booster pumps for camshaft and exhaust valve actuators lube oil supply "Y", see Figs: 6.03.01 and 6.03.08.

This system supplies lubricating oil to the engine bearings through inlet "R", and lubricating oil to the crosshead and cooling oil to the pistons etc. through inlet "U".



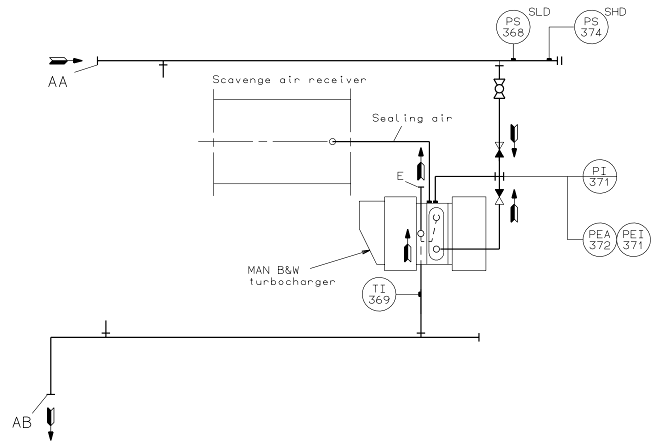
The letters refer to “List of flanges”
The pos. numbers refer to “List of instruments”
The piping is delivered with and fitted onto the engine

Fig. 6.03.02: Lubricating and cooling oil pipes



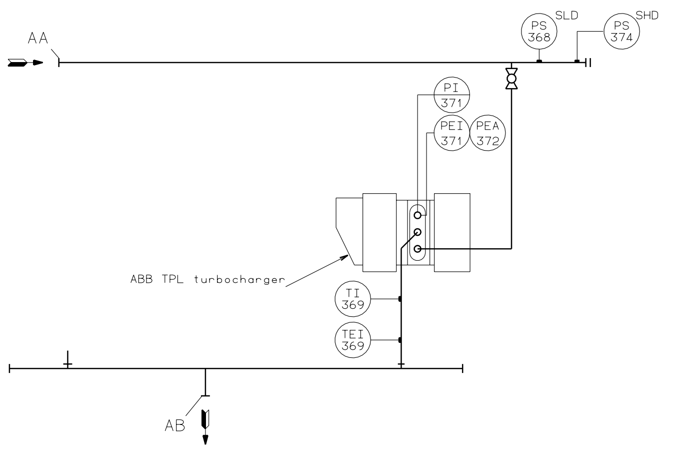
178 47 98-9.0

Fig. 6.03.03a: Separate inlet and outlet for lube oil pipes for MAN B&W turbocharger type NA/S, option: 4 40 140



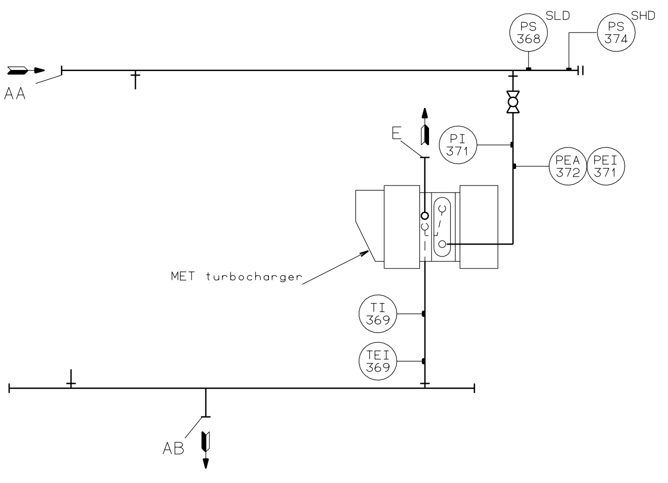
178 47 99-0.0

Fig. 6.03.03b: Separate inlet and outlet for lube oil pipes for MAN B&W turbocharger type NA/T, option: 4 40 140



178 45 00-6.0

Fig. 6.03.03c: Separate inlet and outlet for lube oil pipes for ABB turbocharger type TPL, option: 4 40 140



178 38 67-9.1

Fig. 6.03.03d: Separate inlet and outlet for lube oil pipes for Mitsubishi turbocharger type MET, option 4 40 140

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. 6.03.07. Drains from the engine bedplate “AE” are fitted on both sides, see Fig. 6.03.09 “Bedplate drain pipes”.

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, where it is distributed to pistons and bearings.

The major part of the oil is divided between piston cooling and crosshead lubrication.

As previously mentioned, it has been necessary to introduce the booster pumps (4 40 624) for the large bore engines in order to mantain the required oil pressure at inlet “Y” for the exhaust valve actuators.

From the engine, the oil collects in the oil pan, from where it is drained off to the bottom tank, see Fig. 6.03.06 “Lubricating oil tank, with cofferdam”.

For external pipe connections, we prescribe a maximum oil velocity of 1.8 m/s.

The MAN B&W, ABB type TPL and Mitsubishi turbochargers are lubricated from the main engine system through the separate inlet “AA”, see Fig. 6.03.03a, b, c, d and f. “Turbocharger lubricating oil pipes”, “AB” being the lubricating oil outlet from the turbocharger to the lubricating oil bottom tank and it is vented through “E” directly to the deck.

Lubricating oil centrifuges

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 l/kWh = 0.1 l/BHPh

The *Nominal MCR* is used as the total installed effect.

List of lubricating oils

The circulating oil (Lubricating and cooling oil) must be a rust and oxidation inhibited engine oil, of SAE 30 viscosity grade.

In order to keep the crankcase and piston cooling space clean of deposits, the oils should have adequate dispersion and detergent properties.

Alkaline circulating oils are generally superior in this respect.

The oils listed have all given satisfactory service in MAN B&W engine installations:

Company	Circulating oil SAE 30/TBN 5-10
Elf-Lub.	Atlanta Marine D3005
BP	Energol OE-HT-30
Castrol	Marine CDX-30
Chevron	Veritas 800 Marine
Exxon	Exxmar XA
Fina	Alcano 308
Mobil	Mobilgard 300
Shell	Melina 30/30S
Texaco	Doro AR 30

Also other brands have been used with satisfactory results.

Components for lube oil system

Lubricating oil pump (4 40 601)

The lubricating oil pump can be of the screw 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 . . . . 4.0 bar
Delivery pressure. . . . . 4.0 bar
Max. working temperature . . . . 50 °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 is to be within a tolerance of: 0 +12%.

The pump head is based on a total pressure drop across cooler and filter of maximum 1 bar.

The by-pass valve, shown between the main lubricating oil pumps, may be omitted in cases where the pumps have a built-in by-pass or if centrifugal pumps are used.

If centrifugal pumps are used, it is recommended to install a throttle valve at position "005", its function being 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 (4 40 605)

The lubricating oil cooler is to 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 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 . . . . 4.0 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 is to be within a tolerance of: 0 to + 12%.

The cooling water flow capacity is to be within a tolerance of: 0% +10%.

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 (4 40 610)

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 . . . . 40-45 °C

Lubricating oil full flow filter (4 40 615)

Lubricating oil flow . . . . see “List of capacities”
Working pressure . . . . 4.0 bar
Test pressure . . . . according to class rules
Absolute fineness . . . . 40 m *
Working temperature . . . . approximately 45 °C
Oil viscosity at working temperature. . . . . 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 m at a retaining rate of 90%

The flow capacity is to be within a tolerance of:
0 to 12%.

The full-flow filter is to 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 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
- In those cases where an automatically-cleaned filter is installed, it should be noted that in order to activate the cleaning process, certain makes of filter 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.

Lubricating oil booster pump for camshaft and exhaust valve actuators (4 40 624)

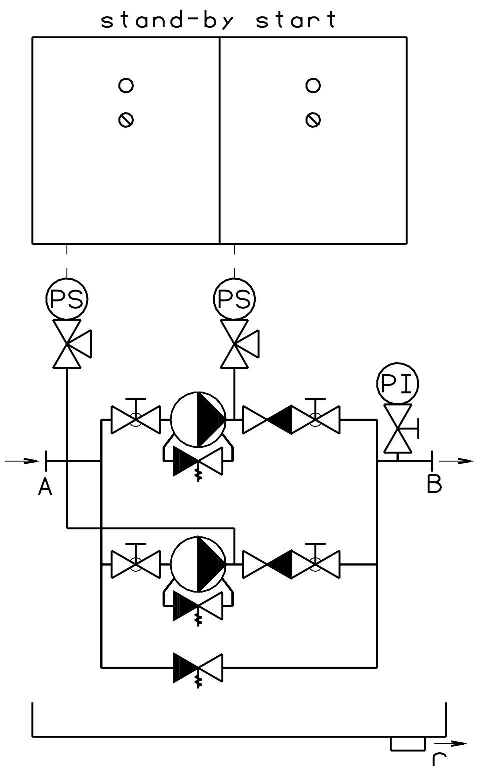
The lubricating oil boster pump can be of the screw wheel, the gear wheel, or the centrifugal type:

Lubricating oil viscosity, specified . . . . . . 75 cSt at 50 °C
Lubricating oil viscosity, ... maximum 400 cSt
Lubricating oil flow . . . . see “List of capacities”
Pump head . . . . 3 bar
Working temperature . . . . 60 °C

The flow capacity is to be within a tolerance of:
0 to+12%.

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 B&W’s recommendations: “Flushing of Main Lubricating Oil System”, which is available on request.



A: Inlet from main lube oil pipe
B: Outlet to exhaust valve actuator
C: Waste oil drain

178 14 87-0.0

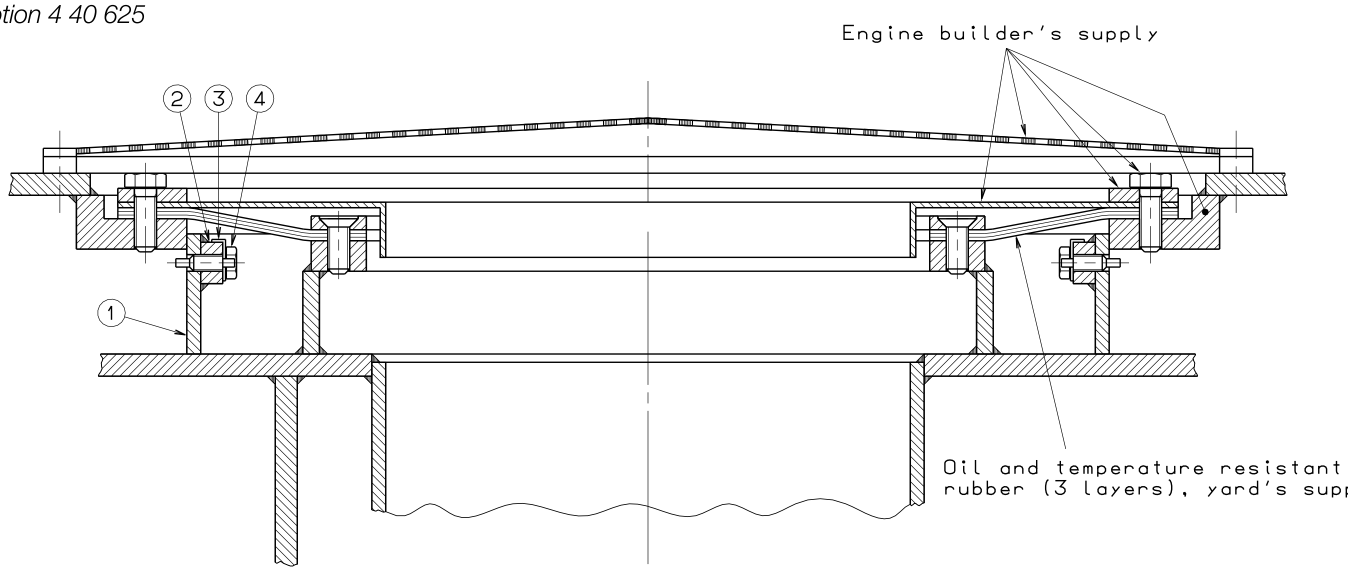
Fig: 6.03.04: Booster module, for camshaft and exhaust valve actuator lubrication MAN B&W Diesel / C.C. Jensen, option 4 40 625

Booster unit for camshaft and exhaust valve actuator lubrication (4 40 625)

The units consisting of the two booster pumps and the control system can be delivered as a module, “Booster module, MAN B&W/C.C. Jensen”.

Engine type	Units	
	60 Hz 3 x 440 V	50 Hz 3 x 380 V
4S60MC	B - 5.8 - 6	B - 6.3 - 5
5S60MC	B - 7.9 - 6	B - 8.4 - 5
6S60MC	B - 7.9 - 6	B - 8.4 - 5
7S60MC	B - 10.3 - 6	B - 9.3 - 5
8S60MC	B - 11.4 - 6	B - 11.9 - 5

178 89 10-2.0

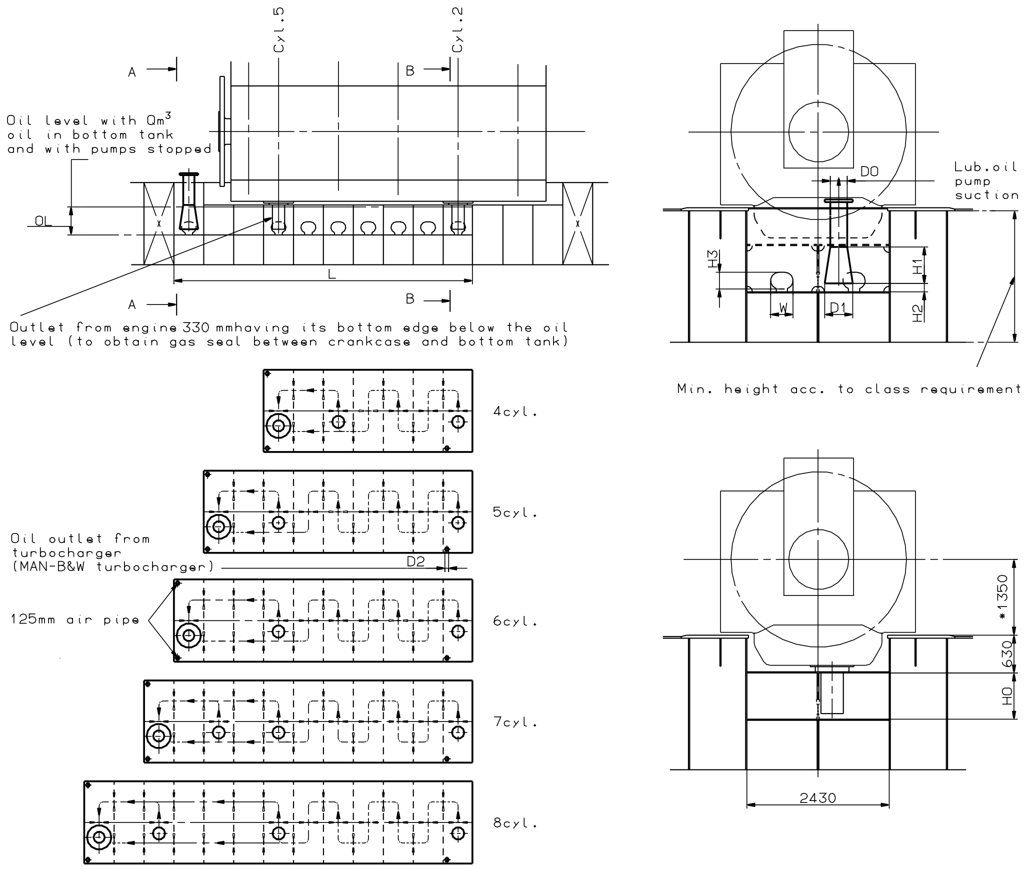


A protecting ring position 1-4 is to be installed if required, by class rules, and is placed loose on the tanktop and guided by the hole in the flange

In the vertical direction it is secured by means of screws position 4 so as to prevent wear of the rubber plate.

178 07 41-6.0

Fig. 6.03.05: Lubricating oil outlet



178 31 05-9.0

Note:
When calculating the tank heights, allowance has not been made for the possibility that part of the oil quantity from the system outside the engine may, when the pumps are stopped, be returned to the bottom tank.

If the system outside the engine is so executed, that a part of the oil quantity is drained back to the tank when the pumps are stopped, the height of the bottom tank indicated on the drawing is to be increased to include this additional quantity.

If space is limited other proposals are possible.

* Based on 50 mm thickness of supporting chocks
** Minimum dimensions for man holes

The lubricating oil bottom tank complies with the rules of the classification socities by operation under the following conditions and the angles of inclination in degrees are:

Athwartships		Fore and aft	
Static	Dynamic	Static	Dynamic
15	22.2	5	7.5

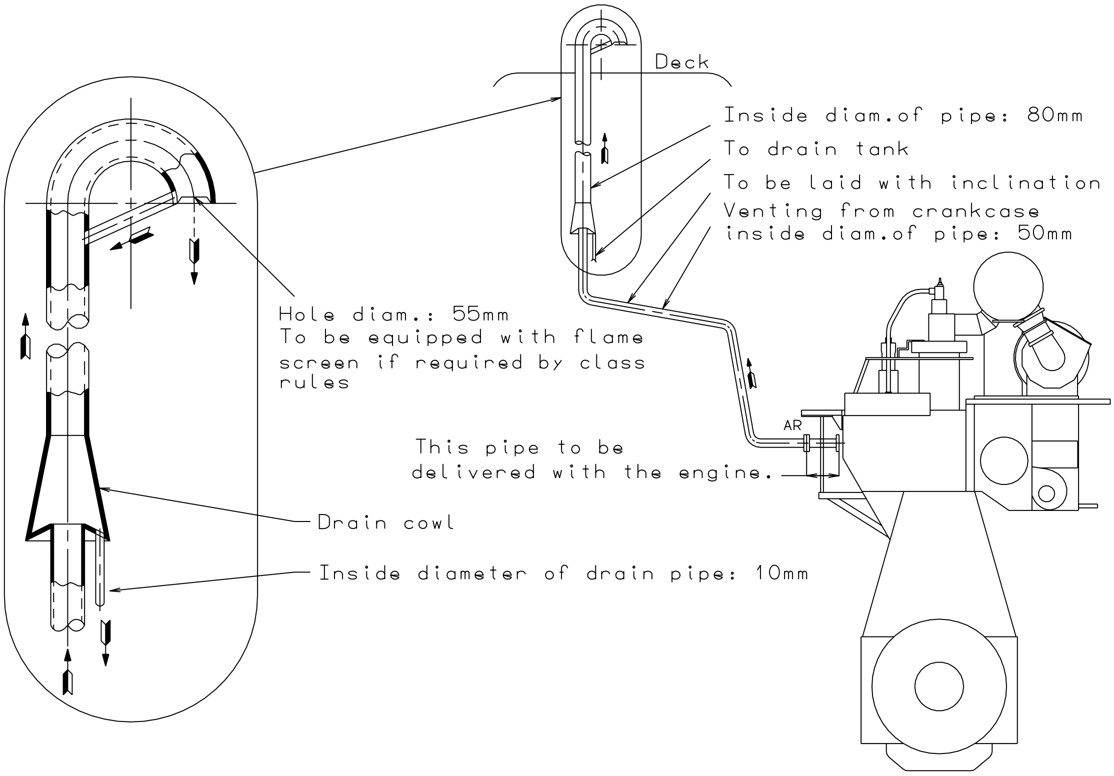
Minimum lubricating oil bottom tank volume are following:

4 cylinder	5 cylinder	6 cylinder	7 cylinder	8 cylinder
10.9 m^3	13.6 m^3	15.8 m^3	18.5 m^3	21.2 m^3

Cylinder No.	Drain at cylinder No.	D0	D1	D2	H0	H1	H2	H3	W	L	OL	Qm^3
4	2-4	200	425	65	920	425	85	300	400	5600	825	11.2
5	2-5	225	450	65	1000	450	90	300	400	7200	905	15.8
6	2-6	250	450	65	1060	475	90	300	500	8000	970	18.8
7	2-5-7	250	475	100	1105	475	95	400	500	8800	1015	21.6
8	2-5-8	275	550	100	1175	550	110	400	500	10400	1080	27.3

178 89 15-1.0

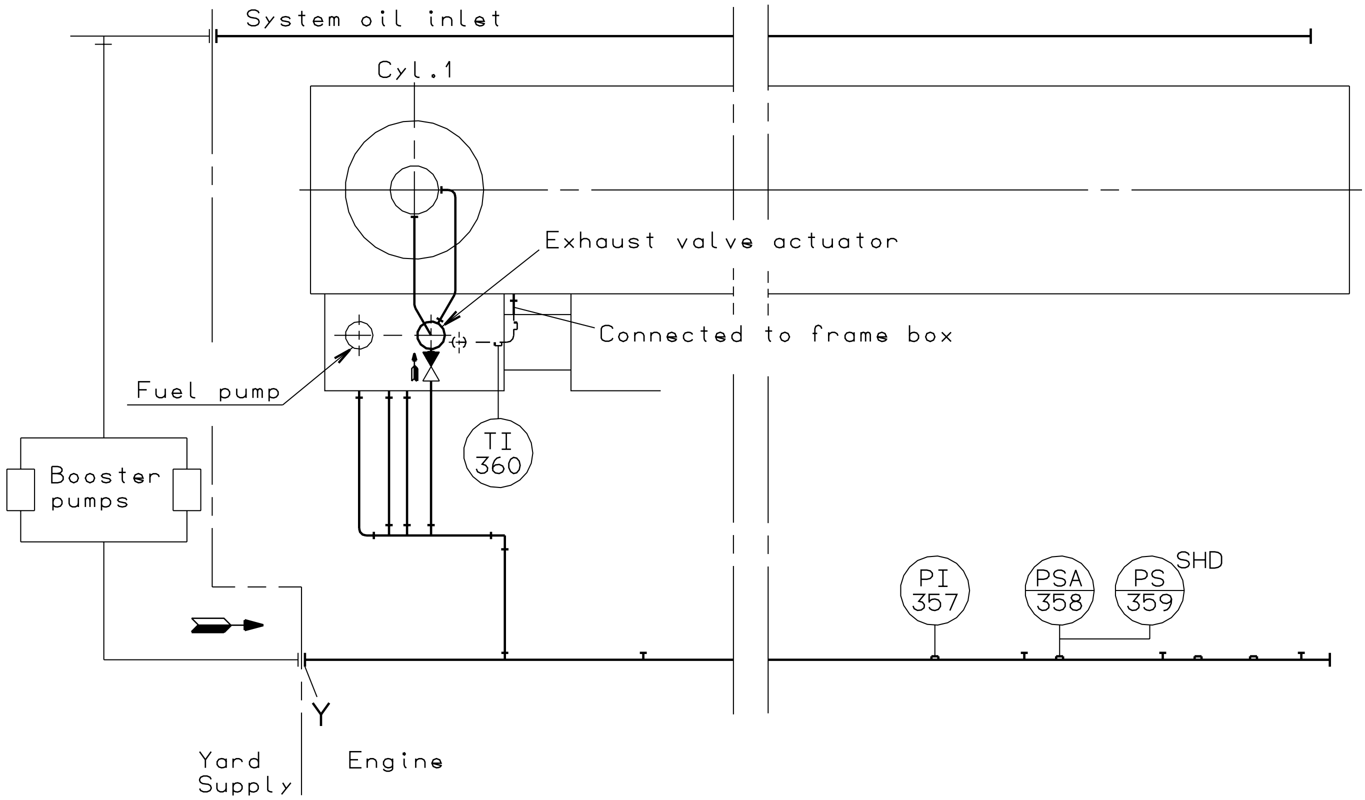
Fig. 6.03.06: Lubricating oil tank, with cofferdam and vertical outlets



The letters refer to "List of flanges"

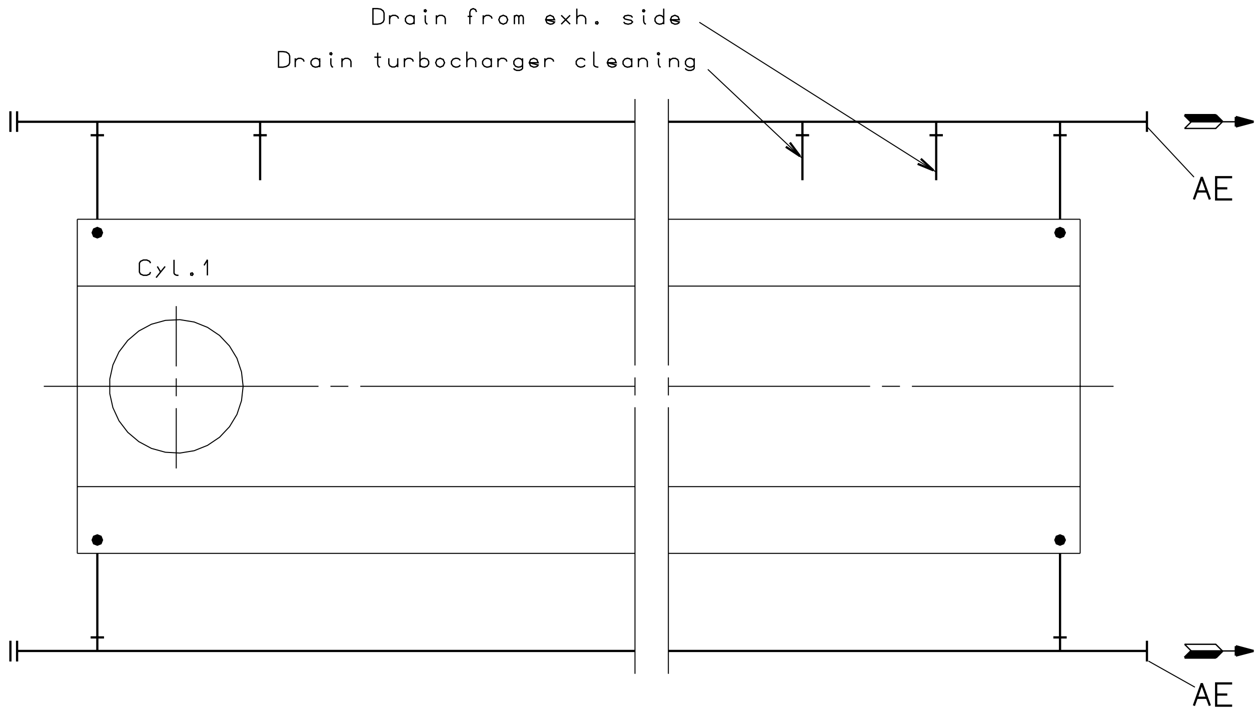
178 34 43-7.0

Fig.6.03.07: Crankcase venting



178 12 43-7.4

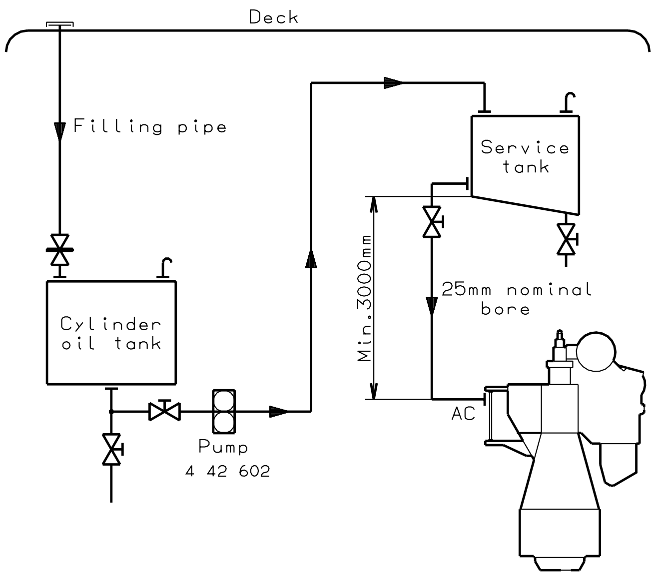
Fig.6.03.08: Lubricating oil pipes for camshaft and exhaust valve actuator



143 08 79-9.4

Fig. 6.03.09: Bedplate drain pipes

6.04 Cylinder Lubricating Oil System



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178 06 14-7.2

Fig. 6.04.01: Cylinder lubricating oil system

The cylinder lubricators can be either of the mechanical type driven by the engine (4 42 111) or of the electronic type, option: 4 42 140. The cylinder lube oil is supplied from a gravity-feed cylinder oil service tank, Fig. 6.04.01.

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.

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. Due to the traditional link between high detergency and high TBN in cylinder oils, we recommend the use of a TBN 70 cylinder oil in combination with all fuel types within our guiding specification, regardless of the sulphur content.

Consequently, TBN 70 cylinder oil should also be used on testbed and at seatrial. However, cylinder oils with higher alkalinity, such as TBN 80, may be beneficial, especially in combination with high-sulphur fuels.

The cylinder oils listed below have all given satisfactory service during heavy fuel operation in MAN B&W engine installations:

Company	Cylinder oil SAE 50/TBN 70
Elf-Lub.	Talusia HR 70
BP	CLO 50-M
Castrol	S/DZ 70 cyl.
Chevron	Delo Cyloil Special
Exxon	Exxmar X 70
Fina	Vegano 570
Mobil	Mobilgard 570
Shell	Alexia 50
Texaco	Taro Special

Also other brands have been used with satisfactory results.

Cylinder Oil Feed Rate (Dosage)

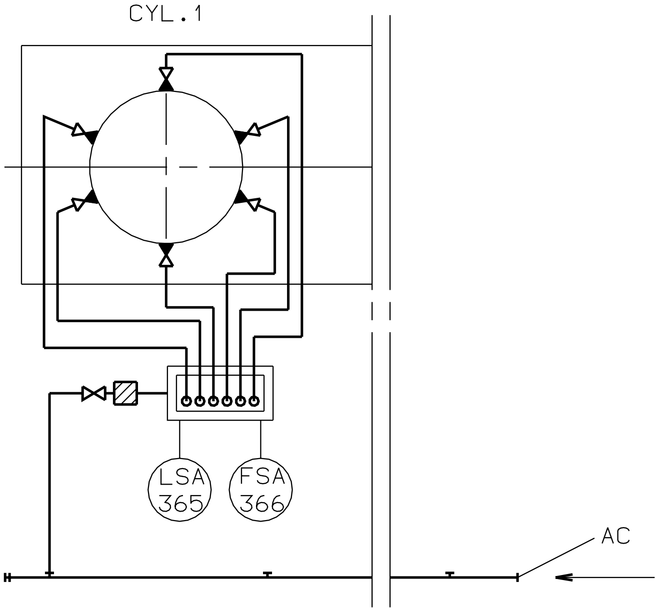
The following guideline for cylinder oil feed rate is based on service experience from other MC engine types, as well as today's fuel qualities and operating conditions.

The recommendations are valid for all plants, whether controllable pitch or fixed pitch propellers are used.

The nominal cylinder oil feed rate at nominal MCR is:
0.95–1.5 g/kWh
0.7–1.1 g/BHPh

During the first operational period of about 1500 hours, it is recommended to use the highest feed rate in the range.

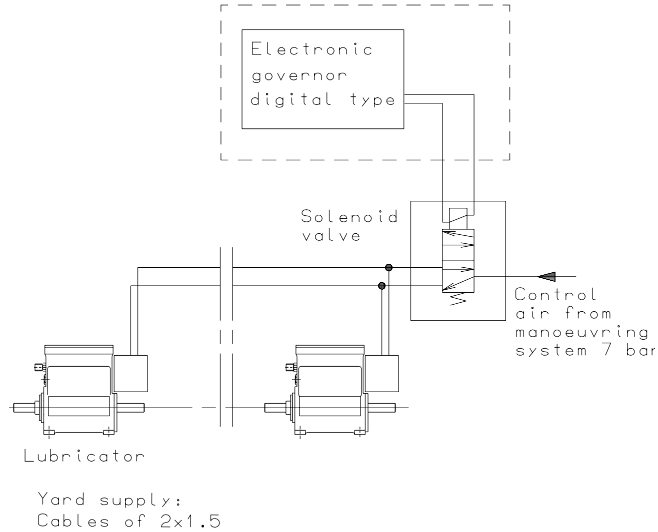
The feed rate at part load is proportional to the second power of the speed: $Q_p = Q \times \left\{\frac{n_p}{n}\right\}^2$



The letters refer to "List of flanges"
The piping is delivered with and fitted onto the engine

178 30 79-5.1

Fig. 6.04.02: Cylinder lubricating oil pipes



178 45 03-1.0

Fig. 6.04.03: Load change dependent lubricator

Mechanical Cylinder Lubricators

Each cylinder liner has a number of lubricating orifices (quills), through which the cylinder oil is introduced into the cylinders, see Fig. 6.04.02. The oil is delivered into the cylinder via non-return valves, when the piston rings during the upward stroke pass the lubricating orifices.

The mechanical cylinder lubricators are mounted on roller guide housings, one per cylinder, and are interconnected with a drive shaft. The lubricators have a built-in capability for adjustment of the oil quantity. They are of the "Sight Feed Lubricator" type and are provided with a sight glass for each lubricating point.

The lubricators in Fig. 6.04.02 are fitted with:

- Electrical heating coils
- Low flow and low level alarms.

The lubricator will, in the basic "Speed Dependent" design (4 42 111), pump a fixed amount of oil to the cylinders for each engine revolution.

The "speed dependent" as well as the "mep dependent" lubricator is equipped with a "Load Change Dependent" system (4 42 120), such that the cylinder feed oil rate is automatically increased during starting, manoeuvring and, preferably, during sudden load changes, see Fig. 6.04.03.

The signal for the "load change dependent" system comes from the electronic governor.

Type: 18F010
For alarm for low level and no flow

Low level switch “A” opens at low level
Low flow switch “B” opens at zero flow
in one ball control glass

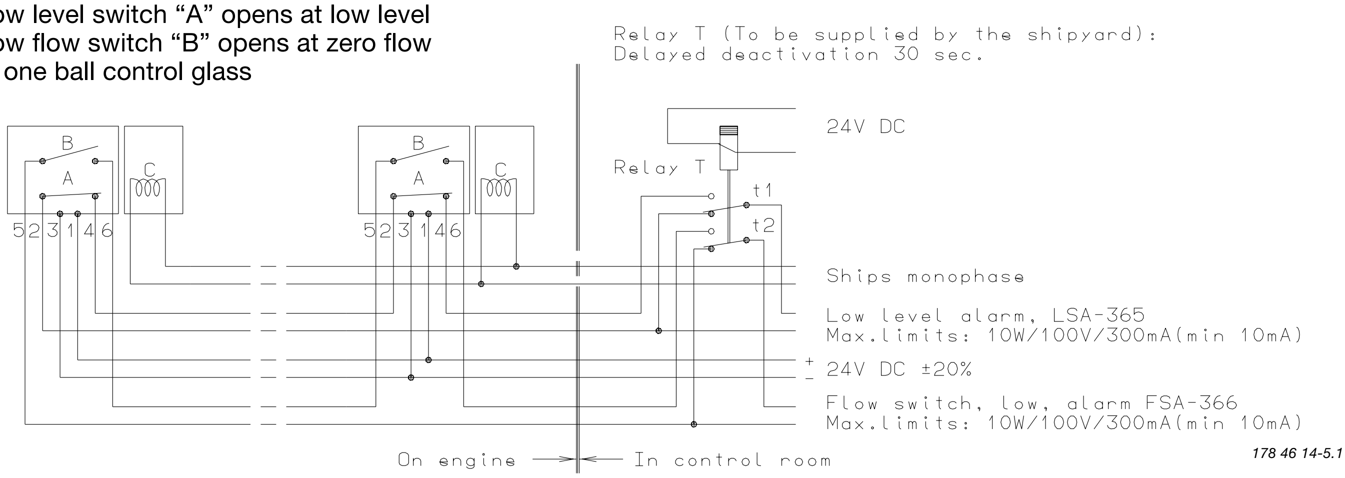


Fig. 6.04.04a: Electrical diagram, mechanical cylinder lubricator

Type: 18F001
For alarm for low level and alarm and
slow down for no flow
Required by: ABS, GL, RINa,
RS and recommended by IACS

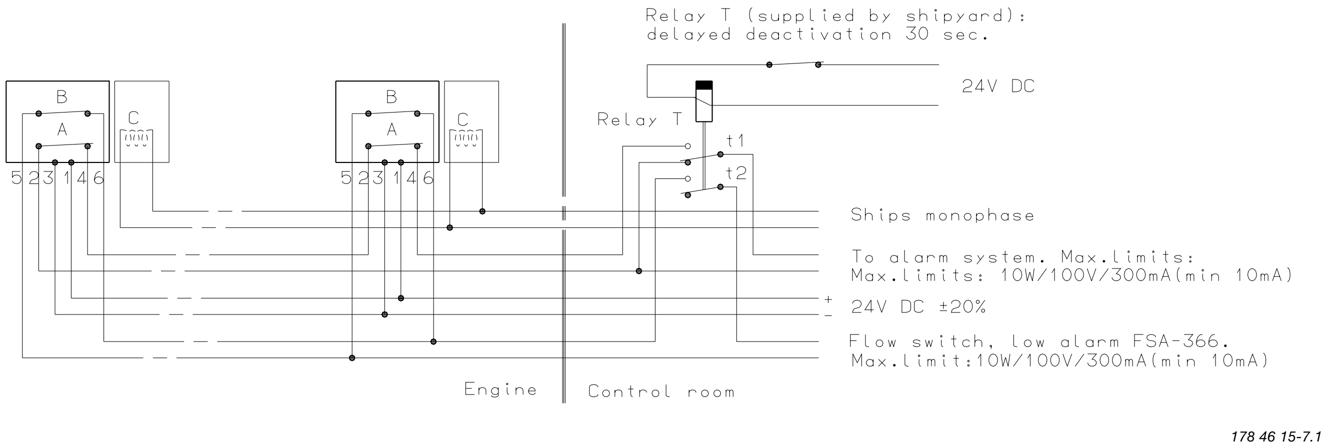


Fig. 6.04.04b: Electrical diagram, mechanical cylinder lubricator

All cables and cable connections to be yard’s supply
One 55 watt lubricator with six glasses per cylinder.
Power supply according to ship’s monophase 110 V or 220 V.
Heater ensures oil temperature of approximately 40-50 °C
No flow and low level alarms, for cylinder lubricators

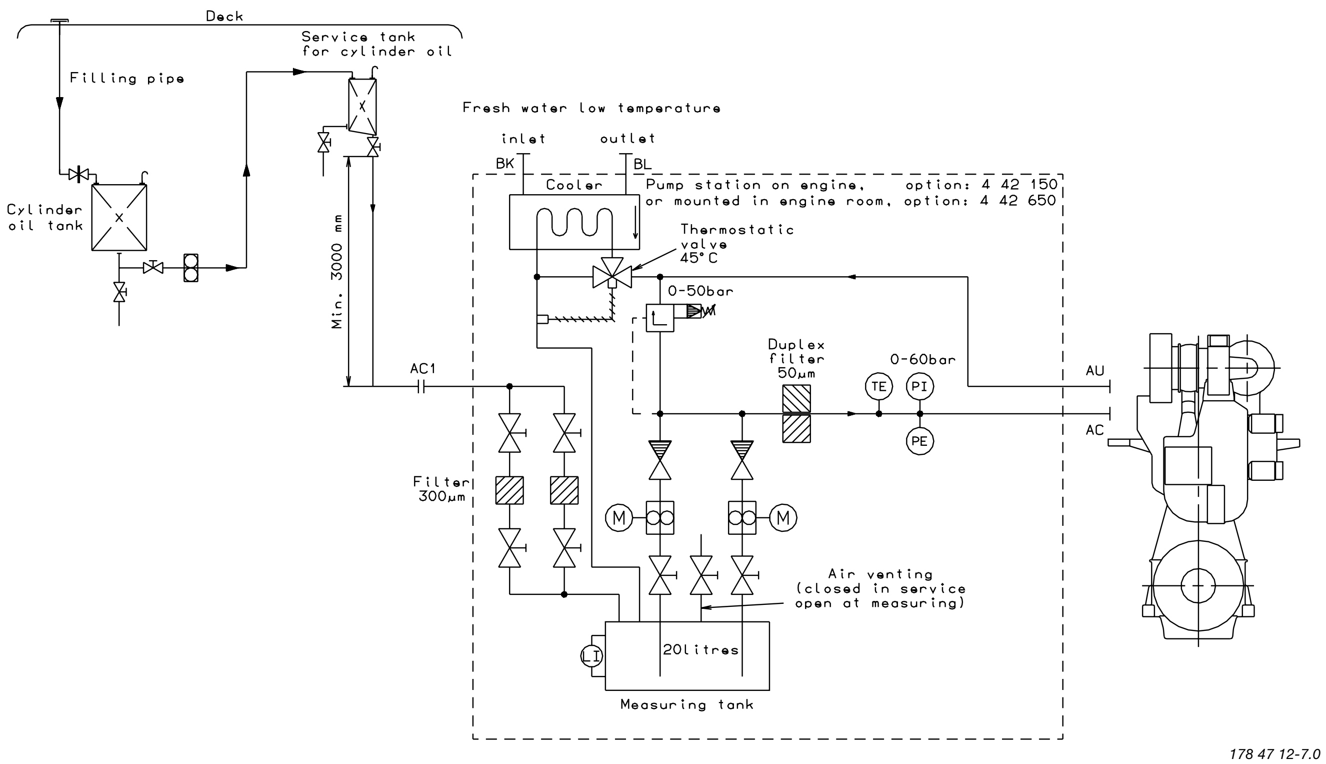


Fig. 6.04.05: Electronic Alpha cylinder lubricating oil system

Electronic Alpha Cylinder Lubrication System
Option: 4 42 105

The electronic Alpha cylinder lubrication system, Fig. 6.04.05, is an alternative to the mechanical engine-driven lubrication system.

The system is designed to supply cylinder oil intermittently, e.g. every four engine revolutions, at a constant pressure and 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 can be mounted either on the engine, option 4 42 150, or in the engine room, option 4 42 650.

The oil fed to the injectors is pressurised by means of one lubricator on each cylinder, equipped with small multi-piston pumps, Fig. 6.04.06. The basic oil feed rate to the injectors is adjusted by a shim, which limits the length of the piston stroke.

Fig. 6.04.07 shows the wiring diagram of the electronic Alpha cylinder lubricator.

The whole 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.

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 switchboard unit (SBU).

The electronic lubricating system incorporates all the lubricating oil functions of the mechanical system, such as “speed dependent, mep dependent, and load change dependent”.

Prior to start up, the cylinders can be pre-lubricated and, during the running-in period, the operator can choose to increase the lube oil feed rate by 25%, 50% or 100%.

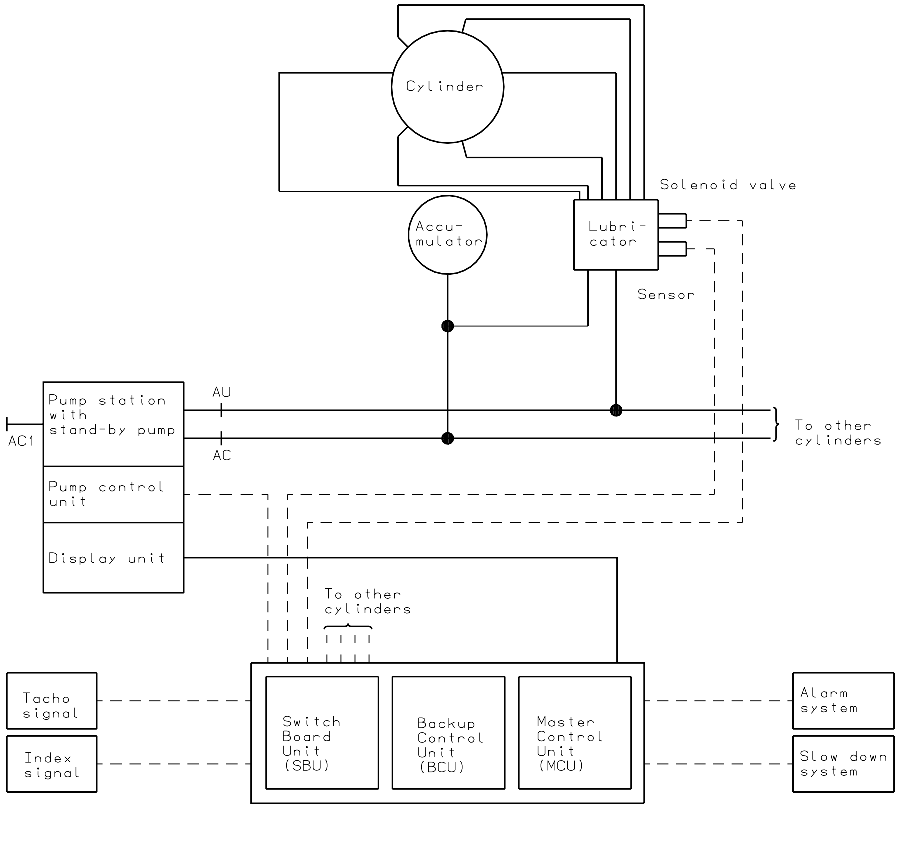


Fig. 6.04.06: Electronic Alpha cylinder lubricators on engine

The external electrical system must be capable of providing the MCU and BCU with an un-interruptable 24 Volt DC power supply.

The electronic Alpha cylinder lubricator system is equipped with the following (Normally Closed) alarms:

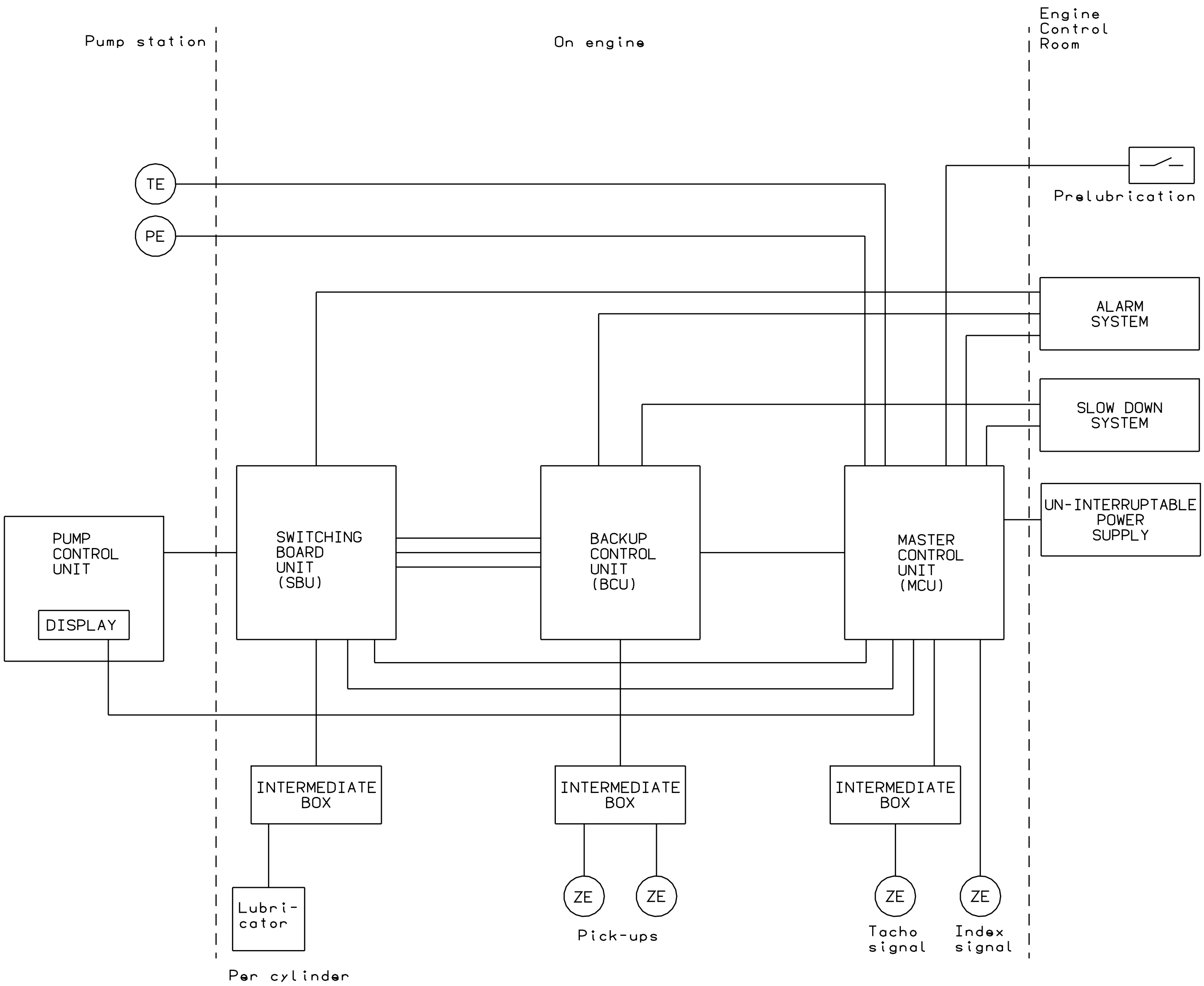
- MCU–Unit failure
- MCU–Power failure
- MCU–Common alarm
- BCU–Unit in control
- BCU–Unit failure
- BCU–Power failure
- SBU–Failure

and slow down for:

- Electronic cylinder lubricator system

The system has a connection for coupling it to a computer system or a Display Unit (DU) so that engine speed, fuel index, injection frequency, alarms, etc. can be monitored.

The DU can be delivered separately for mounting in the engine control room: option 4 42 655.



178 47 16-4.1

Fig. 6.04.07: Wiring diagram for electronic Alpha cylinder lubricator

6.05 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.

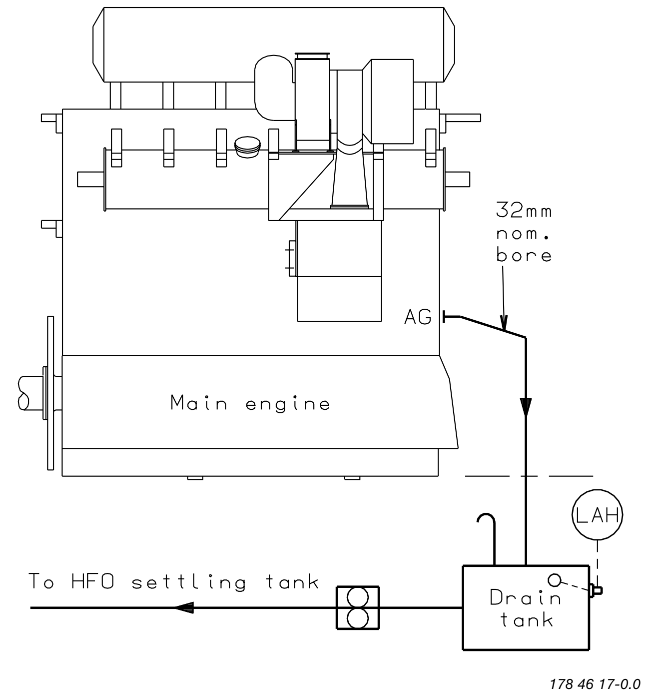


Fig. 6.05.01a: Stuffing box drain oil system

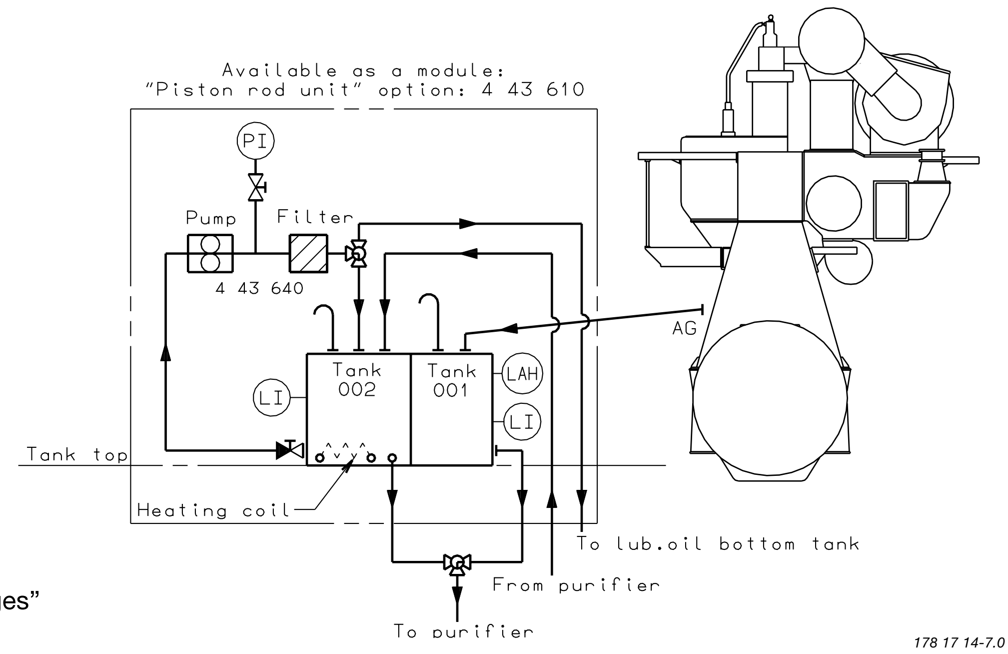
The performance of the piston rod stuffing box on the MC engines has proved to be very efficient, primarily because the hardened piston rod allows a higher scraper ring pressure.

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.

We therefore consider the piston rod stuffing box drain oil cleaning system as an option, and recommend that this relatively small amount of drain oil is either mixed with the fuel oil in the fuel oil settling tank before centrifuging and subsequently burnt in the engine Fig. 6.05.01a or that it is burnt in the incinerator.

If the drain oil is to be re-used as lubricating oil Fig. 6.05.01b, it will be necessary to install the stuffing box drain oil cleaning system described below.

As an alternative to the tank arrangement shown, the drain tank (001) can, if required, be designed as a bottom tank, and the circulating tank (002) can be installed at a suitable place in the engine room.



The letters refer to "List of flanges"

Fig. 6.05.01b: Optional cleaning system of piston rod, stuffing box drain oil

No. of cylinders	C.J.C. Filter	Minimum capacity of tanks		Capacity of pump 4 43 640
		Tank 001	Tank 002	at 2 bar
		m^3	m^3	m^3/h
4 – 8	1 x HDU 427/54	0.6	0.7	0.2

178 38 28-5.1

Fig. 6.05.02: Capacities of cleaning system, stuffing box drain

Piston rod lub oil pump and filter unit

The filter unit consisting of a pump and a finefilter (option: 4 43 640) could be of make C.C. Jensen A/S, Denmark. The fine filter cartridge is made of cellulose fibres and will retain small carbon particles etc. with relatively low density, which are not removed by centrifuging.

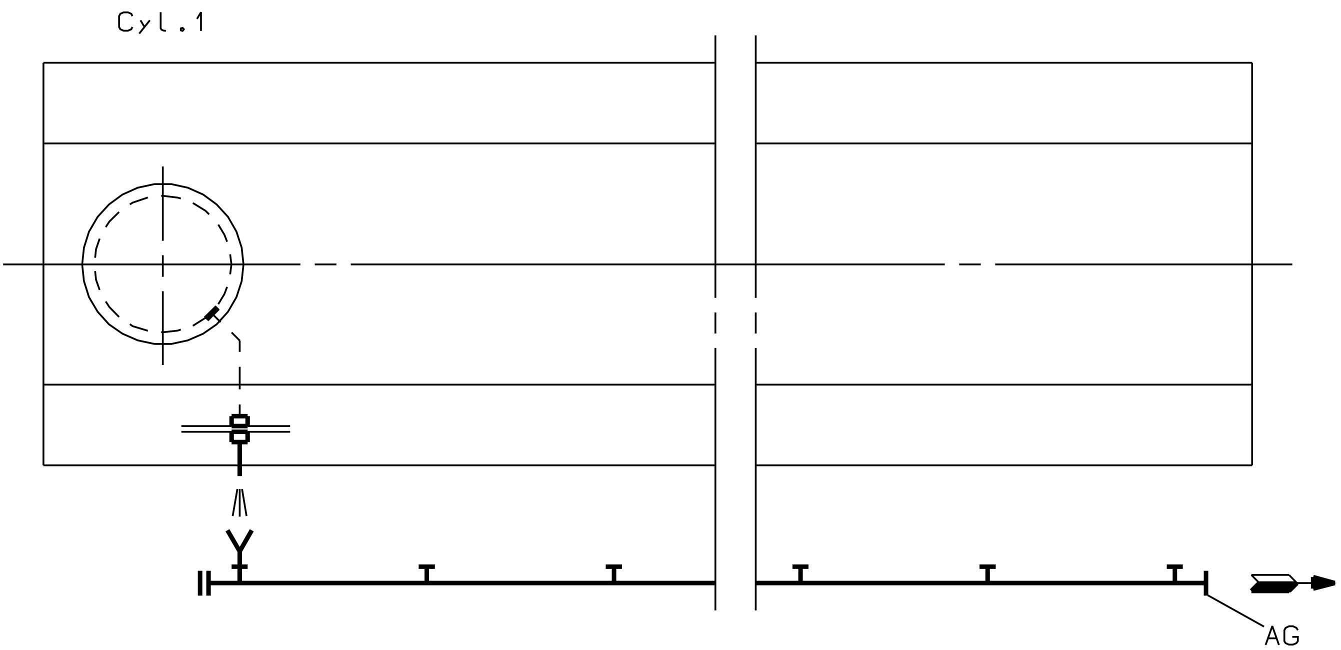
Lube oil flow . . . . see table in Fig. 6.05.02
Working pressure . . . . 0.6-1.8 bar
Filtration fineness . . . . 1 m
Working temperature . . . . 50 °C
Oil viscosity at working temperature . . . . . . 75 cSt
Pressure drop at clean filter . . . . maximum 0.6 bar
Filter cartridge . . . maximum pressure drop 1.8 bar

The relevant piping arranged on the engine is shown in Fig. 6.05.03:
"Stuffing box, drain pipes".

No. of cylinders	3 x 440 volts 60 Hz	3 x 380 volts 50 Hz
4 – 8	PR – 0.2 – 6	PR – 0.2 – 5

178 38 29-7.1

Fig. 6.05.04: Types of piston rod units



The letters refer to "List of flanges"
The piping is delivered with and fitted onto the engine

178 30 86-6.0

Fig. 6.05.03: Stuffing box, drain pipes

Designation of piston rod units

PR – 0.2 – 6

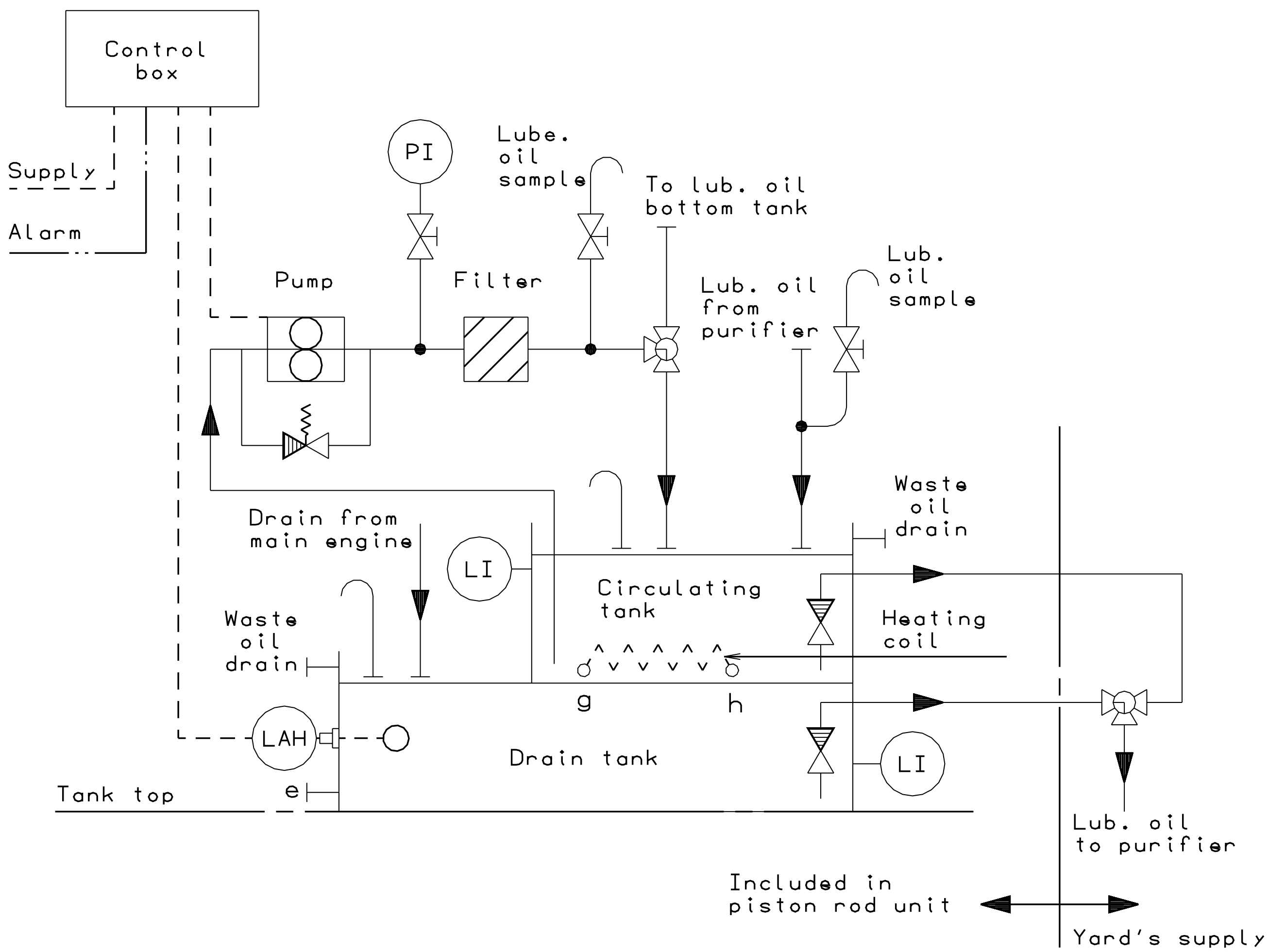
- 5 = 50 Hz, 3 x 380 Volts
- 6 = 60 Hz, 3 x 440 Volts
- Pump capacity in m^3/h
- Piston rod unit

A modular unit is available for this system, option: 4 43 610. See Fig. 6.05.05 “Piston rod unit, MAN B&W/C.C. Jensen”.

The modular unit consists of a drain tank, a circulating tank with a heating coil, a pump and a fine filter, and also includes wiring, piping, valves and instruments.

The piston rod unit is tested and ready to be connected to the supply connections on board.

178 30 89-1.0



178 30 87-8.0

Fig. 6.05.05: Piston rod unit, MAN B&W/C.C. Jensen, option: 4 43 610

6.06 Cooling Water Systems

The water cooling can be arranged in several configurations, the most common system choice being:

- A **seawater cooling system**
  and a jacket cooling water system

- A **central cooling water system,**
  option: 4 45 111 with three circuits:
  a seawater system
  a low temperature freshwater system
  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.

The advantages of the *central cooling system are:*

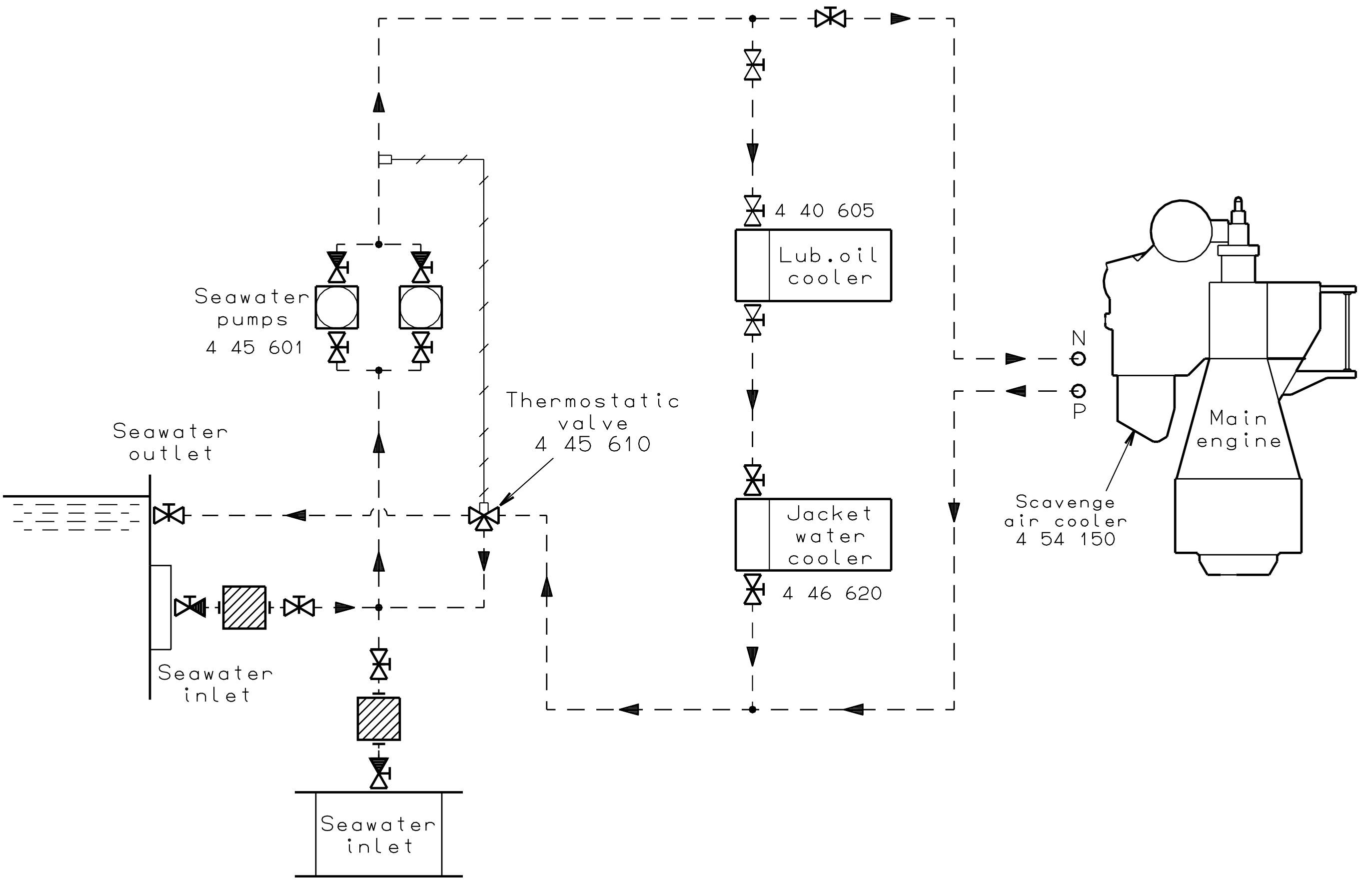
- Only one heat exchanger cooled by seawater, and thus, only one exchanger to be overhauled
- All other heat exchangers are freshwater cooled and can, therefore, be made of a less expensive material
- Few non-corrosive pipes to be installed
- Reduced maintenance of coolers and components
- Increased heat utilisation.

whereas the disadvantages are:

- Three sets of cooling water pumps (seawater, freshwater low temperature, and jacket water high temperature)
- Higher first cost.

For further information about common cooling water system for main engines and auxiliary engines please refer to our publication:

P. 281 Uni-concept Auxiliary Systems for Two-stroke Main Engine and Four-stroke Auxiliary Engines.



The letters refer to “List of flanges”

178 12 39-1.2

Fig. 6.06.01: Seawater cooling system

Seawater Cooling System

The seawater cooling system is used for cooling, the main engine lubricating oil cooler (4 40 605), the jacket water cooler (4 46 620) and the scavenge air cooler (4 54 150).

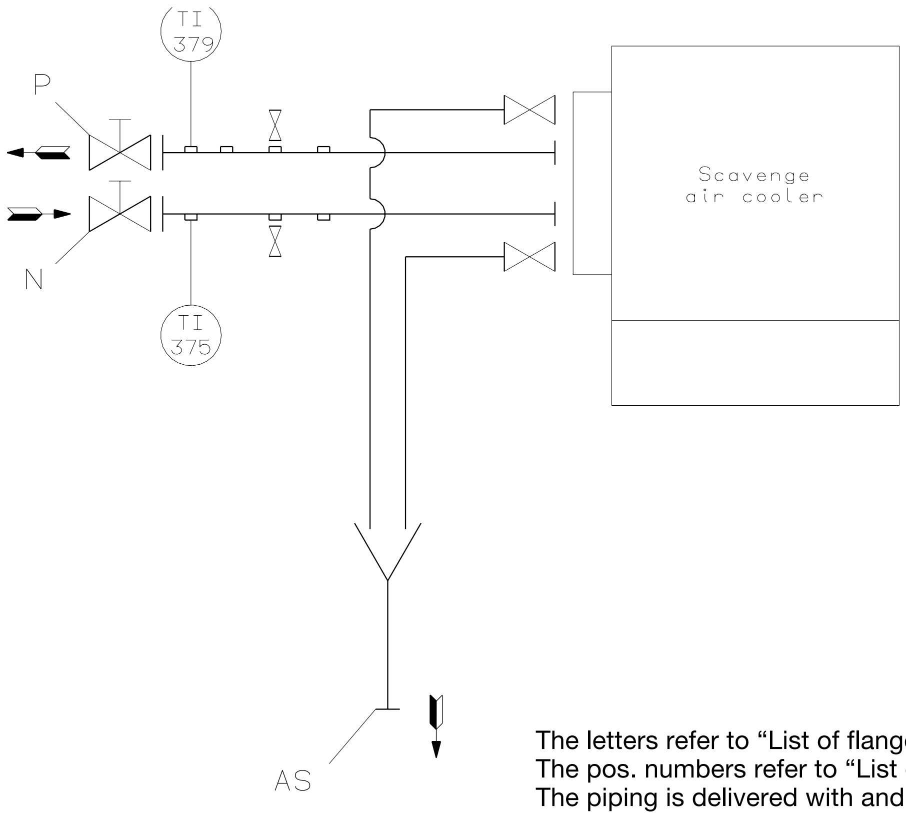
The lubricating oil cooler for a PTO step-up gear should be connected in parallel with the other coolers.The capacity of the SW pump (4 45 601) is based on the outlet temperature of the SW being maximum 50 °C after passing through the coolers – with an inlet temperature of maximum 32 °C (tropical conditions), 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.

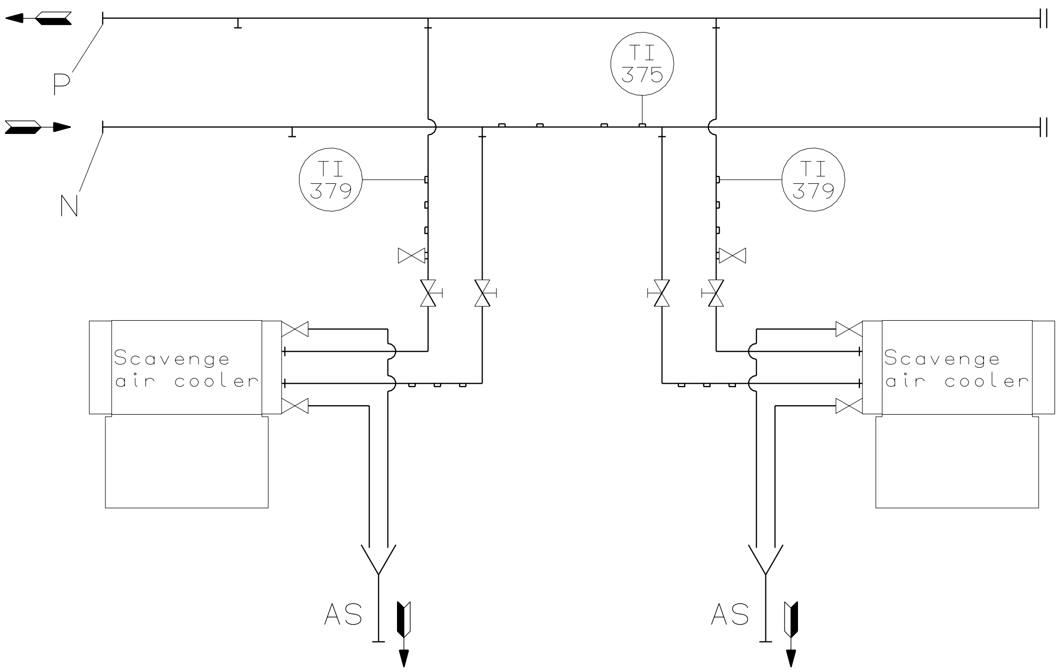
The piping delivered with and fitted onto the engine is, for your guidance shown on Fig. 6.06.02.



The letters refer to "List of flanges"
The pos. numbers refer to "List of instruments"
The piping is delivered with and fitted onto the engine

Fig. 6.06.02: Cooling water pipes, air cooler, one turbocharger

178 31 11-8.0



The letters refer to "List of flanges"
The pos. numbers refer to "List of instruments"
The piping is delivered with and fitted onto the engine

178 31 10-6.0

iFig. 6.06.03: Cooling water pipes, air cooler, two turbochargers, option 4 59 113

Components for seawater system

Seawater cooling pump (4 45 601)

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.

Lube oil cooler (4 40 605)

See chapter 6.03 " Uni-Lubricating oil system".

Jacket water cooler (4 46 620)

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 SW side . . . . . maximum 0.2 bar

The heat dissipation and the SW flow are based on an MCR output at tropical conditions, i.e. SW temperature of 32 °C and an ambient air temperature of 45 °C.

Scavenge air cooler (4 54 150)

The scavenge air cooler is an integrated part of the main engine.

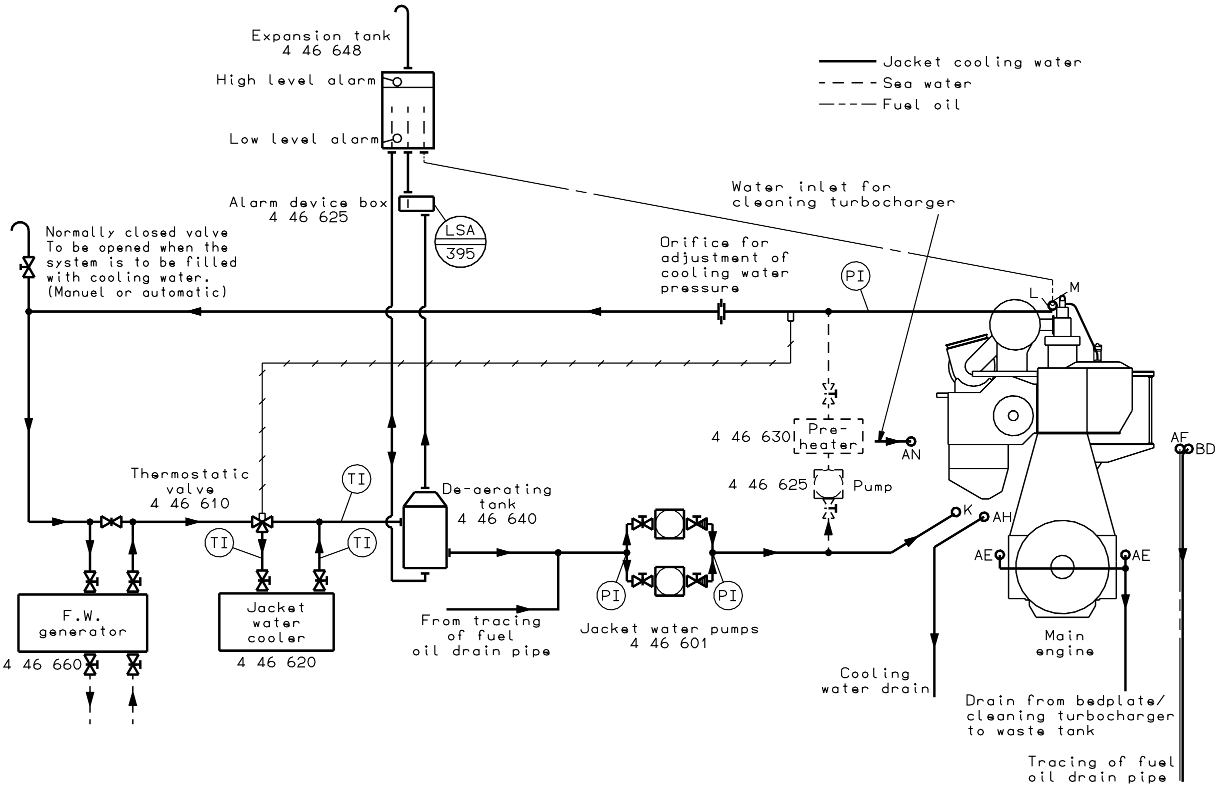
Heat dissipation . . . . see "List of capacities"
Seawater flow . . . . see "List of capacities"
Seawater temperature,
for SW cooling inlet, max. . . . . 32 °C
Pressure drop on
cooling water side . . . . . between 0.1 and 0.5 bar

The heat dissipation and the SW flow are based on an MCR output at tropical conditions, i.e. SW temperature of 32 °C and an ambient air temperature of 45 °C.

Seawater thermostatic valve (4 45 610)

The temperature control valve is a three-way valve which can recirculate all or part of the SW 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



The letters refer to "List of flanges"

178 12 41-3.2

Fig. 6.06.03: Jacket cooling water system

Jacket Cooling Water System

The jacket cooling water system, shown in Fig. 6.06.03, is used for cooling the cylinder liners, cylinder covers and exhaust valves of the main engine and heating of the fuel oil drain pipes.

The jacket water pump (4 46 601) 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 (4 46 610), 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.

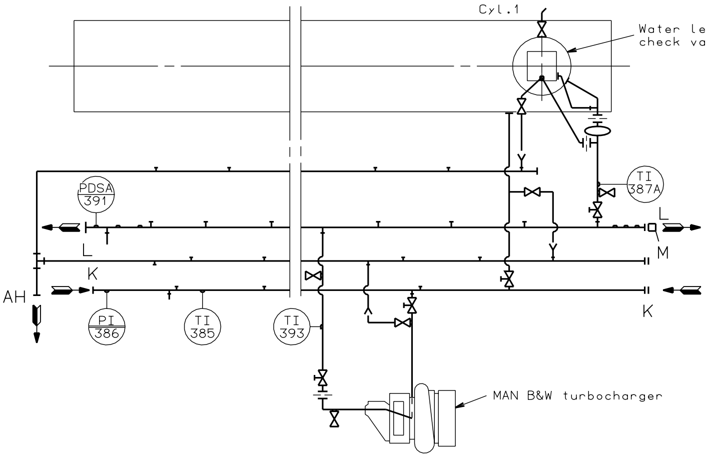
The venting pipe in the expansion tank should end just below the lowest water level, and the expansion tank must be located at least 5 m above the engine cooling water outlet pipe.

MAN B&W's recommendations about the fresh- water system de-greasing, descaling and treatment by inhibitors are available on request.

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.

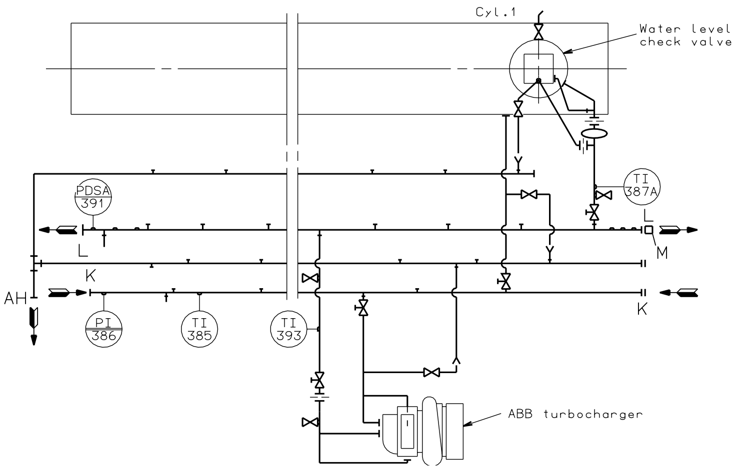
For external pipe connections, we prescribe the following maximum water velocities:

Jacket water . . . . 3.0 m/s
Seawater. . . . . 3.0 m/s



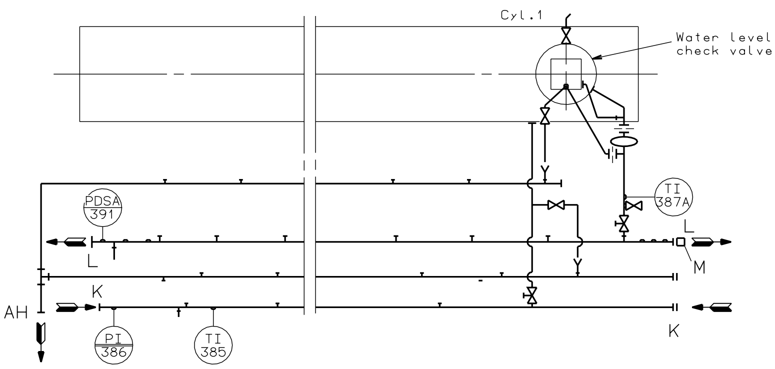
178 31 25-1.0

Fig. 6.06.04a: Jacket water cooling pipes MAN B&W turbocharger



178 31 26-3.0

Fig. 6.06.04b: Jacket water cooling pipes ABB turbocharger



The letters refer to “List of flanges”
The pos. numbers refer to “List of instruments”
The piping is delivered with and fitted onto the engine

178 31 27-5.0

Fig. 6.06.04c: Jacket water cooling pipes MHI turbocharger

Components for jacket water system

Jacket water cooling pump (4 46 601)

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...normal 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 (4 46 660)

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 6.01 "List of capacities".

Jacket water thermostatic valve (4 46 610)

The temperature control system can be 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 (4 46 630)

When a preheater see Fig. 6.06.03 is installed in the jacket cooling water system, its water flow, and thus the preheater pump capacity (4 46 625), 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 relationships are shown in Fig. 6.06.06.

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 enigne's nominal MCR power.

Deaerating tank (4 46 640)

Design and dimensions are shown on Fig. 6.06.06 "Deaerating tank" and the corresponding alarm device (4 46 645) is shown on Fig. 6.06.07 "Deaerating tank, alarm device".

Expansion tank (4 46 648)

The total expansion tank volume has to be approximate 10% of the total jacket cooling water amount in the system.

As a guideline, the volume of the expansion tanks for main engine output are:

Between 2,700 kW and 15,000 kW . . . . . . 1.00 m^3
Above 15,000 kW. 1.25 m^3

Fresh water treatment

The MAN B&W Diesel recommendations for treatment of the jacket water/freshwater are available on request.

Temperature at start of engine

In order to protect the engine, some minimum temperture 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 pos-sible to comply with the abovementioned 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.

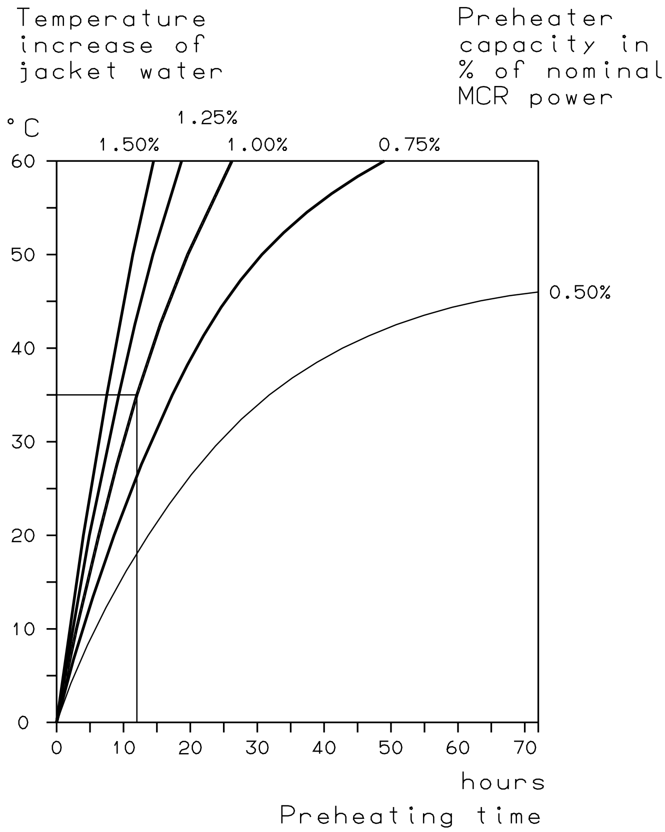


Fig. 6.06.06: Jacket water preheater

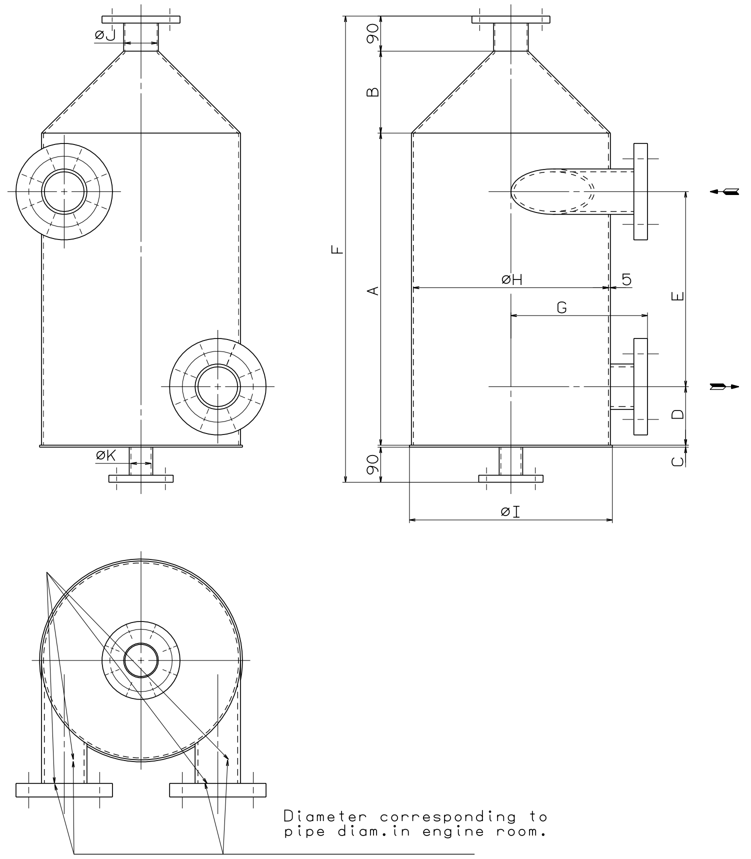
178 16 63-1.0

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.



178 06 27-9.1

Fig. 6.06.07: De-aerating tank

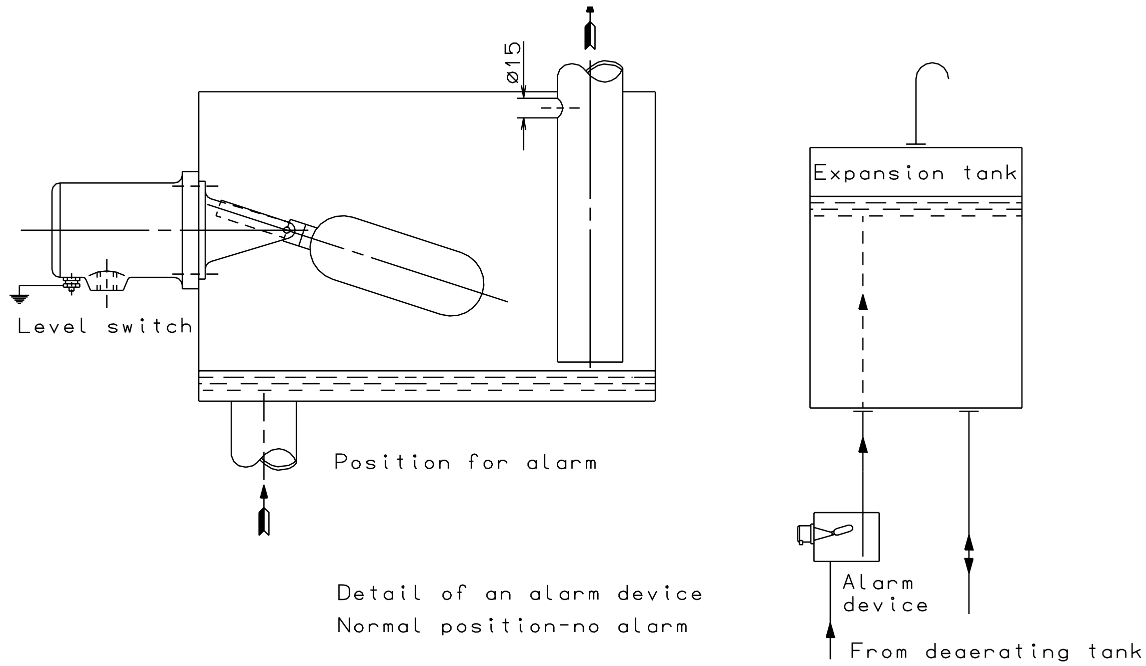
Dimensions in mm		
Tank size	0.05 m^3	0.16 m^3
Max. J.W. capacity	120 m^3/h	300 m^3/h
Max. nominal bore	125	200
A	600	800
B	125	210
C	5	5
D	150	150
E	300	500
F	910	1195
G	250	350
øH	300	500
øI	320	520
øJ	ND 50	ND 80
øK	ND 32	ND 50

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.

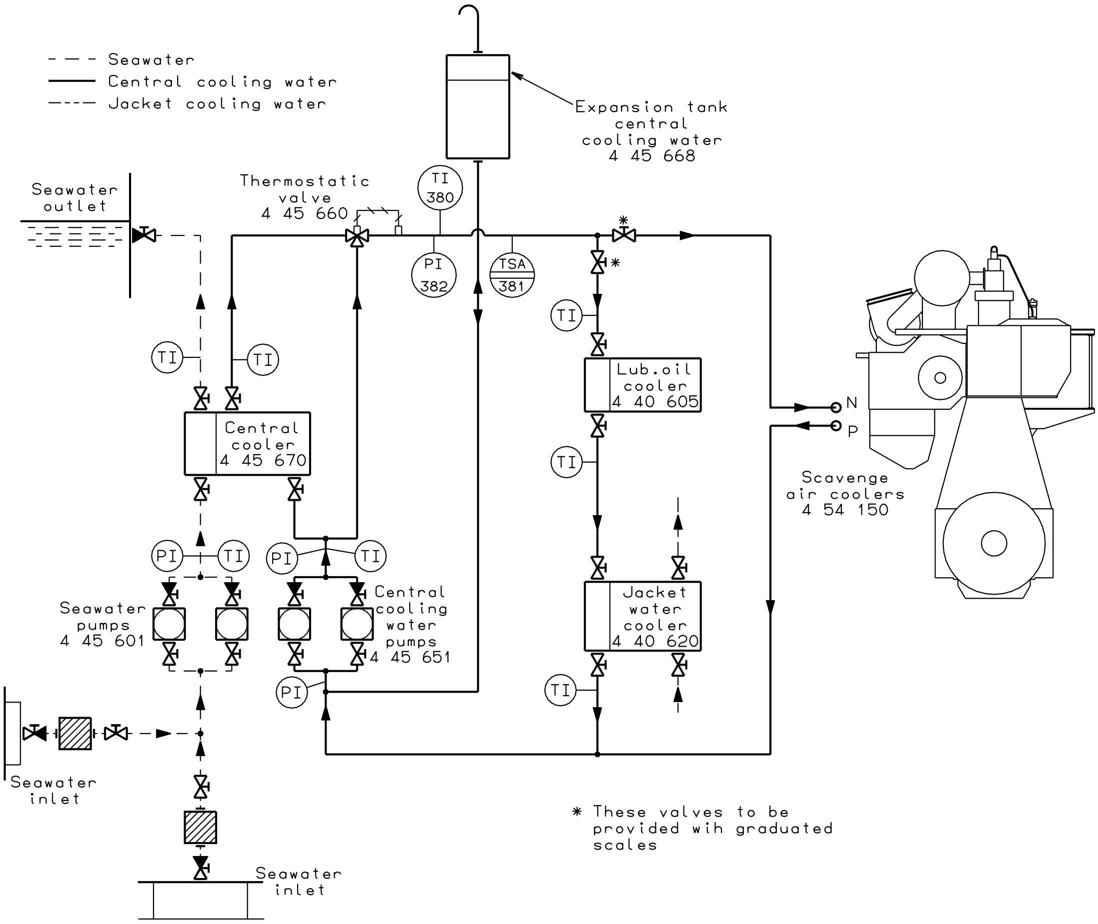
178 31 20-2.1



178 07 37-0.1

Fig. 6.06.08: De-aerating tank, alarm device

6.07 Central Cooling Water System



Letters refer to "List of flanges"

178 12 37-8.3

Fig. 6.07.01: Central cooling 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 the freshwater low temperature (FW-LT) system.

In order to prevent too high a scavenge air temperature, the cooling water design temperature in the FW-LT 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 FW-LT circuit is to be set to minimum 10 °C, whereby the temperature follows the outboard seawater temperature when this exceeds 10 °C.

For further information about common cooling water system for main engines and MAN B&W Holeby auxiliary engines please refer to our publication:

P.281 Uni-concept Auxiliary Systems for Two-stroke Main Engine and Four-stroke Auxiliary Engines.

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

Jacket water . . . . 3.0 m/s
Central cooling water (FW-LT) . . . . 3.0 m/s
Seawater. . . . . 3.0 m/s

Components for central cooling water system

Seawater cooling pumps (4 45 601)

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% +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 (4 45 670)

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...................... maximum 0.2 bar
Seawater flow .... see "List of capacities"
Seawater temperature,
inlet .... 32 °C
Pressure drop on SW side ..... maximum 0.2 bar

The pressure drop may be larger, depending on the actual cooler design.

The heat dissipation and the SW flow figures are based on MCR output at tropical conditions, i.e. a SW 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, low temperature (4 45 651)

The pumps are to be of the centrifugal type.

Freshwater 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,
normal .... approximately 80 °C
maximum 90 °C

The flow capacity is to be within a tolerance of 0% +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 (4 45 660)

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 cooler (4 46 620)

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 FW-LT flow figures are based on an MCR output at tropical conditions, i.e. a maximum SW temperature of 32 °C and an ambient air temperature of 45 °C.

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
FW-LT flow . . . . see “List of capacities”
FW-LT temperature, inlet . . . . approx. 42 °C
Pressure drop on FW-LT side . . . . . . max. 0.2 bar

The other data for the jacket cooling water system can be found in section 6.06.

Scavenge air cooler (4 54 150)

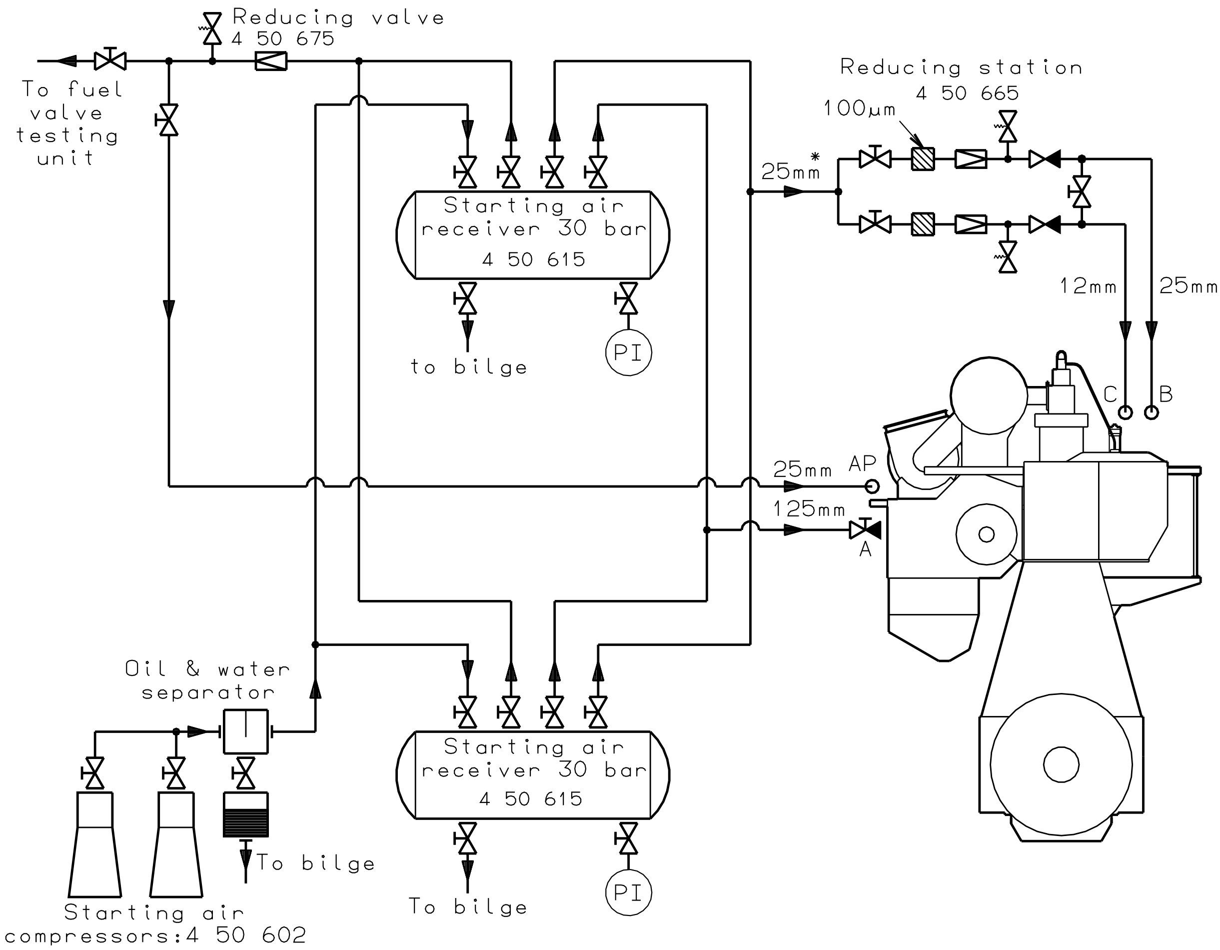
The scavenge air cooler is an integrated part of the main engine.

Heat dissipation . . . . see “List of capacities”
FW-LT water flow . . . . see “List of capacities”
FW-LT water temperature, inlet . . . . 36 °C
Pressure drop on FW-LT
water side . . . . approx. 0.5 bar

Lubricating oil cooler (4 40 605)

See "Lubricating oil system".

6.08 Starting and Control Air Systems



A: Valve "A" is supplied with the engine
AP: Air inlet for dry cleaning of turbocharger
The letters refer to "List of flanges"

* The size of the pipe depends on the length

178 06 12-3.4

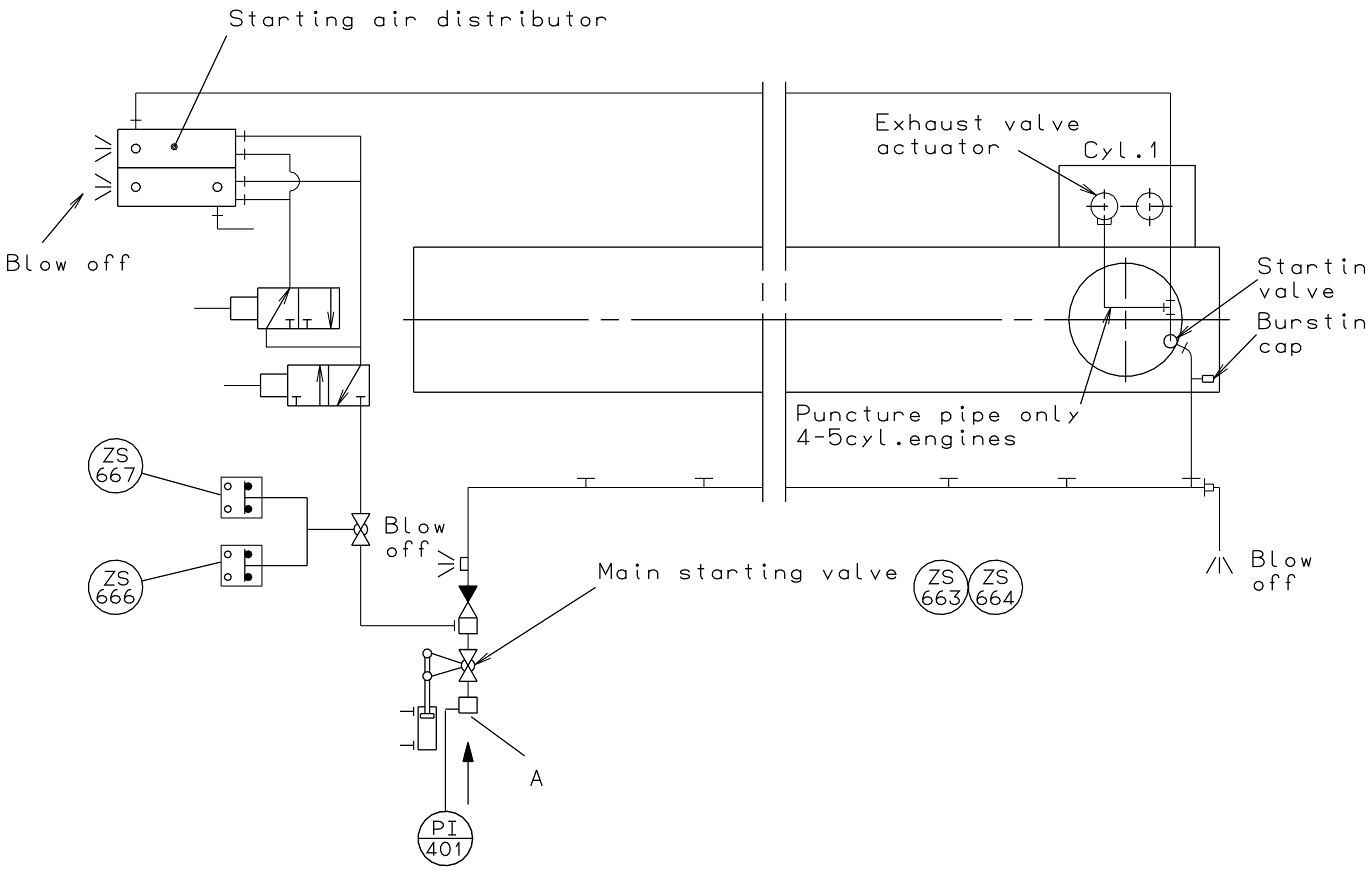
Fig. 6.08.01: Starting and control air systems

The starting air of 30 bar is supplied by the starting air compressors (4 50 602) in Fig. 6.08.01 to the starting air receivers (4 50 615) and from these to the main engine inlet "A".

Through a reducing station (4 50 665), compressed air at 7 bar is supplied to the engine as:

- Control air for manoeuvring system, and for exhaust valve air springs, through "B"
- Safety air for emergency stop through "C"
- Through a reducing valve (4 50 675) is supplied compressed air 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, sealing air for exhaust valve and for fuel valve testing unit are momentary requirements of the consumers. The capacities stated for the air receivers and compressors in the "List of Capacities" cover the main engine requirements and starting of the auxiliary engines.



I = Pneumatic components box
The letters refer to “List of flanges”
The pos. numbers refer to “List of instruments”
The piping is delivered with and fitted onto the engine

178 31 37-1.0

Fig. 6.08.02: Starting air pipes

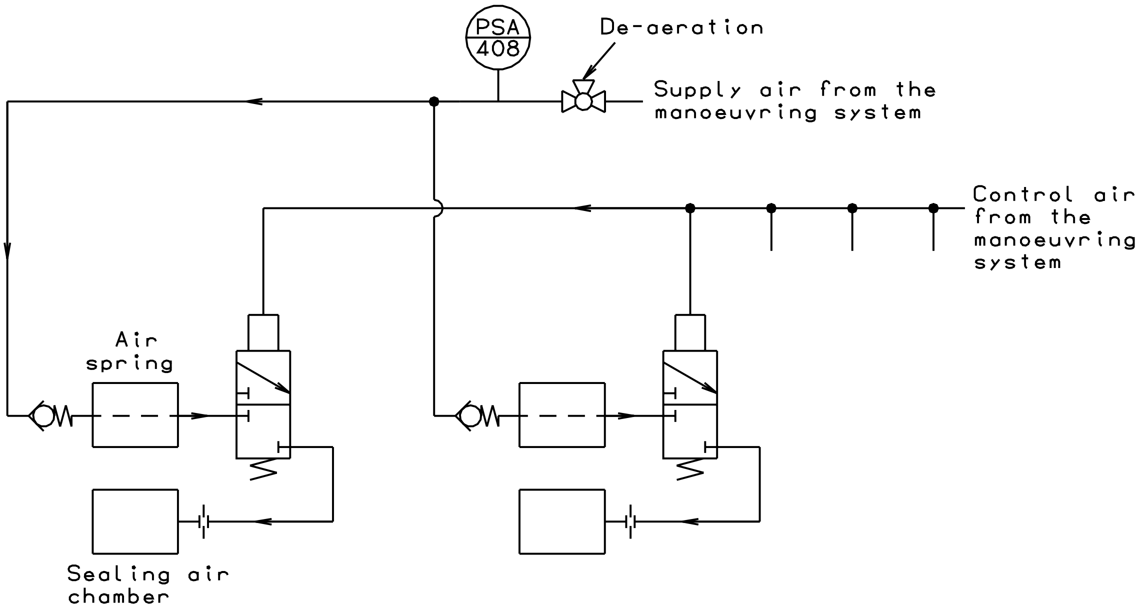
The starting air pipes, Fig. 6.08.02, contains a main starting valve (a ball valve with actuator), a non-return valve, a starting air distributor and starting valves. The main starting valve is combined with the manoeuvring system, which controls the start of the engine. Slow turning before start of engine is an option: 4 50 140 and is recommended by MAN B&W Diesel, see section 6.11.

The starting air distributor regulates the supply of control air to the starting valves in accordance with the correct firing sequence.

An arrangement common for main engine and MAN B&W Holeby auxiliary engines is available on request.

For further information about common starting air system for main engines and auxiliary engines please refer to our publication:

P. 281 “Uni-concept Auxiliary Systems for Two-stroke Main Engine and Four-stroke Auxiliary Engines”



The pos. numbers refer to “List of instruments”
The piping is delivered with and fitted onto the engine

178 38 48-8.0

Fig. 6.08.03: Air spring and sealing air pipes for exhaust valves

The exhaust valve is opened hydraulically, and the closing force is provided by a “pneumatic spring” which leaves the valve spindle free to rotate. The compressed air is taken from the manoeuvring air system.

The sealing air for the exhaust valve spindle comes from the manoeuvring system, and is activated by the control air pressure, see Fig. 6.08.03.

Components for starting air system

Starting air compressors (4 50 602)

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 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 (4 50 615)

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 m bar

Reducing station (4 50 665)

Reduction................ from 30 bar to 7 bar
(Tolerance -10% +10%)
Capacity:
2100 Normal litres/min of free air..... 0.035 m^3/s
Filter, fineness .... 100 m

Reducing valve (4 50 675)

Reduction from .... 30 bar to 7 bar
(Tolerance -10% +10%)
Capacity:
2600 Normal litres/min of free air..... 0.043 m^3/s

The piping delivered with and fitted onto the main engine is, for your guidance, shown on:

Starting air pipes
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 axial movement of the pinion.

The turning gear is driven by an electric motor with a built-in gear and brake. The size of the electric motor is stated in Fig. 6.08.04. The turning gear is equipped with a blocking device that prevents the main engine from starting when the turning gear is engaged.

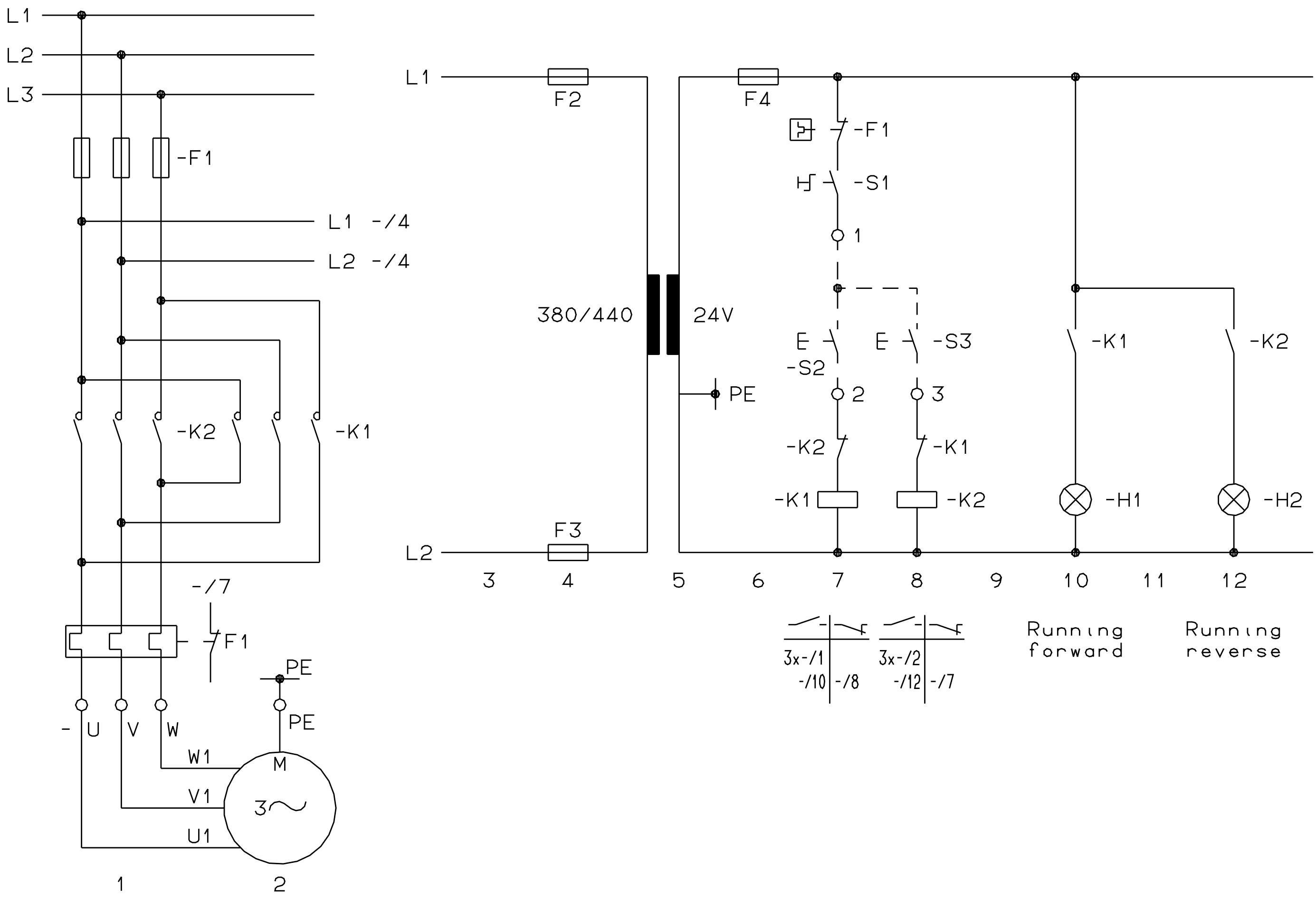
Electric motor 3 x 440V – 60Hz
Brake power supply 220V – 60Hz

		Current	
No. of cylinders	Power kW	Start Amp.	Normal Amp.
4-8	2.2	23.4	4.8

Electric motor 3 x 380V – 50Hz
Brake power supply 220V – 50Hz

		Current	
No. of cylinders	Power kW	Start Amp.	Normal Amp.
4-8	2.2	26.9	5.5

178 38 51-1.0



178 31 30-9.0

Fig. 6.08.04: Electric motor for turning gear

6.09 Scavenge Air System

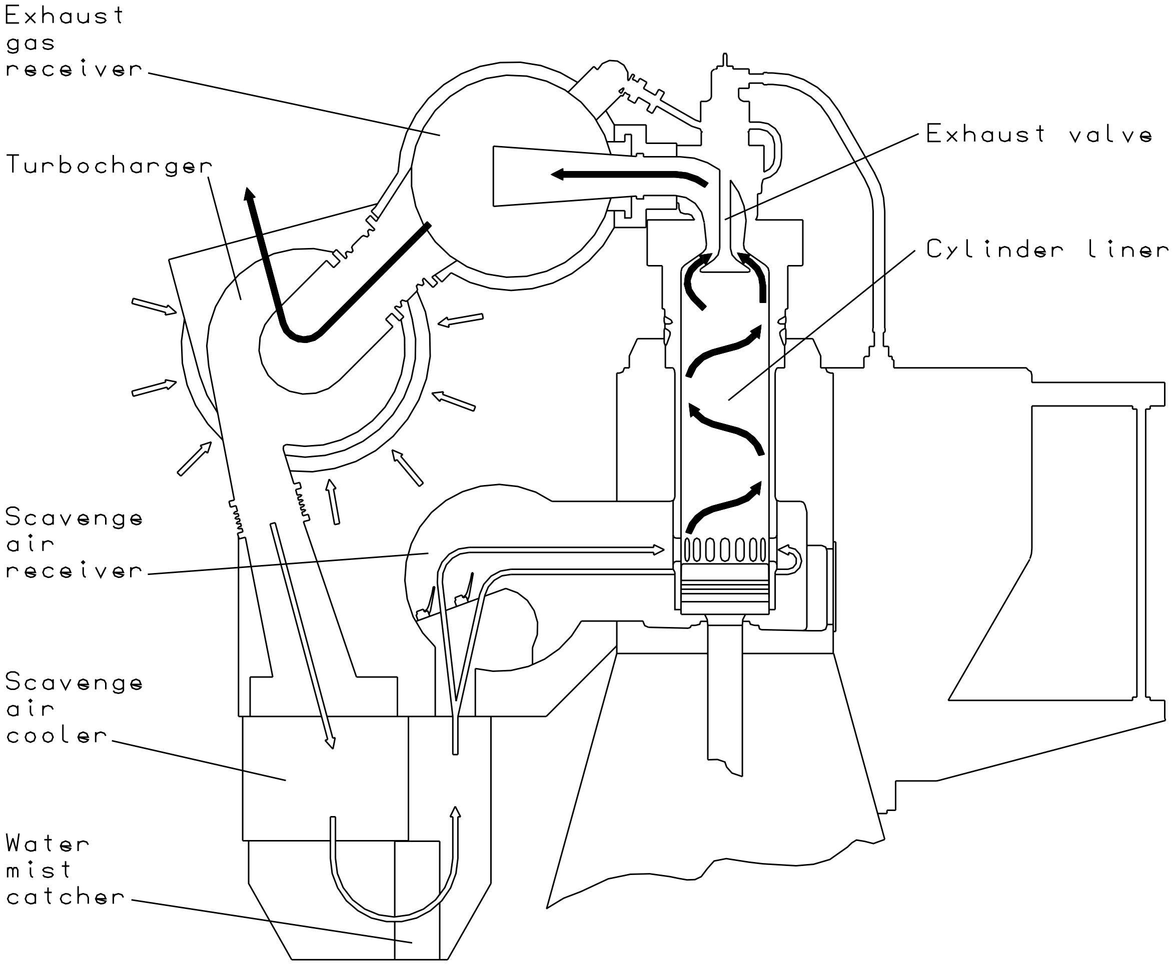


Fig. 6.09.01a: Scavenge air system running on turbocharger

178 07 27-4.1

The engine is supplied with scavenge air from one or two turbochargers located on the exhaust side, or by one turbocharger located on the aft end of the engine, option: 4 59 124.

The compressor of the turbocharger sucks air from the engine room, through an air filter, and the compressed air is cooled by the scavenge air cooler, one per turbocharger. 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. 6.09.01 and 6.09.02) is an integrated part of the main engine.

The heat dissipation and cooling water quantities are based on MCR at tropical conditions, i.e. a SW temperature of 32 °C, or a FW temperature of 36 °C, and an ambient air inlet temperature of 45 °C.

Auxiliary Blowers

The engine is provided with two electrically driven auxiliary blowers. 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.

Both 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 action, the other auxiliary blower will function in the system, without any manual readjustment of the valves being necessary. This is achieved by automatically working non-return valves.

Electrical panel for two auxiliary blowers

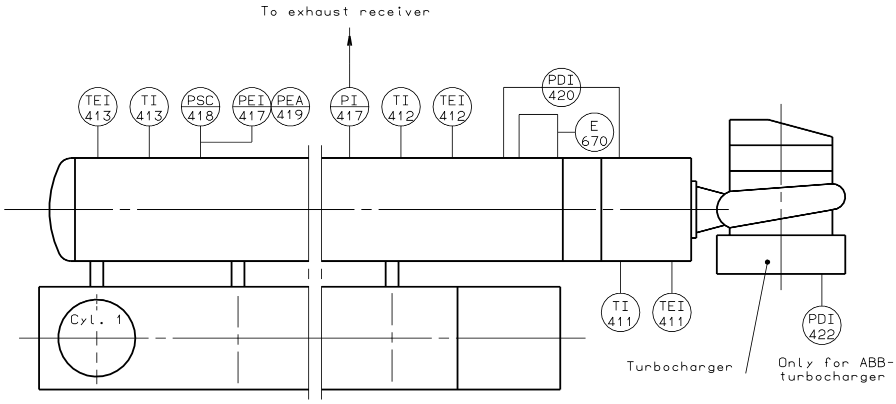
The auxiliary blowers are, as standard, fitted onto the main engine, and the control system for the auxiliary blowers can be delivered separately as an option: 4 55 650.

The layout of the control system for the auxiliary blowers is shown in Figs. 6.09.03a and 6.09.03b “Electrical panel for two auxiliary blowers”, and the data for the electric motors fitted onto the main engine is found in Fig. 6.09.04 “Electric motor for auxiliary blower”.

The data for the scavenge air cooler is specified in the description of the cooling water system chosen.

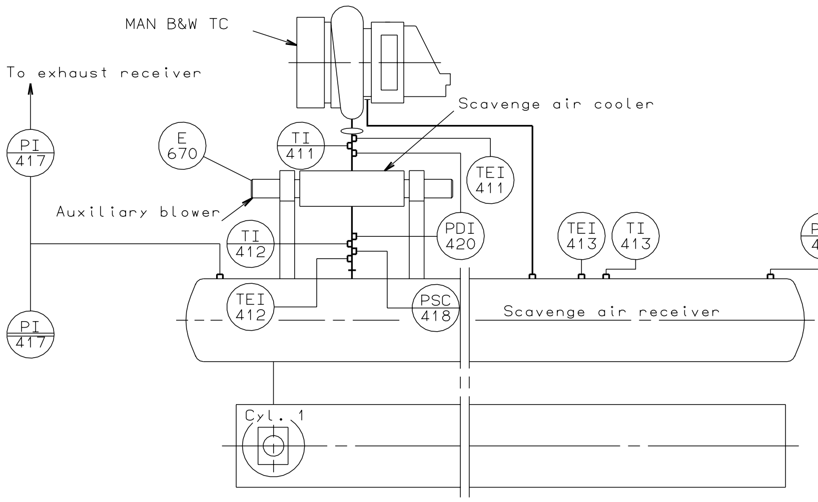
For further information please refer to our publication:

P.311 Influence of Ambient Temperature Conditions on Main Engine Operation



178 38 54-7.0

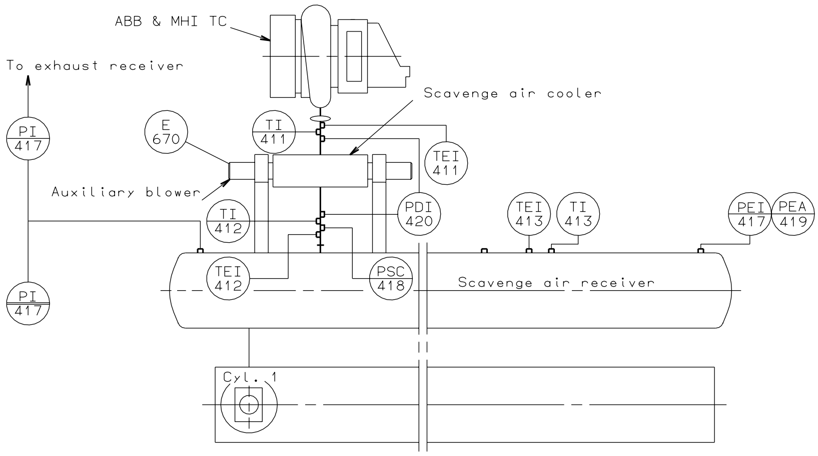
Fig. 6.09.02a: Scavenge air pipes, for engine with one turbocharger on aft end



The letters refer to “List of flanges”
The position numbers refer to “List of instruments”

178 38 55-9.0

Fig. 6.09.02b: Scavenge air pipes, for engines with one turbocharger exhaust side, make MAN B&W



The letters refer to “List of flanges”
The position numbers refer to “List of instruments”

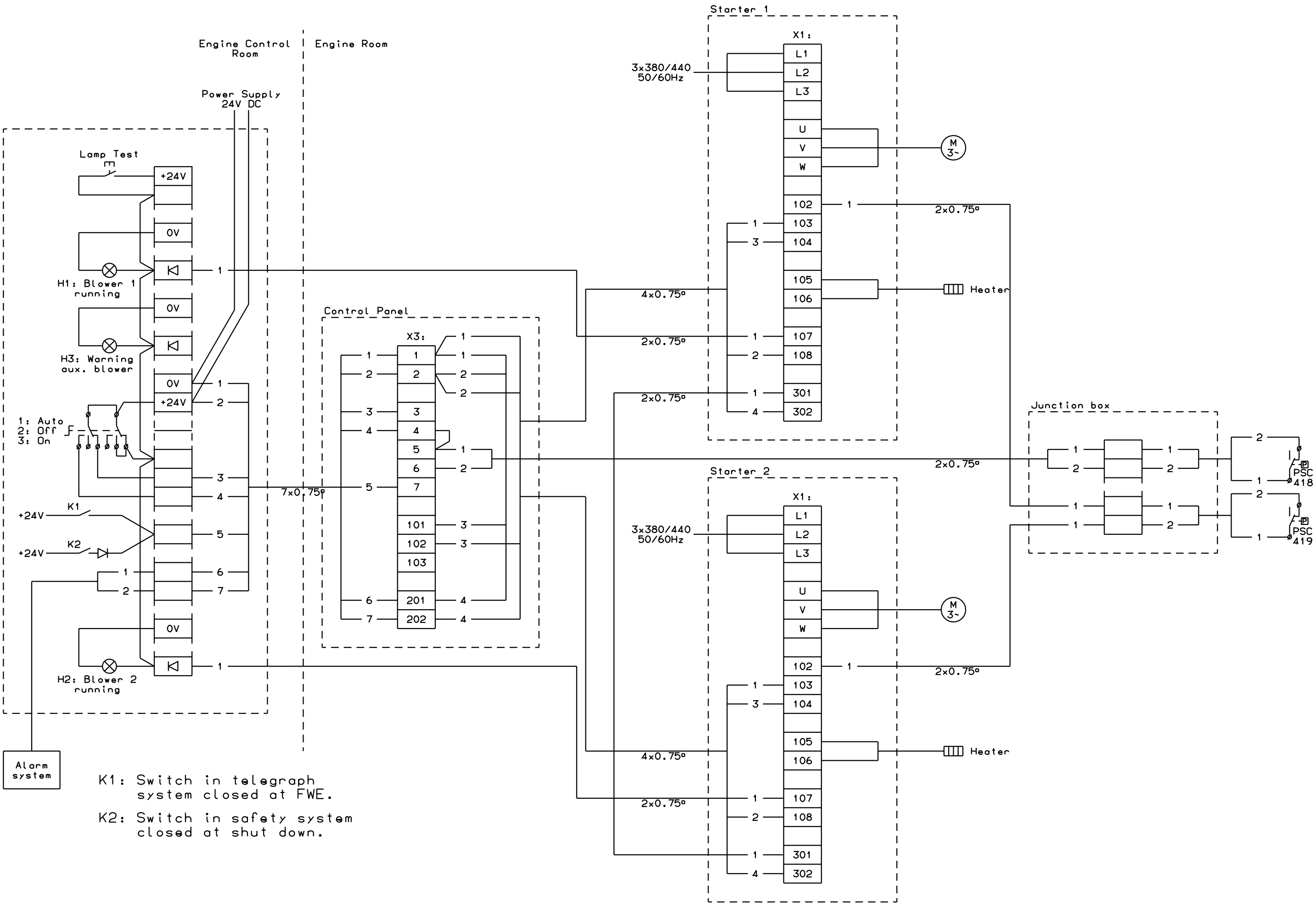
178 38 56-0.0

Fig. 6.09.02c: Scavenge air pipes, for engines with one turbocharger on exhaust side, make ABB or MHI

Electric motor size		Dimensions of control panel for two auxiliary blowers			Dimensions of electric panel			Maximum stand-by heating element
3 x 440 V 60 Hz	3 x 380 V 50 Hz	W mm	H mm	D mm	W mm	H mm	D mm	
18 - 80 A 11 - 45 kW	18 - 80 A 9 - 40 kW	300	460	150	400	600	300	100 W
63 - 250 A 67 - 155 kW	80 - 250 A 40 - 132 kW	300	460	150	600	600	350	250 W

178 31 47-8.0

Fig. 6.09.03a: Electrical panel for two auxiliary blowers including starters, option 4 55 650



PSC 418: Pressure switch for control of scavenge air auxiliary blowers. Start at 0.55 bar. Stop at 0.7 bar
PSA 419: Low scavenge air pressure switch for alarm. Upper switch point 0.56 bar. Alarm at 0.45 bar
K1: Switch in telegraph system. Closed at “finished with engine”
K2: Switch in safety system. Closed at “shut down”

178 47 77-4.0

Fig. 6.09.03b: Control panal for two auxiliary blowers inclusive starters, option: 4 55 650

Number of cylinders	Make: ABB, or similar 3 x 440V-60Hz-2p Type	Power kW	Current		Mass kg
			Start Amp.	Nominal Amp.	
4	2 x M2AA180M	2 x 26	1 x 242	2 x 42	2 x 119
5	2 x M2AA200MLA	2 x 35	1 x 369	2 x 55	2 x 175
6	2 x M2AA200MLB	2 x 43	1 x 449	2 x 68	2 x 200
7	2 x M2AA225SMB	2 x 54	1 x 559	2 x 86	2 x 235
8	2 x M2AA250SMA	2 x 65	1 x 687	2 x 101	2 x 285

Number of cylinders	Make: ABB, or similar 3 x 380V-50Hz-2p Type	Power kW	Current		Mass kg
			Start Amp.	Nominal Amp.	
4	2 x M2AA180M	2 x 23	1 x 242	2 x 43	2 x 119
5	2 x M2AA200MLB	2 x 37	1 x 442	2 x 68	2 x 200
6	2 x M2AA200SMB	2 x 47	1 x 550	2 x 86	2 x 235
7	2 x M2AA200SMB	2 x 57	1 x 667	2 x 101	2 x 285
8	2 x M2AA250SMA	2 x 75	1 x 884	2 x 134	2 x 330

Enclosure IP44
Insulation class: minimum B
Speed of fan: about 2940 and 3540 r/min for 50Hz and 60Hz respectively
The electric motors are delivered with and fitted onto the engine

178 32 53-2.2

Fig. 6.09.04: Electric motor for auxiliary blower

Air Cooler Cleaning System

The air side of the scavenge air cooler can be cleaned by injecting a grease dissolvent through “AK” (see Fig. 6.09.06) 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 onto the engine is shown in Fig. 6.09.05 “Air cooler cleaning pipes”.

Scavenge air box drain system

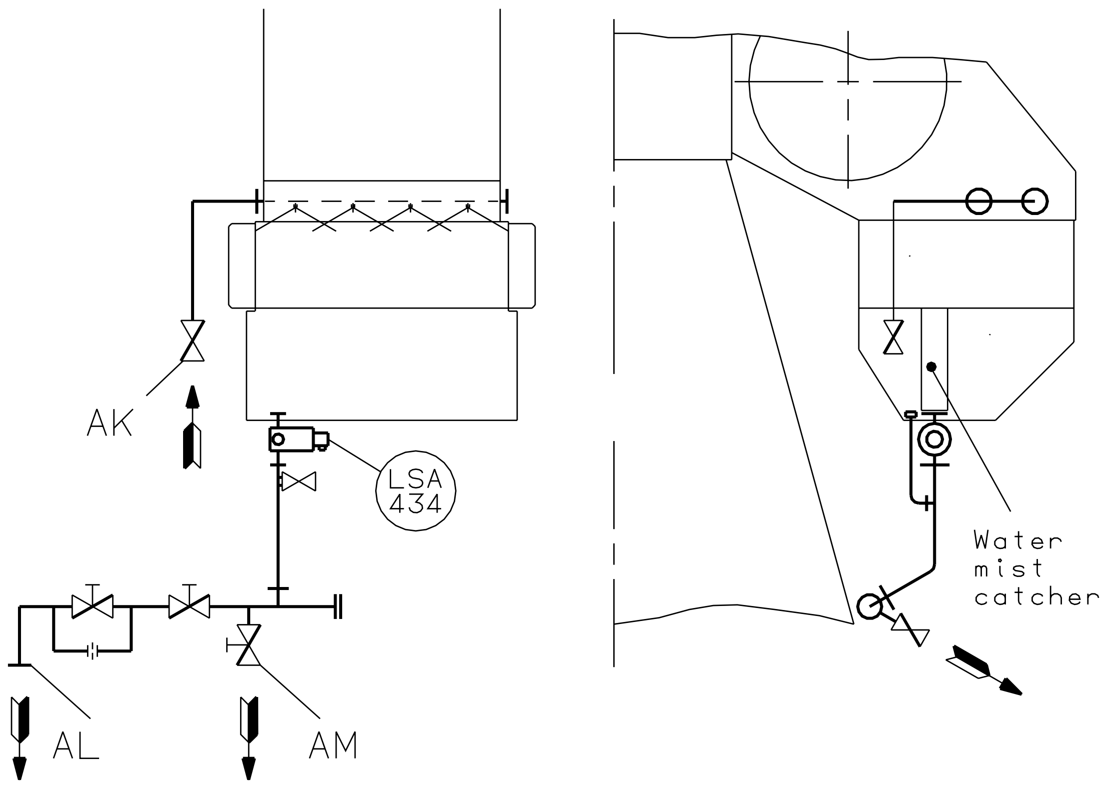
The scavenge air box is continuously drained through “AV” (see Fig. 6.09.07) to a small “pressurised drain tank”, from where the sludge is led to the sludge tank. Steam can be applied through “BV”, if required, to facilitate the draining.

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 though an orifice to prevent major losses of scavenge air. The system is equipped with a drain box, where a level switch LSA 434 is mounted, indicating any excessive water level.

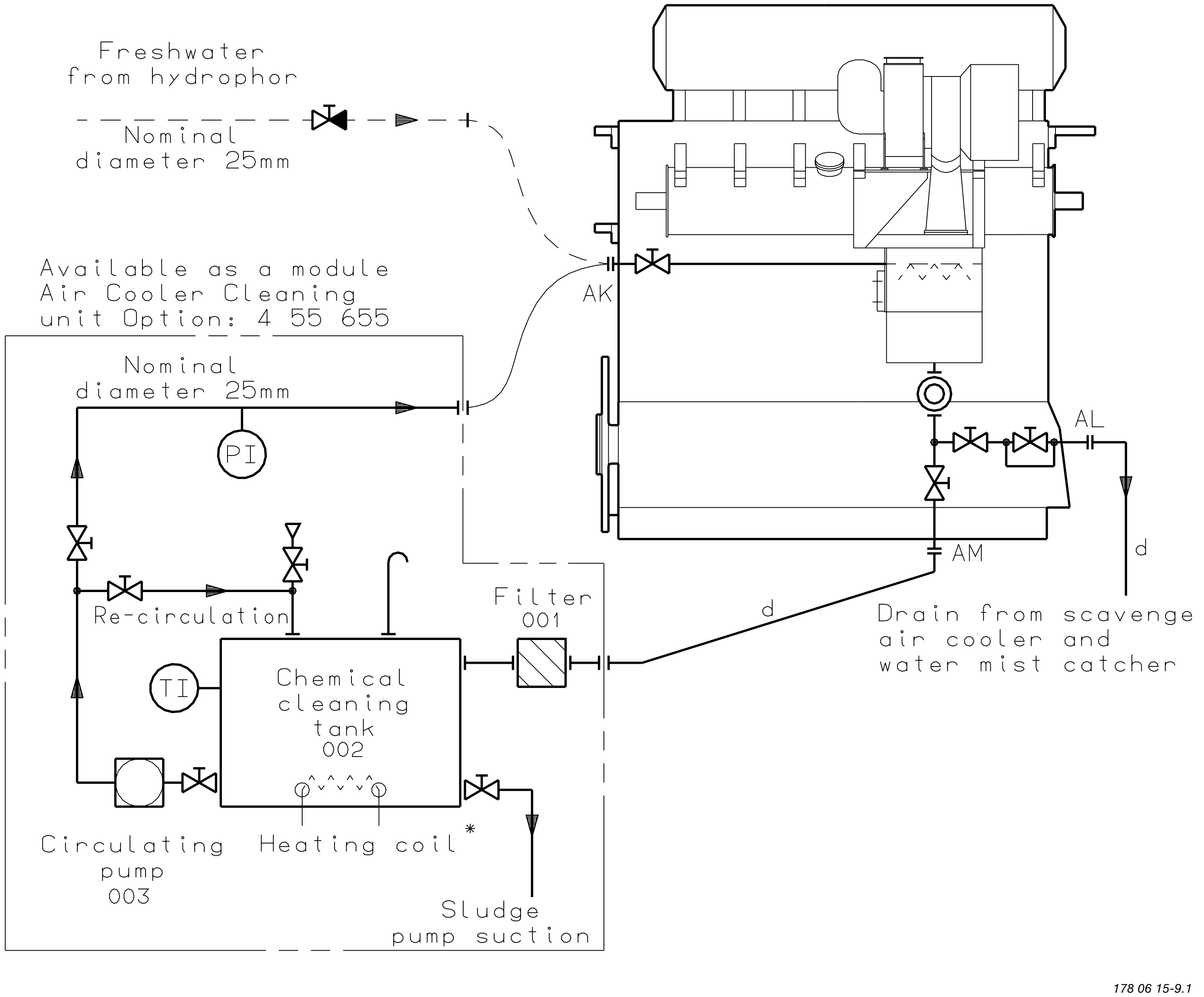
The system delivered with and fitted onto the engine is shown in Fig. 6.09.08 “Scavenge air space, drain pipes”.



The letters refer to “List of flanges”
The piping is delivered with and fitted onto the engine

178 31 45-4.0

Fig. 6.09.05: Air cooler cleaning pipes

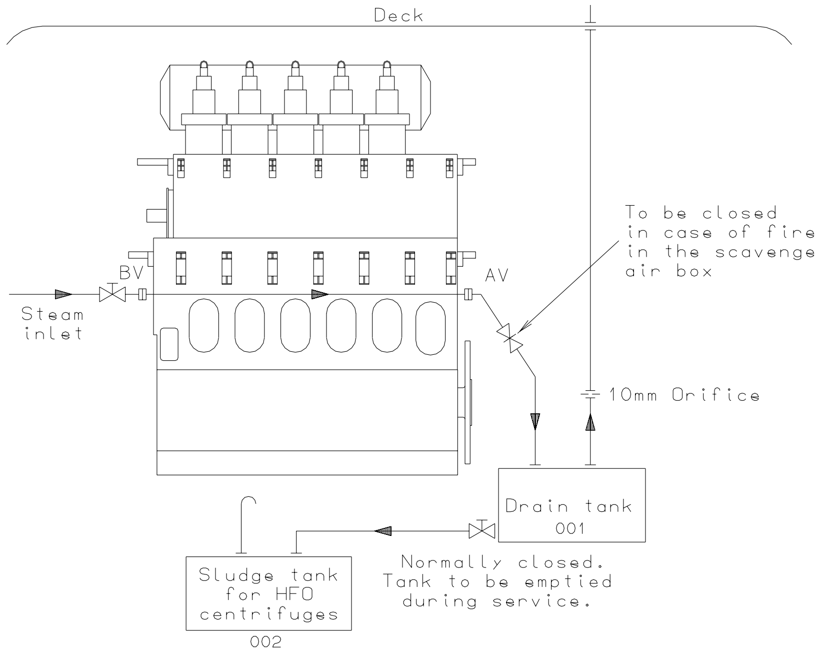


*To suit the chemical requirement

	4-5 cyl.	6-8 cyl.
Chemical tank capacity	0.3 m^3	0.6 m^3
Circulating pump capacity at 3 bar	1 m^3/h	2 m^3/h
d: Nominal diameter	25 mm	32 mm

The letters refer to “List of flanges”

Fig. 6.09.06: Air cooler cleaning system

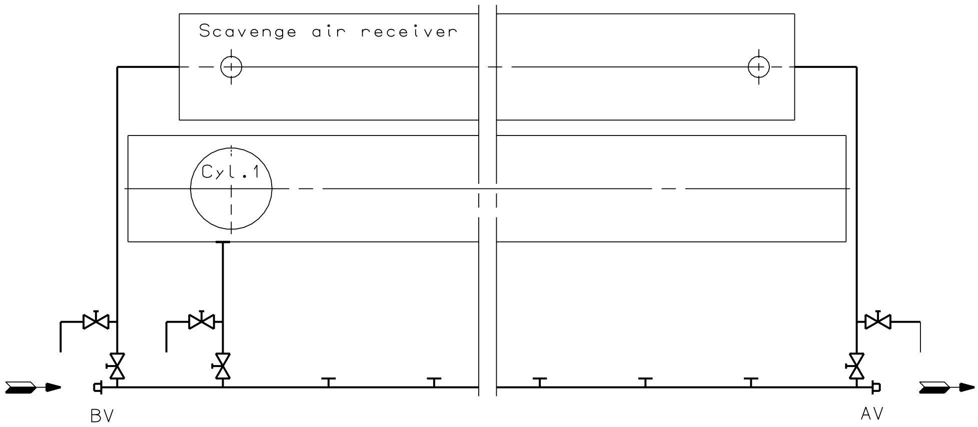


No. of cylinders	Capacity of drain tank
4-6	0.4 m^3
7-8	0.7 m^3

The letters refer to “List of flanges”

178 0616-0.0

Fig. 6.09.07: Scavenge box drain system



The letters refer to “List of flanges”
The piping is delivered with and fitted onto the engine

178 31 46-6.0

Fig. 6.09.08: Scavenge air space, drain pipes

Fire Extinguishing System for Scavenge Air Space

Fire in the scavenge air space can be extinguished by steam, being the standard version, or, optionally, by water mist or CO_2.

The alternative external systems are shown in Fig. 6.09.09:

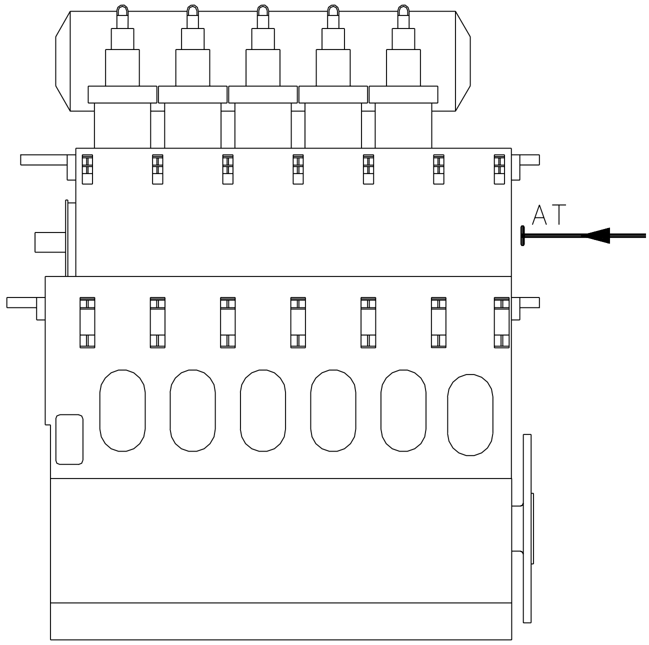
"Fire extinguishing system for scavenge air space"
standard: 4 55 140 Steam
or option: 4 55 142 Water mist
or option: 4 55 143 CO_2

The corresponding internal systems fitted on the engine are shown in Figs. 6.09.10a and 6.09.10b:

"Fire extinguishing in scavenge air space (steam)"
"Fire extinguishing in scavenge air space (water mist)"
"Fire extinguishing in scavenge air space (CO_2)"

Steam pressure: 3-10 bar
Steam approx.: 3.2 kg/cyl.

Freshwater pressure: min. 3.5 bar
Freshwater approx.: 2.6 kg/cyl.

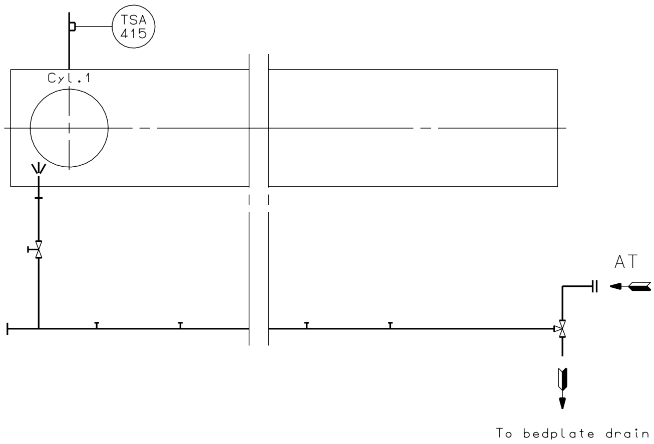


178 06 17-2.0

The letters refer to "List of flanges"

Fig. 6.09.09: Fire extinguishing system for scavenge air space

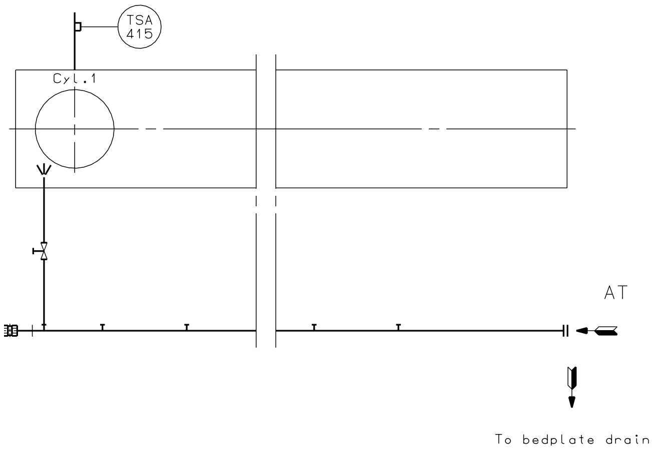
CO_2 test pressure: 150 bar
CO_2 approx.: 6.5 kg/cyl.



178 12 89-3.0

The letters refer to "List of flanges"
The piping is delivered with and fitted onto the engine

Fig. 6.09.10a: Fire extinguishing pipes in scavenge air space (steam): 4 55 140, (water mist), option: 4 55 142



178 12 90-3.0

Fig. 6.09.10b: Fire extinguishing pipes in scavenge air space (CO_2), option: 4 55 143

6.10 Exhaust Gas System

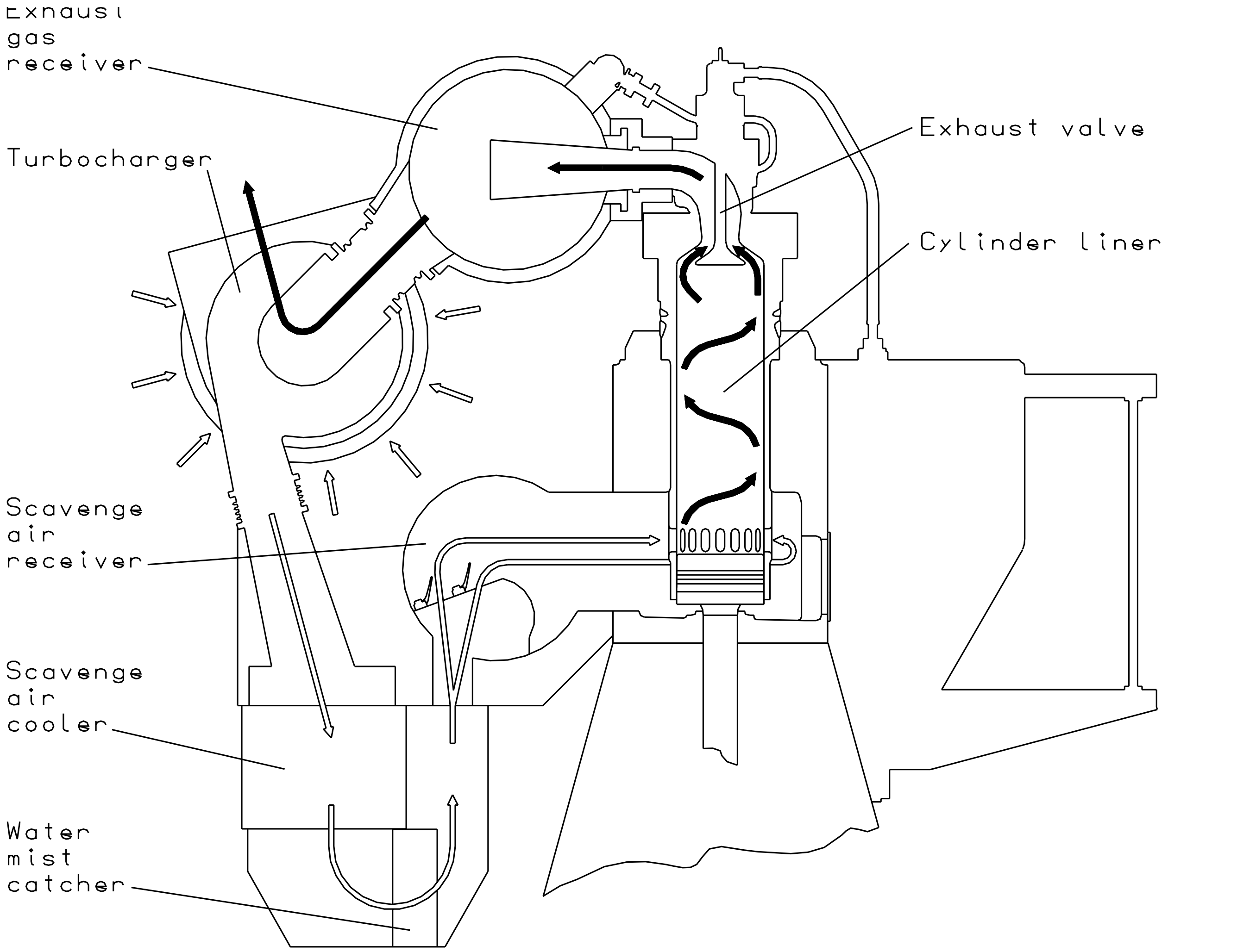


Fig. 6.10.01: Exhaust gas system on engine

Exhaust Gas System on Engine

The exhaust gas is led from the cylinders to the exhaust gas receiver where the fluctuating pres-sures from the cylinders are equalised and from where the gas is led further on to the turbocharger at a constant pressure, see Fig.6.10.01.

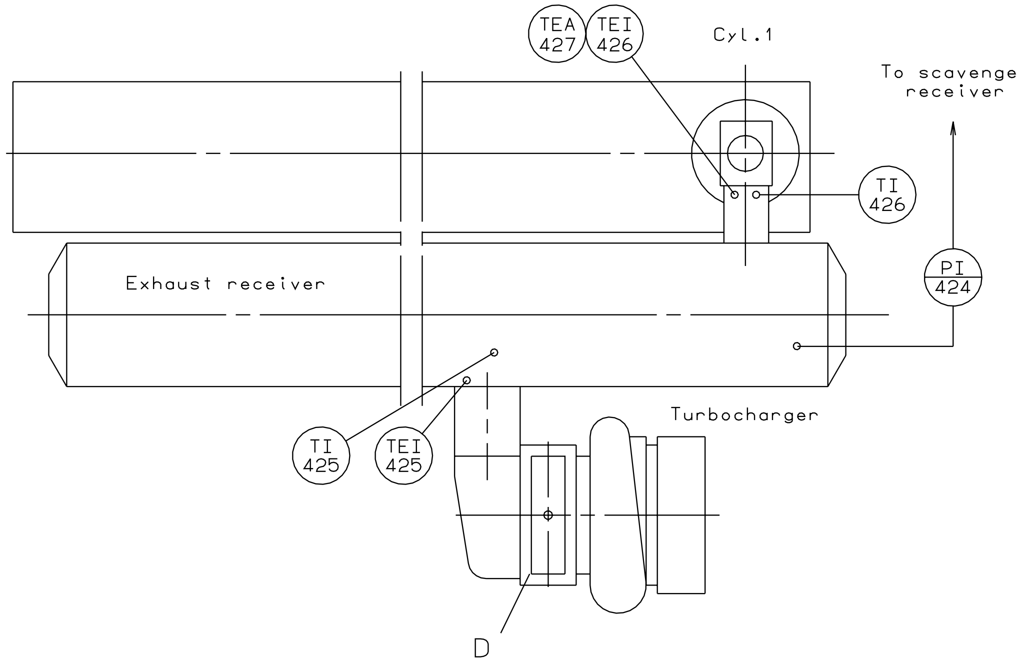
Compensators are fitted between the exhaust valves and the exhaust gas receiver and between the receiver and the turbocharger. A protective grating is placed between the exhaust gas receiver and the turbocharger. The turbocharger is fitted with a pick-up for remote indication of the turbocharger speed.

For quick assembling and disassembling of the joints between the exhaust gas receiver and the exhaust valves, clamping bands are fitted.

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

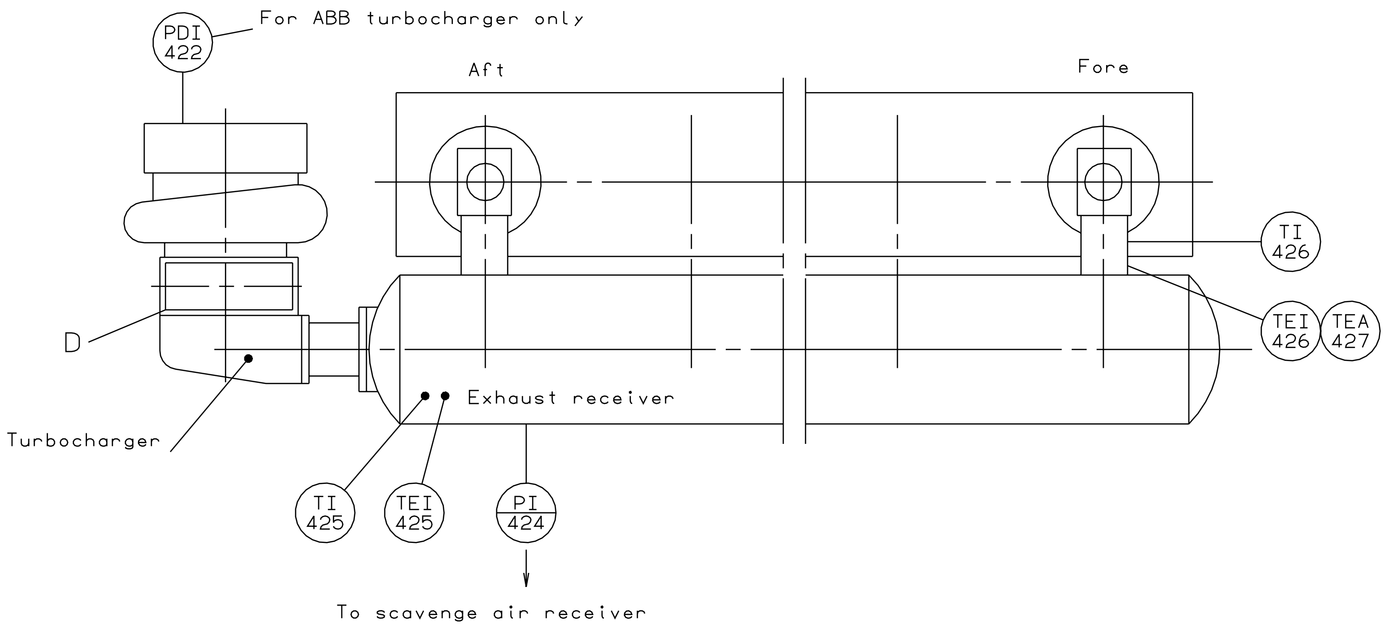
Turbocharger arrangement and cleaning systems

The turbocharger is, in the basic design (4 59 122), arranged on the exhaust side of the engine, see Fig. 6.10.02a, but can, as an option: 4 59 124, be arranged on the aft end of the engine, see Fig. 6.10.02b.



178 38 69-2.0

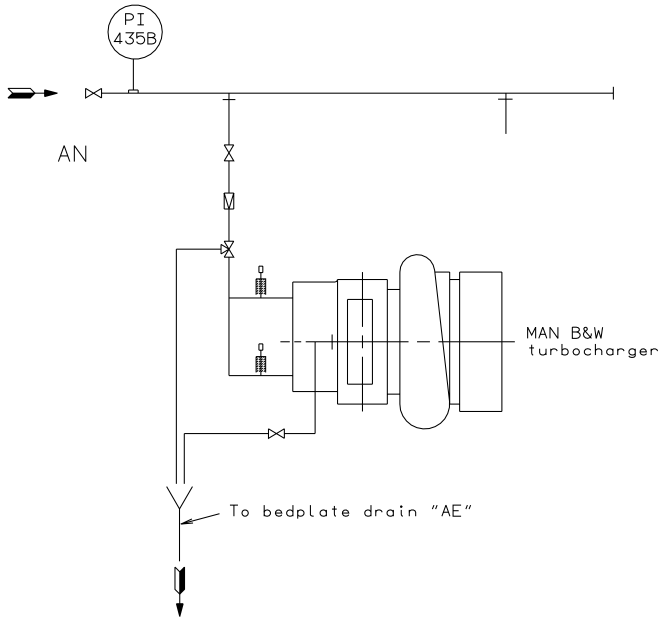
Fig. 6.10.02a: Exhaust gas pipes, with turbocharger located on exhaust side of engine (4 59 122)



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 70-2.0

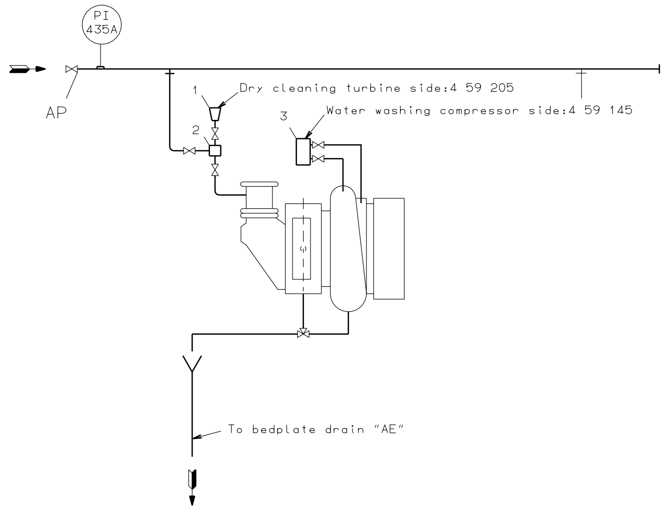
Fig. 6.10.02b: Exhaust gas pipes, with turbocharger located on aft end of engine, option 4 59 124



The letters refer to "List of flanges"
The position numbers refer to "List of instruments'

178 31 53-7.1

Fig. 6.10.03: Water washing, turbine side



178 38 71-4.0

Fig. 6.10.04: Water washing of compressor side and soft blast cleaning of turbine side

The engine is designed for the installation of either MAN B&W turbocharger type NA/TO (4 59 101), or ABB turbocharger type VTR or TPL (4 59 102), or MHI turbocharger type MET (4 59 103).

All turbocharger makes are fitted with an arrangement for water washing of the compressor side, and soft blast cleaning of the turbine side. Water washing of the turbine side is only available on MAN B&W and ABB turbochargers, see Figs. 6.10.03 and 6.10.04.

Exhaust Gas System for main engine

At specified MCR (M), the total back-pressure in the exhaust gas system after the turbocharger – 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 about 300 mm WC (0.030 bar).

For dimensioning of the external exhaust gas pipings, the recommended maximum exhaust gas velocity is 50 m/s at specified MCR (M). For dimensioning of the external exhaust pipe connections, see Fig. 6.10.07.

The actual back-pressure in the exhaust gas system at 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 dia-meter 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 of about 35 m/sec at specified MCR. This means that the pipe diameters often used may be bigger than the diameter stated in Figs. 6.10.08 and 6.10.09.

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 in Fig. 6.10.07. The general design guidelines for each component, described below, can be used for guidance purposes at the initial project stage.

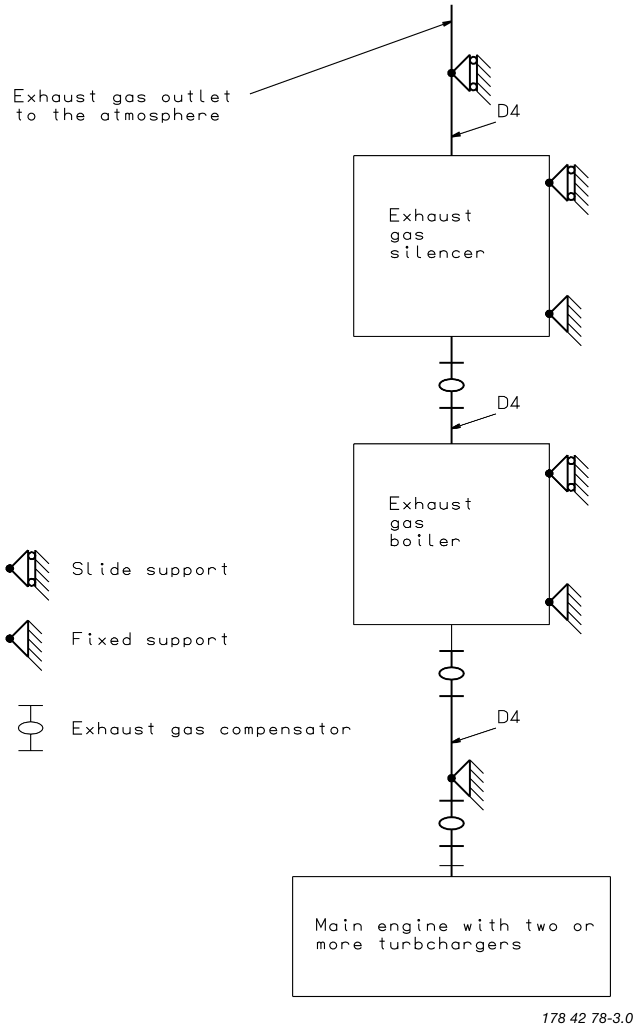


Fig. 6.10.05a: Exhaust gas system, turbocharger aft

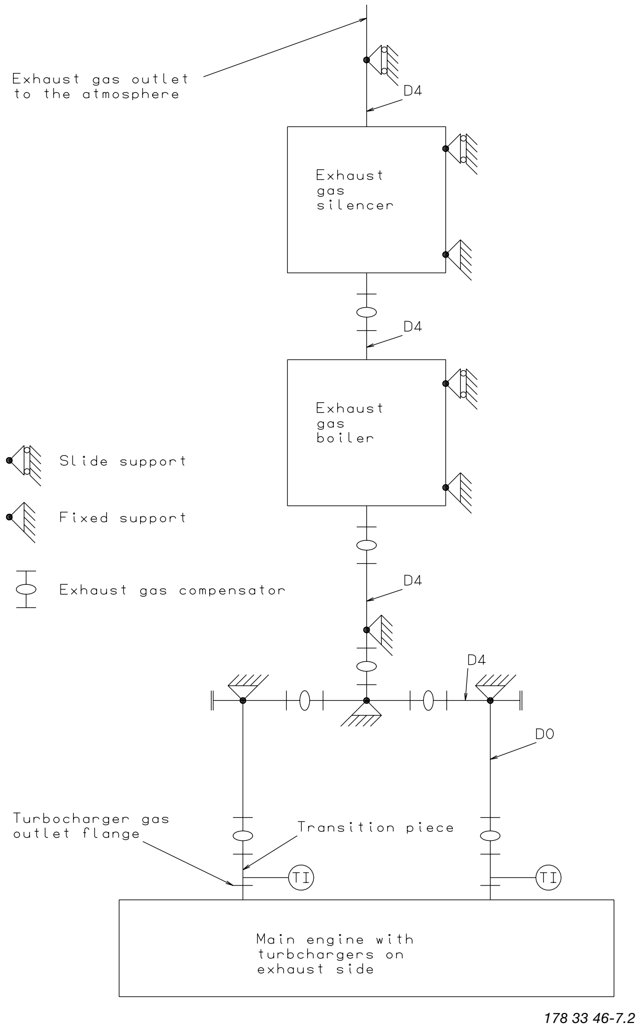


Fig. 6.10.05b: Exhaust gas system, turbocharger on exhaust side

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 on Figs. 6.10.05a and 6.10.05b.

The exhaust piping system for the main engine comprises:

- Exhaust gas pipes
- Exhaust gas boiler
- Silencer
- Spark arrester
- Expansion joints
- 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)
- 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
- Utilising the exhaust gas energy
- Attenuation of noise from the exhaust pipe outlet
- Pressure drop across the exhaust gas system
- Expansion joints.

Diameter of exhaust gas pipes

The exhaust gas pipe diameters shown on Fig. 6.10.09 for the specified MCR should be considered an initial choice only.

As previously mentioned a lower gas velocity than 50 m/s can be relevant with a view to reduce the pressure drop across pipes, bends and components in the entire exhaust piping system.

Exhaust gas compensator after turbocharger

When dimensioning the compensator, option: 4 60 610 for the expansion joint on the turbocharger gas outlet transition pipe, option: 4 60 601, the exhaust gas pipe 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 vertical and horizontal heat expansion of the engine measured at the top of the exhaust gas transition piece of the turbocharger outlet are indicated in Fig. 6.10.10 as DA and DR.

The movements stated are related to the engine seating. 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 limit the forces and the moments of the exhaust gas outlet flange of the turbocharger as stated for each of the turbocharger makers on Fig. 6.10.08 where are shown the orientation of the maximum allowable forces and moments on the gas outlet flange of the turbocharger.

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 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 silencer and/or spark arrester shall 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 – related to the distance of one metre from the top of the exhaust gas uptake – are shown in Fig. 6.10.06.

The need for an exhaust gas silencer can be decided based on the requirement of a maximum noise level at a certain place.

The exhaust gas noise data is valid for an exhaust gas system without boiler and silencer, etc.

The noise level refers to 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 requirements 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.

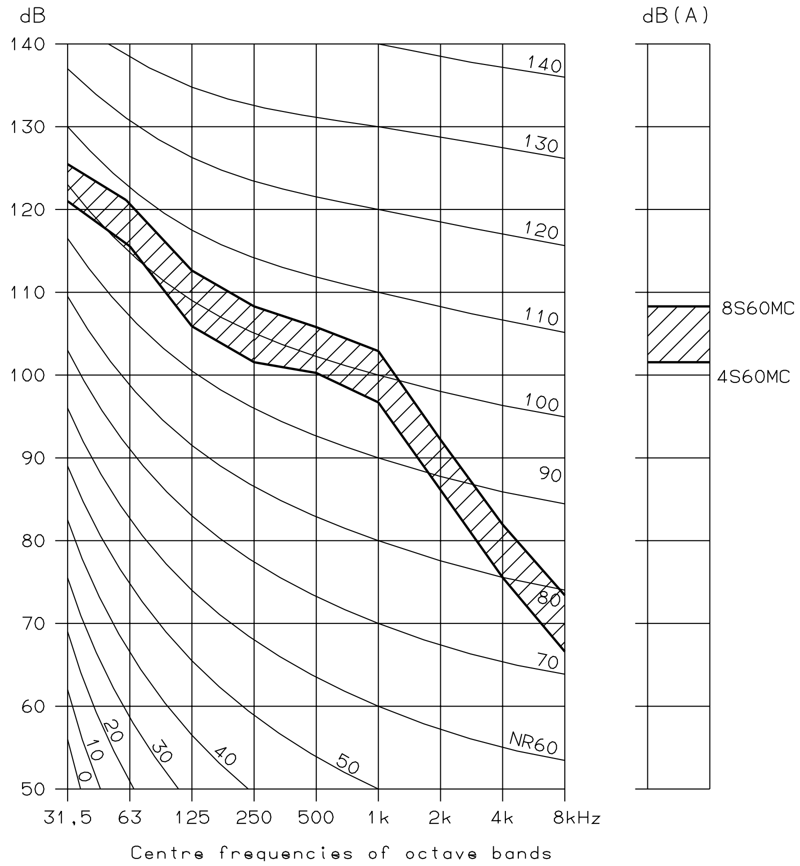


Fig. 6.10.06: ISO's NR curves and typical sound pressure levels from diesel engine's exhaust gas system
The noise levels refer to nominal MCR and a distance of 1 metre from the edge of the exhaust gas pipe opening at an angle of 30 degrees to the gas flow and valid for an exhaust gas system – without boiler and silencer, etc.

Spark arrester

To prevent sparks from the exhaust gas from 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 – depending, of course, on the pressure loss in the remaining part of the system, thus if no exhaust gas boiler is installed, 200mm WC could be possible.

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. 6.10.07 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 the early project stage.

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 Section 6.01.

Mass density of exhaust gas ( )

$$1.293 \frac{273}{273 + T} \times 1.015 \text{ in kg/m}^3$$

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:

$$v = \frac{M}{\ } \times \frac{4}{\ \times D^2} \text{ in m/sec}$$

Pressure losses in pipes (p)

For a pipe element, like a bend etc., with the resistance coefficient , the corresponding pressure loss is:

$$p \quad \times \tfrac{1}{2} \quad v^2 \times \frac{1}{9.81} \text{ in mm WC}$$

where the expression after 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 1 x diameter length

whereas the positive influence of the up-draught in the vertical pipe is normally negligible.

Pressure losses across components (p)

The pressure loss p across silencer, exhaust gas boiler, spark arrester, rain water trap, etc., to be measured/ stated as shown in Fig. 6.11.07 (at specified MCR) is normally given by the relevant manufacturer.

Total back-pressure (pm)

The total back-pressure, measured/stated as the static pressure in the pipe after the turbocharger, is then:

pM = p

where p incorporates all pipe elements and components etc. as described:

pM 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 of Back Pressure

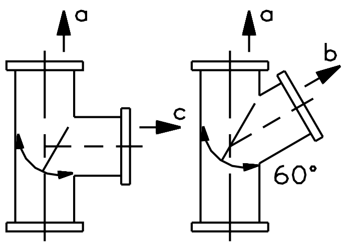
At any given position in the exhaust gas system, the total pressure of the flow can be divided into dynamic pressure (referring to the gas velocity) and static pressure (referring to the wall pressure, where the gas velocity is zero).

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. The taking of measurements, for example, in a transition piece, may lead to an unreliable measurement of the static pressure.

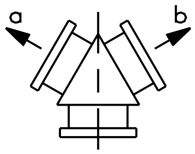
In consideration of the above, therefore, the total back pressure of the system has to be measured after the turbocharger in the circular pipe and not in the transition piece. The same considerations apply to the measuring points before and after the exhaust gas boiler, etc.

Change-over valves



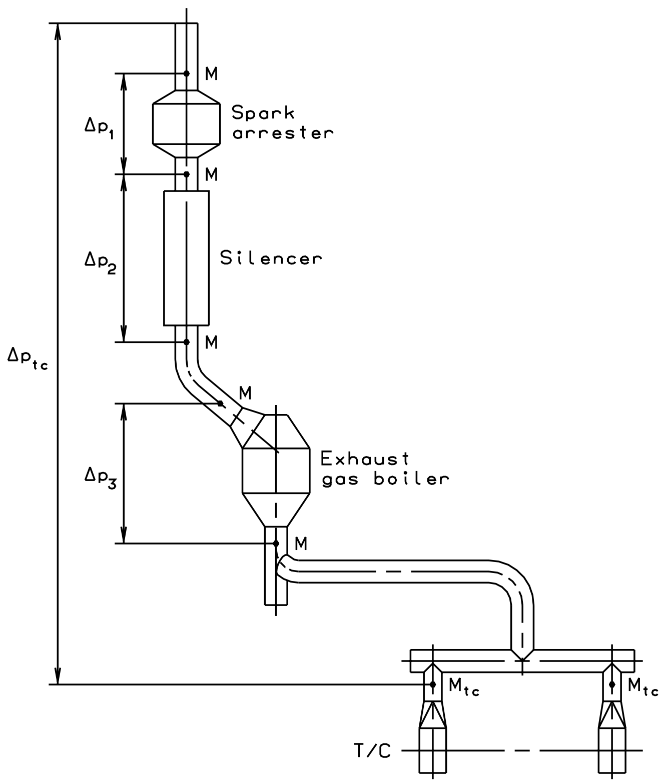
Change-over valve of type with constant cross section

a = 0.6 to 1.2
b = 1.0 to 1.5
c = 1.5 to 2.0



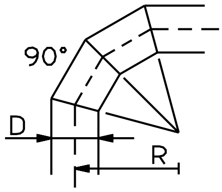
Change-over valve of type with volume

a = b = about 2.0

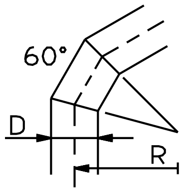


178 32 09-1.0

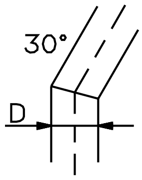
Pipe bends etc.



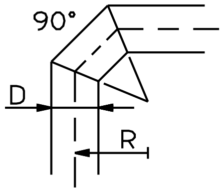
R = D = 0.28
R = 1.5D = 0.20
R = 2D = 0.17



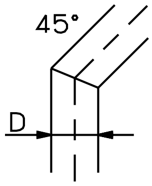
R = D = 0.16
R = 1.5D = 0.12
R = 2D = 0.11



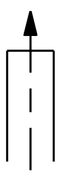
= 0.05



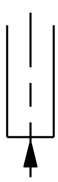
R = D = 0.45
R = 1.5D = 0.35
R = 2D = 0.30



= 0.14



Outlet from top of exhaust gas uptake = 1.00



Inlet (from turbocharger) = – 1.00

178 06 85-3.0

Fig. 6.10.07: Pressure losses and coefficients of resistance in exhaust pipes

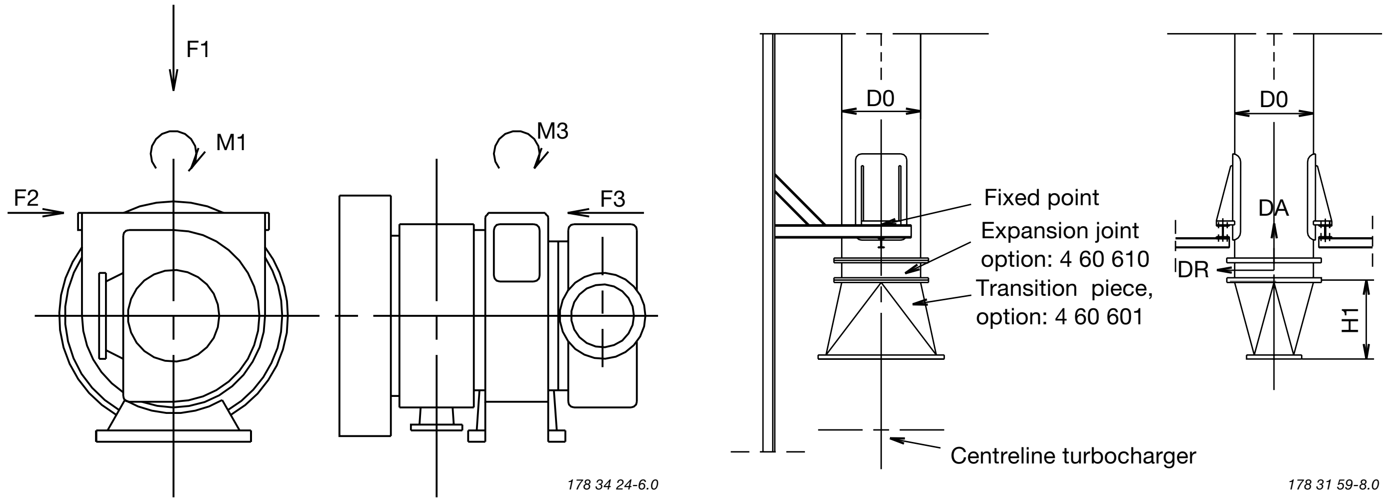


Fig 6.10.08a: Exhaust pipe system, with turbocharger located on aft end of engine, option: 4 59 124

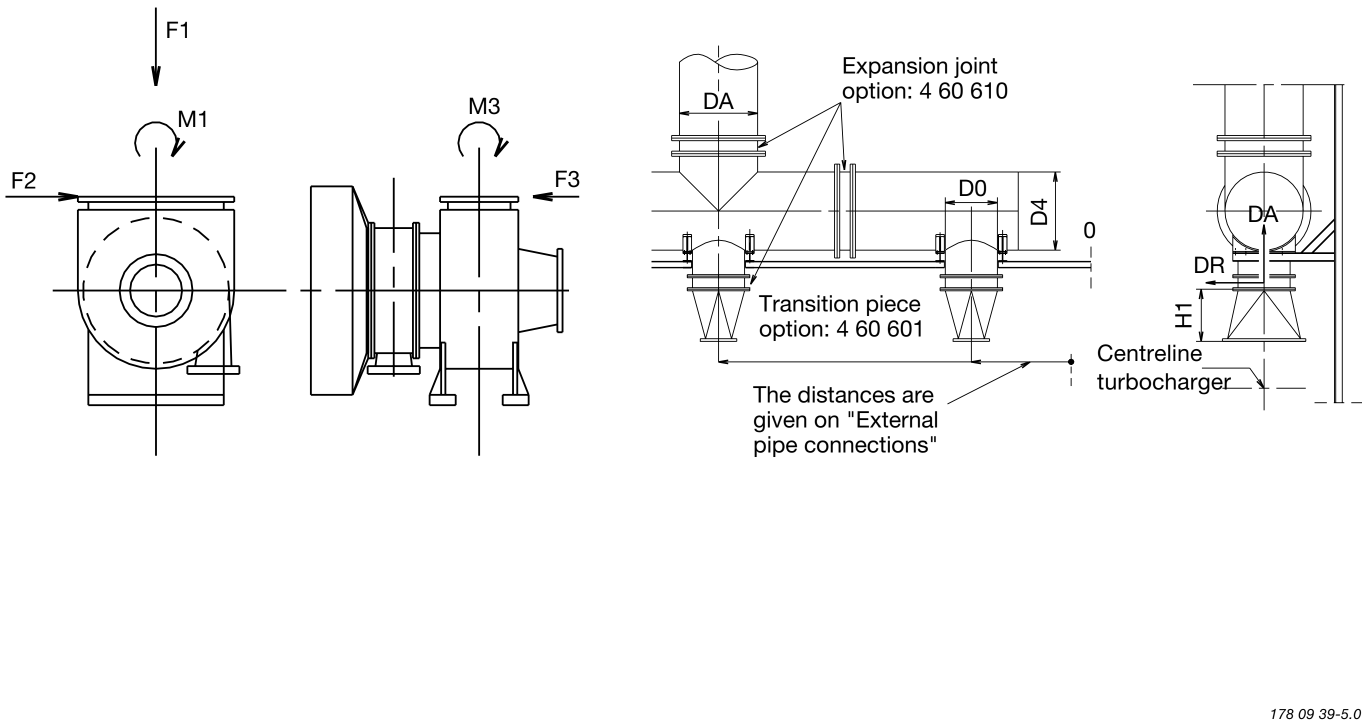


Fig 6.10.08b: Exhaust pipe system, with turbocharger located on exhaust side of engine (4 59 122)

Turbocharger located on exhaust side of engine

Engine specified MCR in kW	Exhaust pipe dia. D0 and H1 in mm			D4 in mm
	1 TC	2 TC		
4000	650	-	-	650
4500	650	-	-	650
5000	700	500	-	700
5500	750	550	-	750
6000	750	550	-	750
6500	800	550	-	800
7000	850	600	-	850
7500	850	600	-	850
8000	900	650	-	900
8500	900	650	-	900
9000	950	650	-	950
9500	950	700	-	950
10000	1000	700	-	1000
11000	1050	750	-	1050
12000	1100	750	-	1100
13000	1100	800	-	1100
14000	1150	850	700	1400
15000	1200	850	700	1400
16000	1250	900	750	1500
17000	1300	900	750	1550

Turbocharger located on aft end

Engine specified MCR in kW	Exhaust pipe dia. D0 and H1 in mm	
4000	650	-
4500	650	-
5000	700	-
5500	750	-
6000	750	-
6500	800	-
7000	850	-
7500	850	-
8000	900	-
8500	900	-
9000	950	-
9500	950	-
10000	1000	-
11000	1050	-
12000	1100	-
13000	1100	-
14000	1150	1400
15000	1200	1450
16000	1250	1500
17000	1300	1500

Fig. 6.10.10: Movement at expansion joint based on the thermal expansion of the engine from ambient temperature to service

Cylinder No.	4	5	6	7	8
DA* mm	7.8	8.6	8.7	9.0	7.8
DR** mm	2.4	2.9	2.9	2.9	2.8

Cylinder No.	4	5	6	7	8
DA* mm	8.5	9.5	9.6	9.9	10.6
DR** mm	2.7	3.2	3.6	3.9	4.4

* DA = axial movement at compensator

** DR = lateral movement at compensator

Fig. 6.10.09: Minimum diameter of exhaust pipe for a standard installation based on an exhaust gas velocity of 50 m/s

MAN B&W	NA40	NA48	NA57	NA70
M1 Nm	3000	3600	4300	5300
M3 Nm	2000	2400	3000	3500
F1 N	5000	6000	7000	8800
F2 N	5000	6000	7000	8800
F3 N	2000	2400	3000	3500

ABB	VTR454	VTR564	VTR714	TPL73	TPL77	TPL80	TPL85
M1 Nm	3500	5000	7200	2200	3200	4400	7100
M3 Nm	2300	3300	4700	1100	1600	2000	3100
F1 N	5500	6700	8000	1000	1200	1300	1600
F2 N	2700	3800	5400	2200	2600	3000	3700
F3 N	1900	2800	4000	1500	1800	2000	2500

MHI	MET42SE	MET53SE	MET66SE	MET83SE
M1 Nm	3400	4900	6800	9800
M3 Nm	1700	2500	3400	4900
F1 N	5800	7300	9300	11700
F2 N	2000	2600	3200	4100
F3 N	1800	2300	3000	3700

Fig. 6.10.11: Maximum forces and moments permissible at the turbocharger's gas outlet flanges

6.11 Manoeuvring System

Manoeuvring System on Engine

The basic diagram is applicable for reversible engines, i.e. those with fixed pitch propeller (FPP).

The engine is, as standard, provided with a pneumatic/electronic manoeuvring system, see diagram Fig. 6.11.01, whcih also shows the options.

The lever on the “Engine side manoeuvring console” can be set to either **Manual** or **Remote** position.

In the **‘Manual’** position the engine is controled from the Engine Side Manoeuvring console by the push buttons START, STOP, and the AHEAD/ASTERN. The load is controlled by the “Manual speed setting” handwheel, Figs. 6.11.01 and 6.11.05.

In the **‘Remote’** position all signals to the engine are electronic, the START, STOP, AHEAD and ASTERN signals activate the solenoid valves EV684, EV682, EV683 and EV685 respectively Figs. 6.11.01, 6.11.02 and 6.11.06, and the speed setting signal via the electronic governor and the actuator E672.

The electrical signal comes from the remote control system, i.e. the Bridge Control (BC) console, or from the Engine Control Room (ECR) console, if any.

The engine side manoeuvring console is shown on Fig. 6.11.05.

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 EV658.

Options

Some of the options are indicated in Fig. 6.11.01 by means of item numbers that refer to the “Extent of Delivery” forms.

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 Figs. 6.11.01, 6.11.02 and 6.11.03, option 4 50 140.

The slow turning valve allows the starting air to partially by pass 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.

Governor

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.

"Conventional" plants

A typical example of a "conventional" marine installation is:

- An engine directly coupled to a fixed pitch propeller
- An engine directly coupled to a controllable pitch propeller, without clutch and without extreme demands on the propeller pitch change
- Plants with controllable pitch propeller with a shaft generator of less than 15% of the engine's MCR output.

With a view to such an installations, the engine is, as standard, equipped with a "conventional" electronic governor approved by MAN B&W, e.g.:

4 65 172	Lyngsø Marine A/S electronic governor system, type EGS 2000 or EGS 2100
4 65 174	Kongsberg Norcontrol Automation A/S digital governor system, type DGS 8800e
4 65 175	NABCO Ltd. electronic governor, type MG-800
4 65 177	Siemens digital governor system, type SIMOS SPC 33.

"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.

Fixed Pitch Propeller (FPP)

Plants equipped with a fixed pitch propeller require no modifications to the basic diagram – the components for the reversible engine (4 30 101), shown in Fig. 6.11.01, are applied.

Controllable Pitch Propeller (CPP)

For plants with CPP, two alternatives are available:

- **Non-reversible engine**
  Option: 4 30 104:
  If a controllable pitch propeller is coupled to the engine, a manoeuvring system according to Fig. 6.11.02 is to be used. The electric manoeuvring system permits the engine to start only when the propeller pitch is zero. The fuel pump roller guides are provided with non-displaceable rollers

- **Engine with emergency reversing**
  Option 4 30 109:
  The fuel pump roller guides are of the reversible type and are supplied with permanent air pressure for **Ahead** position during the start procedure

  Emergency reversing from the manoeuvring console is effected with a separate handle, as the manoeuvring handle has no reversing switches.

Engine Side Manoeuvring Console

The layout of the engine side mounted manoeuvring console includes the components indicated in the manoeuvring diagram, shown in Fig. 6.11.05. The console is located on the camshaft side of the engine.

Control System for Plants with CPP

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 opera-tion 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.

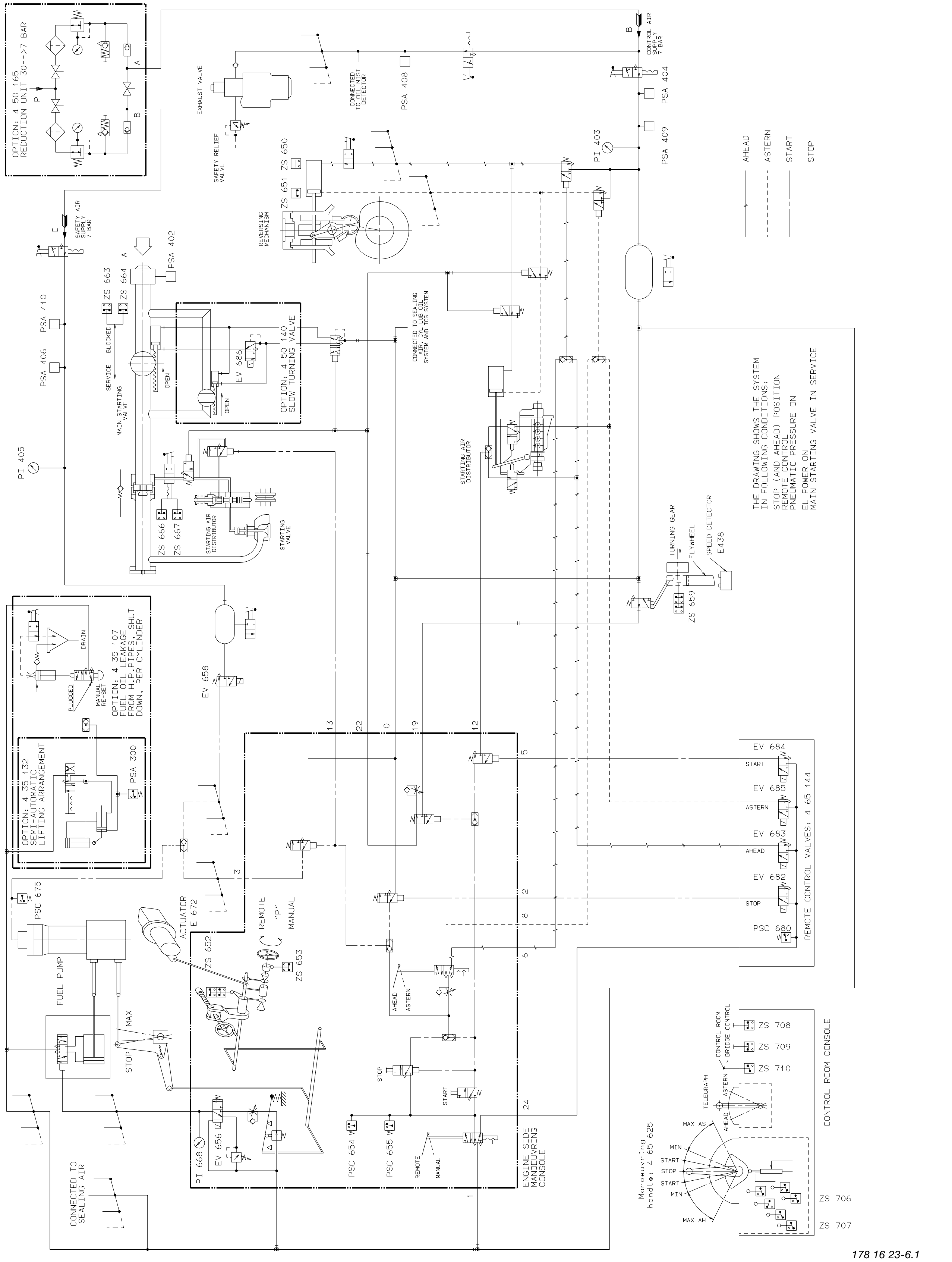
Sequence Diagram for Plants with Bridge Control

MAN B&W Diesel's requirements to the remote control system makers are indicated graphically in Fig. 6.11.08 "Sequence diagram" for fixed pitch propeller.

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.

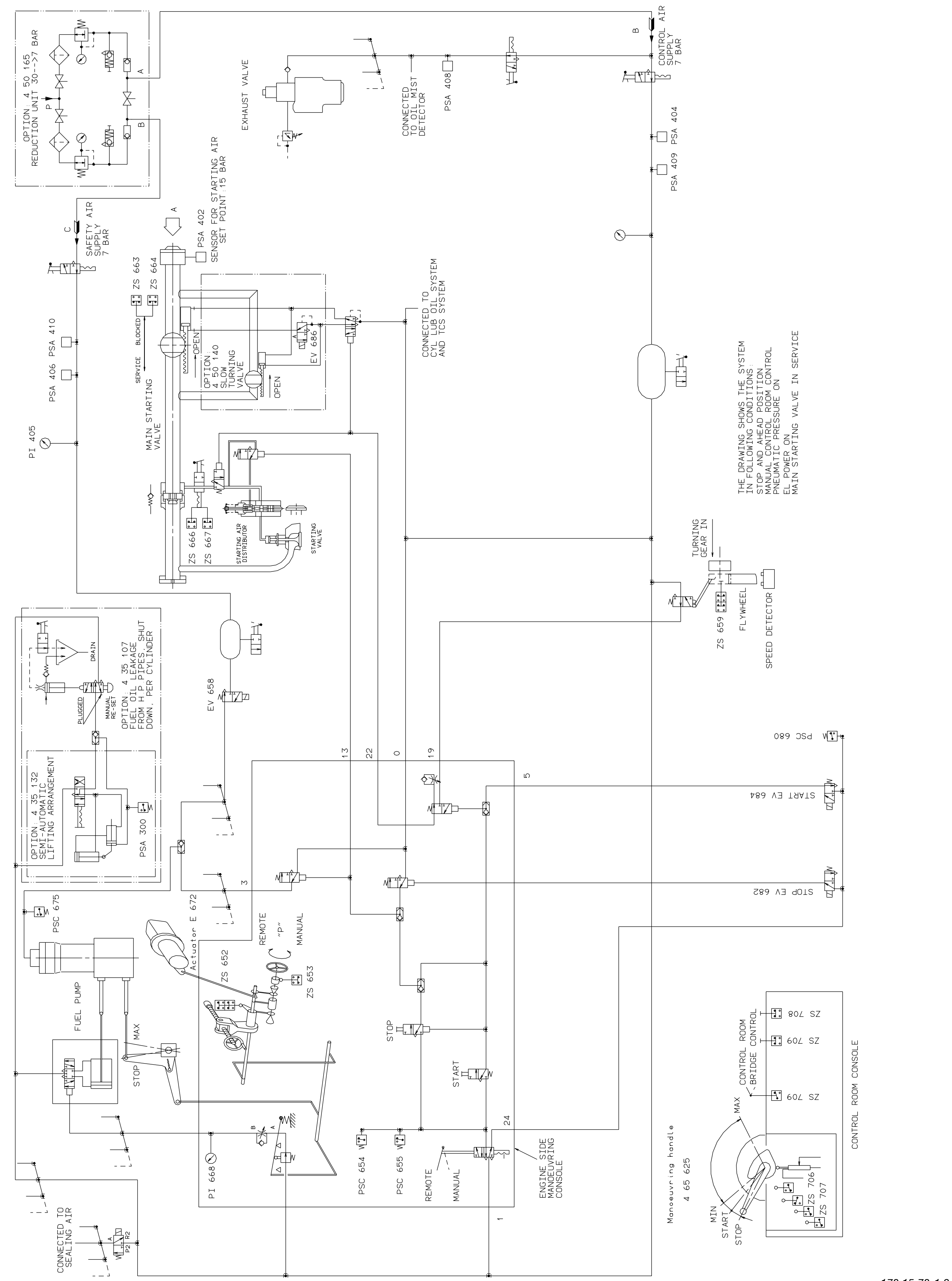
On the right of the diagram, a situation is shown where the order Astern is over-ridden by an Ahead order – the engine immediately starts Ahead if the engine speed is above the spicified starting level.

The corresponding sequence diagram for a non-reversible plant with power take-off (Gear Constant Ratio) is shown in Fig. 6.11.09.



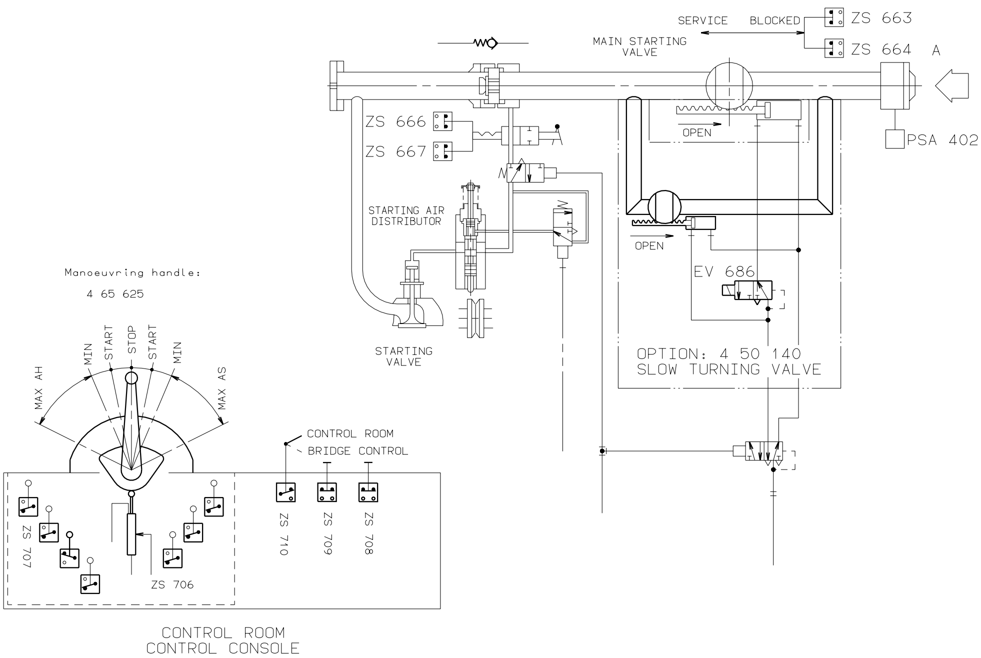
178 16 23-6.1

Fig. 6.11.01: Diagram of manoeuvring system for reversible engine with FPP, with bridge control



178 15 78-1.2

Fig. 6.11.02: Diagram of manoeuvring system for non-reversible engine with bridge control

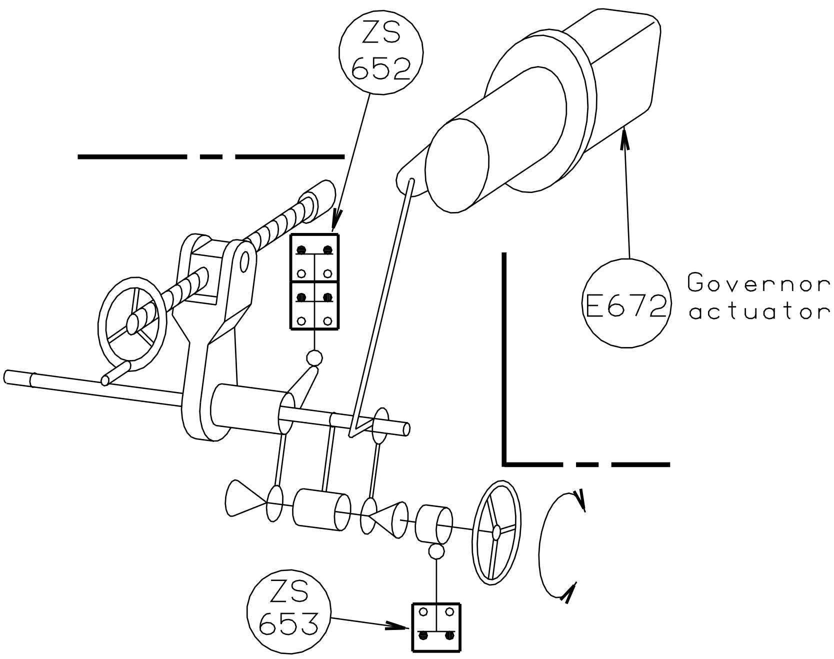


178 16 24-8.0

Pos.	Qty.	Description
EV686	1	3/4-way solenoid valve
ZS708	1	Switch, yard's supply

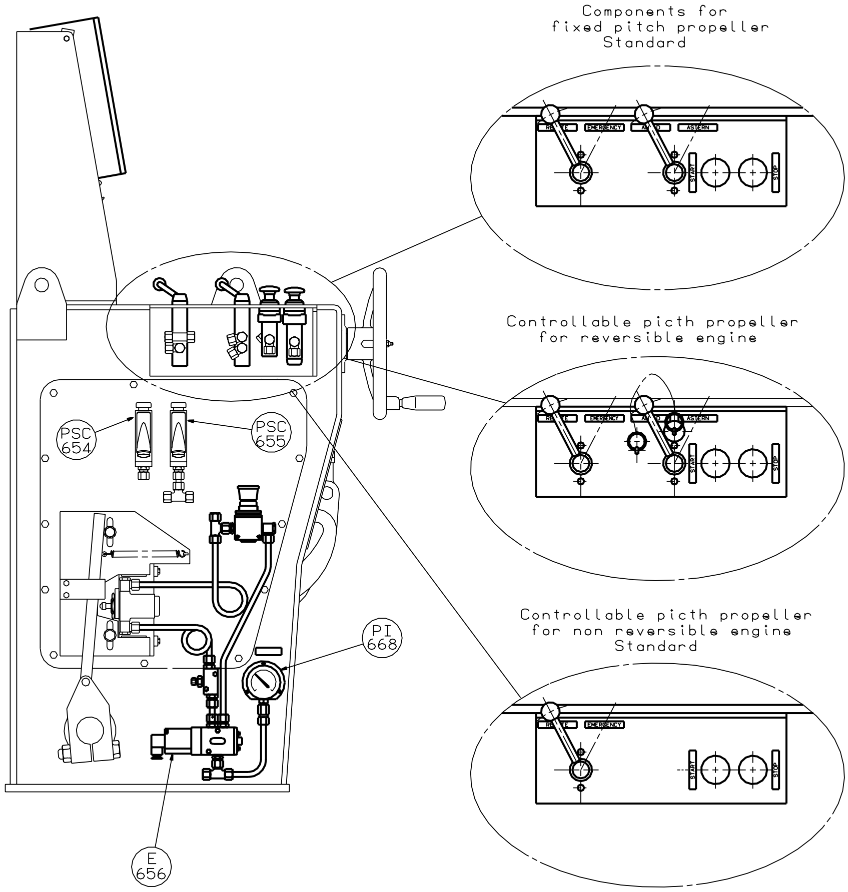
Additional components for slow turning are the slow turning valve in by-pass and items 28 and 78
The pos. numbers refer to "List of instruments"
The piping is delivered with and fitted onto the engine
The letters refer to "List of flanges"

Fig. 6.11.04: Starting air system, with slow turning, option: 4 50 140



178 30 42-3.0

Fig. 6.11.04: Actuator Lyngsø Marine electronic governor, EGS 2000 or EGS 2100: 4 65 172 or for Kongsberg Norcontrol Automation electronic governor DGS 8800e: 4 65 174



Components included for:

Fixed pitch propeller	Controllable pitch propeller, reversible engine	Controllable pithc propeller, non-reversibel engine	
x	x	x	Remote control – emergency control handle
x	x		Ahead – Astern handle
x	x	x	Start button
x	x	x	Stop button

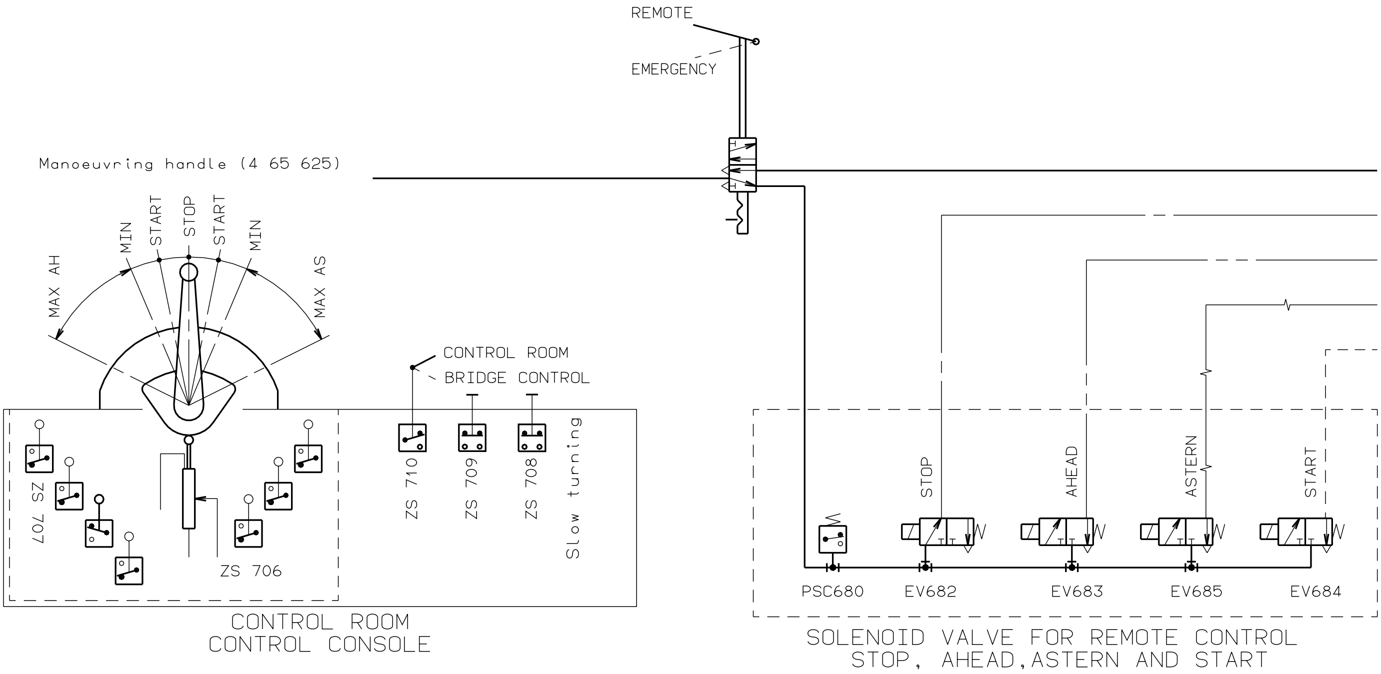
The pos. numbers refer to "List of instruments"
Is delivered with and fitted onto the engine

The instrument panel includes:

For reversible engine	For non-reversible engine	
x	x	Tachometer for engine
x	x	Indication for engine side control
x	x	Indication for control room control (remote)
x	x	Indication for bridge control (remote)
x		Indication for "Ahead"
x		Indication for "Astern"
x		Indication for auxiliary blower running
x		Indication and buzzer for wrong way alarm
x	x	Indication for turning gear engaged
x	x	Indication for "Shut down"
x	x	Push button for cancelling "Shut down", with indication
x	x	Push button for"emergency stop", with indication
x	x	Push button for lamp test

178 69 57-5.1

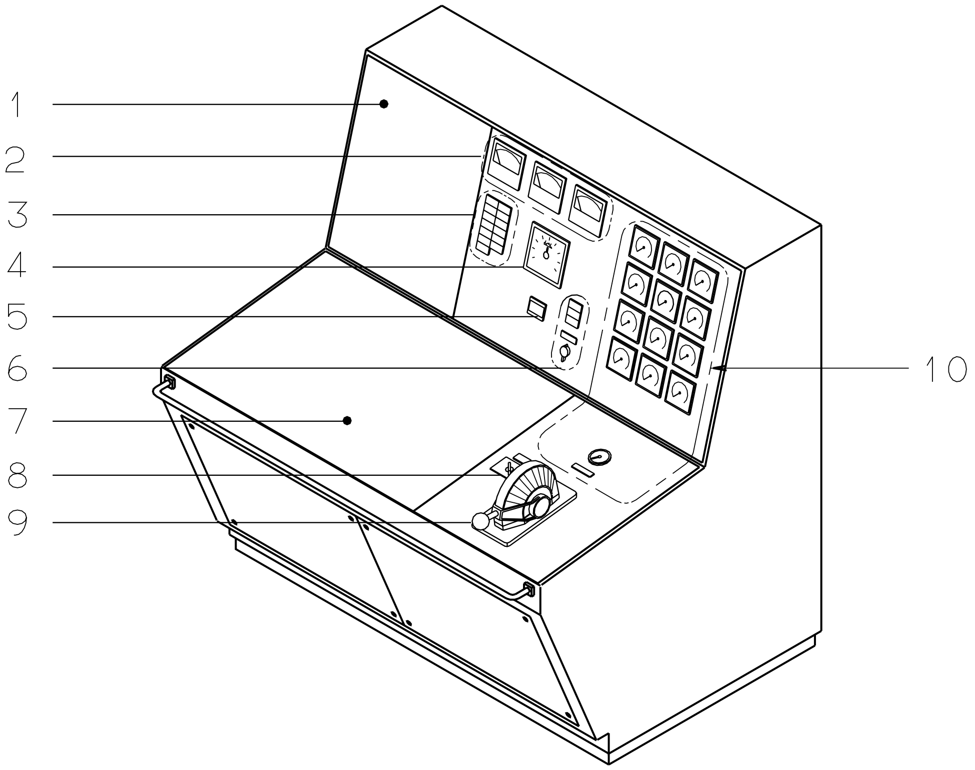
Fig. 6.11.05: Engine side manoeuvring console, and instrument panel



Item 4 65 625 is included in the basic scope of supply

178 16 26-1.0

Fig. 6.11.06: Diagram of engine side control 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 contro
    Wrong way alarm
    Turning gear engaged
    Main starting valve in service
    Main starting valve in blocked
    Remote control
    Emergency stop
    (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 equiment for main engine

8 Switch and lamp for cancelling of limiters for governor
9 Engine control handle: 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

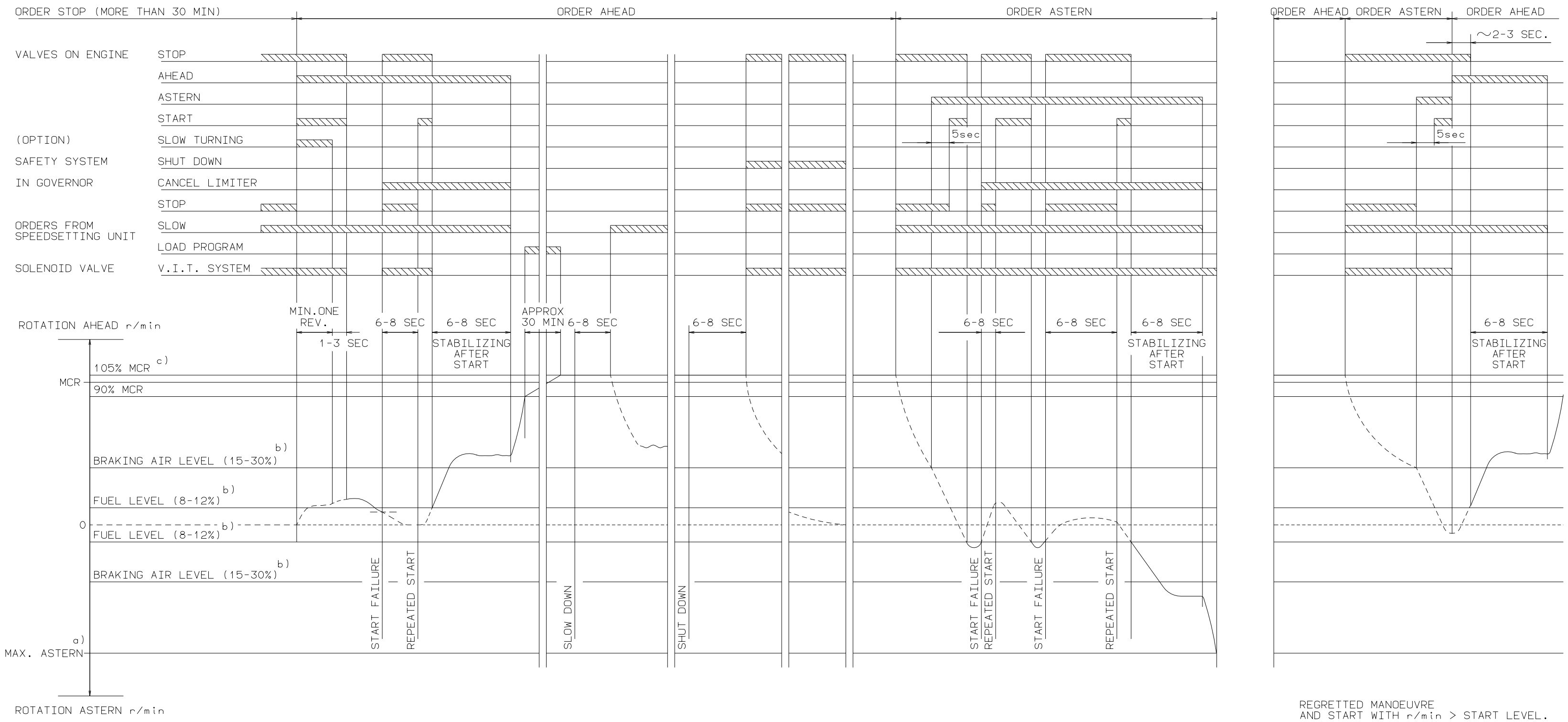
∗10 Thermometer:
    Jacket cooling water
    Lubricating oil water

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, see Figs. 8.02a and 8.02b.

178 30 45-9.0

Fig. 6.11.07: Instruments and pneumatic components for engine control room console, yard's supply



a) MAX.ASTERN: 80% SPECIFIED MCR r/min

b) THESE VALUES GIVEN IN % REFER TO NOMINAL MCR r/min, (IF NOTHING ELSE STATED VALUES REFER TO SPECIFIED MCR r/min.)

c) ONLY PERMISSIBLE FOR LIGHT RUNNING PROPELLER, REF. LOAD DIAGRAM FOR ACTUAL ENGINE.

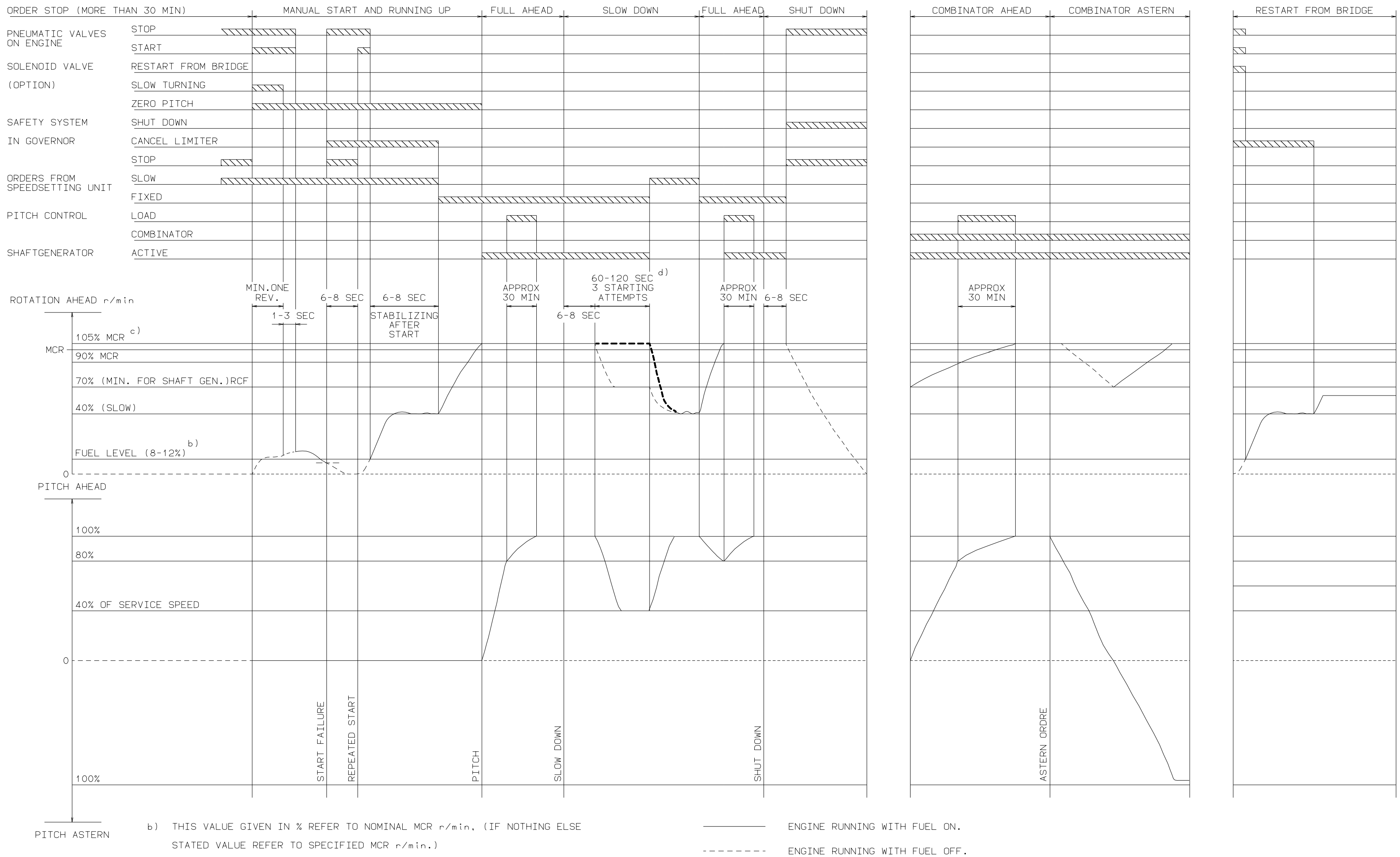
——— ENGINE RUNNING WITH FUEL ON.

- - - - - ENGINE RUNNING WITH FUEL OFF.

178 08 65-1.2

Fig. 6.11.08: Sequence diagram for fixed pitch propeller, with shaft generator type GCR

When the shaft generator is disconnected, the slow down will be effectuated after a prewarning of 6-8 sec.
Demand for quick passage of barred speed range will have an influence on the slow down procedure



b) THIS VALUE GIVEN IN % REFER TO NOMINAL MCR r/min. (IF NOTHING ELSE STATED VALUE REFER TO SPECIFIED MCR r/min.)

c) ONLY PERMISSIBLE FOR LIGHT RUNNING PROPELLER. REF. LOAD DIAGRAM FOR ACTUAL ENGINE.

d) WHEN SHAFT GENERATOR IS DISCONNECTED. SLOW DOWN WILL BE EFFECTED AFTER THE PREWARNING OF 6-8 SEC.

NB: A DEMAND FOR QUICK PASSING OF BARRED SPEED RANGE WILL INFLUENCE ON THE SLOW DOWN PROCEDURE.

ENGINE RUNNING WITH FUEL ON.

ENGINE RUNNING WITH FUEL OFF.

FIXED SPEED SHAFT GENERATOR.

When the shaft generator is disconnected, the slow down will be effectuated after a prewarning of 6-8 sec.
Demand for quick passage of barred speed range will have an influence on the slow down procedure

178 08 66-3.3

Fig. 6.11.09: Sequence diagram for controlable pitch propeller, with shaft generator type GCR

Vibration Aspects 7

7 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. 7.01.

In the following, a brief description is given of their origin and of the proper countermeasures needed to render them harmless.

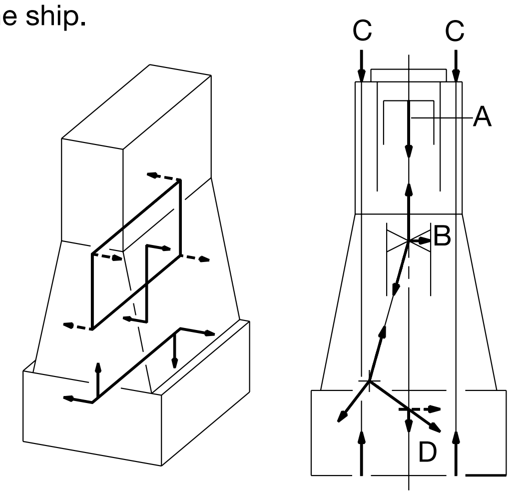
External unbalanced moments

The inertia forces originating from the unbalanced rotating and reciprocating masses of the engine create unbalanced external moments although the external forces are zero.

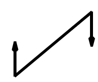
Of these moments, the 1st order (one cycle per revolution) and the 2nd order (two cycles per revolution) need to be considered for engines with a low number of cylinders. On some 7-cylinder engines, also the 4th order external moment may have to be examined. The inertia forces on engines with more than 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).

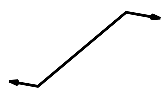
The natural frequency of the hull depends on the hull's rigidity and distribution of masses, whereas the vibration level at resonance depends mainly on the magnitude of the external moment and the engine's position in relation to the vibration nodes of the ship.



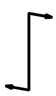
A – Combustion pressure
B – Guide force
C – Staybolt force
D – Main bearing force



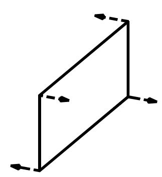
1st order moment vertical 1 cycle/rev
2nd order moment Vertical 2 cycle/rev



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

178 06 82-8.0

Fig. 7.01: External unbalanced moments and guide force moments

1st order moments on 4-cylinder engines

1st order moments act in both vertical and horizontal direction. For our two-stroke engines with standard balancing these are of the same magnitudes.

For engines with five cylinders or more, the 1st order moment is rarely of any significance to the ship. It can, however, be of a disturbing magnitude in four-cylinder engines.

Resonance with a 1st order moment may occur for hull vibrations with 2 and/or 3 nodes, see Fig. 7.02. This resonance can be calculated with reasonable accuracy, and the calculation will show whether a compensator is necessary or not on four-cylinder engines.

A resonance with the vertical moment for the 2 node hull vibration can often be critical, whereas the resonance with the horizontal moment occurs at a higher speed than the nominal because of the higher natural frequency of horizontal hull vibrations.

As standard, four-cylinder engines are fitted with adjustable counterweights, as illustrated in Fig. 7.03. These can reduce the vertical moment to an insignificant value (although, increasing correspondingly the horizontal moment), so this resonance is easily dealt with. A solution with zero horizontal moment is also available.

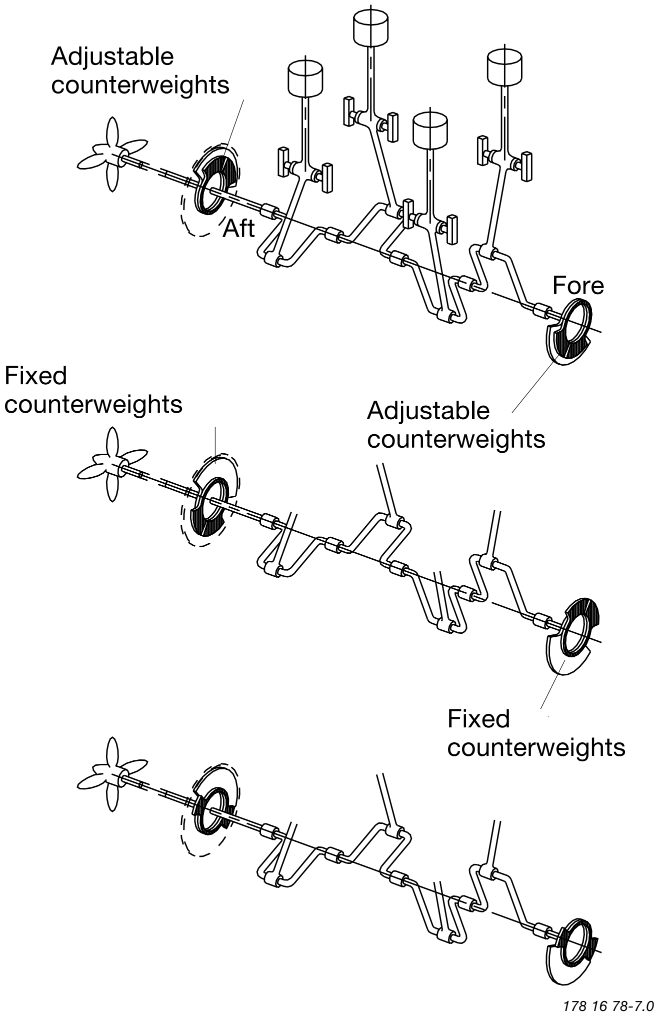


Fig. 7.03: Adjustable counterweights: 4 31 151

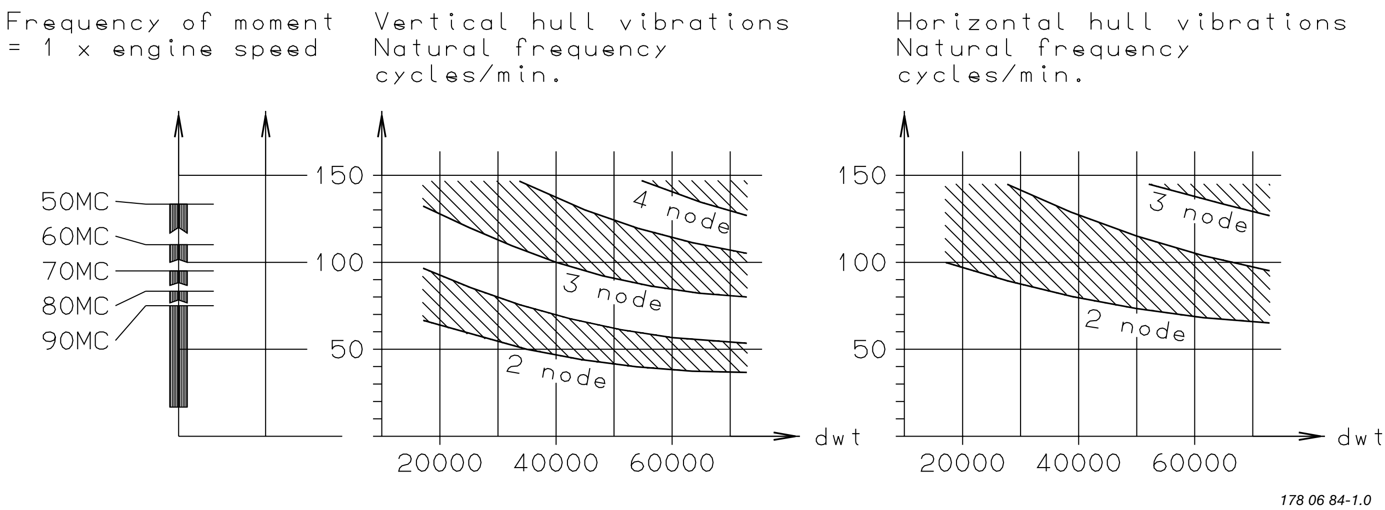


Fig. 7.02: Statistics of tankers and bulk carriers with 4 cylinder MC engines

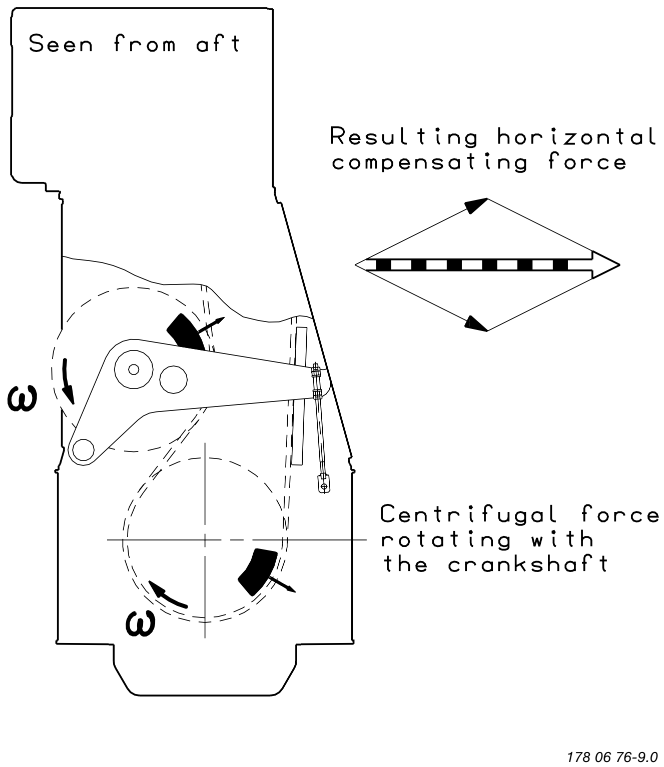


Fig. 7.04: 1st order moment compensator

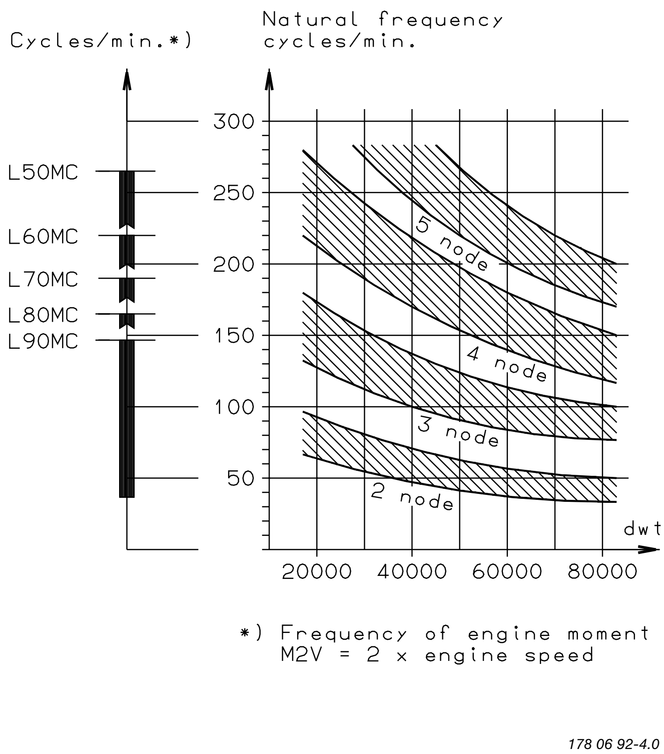


Fig. 7.05: Statistics of vertical hull vibrations in tankers and bulk carriers

In rare cases, where the 1st order moment will cause resonance with both the vertical and the horizontal hull vibration mode in the normal speed range of the engine, a 1st order compensator, as shown in Fig. 7.04, can be introduced (as an option: 4 31 156), in the chain tightener wheel, reducing the 1st order moment to a harmless value. The compensator comprises two counter-rotating masses running at the same speed as the crankshaft.

With a 1st order moment compensator fitted aft, the horizontal moment will decrease to between 0 and 30% of the value stated in the last table of this chapter, depending on the position of the node. The 1st order vertical moment will decrease to about 30% of the value stated in the table.

Since resonance with both the vertical and the horizontal hull vibration mode is rare, the standard engine is not prepared for the fitting of such compensators.

2nd order moments on 4, 5 and 6-cylinder engines

The 2nd order moment acts only in the vertical direction. Precautions need only to be considered for four, five and six cylinder engines.

Resonance with the 2nd order moment may occur at hull vibrations with more than three nodes, see Fig. 7.05. 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, despite advanced calculation methods, is often not very accurate. Consequently, only a rather uncertain basis for decisions is available relating to the natural frequency as well as the position of the nodes in relation to the main engine.

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 shown in Fig. 7.06 for compensation or elimination of the 2nd order moment. The most cost efficient solution must be found in each 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
3) A compensator mounted on the front end, driven from the crankshaft through a separate chain drive, option: 4 31 213
4) Compensators on both aft and fore end completely eliminating the external 2nd order moment, options: 4 31 203 and 4 31 213

Briefly speaking, compensators positioned on a node or near it are inefficient. If it is necessary, solution no. 4 should be considered.

A decision regarding the vibration aspects and the possible use of compensators must be reached at the contract stage preferably based on data from sister ships. If no sister ships have been built, we recommend to make calculations to determine which of the above solutions should be chosen.

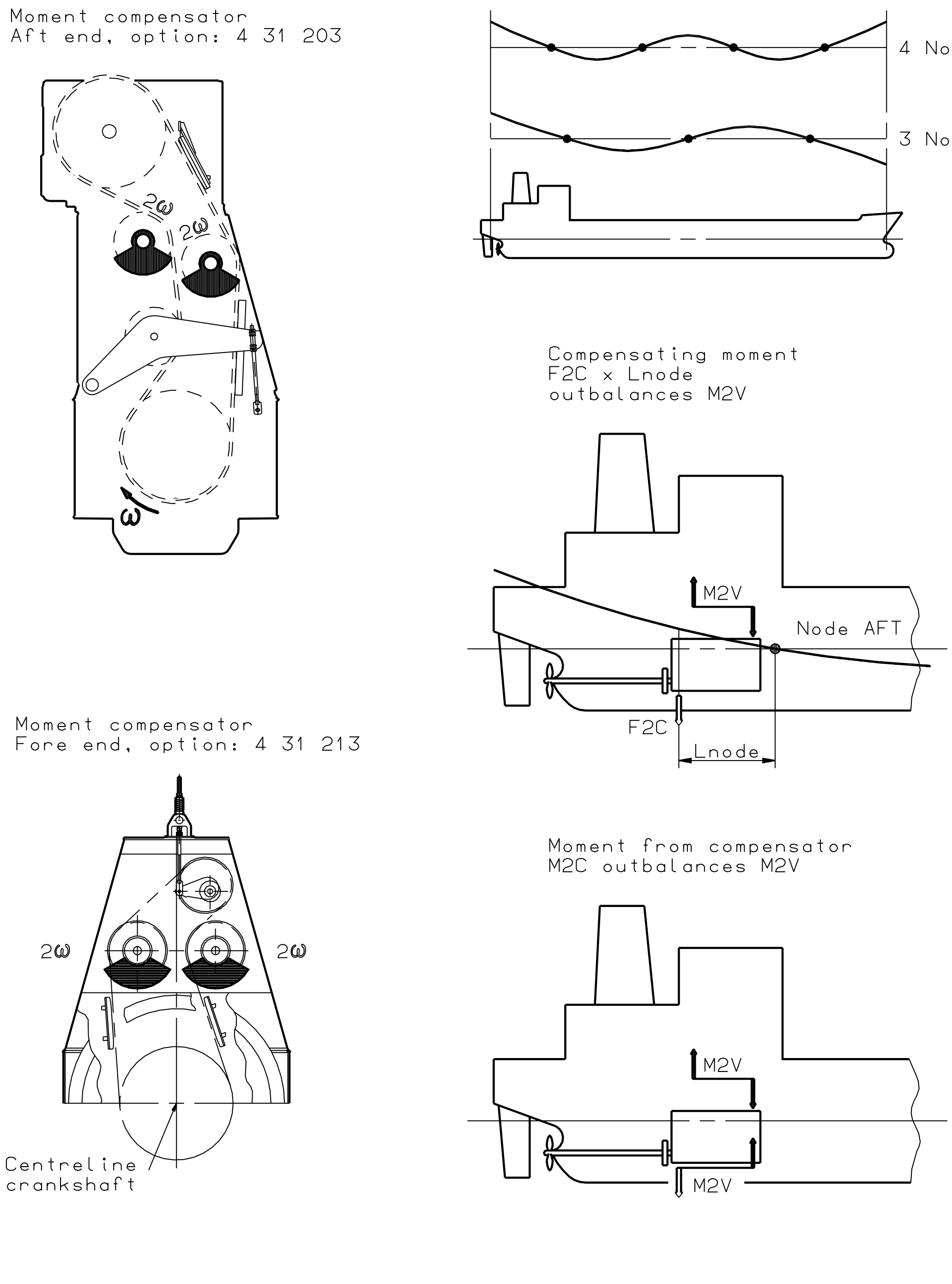
If no compensators are chosen, the engine can be delivered prepared for retro-fitting of compensators on the fore end, see option: 4 31 212. The decision to prepare the engine must also be made at the contract stage. Measurements taken during sea trial or in service with fully loaded ship can show whether there is a need for compensators.

If no calculations are available at the contract stage we advise ordering the engine with a 2nd order moment compensator on the aft end, option: 4 31 203, and to make preparations for the fitting of a compensator on the front end, option: 4 31 212.

If it is decided neither to use compensators nor prepare the main engine for retro-fitting,the following solution can be used:

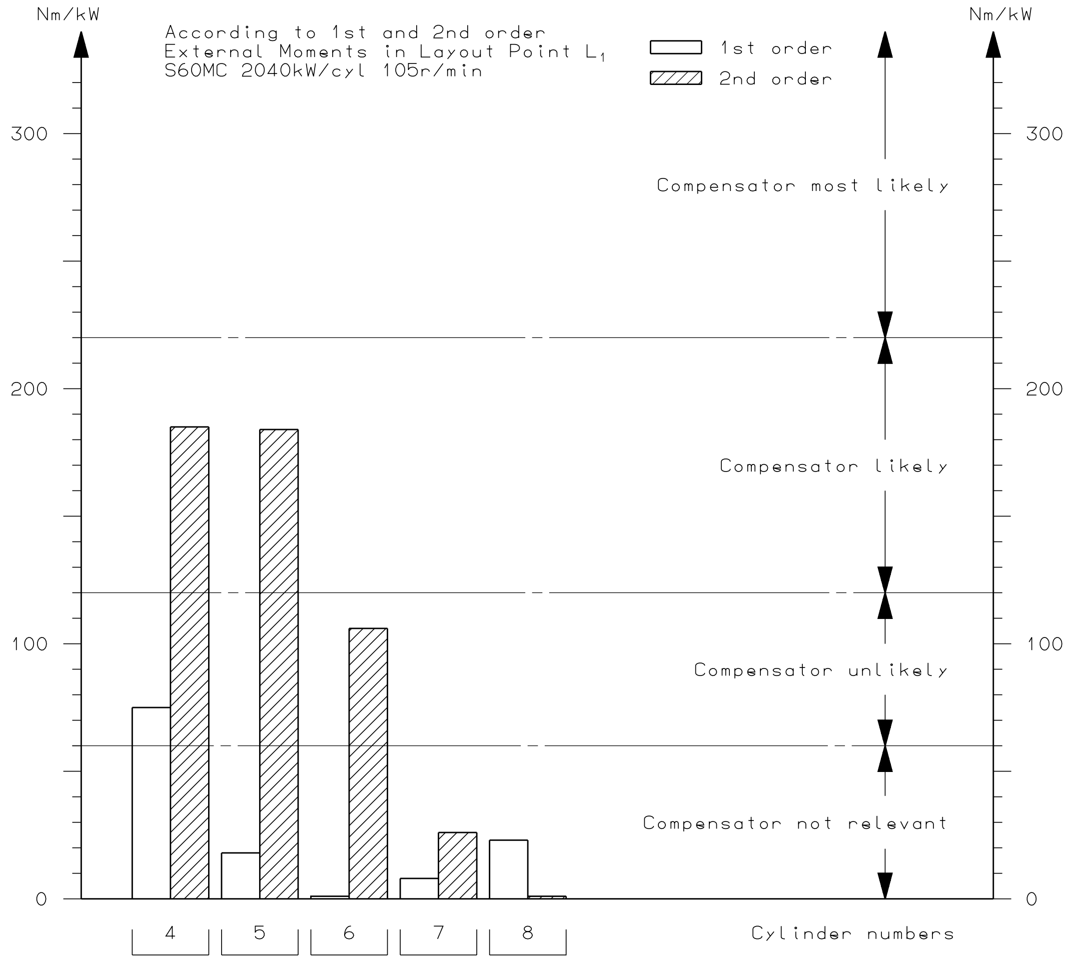
An **electrically driven compensator**, option: 4 31 601, synchronised to the correct phase relative to the external force or moment can neutralise the excitation. This type of compensator needs an extra seating fitted, preferably in the steering gear room where deflections are largest, and the compensator will have the greatest effect.

The electrically driven compensator will not give rise to distorting stresses in the hull, but it is more expensive than the engine-mounted compensators as listed above. More than 70 electrically driven compensators are in service with good results.



178 06 80-4.0

Fig. 7.06: Optional 2nd order moment compensators



178 67 06-7.2

Fig. 7.07: 2nd order moment compensator

Power Related Unbalance (PRU)

To evaluate if there is a risk that 1st and 2nd order external moments will excite disturbing hull vibrations, the concept Power Related Unbalance can be used as a **guidance**, see fig. 7.07.

$$\text{PRU} \quad \frac{\text{External moment}}{\text{Engine power}} \quad \text{Nm/kW}$$

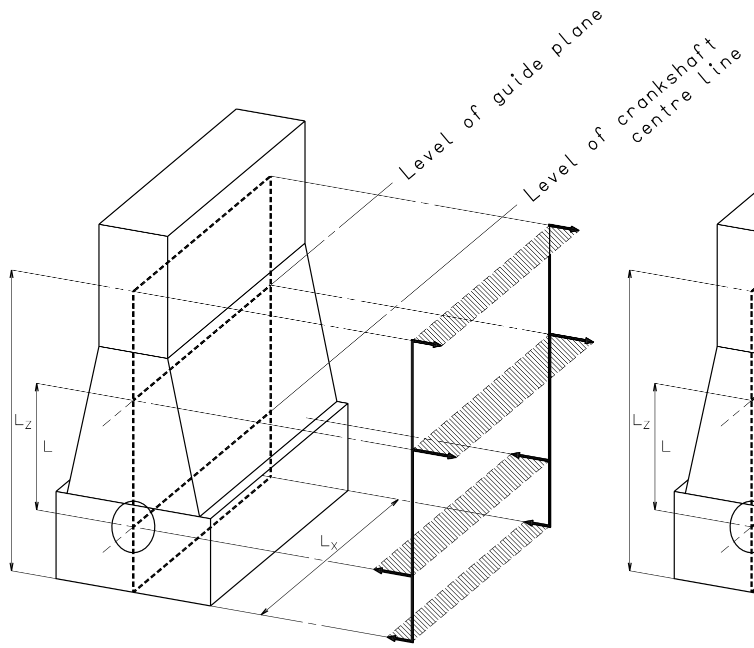
With the PRU-value, stating the external moment relative to the engine power, it is possible to give an estimate of the risk of hull vibrations for a specific engine. Based on service experience from a greater number of large ships with engines of different types and cylinder numbers, the PRU-values have been classified in four groups as follows:

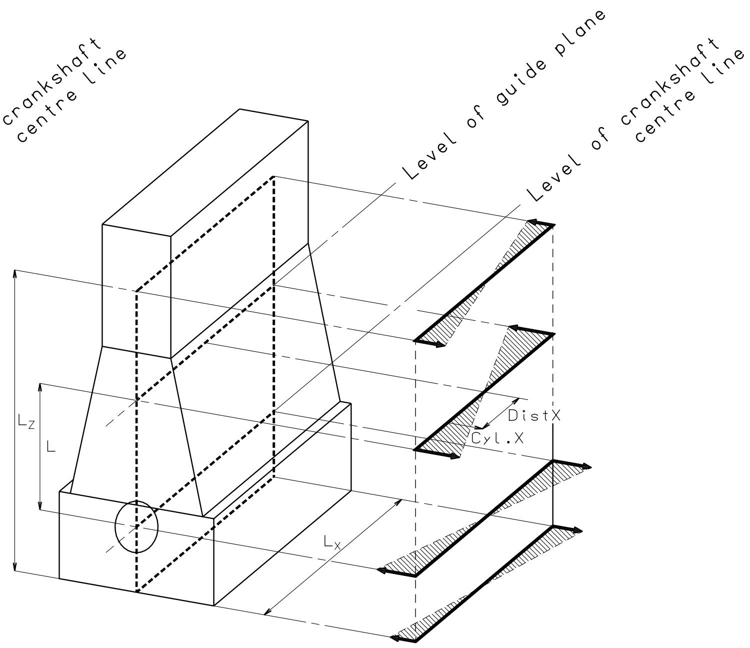
PRU Nm/kW	Need for compensator
from 0 to 60	not relevant
from 60 to 120	unlikely
from 120 to 220	likely
above 220	most likely

In the table at the end of this chapter, the external moments (M1) are stated at the speed (n1) and MCR rating in point L1 of the layout diagram. For other speeds (n_A), the corresponding external moments (M_A) are calculated by means of the formula:

$$M_A = M_1 \left\{ \frac{n_A}{n_1} \right\}^2 \text{kNm}$$

(The tolerance on the calculated values is 2.5%).





178 06 81-6.1

Fig. 7.08a: H-type guide force moments

Fig. 7.08b: X-type guide for moments

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/crankshaft 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 Fig. 7.08.

The guide force moments corresponding to the MCR rating (L_1) are stated in the last table.

Top bracing

The guide force moments are harmless except when resonance vibrations occur in the engine/ship structure system.

As this system is very difficult to calculate with the necessary accuracy MAN B&W Diesel strongly recommend, as standard, that a top bracing is installed between the engine`s upper platform brackets and the casing side.

The mechanical top bracing, option: 4 83 112 comprises stiff connections (links) with friction plates and alternatively a hydraulic top bracing, option: 4 83 122 to allow adjustment to the loading conditions of the ship. With both types of top bracing the 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 section 5.

Definition of Guide Force Moments

During the years the definition of guide force moment has been discussed. Especially nowadays where complete FEM-models are made to predict hull/engine interaction this definition has become important.

H-type Guide Force Moment (M_H)

Each cylinder unit produces a force couple consisting of:

1: A force at level of crankshaft centreline.

2: Another force at level of the guide plane. The position of the force changes over one revolution, as the guide shoe reciprocates on the guide plane.

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: $N \bullet M_{H(\text{one cylinder})}$.

For modelling purpose 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 guide plane (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:

$Force_Z = M_H / L_Z$ kN

Any other vertical distance may be applied, so as to accommodate the actual hull (FEM) model.

The force couple may be distributed at any number of points in longitudinal direction. A reasonable way of dividing the couple is by the number of top bracing, and then apply the forces in those points.

$Force_{Z,\text{one point}} = Force_{Z,\text{total}} / N_{\text{top bracing, total}}$ 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 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. 7.08):

”Bi-moment” = $\sum$ [force-couple(cyl.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 (see Fig. 7.08) can be calculated:

$Force = M_x / L_x$ kN

where:

L_X : is horizontal length between ”force points” (Fig. 7.08)

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 centreline.These forces can be calculated as follows:

$$Force_{Z,\text{one point}} = \frac{M_X \bullet L}{L_Z \bullet L_X} \quad \text{kN}$$

The length of the connecting rod L is 2050 mm for this engine type.

For calculating the forces the lenght of the connecting rod is to be used: L = 2628 mm.

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: 4 31 111 to all MC engines minimising the effects of the axial vibrations.

The five-cylinder engines are equipped with an axial vibration monitor (4 31 117).

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 (inertia) 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, .e., five cycles per revolution on a five 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), option: 4 31 108, 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 has to be decided by the engine maker and MAN B&W Diesel A/S based on final torsional vibration calculations.

Four, five and 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 under critical 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.

Under critical 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 under critical conditions can be realised by choosing a rigid shaft system, leading to a relatively high natural frequency.

The characteristics of an under critical 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, option: 4 07 016.

When running under critical, 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 (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, option: 4 31 105.

Overcritical layout is normally applied for engines with more than four cylinders.

Please note:
We do not include any tuning wheel, option: 4 31 101 or torsional vibration damper, option: 4 31 105 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:

P.222 “An introduction to Vibration Aspects of Two-stroke Diesel Engines in Ships”
P.268 “Vibration Characteristics of Two-stroke Low Speed Diesel Engines”

No. of cyl.	4	5	6	7	8
Firing order	1-3-2-4	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 in kN					
	0	0	0	0	0
External moments in kNm					
Order:					
1st a	582 b	185	0	110	369
2nd	1510 c	1880 c	1308 c	380	0
4th	0	9	69	195	74
Guide force H-moments in kNm					
Order:					
1 x No. of cyl.	949	937	708	552	380
2 x No. of cyl.	190	82	32		
3 x No. of cyl.	21				
Guide force X-moments in kNm					
Order:					
1st	334	106	0	63	212
2nd	109	136	94	27	0
3rd	66	233	421	460	590
4th	0	43	334	949	386
5th	108	0	0	77	961
6th	192	22	0	13	0
7th	45	160	0	0	29
8th	0	96	67	5	0
9th	15	5	95	11	9
10th	27	0	23	65	0
11th	5	2	0	37	47
12th	0	11	0	2	9

a 1st order moments are, as standard, balanced so as to obtain equal values for horizontal and vertical moments for all cylinder numbers.

b By means of the adjustable counterweights on 4-cylinder engines, 70% of the 1st order moment can be moved from horizontal to vertical direction or vice versa, if required.

c 4,5 and 6-cylinder engines can be fitted with 2nd order moment compensators on the aft and fore end, eliminating the 2nd order external moment.

178 87 62-7.0

Fig. 7.09: External forces and moments in layout point L_1 for S60MC

Instrumentation 8

8 Instrumentation

The instrumentation on the diesel engine can be roughly divided into:

- Local instruments, i.e. thermometers, pressure gauges and tachometers
- Control devices, i.e. position switches and solenoid valves
- Analog sensors for Alarm, Slow Down and remote indication of temperatures and pressures
- Binary sensors, i.e. thermo switches and pressure switches for Shut Down etc.

All instruments are identified by a combination of symbols as shown in Fig. 8.01 and a position number which appears from the instrumentation lists in this chapter.

Local Instruments

The basic local instrumentation on the engine comprises thermometers and pressure gauges located on the piping or mounted on panels on the engine, and an engine tachometer located at the engine side control panel.

These are listed in Fig. 8.02.

Additional local instruments, if required, can be ordered as option: 4 70 129.

Control Devices

The control devices mainly include the position switches, called ZS, incorporated in the manoeuvring system, and the solenoid valves (EV), which are listed in Fig. 8.05.

Sensors for Remote Indication Instruments

Analog sensors for remote indication can be ordered as options 4 75 127, 4 75 128 or for CoCoS as 4 75 129, see Fig. 8.03. These sensors can also be used for Alarm or Slow Down simultaneously.

Alarm, Slow Down and Shut Down Sensors

It is required that the system for shut down is electrically separated from the other systems.

This can be accomplished by using independent sensors, or sensors with galvanically separated electrical circuits, i.e. one sensor with two sets of electrically independent terminals.

The International Association of Classification Societies (IACS) have agreed that a common sensor can be used for Alarm, Slow Down and remote indication. References are stated in the lists if a common sensor can be used.

A general outline of the electrical system is shown in Fig. 8.07.

The extent of sensors for a specific plant is the sum of requirements of the classification society, the yard, the owner and MAN B&W's minimum requirements.

Figs. 8.08, 8.09 and 8.10 show the classification societies' requirements for UMS and MAN B&W's minimum requirements for Alarm, Slow Down and Shut Down as well as IACS`s recommendations, respectively.

Only MAN B&W's minimum requirements for Alarm and Shut Down are included in the basic scope of supply (4 75 124).

For the event that further signal equipment is required, the piping on the engine has additional sockets.

Fuel oil leakage detection

Oil leaking oil from the high pressure fuel oil pipes is collected in a drain box (Fig. 8.10), which is equipped with a level alarm, LSA 301, option 4 35 105.

Slow down system

The slow down functions are designed to safeguard the engine components against overloading during normal service conditions and, at the same time, to keep the ship manoeuvrable, in the event that fault conditions occur.

The slow down sequence has to be adapted to the plant (FPP/CPP, with/without shaft generator, etc.) and the required operating mode.

For further information please contact the engine supplier.

Attended Machinery Spaces (AMS)

The basic alarm and safety system for an MAN B&W engine is designed for Attended Machinery Spaces and comprises the temperature switches (thermostats) and pressure switches (pressure stats) that are specified in the "MAN B&W" column for alarm and for shut down in Figs. 8.07 and 8.09, respectively. The sensors for shut down are included in the basic scope of supply (4 75 124), see Fig. 8.09.

Additional digital sensors can be ordered as option: 4 75 128.

Unattended Machinery Spaces (UMS)

The "Standard Extent of Delivery for MAN B&W Diesel A/S" engines includes the temperature switches, pressure switches and analog sensors stated in the "MAN B&W" column for alarm, slow down and shut down in Figs. 8.07, 8.08 and 8.09.

The shut down and slow down panel can be ordered as option: 4 75 610, 4 75 611 or 4 75 613, whereas the alarm panel is a yard's supply, as it has to include several other alarms than those of the main engine.

For practical reasons, the sensors to be applied are normally delivered from the engine supplier, so that 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 for the forwarding of the engine, see "Dispatch Pattern" in Section 9.

Oil Mist Detector and Bearing Monitoring Systems

Based on our experience, the basic scope of supply for all plants for attended as well as for unattended machinery spaces (AMS and UMS) includes an oil mist detector, Fig. 8.11.

Make: Kidde Fire Protection, Graviner
Type: MK 5. . . . . 4 75 161
or
Make: Schaller
Type: Visatron VN 215 . . . . 4 75 163

The combination of an oil mist detector and a bearing temperature monitoring system with deviation from average alarm (option 4 75 133, 4 75 134 or 4 75 135) will in any case provide the optimum safety.

PMI Calculating Systems

The PMI systems permit the measuring and monitoring of the engine's main parameters, such as cylinder pressure, fuel oil injection pressure, scavenge air pressure, engine speed, etc., which enable the engineer to run the diesel engine at its optimum performance.

The designation of the different types are:

Main engine:

PT: Portable transducer for cylinder pressure

S: Stationary junction and converter boxes on engine

P: Portable optical pick-up to detect the crankshaft position at a zebra band on the intermediate shaft

PT/S

The following alternative types can be applied:

- MAN B&W Diesel, PMI system type **PT/S** option: 4 75 208

The cylinder pressure monitoring system is based on a **P**ortable **T**ransducer, **S**tationary junction and converter boxes.
Power supply: 24 V DC

- MAN B&W Diesel, PMI system, type **PT/P** option: 4 75 207

The cylinder pressure monitoring system is based on a **P**ortable **T**ransducer, and **P**ortable pick-up.

Power supply: 24 V DC

CoCoS

The **Co**mputer **Co**ntrolled **S**urveillance system is the family name of the software application products from the MAN B&W Diesel group.

CoCoS comprises four individual software application products:

CoCoS-EDS:
Engine **D**iagnostics **S**ystem, option: 4 09 660.
CoCoS-EDS assists in the engine performance evaluation through diagnostics.
Key features are: on-line data logging, monitoring, diagnostics and trends.

CoCoS-MPS:
Maintenance **P**lanning **S**ystem, option: 4 09 661.
CoCoS-MPS assists in the planning and initiating of preventive maintenance.
Key features are: scheduling of inspections and overhaul, forecasting and budgeting of spare part requirements, estimating of the amount of work hours needed, work procedures, and logging of maintenance history.

CoCoS-SPC:
Spare **P**art **C**atalogue, option: 4 09 662.
CoCoS-SPC assists in the identification of spare part.
Key features are: multilevel part lists, spare part information, and graphics.

CoCoS-SPO:
Stock Handling and Spare **P**art **O**rdering,
option: 4 09 663.
CoCoS-SPO assists in managing the procurement and control of the spare part stock.
Key features are: available stock, store location, planned receipts and issues, minimum stock, safety stock, suppliers, prices and statistics.

CoCoS Suite:
Package: option: 4 09 665
Includes the four above-mentioned system:
4 09 660+661+662+663.

CoCoS MPS, SPC, and SPO can communicate with one another, or they can be used as separate stand-alone system. These three applications can also handle non-MAN B&W Diesel technical equipment; for instance pumps and separators.

Fig. 8.03 shows the maximum extent of additional sensors recommended to enable on-line diagnostics if CoCoS-EDS is ordered.

Identification of instruments

The measuring instruments are identified by a combination of letters and a position number:

LSA 372 high

Level: high/low

Where: in which medium (lube oil, cooling water...) location (inlet/outlet engine)

Output signal:

A: alarm
I : indicator (thermometer, manometer...)
SHD: shut down (stop)
SLD: slow down

How: by means of

E: analog sensor (element)
S: switch (pressure stat, thermostat)

What is measured:

D:density
F: flow
L: level
P: pressure
PD: pressure difference
S: speed
T: temperature
V: viscosity
W: vibration
Z: position

Functions

DSA	Density switch for alarm (oil mist)
DS - SLD	Density switch for slow down
E	Electric devices
EV	Solenoid valve
ESA	Electrical switch for alarm
FSA	Flow switch for alarm
FS - SLD	Flow switch for slow down
LSA	Level switch for alarm
PDEI	Pressure difference sensor for remote indication (analog)
PDI	Pressure difference indicator
PDSA	Pressure difference switch for alarm
PDE	Pressure difference sensor (analog)
PI	Pressure indicator
PS	Pressure switch
PS - SHD	Pressure switch for shut down
PS - SLD	Pressure switch for slow down
PSA	Pressure switch for alarm
PSC	Pressure switch for control
PE	Pressure sensor (analog)
PEA	Pressure sensor for alarm (analog)
PEI	Pressure sensor for remote indication (analog)
PE - SLD	Pressure sensor for slow down (analog)
SE	Speed sensor (analog)
SEA	Speed sensor for alarm (analog)
SSA	Speed switch for alarm
SS - SHD	Speed switch for shut down
TI	Temperature indicator
TSA	Temperature switch for alarm
TSC	Temperature switch for control
TS - SHD	Temperature switch for shut down
TS - SLD	Temperature switch for slow down
TE	Temperature sensor (analog)
TEA	Temperature sensor for alarm (analog)
TEI	Temperature sensor for remote indication (analog)
TE - SLD	Temperature sensor for slow down (analog)
VE	Viscosity sensor (analog)
VEI	Viscosity sensor for remote indication (analog)
VI	Viscosity indicator
ZE	Position sensor
ZS	Position switch
WEA	Vibration signal for alarm (analog)
WI	Vibration indicator
WS - SLD	Vibration switch for slow down

The symbols are shown in a circle indicating:

Instrument locally mounted

Instrument mounted in panel on engine

Control panel mounted instrument

178 30 04-4.1

Fig. 8.01: Identification of instruments

Description

Thermometer stem type	Use sensor for remote indication	Point of location
		Fuel oil
TI 302	TE 302	Fuel oil, inlet engine
		Lubricating oil
TI 311	TE 311	Lubricating oil inlet to main bearings, thrust bearing, axial vibration damper, piston cooling oil and turbochargers
TI 317	TE 317	Piston cooling oil outlet/cylinder
TI 349	TE 349	Thrust bearing segment
TI 355	TE 355	Lubricating oil inlet to camshaft and/or exhaust valve actuators
TI 369	TE 369	Lubricating oil outlet from turbocharger/turbocharger (depends on turbocharger design)
		Low temperature cooling water: seawater or freshwater for central cooling
TI 375	TE 375	Cooling water inlet, air cooler
TI 379	TE 379	Cooling water outlet, air cooler/air cooler
		High temperature jacket cooling water
TI 385	TE 385	Jacket cooling water inlet
TI 387A	TE 387A	Jacket cooling water outlet, cylinder cover/cylinder
TI 393		Jacket cooling water outlet/turbocharger
		Scavenge air
TI 411	TE 411	Scavenge air before air cooler/air cooler
TI 412	TE 412	Scavenge air after air cooler/air cooler
TI 413	TE 413	Scavenge air receiver
Thermometers dial type		
		Exhaust gas
TI 425	TE 425	Exhaust gas inlet turbocharger/turbocharger
TI 426	TE 426	Exhaust gas after exhaust valves/cylinder

178 86 42-9.0

Fig. 8.02a: Local standard thermometers on engine (4 70 120) and option: 4 75 127 remote indication sensors

Pressure gauges (manometers)	Use sensor for remote indication	Point of location
		Fuel oil
PI 305	PE 305	Fuel oil , inlet engine
		Lubricating oil
PI 330	PE 330	Lubricating oil inlet to main bearings thrust bearing, axial vibration damper and piston cooling oil inlet
PI 357	PE 357	Lubricating oil inlet to camshaft and/or exhaust valve actuators
PI 371	PE 371	Lubricating oil inlet to turbocharger with slide bearings/turbocharger
		Low temperature cooling water:
PI 382	PE 382	Cooling water inlet, air cooler
		High temperature jacket cooling water
PI 386	PE 386	Jacket cooling water inlet
		Starting and control air
PI 401	PE 401	Starting air inlet main starting valve
PI 403	PE 403	Control air inlet
PI 405		Safety air inlet
		Scavenge air
PI 417	PE 417	Scavenge air receiver
		Exhaust gas
PI 424		Exhaust gas receiver
PI 435A		Air inlet for dry cleaning of turbocharger
PI 435B		Water inlet for cleaning of turbocharger
		Manoeuvring system
PI 668		Pilot pressure to actuator for V.I.T. system
		Differential pressure gauges
PDI 420		Pressure drop across air cooler/air cooler
PDI 422		Pressure drop across blower filter of turbocharger (For ABB turbochargers only)

Tacho-meters		
SI 438	SE 438	Engine speed
SI 439	SE 439	Turbocharger speed/turbocharger
WI 471		Mechanical measuring of axial vibration

178 86 42-9.0

Fig. 8.02b: Local standard manometers and tachometers on engine (4 70 120) and option: 4 75 127 remote indication

Use sensor	Point of location
	Fuel oil system
TE 302	Fuel oil, inlet fuel pumps
VE 303	Fuel oil viscosity, inlet engine (yard's supply)
PE 305	Fuel oil, inlet engine
PDE 308	Pressure drop across fuel oil filter (yard's supply)
	Lubricating oil system
TE 311	Lubricating oil inlet, to main bearings, thrust bearing, axial vibration damper, piston cooling oil and turbochargers
TE 317	Piston cooling oil outlet/cylinder
PE 330	Lubricating oil inlet to main bearings, thrust bearing, axial vibration damper and piston cooling oil inlet
TE 349	Thrust bearing segment
TE 355	Lubricating oil inlet to camshaft and/or exhaust valve actuator
PE 357	Lubricating oil inlet to camshaft and/or exhaust valve actuator and piston cooling oil inlet
TE 369	Lubricating oil outlet from turbocharger/turbocharger (Depending on turbocharger design)
PE 371	Lubricating oil inlet to turbocharger with slide bearing/turbocharger

178 86 42-9.0

Fig 8.03a: List of sensors for CoCoS, option: 4 75 129

Use sensor	Point of location
	Cooling water system
TE 375	Cooling water inlet air cooler/air cooler
PE 382	Cooling water inlet air cooler
TE 379	Cooling water outlet air cooler/air cooler
TE 385	Jacket cooling water inlet
PE 386	Jacket cooling water inlet
TE 387A	Jacket cooling water outlet/cylinder
PDSA 391	Jacket cooling water across engine
TE 393	Jacket cooling water outlet turbocharger/turbocharger (Depending on turbocharger design)
PDE 398	Pressure drop of cooling water across air cooler/air cooler
	Scavenge air system
TE 336	Engine room air inlet turbocharger/turbocharger
PE 337	Compressor spiral housing pressure at outer diameter/turbocharger (Depending on turbocharger design)
PDE 338	Differential pressure across compressor spiral housing/turbocharger (Depending on turbocharger design)
TE 411	Scavenge air before air cooler/air cooler
TE 412	Scavenge air after air cooler/air cooler
TE 412A	Scavenge air inlet cylinder/cylinder
TE 413	Scavenge air reciever
PE 417	Scavenge air reciever
PDE 420	Pressure drop of air across air cooler/air cooler
PDE 422	Pressure drop air across blower filter of compressor/turbocharger
ZS 669	Auxiliary blower on/off signal from control panel (yard’s supply)

178 89 00-6.0

Fig. 8.03b: List of sensors for CoCoS, option: 4 75 129

Use sensor	Point of location	
	Exhaust gas system	
TE 363	Exhaust gas receiver	
ZE 364	Exhaust gas blow-off, on/off or valve angle position/turbocharger	2)
PE 424	Exhaust gas receiver	
TE 425A	Exhaust gas inlet turbocharger/turbocharger	
TE 426	Exhaust gas after exhaust valve/cylinder	
TE 432	Exhaust gas outlet turbocharger/turbocharger	
PE 433A	Exhaust gas outlet turbocharger/turbocharger (Back pressure at transition piece related to ambient)	
SE 439	Turbocharger speed/turbocharger	
PDE 441	Pressure drop across exhaust gas boiler (yard's supply)	
	General data	
N	Time and data	1)
N	Counter of running hours	1)
PE 325	Ambient pressure (Engine room)	3)
SE 438	Engine speed	
N	P_{max} set point	2)
ZE 477	Fuel pump index/cylinder	2)
ZE 478	VIT index/cylinder	2)
ZE 479	Governor index	
E 480	Engine torque	1)
N	Mean indicated pressure (mep)	4)
N	Maximum pressure (P_{max})	4)
N	Compression pressure (P_{comp})	4)

N Numerical input
1) Originated by alarm/monitoring system
2) Manual input can alternatively be used
3) Yard's supply
4) Originated by the PMI system

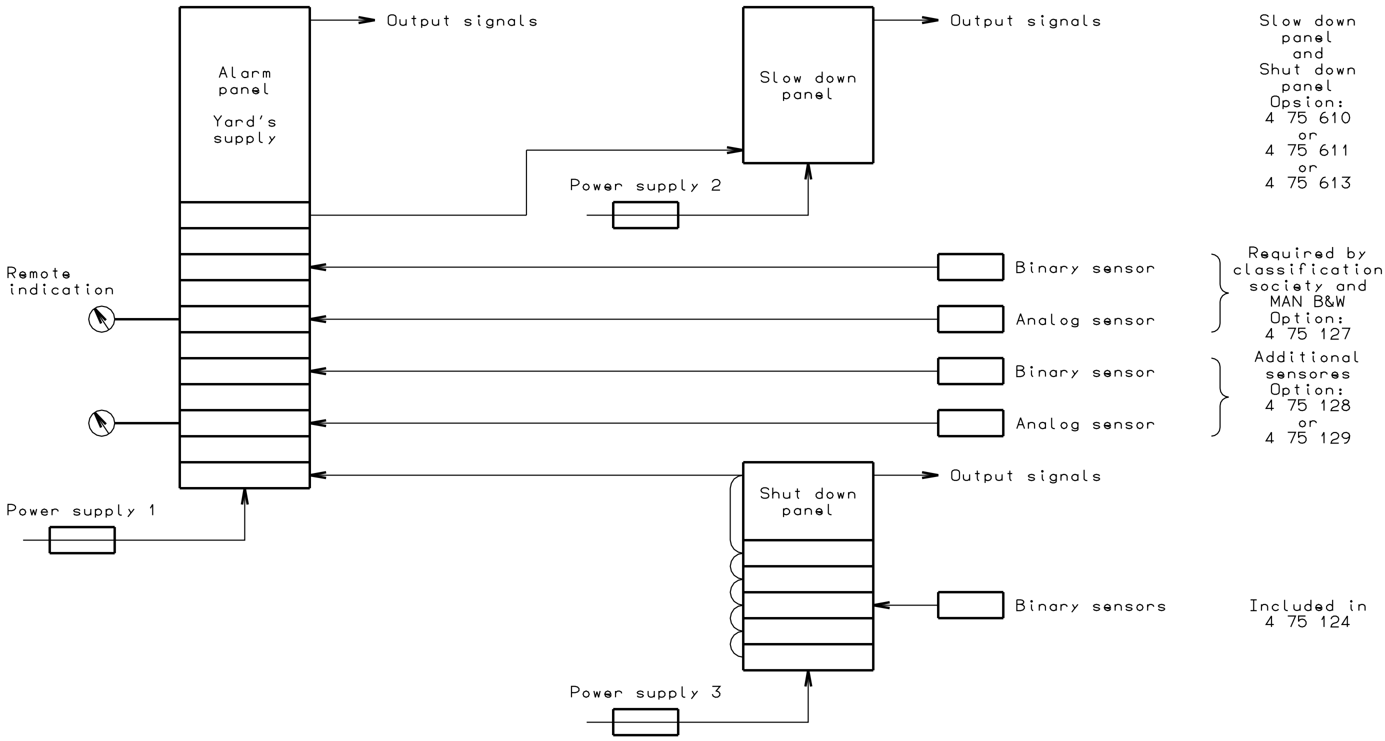
178 89 00-6.0

Fig. 8.03c: List of sensors for CoCoS, option: 4 75 129

Description	Symbol/Position	
Scavenge air system		
Scavenge air receiver auxiliary blower control	PSC	418
Manoeuvering system		
Engine speed detector	E	438
Reversing Astern/cylinder	ZS	650
Reversing Ahead/cylinder	ZS	651
Resets shut down function during engine side control	ZS	652
Gives signal when change-over mechanism is in Remote Control mode	ZS	653
Gives signal to manoeuvring system when on engine side control	PSC	654
Solenoid valve for control of V.I.T. system stop or astern	EV	656
Solenoid valve for stop and shut down	EV	658
Turning gear engaged indication	ZS	659
Fuel rack transmitter, if required, option: 4 70 150	E	660
Main starting valve – Blocked	ZS	663
Main starting valve – In Service	ZS	664
Air supply starting air distributor, Open – Closed	ZS	666/667
Electric motor, Auxiliary blower	E	670
Electric motor, turning gear	E	671
Actuator for electronic governor	E	672
Gives signal to manoeuvring system when remote control is ON	PSC	674
Cancel of tacho alarm from safety system, when “Stop” is ordered	PSC	675
Gives signal Bridge Control active	PSC	680
Solenoid valve for Stop	EV	682
Solenoid valve for Ahead	EV	683
Solenoid valve for Start	EV	684
Solenoid valve for Astern	EV	685
Slow turning, option: 4 50 140	EV	686

178 46 49-3.1

Fig. 8.05: Control devices on engine



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 to have common sensors for slow down, alarm and remote indication
One common power supply might be used, instead of the three indicated, if the systems are equipped with separate fuses

178 30 10-0.1

Fig. 8.06: Panels and sensors for alarm and safety systems

Class requirements for UMS

ABS	BV	DnVC	GL	LR	NKK	RINa	RS	IACS	MAN B&W	Functzion	Use sensor	Point of location	
												Fuel oil system	
									1**	PSA 300 high		Fuel pump roller guide gear activated	
1		1		1	1	1	1	1	1*	LSA 301 high		Leakage from high pressure pipes	
1	1	1	1	1	1	1	1	1	A*	PEA 306 low	PE 305	Fuel oil, inlet engine	
												Lubricating oil system	
1		1	1	1	1	1	1	1	A*	TEA 312 high	TE 311	Lubricating oil inlet to main bearings, thrust bearing	
	1									TEA 313 low	TE 311	and axial vibration damper	
1	1	1	1	1	1	1	1	1	A*	TEA 318 high	TE 317	Piston cooling oil outlet/cylinder	
1	1	1	1	1		1	1	1	1*	FSA 320 low		Piston cooling oil outlet/cylinder	
1	1	1	1	1	1	1	1	1	A*	PEA 331 low	PE 330	Lubricating oil inlet to main bearings, thrust bearing, axial vibration damper and piston colling outlet	
1		1	1	1	1	1	1	1	A*	TEA 350 high	TE 349	Thrust bearing segment	
1			1	1		1	1	1	A*	TEA 356 high	TE 355	Lubricating oil inlet to camshaft and/or exhaust valve actuators	
1	1	1	1	1	1	1	1	1	A*	PEA 358 low	PE 357	Lubricating oil inlet to camshaft and exhaust valve actuators	
									1*	LSA 365 low		Cylinder lubricators (built-in switches)	
1	1	1		1	1	1	1	1	1*	FSA 366 low		Cylinder lubricators (built-in switches)	
1	1	1	1	1		1	1	1		TSA 370 high		Turbocharger lubricating oil outlet from turbocharger/turbocharger	a)
1	1	1	1	1		1	1	1	A*	PEA 372 low	PE 371	Lubricating oil inlet to turbocharger/turbocharger	a)
				1						TEA 373 high	TE 311	Lubricating oil inlet to turbocharger/turbocharger	a)
1	1	1	1	1	1	1	1	1	1*	DSA 436 high		Oil mist in crankcase/cylinder and chain drive	
										WEA 472 high	WE 471	Axial vibration monitor Required for all 5-cylinder S..MC engines and for engines with PTO on fore end.	

a) For turbochargers with slide bearings

▽ For Bureau Veritas, at least two per lubricator, or minimum one per cylinder, whichever is the greater number

178 30 11-2.2

Fig. 8.07a: List of sensors for alarm

Class requirements for UMS

ABS	BV	DnVC	GL	LR	NKK	RINa	RS	IACS	MAN B&W	Functzion	Use sensor	Point of location
												Cooling water system
			1							TEA 376 high	TE 375	Cooling water inlet air cooler/air cooler (for central cooling only)
1	1	1	1	1	1	1	1	1	A*	PEA 378 low	PE 382	Cooling water inlet air cooler
1	1	1	1	1	1	1	1	1	A*	PEA 383 low	PE 386	Jacket cooling water inlet
			1						A*	TEA 385A low	TE 385	Jacket cooling water inlet
1	1	1	1	1	1	1	1	1	A*	TEA 388 high	TE 387	Jacket cooling water outlet/cylinder
									1*	PDSA 391 low		Jacket cooling water across engine
												Air system
1	1	1	1	1	1	1	1	1	A*	PEA 402 low	PE 401	Starting air inlet
1	1	1	1	1	1	1	1	1	A*	PEA 404 low	PE 403	Control air inlet
1	1	1	1	1	1	1	1	1	1*	PSA 406 low		Safety air inlet
									1*	PSA 408 low		Air inlet to air cylinder for exhaust valve
									1*	PSA 409 high		Control air inlet, finished with engine
									1*	PSA 410 high		Safety air inlet, finished with engine
												Scavenge air system
			1		1		1			TEA 414 high	TE 413	Scavenge air reciever
1	1	1		1		1		1	A*	TEA 415 high		Scavenge air – fire /cylinder
							1		1*	PSA 419 low		Scavenge air, auxiliary blower, failure
1			1			1		1	1*	LSA 434 high		Scavenge air – water level

178 30 11-2.2

Fig. 8.07b: List of sensors for alarm

Class requirements for UMS

ABS	BV	DnVC	GL	LR	NKK	RINa	RS	IACS	MAN B&W	Functzion	Use sensor	Point of location
												Exhaust gas system
1			1		1	1	1	1		TEA 425A high	TE 425	Exhaust gas inlet turbocharger/turbocharger
1		1		1	1	1	1	1	A*	TEA 427 high	TE 426	Exhaust gas after cylinder/cylinder
1	1	1	1	1		1	1	1		TEA 429/30 high	TE 426	Exhaust gas after cylinder, deviation from average
1		1	1	1		1		1		TEA 433 high	TE 432	Exhaust gas outlet turbocharger/turbocharger
												Manoeuvring system
1	1	1	1	1	1	1	1	1	1*	ESA low		Safety system, power failure, low voltage
1	1	1	1	1	1	1	1	1	1*	ESA low		Tacho system, power failure, low voltage
									1*	ESA		Safety system, cable failure
1	1	1	1	1	1	1	1		1*	ESA		Safety system, group alarm, shut down
								1	1*	ESA		Wrong way (for reversible engine only)
1	1	1	1	1	1	1	1	1	A*		SE 438	Engine speed
								1		SEA 439	SE 439	Turbocharger speed

IACS: International Association of Classification Societies
The members of IACS have agreed that the stated sensors are their common **recommendation**, apart from each class' requirements

The members of IACS are:
ABS America Bureau of Shipping
BV Bureau Veritas
CCS Chinese Register of Shipping
DnVC Det norske Veritas Classification
GL Germanischer Lloyd
KRS Korean Register of Shipping
LR Lloyd's Register of Shipping
NKK Nippon Kaiji Kyokai
RINa Registro Italiano Navale
RS Russian Maritime Register of Shipping

and the assosiated members are:
KRS Kroatian Register of Shipping
IRS Indian Register of Shipping
PRS Polski Rejestr Statkow

1 Indicates that a binary (on-off) sensor/signal is required

A Indicates that an analogue sensor is required for alarm, slow down and remote indication

1*, A* These alarm sensors are MAN B&W Diesel's minimum requirements for Unattended Machinery Space (UMS), option: 4 75 127

1** Optional on 70 and 60 types

1 For disengageable engine or with CPP

Select one of the alternatives

Or alarm for overheating of main, crank, crosshead and chain drive bearings, option: 4 75 134

Or alarm for low flow

178 30 11-2.2

Fig. 8.07c: List of sensors for alarm

Class requirements for slow down

ABS	BV	DnVC	GL	LR	NKK	RINa	RS	IACS	MAN B&W	Function		Use sensor	Point of Location	
			1							TE SLD	314 high	TE 311	Lubricating oil inlet, system oil	
1	1	1	1	1		1	1	1		TE SLD	319 high	TE 317	Piston cooling oil outlet/cylinder	
1	1	1	1	1	1	1	1	1	1*	FS SLD	321 low		Piston cooling oil outlet/cylinder	
1		1		1				1	A*	PE SLD	334 low	PE 330	Lubricating oil to main and thrust bearings, piston cooling and crosshead lubricating oil inlet	
1		1	1	1		1		1	A*	TE SLD	351 high	TE 349	Thrust bearing segment	
			1	1						TE SLD	361 high	TE 355	Lubricating oil inlet to camshaft and/or exhaust valve actuators	
1		1	1	1		1	1	1		FS SLD	366A low		Cylinder lubricators (built-in switches)	
									1*	PS SLD	368 low		Lubricating oil inlet turbocharger main pipe	b)
1	1	1		1	1	1	1	1		PE SLD	384 low	PE 386	Jacket cooling water inlet	
1	1	1	1	1		1	1	1		TE SLD	389 high	TE 387A	Jacket cooling water outlet/cylinder	
	1						1			TE SLD	414A high	TE 413	Scavenge air receiver	
1		1	1	1	1			1	1*	TS SLD	416 high	TS 415	Scavenge air fire/cylinder	
							1			TE SLD	425B high	TE 425A	Exhaust gas inlet turbocharger/turbocharger	
1	1	1		1			1	1		TE SLD	428 high	TE 426	Exhaust gas outlet after cylinder/cylinder	
			1	1		1				TE SLD	431	TE 426	Exhaust gas after cylinder, deviation from average	
1	1	1	1	1	1	1	1	1	1*	DS SLD	437 high		Oil mist in crankcase/cylinder	
									1*	WS SLD	473 high	WE 471	Axial vibration monitor Required for all 5-cylinder S..MC engines and for engines with PTO on fore end	

b) PE 371 can be used if only 1 turbocharger is applied

1 Indicates that a binary sensor (on-off) is required

A Indicates that a common analogue sensor can be used for alarm/slow down/remote indication

1*, A* These analogue sensors are MAN B&W Diesel's minimum requirements for Unattended Machinery Spaces (UMS), option: 4 75 127

Select one of the alternatives

Or alarm for low flow

Or alarm for overheating of main, crank, crosshead and chain drive bearings, option: 4 75 134

The tables are liable to change without notice, and are subject to latest class requirements.

178 30 12-4.2

Fig. 8.08: Slow down functions for UMS, option: 4 75 127

Class requirements for shut down

ABS	BV	DnVC	GL	LR	NKK	RINa	RS	IACS	MAN B&W	Function		Point of location
1	1	1	1	1	1	1	1	1	1*	PS SHD	335 low	Lubricating oil to main bearings and thrust bearing
1	1	1				1		1	1*	TS SHD	352 high	Thrust bearing segment
1	1	1	1	1	1	1	1	1	1*	PS SHD	359 low	Lubricating oil inlet to camshaft and/or exhaust valve actuators
									1*	PS SHD	374 low	Lubricating oil inlet to turbocharger main pipe
			1							PS SHD	384B low	Jacket cooling water inlet
1	1	1	1	1	1	1	1	1	1*	SE SHD	438 high	Engine overspeed

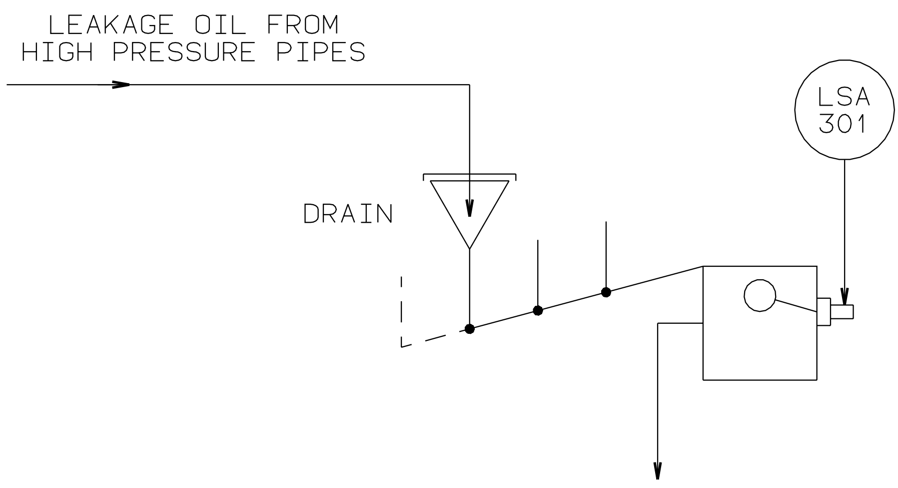
1 Indicates that a binary sensor (on-off) is required

1* These binary sensors for shut down are included in the basic scope of supply (4 75 124)

The tables are liable to change without notice, and are subject to latest class requirements.

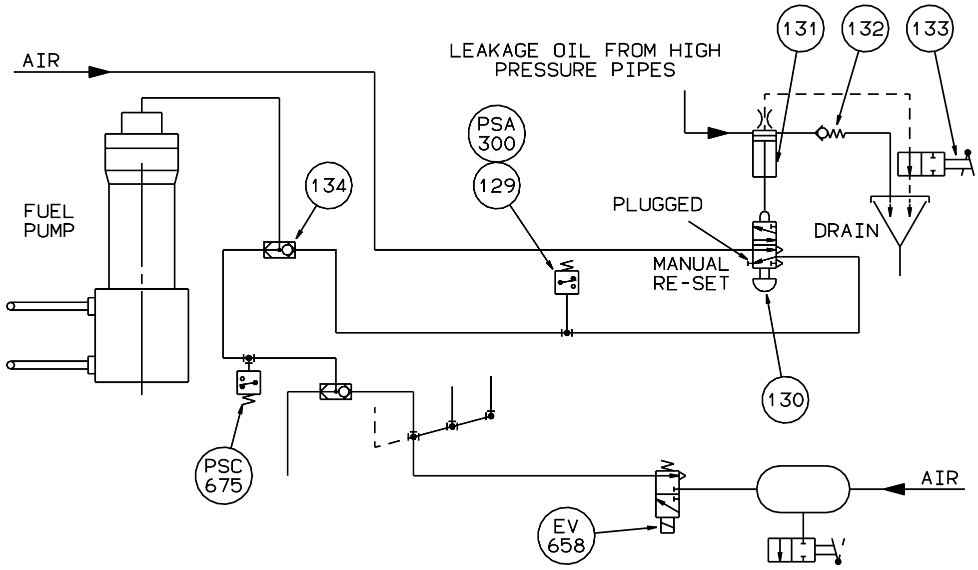
178 30 13-6.2

Fig. 8.09: Shut down functions for AMS and UMS



178 30 14-8.1

Fig. 8.10a: Heated drain box with fuel oil leakage alarm, option: 4 35 105



The pos. numbers refer to “list of instruments”
The piping is delivered with and fitted onto the engine

Pos.	Qty.	Description
129	1	Pressure switch
130	1	5/2-way valve
131	1	Diaphragm

Pos.	Qty.	Description
132	1	Non-return valve
133	1	Ball valve
134	1	Non-return valve

178 30 16-1.0

Fig. 8.10b: Fuel oil leakage, cut-out per cylinder, option: 4 35 106

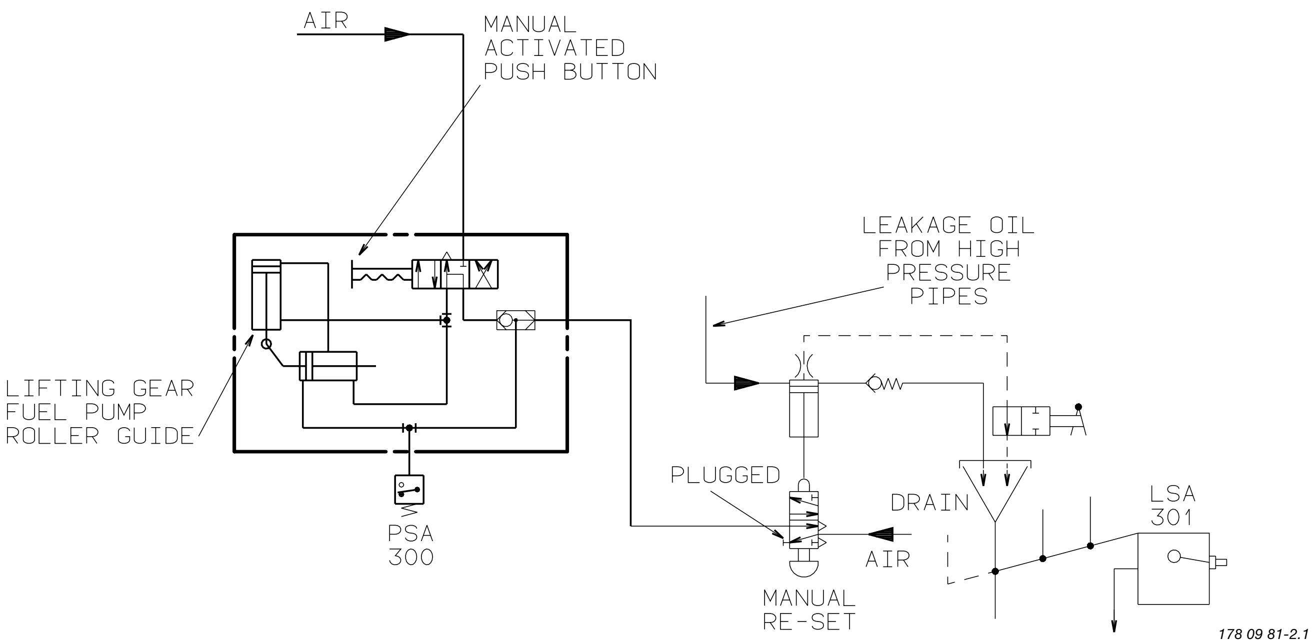
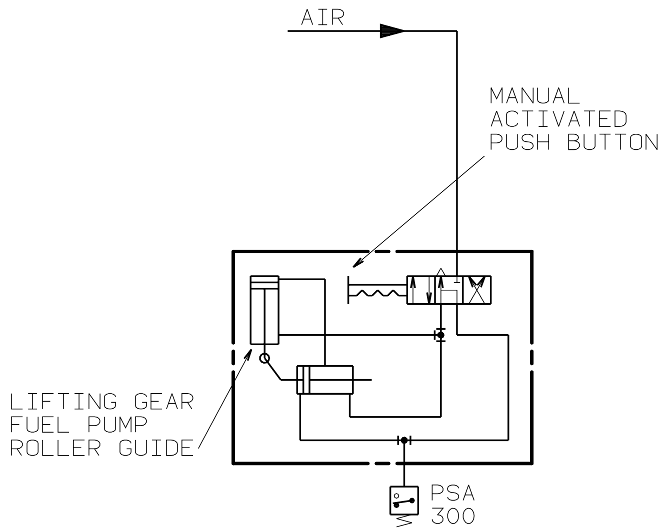


Fig. 8.11a: Fuel oil leakage with automatic or manually activated lift of fuel pump roller guide per cylinder, option 4 35 107



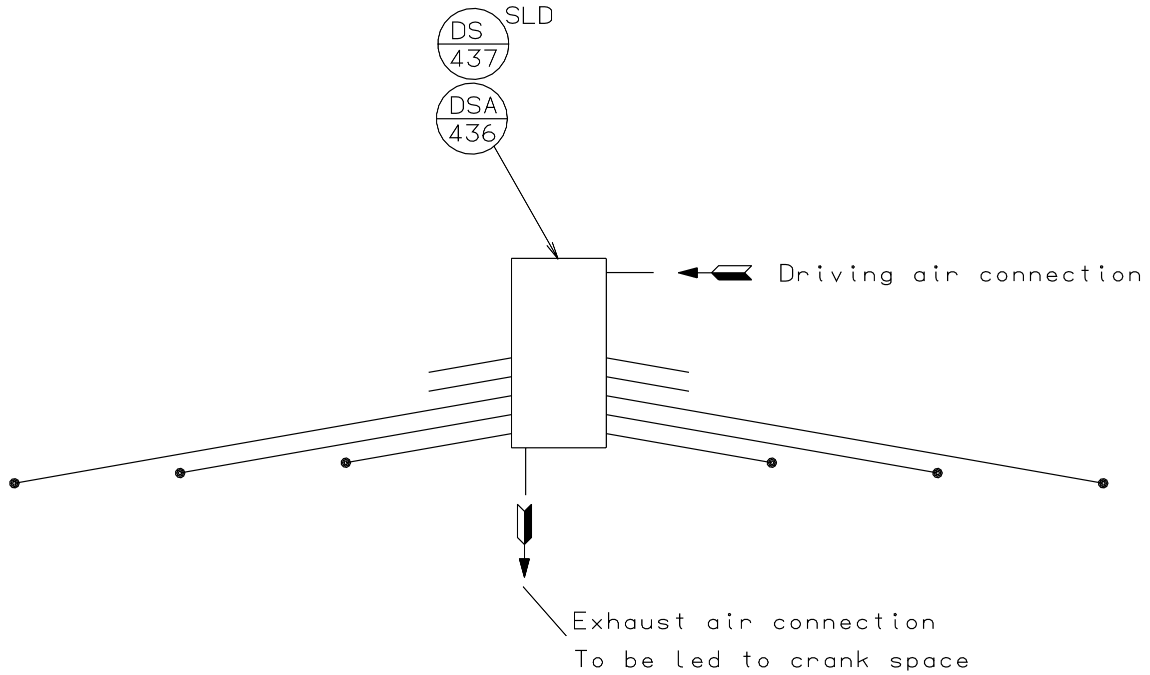
The pos. numbers refer to "list of instruments"
The piping is delivered with and fitted onto the engine

Pos.	Qty.	Description
129	1	Pressure switch
130	1	5/2-way valve
131	1	Diaphragm

Pos.	Qty.	Description
132	1	Non-return valve
133	1	Ball valve
134	1	Non-return valve

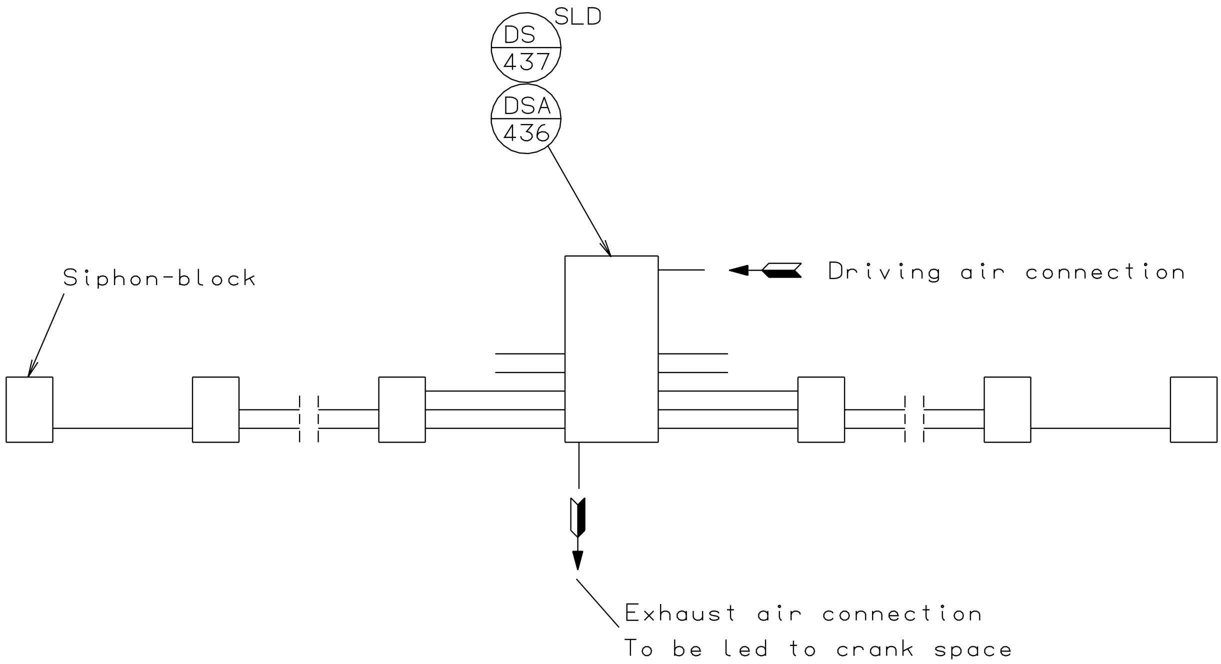
178 09 80-0.1

Fig. 8.11b: Semi-automatic, manually activated lifting arrangement of fuel pump roller guide, option: 4 35 132



178 30 18-5.1

Fig. 8.12a: Oil mist detector pipes on engine, from Kidde Fire Protection, Graviner, type MK 5 (4 75 161)



178 30 19-7.1

Fig. 8.12b: Oil mist detector pipes on engine, from Schaller, type Visatron VN215 (4 75 163)

Dispatch Pattern, Testing, Spares and Tools 9

9 Dispatch Pattern, Testing, Spares and Tools

Painting of Main Engine

The painting specification (Fig. 9.01) 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 in Fig. 9.01.

Dispatch Pattern

The dispatch patterns are divided into two classes, see Figs. 9.02 and 9.03:

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 from Fig. 9.03. 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 B&W 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 Fig. 9.04.

MAN B&W Diesel’s recommendations for shop trial, quay trial and sea trial are available on request.

An additional test may be required for measuring the NO_x emissions, if required, option: 4 14 003.

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 B&W 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 Fig. 9.05.

This amount is to be considered as minimum safety stock for emergency situations.

Additional spare parts recommended by MAN B&W Diesel

The above-mentioned set of spare parts can be extended with the 'Additional Spare Parts Recommended by MAN B&W' (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 Fig. 9.06.

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 Fig. 9.07, 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 Fig. 9.08. 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 of the main tools is stated in Fig. 9.09. A complete list will be delivered by the engine maker.

The dimensions and masses of the main tools appear from Figs. 9.10.

Most of the tools can be arranged on steel plate panels, which can be delivered as an option: 4 88 660, see Fig. 9.11 'Tool Panels'.

If such panels are delivered, it is recommended to place them close to the location where the overhaul is to be carried out.

Components to be painted before shipment from workshop	Type of paint	No. of coats/ Total dry film thickness m	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.	Complete coating for long term 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 Tools are to be surface treated according to specifications stated on the drawings. Purchased equipment painted in makers colour is acceptable, unless otherwise stated in the contract/drawing.	Electro-galvanized.	*	
Tool panels	Oil resistant paint.	2/60	**Light grey:** RAL 7038 DIN:24:1:2 MUNSELL N-7.5

* For required thickness of the electro-galvanization, see specification on drawings.

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 20-7.3

Fig. 9.01: Specification for painting of main engine: 4 81 101

Class A + B: Comprises the following basic variants:

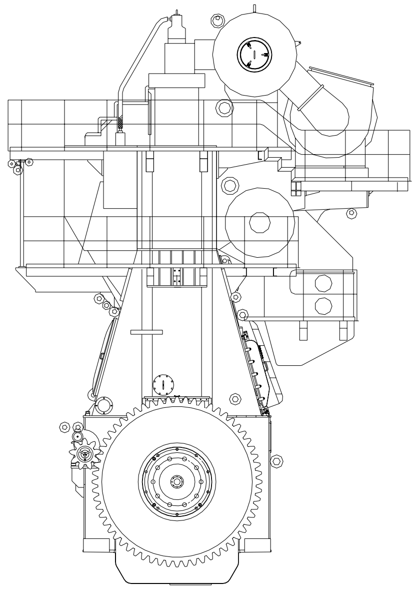
Dismounting must be limited as much as possible.

The classes comprise the following basic variants:

A1 Option: 4 12 021, or **B1**, option: 4 12 031

- Engine
- Spare parts and tools

A1 + B1

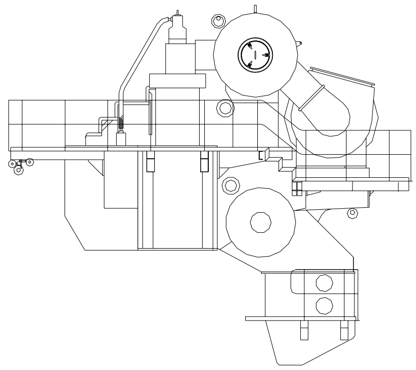


Engine complete

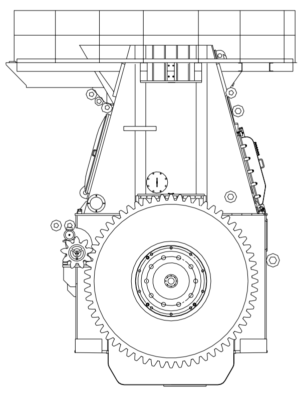
A2 Option: 4 12 022, or **B2** option: 4 12 032

- Top section including cylinder frame complete, cylinder covers complete, scavenge air receiver including cooler box and cooler, turbocharger(s) camshaft, piston rods complete and galleries with pipes
- Bottom section including bedplate complete frame box complete, connecting rods, turning gear, crankshaft with wheels and galleries
- Spares, tools, stay bolts
- Chains, etc.
- Remaining parts

A2 + B2



Top section



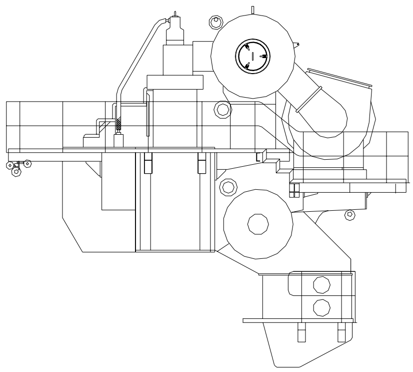
Bottom section

Fig. 9.02a: Dispatch pattern, engine with turbocharger on exhaust side, (4 59 122)

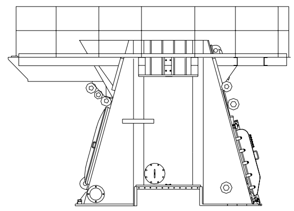
A3 Option: 4 12 023, or **B3** option: 4 12 033

- 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 chain drive, connecting rods and galleries
- Bedplate/cranckshaft section, turning gear and cranckshaft with wheels
- Remaining parts: spare parts, tools, stay bolts, chains, ect.

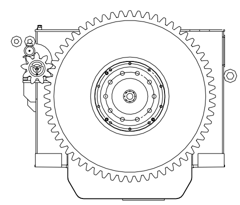
A3 + B3



Top section



Frame box section



Bedplate/cranckshaft section

Note:

The engine supplier is responsible for the necessary lifting tools and lifting instruction for transportation purpose to the yard. The delivery extent of the lifting tools, ownership and lend/lease conditions is to be stated in the contract.
Options: 4 12 120 or 4 12 121.

Furthermore, it must be stated whether a drying machine is to be installed during the transportation and/or storage period.
Option: 4 12 601.

Fig. 9.02b: Dispatch pattern, engine with turbocharger on exhaust side, (4 59 122)

Class A + B: Comprises the following basic variants:

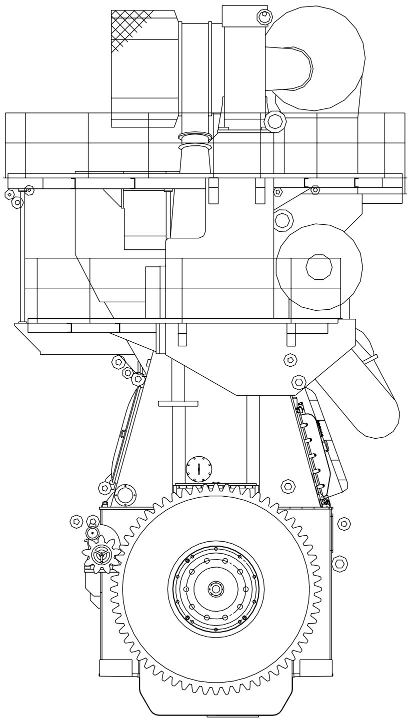
Dismounting must be limited as much as possible.

The classes comprise the following basic variants:

A1 Option: 4 12 021, or **B1**, option: 4 12 031

- Spare parts and tools
- Engine

A1 + B1

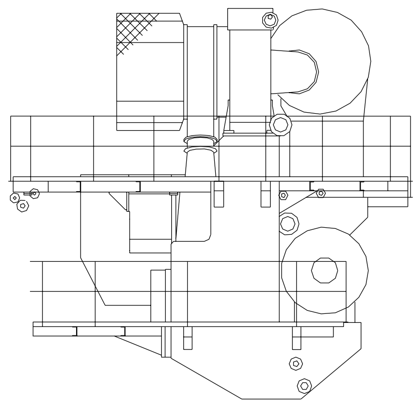


Engine complete

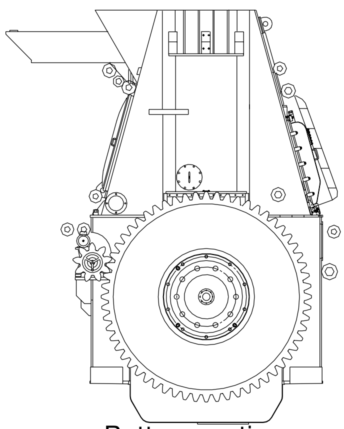
A2 Option: 4 12 022, or **B2** option: 4 12 032

- Top section including cylinder frame complete, cylinder covers complete, scavenge air receiver including cooler box and cooler, turbocharger camshaft, piston rods complete and galleries with pipes
- Bottom section including bedplate complete frame box complete, connecting rods, turning gear, crankshaft with wheels and galleries
- Spares, tools, stay bolts
- Chains, etc.
- Remaining parts

A2 + B2



Top section



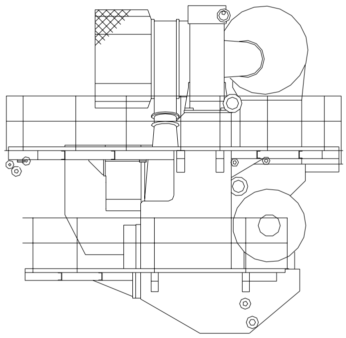
Bottom section

Fig. 9.02c: Dispatch pattern, engine with turbocharger on aft end, option 4 59 124

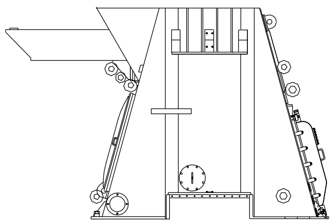
A3 Option: 4 12 023, or **B3** option: 4 12 033

- 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 chain drive, connecting rods and galleries
- Bedplate/crancksshaft section, turning gear and crancksshaft with wheels
- Remaining parts: spare parts, tools, stay bolts, chains, ect.

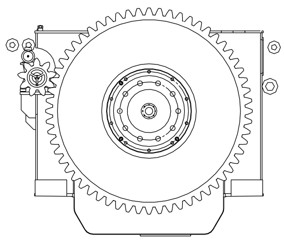
A3 + B3



Top section



Frame box section



Bedplate/crancksshaft section

Note:

The engine supplier is responsible for the necessary lifting tools and lifting instruction for transportation purpose to the yard. The delivery extent of the lifting tools, ownership and lend/lease conditions is to be stated in the contract.
Options: 4 12 120 or 4 12 121.

Furthermore, it must be stated whether a drying machine is to be installed during the transportation and/or storage period.
Option: 4 12 601.

Fig. 9.02d: Dispatch pattern, engine with turbocharger on aft end, option 4 59 124

Pattern	Section	4 cylinder		5 cylinder		6 cylinder		7 cylinder		8 cylinder			
		Mass in t	Length in m	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	284.0	8.1	330.1	9.1	380.9	10.2	422.3	11.3	469.7	12.3	10.7	7.3
A2+B2	Top section	104.2	7.1	123.3	8.2	148.1	9.2	167.2	10.3	186.3	11.4	5.3	7.3
	Bottom section	166.3	8.1	192.1	9.1	217.0	10.2	238.1	11.3	265.3	12.3	6.2	6.7
	Remaining parts	13.5		14.7		15.8		17.0		18.1			
A3+B3	Top section	104.2	7.1	123.3	8.2	148.1	9.2	167.2	10.3	186.3	11.4	5.3	7.3
	Frame box section	66.0	8.1	76.6	9.1	87.9	10.2	91.8	11.3	103.2	12.3	3.1	6.7
	Bedplate/ cranshaft	100.3	6.7	115.5	7.8	129.1	8.8	146.3	9.9	162.1	10.9	3.5	4.1
	Remaining parts	13.5		14.7		15.8		17.0		18.1			
A4+B4	Top section	76.4	7.1	93.4	8.2	110.3	9.2	127.3	10.3	144.2	11.4	4.5	4.0
	Exhaust receiver	5.9	5.1	6.6	6.2	7.4	7.2	8.1	8.3	8.9	9.4	2.5	2.0
	Scav air receiver	12.8	6.0	14.2	7.1	15.9	8.1	17.3	9.2	18.8	10.3	4.0	3.7
	Turbocharger	5.1		5.1		9.8		9.8		9.8			
	Air cooler	4.2		4.2		5.0		5.0		5.0			
	Frame box section	65.8	8.1	76.3	9.1	87.7	10.2	91.5	11.3	102.9	12.3	3.1	6.7
	Crankshaft	51.3	6.5	59.8	7.6	66.7	8.6	79.3	9.7	88.3	10.8	3.2	3.2
	Bedplate	48.5	6.4	55.2	7.5	61.9	8.5	66.6	9.6	73.3	10.7	3.1	4.1
	Remaining parts	14.0		15.2		16.3		17.5		18.6			

The weights are for standard engines with semi-built crankshaft of forged throws, integrated crosshead guides in frame box and MAN B&W turbocharger.

All masses and dimensions are approximate and without packing and lifting tools. The masses of turning wheel, turbocharger specified in dispatch pattern outline can vary, and should be checked.

Moment compensators and tuning wheel are not included in dispatch pattern outline. Turning wheel is assumed to be of 4 tons.

Fig. 9.03a: Dispatch pattern, list of masses and dimensions. Engine with turbocharger located on exhaust side: (4 59 122)

Pattern	Section	4 cylinder		5 cylinder		6 cylinder		7 cylinder		8 cylinder			
		Mass in t.	Length in m	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	288.0	8.5	334.3	10.0	385.0	11.0	426.4	12.4	473.9	13.5	10.7	5.9
A2+B2	Top section	107.6	8.5	127.0	10.0	151.6	11.0	170.7	12.4	189.9	13.5	6.0	5.9
	Bottom section	166.3	8.4	192.1	9.5	217.0	10.6	138.1	11.6	265.3	12.7	6.2	5.5
	Remaining parts	14.1		15.3		16.4		17.6		18.7			
A3+B3	Top section	107.6	8.5	127.0	10.0	151.6	11.0	170.7	12.4	189.9	13.5	6.0	5.9
	Frame box section	65.9	8.4	76.5	9.5	87.9	10.6	91.8	11.6	103.2	12.7	3.1	5.5
	Bedplate/ cranshaft	100.3	6.7	115.5	7.8	129.1	8.8	146.3	9.9	162.1	10.9	3.5	4.1
	Remaining parts	14.1		15.3		16.4		17.6		18.7			
A4+B4	Top section	76.1	8.5	93.0	10.0	110.0	11.0	126.9	12.4	143.9	13.5	4.5	4.0
	Exhaust receiver	6.3	5.7	7.0	6.8	7.7	7.8	8.5	8.9	9.2	10.0	2.5	2.0
	Scav air receiver	7.0	8.2	8.4	9.3	9.9	10.4	11.3	11.5	12.8	12.5	4.0	4.5
	Turbocharger	5.1		5.1		9.8		9.8		9.8			
	Air cooler box	8.5		8.5		8.5		8.5		8.5			
	Air cooler - insert	4.2		4.2		5.0		5.0		5.0			
	Frame box section	65.8	6.2	76.3	7.3	87.7	8.3	91.5	9.4	102.8	10.5	3.1	5.5
	Crankshaft	51.3	6.5	59.8	7.6	66.7	8.6	79.3	9.7	88.3	10.8	3.2	3.2
	Bedplate	48.5	6.4	55.2	7.5	61.9	8.5	66.6	9.6	73.3	10.7	3.1	4.1
	Remaining parts	15.3		16.8		18.0		19.1		20.4			

The weights are for standard engines with semi-built crankshaft of forged throws, integrated crosshead guides in frame box and MAN B&W turbochargers.

All masses and dimensions are approximate and without packing and lifting tools. The masses of turning wheel, turbocharger specified in dispatch pattern outline can vary, and should be checked.

Moment compensators and tuning wheel are not included in dispatch pattern outline. Turning wheel is assumed to be of 4 tons.

Fig. 9.03b: Dispatch pattern, list of masses and dimensions. Engine with turbocharger located on aft end, option: 4 59 124

Minimum delivery test:

- 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 50% of specified MCR
- 0.50 hour running at 75% of specified MCR
- 1.00 hour running at optimised power
  (guaranteed SFOC)
  or
  0.50 hour at 90% of specified MCR
  if SFOC is guaranteed at 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

If an engine with VIT fuel pumps is optimised below 93.5% of the specified MCR, and it is to run at 110% of the specified MCR during the shop trial, it must be possible to blow off either the scavenge air receiver or to by-pass the exhaust gas receiver in order to keep the turbocharger speed and the compression pressure within acceptable limits.

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 engine side manoeuvring console

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 B&W 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

178 30 24-4.2

Fig. 9.04: Shop trial running/delivery test: 4 14 001

Delivery extent of spares

Class requirements

CCS: China Classification Society
GL: Germanischer Lloyd
KR: Korean Register of Shipping
NKK: Nippon Kaiji Kyokai
RINa: Registro Italiano Navale
RS Russian Maritime Register of Shipping

Class recommendations

ABS: American Bureau of Shipping
BV: Bureau Veritas
DNVC: Det Norske Veritas Classification
LR: Lloyd's Register of Shipping

Cylinder cover, section 901 and others

1 Cylinder cover complete with fuel, exhaust, starting and safety valves, indicator valve and sealing rings (disassembled)

Piston, section 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, section 903

1 Cylinder liner with sealing rings and gaskets
1/2 set Studs for 1 cylinder cover

Cylinder lubricator, section 903

1 Mechanical cylinder lubricator, of largest size, complete or
1 set Spares for electronic Alpha lubricator

Connecting rod, and crosshead bearing, section 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, section 905

1 set Thrust pads for one face of each size, if different for "ahead" and "astern"

Chain drive, section 906

1 Of each type of bearings for: Camshaft at chain drive, chain tightener and intermediate shaft
6 Camshaft chain links (only for ABS, DNVC, LR, NKK and RS)
1 Cylinder lubricator drive: 6 chain links or gear wheels
1 Guide ring 2/2 for camshaft bearing

Starting valve, section 907

1 Starting valve, complete

Exhaust valve, section 908

2 Exhaust valves complete (1 for GL)
1 Pressure pipe for exhaust valve pipe

Fuel pump, section 909

1 Fuel pump barrel, complete with plunger
1 High-pressure pipe, each type
1 Suction and puncture valve, complete

Fuel valve, section 909

1 set Fuel valves for half the number of cylinders on the engine for ABS
1 set Fuel valves for all cylinders on one engine for BV, CCS, DNVC, GL, KR, LR, NKK, RINa, RS and IACS

Turbocharger, section 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, section 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

Safety valve, section 911

1 Safety valve, complete

Bedplate, section 912

1 Main bearing shell in 2/2 of each size
1 set Studs and nuts for 1 main bearing

a) Only required for RS and recommended for DNVC. To be ordered separately as option: 4 87 660 for DNVC and other classification societies

The section figures refer to the instruction books. Subject to change without notice.

178 39 43-4.4

Fig. 9.05: List of spares, unrestricted service: 4 87 601

For easier maintenance and increased security in operation

Beyond class requirements

Cylinder cover, plate 90101

4		Studs for exhaust valve
4		Nuts for exhaust valve
50	%	O-rings for cooling jacket
1		Cooling jacket
50	%	Sealing between cyl.cover and liner
4		Spring housings for fuel valve

Hydraulic tool for cylinder cover, plate 90161

1	set	Hydraulic hoses complete with couplings
8	pcs	O-rings with backup rings, upper
8	pcs	O-rings with backup rings, lower

Piston and piston rod, plate 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, plate 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, plate 90301

50	%	Studs for cylinder cover (1cyl.)
1		Bushing

Cylinder liner and cooling jacket, plate 90302

1		Cooling jacket of each kind
4		Non return valves
100	%	O-rings for one cylinder liner
50	%	Gaskets for cooling water connection
50	%	O-rings for cooling water pipes
100	%	Cooling water pipes between liner and cover for one cylinder

* % Refer to one cylinder

Mechanical lubricator drive, plate 90305

1		Coupling
3		Discs

Connecting rod and crosshead, plate 90401

1		Telescopic pipe
2		Thrust piece

Chain drive and guide bars, plate 90601

4		Guide bar
1	set	Locking plates and lock washers

Chain tightener, plate 90603

2		Locking plates for tightener

Camshaft, plate 90611

1		Exhaust cam
1		Fuel cam

Indicator drive, plate 90612

100	%	Gaskets for indicator valves
3		Indicator valve/cock complete

Regulating shaft, plate 90618

3		Resilient arm, complete

Arrangement of engine side console, plate 90621

2		Pull rods

Main starting valve, plate 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, plate 90704

2		Locking plates
2		Piston
2		Spring
2		Bushing
100	%	O-ring
1		Valve spindle

178 33 97-0.4

Fig. 9.06a: Additional spare parts beyond class requirements, option: 4 87 603

Exhaust valve, plate 90801

1		Exhaust valve spindle
1		Exhaust valve seat
50	%	O-ring exhaust valve/cylinder cover
4		Piston rings
50	%	Guide rings
50	%	Sealing rings
50	%	Safety valves
100	%	Gaskets and O-rings for safety valve
1		Piston complete
1		Damper piston
100	%	O-rings and sealings between air piston and exhaust valve housing/spindle
1		Liner for spindle guide
100	%	Gaskets and O-rings for cool.w.conn.
1		Conical ring in 2/2
100	%	O-rings for spindle/air piston
100	%	Non-return valve

Valve gear, plate 90802

3		Filter, complete
5		O-rings of each kind

Valve gear, plate 90805

1		Roller guide complete
2		Shaft pin for roller
2		Bushing for roller
4		Discs
2		Non return valve
4		Piston rings
4		Discs for spring
2		Springs
2		Roller

Valve gear, details, plate 90806

1		High pressure pipe, complete
100	%	O-rings for high pressure pipes
4		Sealing discs

Cooling water outlet, plate 90810

2		Ball valve
1		Butterfly valve
1		Compensator
1	set	Gaskets for butterfly valve and compensator

Fuel pump, plate 90901

1		Top cover
1		Plunger/barrel, complete
3		Suctions valves
3		Puncture valves
50	%	Sealings, O-rings, gaskets and lock washers

Fuel pump gear, plate 90902

1		Fuel pump roller guide, complete
2		Shaft pin for roller
2		Bushings for roller
2		Internal springs
2		External springs
100	%	Sealings
2		Roller

Fuel pump gear, details, plate 90903

50	%	O-rings for lifting tool

Fuel pump gear, details, plate 90904

1		Shock absorber, complete
1		Internal spring
1		External spring
100	%	Sealing and wearing rings
4		Felt rings

Fuel pump gear, reversing mechanism, plate 90905

1		Reversing mechanism, complete
2		Spare parts set for air cylinder

Fuel valve, plate 90910

100	%	Fuel nozzles
100	%	O-rings for fuel valve
3		Spindle guides, complete
50	%	Springs
50	%	Discs, +30 bar
3		Thrust spindles
3		Non return valve (if mounted)

Fuel oil high pressure pipes, plate 90913

1		High pressure pipe, complete of each kind
100	%	O-rings for high pressure pipes

Overflow valve, plate 90915

1		Overflow valve, complete
1		O-rings of each kind

Turbocharger, plate 91000

1		Spare rotor, complete with bearings, option: 4 87 660
1		Spare part set for turbocharger

Scavenge air receiver, plate 91001

2		Non-return valves complete
1		Compensator

* % Refer to one engine

178 33 97-0.4

Fig. 9.06b: Additional spare parts beyond class requirements, option: 4 87 603

Exhaust pipes and receiver, plate 91003

1	Compensator between TC and receiver
2	Compensator between exhaust valve and receiver
1 set	Gaskets for each compensator

Air cooler, plate 91005

16	Iron blocks (Corrosion blocks)

Safety valve, plate 91101

100 %	Gasket for safety valve
2	Safety valve, complete

Arrangement of safety cap, plate 91104

100 %	Bursting disc

The plate figures refer to the instruction book
Where nothing else is stated, the percentage refers to one engine
Liable to change without notice

178 33 97-0.4

Fig. 9.06c: Additional spare parts beyond class requirements, option: 4 87 603

Table A

Group No.	Plate	Qty.	Descriptions
1	90201	1 set	Piston rings for 1 cylinder
		1 set	O-rings for 1 cylinder
2	90205	1 set	Lamella rings 3/3 for 1 cylinder
		1 set	O-rings for 1 cylinder
3	90205	1 set	Top scraper rings 4/4 for 1 cylinder
		1 set	Sealing rings 4/4 for 1 cylinder
4	90302	1	Cylinder liner
		1 set	Outer O-rings for 1 cylinder
		1 set	O-rings for cooling water connections for 1 cylinder
		1 set	Gaskets for cooling water connection's for 1 cylinder
		1 set	Sealing rings for 1 cylinder
5	90801	1	Exhaust valve spindle
		1 set	Piston rings for exhaust valve air piston and oil piston for 1 cylinder
6	90801	1 set	O-rings for water connections for 1 cylinder
		1 set	Gasket for cooling for water connections for 1 cylinder
		1 set	O-rings for oil connections for 1 cylinder
7	90801	1	Spindle guide
		2	Air sealing ring
		1 set	Guide sealing rings for 1 cylinder
8	90801	1	Exhaust valve bottom piece
		1 set	O-rings for bottom piece for 1 cylinder
9	90805	1 set	Bushing for roller guides for 1 cylinder
		1 set	Washer for 1 cylinder
10	90901	1	Plunger and barrel for fuel pump
		1	Suction valve complete
		1 set	O-rings for 1 cylinder
11	90910	2	Fuel valve nozzle
		2	Spindle guide complete
		2 sets	O-rings for 1 cylinder
12		1	Slide bearing for turbocharger for 1 engine
		1	Guide bearing for turbocharger for 1 engine
13		1 set	Guide bars for 1 engine
14		2	Set bearings for auxiliary blowers for 1 engine

The wearing parts are divided into 14 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.

178 32 92-6.0

Fig. 9.07a: Wearing parts, option: 4 87 629

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	Set of piston rings	0	0	0	0	0	4	5	6	7	8
2	Set of piston rod stuffing box, lamella rings	0	0	0	0	0	4	5	6	7	8
3	Set of piston rod stuffing box, sealing rings	0	0	0	0	0	0	0	0	0	0
4	Cylinder liners	0	0	0	0	0	0	0	0	0	0
5	Exhaust valve spindles	0	0	0	0	0	0	0	0	0	0
6	O-rings for exhaust valve	4	5	6	7	8	8	10	12	14	16
7	Exhaust valve guide bushings	0	0	0	0	0	0	0	0	0	0
8	Exhaust seat bottom pieces	0	0	0	0	0	0	0	0	0	0
9	Bushings for roller guides for fuel pump and exhaust valve	0	0	0	0	0	0	0	0	0	0
10	Fuel pump plungers	0	0	0	0	0	0	0	0	0	0
11	Fuel valve guides and atomizers	0	0	0	0	0	0	0	0	0	0
12	Set slide bearings per TC	0	0	0	0	0	0	0	0	0	0
13	Set guide bars for chain drive	0	0	0	0	0	0	0	0	0	0
14	Set bearings for auxiliary blower	0	0	0	0	0	0	0	0	0	0

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	Set of piston rings	4	5	6	7	8	8	10	12	14	16
2	Set of piston rod stuffing box, lamella rings	4	5	6	7	8	8	10	12	14	16
3	Set of piston rod stuffing box, sealing rings	0	0	0	0	0	4	5	6	7	8
4	Cylinder liners	0	0	0	0	0	0	0	0	0	0
5	Exhaust valve spindles	0	0	0	0	0	0	0	0	0	0
6	O-rings for exhaust valve	12	15	18	21	24	16	20	24	28	32
7	Exhaust valve guide bushings	4	5	6	7	8	4	5	6	7	8
8	Exhaust seat bottom pieces	0	0	0	0	0	0	0	0	0	0
9	Bushings for roller guides for fuel pump and exhaust valve	0	0	0	0	0	0	0	0	0	0
10	Fuel pump plungers	0	0	0	0	0	0	0	0	0	0
11	Fuel valve guides and atomizers	8	10	12	14	16	8	10	12	14	16
12	Set slide bearings per TC	0	0	0	0	0	1	1	1	1	1
13	Set guide bars for chain drive	0	0	0	0	0	0	0	0	0	0
14	Set bearings for auxiliary blower	0	0	0	0	0	1	1	1	1	1

178 32 92-6.0

Fig.9.07b: 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	Set of piston rings	8	10	12	14	16	12	15	18	21	24
2	Set of piston rod stuffing box, lamella rings	8	10	12	14	16	12	15	18	21	24
3	Set of piston rod stuffing box, sealing rings	4	5	6	7	8	4	5	6	7	8
4	Cylinder liners	0	0	0	0	0	0	0	0	0	0
5	Exhaust valve spindles	0	0	0	0	0	4	5	6	7	8
6	O-rings for exhaust valve	20	25	30	35	40	24	30	36	42	48
7	Exhaust valve guide bushings	8	10	12	14	16	8	10	12	14	16
8	Exhaust seat bottom pieces	0	0	0	0	0	4	5	6	7	8
9	Bushings for roller guides for fuel pump and exhaust valve	0	0	0	0	0	4	5	6	7	8
10	Fuel pump plungers	0	0	0	0	0	4	5	6	7	8
11	Fuel valve guides and atomizers	8	10	12	14	16	16	20	24	28	32
12	Set slide bearings per TC	1	1	1	1	1	1	1	1	1	1
13	Set guide bars for chain drive	0	0	0	0	0	1	1	1	1	1
14	Set bearings for auxiliary blower	1	1	1	1	1	1	1	1	1	1

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	Set of piston rings	12	15	18	21	24	16	20	24	28	32
2	Set of piston rod stuffing box, lamella rings	12	15	18	21	24	16	20	24	28	32
3	Set of piston rod stuffing box, sealing rings	8	10	12	14	16	8	10	12	14	16
4	Cylinder liners	0	0	0	0	0	0	0	0	0	0
5	Exhaust valve spindles	4	5	6	7	8	4	5	6	7	8
6	O-rings for exhaust valve	28	35	42	49	56	32	40	48	56	64
7	Exhaust valve guide bushings	12	15	18	21	24	12	15	18	21	24
8	Exhaust seat bottom pieces	4	5	6	7	8	4	5	6	7	8
9	Bushings for roller guides for fuel pump and exhaust valve	4	5	6	7	8	4	5	6	7	8
10	Fuel pump plungers	4	5	6	7	8	4	5	6	7	8
11	Fuel valve guides and atomizers	16	20	24	28	32	24	30	36	42	48
12	Set slide bearings per TC	1	1	1	1	1	2	2	2	2	2
13	Set guide bars for chain drive	1	1	1	1	1	1	1	1	1	1
14	Set bearings for auxiliary blower	1	1	1	1	1	2	2	2	2	2

178 32 92-6.0

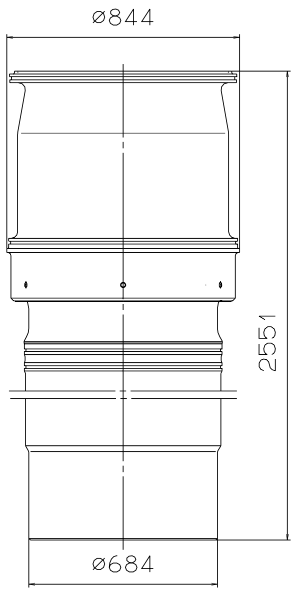
Fig. 9.07c: Wearing parts, option: 4 87 629

Table B

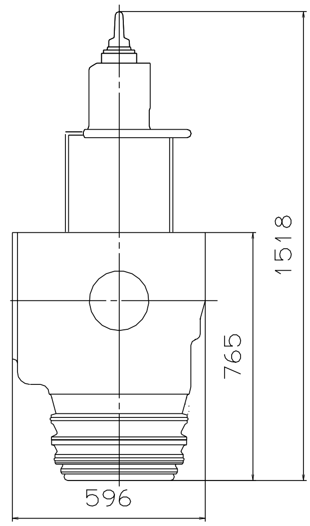
Group No.	Service hours	0-54000					0-60000				
		Number of cylinders									
	Description	4	5	6	7	8	4	5	6	7	8
1	Set of piston rings	16	20	24	28	32	20	25	30	35	40
2	Set of piston rod stuffing box, lamella rings	16	20	24	28	32	20	25	30	35	40
3	Set of piston rod stuffing box, sealing rings	8	10	12	14	16	12	15	18	21	24
4	Cylinder liners	0	0	0	0	0	0	0	0	0	0
5	Exhaust valve spindles	4	5	6	7	8	4	5	6	7	8
6	O-rings for exhaust valve	36	45	54	63	72	40	50	60	70	80
7	Exhaust valve guide bushings	16	20	24	28	32	16	20	24	28	32
8	Exhaust seat bottom pieces	4	5	6	7	8	4	5	6	7	8
9	Bushings for roller guides for fuel pump and exhaust valve	4	5	6	7	8	4	5	6	7	8
10	Fuel pump plungers	4	5	6	7	8	4	5	6	7	8
11	Fuel valve guides and atomizers	24	30	36	42	48	24	30	36	42	48
12	Set slide bearings per TC	2	2	2	2	2	2	2	2	2	2
13	Set guide bars for chain drive	1	1	1	1	1	1	1	1	1	1
14	Set bearings for auxiliary blower	2	2	2	2	2	2	2	2	2	2

178 32 92-6.0

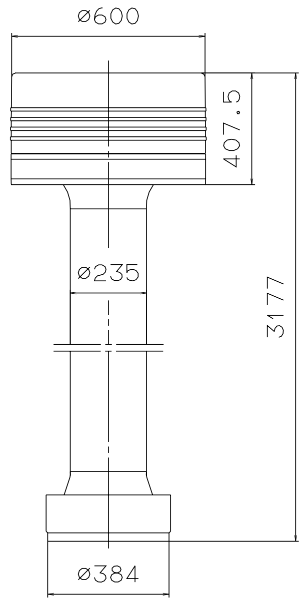
Fig. 9.07d: Wearing parts, option: 4 87 629



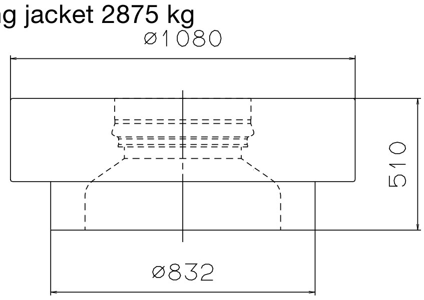
Cylinder liner 2643 kg
Cylinder liner inclusive
cooling jacket 2875 kg



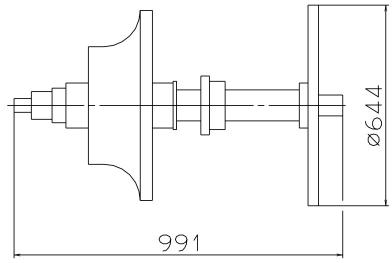
Exhaust valve
753,5 kg



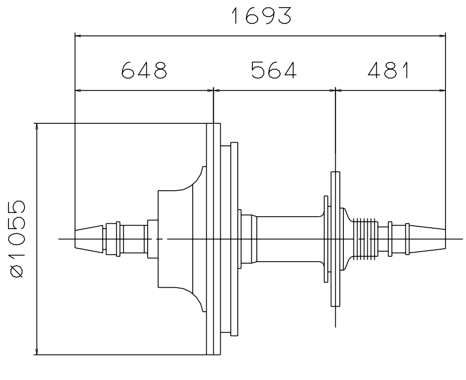
Piston complete
with piston rod
1396 kg



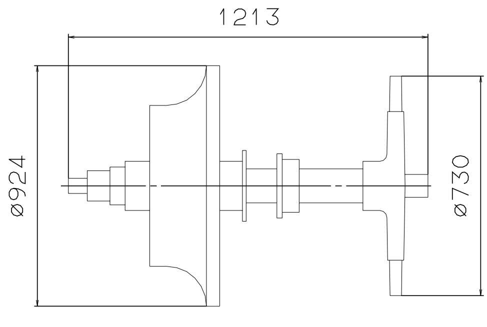
Cylinder cover 1715 kg
Cylinder cover inclusive
starting and fuel valves 767 kg



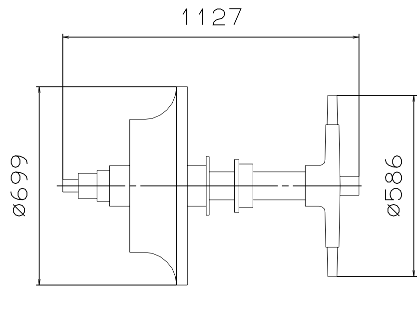
Rotor for turbocharger
Type NA57
170 kg



Rotor for turbocharger
Type VTR564
487 kg



Rotor for turbocharger
Type MET66SD
250 kg



Rotor for turbocharger
Type TPL 77
162 kg

All dimensions are given in mm

1784941-3.0

Fig. 9.08: Large spare parts, dimensions and masses

Mass of the complete set of tools: about 2,700 kg

The engine is delivered with all necessary special tools for overhaul. The extent of the tools is stated below. Most of the tools can be arranged on steel plate panels which can be delivered as option: 4 88 660 at extra cost. Where such panels are delivered, it is recommended to place them close to the location where the overhaul is to be carried out.

Cylinder cover, section 901

1 Cylinder cover and liner surface grinder (option 4 88 610)
1 set Milling and grinding tool for valve seats
1 set Fuel valve extractor
1 set Chains for lift of cylinder cover
1 set Hydraulic jacks for cylinder cover studs (hydraulic tightening)
1 set Starting valve overhaul tool
1 set Safety valve pressure testing tool

Piston with rod and stuffing box, section 902

1 set Lifting and tilting gear for piston
1 Lifting tool for piston
1 Guide ring for piston
1 Support for piston
1 set Piston overhaul tool
1 set Stuffing box overhaul tool
1 set Cylinder liner lifting and tilting gear

Crosshead and connecting rod, section 904

1 set Covers for crosshead
1 set Hydraulic jacks for crosshead and crankpin bearing bolt
1 set Support of crosshead
1 Lifting tool for crosshead
1 set Crankpin bearing lifting tool
1 set Connecting rod lifting tool
1 set Lifting tool for crankpin shell
1 set Hydraulic jack for connecting rod

Crankshaft and main bearing, section 905

1 set Hydraulic jack for main bearing segment stop
1 set Lifting tool for main bearing cap
1 set Dismantling/mounting tools for main bearing
1 Tools for turning out segments
1 set Crankcase relief valve testing tool
1 Crossbar lifting segment stops
1 Lifting tool for thrust shaft

Camshaft and chain drive, section 906

1 set Dismantling tool for camshaft bearing
1 Dismantling tool for camshaft coupling
1 set Camshaft adjusting tool
1 set Pin gauge for camshaft
1 Pin gauge for crankshaft top dead centre
1 set Chain assembling tool
1 set Chain disassembling tool

Exhaust valve and valve gear, section 908

1 Tightening gauge for actuator housing
1 set Hydraulic jack for exhaust valve stud
1 Claw for exhaust valve spindle
1 Exhaust valve spindle and seat pneumatic support grinding machine, option: 4 88 616
1 set Exhaust valve spindle and seat checking template
1 Guide ring for pneumatic piston
1 set Overhaul tool for high pressure connections
1 set Lifting device for roller guide and hydraulic actuator
1 set Roller guide dismantling tool
1 Bridge gauge, exhaust valve
1 Tool for hydraulic piston

178 88 86-2.0

Fig. 9.09a: List of standard tools for maintenance: 4 88 601

Fuel valve and fuel pump, section 909

1 Tightening gauge for fuel pump housing
1 Fuel valve pressure testing device
1 set Fuel valve overhaul tool
1 Fuel pump lead measuring tool
1 Lifting tool for fuel pump
1 set Fuel pump overhaul tool
1 set Fuel oil high pressure pipe and connection overhaul tool

Turbocharger and air cooler system, section 910

1 set Turbocharger overhaul tool
1 set Exhaust gas system blanking-off tool (only when two or more TC`s are fitted)
1 set Air cooler tool
1 Travelling trolley for scavenge air cooler

Main part assembling, section 912

1 set Staybolt hydraulic jack
1 set Cover for oil drain

General tools, section 913

Accessories, plate 913.1

1 Hydraulic pump, pneumatically operated
1 Hydraulic pump, manually operated
1 set High pressure hose and connection

Ordinary hand tools, plate 913.2

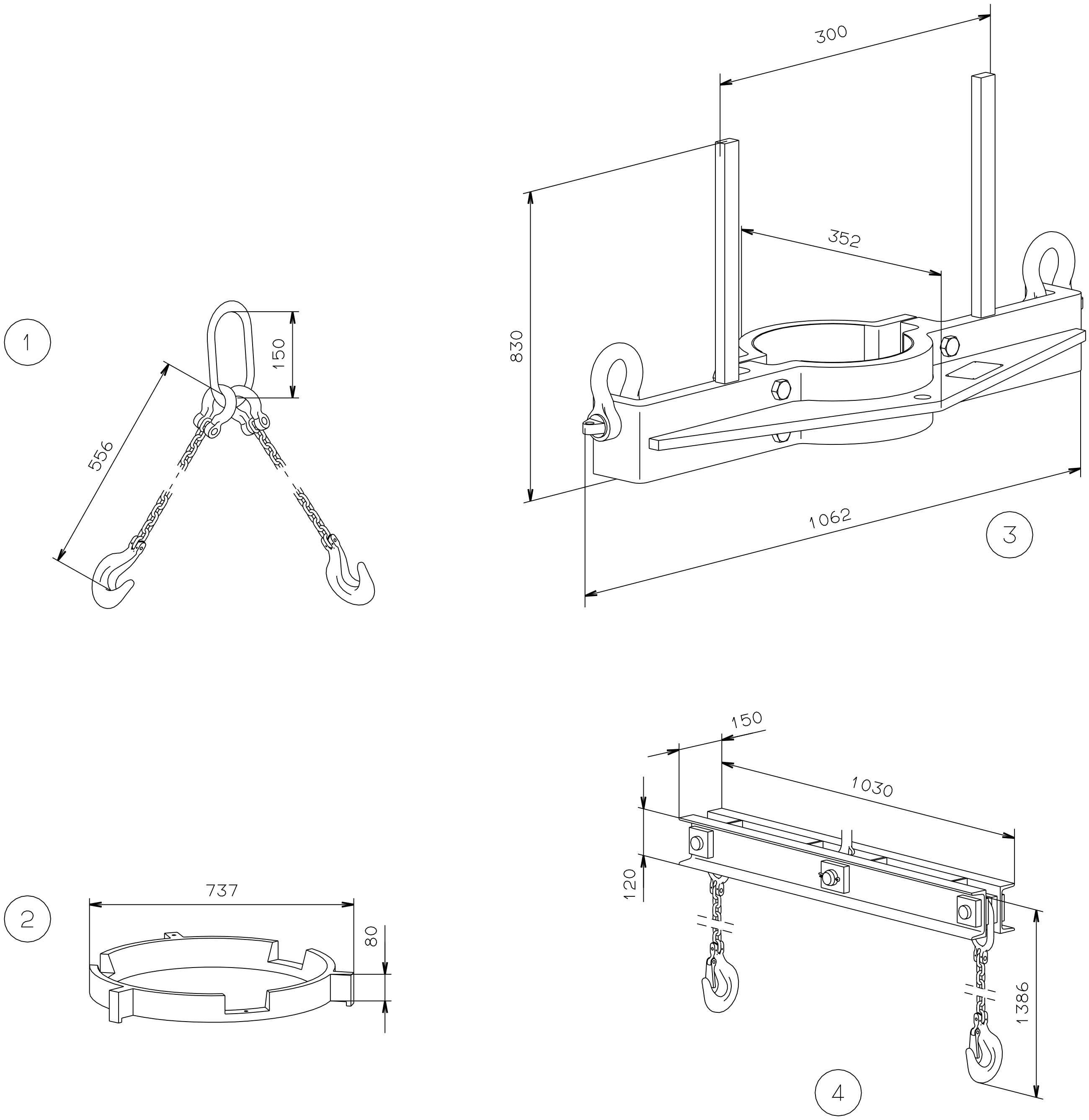
1 set Torque wrench
1 set Socket wrench
1 set Hexagon key
1 set Combination wrench
1 set Double open-ended wrench
1 set Ring impact wrench
1 set Open-ended impact wrench
1 set Pliers for circlip
1 set Special spanner

Miscellaneous, plate 913.3

1 set Pull-lift and tackle
1 set Shackle
1 set Eye-bolt
1 set Foot grating
1 Indicator with cards
1 set Feeler blade
1 Crankshaft alignment indicator
1 Cylinder gauge
1 Planimeter (if indicator gear is fitted)

178 88 86-2.0

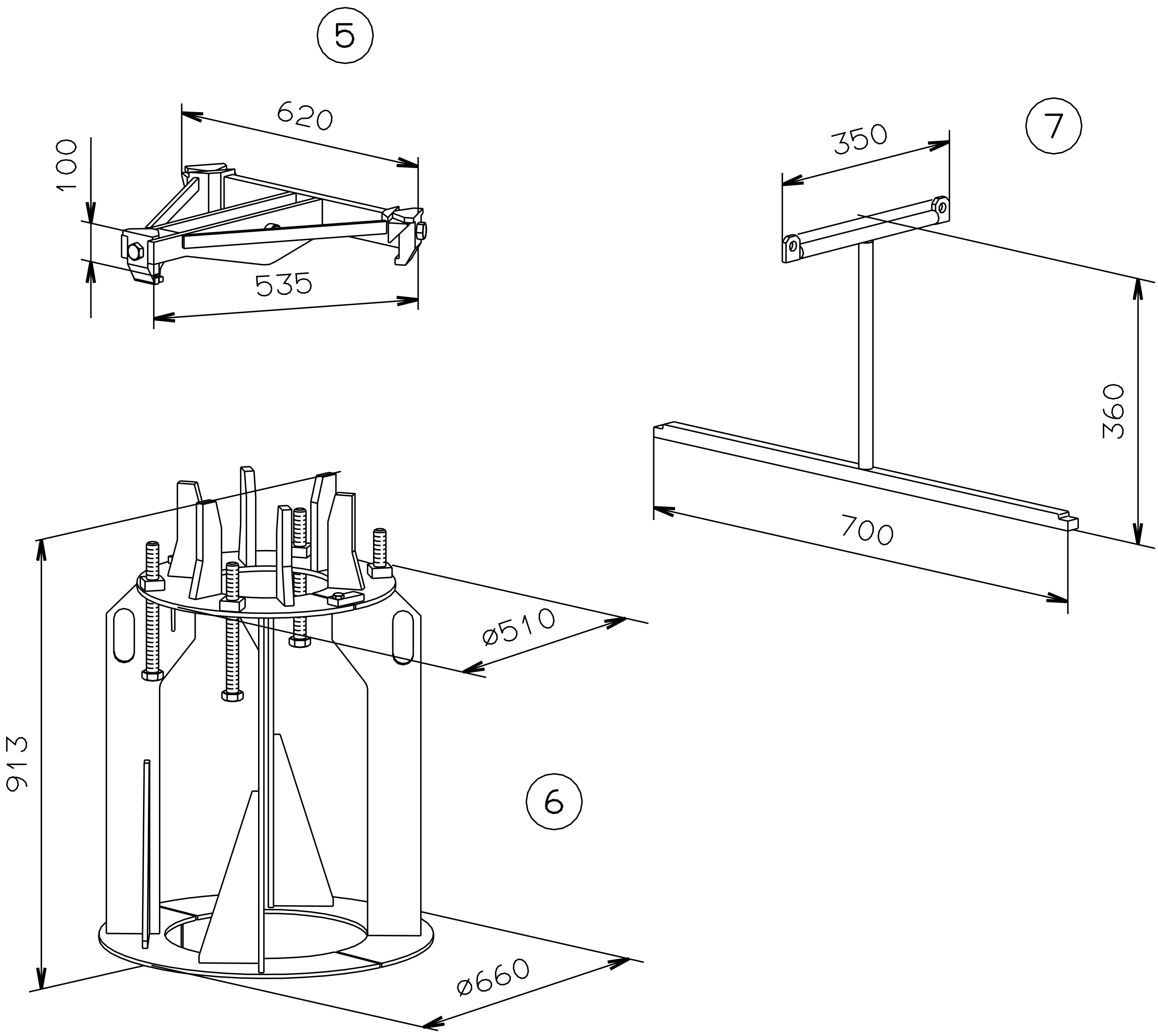
Fig. 9.09b: List of standard tools for maintenance: 4 88 601



Pos.	Sec	Description	Mass in kg
1	901	Chain for lift of cylinder cover	6
2	902	Guide ring for piston	47
3	902	Collar ring for piston	50
4	902	Crossbar for cylinder liner and piston	46

178 45 78-1.1

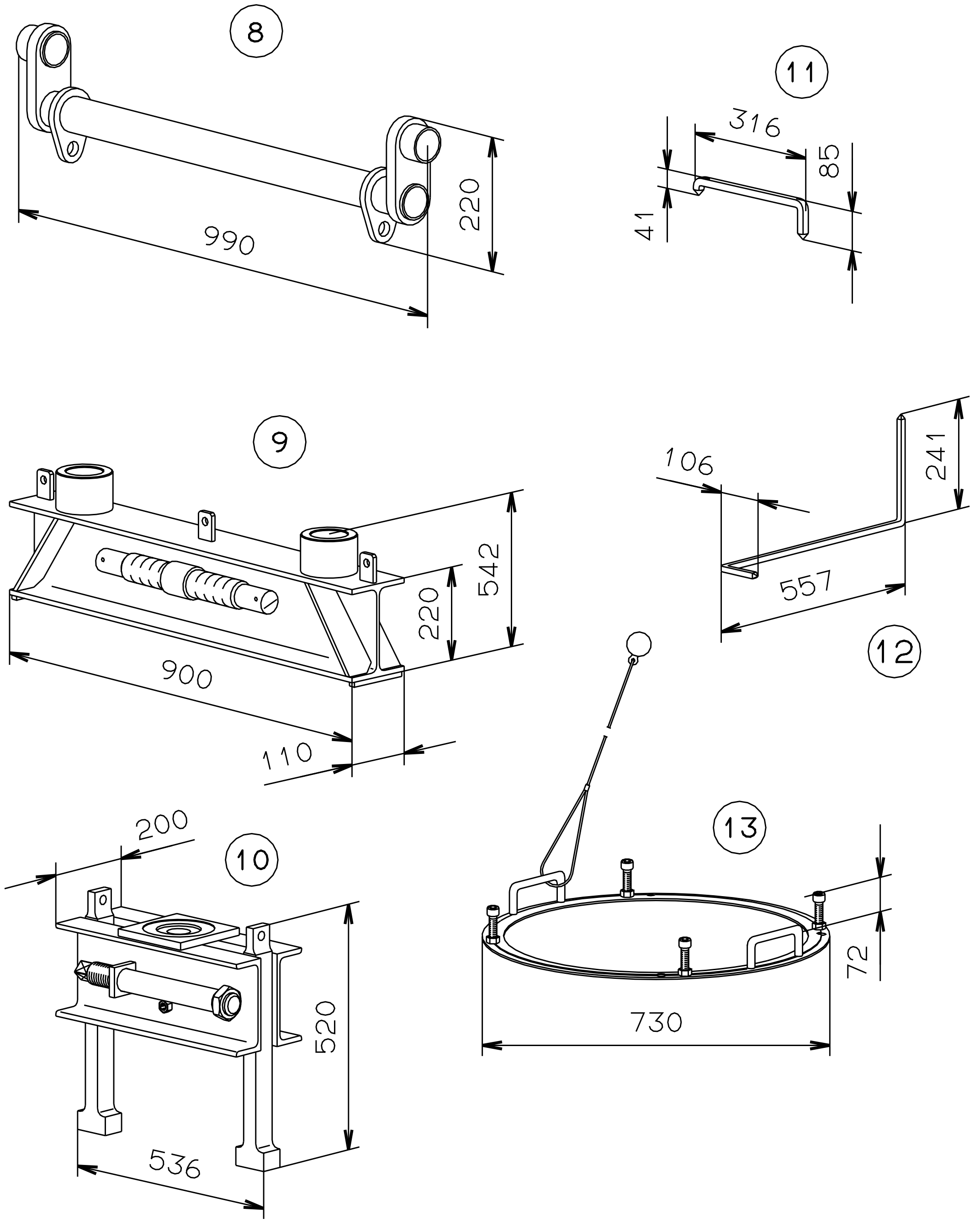
Fig. 9.10a: Dimensions and masses of tools (for guidance only)



Pos.	Sec	Description	Mass in kg
5	902	Lifting tool for piston	23
6	902	Support for piston	73
7	904	Lifting tool for cran pin shell	8

178 45 78-1.1

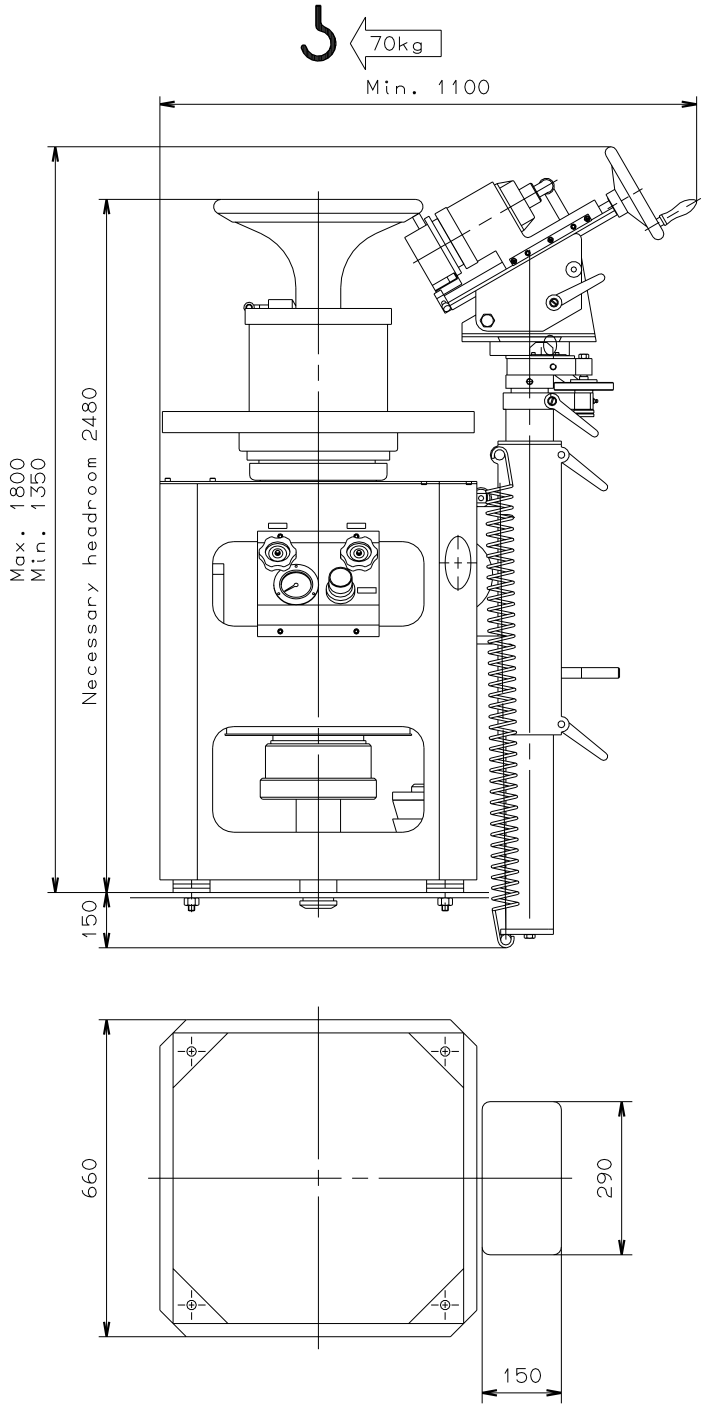
Fig. 9.10b: Dimensions and masses of tools (for guidance only)



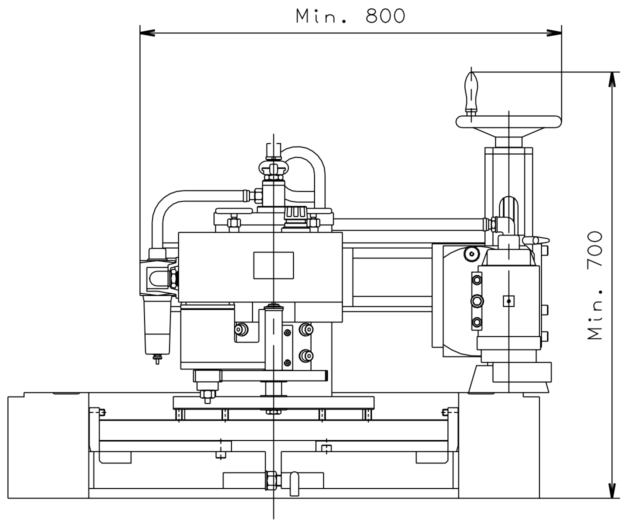
Pos.	Sec	Description	Mass in kg
8	905	Crossbar for lift of segment stops	4
9	905	Lifting tool for crankshaft	36
10	905	Lifting tool for thrust shaft	44
11	906	Pin gauge for camshaft	1
12	906	Pin gauge for crankshaft top dead centre	1
13	912	Cover for oil drain	10

178 45 78-1.1

Fig. 9.10c: Dimensions and masses of tools (for guidance only)



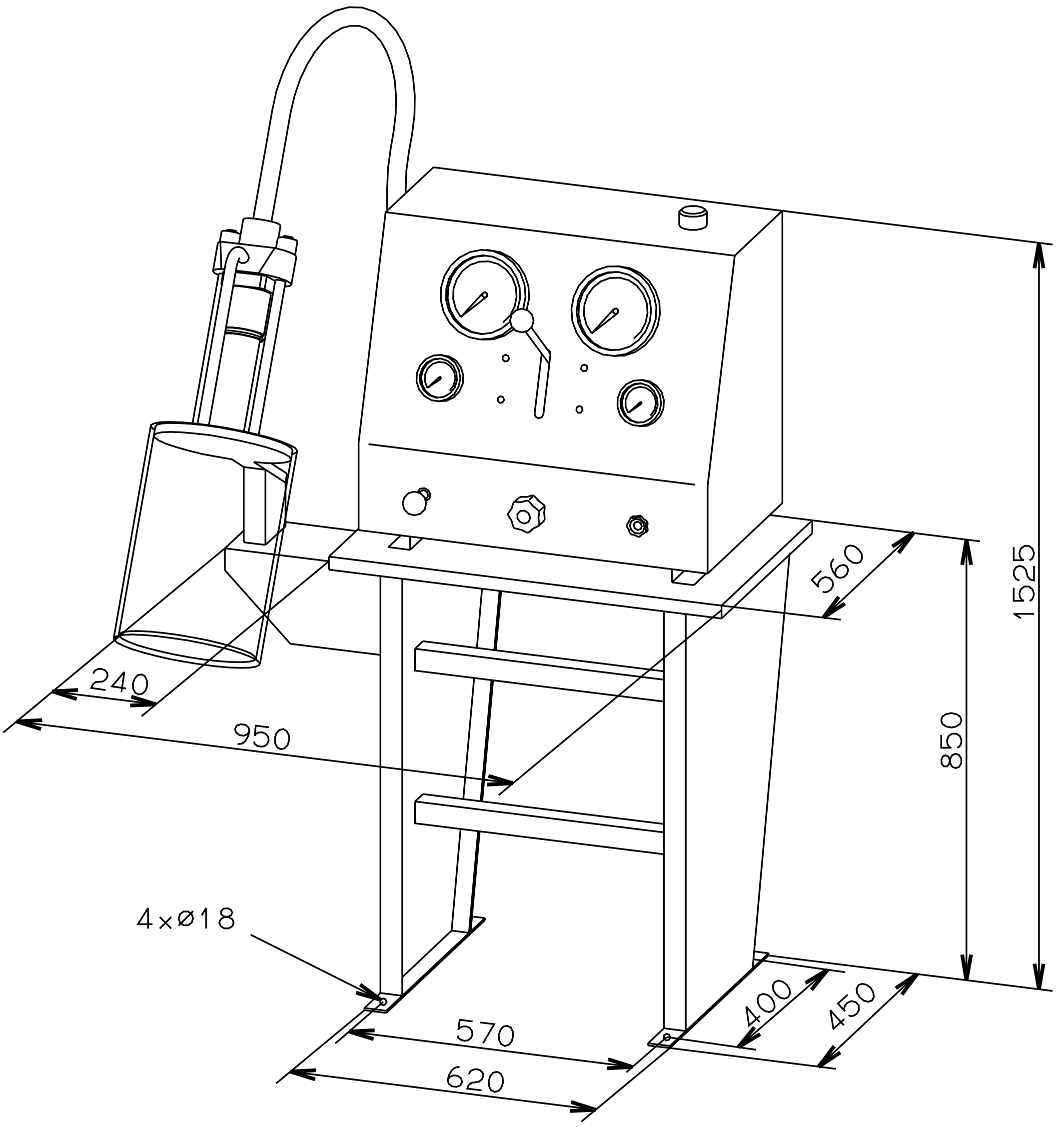
Option: 4 88 617
Grinding machine
exhaust valve seat
and spindle
Mass 500 kg



Option: 4 88 610
Grinding machine
Cylinder liner and
cylinder cover
Mass 410 kg

178 14 69-1.2

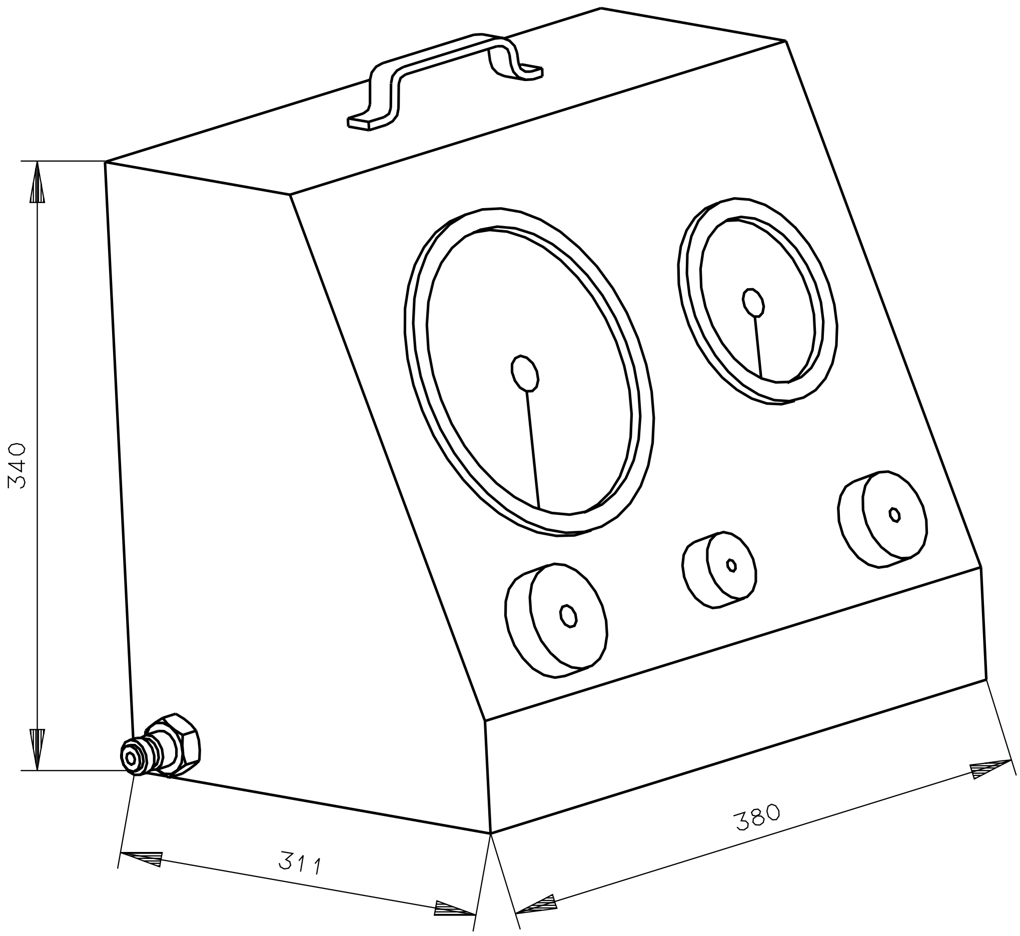
Fig. 9.10d: Dimensions and masses of tools (for guidance only)



Sec.	Description	Mass in kg
909	Fuel valve pressure control device	100

178 13 50-1.1

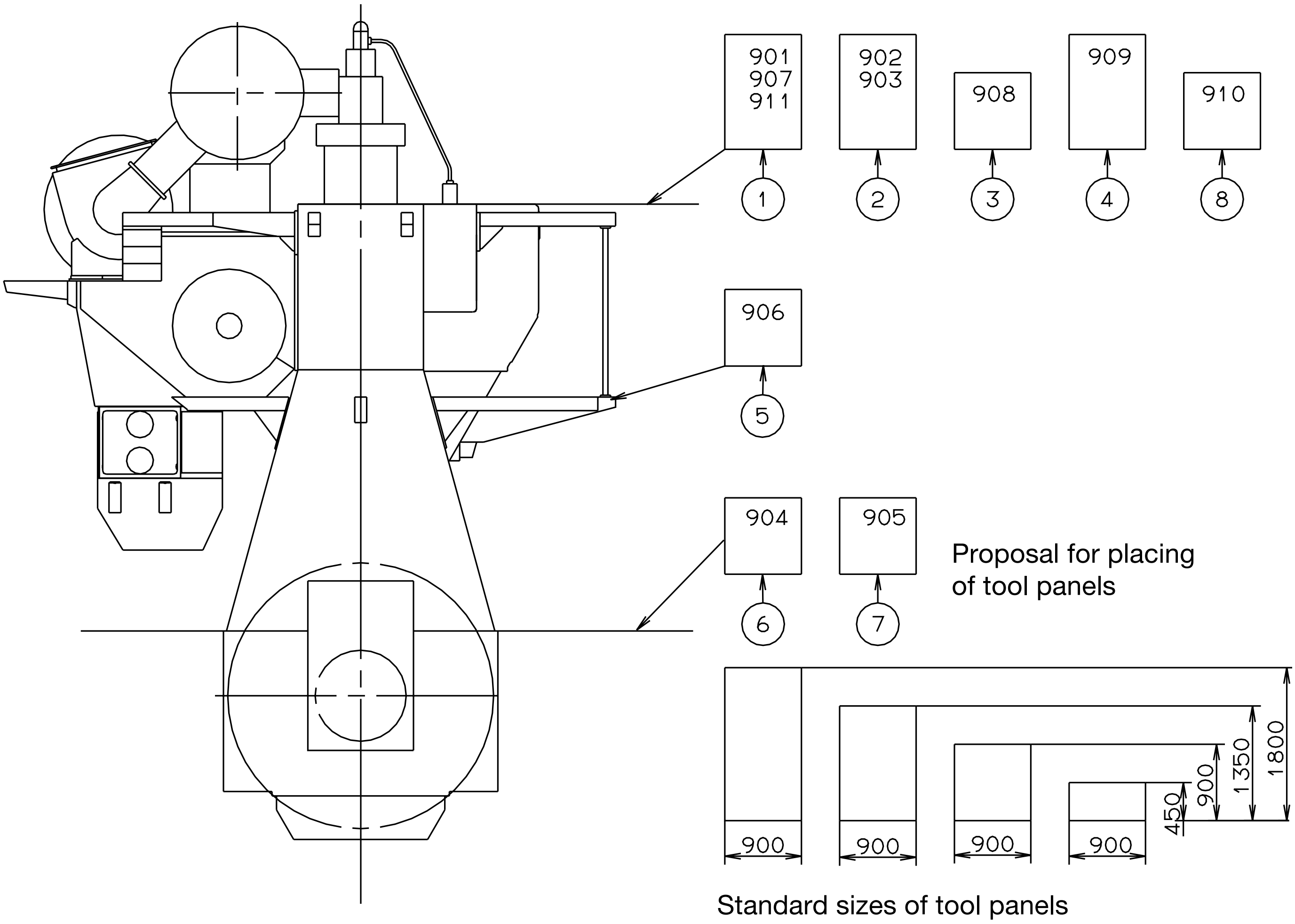
Fig. 9.10e: Dimension and masses of tools (for guidance only)



Sec.	Description	Mass in kg
913	Pump for hydraulic jacks	20

178 34 38-1.1

Fig. 9.10f: Dimension and masses of tools (for guidance only)



Pos.	Section	Description	Mass of tools in kg
1	901 907 911	Cylinder cover Starting air system* Safety equipment*	94
2	902 903	Piston, piston rod and stuffing box Cylinder liner and cylinder frame**	100
3	908	Exhaust valve and valve gear	61
4	909	Fuel valve and fuel pump	81
5	906	Camshaft, chain drive	138
6	904	Crosshead and connecting rod	109
7	905	Crankshaft and main bearing	55
8	910	Turbocharger, scavenge air cooler	90

* Tools for MS. 907 are being delivered on tool panel under MS. 901

** Tools for MS. 903 are being delivered on tool panel under MS. 902

178 39 64-9.0

Fig. 9.11: Tool panels, option: 4 88 660

Documentation 10

10 Documentation

MAN B&W Diesel is capable of providing a wide variety of support for the shipping and shipbuilding industries all over the world.

The knowledge accumulated over many decades by MAN B&W 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 knowledge is presented in the book entitled “Engine Selection Guide”, other details can be found in more specific literature issued by MAN B&W Diesel, such as “Project Guides” similar to the present, and in technical papers on specific subjects, while supplementary information is available on request. An “Order Form” for such printed matter listing the publications currently in print, is available from our agents, overseas offices or directly from MAN B&W Diesel A/S, Copenhagen.

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.

Engine Selection Guide

The “Engine Selection Guide” is intended as a tool to provide assistance at the very initial stage of the project work. The Guide gives a general view of the MAN B&W two-stroke MC Programme and includes information on the following subjects:

- Engine data
- Layout and load diagrams specific fuel oil consumption
- Turbocharger choice
- Electricity production, including power take off
- Installation aspects
- Auxiliary systems
- MC-engine packages, including controllable pitch propellers, auxiliary units, remote control system
- 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 detailed project can be carried out based on the “Project Guide” for the specific engine type selected.

Project Guides

For each engine type 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 contract, depending 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:
- Turbocharger choice
- Instrumentation
- Dispatch pattern
- Testing
- Dispatch pattern
- Testing
- Spares and
- Tools.

Project Support

Further customised documentation can be obtained from MAN B&W Diesel A/S, 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 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, FW production
- Starting air system.

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 MC engines.

There are two versions of the EOD:

- Extent of Delivery for 98 - 50 type engines, and
- Extent of Delivery for 46 - 26 type engines.

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	Electrical power available
4 12 xxx	Dismantling and packing of engine
4 14 xxx	Testing of diesel engine
4 17 xxx	Supervisors and advisory work

Diesel engine

4 30 xxx	Diesel engine
4 31 xxx	Torsional and axial vibrations
4 35 xxx	Fuel oil system
4 40 xxx	Lubricating oil system
4 42 xxx	Cylinder lubricating oil system
4 43 xxx	Piston rod stuffing box drain system
4 45 xxx	Low temperature cooling water system
4 46 xxx	Jacket cooling water system
4 50 xxx	Starting and control air systems
4 54 xxx	Scavenge air cooler
4 55 xxx	Scavenge air system
4 59 xxx	Turbocharger
4 60 xxx	Exhaust gas system
4 65 xxx	Manoeuvring system
4 70 xxx	Instrumentation
4 75 xxx	Safety, alarm and remote indi. system
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 some "basic" items and some "optional" items.

The "Basic" items defines 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 scope of supply mostly required, 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 B&W
- Moment compensator for certain numbers of cylinders
- MAN B&W turbochargers
- Slow turning before starting
- Spare parts either required or recommended by the classification societies and MAN B&W
- Tools required or recommended by the classification societies and MAN B&W.

The 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.

The "Installation Documentation" is 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 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 yard'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 B&W Diesel A/S and most of our licensees are using computerised drawings (Cadam), 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 disc.

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

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

915 Engine connections
Scaled engine outline
Engine outline
List of flanges
Engine pipe connections
Gallery outline

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