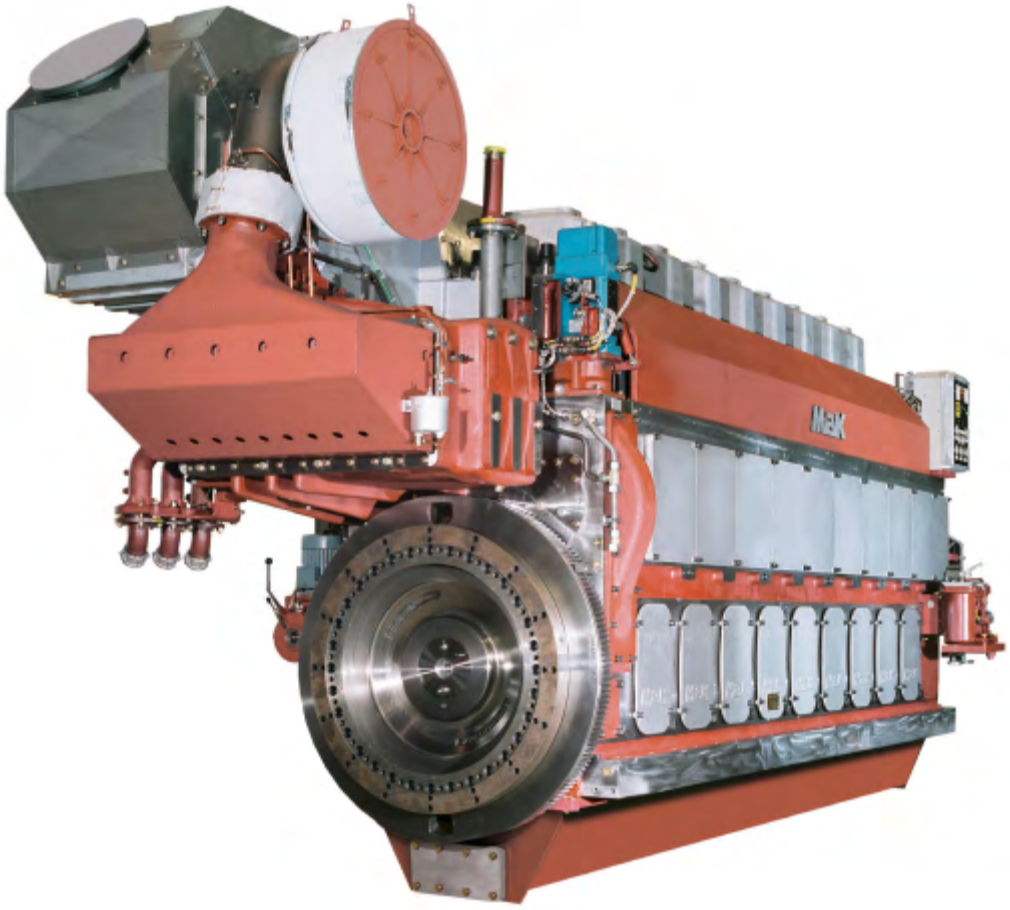
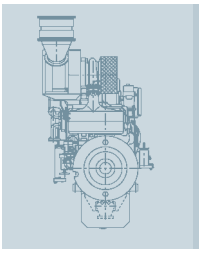
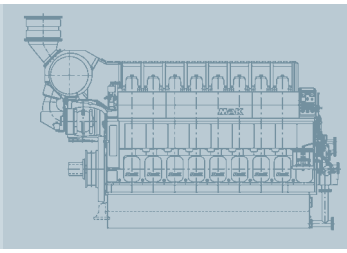
Contents

M 25 C

Project Guide • Propulsion







MaK

Introduction

Information for the user of this project guide

The project information contained in the following is not binding, since technical data of products may especially change due to product development and customer requests. Caterpillar Motoren reserves the right to modify and amend data at any time. Any liability for accuracy of information provided herein is excluded.

Binding determination of data is made by means of the Technical Specification and such other agreements as may be entered into in connection with the order. We will supply further binding data, drawings, diagrams, electrical drawings, etc. in connection with a corresponding order.

This edition supersedes the previous edition of this project guide.

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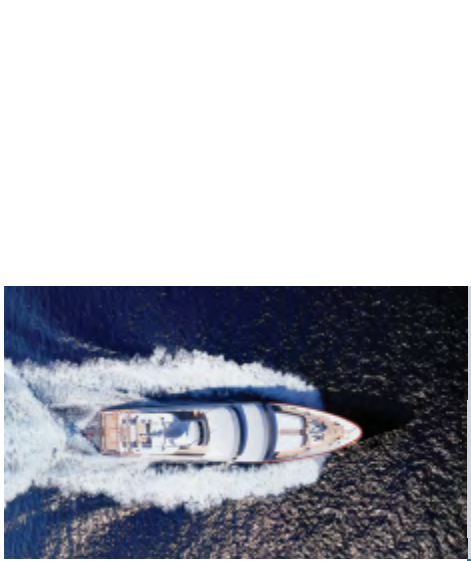

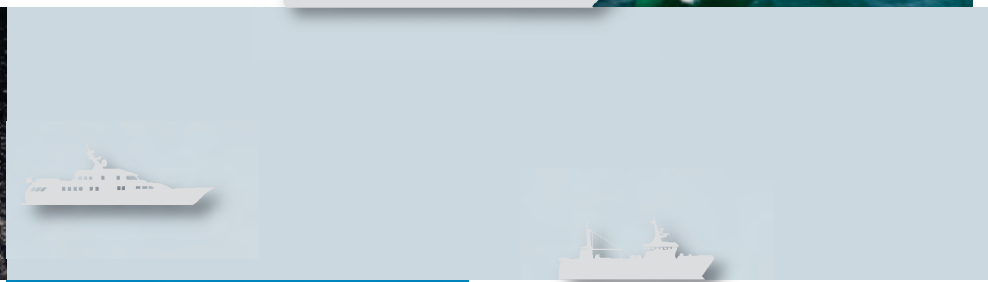

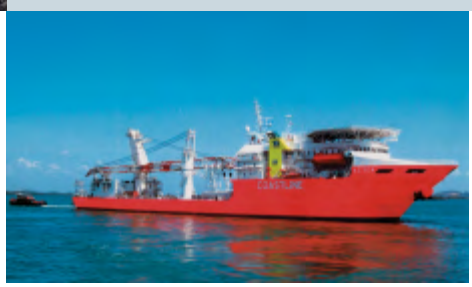

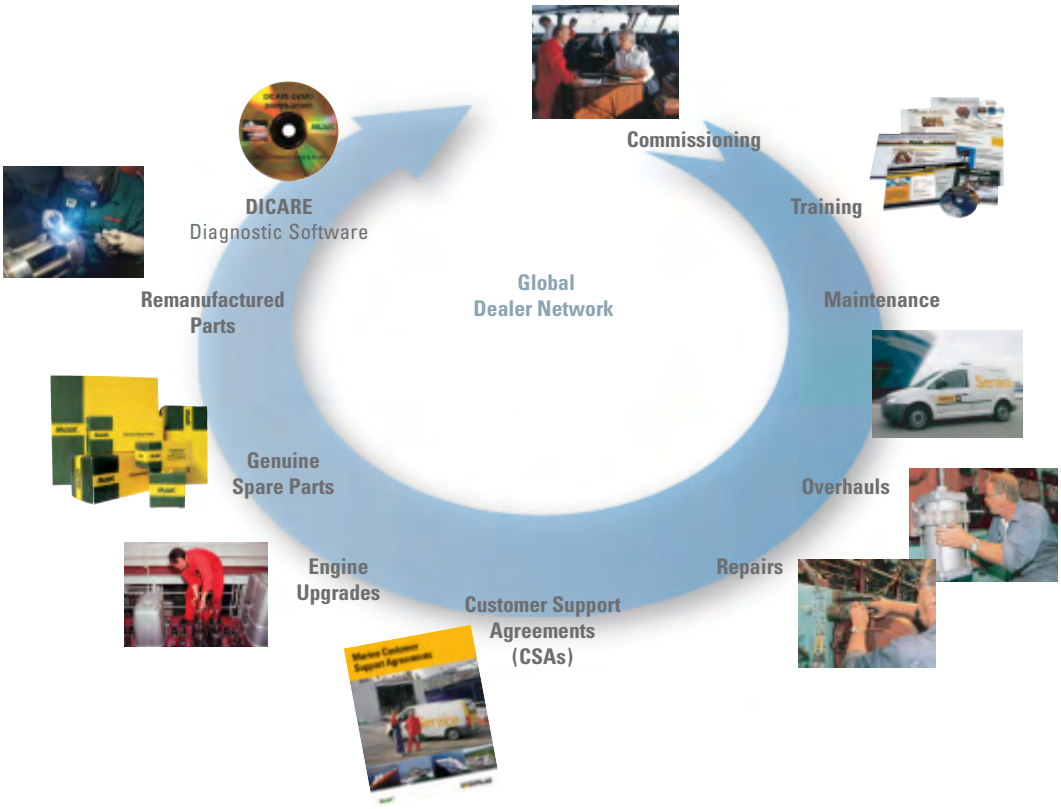

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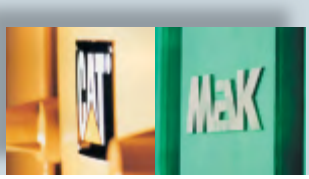

DET NORSKE VERITAS

MANAGEMENT SYSTEM CERTIFICATE

Certificate No.: 81311-2010-AQ-GER-TGA

This is to certify that

Caterpillar Motoren GmbH & Co. KG

Falckensteiner Str. 2
24159 Kiel - Germany

and the sites

Caterpillar Motoren Rostock GmbH
Werftallee 13
18119 Rostock

Caterpillar Power Generation Systems
Koboldstraße 2-4
24118 Kiel

Caterpillar Motoren Henstedt-Ulzburg GmbH
Rudolf-Diesel Straße 5-9
24558 Henstedt-Ulzburg

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Shunde District, Foshan City
528341 P. R. China

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ISO 9001:2008

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For Catarpillar Motoren Rostock:
Manufacture of gas and diesel engines
For Caterpillar Motoren Guangdong:
Production of diesel engines
For Caterpillar Power Generation Systems:
Sales, Engineering, Project Procurement, Project Management, Commissioning and Product Support Services for Power Plant based on Medium Speed Diesel and Gas Engines including turn.key installations
For Caterpillar Motoren Henstedt-Ulzburg GmbH:
Logistcs services for shipment of service and production parts for medium-speed large engines for the marine and electric power generation sectors as well as the oil and gas industry

Initial Certification date:
03.11.2003

This certificate is valid until:
14.11.2013

The audit has been performed under the supervision of
Jürgen Weißbauer
Lead Auditor

Deutscher Akkreditierungs Rat
DAR
TGA-ZM-04-92-00

Place and date:
Essen, 15.11.2010

for the Accredited Unit:
DNV ZERTIFIZIERUNG UND UMWELTGUTACHTER GMBH

Nikolaus Kim
Management Representative

Lack of fulfilment of conditions as set out in the Certification Agreement may render this Certificate invalid.
DNV Zertifizierung und Umweltgutachter GmbH, Schnieringshof 14, 45329 Essen, Tel: +49 201 7296 300 Fax: +49 201 7296 333 - www.dnv.de/zertifizierung

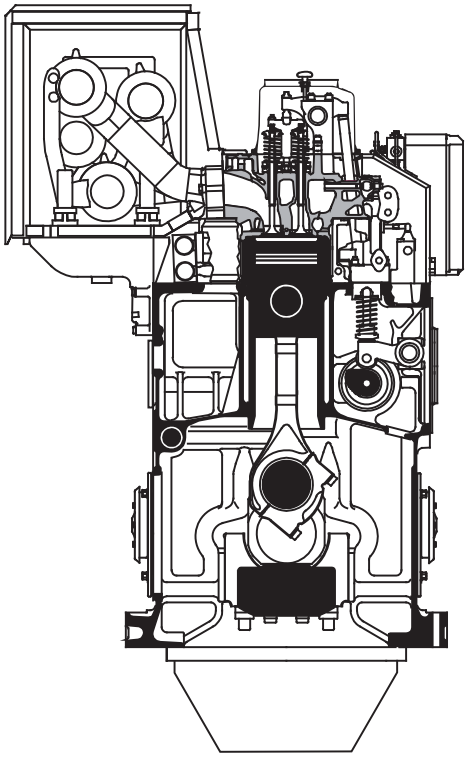
Contents

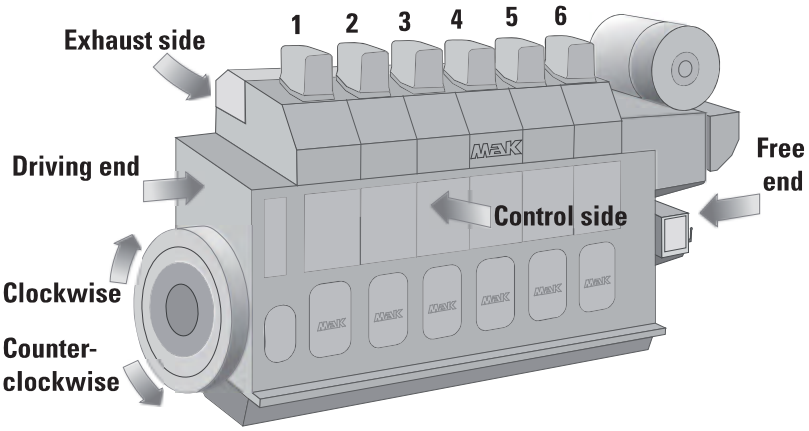
1. Engine description

1.1 Engine description

The M 25 C is a four-stroke diesel engine, non-reversible, turbocharged and intercooled with direct fuel injection.

In-line engine M 25 C





Cylinder configuration:	6,8,9 in-line
Bore:	255 mm
Stroke:	400 mm
Stroke/bore ratio:	1.57
Swept volume:	20.4 l/Cyl.
Output/cyl.:	317 - 333 kW
BMEP:	25.8 bar
Revolutions:	720/750 rpm
Mean piston speed:	9.6/10.0 m/s
Turbocharging:	pulse pressure
Direction of rotation:	clockwise, option: counter-clockwise

1. Engine description

1.2 Engine design features

- Designed for heavy fuel operation up to 700 cSt/50°C, fuel grade acc. to CIMAC H55 K55, ISO 8217, 2010 (E), ISO-F-RMH55 RMK55.
- 1-piece dry engine block made of nodular cast iron. It includes the crankshaft bearings, camshaft bearings, charge air duct, vibration damper housing and gear drive housing.
- Underslung crankshaft with corrosion resistant main and big end bearing shells.
- Natural hardened liners, centrifugally cast, with anti-polishing ring.
- Composite type pistons with steel crown and nodular cast iron skirt.
- Piston ring set consisting of 2 chromium plated compression rings, first ring with chromium-ceramic layer and 1 chromium plated oil control ring. All ring grooves are hardened and located in the steel crown.
- 2-piece connecting rod, fully machined, obliquely split with serrated joint.
- Cylinder head made of nodular cast iron with 2 inlet and 2 exhaust valves with valve rotators. Directly cooled exhaust valve seats.
- Camshaft consisting of individual cylinder sections allowing a removal of the pieces sideways.
- Turbocharger supplied with integrated plain bearings lubricated by engine lubricating oil.
- 2-stage fresh water cooling system with 2-stage charge air cooler.
- Nozzle cooling for heavy fuel operation with engine lubricating oil.
- For invisible smoke at part load operation Flexible Camshaft Technology is available for CPP- and DE-applications.

2. General data and operation of the engine

Type	720/750 rpm [kW]
6 M 25 C	1,900 / 2,000
8 M 25 C	2,534 / 2,666
9 M 25 C	2,850 / 3,000

The maximum fuel rack position is mechanically limited to 100 % output for CPP and FPP applications. Limitation of 110 % for gensets and DE applications.

2.1 General data and outputs

2.1.1 Output definition

The maximum continuous rating stated by Caterpillar Motoren refers to the following reference conditions according to "IACS" (International Association of Classification Societies) for main and auxiliary engines:

Reference conditions according to IACS (tropical conditions):

Air pressure	100 kPa (1 bar)
Air temperature	318 K (45 °C)
Relative humidity	60 %
Seawater temperature	305 K (32 °C)

An overload of 10 % is permitted for one hour within 12 hours of operation. The blocking will be fixed to 10 % above the maximum continuous rating.

2. General data and operation of the engine

2.1.2 Fuel consumption

The fuel consumption data refers to the following reference conditions:

Intake temperature	298 K (25 °C)
Charge air temperature	318 K (45 °C)
Charge air coolant inlet temperature	298 K (25 °C)
Net heating value of the diesel oil	42,700 kJ/kg
Tolerance of the stated consumption data	5 %

Specification of the fuel consumption data without engine driven pumps; for each fitted pump an additional consumption of 1 % has to be calculated.

2.1.3 Lubricating oil consumption

Actual data can be inferred from the technical data.

2.1.4 Nitrogen oxide emissions (NO_x values)

NO_x limit values according to MARPOL 73/78 Annex VI:	9.6 g/kWh (n = 750 rpm)
CPP and DE propulsion acc. to cycle E2:	9.3 g/kWh (n = 750 rpm)
FPP propulsion acc. to cycle E3:	9.5 g/kWh (n = 750 rpm)

2.1.5 Emergency operation without turbocharger

Emergency operation is permissible with MDO only and up to approx. 20 % of the MCR.

2. General data and operation of the engine

2.1.6 Technical data

Performance Data	Cylinder	6		8		9	
Maximum continuous rating acc. ISO 3046/1	kW	1,900	2,000	2,534	2,666	2,850	3,000
Speed	1/min	720	750	720	750	720	750
Minimum speed	1/min	240	250	240	250	240	250
Brake mean effective pressure	bar	25.8	26.1	25.8	26.1	25.8	26.1
Charge air pressure	bar	3.1	3.2	3.0	3.2	3.2	
Firing pressure	bar	205	210	205	210	205	210
Combustion air demand (ta = 20°C)	m³/h	10,800	11,505	13,740	14,605	16,280	17,190
Specific fuel oil consumption							
n = const [1] 100%	g/kWh	186		187		187	
85%	g/kWh	184		184		184	
75%	g/kWh	184		184		184	
50%	g/kWh	193		193		193	
Lubricating oil consumption [2]	g/kWh	0.6		0.6		0.6	
NO_x-emission [6]	g/kWh	9.6		9.6		9.6	
Turbocharger type		KBB HPR6000		KBB HPR6000		KBB HPR6000	
Fuel							
Engine driven booster pump	m³/h/bar	1.5/3		1.5/3		1.5/3	
Stand-by booster pump	m³/h/bar	2.2/10	2.3/10	2.7/10	2.8/10	2.7/10	2.8/10
Mesh size MDO fine filter	mm	0.025		0.025		0.025	
Mesh size HFO automatic filter	mm	0.010		0.010		0.010	
Mesh size HFO fine filter	mm	0.034		0.034		0.034	
Lubricating Oil							
Engine driven pump	m³/h/bar	89/10	93/10	89/10	93/10	89/10	93/10
Independent pump	m³/h/bar	45/10		60/10		60/10	
Working pressure at engine inlet	bar	4 - 5		4 - 5		4 - 5	
Independent suction pump	m³/h/bar	57/3		70/3		70/3	
Primimg pump pressure/suction pump	m³/h/bar	6.6/8/5		10/13/5		10/13/5	
Sump tank content/dry sump content	m³	2.6	2.7	3.4	3.6	3.9	4.0
Temperature at engine inlet	°C	60 - 65		60 - 65		60 - 65	
Temperature controller NB	mm	80		100		100	
Double filter NB	mm	80		80		80	
Mesh size double filter	mm	0.08		0.08		0.08	
Mesh size automatic filter	mm	0.03		0.03		0.03	

2. General data and operation of the engine

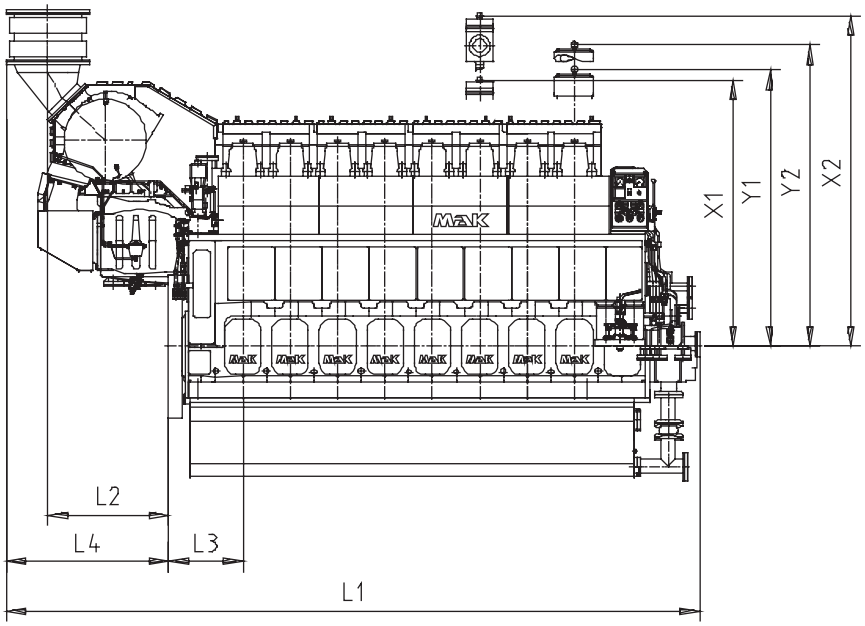
Fresh water cooling	Cylinder	6		8		9	
Engine content	m³	0.4		0.5		0.6	
Pressure at engine inlet min/max	bar	4.6/6.0		4.5/6.0		4.5/6.0	
Header tank capacity	m³	0.2		0.25		0.3	
Temperature at engine outlet	°C	80 - 90		80 - 90		80 - 90	
Two-circuit system							
Engine driven pump HT	m³/h/bar	40/4.5		55/4.5		60/4.7	
Independent pump HT	m³/h/bar	40/4.0		55/4.0		60/4.0	
HT-controller NB	mm	80		100		100	
Water demand LT-charge air cooler	m³/h	40		55		60	
Temperature at LT-charger air cooler inlet	°C	38		38		38	
Heat dissipation							
Specific jacket water heat	kJ/kW	500		500		500	
Specific lube oil heat	kJ/kW	490		490		490	
Lube oil cooler	kW	259	273	345	362	388	410
Jacket water	kW	264	278	352	370	396	417
Charge air cooler (HT stage) [3]	kW	521	576	661	752	794	807
Charge air cooler (LT stage) [3] (HT stage after engine)	kW	181	196	236	256	271	275
Heat radiation engine	kW	85		113		128	
Exhaust gas							
Silencer/spark arrester NB 25 dBA	mm	500/500		600/600		600/600	
Pipe diameter NB after turbine	mm	500		600		600	
Maximum exhaust gas pressure drop	bar	0.03		0.03		0.03	
Exhaust gas temp after turbine (25°C intake air) [5]	°C	323	333	325	333	350	342
Exhaust gas mass flow (25°C intake air) [5]	kg/h	13,345	14,220	16,982	18,050	20,120	21,250
Starting air							
Starting air pressure max.	bar	30		30		30	
Minimum starting air pressure	bar	7		7		7	
Air consumption per start [4]	Nm³	0.8		0.8		0.8	
Max. crankcase pressure, nominal diameter ventilation pipe	mmWs/ mm	15/80		15/80		15/80	

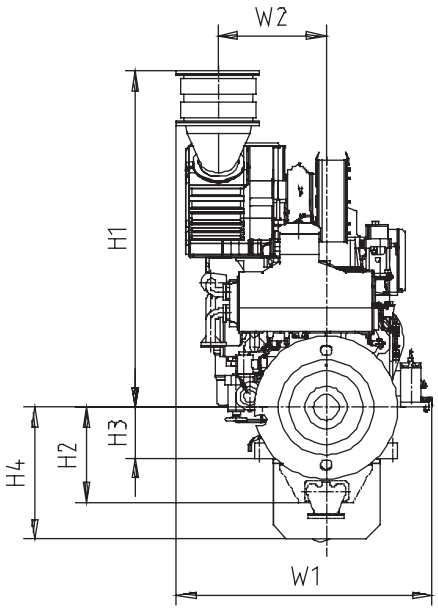
[1] Reference conditions: LCV = 42,700 kJ/kg, ambient temperature 25 °C
charge air coolant temperature 25 °C, tolerance 5 %, + 1 % for engine driven pump
[2] Standard value, tolerance ± 0.3 g/kWh, related on full load
[3] Charge air heat based on 45 °C ambient temperature
[4] Preheated engine
[5] Tolerance 10 %, rel. humidity 60 %
[6] MARPOL 73/78 Annex VI, Cycle E2, E3, D2

2. General data and operation of the engine

2.2 Engine dimensions

2.2.1 Turbocharger at driving end





Engine type	Dimensions [mm]										Weight [t]	
	L1	L2	L3	L4	H1	H2	H3	H4	W1	W2	wet sump	dry sump
6 M 25 C	5,345	1,068	672	1,390	2,905	861	460	1,191	2,261	977	23.5	21.2
8 M 25 C	6,289	1,097	672	1,474	3,052	861	460	1,191	2,316	977	30.0	28.5
9 M 25 C	6,719	1,097	672	1,474	3,052	861	460	1,191	2,316	977	32.0	30.0

Removal of:

Piston: in transverse direction X1 = 2,420 mm
in longitudinal direction X2 = 3,000 mm

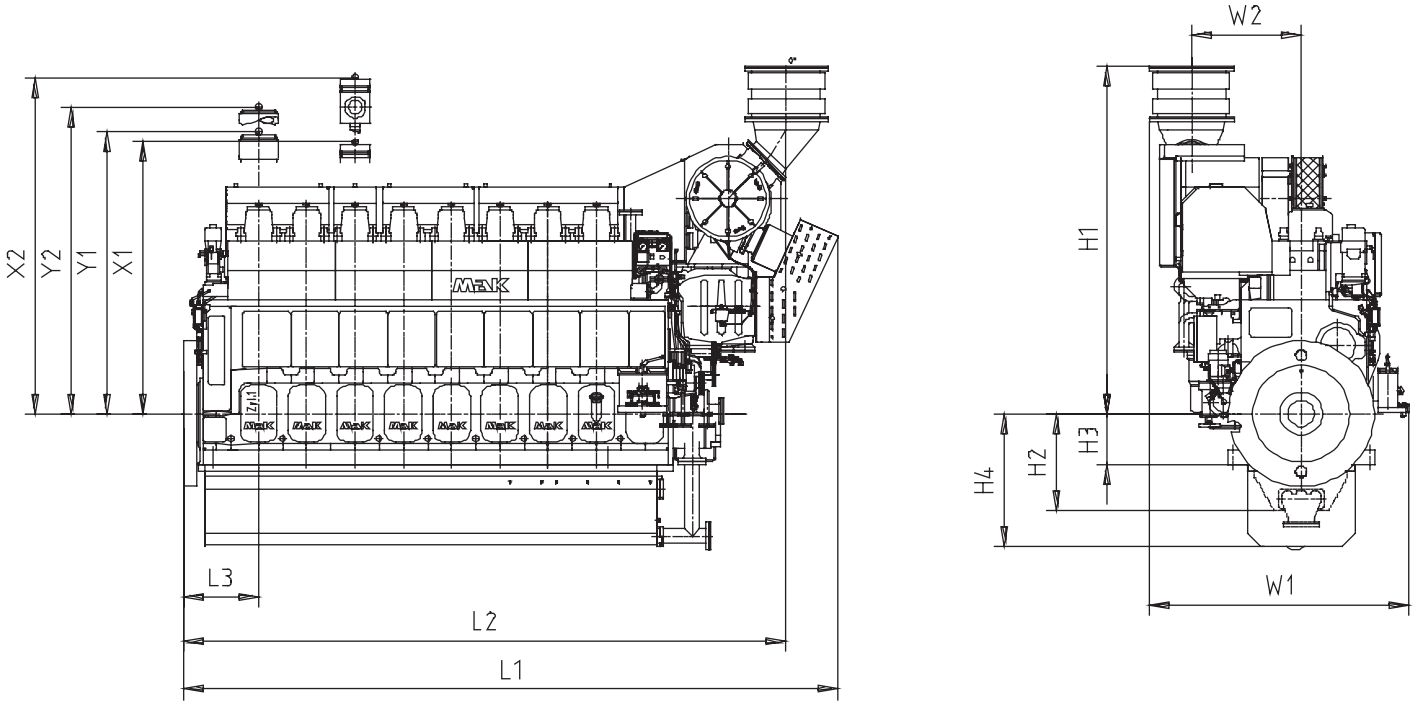
Cylinder liner: in transverse direction Y1 = 2,510 mm
in longitudinal direction Y2 = 2,735 mm

Reduced removal height piston and liner: 2,300 mm
Special tool for liner removal in transverse direction necessary and according to lifting device arrangement.

Engine centre distance 6,8,9 Cyl. 2,500 mm
(2 engines side by side)

2. General data and operation of the engine

2.2.2 Turbocharger at free end



Engine type	Dimensions [mm]									Weight [t]	
	L1	L2	L3	H1	H2	H3	H4	W1	W2	wet sump	dry sump
6 M 25 C	4,973	4,485	672	2,950	861	460	1,191	2,261	977	23.5	21.2
8 M 25 C	5,833	5,373	672	3,097	861	460	1,191	2,316	977	30.0	28.5
9 M 25 C	6,263	5,803	672	3,097	861	460	1,191	2,316	977	32.0	30.0

2. General data and operation of the engine

2.3 Restrictions for low load operation

The engine can be started, stopped and run on heavy fuel oil under all operating conditions.

The HFO system of the engine remains in operation and keeps the HFO at injection viscosity. The temperature of the engine injection system is maintained by circulating hot HFO and heat losses are compensated.

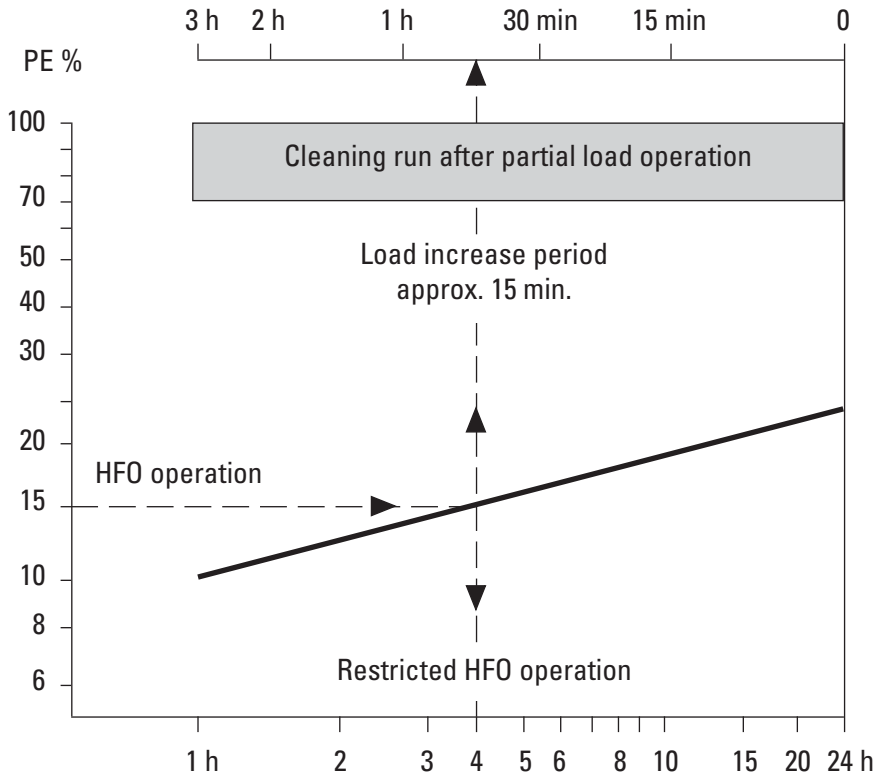
The lube oil treatment system (lube oil separator) remains in operation, the lube oil is separated continuously.

The operating temperature of the engine cooling water is maintained by the cooling water preheater.

Below 25 % output heavy fuel operation is neither efficient nor economical.

A change-over to diesel oil is recommended to avoid disadvantages as e.g. increased wear and tear, contamination of the air and exhaust gas systems and increased contamination of lube oil.

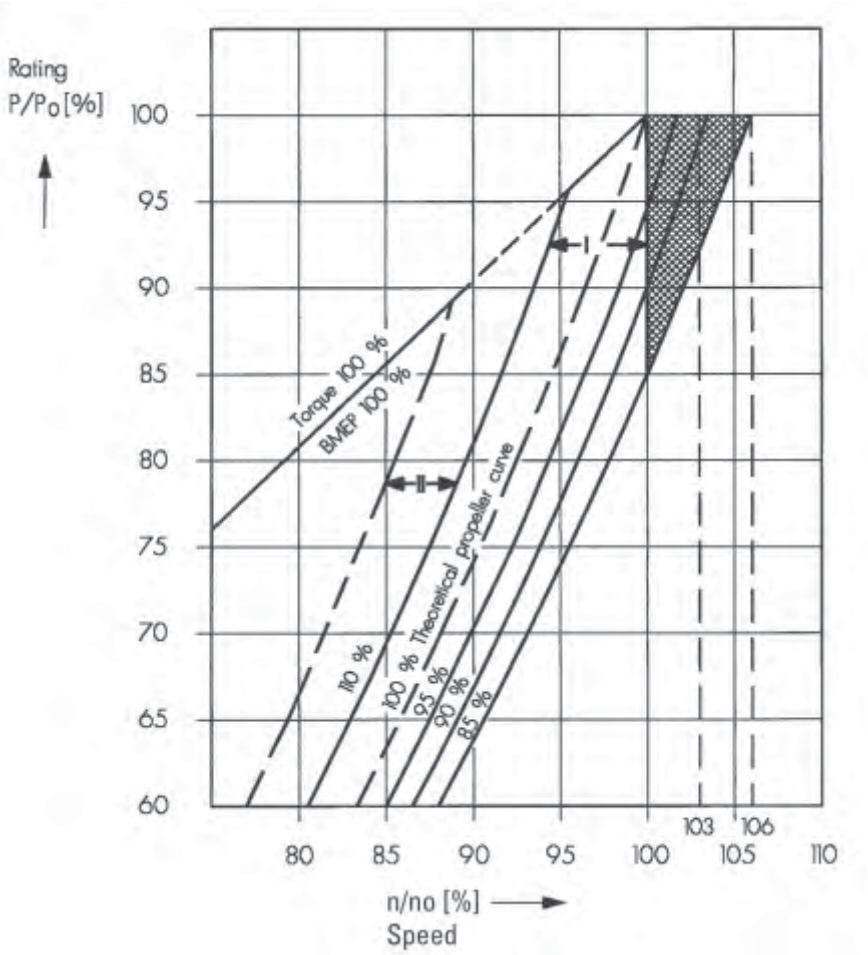
Cleaning run of engine



2. General data and operation of the engine

2.4 Propeller operation

2.4.1 Fixed pitch propeller operation



I. Speed range for continuous operation
This speed tange must not be exceeded for long-term operating conditions.

II. Speed range for short-time operation
Permitted for a short-time only, e.g. during acceleration and manoeuvring (torque limitation)

Fixed-pitch propeller design	Max. output at 100 % rated speed:
Sea going vessels (fully loaded)	max. 85 % for seaships
	max. 100 % for towing ships at bollard pull
Inland waterway vessels (fully loaded)	max. 95 % for inland waterway vessels
	max. 95 % for push boats
Speed increase (grey area)	The speed is blocked always at 100 % of rated speed. If required, 103 % of rated speed is permissible at continuous operation.
	During the yard trial trip the engine speed may be increased to max. 106 % of the rated speed for max. 1 h.

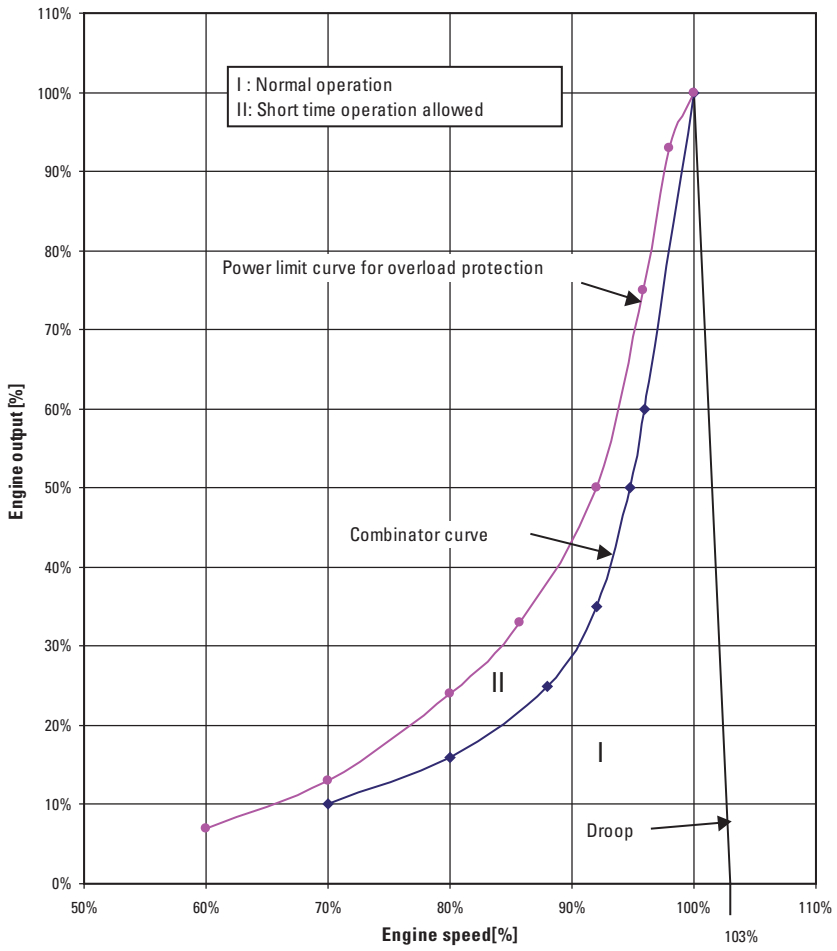
2. General data and operation of the engine

2.4.2 Controllable pitch propeller operation

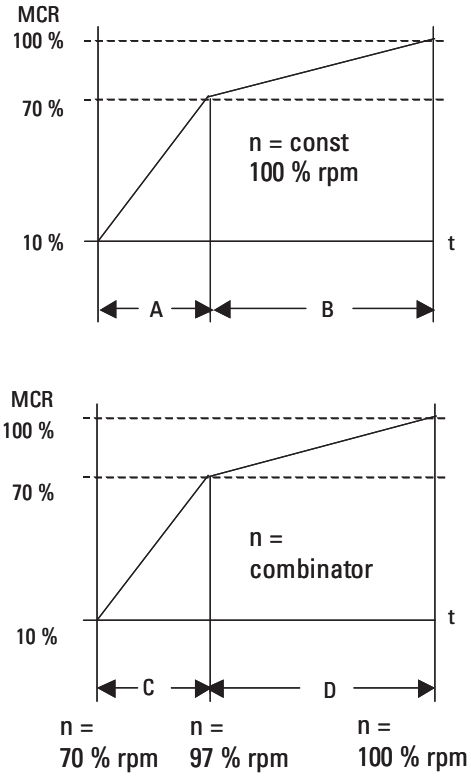
The design area for the combinator has to be on the right-hand side of the theoretical propeller curve and may coincide with the theoretical propeller curve in the upper speed range.

A load above the power limit curve is to be avoided by the use of the load control device or overload protection device.

Binding data (depending on the type of vessel, rated output, speed and the turbocharging system) will be established upon order processing.



Normal acceleration time



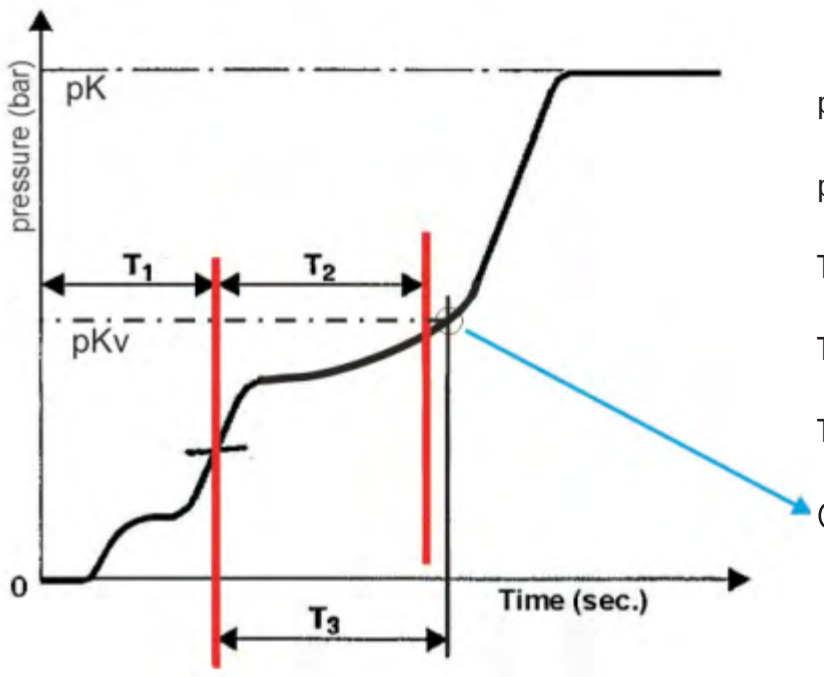
	A [s]	B [s]	C [s]	D [s]
6/8/9 M 25 C	35	180	40	180

2. General data and operation of engine

2.5 General clutch procedure

General clutch in procedure for propulsion system with MaK main engines

The diagram below indicates an example of a typical soft-clutch engagement timeline, required by Caterpillar Motoren for marine main engines.
To avoid engine stalling in case of high speed drop, overload of the flexible couplings and visible smoke, the engaging operation has to be smooth and easily controllable.
Important is the time T2, that includes the real slipping time.
This time has to be minimum 3 seconds. (If minimum 3 second adjustment is not possible, consultation is needed.)



pK = Lube oil switching pressure

pKv = Control pre-pressure

T_1 = Filling time

T_2 = Slipping time

T_3 = Pressure holding time

Θ = Point of synchronization

The clutch-in speed of engine should be min. 70 % of rated speed, but could be 60 % depending on torsional vibration calculation (TVC).

3. Systems

3.1 Combustion air system

3.1.1 General

To obtain good working conditions in the engine room and to ensure trouble-free operation of all equipment attention shall be paid to the engine room ventilation and the supply of combustion air.

The combustion air required and the heat radiation of all consumers/heat producers must be taken into account.

3.1.2 Air intake from engine room (standard)

- Fans are to be designed for a slight overpressure in the engine room.
- On system side the penetration of water, sand, dust, and exhaust gas must be prevented.
- When operating under tropical conditions the air flow must be conveyed directly to the turbocharger.
- The temperature at turbocharger filter should not fall below + 10 °C.
- In cold areas warming up of the air in the engine room must be ensured.

3.1.3 Air intake from outside

- The intake air duct is to be provided with a filter. Penetration of water, sand, dust, and exhaust gas must be prevented.
- Connection to the turbocharger is to be established via an expansion joint (to be supplied by the yard). For this purpose the turbocharger will be equipped with a connection socket.
- At temperatures below + 10 °C Caterpillar Motoren/Application Engineering must be consulted.

3.1.4 Radiated heat

See technical data

To dissipate the radiated heat a slight and evenly distributed air flow is to be conveyed along the engine exhaust gas manifold starting from the turbocharger.

3. Systems

3.2 Starting air system

As required by the classification societies, two air compressors compress the starting air to a nominal pressure of 30 bar. The starting air must have a certain quality, be free from solid particles, oil, and water.

3.2.1 Starting air quality requirements

For the proper operation of the engine a starting air quality of class 4 according ISO 8573-1 is required.

Class	Particle size max. in µm	Particle density max. in mg/m³	Water pressure dew point in °C	Water mg/m³	Oil Residual oil content in mg/m³
1	0.1	0.1	-70	3	0.01
2	1	1	-40	120	0.1
3	5	5	-20	880	1
4	15	8	3	6,000	5
5	40	10	7	7,800	25
6			10	9,400	

The standard DIN ISO 8573-1 defines the quality classes of compressed air as follows:

Oil content

Specification of the residual quantity of aerosols and hydrocarbons which may be contained in the compressed air.

Particle size and density

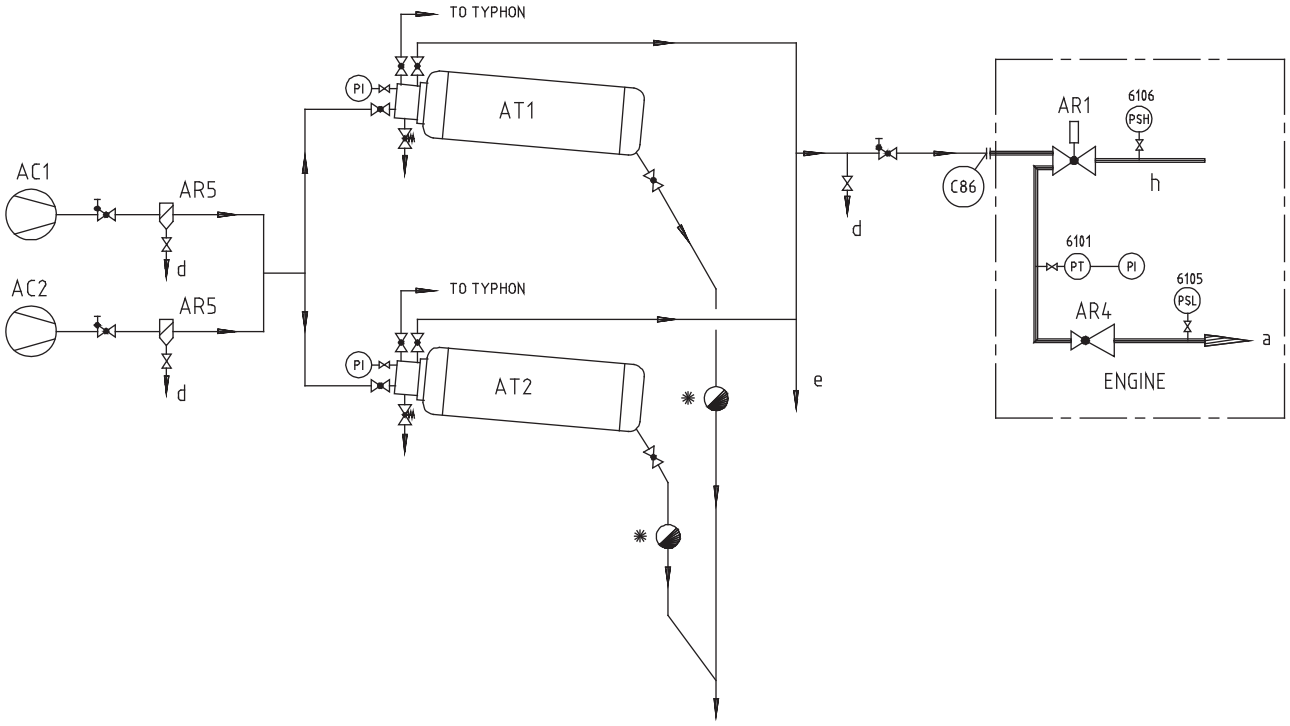
Specification of size and concentration of particles which may still be contained in the compressed air.

Pressure dew point

Specification of the temperature to which the compressed air can cool down without the steam contained in it condensing. The pressure dewpoint changes with the air pressure.

3. Systems

3.2.2 System diagram



General notes:
For location, dimensions, and design (e.g. flexible connection) of the disconnecting points see engine installation drawing.

Clean and dry starting air is required. A starting air filter has to be installed before engine, if required.

Notes:
a Control air
d Water drain (to be mounted at the lowest point)
e To engine No. 2
h Please refer to the measuring point list regarding design of the monitoring devices

* Automatic drain required

Connecting points:
C86 Connection, starting air

Accessories and fittings:

AC1	Compressor
AC2	Stand-by compressor
AR1	Starting valve
AR4	Pressure reducing valve
AR5	Oil and water separator
AT1	Starting air receiver (air bottle)
AT2	Starting air receiver (air bottle)
PI	Pressure indicator
PSL	Pressure switch low, only for main engine
PT	Pressure transmitter

AT1 / AT2 Option:
- Typhon valve
- Relief valve with pipe connection

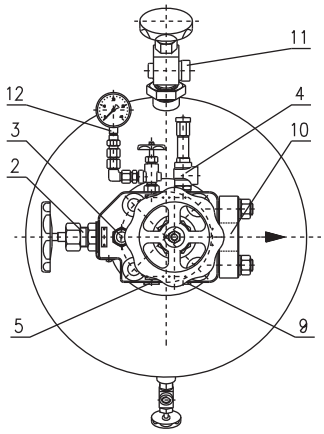
3. Systems

3.2.3 Starting air system components

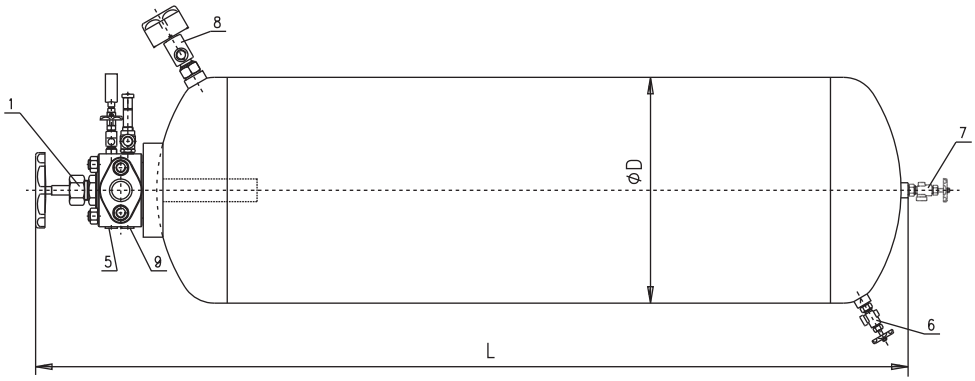
a) Receiver capacity acc. to GL recommendation AT1/AT2

Number of gensets	Number of receivers	Receiver capacity available [l]	L mm	D ø mm	Valve head	Weight approx. kg
2	2	250	1,868	480	DN 40	230
3, 4	2	500	3,355	480	DN 50	320

1 Starting valve DN 38
2 Filling valve DN 18
3 Inlet filling valve
4 Safety valve G1/2“
5 Free connection G1/2“
6 Drainage horizontal
7 Drainage vertical
9 Connection G1/2“ for vent
10 Outlet starting-air valve
12 Pressure Gauge



Option:
8 Typhon valve DN 16
11 Outlet typhon valve



When CO_2 fire extinguishing system is installed in the engine room, the blow-off connection of the safety valve is to be piped to the outside.

Requirement of classification societies (regarding design)

- No. of starts: 6
- No. of receivers: min. 2

3. Systems

b) Compressor AC1/AC2:

2 compressors with a total output of 50 % each are required. The filling time from 0 to 30 bar must not exceed 1 hour.

Capacity

$V\ [m^3/h] = \Sigma\ V_{Rec.} \bullet 30$

$V_{Rec.}$ - Total receiver volume [m^3]

3.3 Exhaust system

The exhaust system carries the engines exhaust gases out of the engine room, through piping, to the atmosphere. A good exhaust system will have a minimum back pressure. Exhaust back pressure is generally detrimental, as it tends to reduce the air flow through the engine. Indirectly, exhaust back pressure tends to raise exhaust temperature which will reduce exhaust valve and turbocharger life.

3.3.1 General

Position of exhaust gas nozzle:

A nozzle position of 0, 30, 45, 60 and 90° from the vertical is possible.
The basic position is 45°. The other positions are reached by using a transition piece.

Design of the pipe cross-section:

The pressure loss is to be minimized in order to optimize fuel consumption and thermal load of the engine.

Max. flow velocity: 40 m/s (guide value).

Max. pressure loss (incl. silencer and exhaust gas boiler): 30 mbar
(lower values will reduce thermal load of the engine).

3.3.2 Exhaust expansion joint

	Diameter DN	Length [mm]
6 M 25 C	500	360
8/9 M 25 C	600	450

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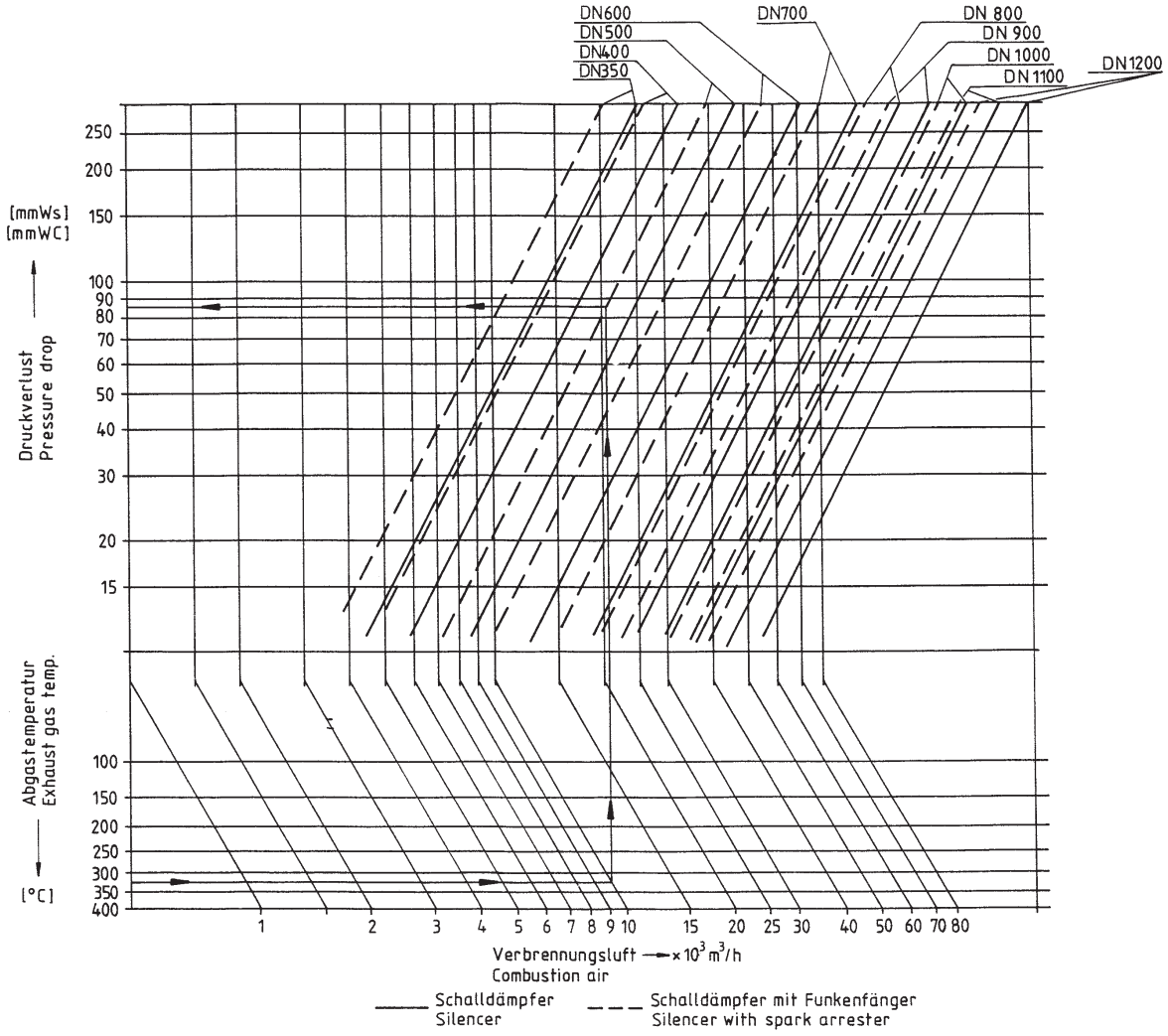
3.3.3 Silencer

Design according to the absorbtion principle with wide-band attenuation over a great frequency range and low pressure loss due to straight direction of flow. Sound absorbing filling consisting of resistant mineral wool.

Sound level reduction 35 dB(A) (standard). Max. permissible flow velocity 40 m/s.

SIlencer with spark arrester: Soot separation by means of a swirl device (particles are spun towards the outside and separated in the collecting chamber). Sound level reduction 35 dB(A). Max. permissible flow velocity 40 m/s.

Silencers are to be insulated by the yard. Foundation brackets are to be provided as an option.

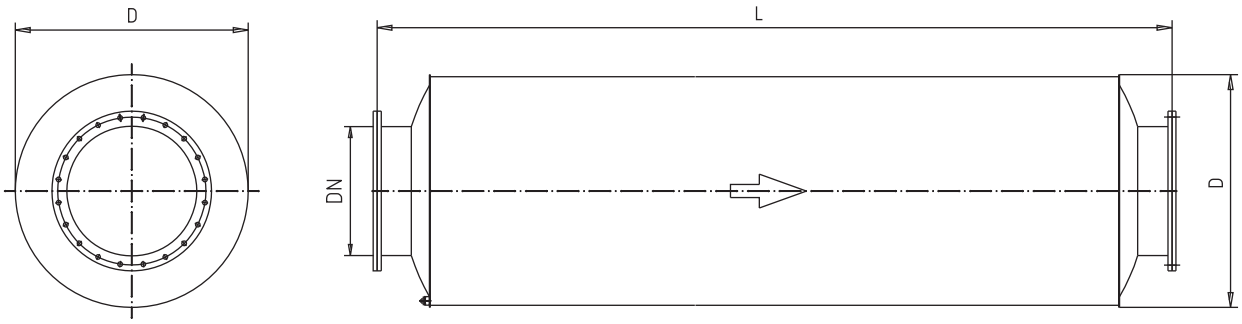


3. Systems

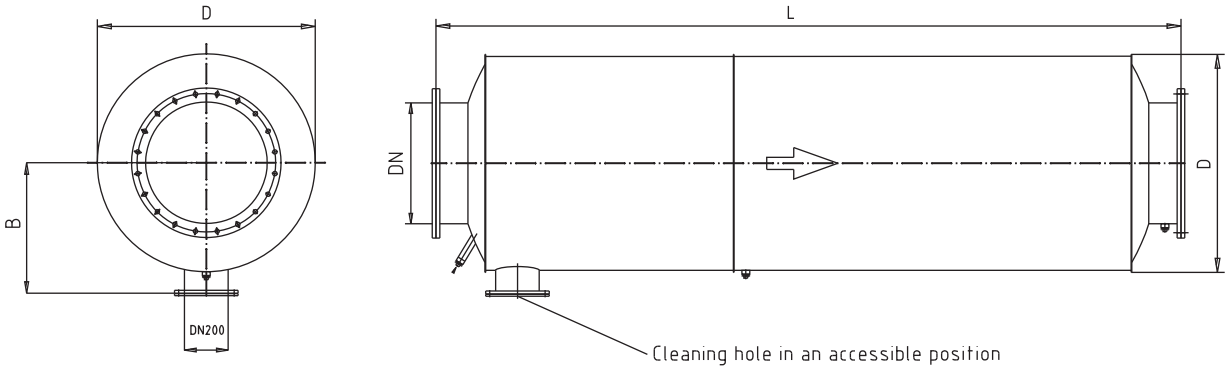
Dimension of silencer/spark arrestor and silencer:

Installation: vertical/horizontal
Flange according to DIN 86044
Counterflanges, screws and gaskets are included, without supports and insulation

Silencer



Spark arrestor and silencer



	Attenuation			35 dB (A)	
	DN	D	B	L	kg
6 M 25 C	500	950	588	3,940	750
8/9 M 25 C	600	1,100	659	4,760	1,300

3.3.4 Exhaust gas boiler

Each engine should have a separate exhaust gas boiler. Alternatively, a common boiler with separate gas sections for each engine is acceptable.

Particularly if exhaust gas boilers are installed attention must be paid to the maximum recommended back pressure.

3. Systems

3.3.5 Turbocharger cleaning device

Cleaning the turbocharger compressor:

The components for cleaning (dosing vessel, pipes, shut-off valve) are installed on the engine.

Water is fed before compressor wheel via injection pipes during full load operation every 24 hours.

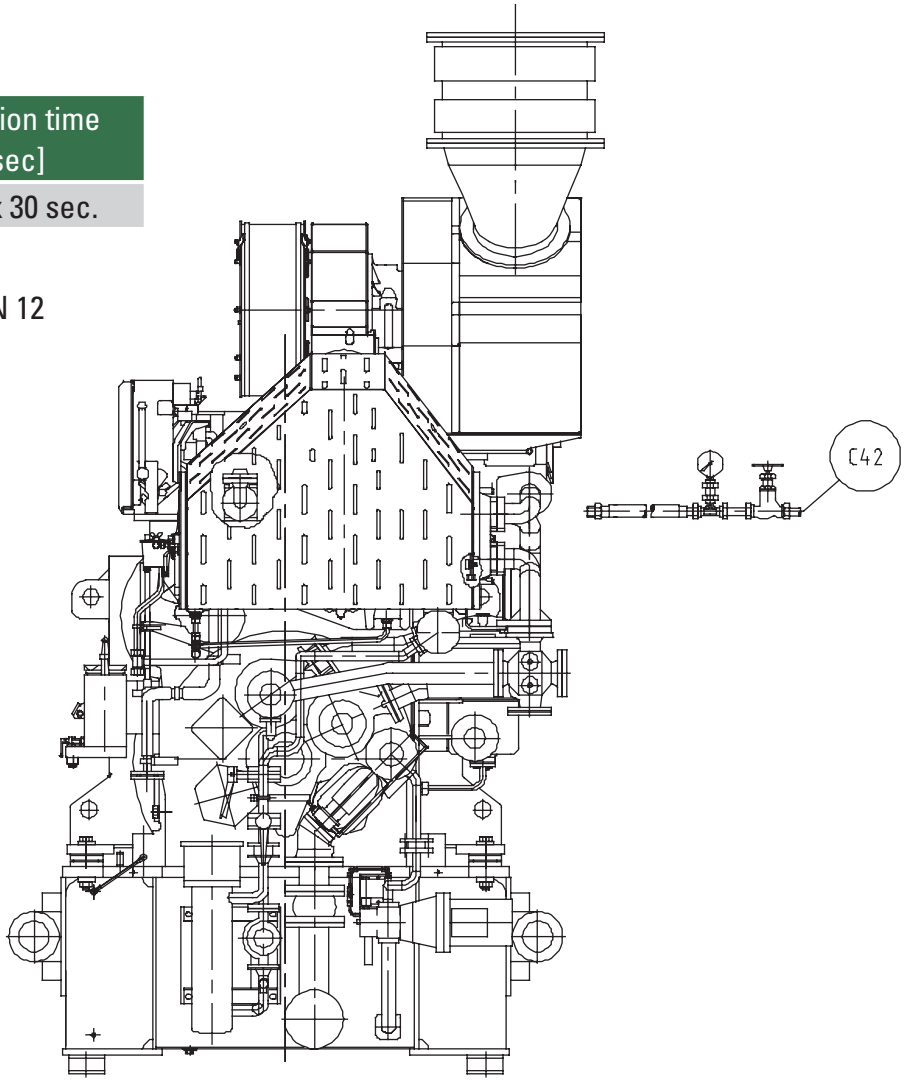
Cleaning the turbine blade and nozzle ring:

The cleaning is carried out with clean fresh water “wet cleaning“ during low load operation at regular intervals of 150 hours, depending on the fuel quality.

Cleaning in 3 - 4 intervals of 30 seconds each.
Fresh water of 2 - 2.5 bar is required.

Water flow [l/min]	Injection time [sec]
17	3 - 4 x 30 sec.

C42 Fresh water supply, DN 12



3. Systems

3.4 Cooling water system

MaK engines generally use two closed water cooling circuits. The High Temperature (HT) cooling water circuit is used to cool the charge air - in first stage - and the engine jacket. The Low Temperature (LT) cooling water circuit cools the charge air - in second stage - and the lub oil. Moreover, the LT cooling water circuit can be used to cool additional equipment, e.g. a generator or gearbox.
The cooling water needs to be treated to ensure a certain quality.

3.4.1 Cooling water quality requirements

The engine cooling water is a medium, which must be carefully selected, treated and controlled. In case of using untreated cooling water corrosion, erosion and cavitation may occur on the walls of the cooling system.

Deposits may impair the heat transfer and result in thermal overload of the components to be cooled. The treatment with an anti-corrosion additive has to be effected before the first commissioning of the plant.

Requirements

The characteristics of the untreated cooling water must be within the following limits:

- distillate or freshwater free from foreign matter (no sea water or waste water)
- a total hardness of max. 10° dH
- pH-value 6.8 - 8
- chloride ion content of max. 50 mg/l

Supplementary information

Distillate: If distilled or fully desalinated water is available, this should preferably be used as engine cooling water.

Hardness: Water with more than 10° dGH (German total hardness) must be mixed with distillate or be softened.

Treatment before operating the engine for the first time

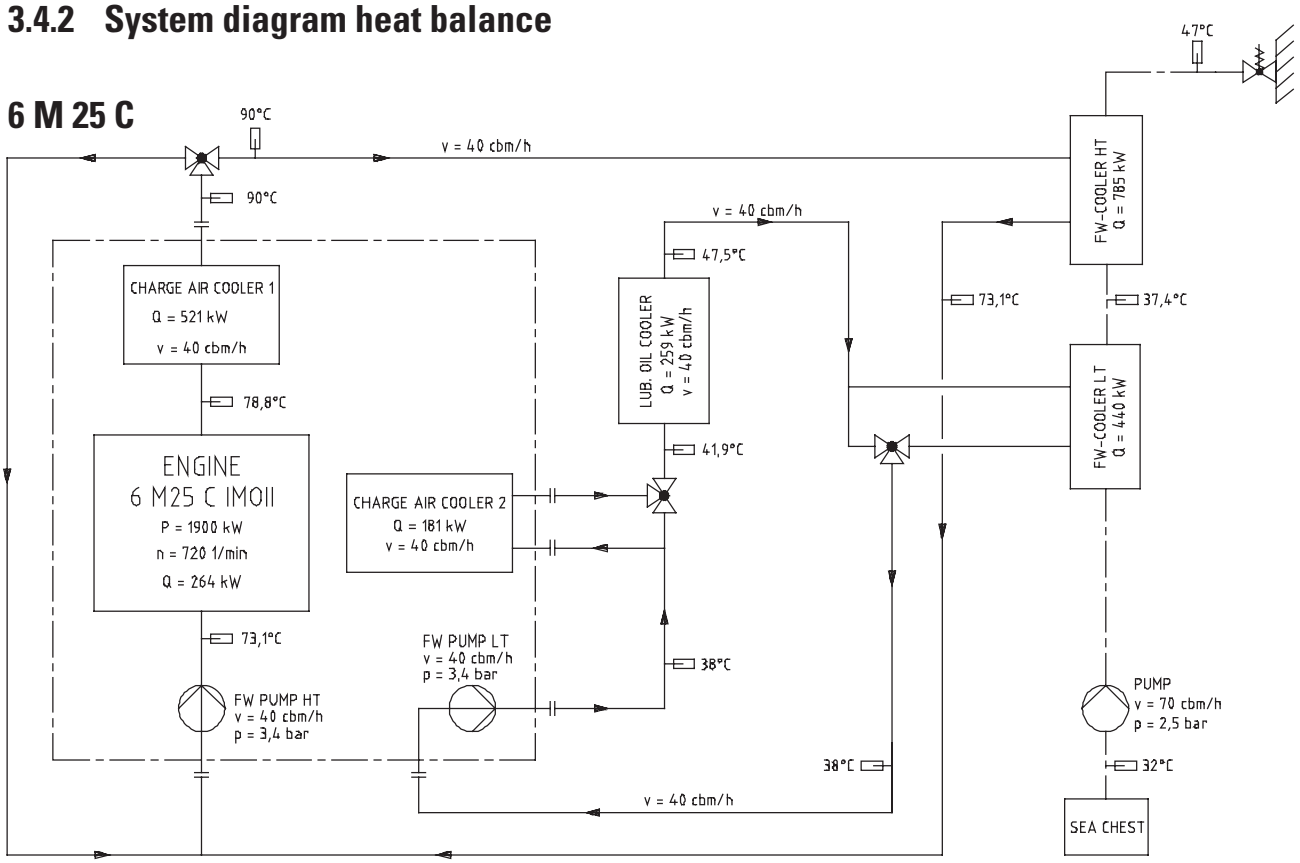
Treatment with an anti-corrosion additive should be done prior the first operation of the engine to prevent irreparable initial damages.

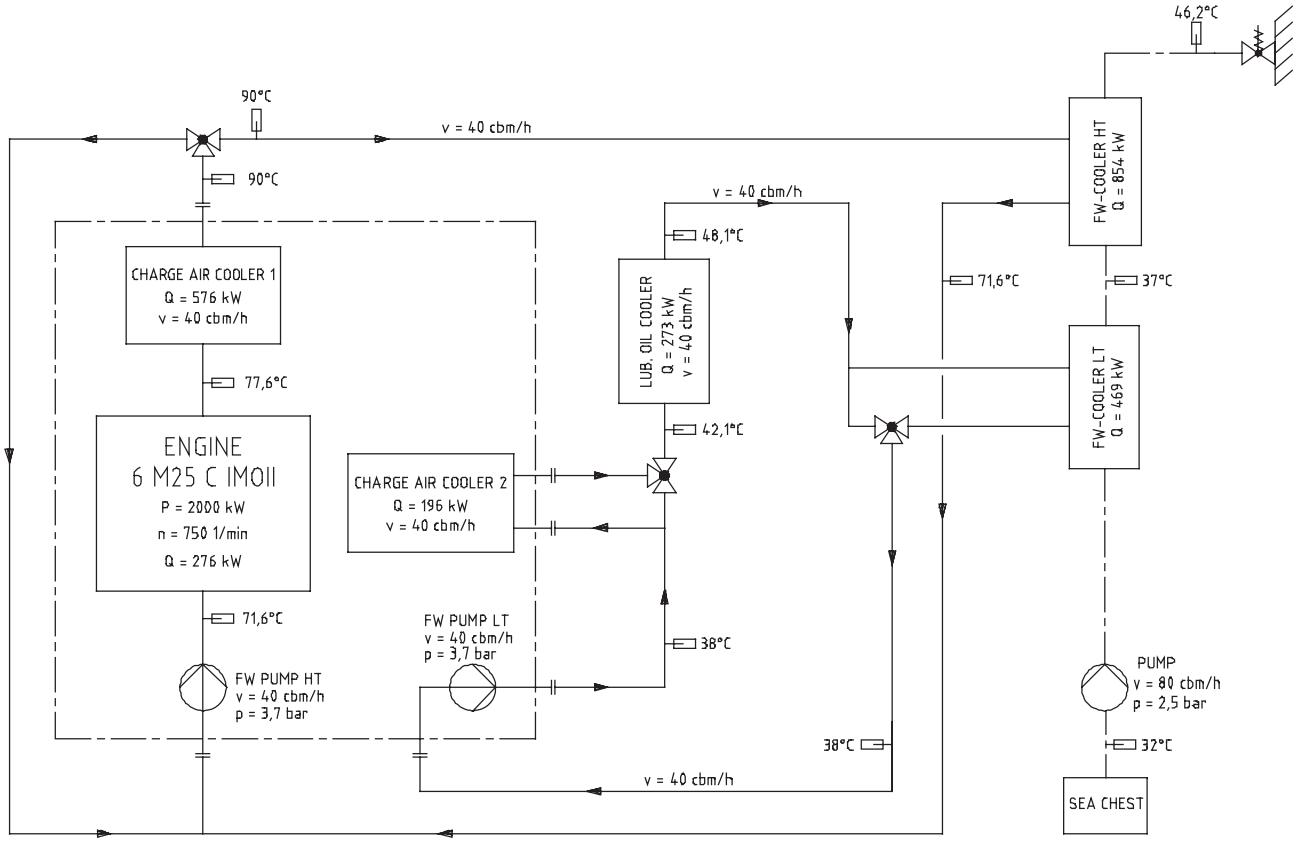
It is not allowed to run the engine without cooling water treatment!

3. Systems

3.4.2 System diagram heat balance

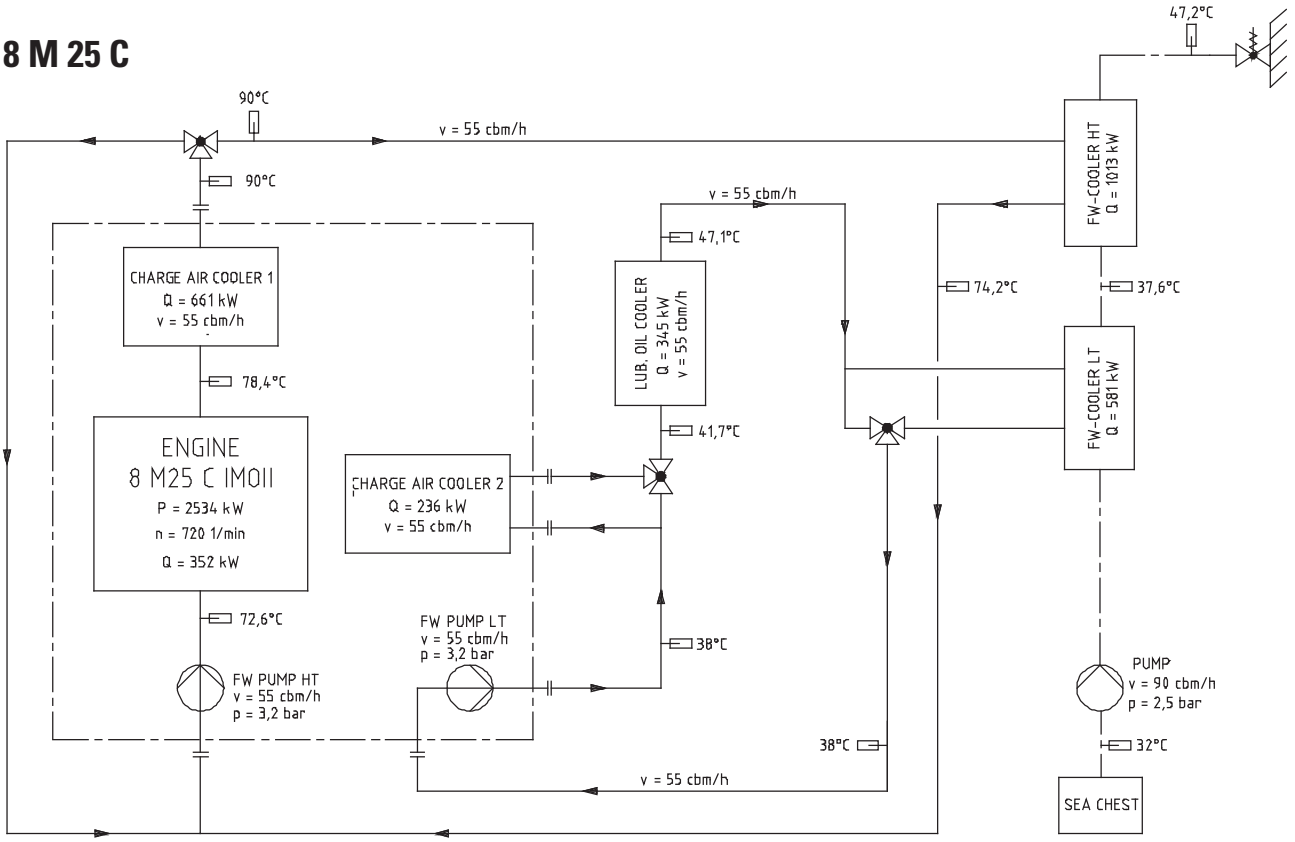
6 M 25 C

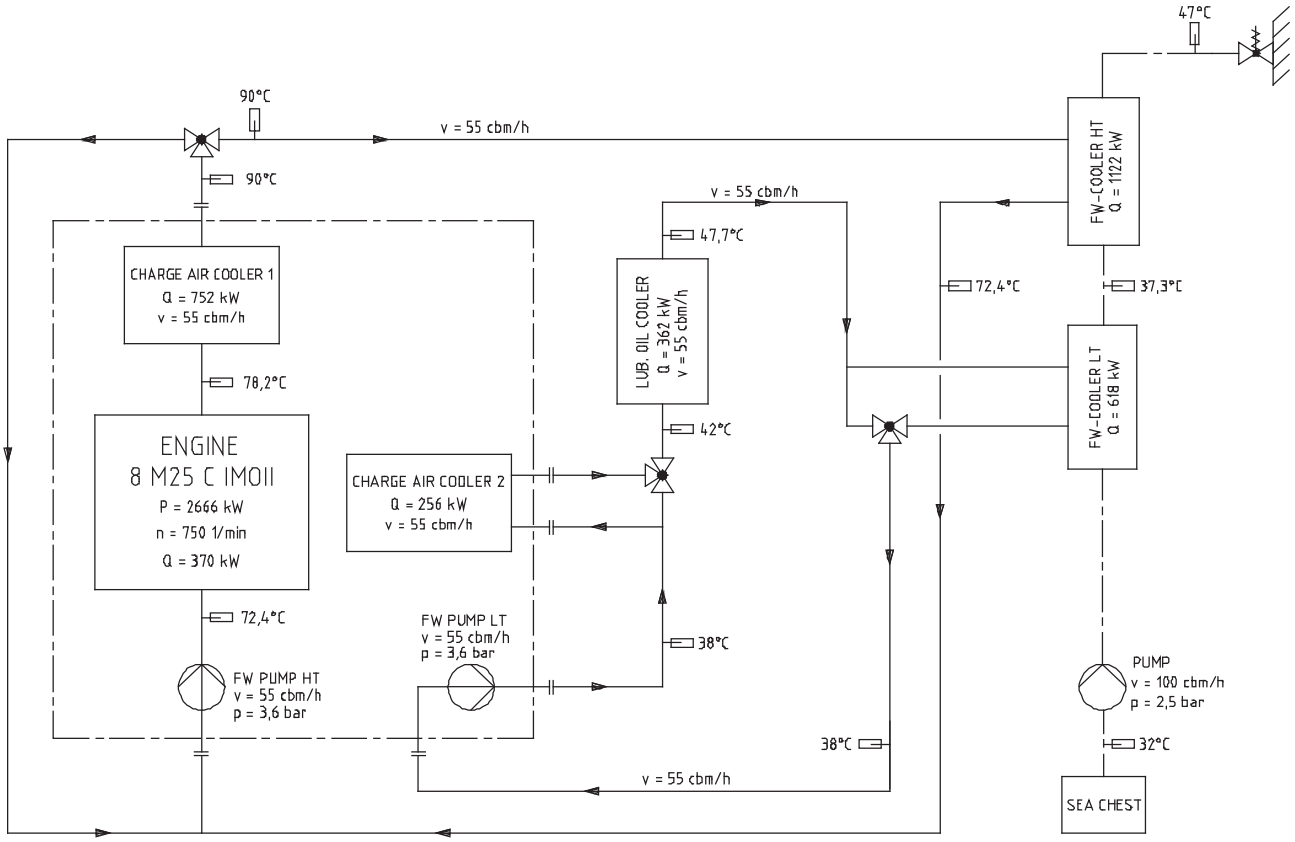




3. Systems

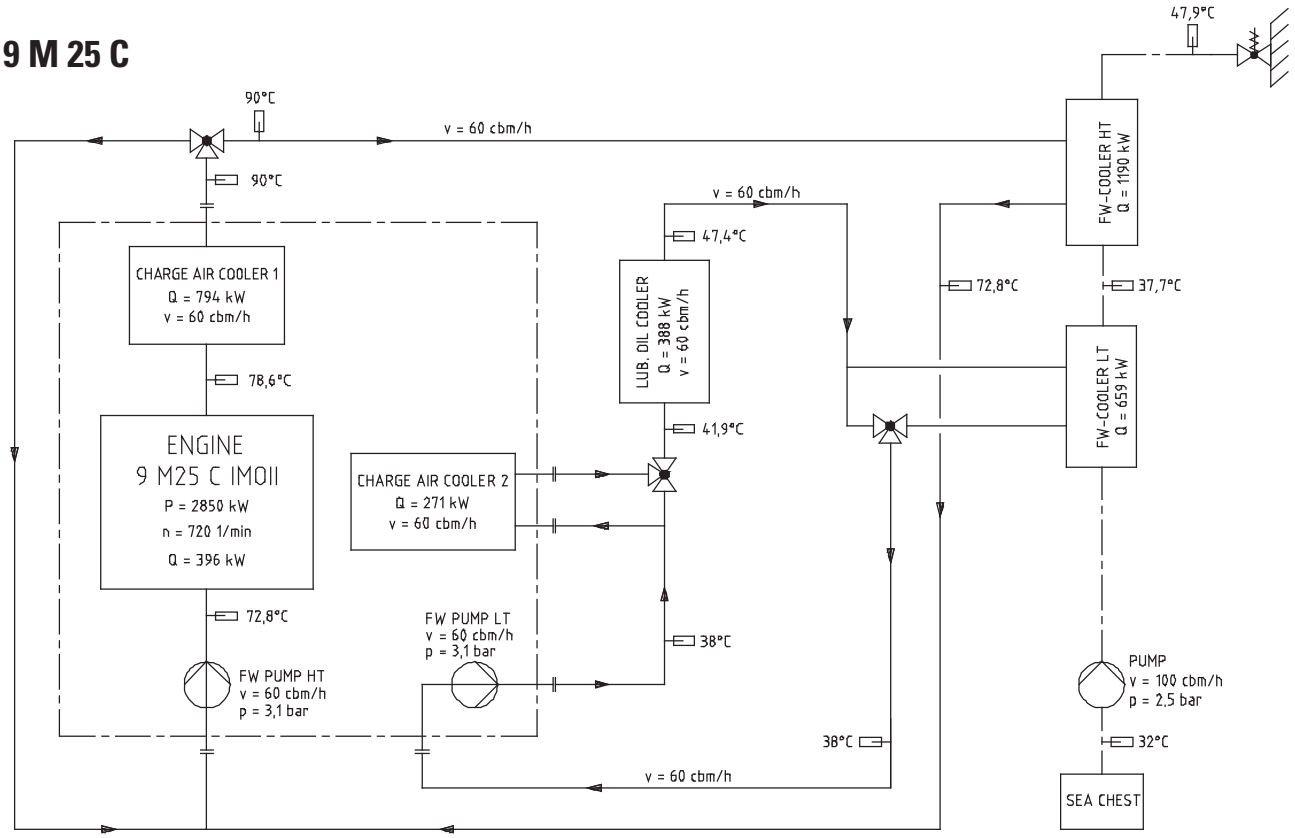
8 M 25 C

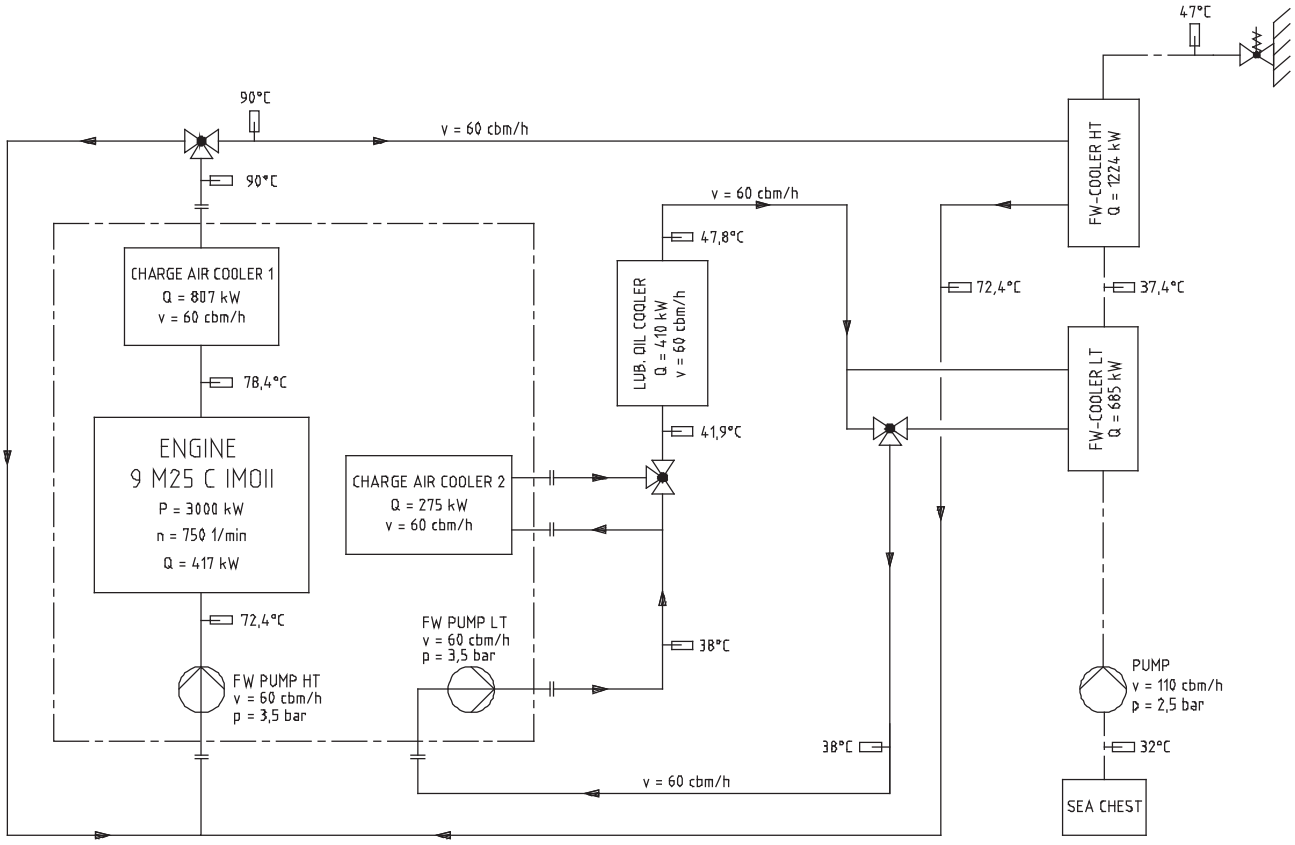




3. Systems

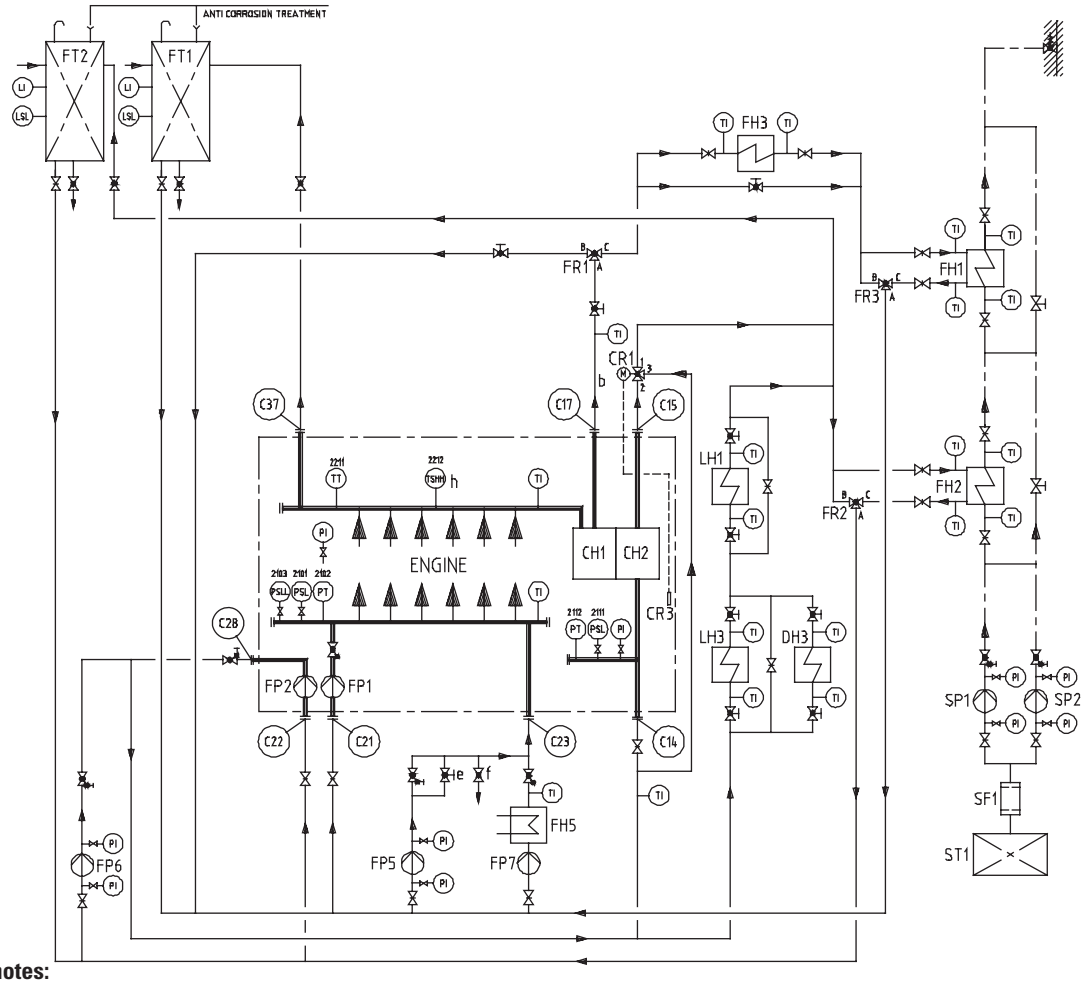
9 M 25 C





3. Systems

3.4.3 System diagram cooling water



General notes:
For location, dimensions and design (e.g. flexible connection) of the connecting points see engine installation drawing. With skin cooler not required:

- Seawater system (SP1, SP2, SF1, ST1)
- Temp. control valve FR3 required, if heat recovery installed.

Accessories and fittings:

CH1 Charge air cooler HT
CH2 Charge air cooler LT
CR1 Charge air temp. control valve
CR3 Sensor for charge air temp. control valve
DH3 Fuel oil cooler for MDO operation
FH1 Freshwater cooler HT *
FH2 Freshwater cooler LT *
FH3 Heat consumer
FH5 Freshwater preheater
FP1 Freshwater pump (fitted on engine) HT
FP2 Freshwater pump (fitted on engine) LT
FP5 Freshwater stand-by pump HT
FP6 Freshwater stand-by pump LT
FP7 Preheating pump
FR1 Temperature control valve HT
FR2 Temperature control valve LT
FR3 Flow temperature control valve HT
FT1 Compensator tank HT
FT2 Compensator tank LT
LH1 Lube oil cooler
LH3 Gear lube oil cooler
SF1 Seawater filter
SP1 Seawater pump
SP2 Seawater stand-by pump
ST1 Sea chest
LI Level indicator
LSL Level switch low
PI Pressure indicator
PSL Pressure switch low
PSLL Pressure switch low low
PT Pressure transmitter
TI Temperature indicator
TSHH Temperature switch high high
TT Temperature transmitter (PT 100)

* Classification society requirements have to be taken into account.

General notes:

b Measurement min. 2.0 m distance to C17
e Bypass DN12
f Drain
h Please refer to the measuring points list regarding design of the monitoring devices

For temp. control valve P-type FR1, FR2, FR3 alternative PI-type possible.

Connecting points:

C14 Charge air cooler LT, inlet
C15 Charge air cooler LT, outlet
C17 Charge air cooler HT, outlet
C21 Freshwater pump HT, inlet
C22 Freshwater pump LT, inlet
C23 Stand-by pump HT, inlet
C28 Freshwater pump LT, outlet
C37 Vent

3. Systems

3.4.4 Cooling water system components

The heat generated by the engine (cylinder, charge air and lube oil) is to be dissipated by treated freshwater acc. to the MaK coolant regulations.

The system components of the LT cooling water circuit are designed for a max. LT cooling water temperature of 38 °C with a corresponding seawater temperature of 32 °C in tropical conditions.

Two-circuit cooling: with two-stage charge air cooler.

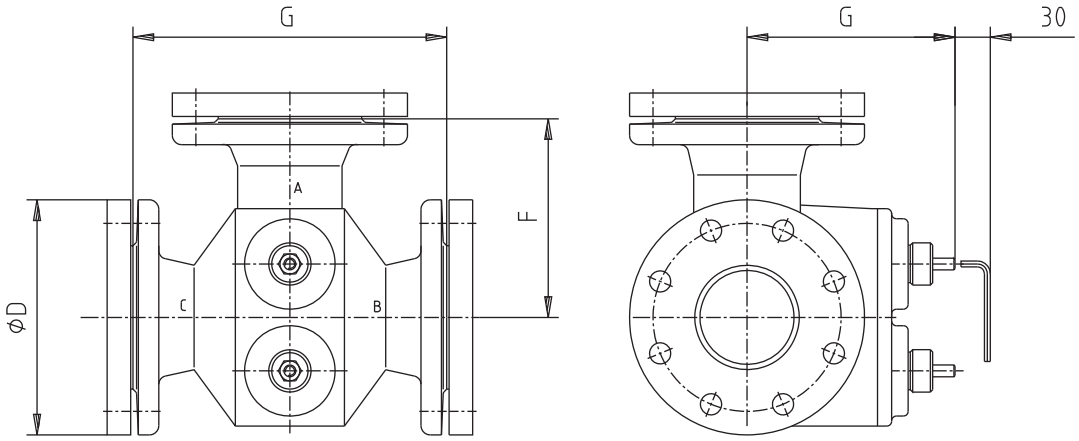
a) LT cooling water pump FP2 (fitted on engine): **Option: separate (FP4)**
Capacity: acc. to heat balance

b) LT cooling water stand-by pump (optional) FP6: Capacity: acc. to heat balance

c) HT cooling water pump (fitted) FP1: **Option: separate (FP3)**
Capacity: acc. to heat balance

d) HT cooling water stand-by pump (optional) FP5: Capacity: acc. to heat balance

e) HT temperature controller (separate) FR1: P-controller with manual emergency adjustment (basis). Option: PI-controller with electric drive (sep. only)



		Dimensions [mm]					Weight [kg]
		DN	D	F	G	H	
6 M 25 C	HT	80	200	171	267	151	27
8/9 M 25 C	HT[1)]	100	220	217	403	167	47
6/8 M 25 C	LT	100*	220	217	403	167	47
9 M 25 C	LT	125*	250	241	489	200	67

[1)] separate
* Minimum, depending on total cooling water flow

3. Systems

f) LT temperature controller (separate) FR2:

P-controller with manual emergency adjustment (basis). Option: PI-controller with electric drive.

g) Pre-heater (separate) FH5/FP7:

Consisting of circulating pump [1], electric preheater [2] and control cabinet (separate: W x H x D = 450 x 300 x 200 mm).

[1]	Capacity	8 m³/h
[2]	Output	24 kW

h) Charge air temperature controller CR1 (separate):

P-controller for charge air heating in part load condition.
Option: PI-controller with electric drive (separate only)

i) HT cooler (separate) FH1:

Plate type (plates made of titanium), size depending on the total heat to be dissipated.

j) LT cooler (separate) FH2:

Plate type (plates made of titanium), size depending on the total heat to be dissipated.

k) Header tank FT1/FT2:

- Arrangement: min. 4 m / max. 16 m above crankshaft centre line (CL).
- Size acc. to technical engine data.
- All continuous vents from engine are to be connected.

Option: Header tank HT (FT1) for two-circuit-cooling

3. Systems

3.4.5 Recommendation for cooling water system

Drain tank with filling pump:

It is recommended to collect the treated water during maintenance work (to be installed by the yard).

Electric motor driven pumps:

Option for fresh and seawater, vertical design.
Rough calculation of power demand for the electric balance.

$$P = \frac{\rho \bullet H \bullet V}{367 \bullet \eta} \quad [kW]$$

P - Power [kW]
P_M - Power of electr. motor [kW]
V - Flow rate [m³/h]
H - Delivery head [m]
ρ - Density [kg/dm³]
η - Pump efficiency
0.70 for centrifugal pumps

PM = 1.5 • P	< 1.5	kW
PM = 1.25 • P	1.5 - 4	kW
PM = 1.2 • P	4 - 7.5	kW
PM = 1.15 • P	> 7.5 - 40	kW
PM = 1.1 • P	> 40	kW

3. Systems

3.5 Fuel oil system, MGO/MDO operation

MaK diesel engines have the capacity to burn a wide variety of fuels. See the information on fuel requirements in section MDO / MGO and heavy fuel operation or consult the MaK technical product support. For proper operation of MaK engines the minimum MaK requirements for storage, treatment and supply systems have to be observed; as shown in the following sections.

3.5.1 Quality requirements for MGO/MDO fuel/permitted fuels

Two fuel product groups are permitted for MaK engines:

Pure distillates: Gas oil, marine gas oil, diesel fuel

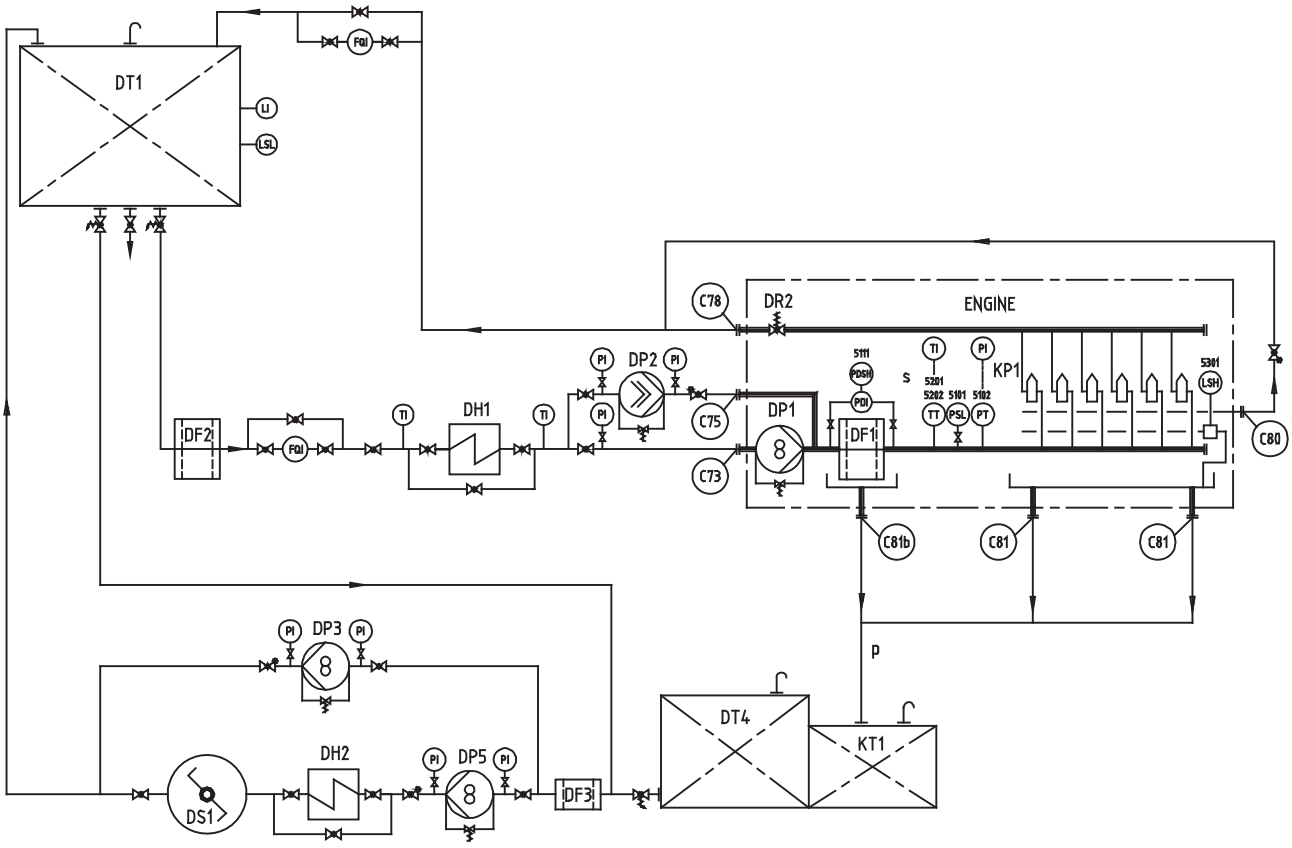
Distillate/mixed fuels: Marine gas oil (MGO), marine diesel oil (MDO). The difference between distillate/mixed fuels and pure distillates is in their higher density, sulphur content and viscosity.

	MGO		MDO	
	Designation	Max. viscosity [cSt/40 °C]	Designation	Max. viscosity [cSt/40 °C]
ISO 8217:2010	ISO-F-DMA	2.0 - 6.0	ISO-F-DMB ISO-F-DMZ	11 6
ASTM D 975-78	No. 1 D No. 2 D	2.4 4.1	No. 2 D No. 4 D	4.1 24.0
DIN	DIN EN 590	8		

Max. injection viscosity 12 cSt (2 °E)

3. Systems

3.5.2 System diagram — Fuel oil system MGO/MDO operation



General notes:
For location, dimensions and design (e. g. flexible connection) of the connecting points see engine installation drawing.
DH1 not required with: - Gas oil ≤ 7 cSt/40°
- heated diesel oil day tank DT1

Accessories and fittings:

DF1	Fuel fine filter (duplex filter)
DF2	Fuel primary filter (duplex filter)
DF3	Fuel coarse filter
DH1	Diesel oil preheater
DH2	Electrical preheater for diesel oil (separator)
DH3	Fuel oil cooler for MDO operation
DP1	Diesel oil feed pump
DP2	Diesel oil stand-by feed pump
DP3	Diesel oul transfer pump (to day tank)
DP5	Diesel oil transfer pump (separator)
DR2	Fuel pressure regulating valve
DS1	Diesel oil separator
DT1	Diesel oil day tank, min. 1 m above crankshaft level
DT4	Diesel oil storage tank
KP1	Fuel injection pump
KT1	Drip fuel tank
FQI	Flow quantity indicator
LI	Level indicator
LSH	Level switch high
LSL	Level switch low
PDI	Diff. pressure indicator
PDSH	Diff. pressure switch high
PI	Pressure indicator
PSL	Pressure switch low
PT	Pressure transmitter
TI	Temperature indicator
TT	Temperature transmitter (PT 100)

Connecting points:

C73	Fuel inlet	C80	Drip fuel
C75	Connection, stand-by pump	C81	Drip fuel
C78	Fuel outlet	C81b	Drip fuel (filter pan)

Notes:
p Free outlet required
s Please refer to the measuring point list regarding design of the monitoring devices

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3.5.3 MGO/MDO fuel system components

a) Fine filter (fitted) DF1:

Duplex filter, mesh size see technical data

b) Strainer (separate) DF2:

Mesh size 0.32 mm, dimensions see HFO-system

c) Pre-heater (separate) DH1:

Heating capacity

$$Q\ [kW] = \frac{P_{eng.}\ [kW]}{166}$$

Not required:
- MGO ≤ 7 cSt/40°C
- Heated day tank

d) MGO/MDO cooler DH3:

Required if the heat can not be removed by heating up of the day tank

e) Feed pump (fitted) DP1:

Capacity see technical data

f) Feed pump (separate) DP1/DP2:

Capacity see technical data
Screw type pump with mechanical seal.
Installation vertical or horizontal.
Delivery head 5 bar.

3. Systems

g) MGO/MDO service tank DT1:

The classification societies require the installation of at least two service tanks. The minimum volume of each tank should, in addition to the MDO/MGO consumption of the generating sets, enable an eight hours full load operation of the main engine.

Cleaning the MDO/MGO by an additional separator should, first of all, be designed to meet the requirements of the diesel generator sets on board.

The tank should be provided with a sludge compartment including a sludge drain valve and an overflow pipe from the MDO/MGO service tank.

h) Intermediate tank (separate) DT2:

Capactiy 49 l

i) Separator DS1:

Recommended for MGO
Required for MDO

The utilisation must be in accordance with the makers official recommendation (details from the head office).

V_{eff} [kg/h] = 0.22 • $P_{eng.}$ [kW]

3.6 Fuel oil system, HFO operation

3.6.1 Quality requirements for HFO/permitted fuels

Minimum requirements for storage, treatment and supply systems

Bunker tanks:

In order to avoid severe operational problems due to incompatibility, each bunkering must be made in a separate storage tank.

Requirements for residual fuels for diesel engines (as bunkered)

	Designation		CIMAC A10	CIMAC B10	CIMAC C10	CIMAC D15	CIMAC E25	CIMAC F25	CIMAC G35	CIMAC H35	CIMAC K35	CIMAC H45	CIMAC K45	CIMAC H55	CIMAC K55
	Related to ISO8217 (2010):E-		RMA10	RMB30	RMB30	RMD80	RME180	RMF180	RMG380	RMH380	RMK380	RMH500	RMK500	RMH700	RMK700
Characteristic	Dim.	Limit													
Density at 15°C	kg/m³	max	960 [2]	975 [3]		980 [4]	991		991		1,010	991	1,010	991	1,010
Kin. viscosity at 100°C		max	10			15	25		35			45		55	
	cSt [1]	min	6 [5]				15 [5]								
Flash point	°C	min	60			60	60		60			60		60	
Pour point (winter) (summer)	°C	max	0 6		24	30	30		30			30		30	
Carbon residue (Conradson)	% (m/m)	max	12 [6]		14	14	15	20	18	22		22		22	
Ash	% (m/m)	max	0.10			0.10	0.10	0.15	0.15	0.15		0.15		0.15	
Total sedim, after ageing	% (m/m)	max	0.10			0.10	0.10		0.10			0.10		0.10	
Water	% (V/V)	max	0.3	0.5		0.5	0.5		0.5			0.5		0.5	
Sulphur	% (m/m)	max	3.5			3.5	3.5		3.5			3.5		3.5	
Vanadium	mg/kg	max	50	150		150	200	350	350		450	450		450	
Aluminium + silicon	mg/kg	max	25	40		40	60		60			60		60	
Zinc	mg/kg	max	15			15	15		15			15		15	
Phosphor	mg/kg	max	15			15	15		15			15		15	
Calcium	mg/kg	max	30			30	30		30			30		30	

[1] An indication of the approximate equivalents in kinematic viscosity at 50 °C and Redw. I sec. 100 °F is given below:

Kinematic viscosity at 100 °C mm²/s (cSt)	7	10	15	25	35	45	55
Kinematic viscosity at 50 °C mm²/s (cSt)	30	40	80	180	380	500	700
Kinematic viscosity at 100 °F Redw. I sec.	200	300	600	1,500	3,000	5,000	7,000

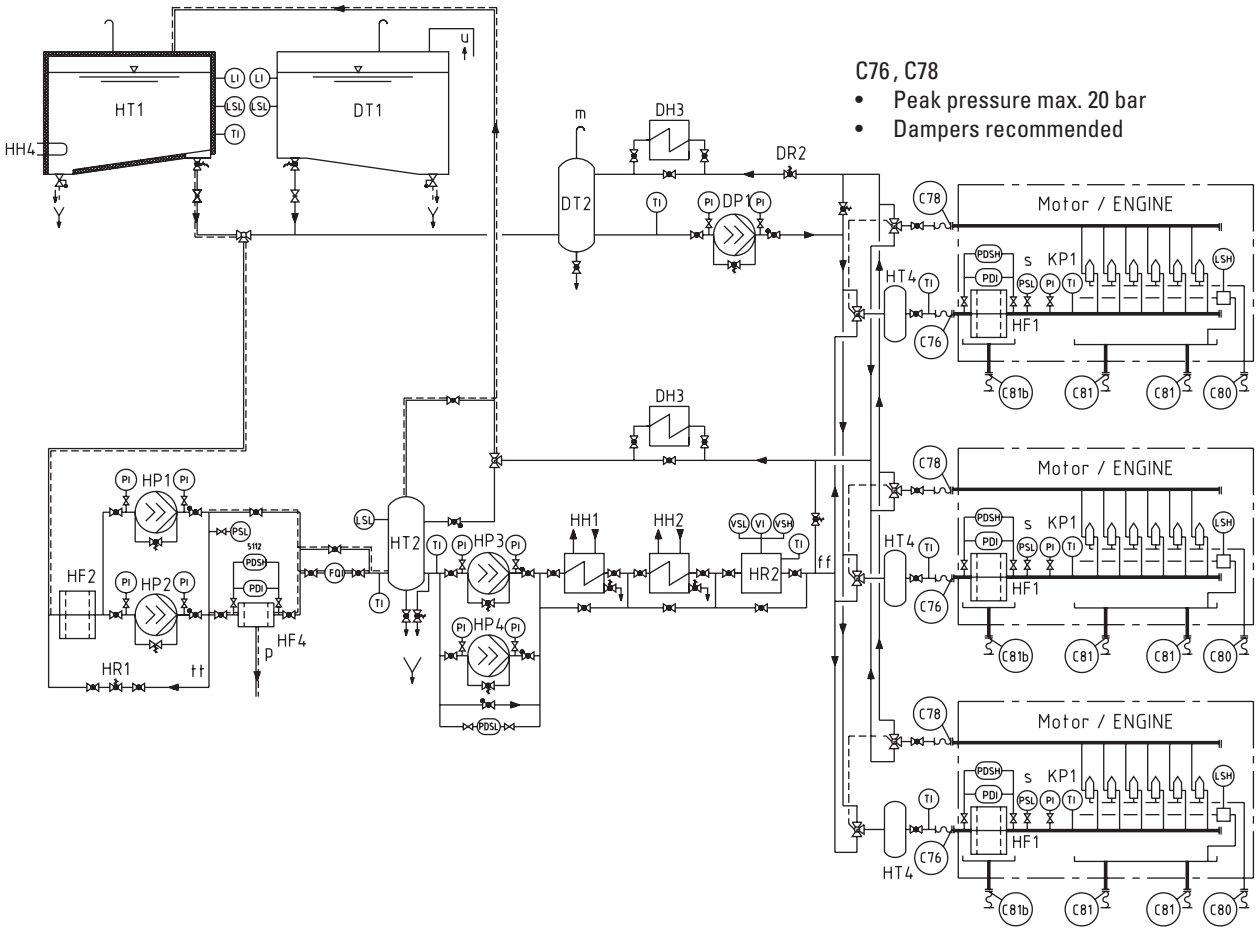
Fuel shall be free of used lube oil (ulo)

[2] ISO: 920
[3] ISO: 960
[4] ISO: 975
[5] ISO: not limited
[6] ISO: Carbon residue 2.5/10

Contents

3. Systems

3.6.2 Heavy fuel operation



General notes:
For location, dimensions and design (e.g. flexible connection) of the connecting points see engine installation drawing.
If a "Fuel oil supply and booster module" is supplied by Caterpillar Motoren, arrangement and scope of the supply components are to be gathered from the module schema.
Non-return valves have to be spring loaded due to pulsation in the fuel lines.

Accessories and fittings:

DH3	MGO/MDO cooler	HT4	Mixing receiver
DP1	Diesel oil feed pump	KP1	Injection pump
DR2	Pressure regulating valve	FQ1	Flow quantity indicator
DT1	Diesel oil day tank	LI	Level indicator
DT2	Diesel oil intermediate tank	LSH	Level switch high
HF1	Fine filter (duplex filter)	LSL	Level switch low
HF2	Primary filter	PDI	Diff. pressure indicator
HF4	Self cleaning filter	PDSH	Diff. pressure swith high
HH1	Heavy fuel final preheater	PDSL	Diff. pressure switch low
HH2	Stand-by final preheater	PI	Pressure indicator
HH4	Heating coil	PSL	Pressure switch low
HP1/HP2	Pressure pump	PT	Pressure transmitter
HP3/HP4	Circulating pump	TI	Temperature indicator
HR1	Pressure regulating valve	VI	Viscosity indicator
HR2	Viscosimeter	VSH	Viscosity control swith high
HT1	Heavy fuel day tank	VSL	Viscosity control switch low
HT2	Mixing tank		

Notes:
ff Flow velocity in circuit system ≤ 0.5 m/s
m Lead vent pipe beyond day tank level
p Free outlet required
s Please refer to the measuring point list regarding design of the monitoring devices
tt Pipe is not insulated nor heated
u From diesel oil separator or diesel oil transfer pump

All heavy fuel pipes must be insulated.
═══ heated pipe

Connecting points:

C76	Inlet duplex filter
C78	Fuel outlet
C80	Drip fuel
C81	Drip fuel
C81b	Drip fuel (filter pan)

3. Systems

3.6.3 HFO system components

Supply system (separate components):

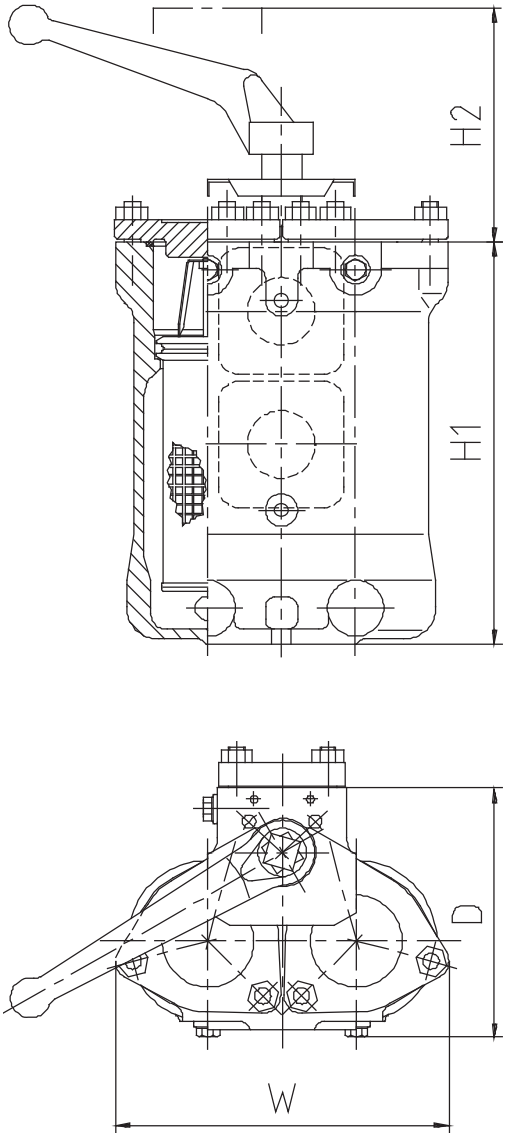
A closed **pressurized system** between day tank and engine is required as well as the installation of an automatic backflushing filter with a mesh size of 10 µm (absolute).

a) Fine filter (fitted) HF1:

- Mesh size 34 µm
- **Without** heating
- Differential pressure indication and alarm contact fitted

b) Strainer HF2:

Mesh size 0.32 mm



Output [kW]	DN	H1	H2	W	D
		[mm]			
≤ 5,000	32	249	220	206	180
≤ 10,000	40	330	300	250	210
≤ 20,000	65	523	480	260	355
> 20,000	80	690	700	370	430

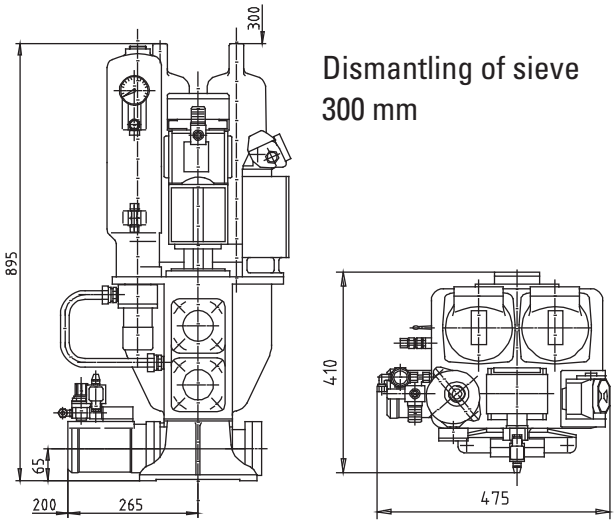
3. Systems

c) Self cleaning filter HF4:

Mesh size 10 µm (absolute), maker Boll & Kirch*, **without** bypass filter.

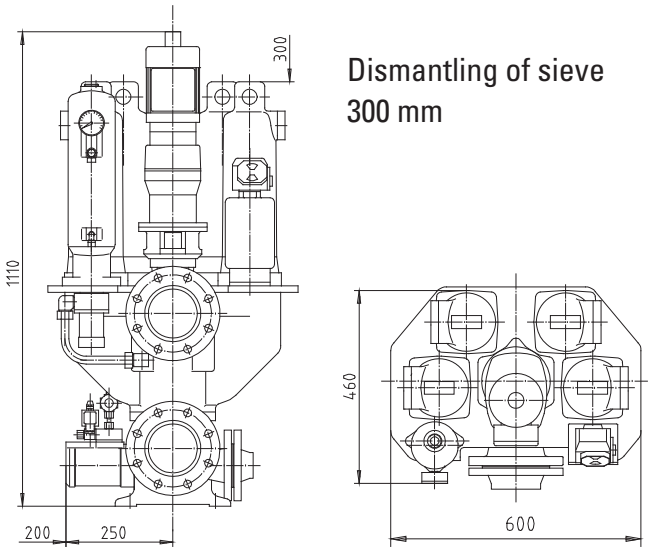
* In case of Caterpillar Motoren supply.

≤ 8,000 kW, Type 6.60, DN 50



Dismantling of sieve 300 mm

> 8,000 kW, Type 6.61, DN 100



Dismantling of sieve 300 mm

d) Viscosimeter HR2:

This device automatically regulates the heating of the final-preheater depending on the viscosity of the bunkered fuel oil, so that the fuel will reach the nozzles with the required viscosity for injection.

e) Pressurizing pumps HP1/HP2:

Screw type pump with mechanical seal.
Installation vertical or horizontal. Delivery head 5 bar.

$$\text{Capacity} \quad V\ [m^3/h] = 0.4 \bullet \frac{P_{eng.}\ [kW]}{1{,}000}$$

f) Circulating pumps HP3/HP4:

Screw type pump with mechanical seal.
Installation vertical or horizontal. Delivery head 5 bar.

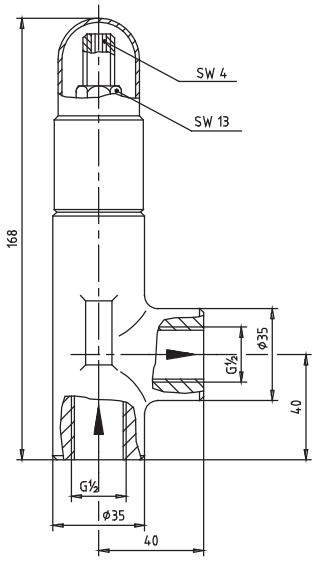
$$\text{Capacity} \quad V\ [m^3/h] = 0.7 \bullet \frac{P_{eng.}\ [kW]}{1{,}000}$$

3. Systems

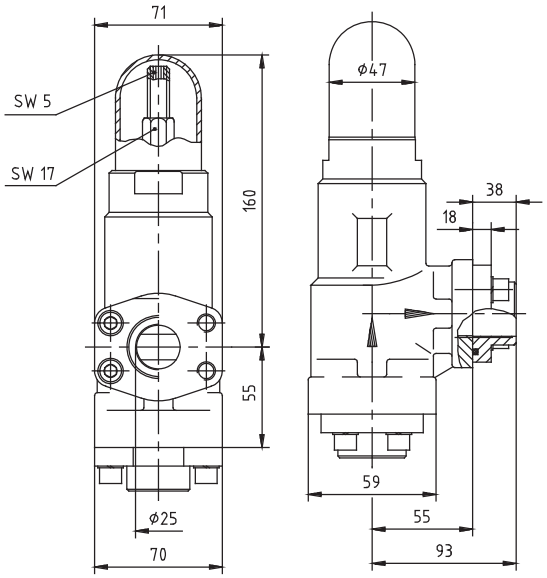
g) Pressure regulating valve HR1: Controls the pressure at the engine inlet, approx. 4 bar.

Engine outputs

≤ 3,000 kW



> 3,000 kW



h) Final preheater HH1/HH2:

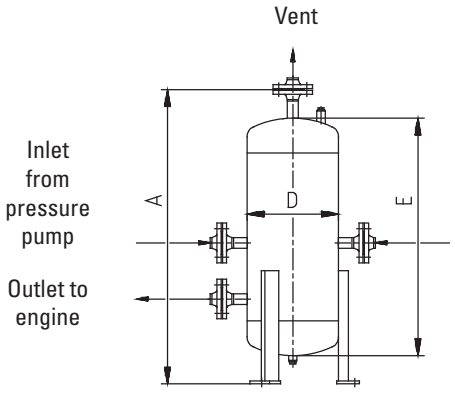
Heating media:

- Electric current (max. surface power density 1.1 W/cm²)
- Steam
- Thermal oil

Temperature at engine inlet max. 150 °C. The piping for both heaters shall be arranged for separate and series operation. Parallel operation with the half flow rate must be avoided due to the risk of sludge deposition.

i) Mixing tank (without insulation) HT2:

Engine output	Volume	Dimensions [mm]			Weight
[kW]	[l]	A	D	E	[kg]
≤ 4,000	50	950	323	750	70
≤ 10,000	100	1,700	323	1,500	120
> 10,000	200	1,700	406	1,500	175



The mixing tank compensates pressure surges which occur in the pressurised part of the fuel system. For this purpose there has to be an air cushion in the tank.

3. Systems

j) Settling tanks HT5/HT6:

In order to ensure a sufficient settling effect, the following settling tank designs are permitted:

- 2 settling tanks, each with a capacity sufficient for 24 hours full load operation of all consumers
- 1 settling tank with a capacity sufficient for 36 hours full load operation of all consumers and automatic filling
- Settling tank temperature 70 - 80 °C

k) Day tank DT1/HT1:

Two day tanks are required. The day tank capacity must cover at least 4 hours/max. 24 hours full load operation of all consumers. An overflow system into the settling tanks and sufficient insulation are required. The tank should have a sludge space with a tank bottom inclination of preferably 10°, with sludge drain valves at the lowest point, and is to be equipped with heating coils.

Guide values for temperatures

Fuel viscosity cSt/50 °C	Tank temperature [°C]
30 - 80	70 - 80
80 - 180	80 - 90
> 180 - 700	max. 98

l) Separators HS1/HS2:

Caterpillar Motoren recommends to install two self-cleaning separators. Design parameters as per supplier recommendation. Separating temperature 98 °C! Maker and type are to be advised by Caterpillar Motoren.

3. Systems

3.6.4 Heavy fuel oil supply and booster standard module

(Pressurized System), up to IFO 700 for steam and thermal oil heating, up to IFO 180 for elect. heating

Technical specification of the main components:

a) Primary filter FIL1
1 pc. duplex strainer 540 microns

b) Fuel pressure pumps, vertical installation SP1/SP2
2 pcs. screw pumps with mechanical seal

c) Pressure regulating system PCV1
1 pc. pressure regulating valve

d) Self-cleaning fine filter AF1
1 pc. automatic self cleaning fine filter 10 microns absolute (without by-pass filter)

e) Consumption measuring system FLOW1
1 pc. flowmeter with local totalizer

f) Mixing tank with accessories T1

1 pc. pressure mixing tank	approx. 49 l volume up to 4,000 kW approx. 99 l volume from 4,001 - 20,000 kW (with quick-closing valve)

g) Circulating pumps, vertical installation BP1/BP2
2 pcs. screw pumps with mechanical seal

h) Final preheater H1/H2

2 pcs. shell and tube heat exchangers	each 100 % (saturated 7 bar or thermal oil 180 °C) each 100 % electrical

- **Heating medium control valve CV1** (steam/thermal oil)
- **Control cabinet** (electrical)

1 pc. control valve with built-on positioning drive 1 pc. control cabinet for electr. preheater

Viscosity control system VA1
1 pc. automatic viscosity measure and control system VAF

Cooler CL1
1 pc. shell and tube heat exchanger for operating on MGO/MDO

3. Systems

Module controlled automatically with alarms and starters
Pressure pump starters with stand-by automatic
Circulating pump starters with stand-by automatic
PI-controller for viscosity controlling
Starter for the viscosimeter
Analog output signal 4 - 20 mA for viscosity

Alarms
Pressure pump stand-by start
Low level in the mixing tank
Circulating pump stand-by start
Self cleaning fine filter clogged
Viscosity alarm high/low
Alarms with potential free contacts

Alarm cabinet with alarms to engine control room and connection possibility for remote start/stop and indicating lamp of fuel pressure and circulating pumps

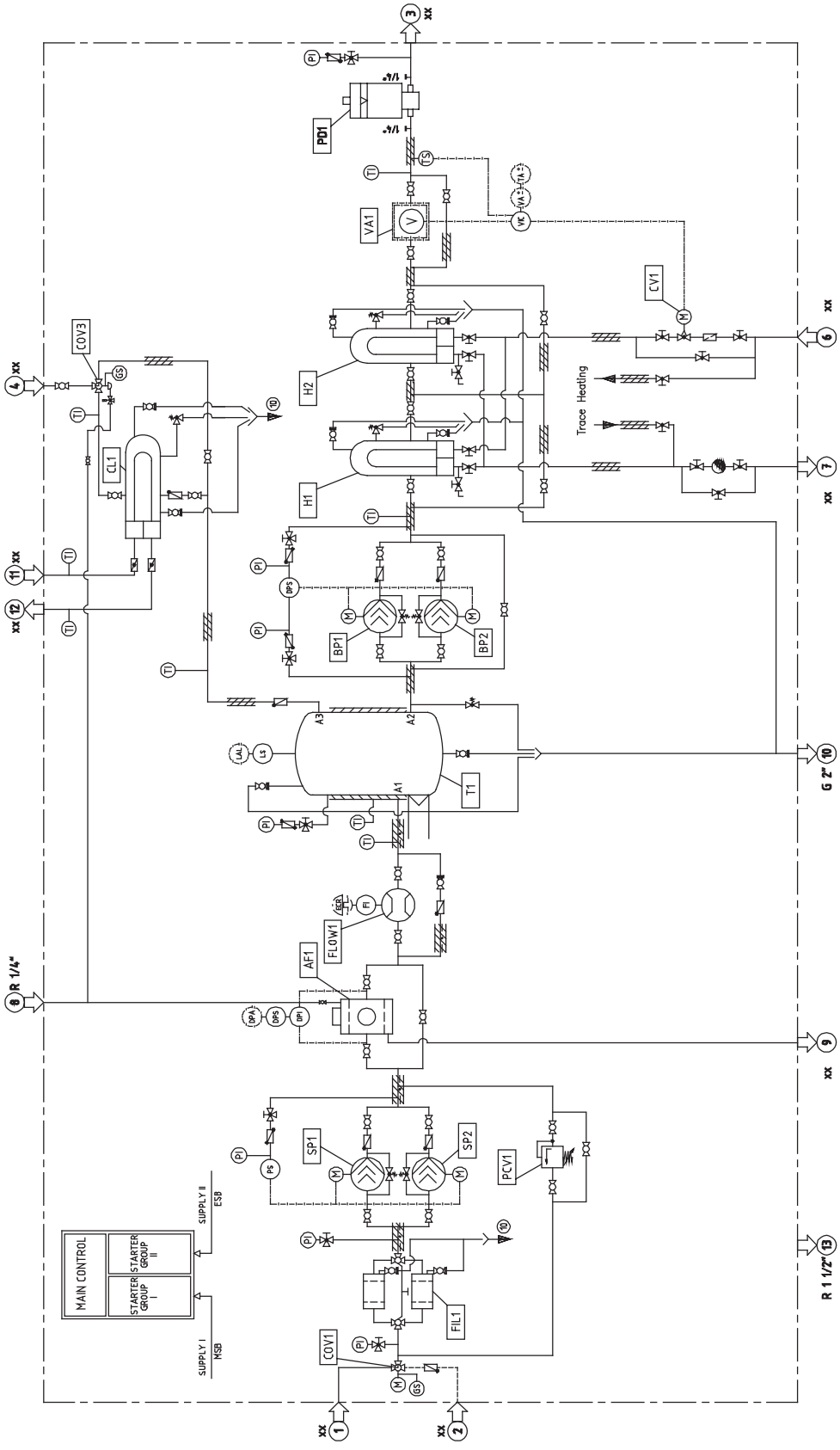
Performance and materials:
The whole module is piped and cabled up to the terminal strips in the electric switch boxes which are installed on the module. All necessary components like valves, pressure switches, thermometers, gauges etc. are included. The fuel oil pipes are equipped with trace heating (steam, thermaloil or electrical) where necessary.

The module will be tested hydrostatically and functionally in the workshop without heating.

Capacity [kW]	Type	Weight [kg]	L x B x H [mm]
2,400 - 3,000	Steam / Thermal Electric	1,800 1,700	2,800 x 1,200 x 2,000
4,000 - 4,500	Steam / Thermal Electric	2,600 2,400	3,000 x 1,200 x 2,100
5,000 - 6,000	Steam / Thermal Electric	3,200 3,000	3,200 x 1,300 x 2,100
8,000 - 9,000	Steam / Thermal Electric	3,600 3,200	3,400 x 1,400 x 2,100
10,000 - 12,000	Steam / Thermal	4,000	3,600 x 1,400 x 2,100
13,400 - 16,000	Steam / Thermal	4,200	4,200 x 1,600 x 2,100
19,200 - 24,000	Steam / Thermal	5,400	5,000 x 1,700 x 2,100
25,600 - 32,000	Steam / Thermal	6,000	6,000 x 2,000 x 2,100

3. Systems

Steam heated



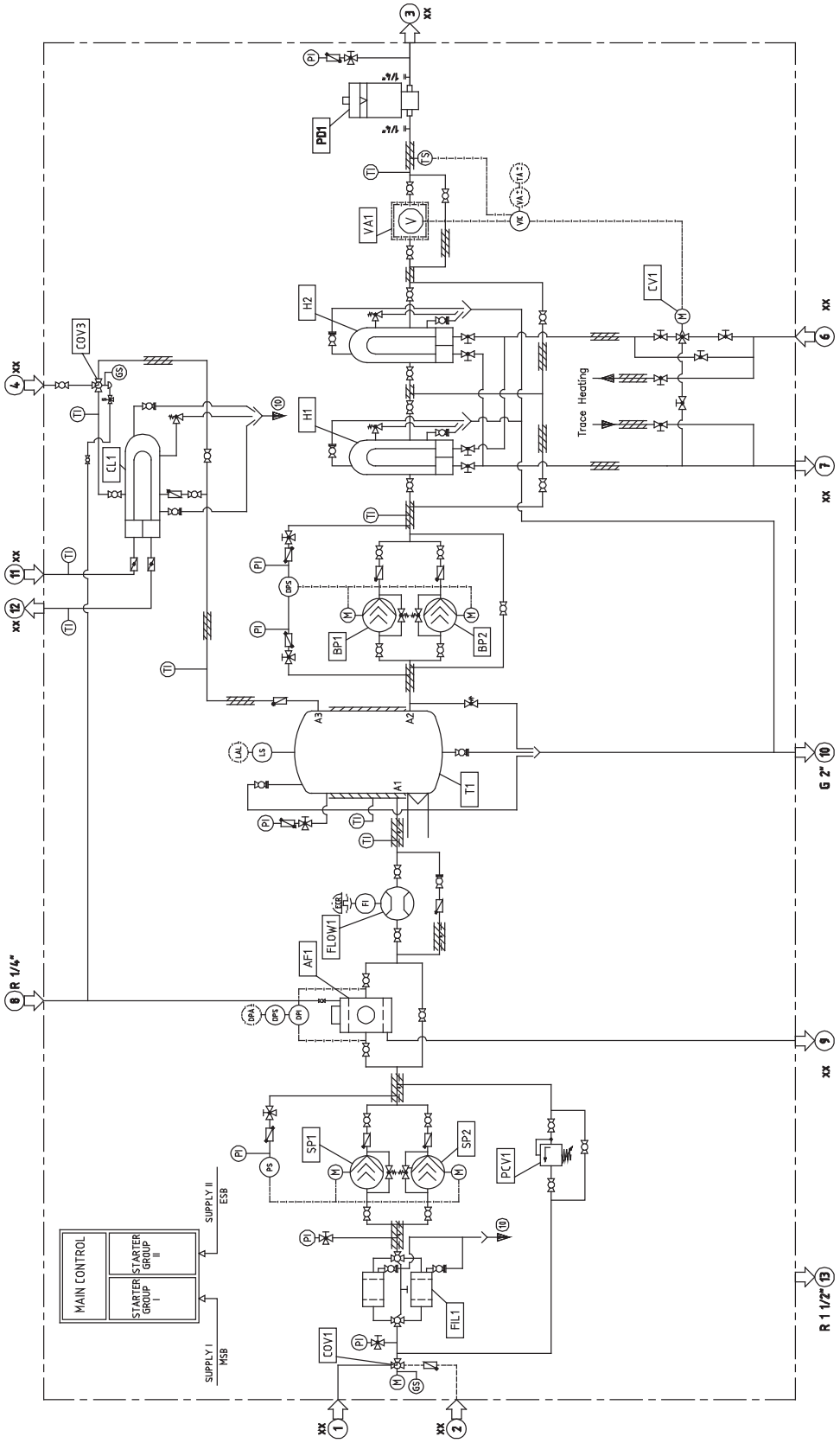
Symbols

	FLOW1	Flowmeter
	SP1/SP2 BP1/BP2	Screw displacement pump
	H1/H2	steam heater
	CL1	Cooler
	VA1	Viscosimeter
	FIL1	Duplex filter
	AF1	Automatic filter
	T1	Mixing tank
	PD1	Metal bellows accumulator
	COV1 COV3	Change over valve
	PCV1	Pressure regulating valve
	CV1	Control valve
		Y-strainer
		Steam trap
		Globe valve
		Non-return valve
		Safety valve, angle
		Magnet valve
		test valve
		Brass pres. gauge shock absorber
		Ball valve locking device
		Ball valve
		Butterfly valve
		Pipe with insulation
		Pipe with insulation & trace heating
		Scope of supply module

DPA	Diff. pressure alarm
DPI	Diff. pressure indicator
DPS	Diff. pressure switch
FI	Flow indicator
GS	Limit switch
LAL	Level alarm low
LS	Level switch
M	Motor drive
PI	Pressure indicator
PS	Pressure switch
TA	Temperature alarm
TI	Temperature indicator
TS	Temperature sensor
VA	Viscosity alarm
VIC	Viscosity controller

3. Systems

Thermal oil heated



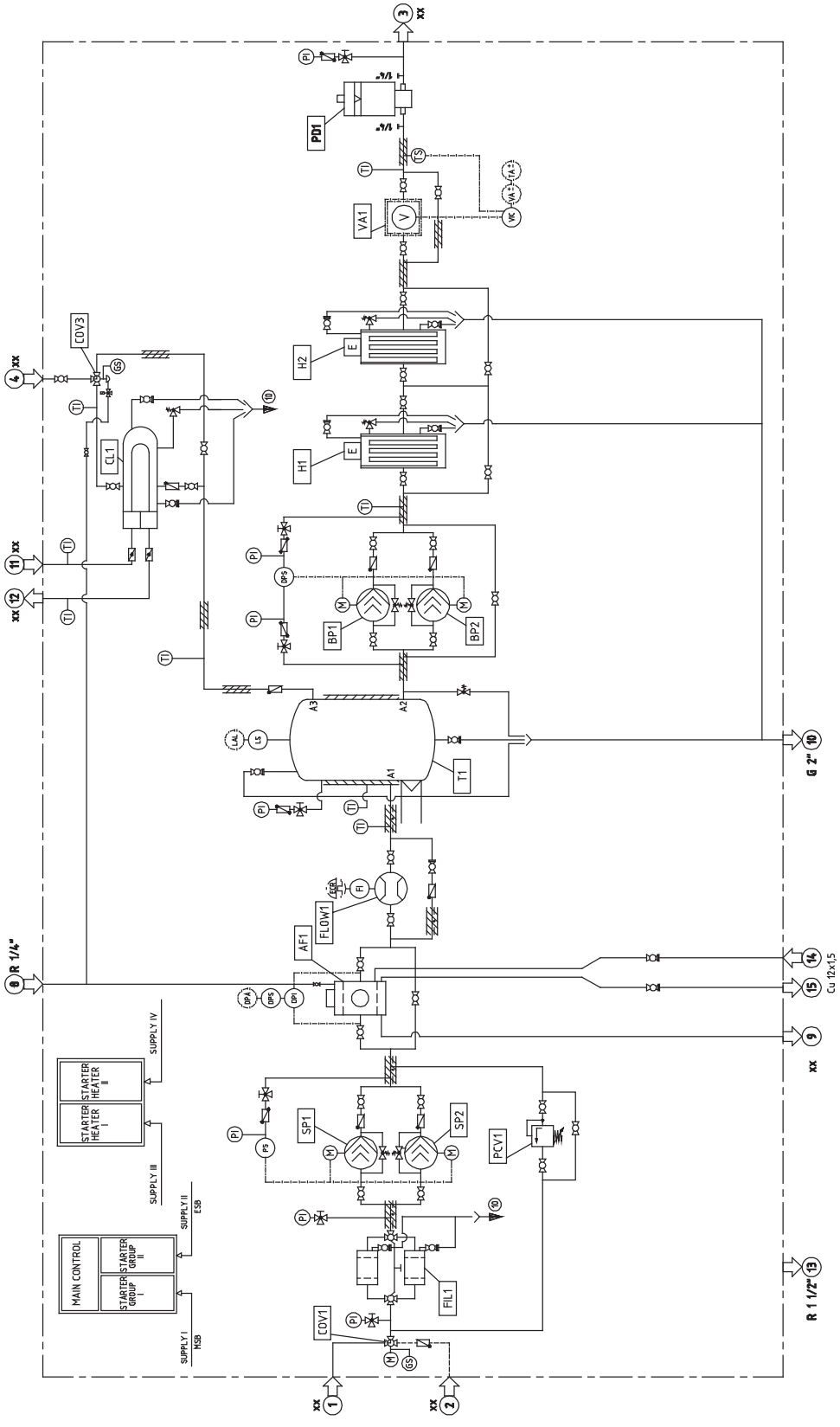
Symbols

	FLOW1	Flowmeter
	SP1/SP2 BP1/BP2	Screw displacement pump
	H1/H2	steam heater
	CL1	Cooler
	VA1	Viscosimeter
	FIL1	Duplex filter
	AF1	Automatic filter
	T1	Mixing tank
	PD1	Metal bellows accumulator
	COV1 COV3	Change over valve
	PCV1	Pressure regulating valve
	CV1	Control valve
		Y-strainer
		Steam trap
		Globe valve
		Non-return valve
		Safety valve, angle
		Magnet valve
		test valve
		Brass pres. gauge shock absorber
		Ball valve locking device
		Ball valve
		Butterfly valve
		Pipe with insulation
		Pipe with insulation & trace heating
		Scope of supply module

DPA	Diff. pressure alarm
DPI	Diff. pressure indicator
DPS	Diff. pressure switch
FI	Flow indicator
GS	Limit switch
LAL	Level alarm low
LS	Level switch
M	Motor drive
PI	Pressure indicator
PS	Pressure switch
TA	Temperature alarm
TI	Temperature indicator
TS	Temperature sensor
VA	Viscosity alarm
VIC	Viscosity controller

3. Systems

Electric heated



Symbols

	FLOW1	Flowmeter
	SP1/SP2 BP1/BP2	Screw displacement pump
	H1/H2	steam heater
	CL1	Cooler
	VA1	Viscosimeter
	FIL1	Duplex filter
	AF1	Automatic filter
	T1	Mixing tank
	PD1	Metal bellows accumulator
	COV1 COV3	Change over valve
	PCV1	Pressure regulating valve
	CV1	Control valve
		Y-strainer
		Steam trap
		Globe valve
		Non-return valve
		Safety valve, angle
		Magnet valve
		test valve
		Brass pres. gauge shock absorber
		Ball valve locking device
		Ball valve
		Butterfly valve
		Pipe with insulation
		Pipe with insulation & trace heating
		Scope of supply module

DPA	Diff. pressure alarm
DPI	Diff. pressure indicator
DPS	Diff. pressure switch
FI	Flow indicator
GS	Limit switch
LAL	Level alarm low
LS	Level switch
M	Motor drive
PI	Pressure indicator
PS	Pressure switch
TA	Temperature alarm
TI	Temperature indicator
TS	Temperature sensor
VA	Viscosity alarm
VIC	Viscosity controller

3. Systems

3.7 Lubricating oil system

3.7.1 Quality requirements of lubricating oil

The engine lubricating oil fulfils several basic functions:

- Cleaning the engine from dirt and wear particles
- Transportation of dirt and wear particles to the filters
- Cooling of heat-affected parts, such as piston, cylinder liner, valves or cylinder head
- Protection of bearings from shocks of cylinder firing
- Lubrication of metal surfaces / reduction of wear and friction
- Neutralisation of corrosive combustion products
- Corrosion protection of metal surfaces

The viscosity class SAE 40 is required.

Wear and tear and thus the service life of the engine depend on the lubricating oil quality. Therefore high requirements are made for lubricants:

Constant uniform distribution of the additives at all operating conditions. Perfect cleaning (detergent effect) and dispersing power, prevention of deposits from the combustion process in the engine. Sufficient alkalinity in order to neutralize acid combustion residues. The TBN (Total Base Number) must be between 30 and 40 KOH/g at HFO operation. For MDO operation the TBN is 12 - 20 depending on sulphur content.

3. Systems

The following oils have been tested and approved by Caterpillar Motoren GmbH & Co. KG:

Manufacturer	Diesel oil/marine-diesel oil operation	I	II	HFO operation	I	II
AGIP	DIESEL SIGMA S		x	CLADIUM 300 S	x	
	CLADIUM 120		x	CLADIUM 400 S	x	
BP	ENERGOL HPDX 40	x		ENERGOL IC-HFX 304	x	
	ENERGOL DS 3-154	x		ENERGOL IC-HFX 404	x	
	ENERGOL IC-HFX 204	x				
	VANELLUS C3		x			
CHEVRON, CALTEX, TEXACO	DELO 1000 MARINE	x		TARO 30 DP	x	
	TARO 12 XD	x		TARO 40 XL	x	
	TARO 16 XD	x		TARO 40 XLX	x	
	TARO 20 DP	x				
	TARO 20 DPX	x				
CASTROL	MARINE MLC	x		TLX PLUS 304	x	
	MHP 154	x		TLX PLUS 404	x	
	TLX PLUS 204	x				
CEPSA	KORAL 1540		x			
ESSO	EXXMAR 12 TP	x		EXXMAR 30 TP	x	
	EXXMAR CM+		x	EXXMAR 40 TP		x
	ESSOLUBE X 301		x	EXXMAR 30 TP PLUS	x	
				EXXMAR 40 TP PLUS	x	
MOBIL	MOBILGARD 412	x		MOBILGARD M 430	x	
	MOBILGARD ADL	x		MOBILGARD M 440	x	
	MOBILGARD M 430	x		MOBILGARD M 50	x	
	MOBILGARD 1-SHC [1)]		x			
	DELVAC 1640	x				
SHELL	GADINIA	x		ARGINA T	x	
	GADINIA AL	x		ARGINA X	x	
	ARGINA S	x				
	ARGINA T	x				
TOTAL LUBMARINE	RUBIA FP		x	AURELIA TI 4030	x	
	DISOLA M 4015	x		AURELIA TI 4040	x	
	AURELIA TI 4030	x				

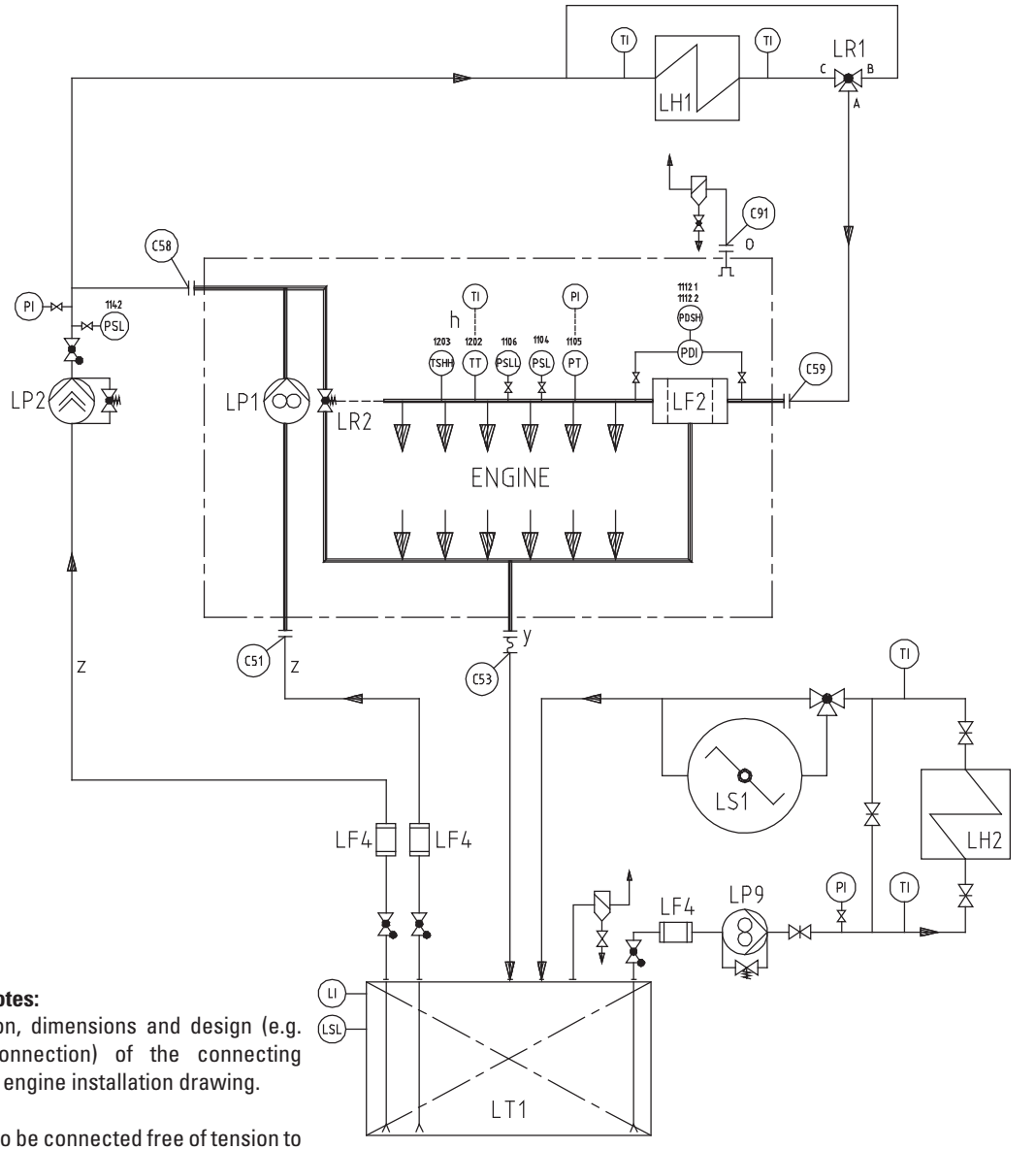
I Approved in operation

II Permitted for controlled use
When these lube oils are used, Caterpillar Motoren must be informed because as currently there is insufficient experience available for MaK engines. Otherwise the warranty is invalid.

[1)] Synthetic oil with a high viscosity index (SAE 15 W/40). Only permitted if the oil inlet temperatures can be decreased by 5 - 10 °C.

3. Systems

3.7.2 System diagram



General notes:
For location, dimensions and design (e.g. flexible connection) of the connecting points see engine installation drawing.

Pipes are to be connected free of tension to the engine connection.

Notes:
- d Opening pressure 1 bar
- h Please refer to the measuring point list regarding design of the monitoring devices
- o See "crankcase ventilation" installation instructions 4-A-9570
- y Provide an expansion joint

Connecting points:

C51	Force pump, suction side
C53	Lube oil discharge
C58	Force pump, delivery side
C59	Lube oil inlet, luboil filter
C91	Crankcase ventilation to stack

Accessories and fittings:

LF2	Lube oil automatic filter
LF4	Suction strainer
LH1	Lube oil cooler
LH2	Lube oil preheater
LP1	Lube oil force pump
LP2	Lube oil stand-by force pump
LP9	Transfer pump (separator)
LR1	Lube oil thermostat valve
LR2	Oil pressure regulating valve
LS1	Lube oil separator
LT1	Lube oil sump tank
LI	Level indicator
LSL	Level switch low
PDI	Diff. pressure indicator
PDSH	Diff. pressure switch high
PI	Pressure indicator
PSL	Pressure switch low
PT	Pressure transmitter
TI	Temperature indicator
TSHH	Temperature switch high
TT	Temperature transmitter (PT 100)

3. Systems

3.7.3 Lubricating oil system components

a) Force pump (fitted) LP1:

Gear pump

b) Prelubrication pump (fitted) LP5:

Delivery head 5 bar
Continuous lubrication is carried out with stopped genset.
Starter to be supplied by the yard.

c) Stand-by force pump (separate) LP2:

- per engine according to classification society requirement
- screw type/gear type pump

d) Strainer LF4:

Mesh size 2 - 3 mm

e) Self-cleaning filter (fitted) LF2:

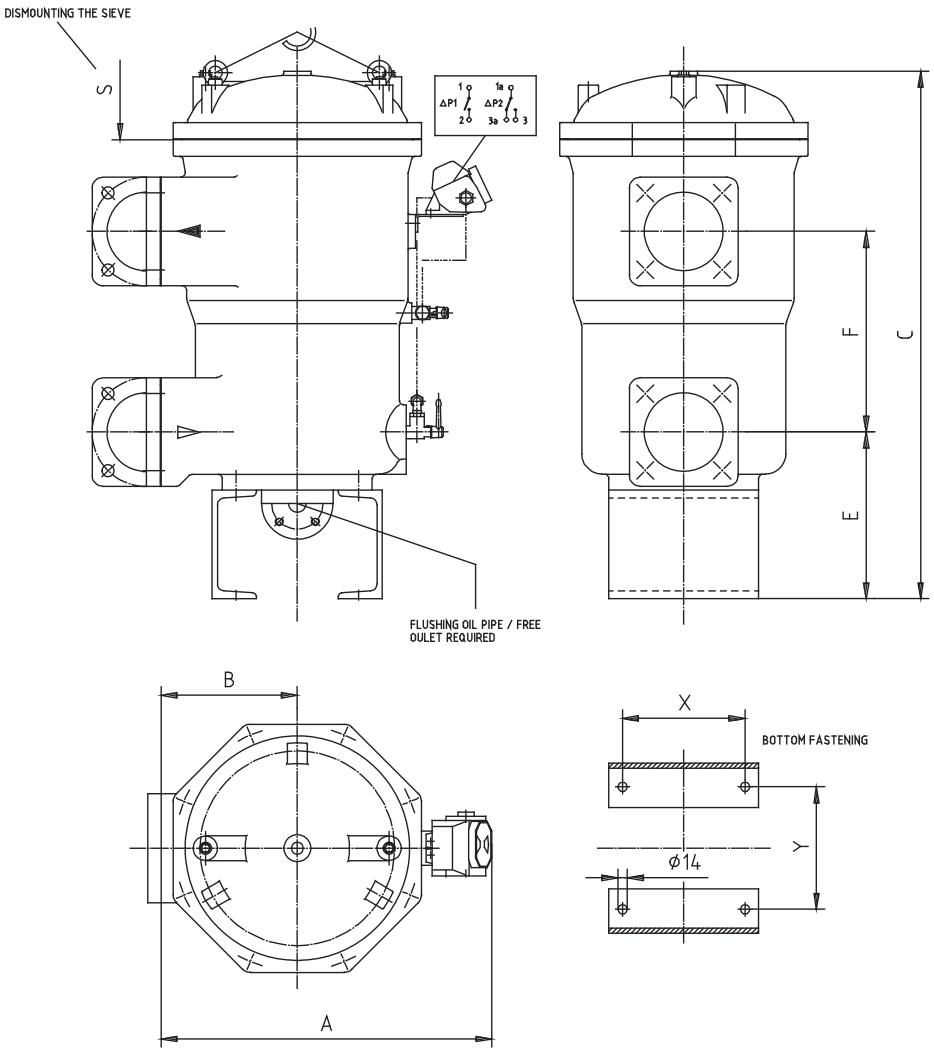
The self-cleaning filter protects the engine against dirt particles which may have accumulated in the oil tank.

The filter is fitted and replaces the duplex filter. Separate self-cleaning filter as an option possible. Dimension see next page.

Mesh size 30 µm (absolute), type 6.46 DN 100, make Boll & Kirch. **Without** by-pass filter. **Without** flushing oil treatment.

3. Systems

Self-cleaning filter separate LF2 (option)



Engine	A	B	C	E	F	S	X	Y	Weight [kg]	ND
6 M 25 C	435	170	735	205	225	400	160	160	77	80
8/9 M 25 C	485	200	775	245	295	400	180	180	112	100

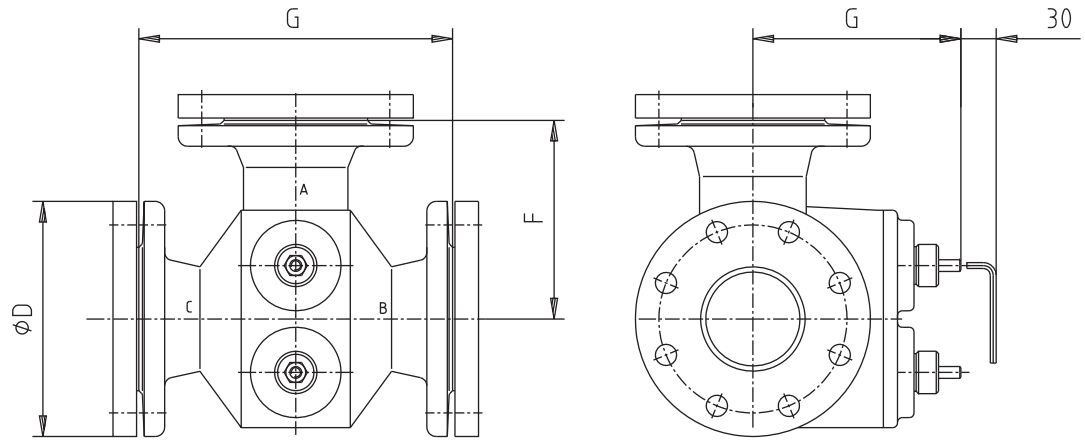
f) Cooler (fitted on base frame) LH1:

Option:
separate plate type (plates made of stainless steel)

3. Systems

g) Temperature controller LR1:

Separate P-controller with manual emergency adjustment



	Dimensions [mm]					Weight
	DN	D	F	G	H	[kg]
6 M 25 C	80	200	171	267	151	27
8/9 M 25 C	100	220	217	403	167	47

h) Circulation tank LT1:

Volume

$$V\,[m^3] = \frac{1.7 \bullet P_{eng.}\,[kW]}{1000}$$

Oil filling approx. 80 % of tank volume.

In case of a high level tank max. 2.5 m above crankshaft.

If no coffer dam can be arranged under the circulation tank, it is necessary to install a remote controlled shut-off valve into drain pipe, which is not supplied by the engine builder. For this class requirement "If the ship is grounded it must be possible to prevent seawater entering the engine" contact the responsible classification society.

3. Systems

Discharge to circulating tank:

DN 200 at driving end or free end. Expansion joint to be supplied by the **yard.**

Option:

Deep oil pan (wetsump). Oil volume approx. 0.8 l/kW output. Please ask for availability.

i) Crankcase ventilation C91:

At engine 1 x DN 80. Approx. 1 m after the connection point has to be enlarged to DN 125.

It must be equipped with a condensate trap and continuous drain. It has to be arranged separately for each genset. Crankcase pressure max. 150 Pa.

j) Separator; treatment at MGO/MDO operation LS1:

Required with the following design:

- Separating temperature 85 - 95 °C
- Quantity to be cleaned three times/day
- Self-cleaning type

V_{eff} [l/h] = 0.18 • P_{eng} [kW]

k) Separator; treatment at HFO operation LS1:

Required with the following design:

- Separating temperature 95 °C
- Quantity to be cleaned five times/day
- Self-cleaning type

V_{eff} [l/h] = 0.29 • P_{eng} [kW]

3. Systems

3.7.4 Recommendation for lubricating oil system

For each engine a separate lube oil system is required.

Lube oil quantities/change intervals:

Recommended/circulating quantity:
approx. 1.3 l/kW output with separate tank
approx. 0.8 l/kW output with wet sump

The change intervals depend on:

- the quantity
- fuel quality
- quality of lube oil treatment (filter, separator)
- engine load

By continuous checks of lube oil samples (decisive are the limit values as per "MaK Operating Media") an optimum condition can be reached.

Suction pipes

Suction pipes must be installed with a steady slope and dimensioned for the total resistance (including pressure drop for the suction filter) not exceeding the pump suction head.

In order to prevent lube oil backflow when the engine has been shut-off a non-return flap must be installed close to the lube oil tank.

In case of using engine-fitted pumps and to protect the pump seals against high pressure because of counter rotation during shutdowns, the non-return flap must be by-passed by a relief valve.

External lubricating oil piping system information

After bending and welding all pipes must be cleaned by using an approved acid cleaning process.

A proper inspection of the inner walls of the pipes is needed by our service engineers before starting the engine to ensure that no weld spatter, slag, rust and oxide remain.

3. Systems

Recommendation of pipe location in the circulating tank (top view)

Prevention of seawater entering the engine

If no coffer dam can be arranged under the circulation tank, it is necessary to install a remote controlled shut-off valve into the drain pipe, which is not supplied by the engine builder. For this class requirement "If the ship is grounded it must be possible to prevent seawater entering the engine" contact the responsible classification society.

Expansion joints

Pipe expansion joints are necessary in systems that convey high-temperature substances, in this case hot oil. The bellows are designed to withstand the internal pressures of the pipe, but are flexible enough to accept the axial, lateral and angular deflections.

For the compensate of the thermal movement pipe expansion joints are required at the connection of the oil drain pipes to the service tank.

Lube oil drain

One connection for the oil drain pipe is located on the driving end of the engine. If there is an inclination angle at the free end the pipe has to be located at the free end.

The drain pipes must be kept short. To create a liquid seal between crankcase and tank, the slanted pipe end must be immersed in the oil.

4. Connecting parts engine

4.1 Power transmission

4.1.1 Coupling between engine and gearbox

For all types of plants the engines will be equipped with flexible flange couplings.

The **guards** for the flexible couplings should be of perforated plate or gratings to ensure an optimum heat dissipation (**yard supply**).

Mass moments of inertia

	Speed [rpm]	Engine * [kgm²]	Flywheel [kgm²]	Total [kgm²]
6 M 25 C	720/750	135	220	355
8 M 25 C		205		425
9 M 25 C		215		435

* Running gear with balance weights and vibration damper

Selection of flexible couplings

The calculation of the coupling torque for main couplings is carried out acc. to the following formula.

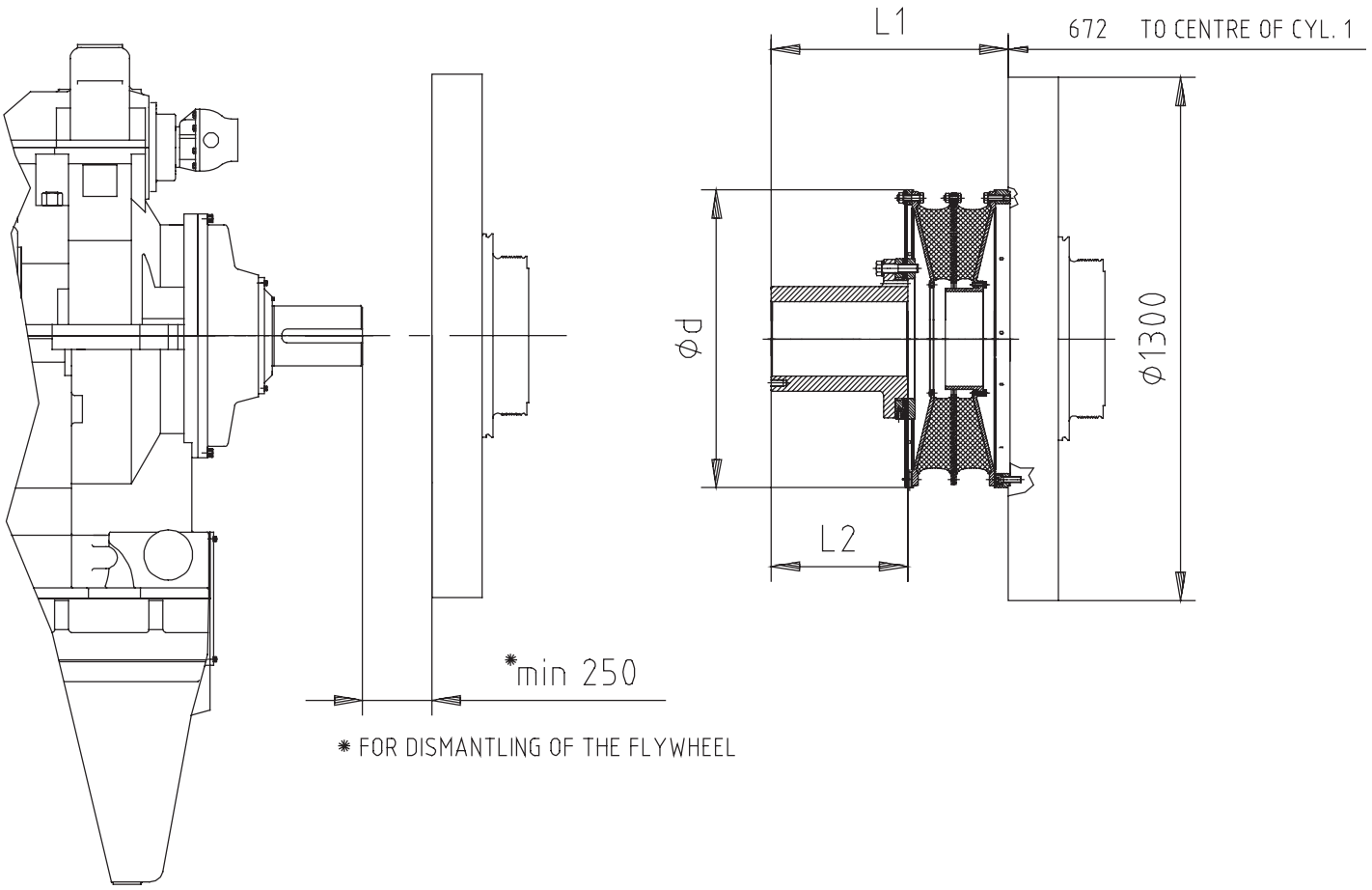
$$T_{KN}[kNm] \geq \bullet \frac{P_0\,[kW]}{n_0\,[min^{-1}]} \bullet 9.55$$

P_0 Engine output
n_0 Engine speed
T_{KN} Nominal torque of the coupling in the catalog

For installations with a gearbox PTO it is recommended to oversize the PTO coupling by factor 1.5 in order to have sufficient safety margin in the event of misfiring.

4. Connecting parts engine

Flywheel and flexible coupling



	Power	Speed	Nominal torque of coupling	Type Vulkan Rato-R				Weight	
				Size	d	L1 [4]	L2 [3]	[1]	[2]
	[kW]	[rpm]	[kNm]	Rato-R	[mm]	[mm]	[mm]	[kg]	[kg]
6 M 25 C	2,000	750	31.5	G 262 ZR	800	594	309	333	352
8 M 25 C	2,666	750	40.0	G 262 TR					
9 M 25 C	3,000	750	45.0	G 262 YR					

1) without torsional limit device
2) with torsional limit device
3) length of hub
4) alignment control (recess depth 5 mm)

Space for OD box to be considered!

Couplings for twin rudder propeller have to be designed with a supplementary torque of 50 %.

4. Connecting parts engine

4.1.2 Power take-off

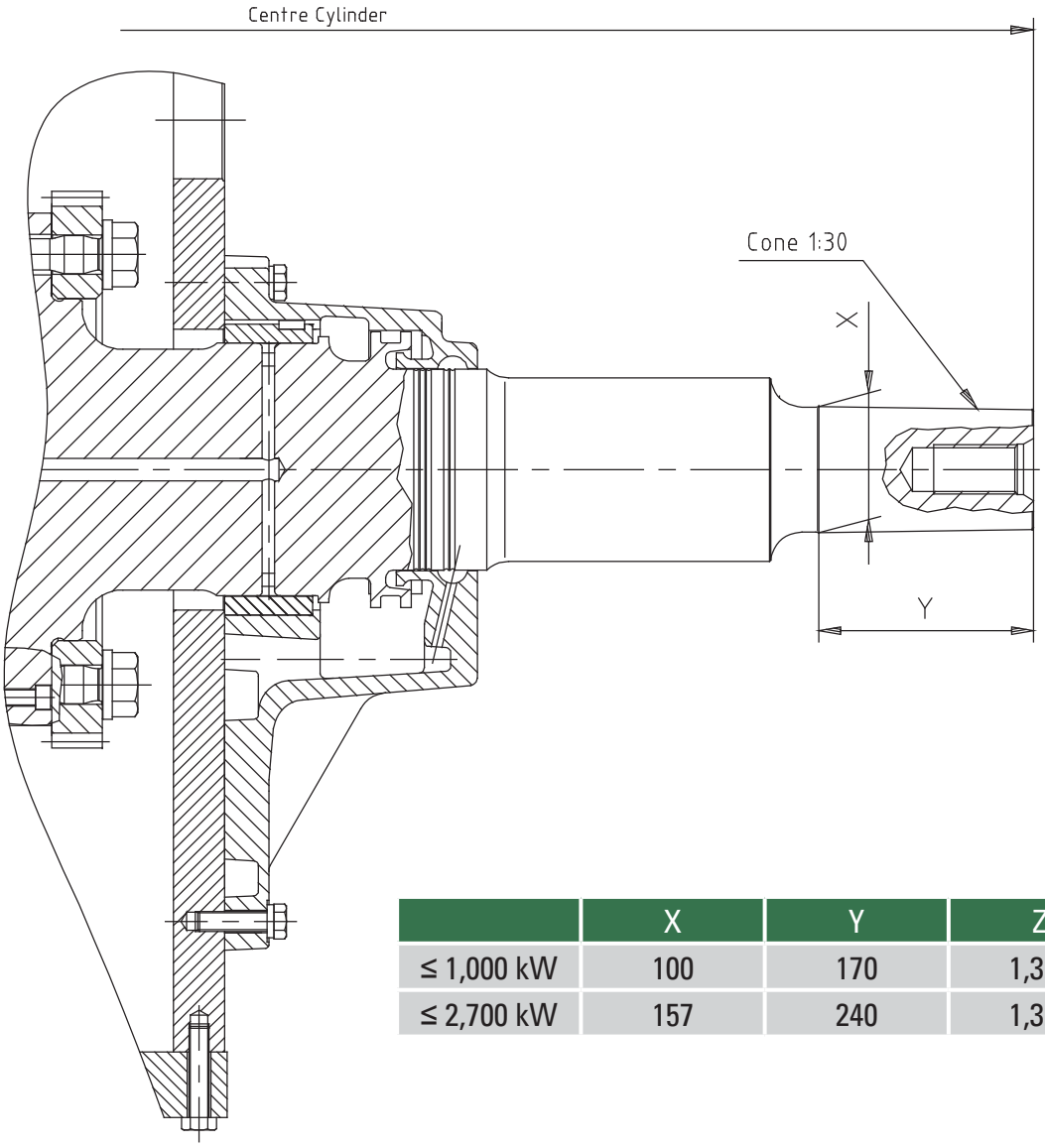
The PTO output 6, 8 and 9 M 25 C is equal to the engine output.

The connection requires a highly flexible coupling, type Vulkan (if supplied by Caterpillar Motoren).

A combination (highly flexible coupling / clutch) will **not** be supplied by Caterpillar Motoren. The weight force of the clutch cannot be absorbed by the engine and must be borne by the succeeding machine.

The coupling hub is to be adapted to suit the PTO shaft journal.

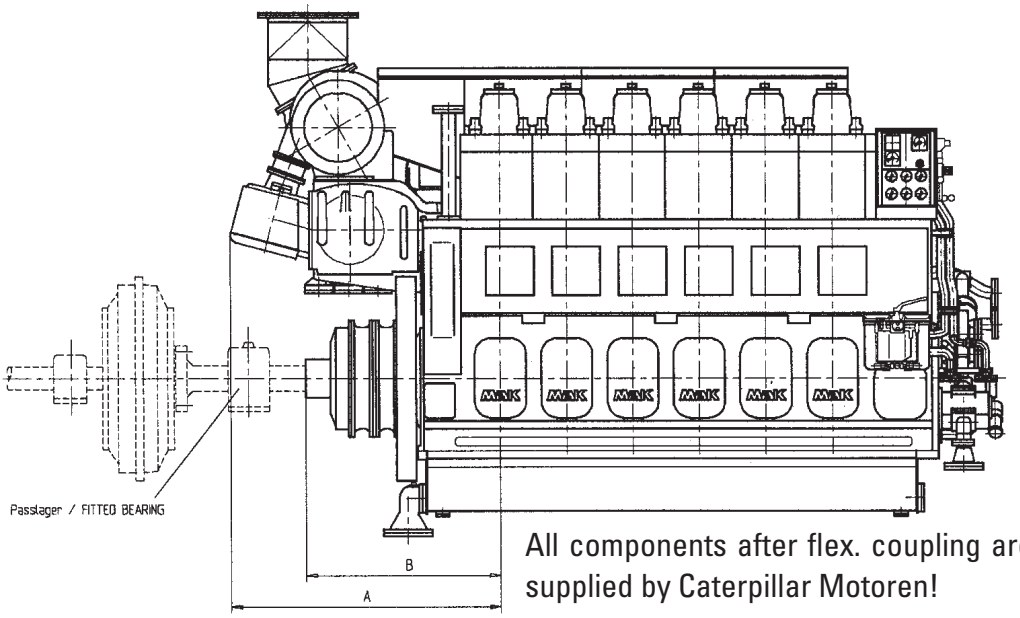
The definite coupling type is subject to confirmation by the torsional vibration calculation.



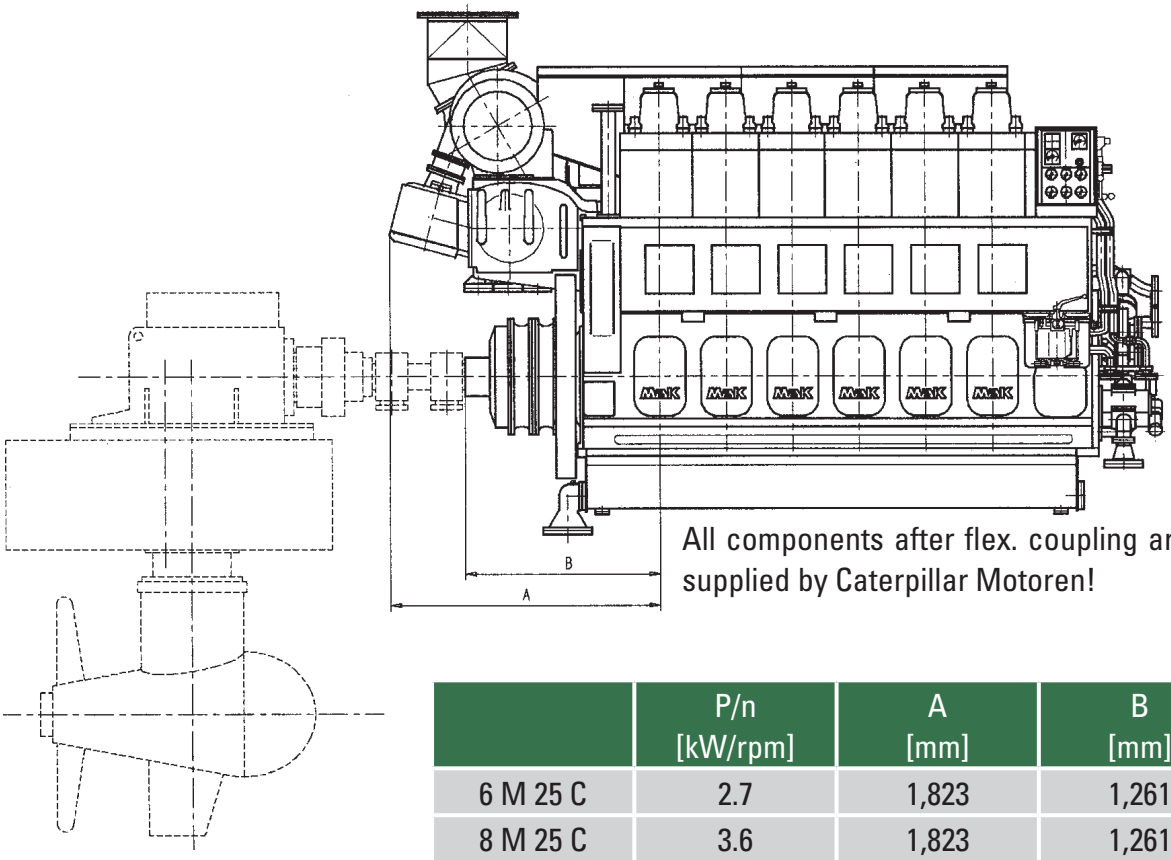
	X	Y	Z
≤ 1,000 kW	100	170	1,320
≤ 2,700 kW	157	240	1,320

4. Connecting parts engine

4.1.3 Voith propeller drive, rudder-propeller-drive



All components after flex. coupling are not supplied by Caterpillar Motoren!



All components after flex. coupling are not supplied by Caterpillar Motoren!

	P/n [kW/rpm]	A [mm]	B [mm]
6 M 25 C	2.7	1,823	1,261
8 M 25 C	3.6	1,823	1,261
9 M 25 C	4.0	1,823	1,261

B Is valid for Vulkan Rato-couplings

4. Connecting parts engine

4.1.4 Data for torsional vibration calculation

Details to be submitted for the torsional vibration calculation

A torsional vibration calculation is made for each installation. For this purpose exact data of all components are required. See table below:

1. Main propulsion

Clutch existing? yes ☐ no ☐
Moments of inertia: Engaged: ..... kgm² Disengaged: ..... kgm²
Flexible coupling: Make: ..... Type: ..... Size: .....
Gearbox: Make: ..... Type: ..... Gear ratio: .....
Moments of inertia and dyn. torsional rigidity (Mass elastic system)
Shaft drawings with all dimensions
CPP : D = ... mm Blade No.: .....
Moments of inertia: in air ..... kgm²/in water = ...kgm²
Exciting moment in percent of nominal moment = ... %
Operation mode CPP: const. speed ☐ Combinator: ☐
Speed range from: ..... -rpm
Normal speed range: CPP = 0.6 Nominal speed

---

2. PTO from gearbox: yes ☐ no ☐

If yes, we need the following information:
Clutch existing? yes ☐ no ☐
Moments of inertia: Engaged: ..... kgm² Disengaged: ..... kgm²
Flexible coupling: Make: ..... Type: ..... Size: .....
Gearbox: Make: ..... Type: ..... Gear ratio: .....
Moments of inertia and dyn. torsional rigidity (Mass diagram)
Kind of PTO driven machine: ..... Rated output: ..... kW
Power characteristics, operation speed range: ..... rpm

---

3. PTO from free shaft end: yes ☐ no ☐

If yes, we need the following information:
Clutch existing? yes ☐ no ☐
Moments of inertia: Engaged: ..... kgm² Disengaged: ..... kgm²
Flexible coupling: Make: ..... Type: ..... Size: .....
Gearbox: Make: ..... Type: ..... Gear ratio: .....
Moments of inertia and dyn. torsional rigidity (Mass diagram)
Kind of PTO driven machine: ..... Rated output: ..... kW
Power characteristics, operation speed range: ..... rpm

---

4. Explanation

Moments of inertia and dyn. torsional rigidity in absolut dimensions, i.e. not reduced.

4. Connecting parts engine

4.2 Resilient mounting

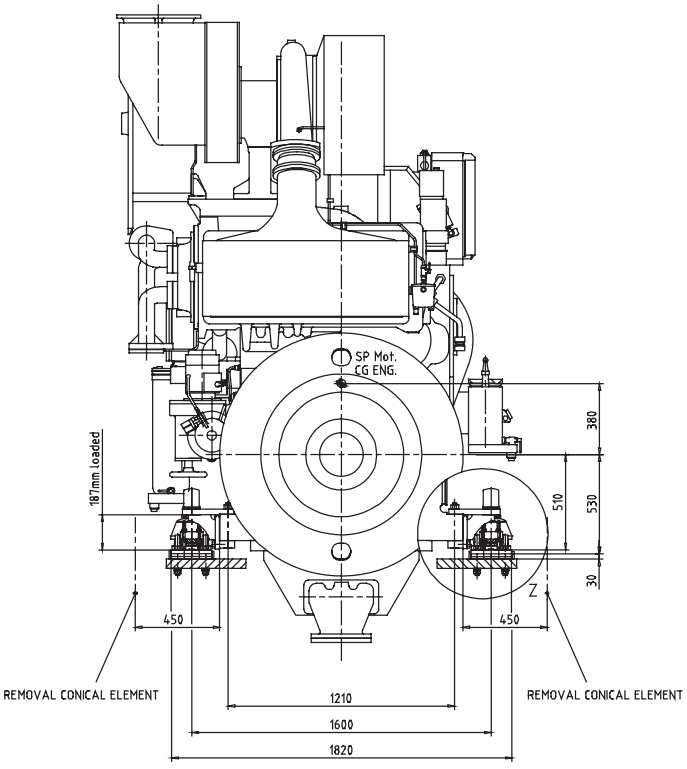
4.2.1 Major components

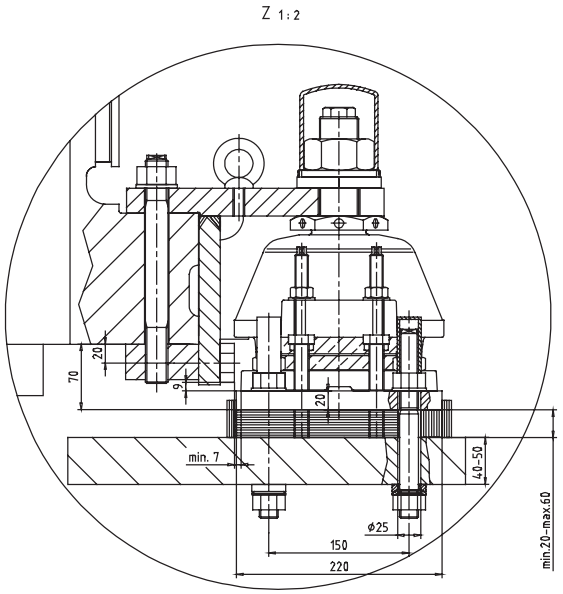
- Conical rubber elements for active insulation of dynamic engine forces and structure-borne noise are combined with horizontal, lateral and vertical stoppers to limit the engine movements.
- Dynamically balanced highly flexible coupling.
- Flexible connections for all media.
- Specially designed exhaust gas below.

Details are shown on binding installation drawings.

No. of elements:

	Conical elements
6 M 25 C	6
8 M 25 C	8
9 M 25 C	8



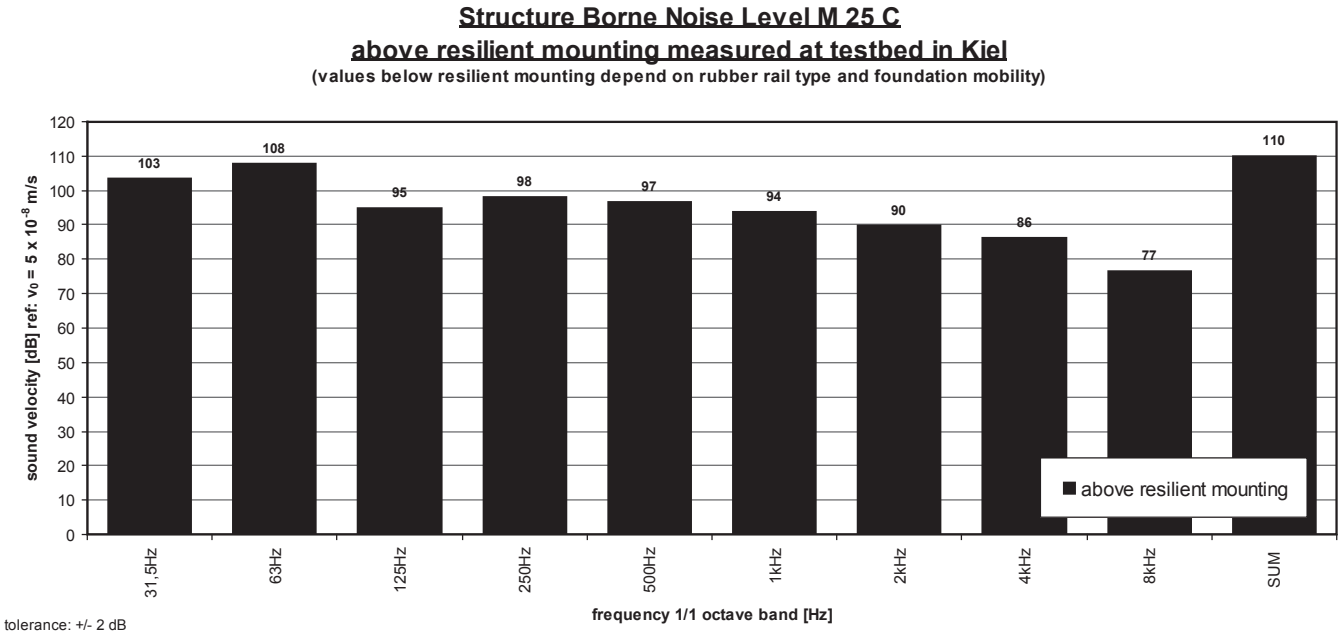


Important note:

- The resilient mounting alone does not provide any garantee for a quiet ship. Other sources of noise like propeller, gearbox and aux. engines have to be considered as well.
- Radial restoring forces of the flexible coupling (due to seaway) may be of importance for the layout of the reduction gear.

4. Connecting parts engine

4.2.2 Structure-borne sound level L_v, expected (measured in the test cell)



tolerance: +/- 2 dB

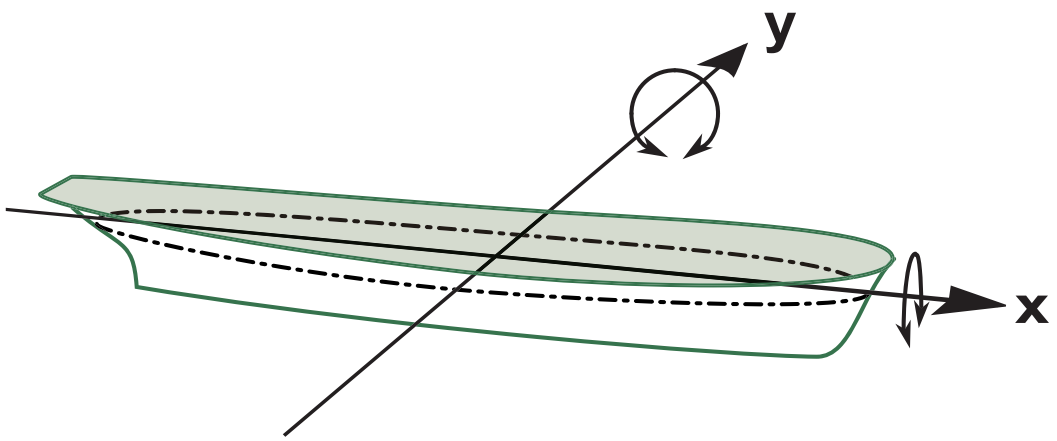
5. Installation and Arrangement

5.1 General installation aspect

Inclination angles of ships at which engine running must be possible:

Rotation X-axis:
Static: heel to each side: 15 °
Dynamic: rolling to each side: ± 22.5 °

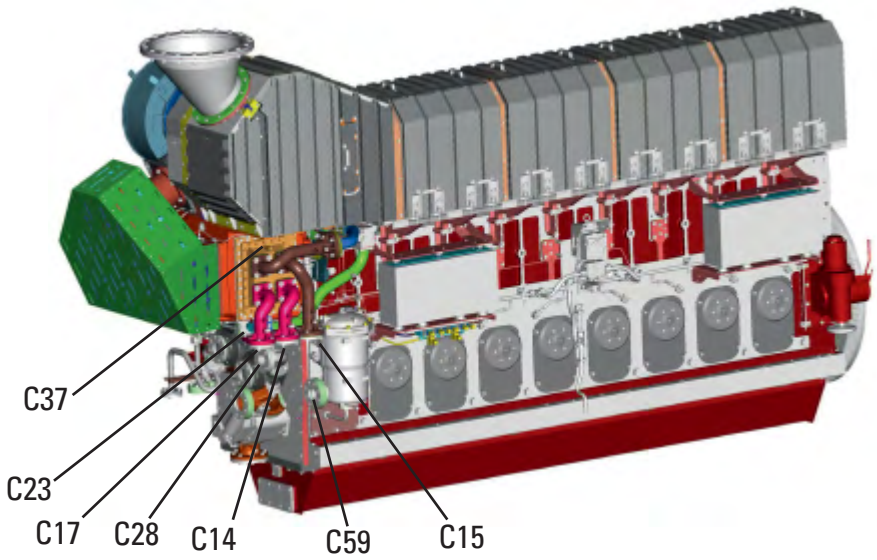
Rotation Y-axis:
Static: trim by head and stern: 5 °
Dynamic: pitching: ± 7.5 °

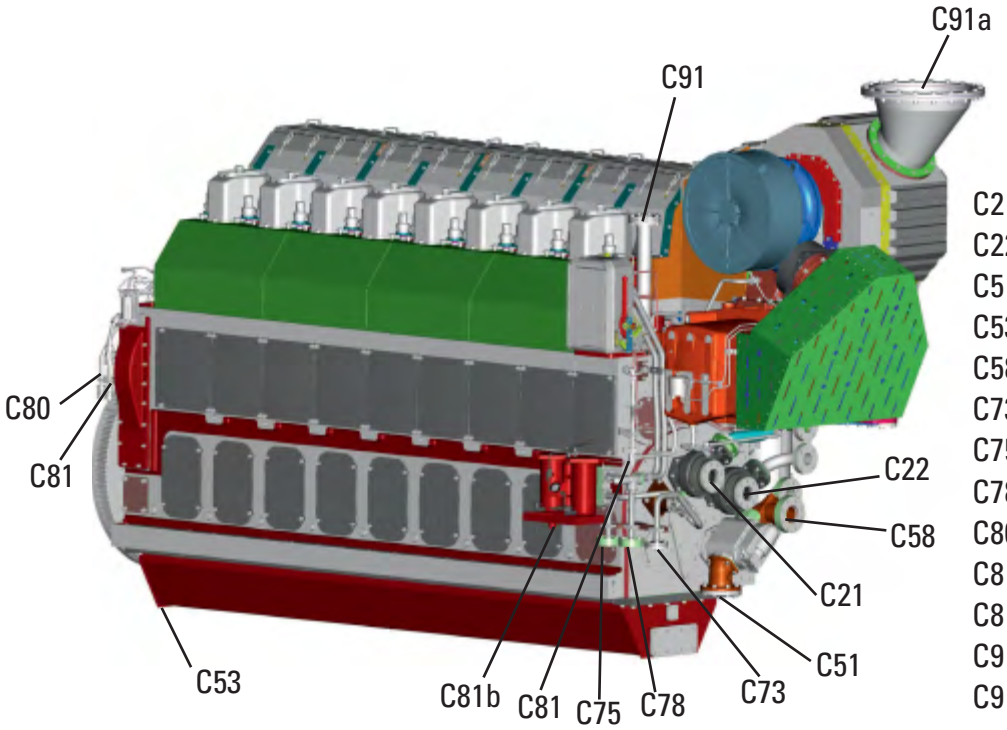


5. Installation and Arrangement

5.2 System connections at engine

C14 Charge air cooler LT, inlet
C15 Charge air cooler LT, outlet
C17 Charge air cooler HT, outlet
C23 Stand-by pump HT, inlet
C28 Freshwater pump LT, outlet
C37 Vent
C59 Lube oil inlet, lube oil filter

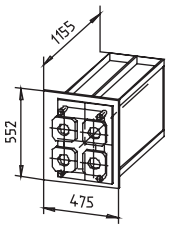


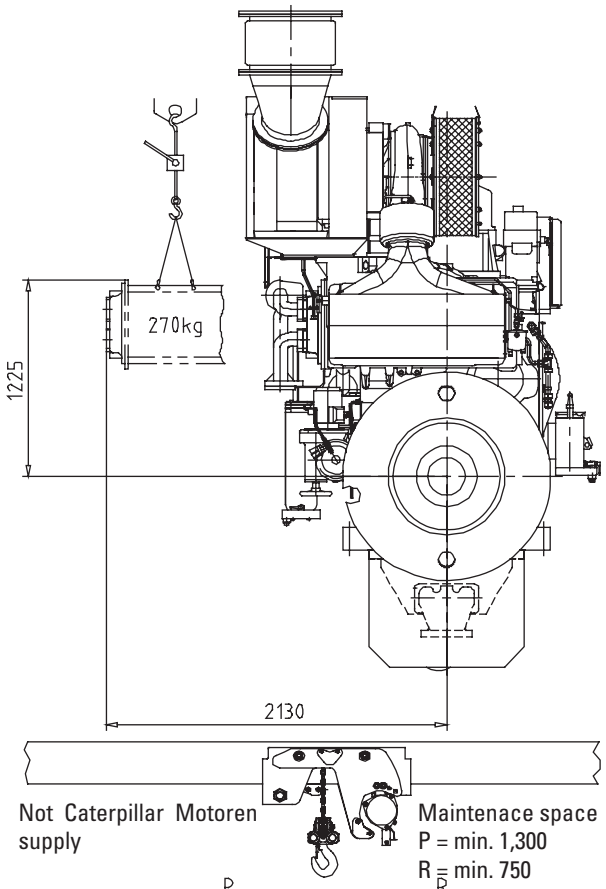


C21 Freshwater pump HT, inlet
C22 Freshwater pump LT, inlet
C51 Force pump, suction side
C53 Lube oil discharge
C58 Force pump, delivery side
C73 Fuel inlet, engine fitted pump
C75 Connection, stand-by pump
C78 Fuel outlet
C80 Drip-fuel connection
C81 Drip-fuel connection
C81b Drip-fuel connection (filter pan)
C91 Crankcase ventilation to stack
C91a Exhaust gas outlet

5. Installation and Arrangement

5.3 Space requirement for dismantling of charge air cooler and turbocharger cartridge





	Dimensions [mm]					Weight
	X	Y	A	B	C	kg
6 M 25 C	1,900	1,225	475	1,155	552	270
8/9 M 25 C	2,130	1,225	475	1,155	552	295

Charge air cooler cleaning

Cleaning is carried out with charge air cooler dismantled. A container to receive the cooler and cleaning liquid is to be supplied by the **yard**. Intensive cleaning is achieved by using ultrasonic vibrators.

Turbocharger removal/maintenance

Caterpillar Motoren recommends providing right above the center of the turbocharger a lifting rail with a travelling trolley to which a lifting gear can be attached in order to carry out the work on the turbocharger according to the maintenance schedule.

Weights M 25 C Turbocharger							
Turbo-charger, compl.	Si-lencer	Com-pressor housing	Turbine inlet housing	Exhaust gas elbow	Car-tridge	Bearing housing	Rotor
563 kg	63 kg	136 kg	125 kg	68 kg	150 kg	100 kg	32 kg

5. Installation and Arrangement

5.4 Foundation

5.4.1 External foundation forces and frequencies

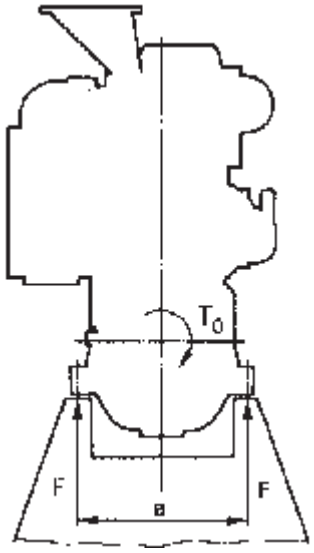
The following information is relevant to the foundation design and the aftship structure.

The engine foundation is subjected to both static and dynamic loads.

Static load

The static load results from the engine weight which is distributed approximately evenly over the engine's foundation supports and the mean working torque T_N resting on the foundation via the vertical reaction forces. T_N increases the weight on one side and reduces it on the other side by the same amount.

	Output [kW]	Speed [1/min]	T_N [kNm]
6 M 25 C	1,900	720	25.2
	2,000	750	25.5
8 M 25 C	2,534	720	33.6
	2,666	750	33.9
9 M 25 C	2,850	720	37.8
	3,000	750	38.2



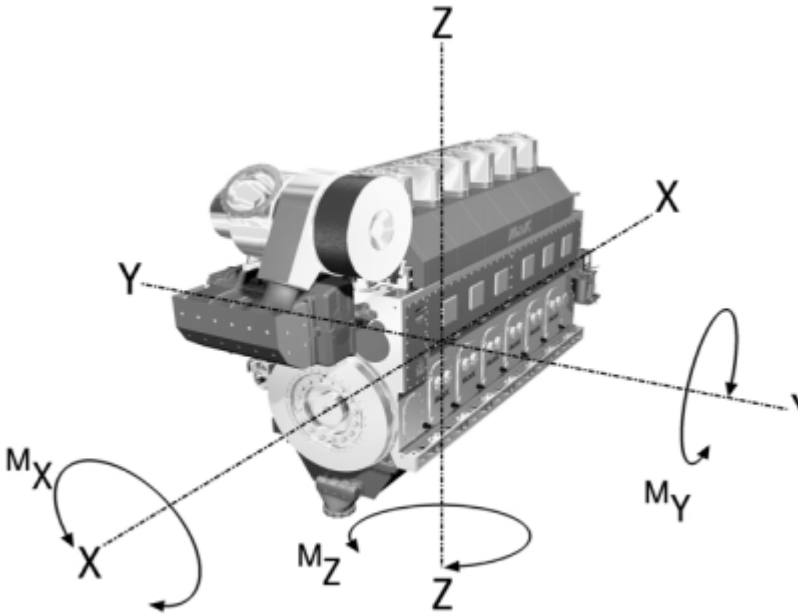
Support distance a = 1,210 mm
$F = T_N / a$

Dynamic load

The dynamic forces and moments are superimposed on the static forces. They result on the one hand from the firing forces causing a pulsating torque and on the other hand from the external mass forces and mass moments.

The tables indicate the dynamic forces and moments as well as the related frequencies.

5. Installation and Arrangement



	Output [kW]	Speed [rpm]	Order No.	Frequency [Hz]	M_x [kNm]
6 M 25 C	1,900	720	3.0 6.0	36.0 72.0	20.7 10.4
	2,000	750	3.0 6.0	37.5 75.0	20.8 10.5
8 M 25 C	2,534	720	4.0 8.0	48.0 96.0	36.1 4.7
	2,666	750	4.0 8.0	50.0 100.0	36.4 4.6
9 M 25 C	2,850	720	4.5 9.0	54.0 108.0	33.9 3.0
	3,000	750	4.5 9.0	56.25 112.5	34.1 3.0

	Output [kW]	Speed [rpm]	Order No.	Frequency [Hz]	M_y [kNm]	M_z [kNm]
6 M 25 C	1,900	720			-	-
	2,000	750			-	-
8 M 25 C	2,534	720			-	-
	2,666	750			-	-
9 M 25 C	2,850	720	1.0 2.0	12.0 24.0	8.6 7.2	-
	3,000	750	1.0 2.0	12.5 25.0	9.3 7.8	-

All forces and moments not indicated are irrelevant or do not occur. The effect of these forces and moments on the ship's foundations depends on the type of engine mounting.

5. Installation and Arrangement

5.4.2 Rigid mounting

The vertical reaction forces resulting from the torque variation M_x are the most important disturbances to which the engine foundation is subjected. As regards dynamic load, the indicated moments M_x only represent the exciting values and can only be compared among each other. The actual forces to which the foundation is subjected depend on the mounting arrangement and the rigidity of the foundation itself.

In order to make sure that there are no local resonant vibrations in the ship's structure, the natural frequencies of important components and partial structures must be at a sufficient distance from the indicated main exciting frequencies.

The dynamic foundation forces can be considerably reduced by means of resilient engine mounting.

General note:

The shipyard is solely responsible for the adequate design and quality of the foundation.

Information on foundation bolts (required pretightening torques, elongation, yield point), steel chocks, side stoppers and alignment bolts is to be gathered from the foundation plans.

Examples "for information only" for the design of the screw connections will be made available as required.

If pourable resin is used it is recommendable to employ authorized workshops of resin manufacturers approves by the classification societies for design and execution.

It has to be taken into account that the permissible surface pressure for resin is lower than for steel chocks and therefore the tightening torques for the bolts are reduced correspondingly.

When installing the engine on steel chocks the top plate should be build with an inclination outwards from the engine centerline. Wedge type chocks with the corresponding inclination only be used.

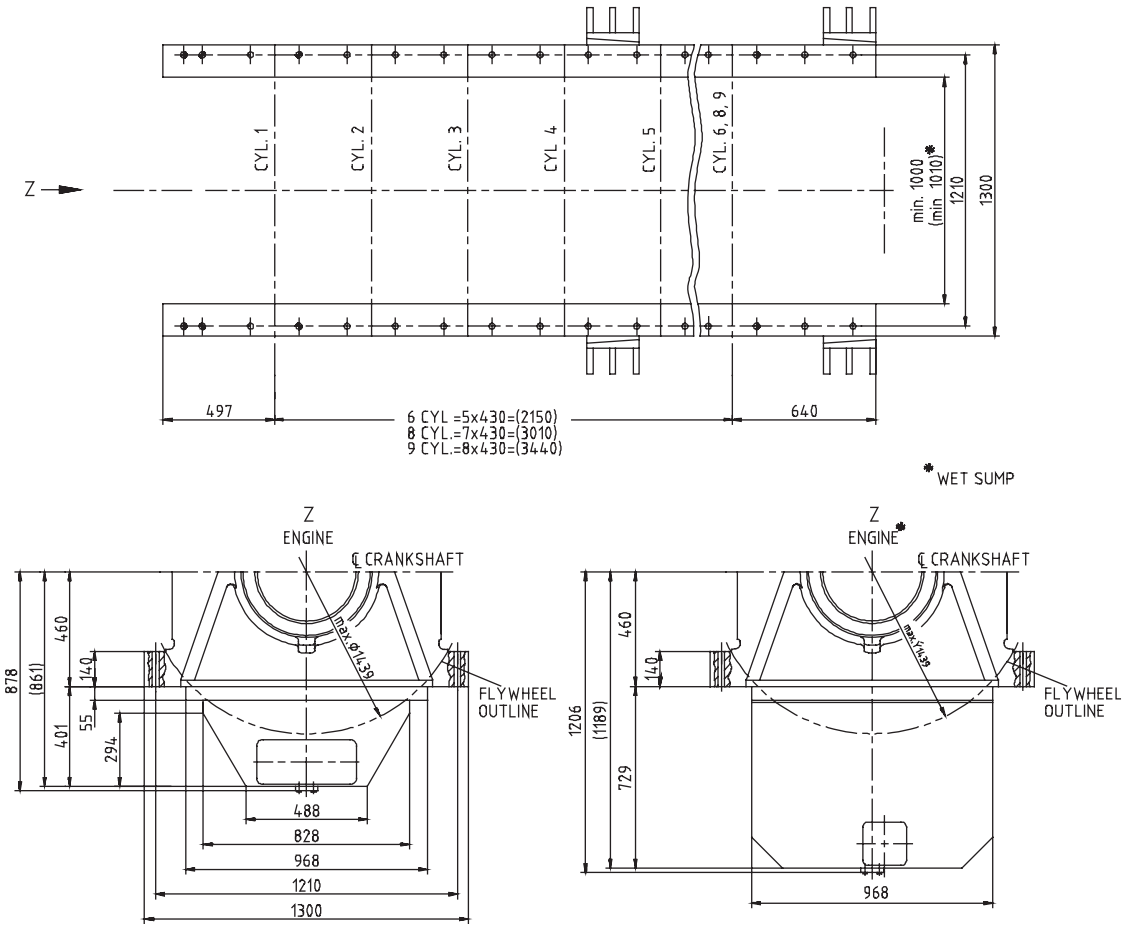
The material can be cast iron or steel.

Surface treatment:

The supporting surface of the top plate has to be milled. When fitting the chocks, a bearing contact of min. 80 % is to be obtained.

Outwards inclination of top plate are needed in case of usinf steel chocks. Withour this it is not permissible to install steel chocks.

5. Installation and Arrangement



Side stoppers

6 M 25 C	8/9 M 25 C
1 Pair [1]	2 Pairs [2]

[1] 1 pair at end of bed plate
[2] 1 pair at end of engine block and 1 pair between cyl. 4 and 5.

Side stopper to be with 1 wedge (see sketch). Wedge to be placed at operating temperature and secured by welding.

Dimensioning according to classification society and cast resin suppliers requirements.

Number of bolts

	Fitted bolts	Foundation bolts
6 M 25 C	4	24
8 M 25 C	4	32
9 M 25 C	4	36

Jacking bolts

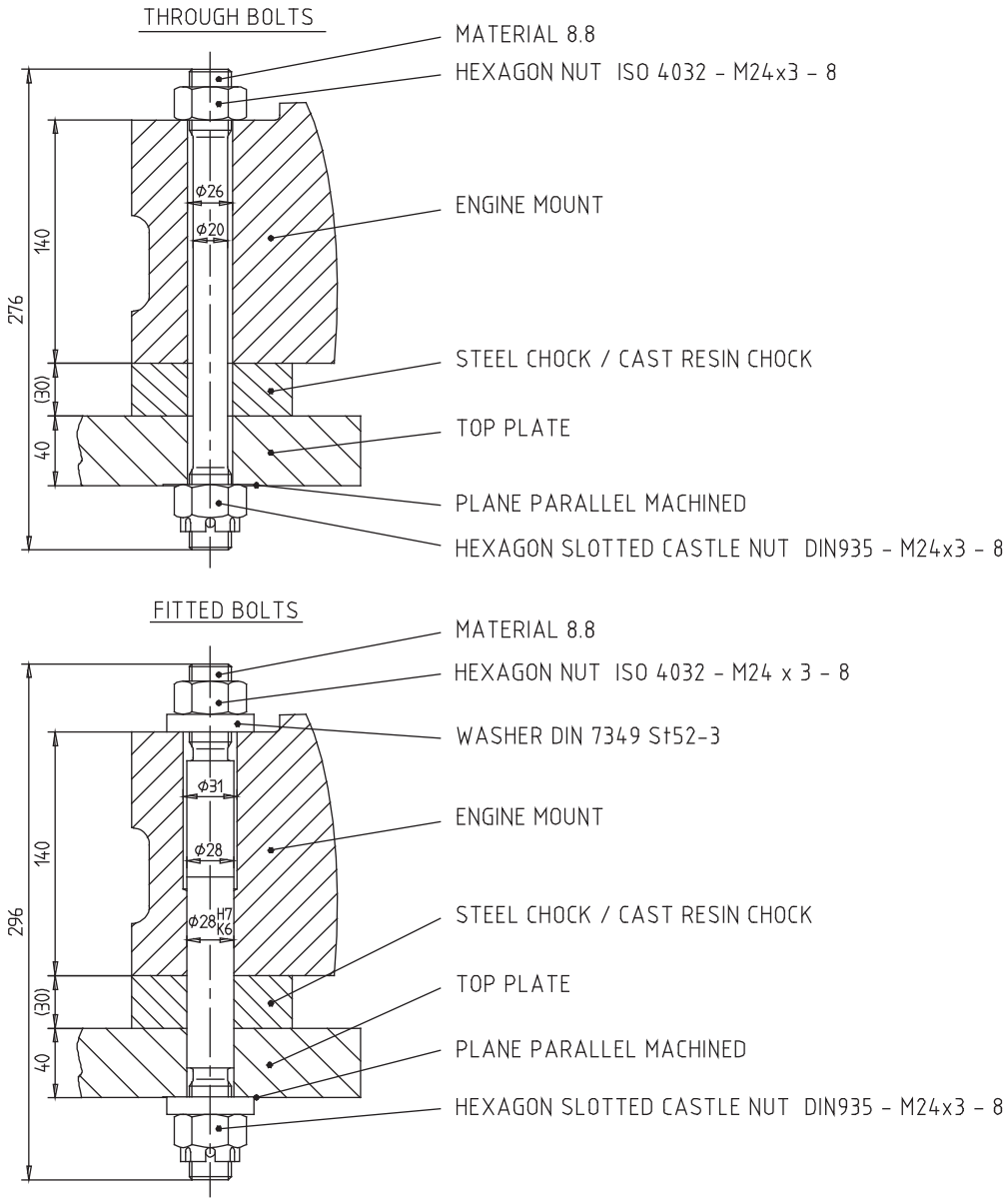
- To be protected against contact/bond with resin
- After setting of resin dismantle the jacking screws completely

To be supplied by yard: Foundation bolts, fitted bolts, nuts and tension sleeves, side stoppers, steel chocks, cast resin

The shipyard is solely responsible for adequate design and quality of the foundation.

5. Installation and Arrangement

Proposal for rigid mounting



Pre-tightening force			
Cast resin		Steel	
Through bolts M 24 [N]	Fitted bolts M 24 [N]	Through bolts M 24 [N]	Fitted bolts M 24 [N]
100,000	100,000	170,000	170,000

Bolts and chocks are yard supply. Design responsibility is with the yard.

5. Installation and Arrangement

5.5 Installation of flexible pipe connections

Flexible pipe connections become necessary to connect resilent mounted genset with external piping systems. These components have to compensate the dynamic movements of the genset relation to the external piping system.

The shipyard's pipe system must be accurately arranged so that the flanges or screw connections do fit without lateral or angular offset. It is recommended to adjust the final position of the pipe connections after engine alignment is completed.

It is important to provide support as close as possible to the flexible connection and stronger as normal. The pipes outside the flexible connection must be well fixed and clamped to prevent from vibrations, which could damage the flexible connections.

Installation of steel expansion joints
Steel expansion joints can compensate movements in line and transversal to their center line. They are not for compensating twisting movements. Expansion joints are very stiff against torsion.

It is very important that all steel expansion joints are not allowed to be installed on resilient mounted engines in vertical direction.

5.6 Notes regarding installation exhaust system

- Arrangement of the first expansion joint directly on the transition pipe
- Arrangement of the first fixed point in the conduit directly after the expansion joint
- Drain opening to be provided (protection of turbocharger and engine against water)
- Each engine requires an eyhaust gas pipe (one common pipe for several engines is **not permissible).**

During commissioning and maintenance work, checking of the exhaust gas sounter pressure by means of a temporarily connected measuring device may become necessary.

For this reason, a measuring socket is to be provided approx. 1 - 2 m after the exhaust gas outlet of the turbocharger at an easily acceptance place.

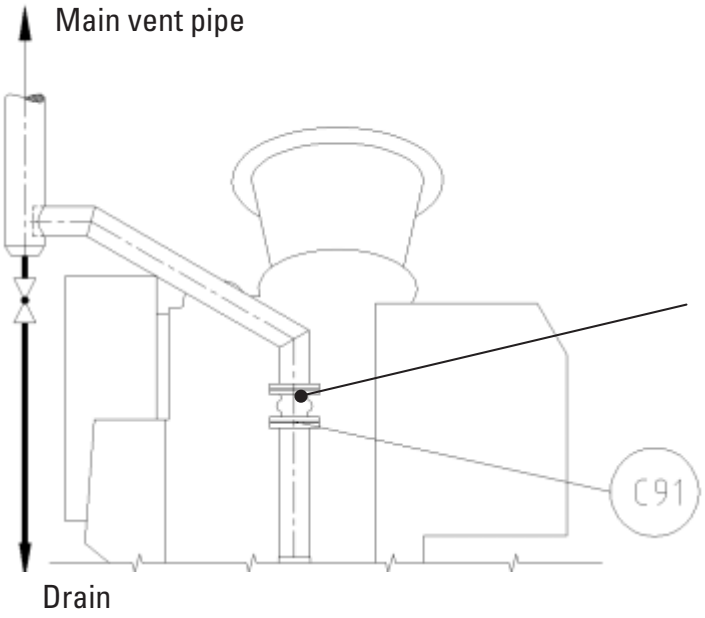
If it should be impossible to use standard transition piece supplied by Caterpillar Motoren, the weight of the transition piece manufactured by the shipyard must not exceed the weight of the standard transition piece. A drawing including the weight will then have to be submitted approval.

5. Installation and Arrangement

5.7 Installation of crankcase ventilation on the engine

Please consider the following design criteria for the piping of crankcase ventilation:

- Outlet crankcase ventilation has to be arranged separately for each engine
- The pipes should run upwards
- A free ventilation under all trim conditions
- Condensate backflow into crankcase has to be prevented
- Provide a permanent drain



Piping sizes for crankcase ventilation

Engine Type	Engine connecting point(s)	Main vent pipe	Collecting vent with lubricating oil circulation tank (observe class rules)
6/8/9 M 25 C	1 x DN 80	1 x DN 100	DN 125

5. Installation and Arrangement

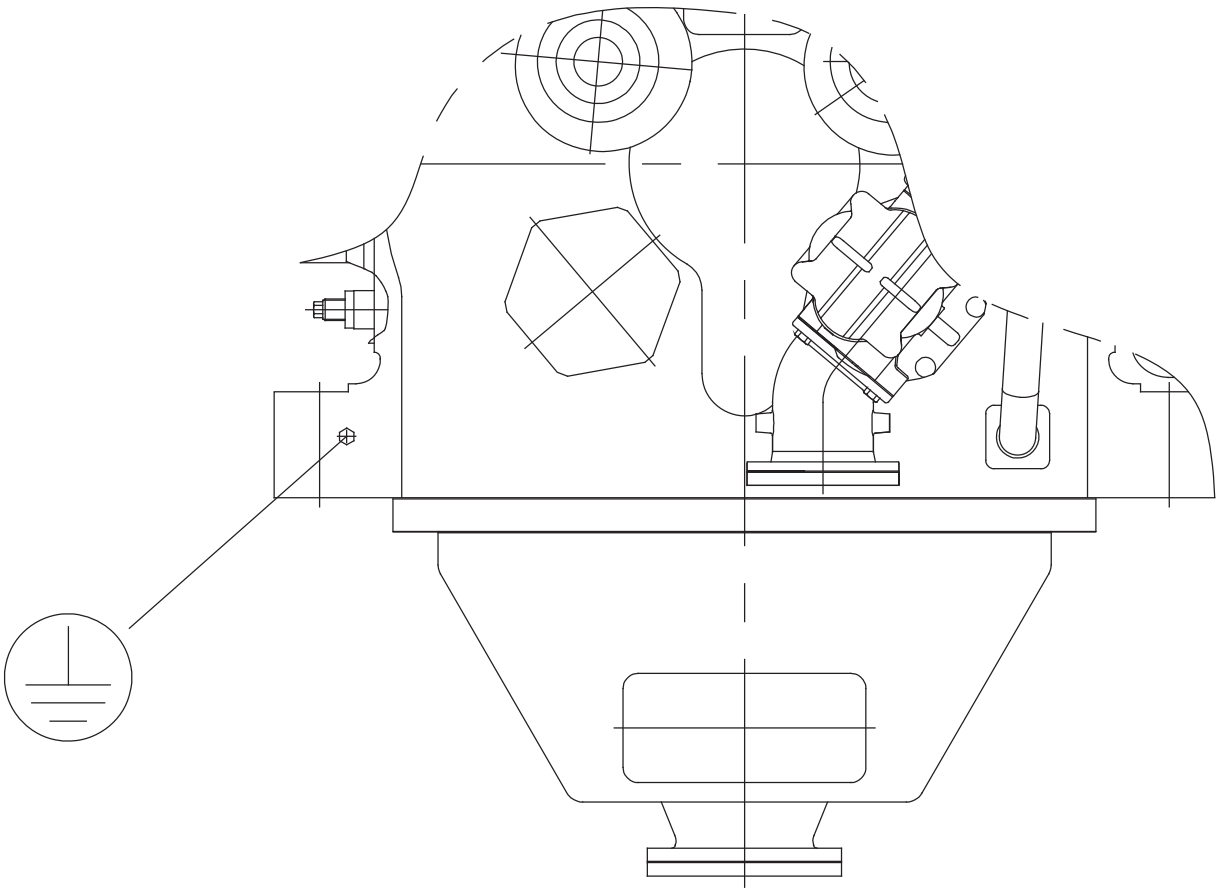
5.8 Earthing of the engine

Information about the execution of the earthing

The earthing has to be carried out by the shipyard during assembly on board. The engine already has M 16, 25 mm deep threaded holes with the earthing symbolp in the engine foot. If the engine is resiliently mounted, it is important to use flexible conductors.

In case of using welding equipment it is important to earth the welding equipment close to the welding area (the distance should not exceed 10 m).

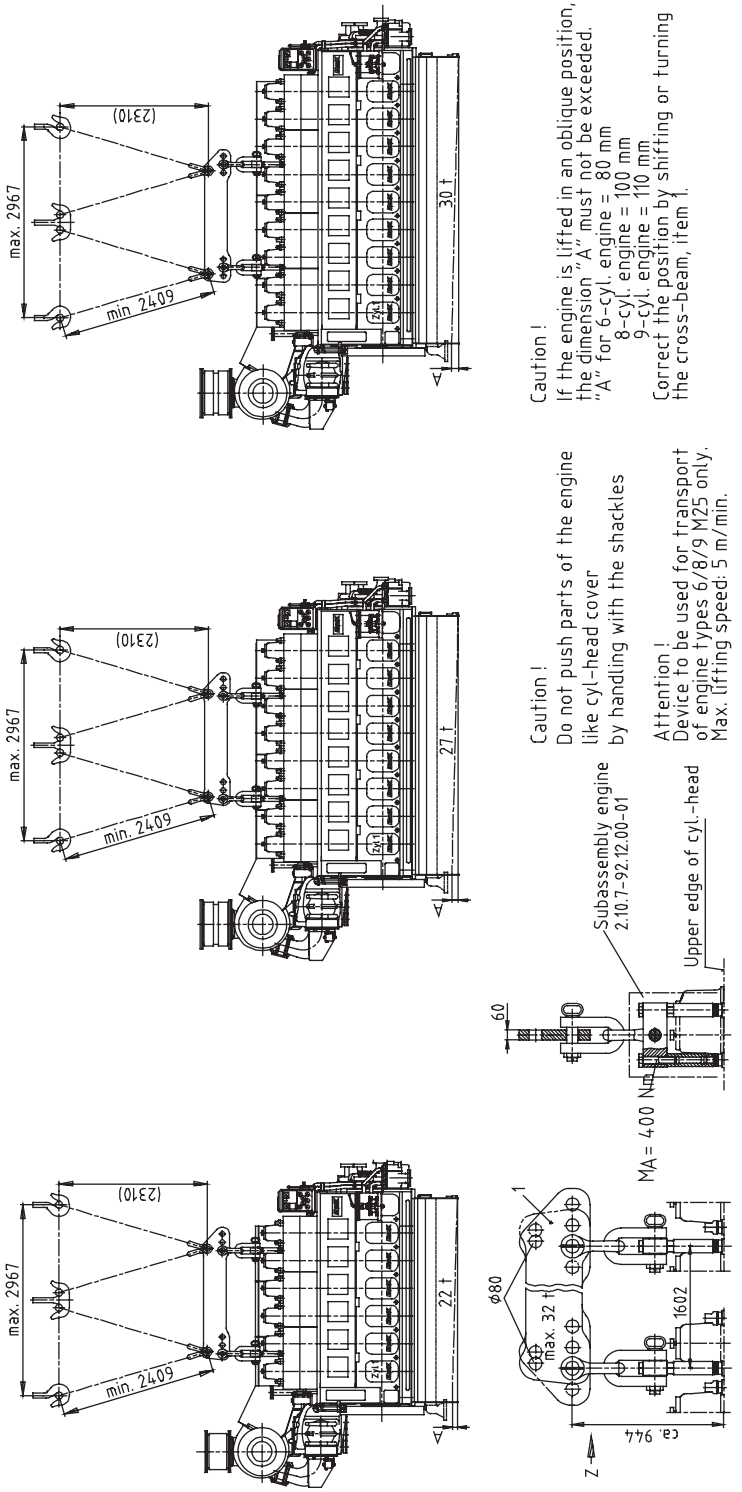
Earthing connection on the engine



5. Installation and Arrangement

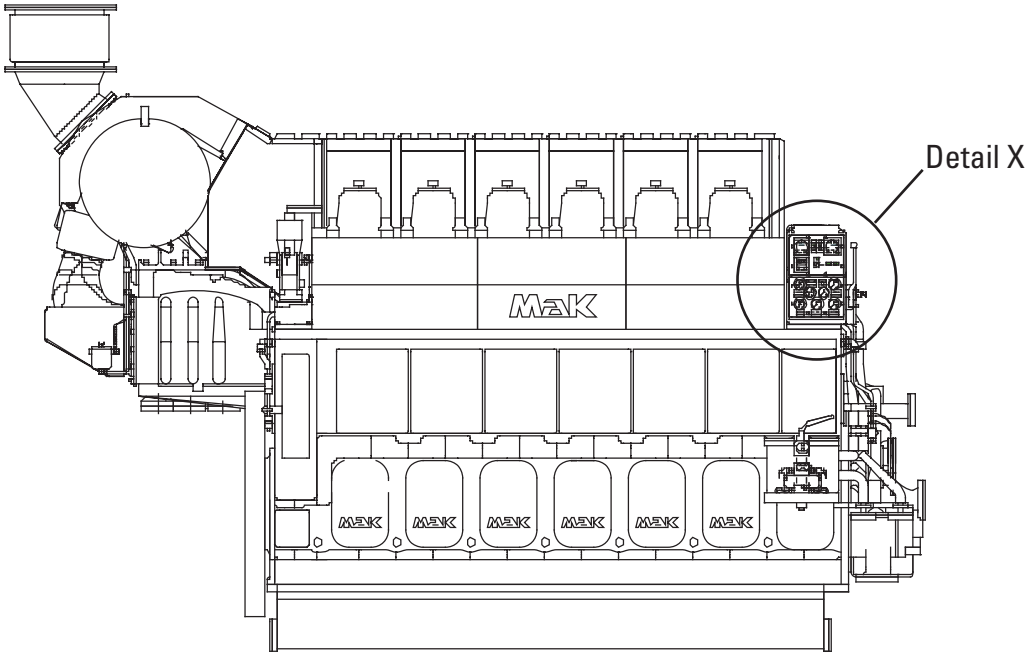
5.7 Lifting of the engine

For the purpose of transport the genset is equipped with a lifting device which shall remain the property of Caterpillar Motoren. It has to be returned in a useable condition free of charge.

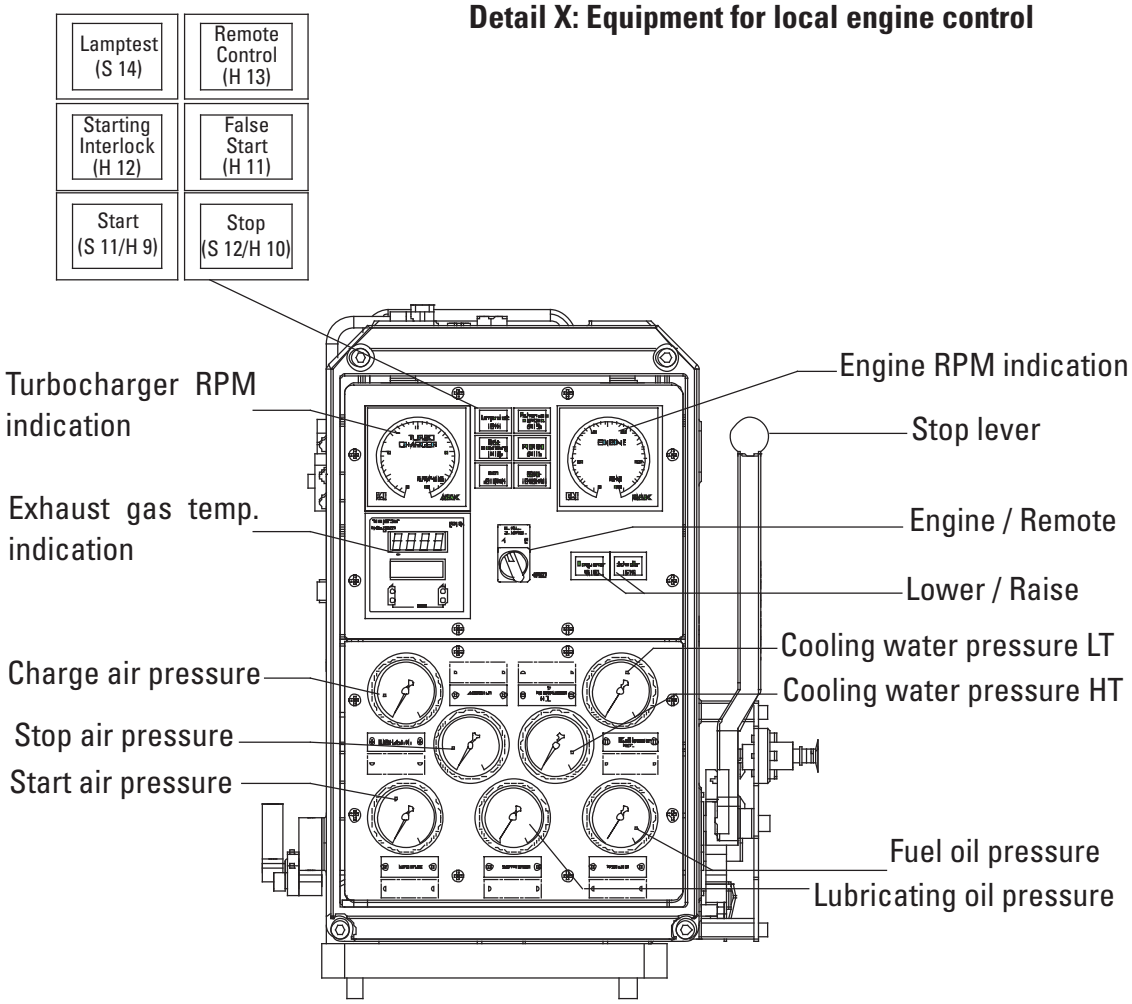


6. Control and monitoring system

6.1 Engine control panel



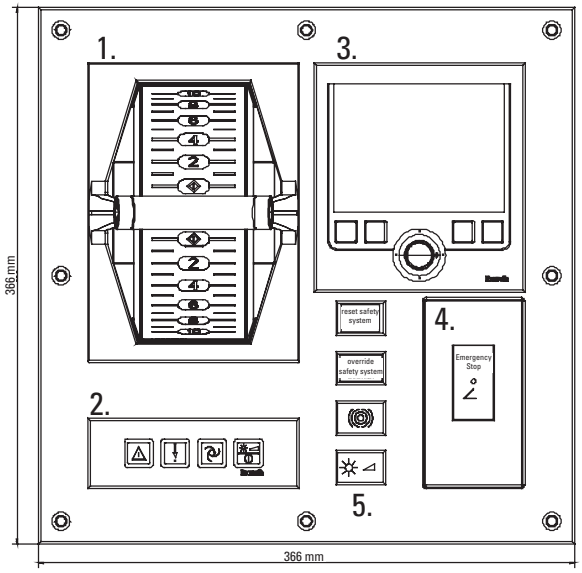
Detail X: Equipment for local engine control

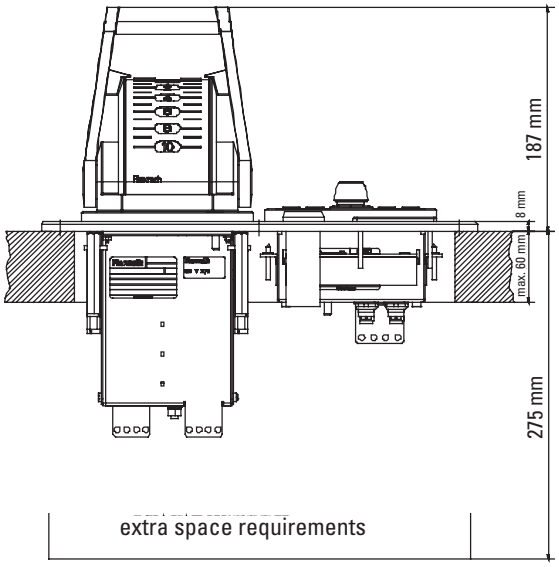


6. Control and monitoring system

6.1.1 Remote control for reversing gear plant

operating panel and control signal transmitter



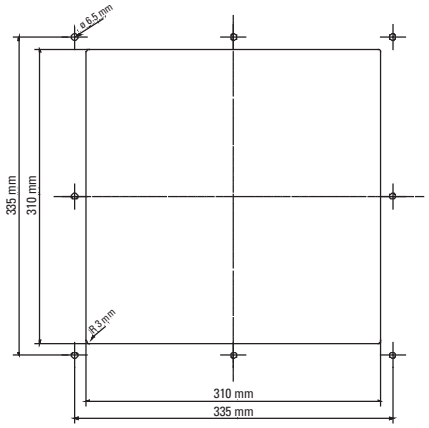


1. Control lever
2. Operating module
- alarm button
- command to take over button
- special function button
- dimming button

3. Display
- main page
- engine start/stop page
- station release page

4. Emergency stop
5. Additional buttons
- reset override safety system
- override safety system
- buzzer
- dimming

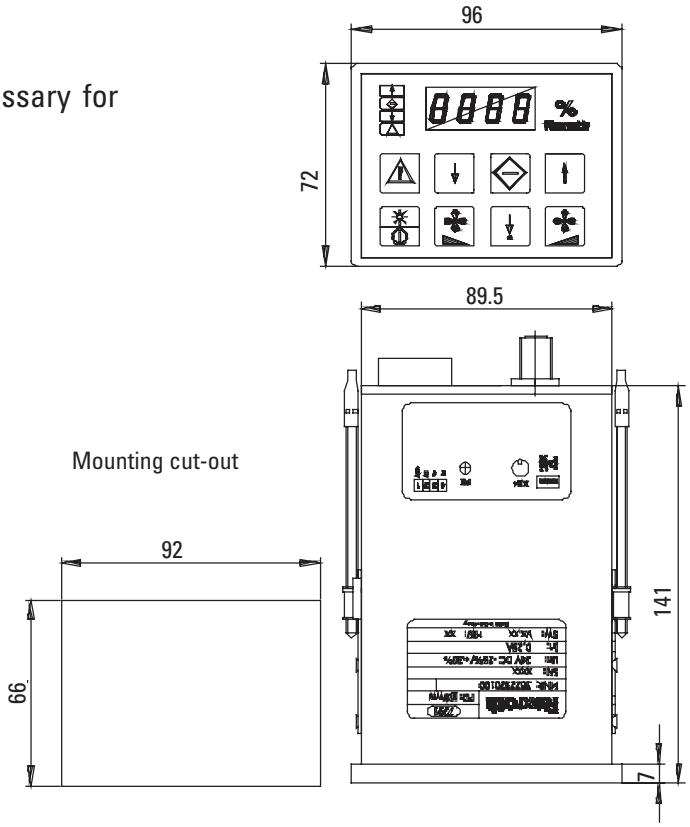
cutout in mounting plate



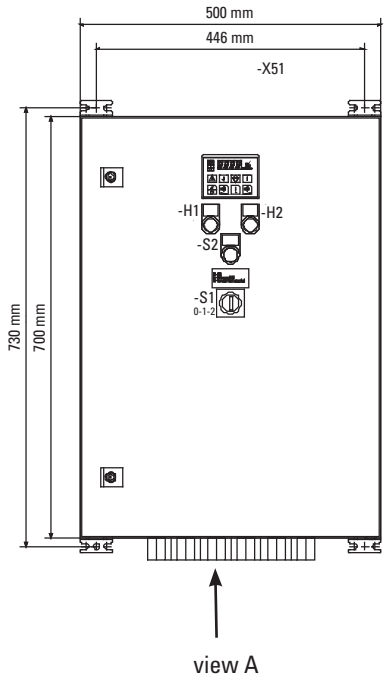
6. Control and monitoring system

Emergency control panel

The emergency control panel is necessary for single-reversing gear plant only.



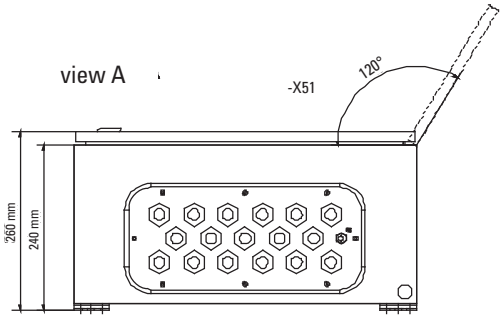
Control cabinet



Back up control

By means of the back up control it is possible to manoeuver the ship in case of a remote or on request after pushing the corresponding key which enables speed setting and gear operation. During the normal operation of the remote control, the back up control continuously reads the actual state of the remote control.

H1: Indication remote is active
H2: Indication back up control is active
S2: Lamp test
S1: 3 position switch
0 = off
1 = Back up control
2 = Remote-/back up control



6. Control and monitoring system

The remote control system Marex OS II operates the electrical speed setting for the engine, as well as the solenoid valves for the gear shifting. Remote control is possible from the active station. The active station is indicated by means of the steady lighted take-over push button on the operation stripe. Gears direction and nominal value for the speed setting are given to the control unit Marex OS II by means of the control head in command.

For the speed setting, a current output is connected to the speed controller of the engine.
Relay outputs operate the solenoid valves of the gears and gives out a signal for "Command active on remote control". After clutch engagement the control unit needs a feed back signal coming from the oil pressure switches indicating ahead or astern. By means of the rotating switch, push button and display of the Marine Propulsion Controller (mpc) the control system can be adjusted and optimized to the requirements of the ship's propulsion system.

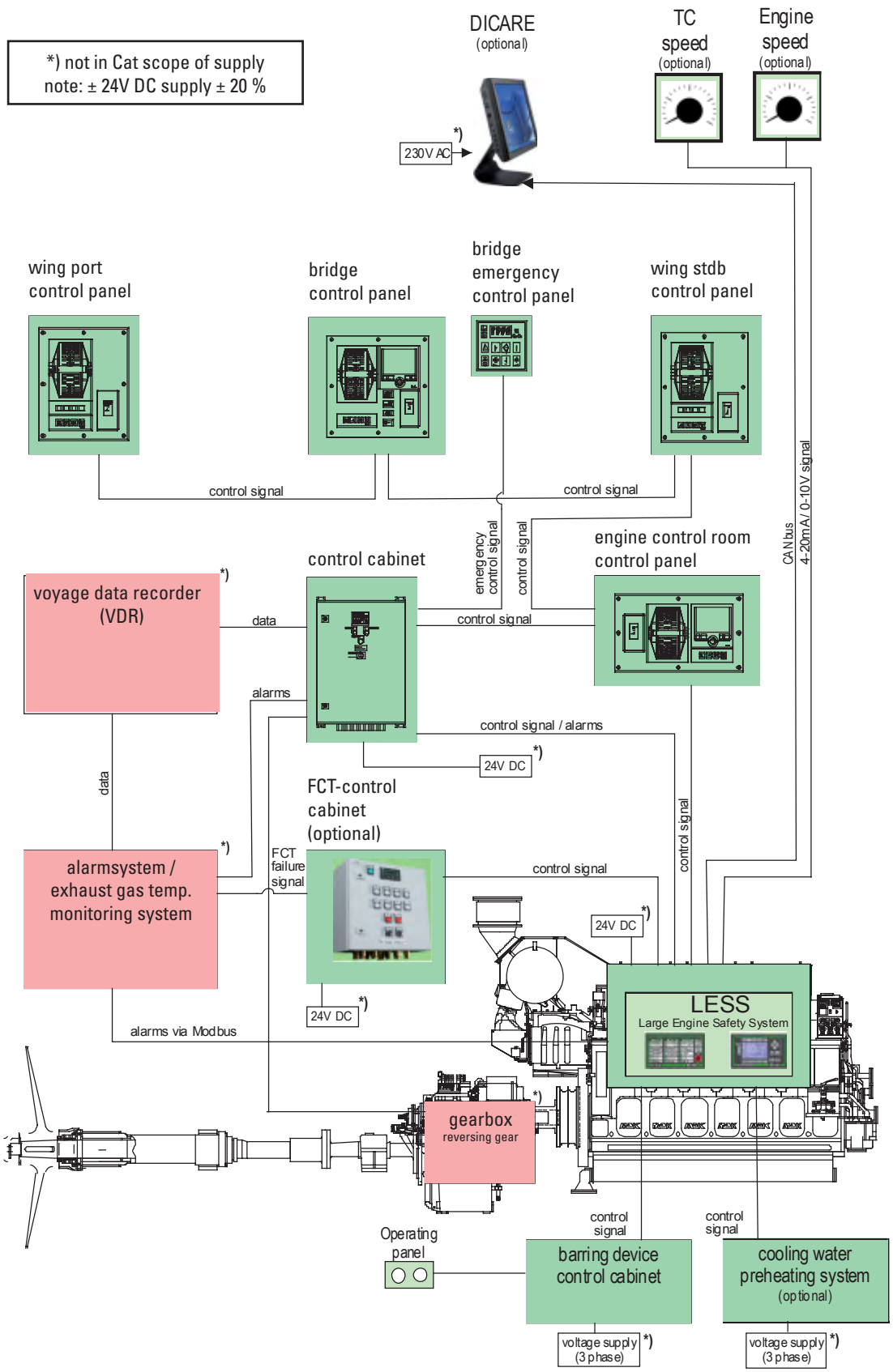
The adjustments are carried out via parameter. The remote control receives an emergency stop signal from the protection system to run down the engine to idle speed and disengage the clutch. Via relays output the signal for remote start and remote stop will be transmitted from the bridge station to the engine start-stop electronic.

Beside this basic function the remote control system includes a number of special functions, like control of PTO's or the control of a trolling gear.

The remote control system Marex OS II includes a NMEA0183-interface to the Voyage Data Recorder (VDR). By this bus connection all required signals and status information will be transmitted to the VDR for later evaluation.

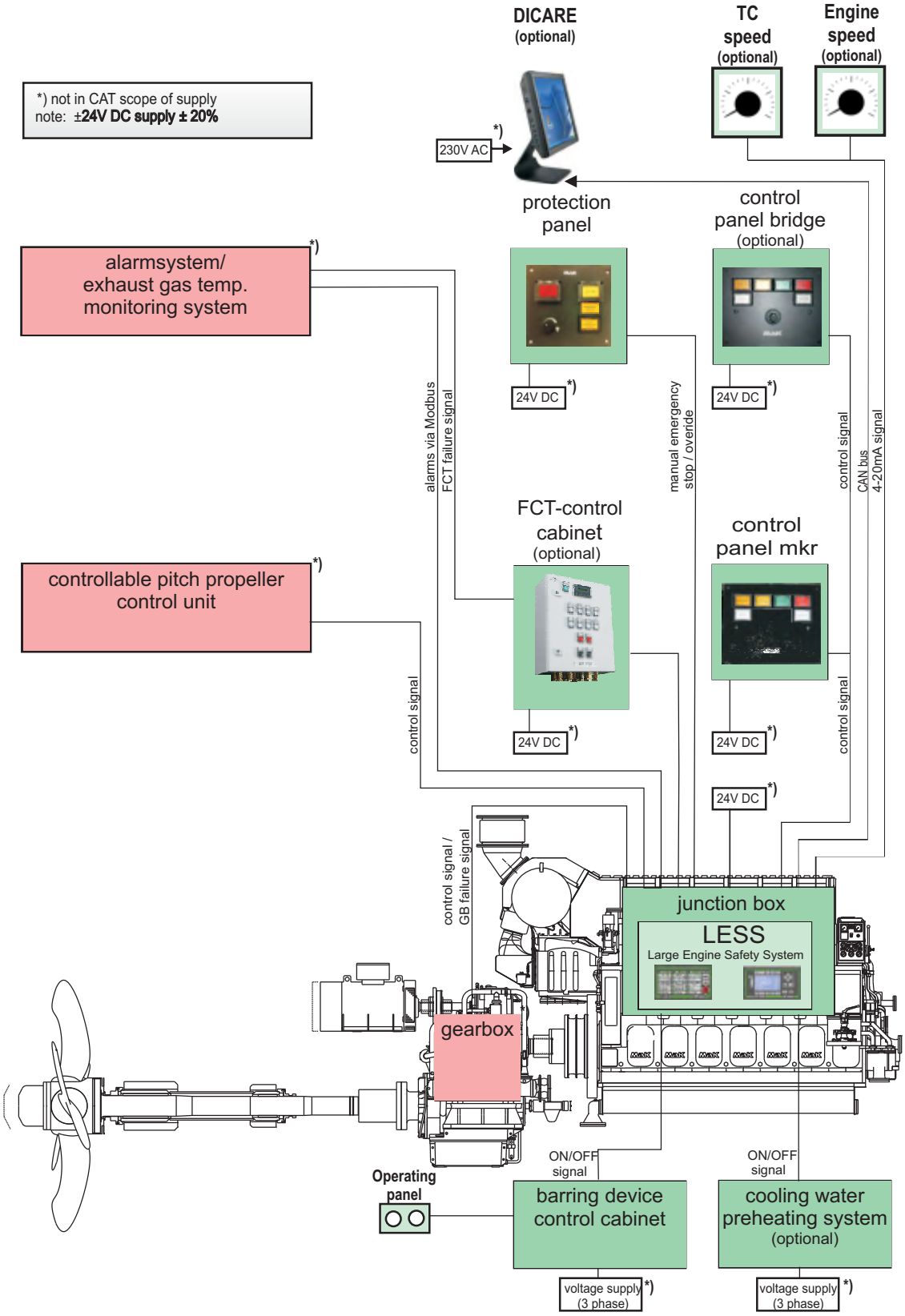
(The VDR is not in the scope of Cat supply).

6. Control and monitoring system



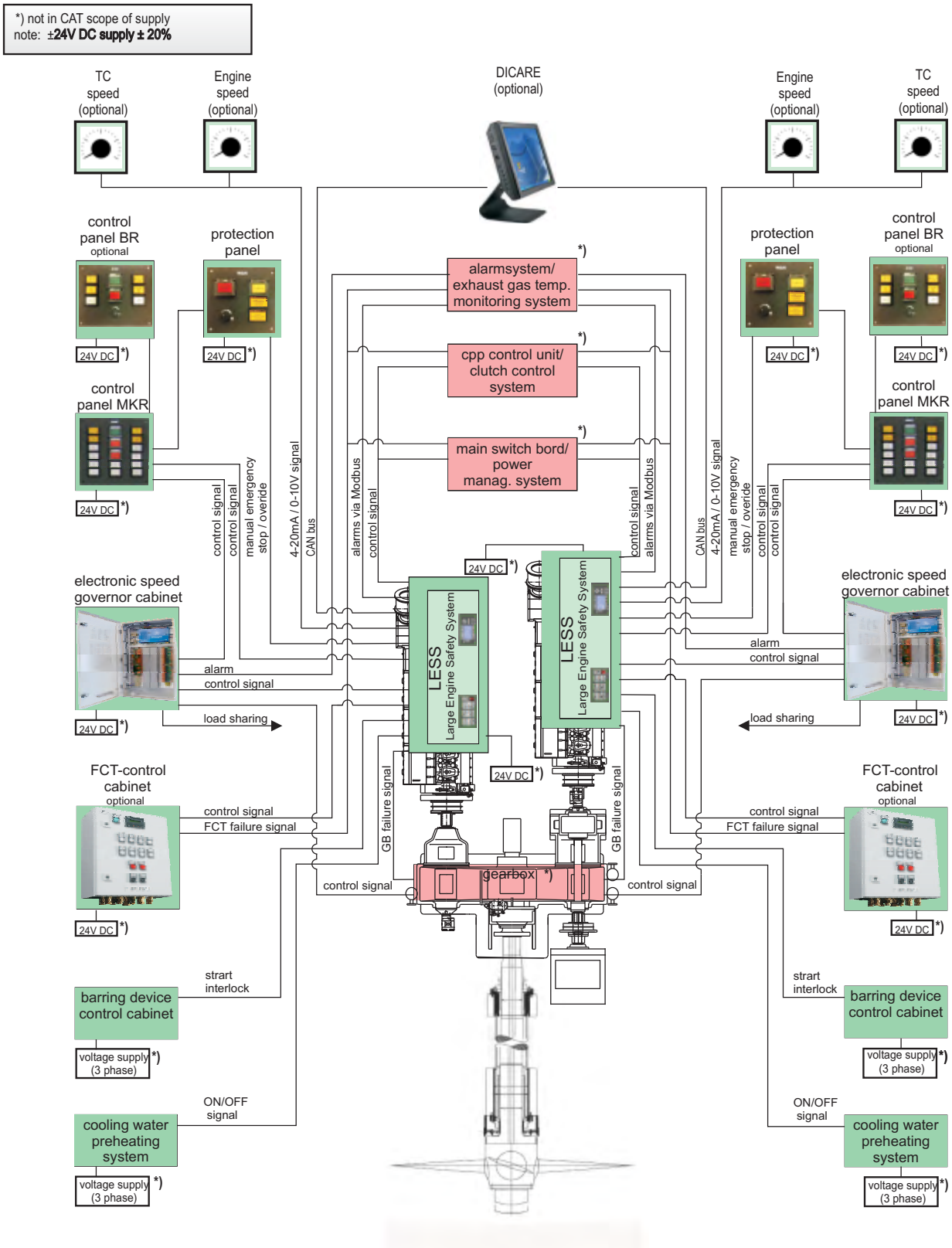
6. Control and monitoring system

6.1.2 Remote control for single-engine plant with one CP propeller



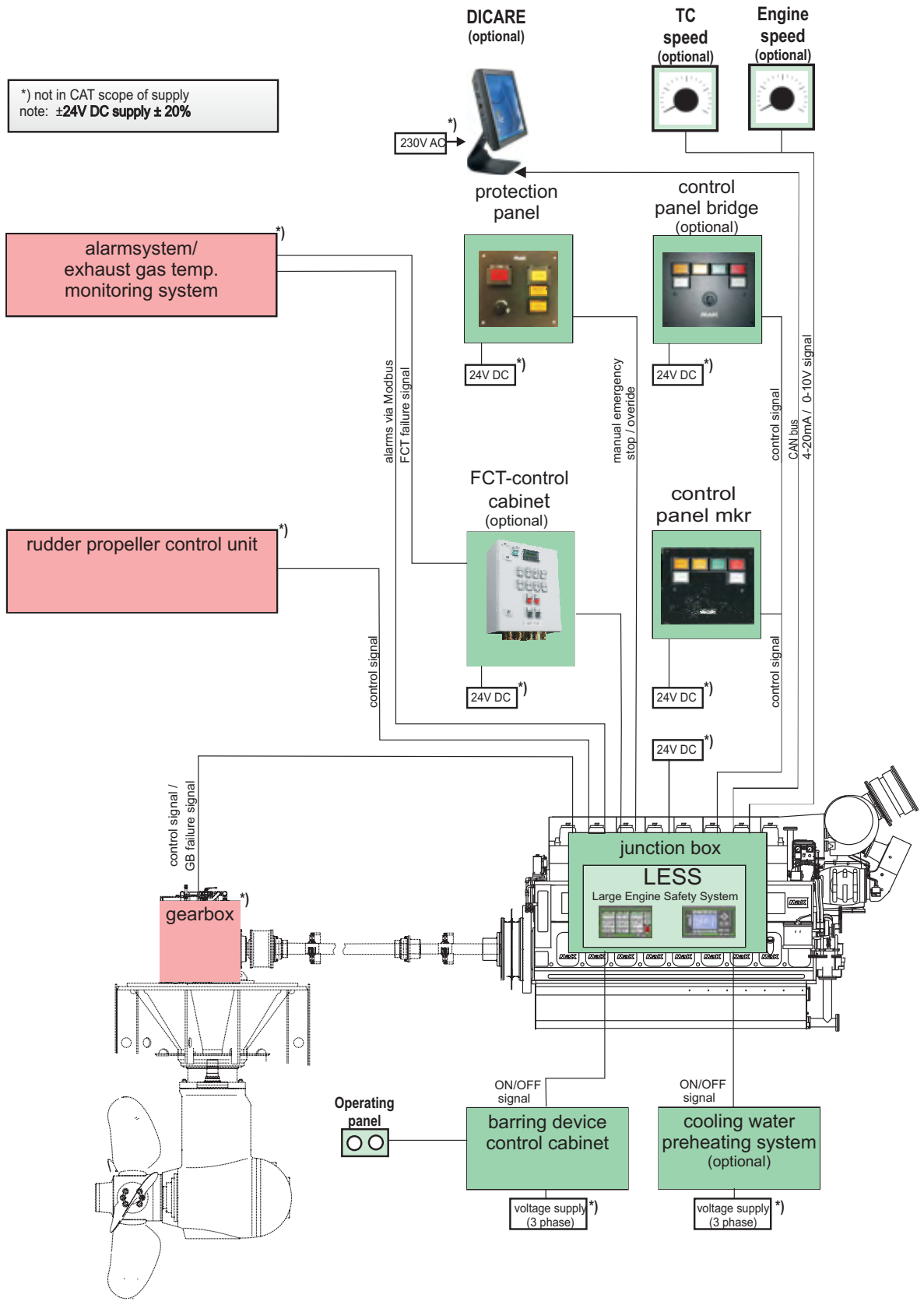
6. Control and monitoring system

6.1.3 Remote control for twin-engine plant with one CP propeller



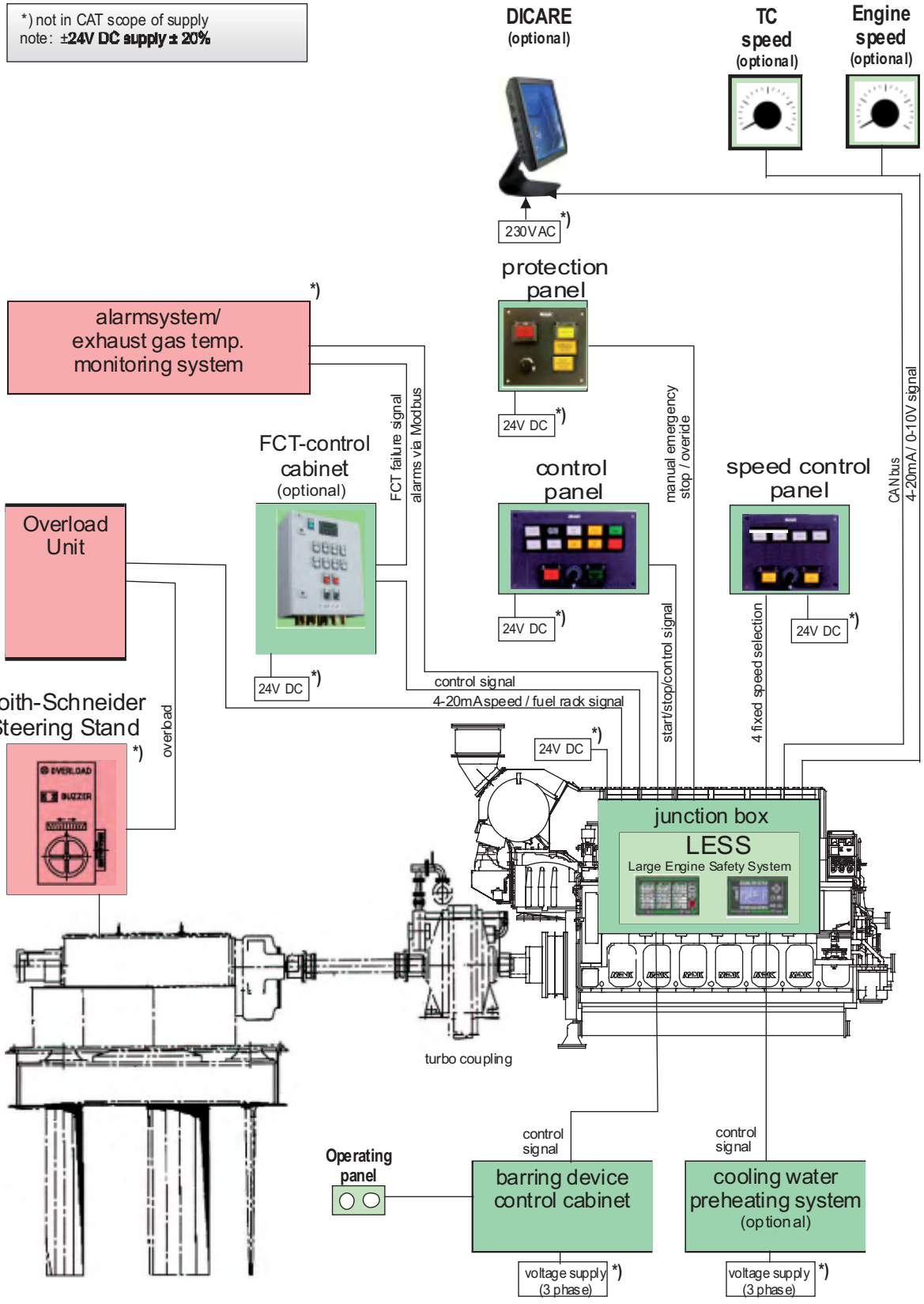
6. Control and monitoring system

6.1.4 Remote control fixed rudder propeller



6. Control and monitoring system

6.1.5 Remote control voith propeller propulsion



6. Control and monitoring system

6.1.6 LESS: Large Engine Safety System

Engine control boxes include

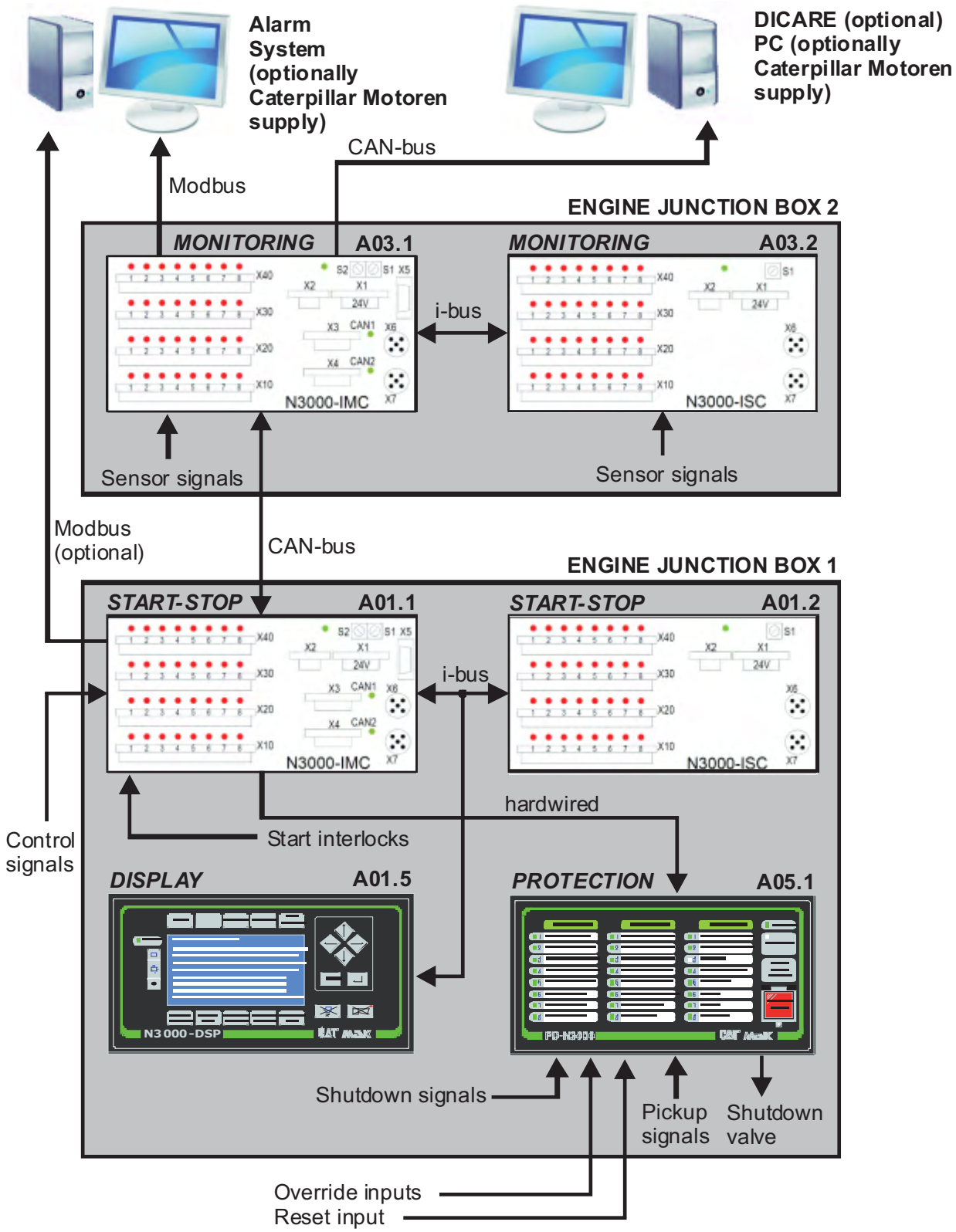
- Engine protection system
- Speed switch unit
- Start-/stop-control
- Alarm display (LED)
- Graphic display (settings)
- Engine monitoring
- Modbus output to alarm system (Modbus RTU protocol RS 482 / 422)
- Data transfer via CAN-bus to DICARE-PC (optional)
- Exhaust gas temperature mean value system (optional)

System data

Inputs:
4 fixed automatic shut down + overspeed inputs
4 manual emergency stop inputs
16 configurable inputs for shutdown, load reduce request or starting interlock
2 separate override inputs
1 remote reset input
All inputs are wire break- and short circuit monitored.

Outputs:
4 x 2 adjustable speed contacts
3 fuel setting signals (1 x 0-10V DC, 2 x 4-20 mA)
1 overload contact at rated speed
4 speed signals (1 x pulse, 1 x 0-10V DC, 2 x 4-20 mA or 0-10V DC → configurable)

6. Control and monitoring system



6. Control and monitoring system

6.2 Speed control

(for CPP single engine, fixed rudder propeller, Voith propeller propulsion, reversing gear plant)

Main engines are equipped with a mech. / hydr. speed governor (milliampere speed setting). With the following equipment:

- Stepper motor in the top part of the governor for remote speed control
- Separate stepper motor control with adjustable speed range and speed ramp.
  Voltage supply = 24 V DC

The control is fitted easily accessible on the engine in the terminal board box (X1) especially provided for control components.

The set speed value of nmin = 4 mA; nmax = 20 mA is converted into a current required by the stepper motor.

- Speed setting knob (emergency speed setting).
- Shut-down solenoid (24 V DC/100 % duty cycle) for remote stop (not for automatic engine stop).
- Steplessly adjustable droop on the governor from 0 - 10 %.
- Standard setting: 0 %.
- Device for optimization of the governor characteristic.
- Serrated drive shaft (for easy service).
- Start fuel limiter.

6. Control and monitoring system

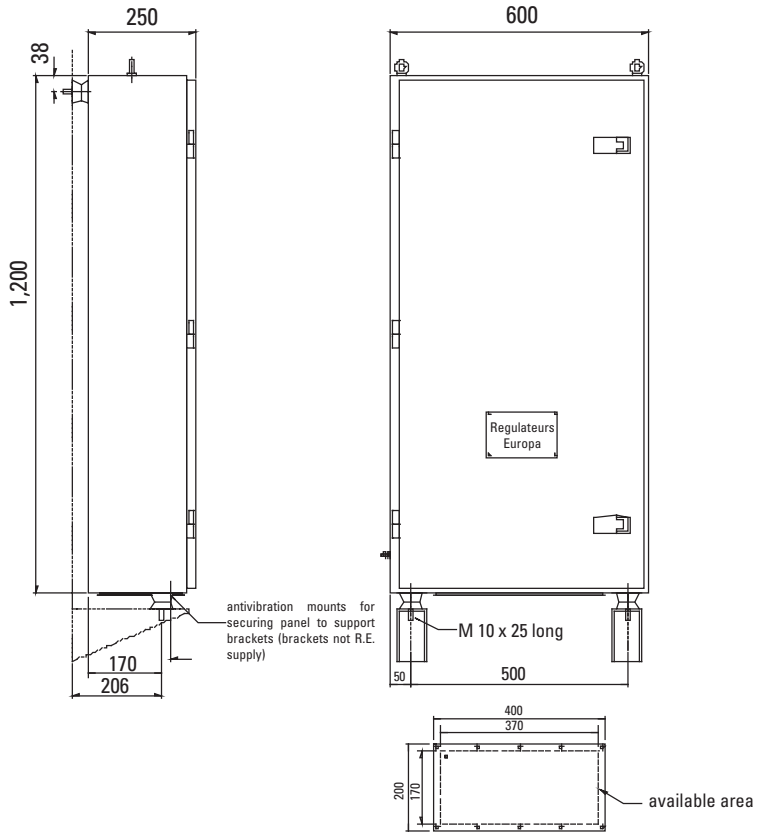
6.2 Speed control

Twin engine plant with one CPP: The engines are equipped with an actuator (optional with mech. back-up). Electronic governors are installed in a separate control cabinet.

The governor comprises the following functions:

- Speed setting range to be entered via parameters
- Adjustable acceleration and deceleration times
- Starting fuel limiter
- Input for stop (not emergency stop)
- 18 - 32 V DC voltage supply
- Alarm output
- Droop operation (primary shaft generator)
- Isochronous load distribution by master/slave principle for twin engine propulsion plants via double-reduction gear

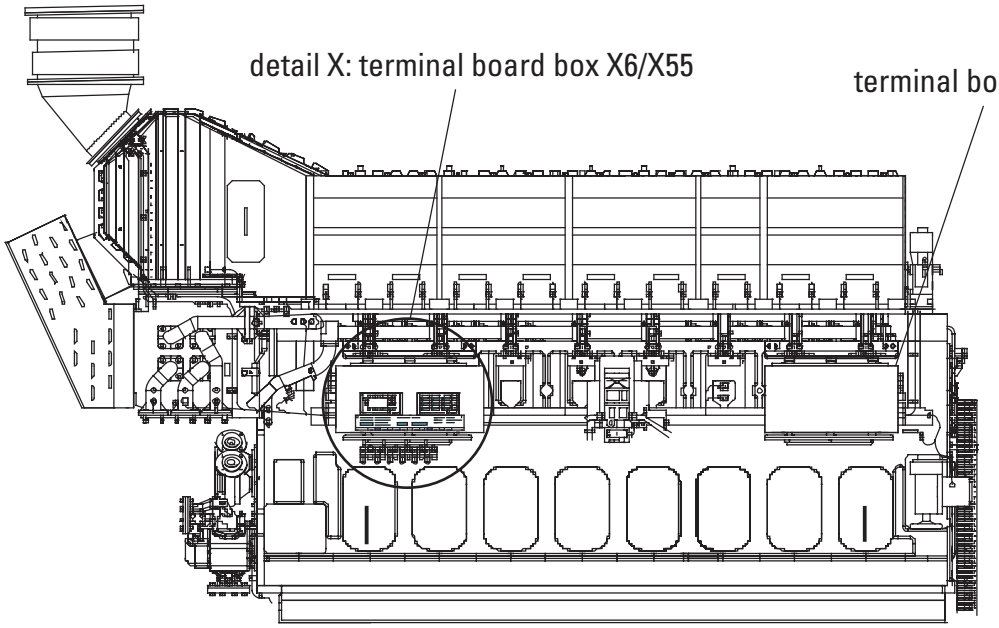
Standard: Regulateurs Europa "Propulsion Panel" with Viking 35 electronic governor (one per engine).



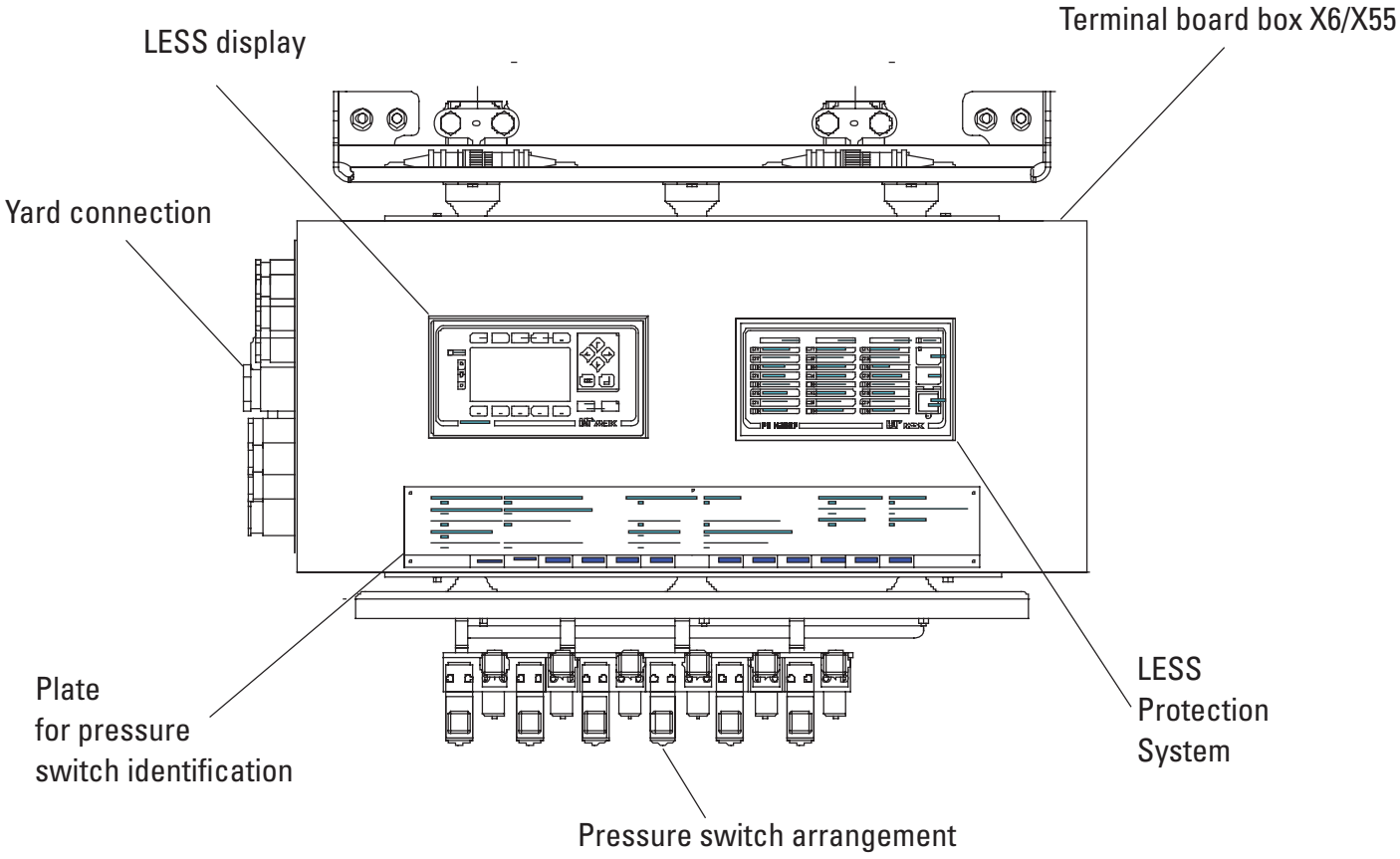
Option: Woodward control twin engine cabinet with Woodward 723+ electronic governor

6. Control and monitoring system

6.3 Engine monitoring



Detail X:



6. Control and monitoring system

6.4 Measuring points

Meas. Point MODbus-Address	Description	Sensor range	Remarks
1103 11195	Pressure switch Lube oil pressure low - load reduction	binary	(**1102** only by FPP)
1104	Pressure switch Lube oil pressure low - start standby pump	binary	
1102/1105 30009	1102 Lube oil pressure low - pre-alarm load reduction	4-20 mA	(**1102** only by FPP) 1 sensor for 1102 & 1105
1106 10113	Pressure transmitter Lube oil pressure low - pre-alarm shutdown	4-20 mA	
1112.1 100034	Differential pressure lube oil automatic filter high - pre-alarm	binary	1 evaluation unit for **1112.1/.2**. Only existing when automatic filter is mounted on engine.
1112.2 10035	Differential pressure lube oil automatic filter high - alarm	binary	
1142 10116	Pre lube oil pressure	binary	
1202 30010	Resistance thermometer Lube oil temperature at engine inlet high - alarm	PT 100	
1203 30119	NTC/switch unit Lube oil temperature at engine inlet high - load reduction	binary	
1251 10046	Oil mist concentration in crankcase high - alarm	binary	1 evaluation unit for **1251, 1253, 9631** **1251.1** (70 % from **1251**)
1251.1 10001	Oil mist concentration in crankcase high - pre-alarm	binary	
1251.2	Opacity	4-20 mA	
1253 10112	Oil mist concentration in crankcase high - shutdown	binary	
9631 10047	Oil mist detector failure - alarm	binary	
1301	Lube oil level at wet sump pan low - alarm	binary	
2101	Cooling water pressure HT at engine inlet low - start standby pump	binary	20 kPa below operating pressure
2102 30011	Cooling water pressure HT at engine inlet low - alarm	4-20 mA	40 kPa below operating pressure
2103 10114	Cooling water pressure HT at engine inlet lo - shutdown	binary	operating pressure stop delay: 20s
2111	Cooling water pressure LT at engine inlet low - start standby pump	binary	20 kPa below operating pressure
2112 30012	Cooling water pressure LT at engine outlet low - alarm	4-20 mA	40 kPa below operating pressure

6. Control and monitoring system

Meas. Point MODbus-Address	Description	Sensor range	Remarks
2201 30013	Cooling water temperature HT at engine inlet low - alarm	PT 100	
2211 30014	Cooling water temperature HT at engine outlet high - alarm	PT 100	
2212 30120	Cooling water temperature HT at engine outlet high - load reduction	binary	
2229 30015	Cooling water temperature LT at engine inlet high - alarm	PT 100	
2321	Oil ingress in fresh water at cooler outlet - alarm	binary	Option: external sensor
5101	Fuel oil pressure at engine inlet low - start standby pump	binary	
5102 30021	Fuel oil pressure at engine inlet low - alarm	4-20 mA	
5105	Fuel oil pressure - start standby pump by pump control		option: external sensor
5111 10036	Differential pressure fuel oil filter high - alarm	binary	
5112	Fuel oil differential pressure at automatic filter		Option: external sensor
5115	Fuel oil differential pressure - start standby pump by pump control		Option: external sensor
5116	Fuel oil differential pressure at circulating pump		Option: external sensor
5201/5202* 30022	**5201** Fuel oil temperature at engine inlet low - alarm **5202** Fuel oil temperature at engine inlet high - alarm	PT 100	1 sensor for 5201 + 5202* * Not in use with HFO
5206 30090	Fuel oil temperature after viscomat - DICARE	PT 100	Not mounted on engine
5251/5252	Fuel oil viscosity at engine inlet high - alarm		Option: external sensor
5253 30089	Fuel oil viscosity at viscomat - DICARE	4-20 mA	Not mounted on engine
5301 10003	Level probe/switch unit Leakage oil level at engine high - alarm	binary	
5333	Fuel oil level mixing tank		Option: external sensor
6101 30032	Pressure transmitter Starting air at engine inlet low - alarm	4-20 mA	
6105 10048	Pressure switch Stopping air pressure at engine low - alarm	binary	
6181 30019	Intake air pressure in engine room - DICARE	4-20 mA	
7109 30017	Charge air pressure at engine inlet - DICARE, Indication	4-20 mA	

6. Control and monitoring system

Meas. Point MODbus-Address	Description	Sensor range	Remarks
7201 30016	Resistance thermometer Charge air temperature at engine inlet high - alarm	PT 100	
7206 30020	Intake air temperature at turbocharger inlet - DICARE	PT 100	
7301 10004	Level probe/switch unit Condense water in charge air canal	binary	
7307 30018	Charge air diff. pressure at charge air cooler - DICARE	4-20 mA	
7309 30087	Charge air temp. at charge air cooler inlet - indication, DICARE	NiCr-Ni (mV)	
8211.1 30073	Exhaust gas temperature after cylinder 1 - load reduction	NiCr-Ni (mV)	
8211.2 30074	Exhaust gas temperature after cylinder 2 - load reduction	NiCr-Ni (mV)	
8211.3 30075	Exhaust gas temperature after cylinder 3 - load reduction	NiCr-Ni (mV)	
8211.4 30076	Exhaust gas temperature after cylinder 4 - load reduction	NiCr-Ni (mV)	
8211.5 30077	Exhaust gas temperature after cylinder 5 - load reduction	NiCr-Ni (mV)	
8211.6 30078	Exhaust gas temperature after cylinder 6 - load reduction	NiCr-Ni (mV)	
8211.7 30079	Exhaust gas temperature after cylinder 7 - load reduction	NiCr-Ni (mV)	
8211.8 30080	Exhaust gas temperature after cylinder 8 - load reduction	NiCr-Ni (mV)	
8211.9 30081	Exhaust gas temperature after cylinder 9 - load reduction	NiCr-Ni (mV)	
8216	Deviation of mean average value reduct alarm cyl.		Load reduction from alarm system to LESS
8218	Exhaust gas temp. reduct alarm of each cyl. absolut		Load reduction from alarm system to LESS
8221 30082	Exhaust gas temp. at turbocharger outlet - load reduction	NiCr-Ni (mV)	
8224	Exhaust gas temp. reduction alarm of turbocharger outlet		Load reduction from alarm system to LESS
8231.1 30083	Exhaust gas temp. at turbocharger outlet - load reduction	NiCr-Ni (mV)	

6. Control and monitoring system

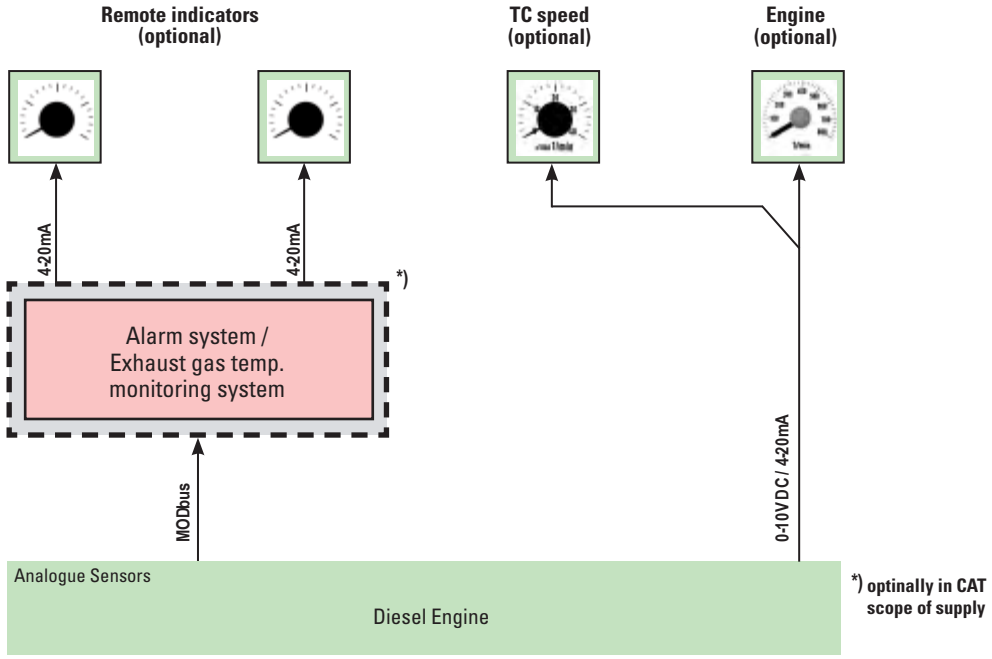
Meas. Point MODbus-Address	Description	Sensor range	Remarks
8231.2 30084	Exhaust gas temp. at turbocharger inlet - indication	NiCr-Ni (mV)	
8231.3 90085	Exhaust gas temp. at turbocharger inlet - indication	NiCr-Ni (mV)	
8234 10136	Common alarm exhaust gas temp. monitoring load reduction included 8216, 8218, 8224		Common alarm from alarm system to LESS
9401	Engine speed	binary	Supression of alarms
9402	Engine speed	binary	Start standby pump
9404 10110	Automatic stop alarm	binary	
9406	Switch off lube oil standby pump	binary	
9407	Engine speed	binary	n adjustable
9419 30051	Engine speed signal From RPM switching equipment - indication, DICARE	4-20 mA	
9419.1	Pick up RPM switching equipment	0-15 KHz	
9419.2	Pick up RPM switching equipment	0-15 KHz	
9429 30042	Turbine speed high - alarm Turbine speed - indication, DICARE	4-20 mA 0-10 V	
9503	Limit switch - control lever at fuel rack - stop position	binary	
9509 30031	Distance sensor/switching device Fuel setting	4-20 mA	
9531	Engine overload at rated speed	binary	
9532	Engine load signal	4-20 mA	
9561 10117	Limit switch Turning gear engaged - starting interlock	binary	
9602 10005	Relay contact CANbus failure - alarm	binary	
9614 10045	Relay contact Steppermotor fault - alarm	binary	
9615	Failure electrical governor	binary	
9616 10137	Failure mechanical governor	binary	
9671.1	Automatic stop failure - alarm	binary	
9671.2	Overspeed failure - alarm	binary	

6. Control and monitoring system

Meas. Point MODbus-Address	Description	Sensor range	Remarks
9671.3	Emergency failure - alarm	binary	
9674	Overspeed - alarm	binary	
9675	Emergency stop - alarm	binary	
9676	Common alarm load reduction	binary	
9677.1	Override oil mist detector activated	binary	
9677.2	Override load reduction activated	binary	
9717	Relay contact Voltage failure at terminal X3 - alarm	binary	
9751	Voltage fail at charge air temp. controller	binary	
9771	Freshwater preheater voltage failure	binary	
9836.1 10107	Relay contact Sensor/isolation fault A01 - alarm	binary	
9836.2 10007	Relay contact Sensor/isolation fault A02 - alarm	binary	
9962.1 30108	Relay contact Common alarm A01 - alarm	binary	
9962.2 30008	Relay contact Common alarm A02 - alarm	binary	

6. Control and monitoring system

6.5 Local and remote indicators



Local indicators	Remote indicators
Installed at the engine	96 x 96mm (optionally)
Fuel oil temperature at engine inlet	X[2]
Fuel oil differential pressure at filter	
Fuel rack position (mean injection pump rack)	
Lube oil temperature at engine inlet	X[2]
Lube oil differential pressure at filter	
Fresh water temperature at engine inlet (HT circuit)	
Fresh water temperature at engine outlet (HT circuit)	X[2]
Fresh water temperature (LT circuit)	X[2]
Fresh water temperature cooler inlet	
Fresh water temperature cooler outlet	
Charge air temperature cooler inlet	
Charge air temperature engine inlet	X[2]
Installed at the engine (gauge board)	
Fuel oil pressure	X[2]
Lube oil pressure	X[2]
Fresh water pressure (HT circuit)	X[2]
Fresh water pressure (LT circuit)	X[2]
Start air pressure	X[2]
Charge air pressure cooler outlet	X[2]
Stop air pressure	
Engine speed	X[1]
Turbocharger speed	X
Charge air temperature cooler inlet (digital value)	
Exhaust gas temperature after cylinder (digital value)	
Exhaust gas temperature before/after turbocharger (digital value)	

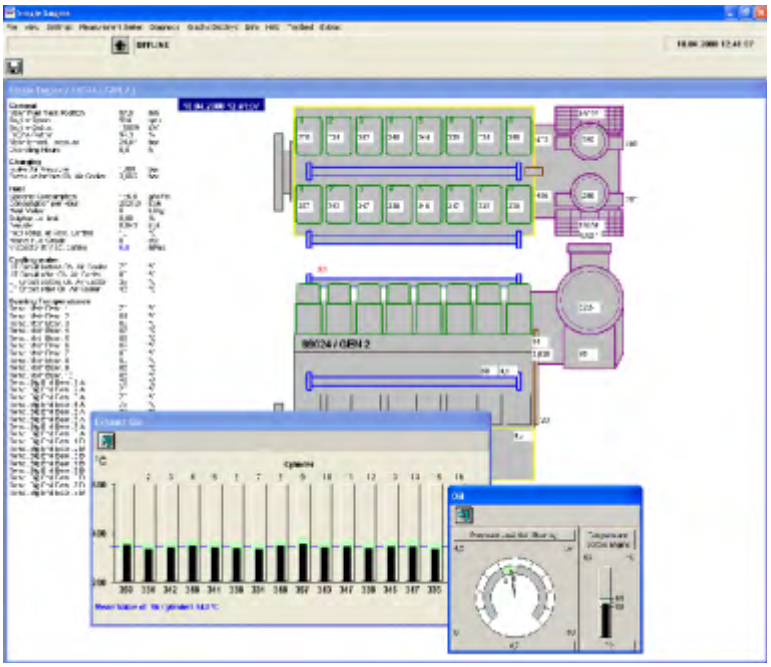
[1] 144 x 144 mm possible
[2] Signal is supplied by the alarm system

7. Diagnostic trending monitoring - DICARE

With MaK DICARE, you can have an expert aboard at all times, ready to serve your needs. The latest, completely revised version combines well-established features with faster signal processing and improved usability, based on common industry standards.
Cat and MaK engines with MaK DICARE remote engine monitoring software provide reliable, condition-specific maintenance suggestions. DICARE continually compares current engine condition to desired state and tells you when maintenance is required. You get the diagnostics you need in easy-to-understand words and graphics so you can take action to keep your engines running strong.
DICARE is only available for medium-speed engines not for high-speed engines.

About 700 MaK engines worldwide, on vessels and in power stations ashore, are currently supervised with DICARE. Malfunctions are indicated immediately and at a glance, taking into account empirical data, plausibility considerations, and built-in expertise from decades of MaK diesel engine design. For ease of use, the initial report is subdivided into the diagnostic sectors of exhaust gas, turbocharger, fuel oil, lube oil, and cooling water, using a simple color-coding of regular versus irregular values. In a second step, the complete set of measured values and detailed troubleshooting instructions can be displayed, also with recommended actions priority-coded.
Special attention is placed on monitoring the following criteria:

- Overall temperature levels to identify thermal overload at an early stage.
- Intake air pressure and temperature to identify performance drops due to fouling or wear.
- Charge air pressure, temperature and dew point to identify fouling or misadjustment.
- Fuel temperature and viscosity to identify any malfunction of the viscosity control unit.
- Fuel rack position and power output to identify injection pump wear.
- Lube oil consumption to identify any possible wear.
- Cooling water pressure and temperature for optimum operation.
- Exhaust gas temperatures to identify deviations in the fuel or air system at an early stage.



7. Diagnostic trending monitoring - DICARE

Transmitter for DICARE ON-LINE M 25 C CANbus

Designation	Meas. point no. CM
Fuel viscosity	5253
Fuel temperature after viscomat	5206
Fuel temperature at engine inlet	5201
Injection pump rack position	9509
Lube oil pressure	1105
Lube oil temperature at engine inlet	1202
Freshwater pressure HT	2102
Freshwater temperature at engine inlet HT	2201
Freshwater temperature at engine outlet HT	2211
Differential pressure charge air cooler	7307
Intake air pressure	6181
Intake air pressure before turbocharger	7206
Charge air pressure after intercooler	7109
Charge air temperature before intercooler	7309
Charge air temperature at engine inlet	7201
Exhaust gas temperature for each cylinder and after turbocharger	8211/8221
Exhaust gas temperature before turbocharger	8231
Engine speed	9419
Turbocharger speed	9429
Service hour counter (manual input)	9409

8. Engine acceptance test

Standard acceptance test run

The acceptance test run is carried out on the testbed with customary equipment and auxiliaries using exclusively MDO and under the respective ambient conditions of the testbed. During this test run the fuel rack will be blocked at the contractual output value. In case of deviations from the contractual ambient conditions the fuel consumption will be converted to standard reference conditions.

The engine will be run at the following load stages acc. to the rules of the classification societies. After reaching steady state condition of pressures and temperatures these will be recorded and registered acc. to the form sheet of the acceptance test certificate:

Load [%]	Duration [min]
50	30
75	30
85	30
100	60
110	30

Additional functional tests

In addition to the acceptance test run the following functional test will be carried out:

- governor test
- overspeed test
- emergency shut-down via minimum oil pressure
- start/stop via central engine control
- starting trials up to a minimum air pressure of 10 bar
- measurement of crank web deflection (cold/warm condition)

After the acceptance test run **main running gear, camshaft drive and timing gear train** will be inspected through the opened covers. Individual inspection of special engine components such as a piston or bearings is not intended, because such inspections are carried out by the classification societies at intervals on production engines.

Engine movement due to vibration referred to the global vibration characteristics of the engine:

The basis for assessing vibration severity are the guidelines ISO 10816-6.

According to these guideline, the MaK engine will be assigned to vibration severity grade 28, class 5. On the engine block the following values will not be exceeded:

Displacement	S_{eff}	< 0.448 mm	f > 2 Hz < 10 Hz
Vibration velocity	V_{eff}	< 28.2 mm/s	f > 10 Hz < 250 Hz
Vibration acceleration	a_{eff}	< 44.2 m/s²	f > 250 Hz < 1000 Hz

9. Engine International Air Pollution Prevention Certificate

The MARPOL Diplomatic Conference has agreed about a limitation of NO_x emissions, referred to as Annex VI to Marpol 73/78.

When testing the engine for NO_x emissions, the reference fuel is Marine Diesel Oil (Distillate) and the test is performed according to ISO 8178 test cycles:

	Test cycle type E2				Test cycle type D2				
Speed	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Power	100 %	75 %	50 %	25 %	100 %	75 %	50 %	25 %	10 %
Weighting factor	0.2	0.5	0.15	0.15	0.05	0.25	0.3	0.3	0.1

Subsequently, the NO_x value has to be calculated using different weighting factors for different loads that have been corrected to ISO 8178 conditions.

An NO_x emission evidence will be issued for each engine showing that the engine complies with the regulation. The evidence will come as EAPP (Engine Air Pollution Prevention) Statement of Compliance, EAPP (Engine Air Pollution Prevention) Document of Compliance or EIAPP (Engine International Air Pollution Prevention) Certificate according to the authorization by the flag state and related technical file. For the most part on basis of an EAPP Statement of Compliance or an EAPP Document of Compliance an EIAPP certificate can be applied for.

According to IMO regulations, a Technical File shall be prepared for each engine. This Technical File contains information about the components affecting NO_x emissions, and each critical component is marked with a special IMO number. Such critical components are piston, cylinder head, injection nozzle (element), camshaft section, fuel injection pump, turbocharger and charge air cooler. (For Common Rail engines the controller and the software are defined as NO_x relevant components instead of the injection pump.) The allowable setting values and parameters for running the engine are also specified in the Technical File.

The marked components can later, on-board the ship, be easily identified by the surveyor and thus an IAPP (International Air Pollution Prevention) certificate for the ship can be issued on basis of the EIAPP certificate and the on-board inspection.

10. Painting/Preservation

Inside preservation

N 576-3.3
The preservation is sufficient for a period of max. 2 years.
It needs to be remmoved when the engine is commissioned!
- Main running gear and internal mechanics

Outside preservation

VCI 368 N 576-3.2
Engine outside preservation with Cortec VCI 368 is applicable for Europe and overseas.
It applies for sea and land transportation and storage of the engines in the open, protected from moisture.
The duration of protection with additional VCI packaging is max. 2 years.

It must be removed before commissioning of the engines! Environmentally compatible disposal is to be ensured.

Durability and effect are determined by proper packaging, transportation, and storage, i.e. protected from moisture, stored at a dry place and sufficiently ventilated. Inspections are to be carried out at regular intervals.

Appearance of the engine:
- Castings with red oxide antirust paint
- Pipes and machined surfaces left as bare metal
- Attached components with colours of the makers

N 576-4.1 - Clear Varnish
Clear varnish painting is applicable within Europe for land transportation with protection from moisture.
It is furthermore applicable for storage in a dry and tempered atmosphere.

Clear varnish painting is not permissible for:
- Sea transportation of engines
- Storage of engines in the open, even if they are covered with tarpaulin

The duration of protection with additional VCI packaging is max. 1 year.

VCI packaging as per N 576-5.2 is generally required!
Durability and effect are determmined by proper packaging, transportation, and storage, i.e. the engine is to be protected from moisture, VCI film not ripped or destroyed.
Inspections are to be carried out at regular intervals.

10. Painting/Preservation

If the above requirements are not met, all warranty claims in connection with corrosion damage shall be excluded.

Appearance of the engine:
- Catings with red oxide antirust paint
- Pipes and machined surfaces left as bare metal
- Attached components with colours of the makers
- Surfaces sealed with clear varnish
- Bare metal surfaces provided with VCI 368 preservation

N 576-4.3 - Painting
The painting is applicable for Europe and overseas.
It applies for sea and land transportation and short-term storage in the open (protected from moisture) up to max. 4 weeks.

In case of Europe and overseas shipment and storage in the open longer than 4 weeks VCI packaging as per N 576-5.2 is required.

The duration of protection with additional VCI packaging is max. 2 years.

Durability and effect are determined by proper packaging, transportation, and storage, i.e. protected from moisture, VCI film not ripped or destroyed. Inspections are to be carried out at regular intervals.

Appearance of the engine:
- Surfaces mostly painted with varnish
- Bare metal surfaces provided provided with VCI 368 preservation

N 576-5.2 - VCI packaging
Corrosion protection with VCI packaging applies for:
- Engines with outside preservation VCI 368 as per N 576-3.2
- Engines with clear varnish according to application group N 576-4.1
  These engines are always to be delivered with VCI packaging!
  Nevertheless, they are not suitable for storage in the open!
- Engines or engine generator sets with painting according to application group N 576-4.3 for shipment to Europe and overseas or storage in the open (protected from moisture).

10. Painting/Preservation

Durability and effect are determined by proper packaging, transportation, and storage, i.e. protected from moisture, VCI film not ripped or destroyed. Inspections are to be carried out at regular intervals.

- Bare metal surfaces provided with VCI 368 or VCI oil
- Cortec VCI impregnated flexible PU foam mats hung up on the engine using tie wraps. Kind and scope denpending on engine type.
  The mats are to be hung up in free position and should not come into contact with the painted surface.
- Cover the engine completely with air cushion film VCI 126 LP. Air cushions are to point towards the inside!
  The air cushion film is fastened to the transportation skid (wooden frame) by means of wooden laths. Overlaps at the face ends and openings for the lifting gear are to be closed by means of PVS scotch tape.
  In case of engines delivered without oil pan the overhanging VCI film between engine and transport frame is to be folded back upwards towards the engine before fastening the air cushion film.

Attention! The corrosion protection is only effective if the engine is completely wrapped with VCI film. The protective space thus formed around the component can be opened for a short time by slitting the film, but afterwards it must be closed again by means of adhesive tape.

N 576-5.2 Suppl. 1 - Information panel for VCI preservation and inspection
Applies for all engines with VCI packaging as per application group N 576-5.2.

Description:
- This panel provides information on the kind of initial preservation and instructions for inspection.
- Arranged on the transport frame on each side so as to be easily visible.

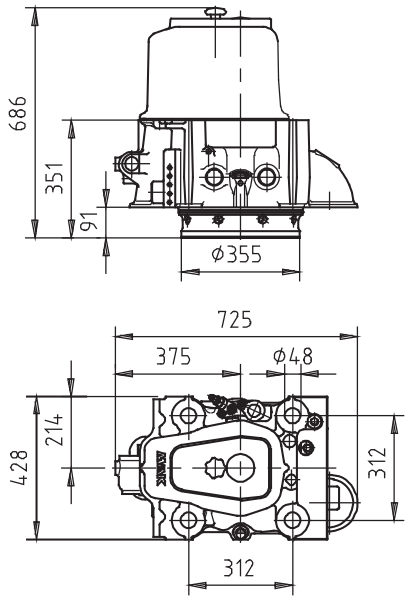
N 576-6.1 - Corrosion Protection Period, Check, and Represervation
There will only be an effective corrosion protection of the engine if the defintions and required work according to factory standard N 576-6.1 are duly complied with.
Normally, the applied corrosion protection is effective for a period of max. 2 years if the engines or engine generator sets are protected from moisture. However, depending on the execution of the preservation shorter periods may be applicable.

After 2 years represervation must be carried out.

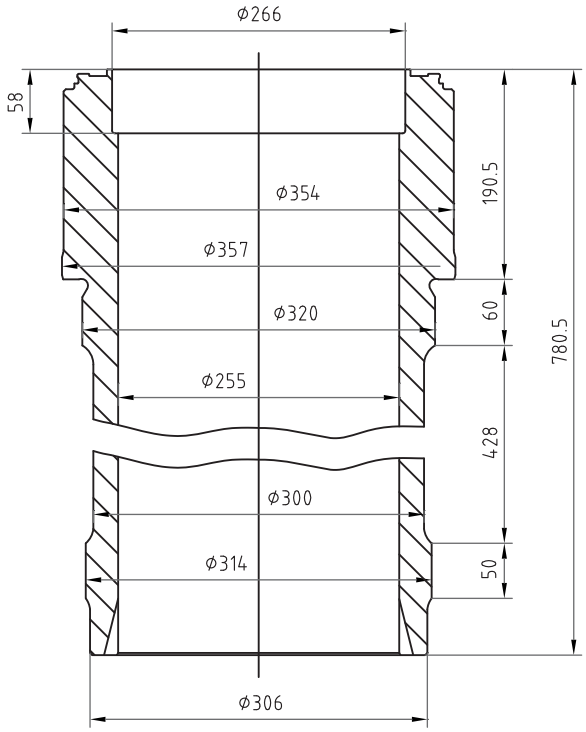
Every 3 months specific inspections are to be carried out the engine or engine generator set at defined inspection points. Any corrosion that is found and existing condensation water are to be removed immediately.

11. Engine parts

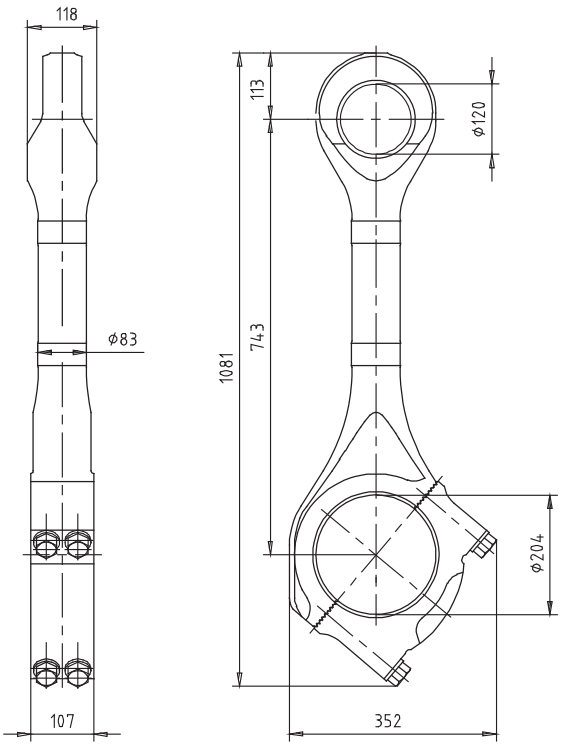
Cylinder head, weight 265 kg



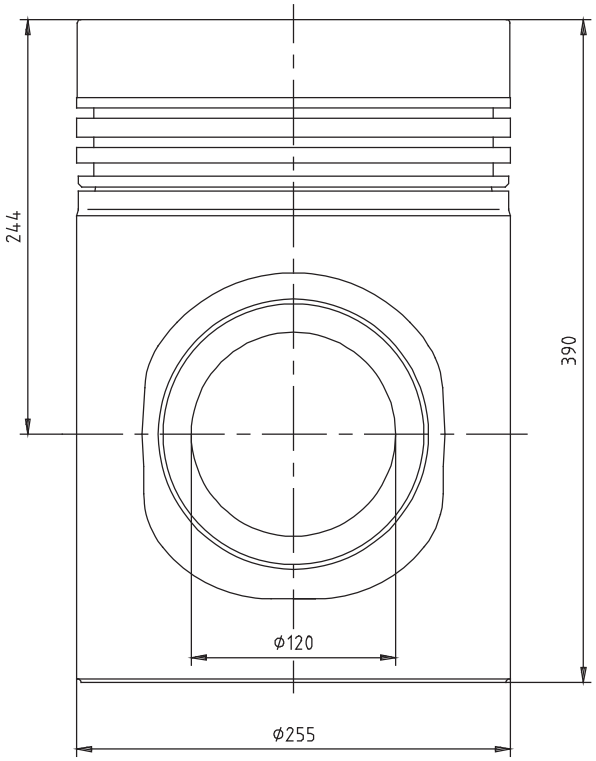
Cylinder liner, weight 162 kg



Connecting rod, weight 79 kg

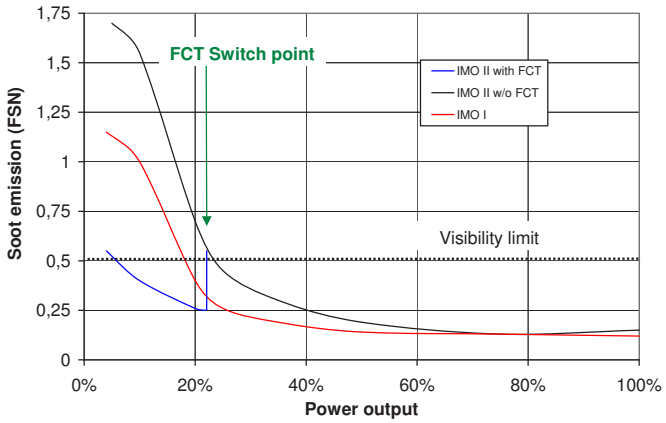


Piston, weight 46 kg

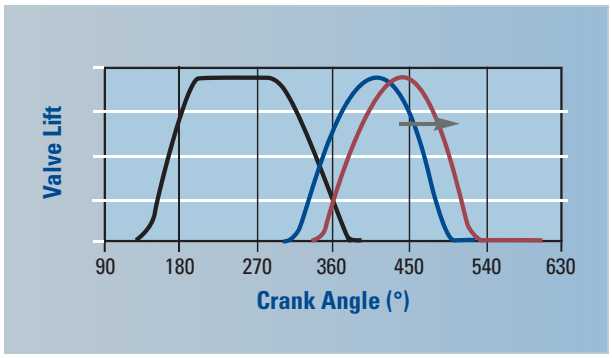


12. Flexible Camshaft Technology - FCT

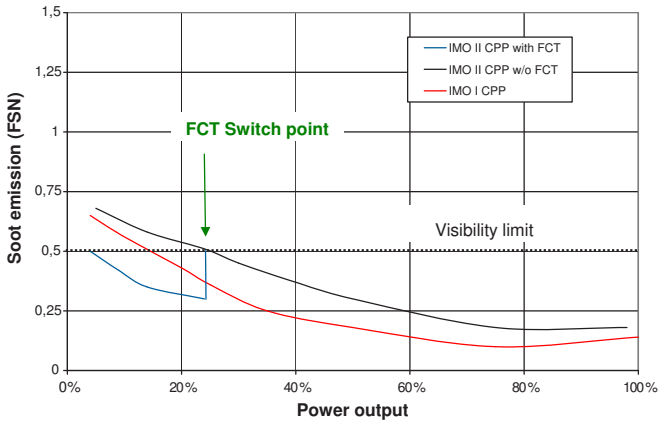
Building upon the Emission Reduction System integration concept, FCT achieves synergy between flexible fuel systems and advanced air systems with maximum utilization of the current engine design. While maintaining high fuel injection pressure over the whole operating range, fuel injection and inlet valve timing are load controlled and influenced by a lever shaft which affects injection timing/pressure and inlet valve events. Valve timing changes at part load to raise effective compression and enhance complete combustion. In addition, shifting the relative position of the lever to the fuel cam increases injection pressure, producing a finer atomization of fuel in a load range where it would otherwise be difficult to control smoke.



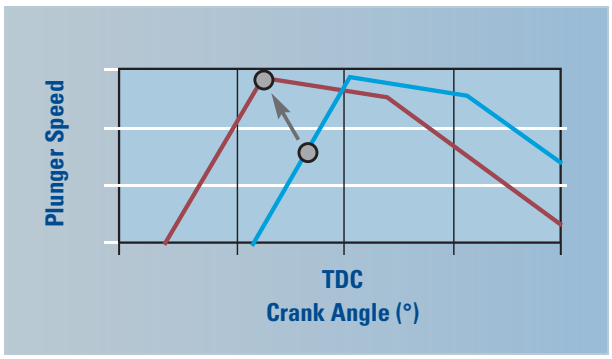
M 25 C constant speed



schematic diagram



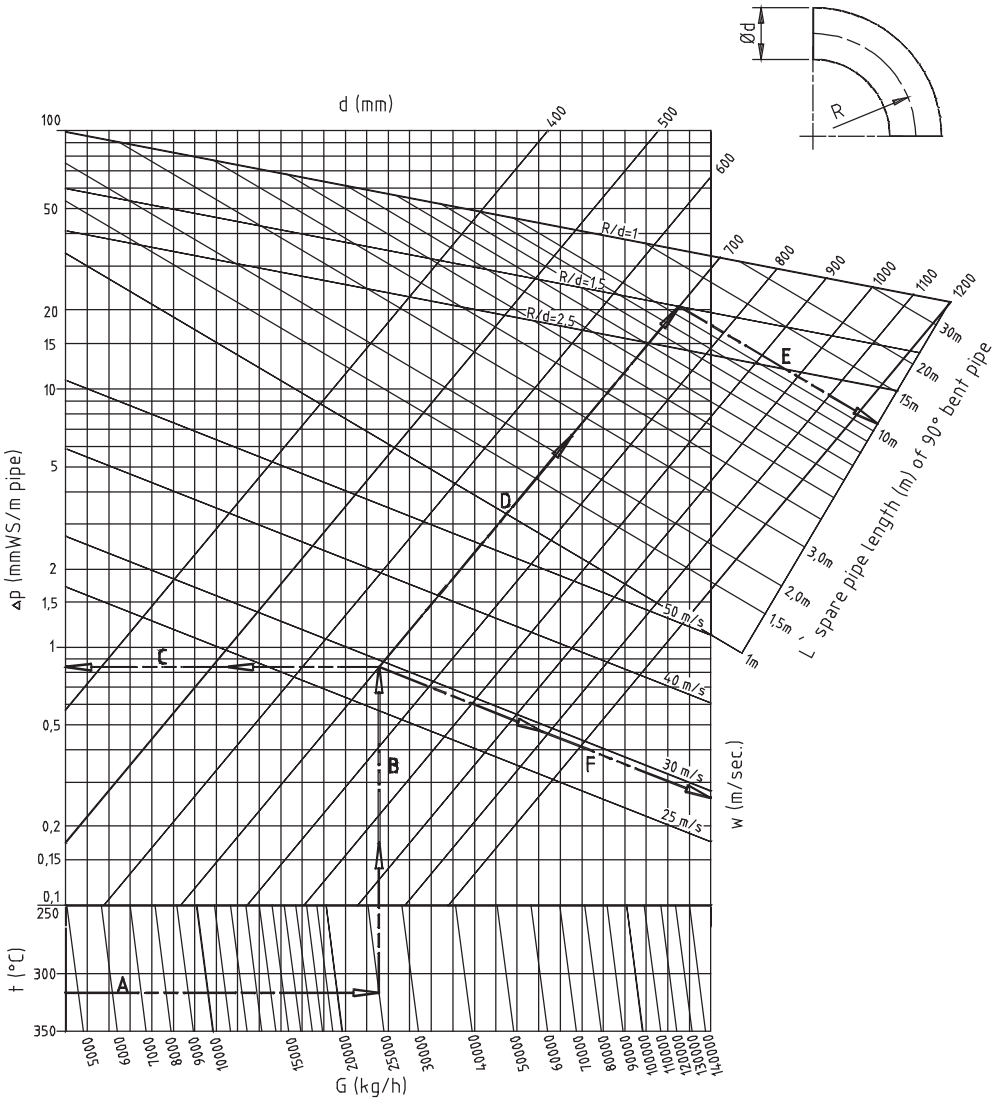
M 25 C CPP / combinator mode



13. Appendix

13.1 Exhaust system

13.1.1 Resistance in exhaust gas piping



Example (based on diagram data A to E):

t = 335 °C, G = 25,000 kg/h
l = 15 m straight pipelength, d = 700 mm
3 off 90° bent R/d = 1.5
1 off 45° bent R/d = 1.5
ΔPg = ?

Δp = 0.83 mm WC/m
L' = 3 • 11 m + 5.5 m
L = l + L' = 15 m + 38.5 m = 53.5 m
ΔPg = Δp • L = 0.83 mm WC/m • 53.5 m = 44.4 mm WC

t	= Exhaust gas temperature	(°C)
G	= Exhaust gas massflow	(kg/h)
Δp	= Resistance/m pipe length	(mm WC/m)
d	= Inner pipe diameter	(mm)
w	= Gas velocity	(m/s)
l	= Straight pipe length	(m)
L'	= Spare pipe length of 90° bent pipe	(m)
L	= Effective substitute pipe length	(m)
ΔPg	= Total resistance	(mm WC)

13. Appendix

13.1.2 Exhaust data

Tolerance: 5 %
Atmospheric pressure: 1 bar
Relative humidity: 60 %
Constant speed

Intake air temperature: 25 °C

	Output [kW]	• Output % • [kg/h] • [°C]					
		100	90	80	70	60	50
6 M 25 C	2,000	14,220	12,980	11,250	9,850	8,450	7,015
		333	337	356	354	370	397
8 M 25 C	2,666	18,050	16,500	14,945	13,080	11,425	9,770
		333	327	325	325	337	350
9 M 25 C	3,000	21,250	19,455	17,660	15,452	13,530	11,600
		342	335	330	330	337	344

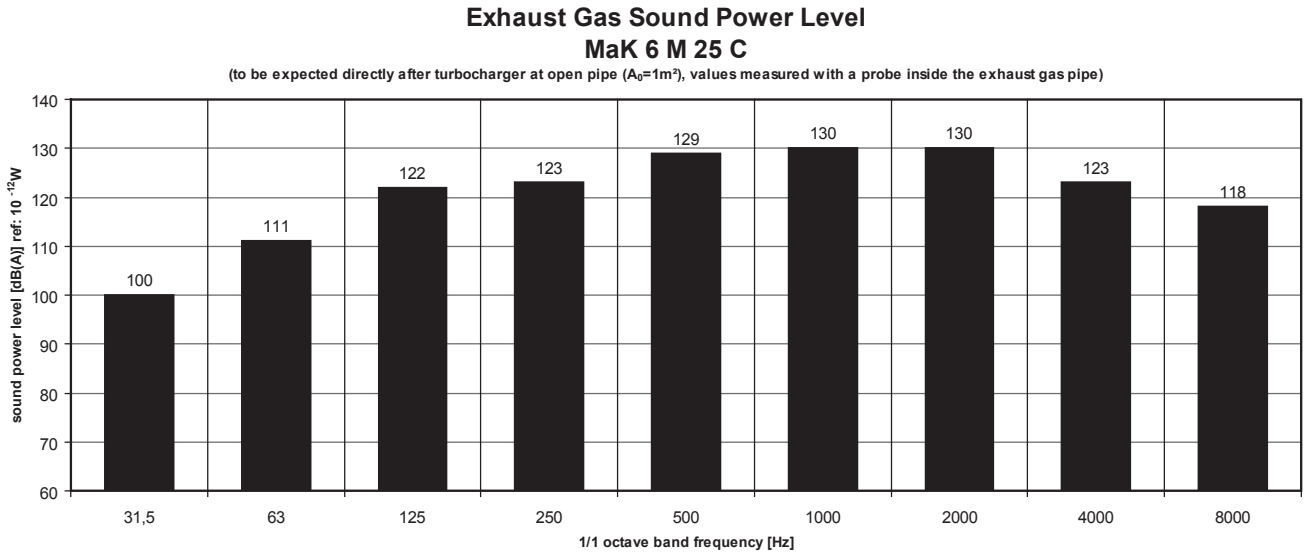
Intake air temperature: 45 °C

	Output [kW]	• Output % • [kg/h] • [°C]					
		100	90	80	70	60	50
6 M 25 C	2,000	13,650	12,460	10,800	9,456	8,110	6,735
		353	357	377	375	392	420
8 M 25 C	2,666	17,330	15,840	14,330	12,550	10,970	9,380
		353	347	344	344	357	371
9 M 25 C	3,000	20,400	18,680	16,950	14,835	12,990	11,140
		362	355	349	350	357	365

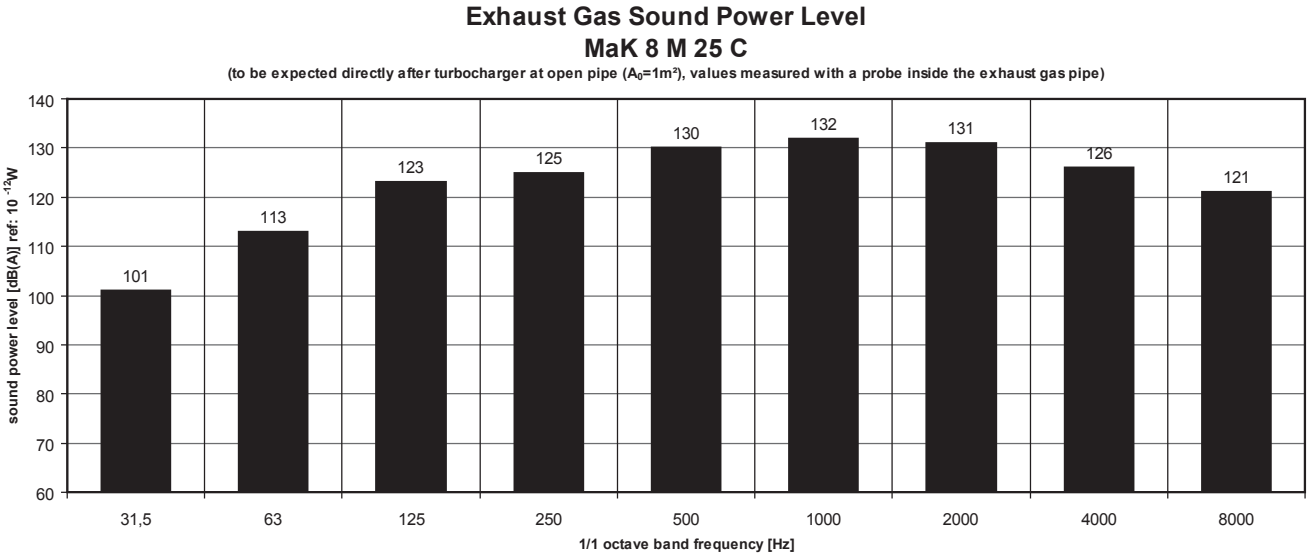
All values for single log charging. Pulse charging values: on request.

13. Appendix

13.1.3 Exhaust gas sound power level



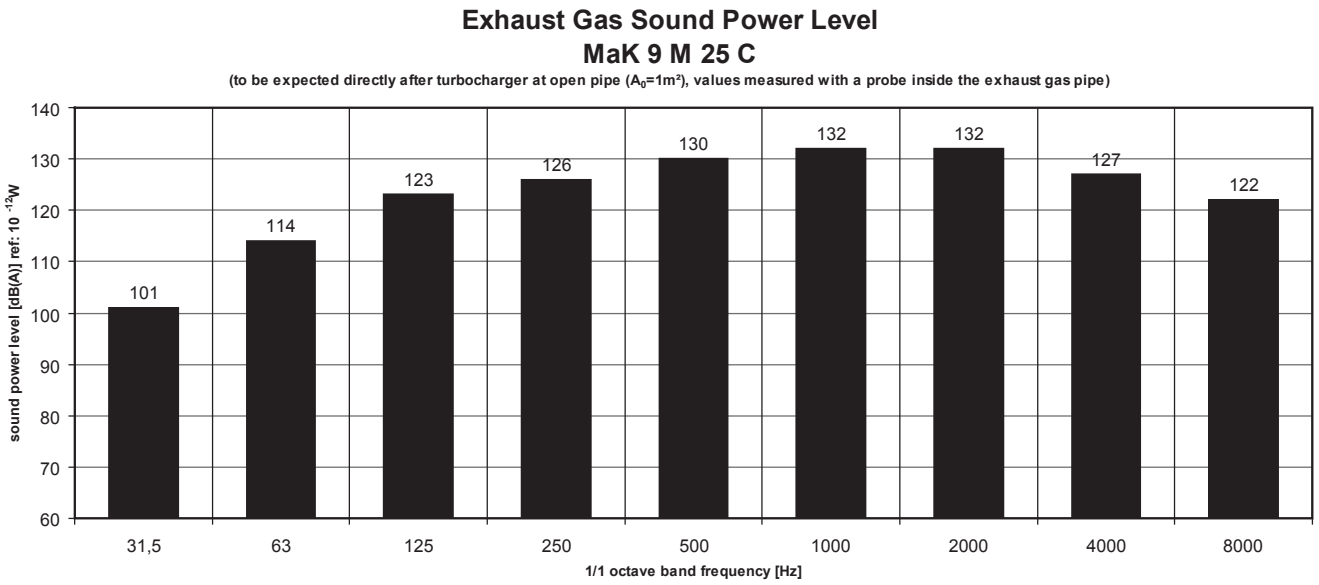
Tolerance: ± 2 dB



Tolerance: ± 2 dB

13. Appendix

13.1.3 Exhaust gas sound power level

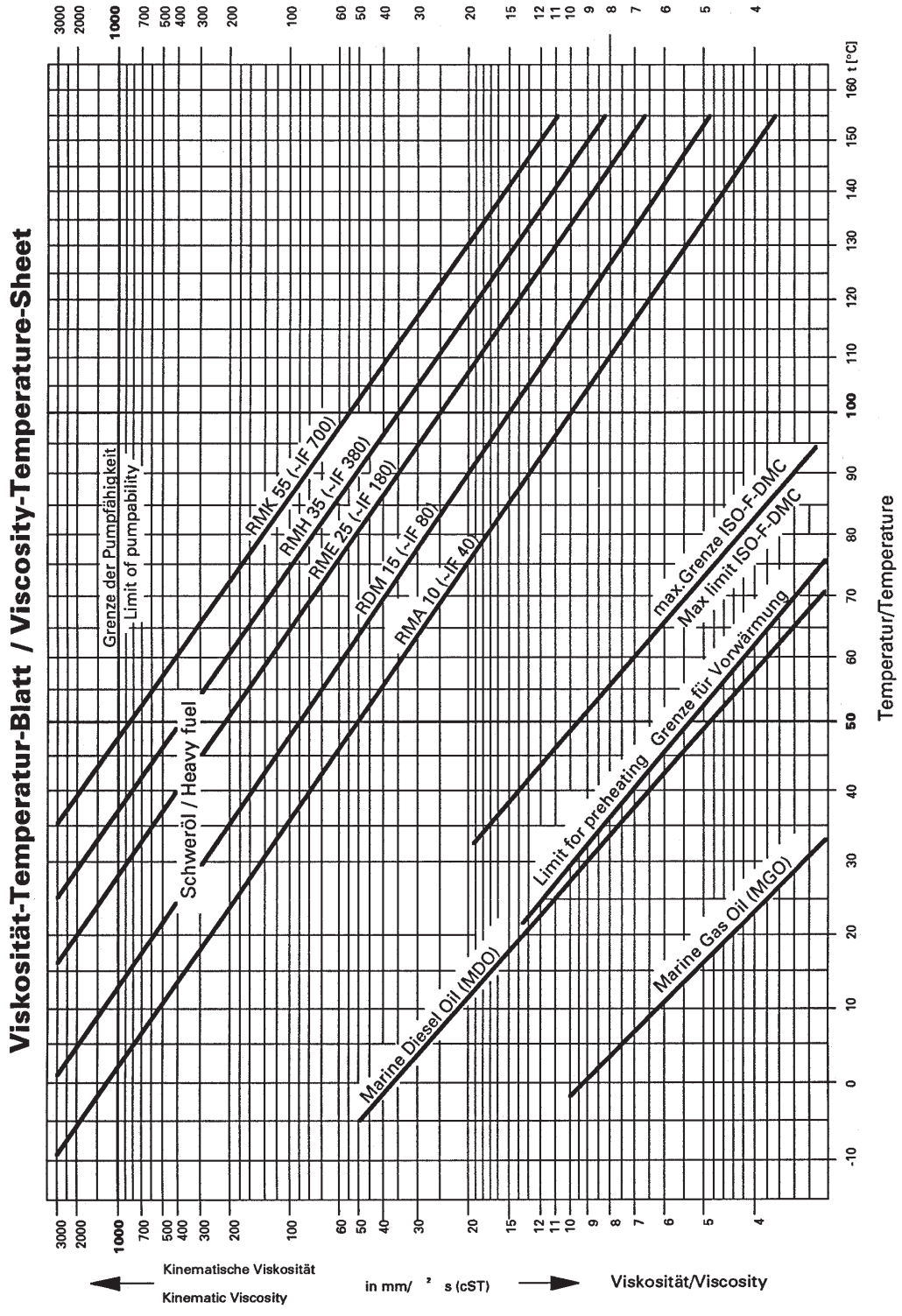


Tolerance: ± 2 dB

13. Appendix

13.2 Fuel oil system

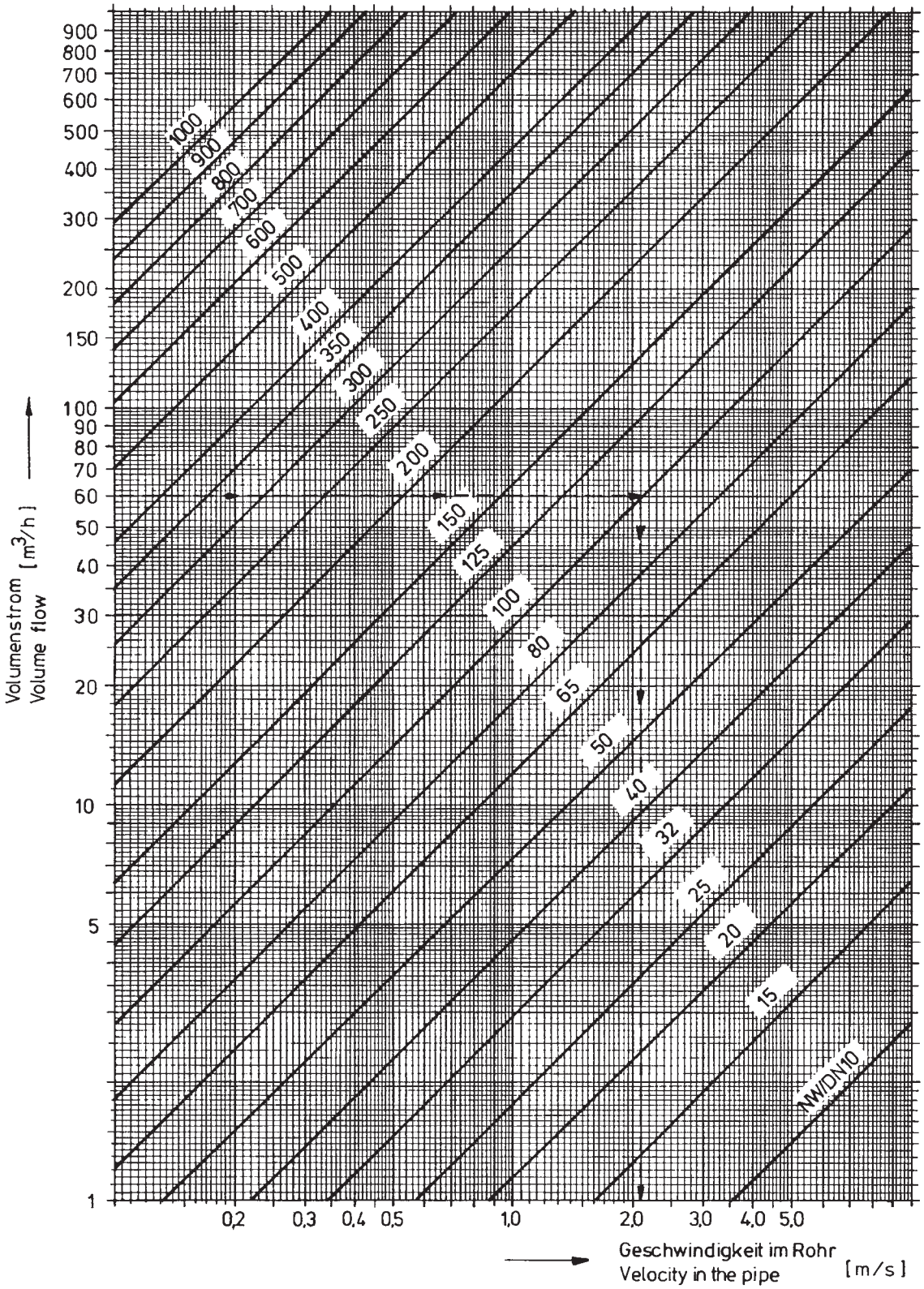
13.2.1 Viscosity/temperature diagram



13. Appendix

13.3 Cooling water system

13.3.1 Flow velocities

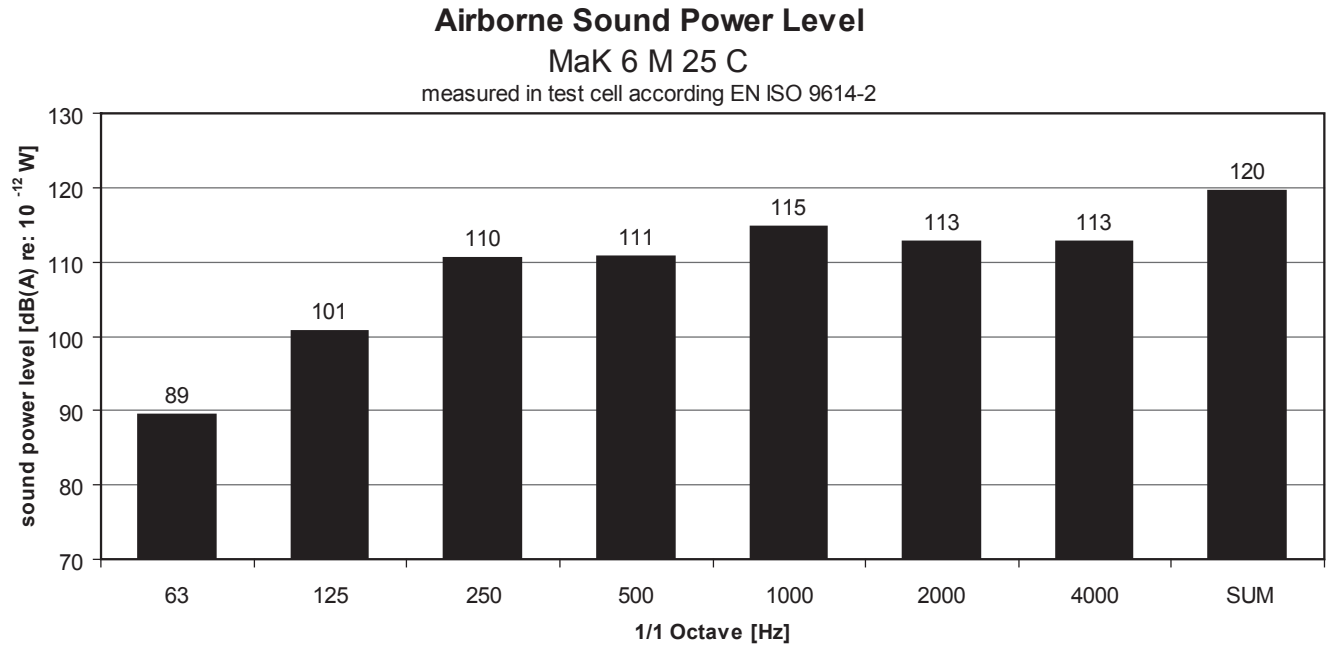


13. Appendix

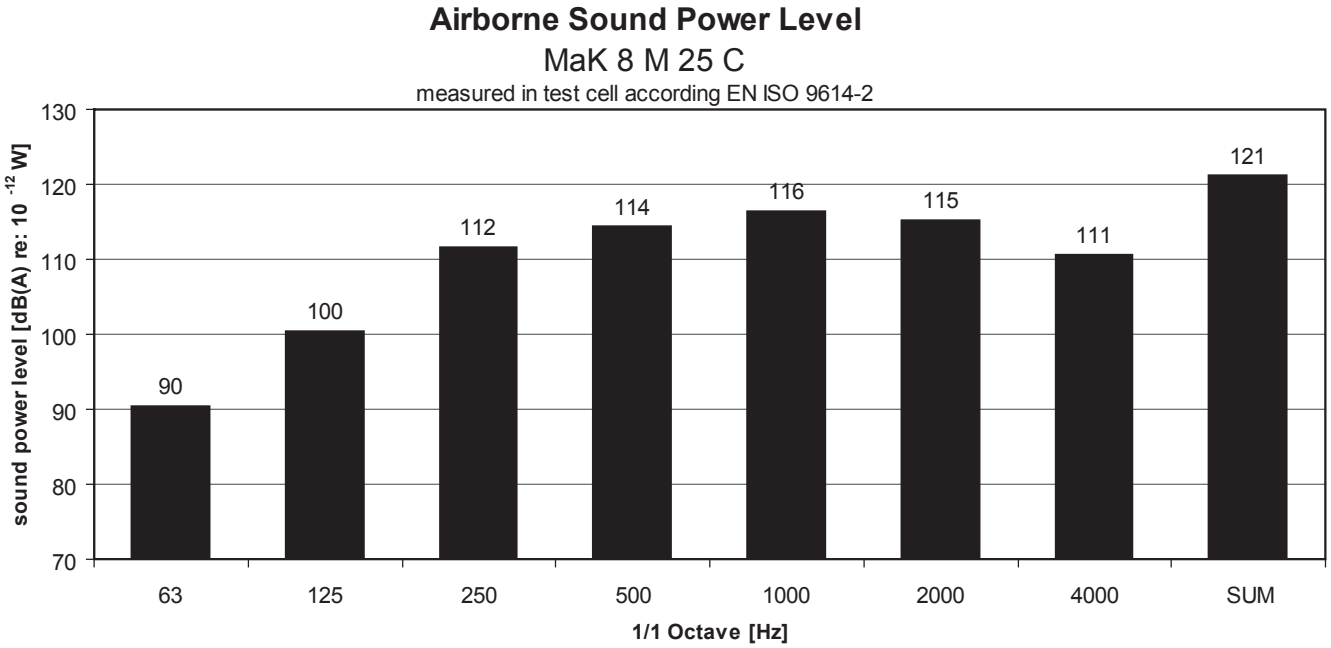
13.4 Air-borne sound power level

The air borne sound power level is measured in a test cell according to EN ISO 9614-2.

Noise level for M 25 C engines



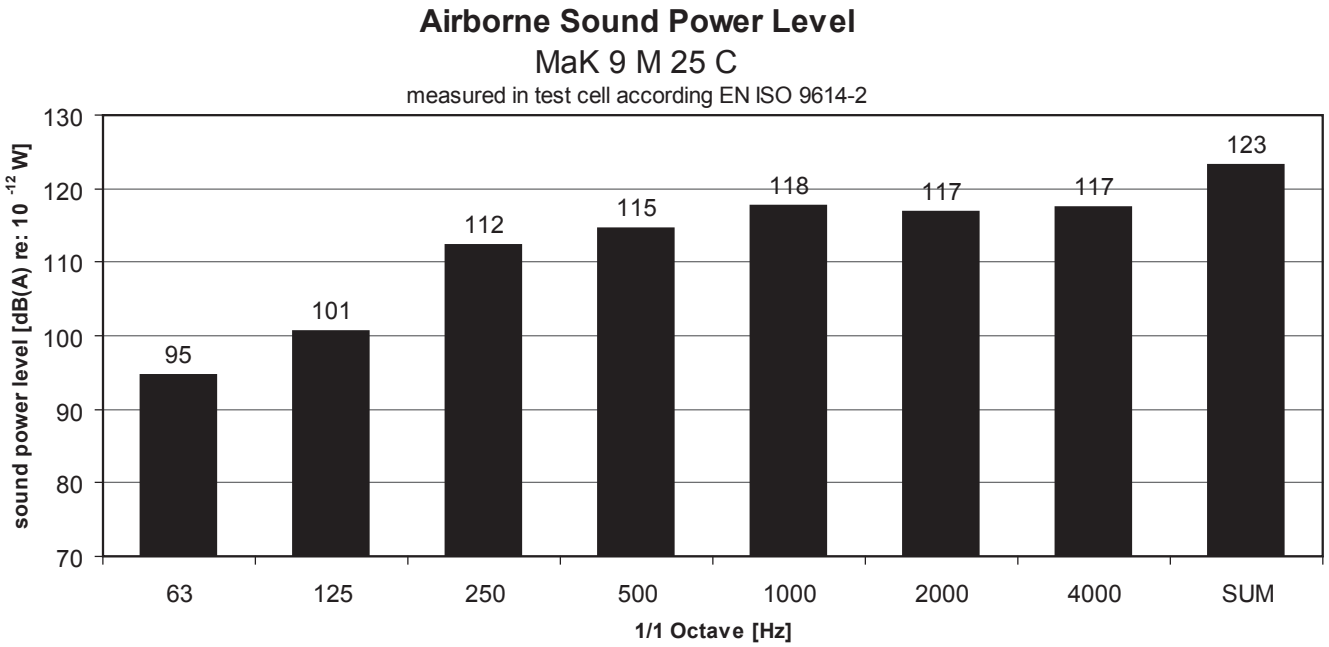
tolerance: +/- 2 dB



tolerance: +/- 2 dB

13. Appendix

13.4 Airborne sound power level



tolerance: +/- 2 dB

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