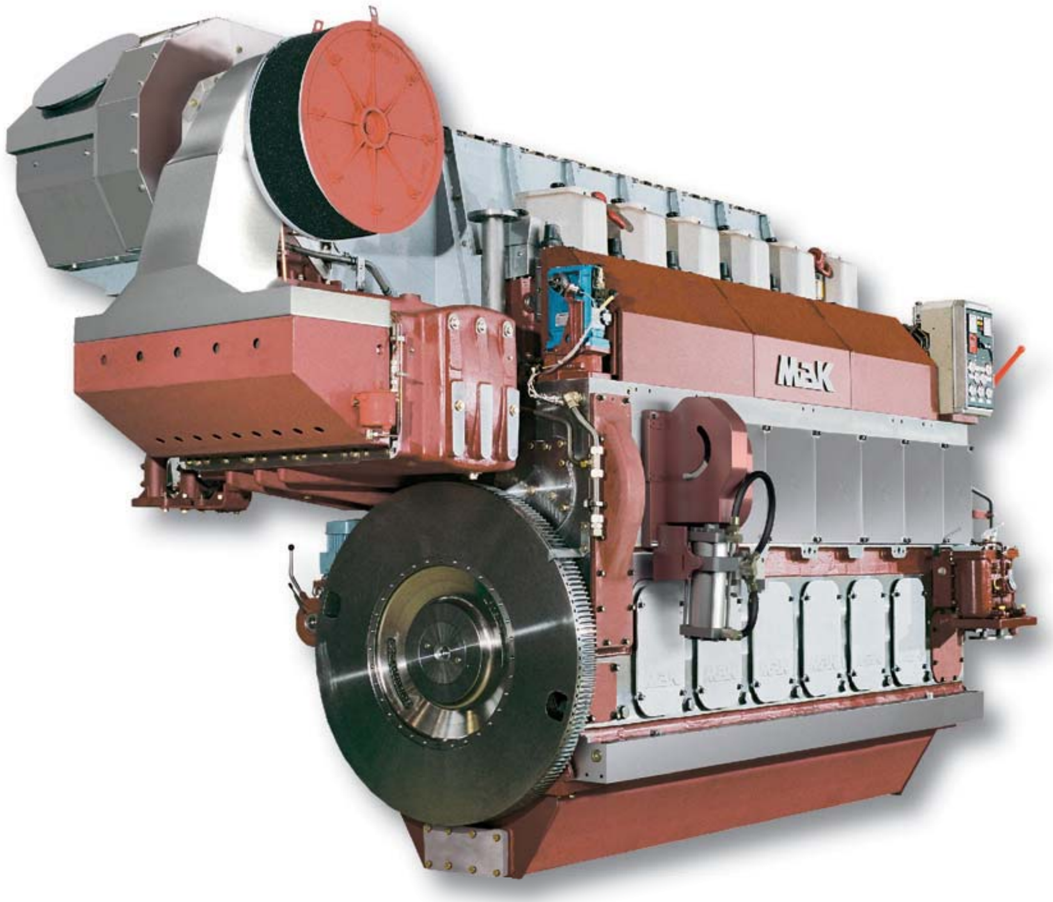
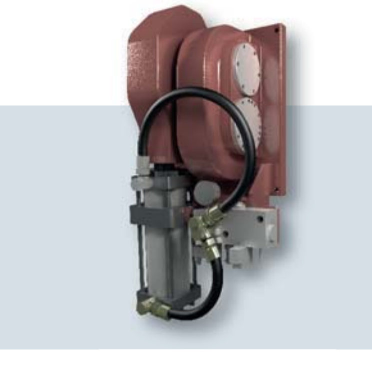
M 25 C

Low Emission Engine





CATERPILLAR®

M 25 C ▶ Low Emission Engine

IMO II in sight – First MaK Low Emission Engine already in operation

Back in 2000, Caterpillar Motoren identified three emission levels for the MaK marine product in order to cope with short to midterm emission regulations. These were a base line IMO engine, which fulfils MARPOL 73/78, Annex VI, an IMO-compliant engine with invisible smoke emissions and a Low Emission Engine (LEE) which meets the expected NO_x emission range of IMO II and is also invisible in smoke. In addition, this strategy favours inside-the-engine means because of their clear advantage with respect to cost, complexity and maintenance.

■ LEE for low NO_x

The key issue for low NO_x emissions is to increase the compression ratio of the base engine. Ten years ago, a compression ratio of 11–12 was standard, for IMO I the ratio was raised to 14–15 and for IMO II ratios of 17 will be needed. Another cornerstone of the MaK LEE concept is the Miller Cycle, i. e. modification of the engine's valve timing to achieve cooler combustion. For IMO I only a small Miller effect of 5% was utilised, however, IMO II requires a Miller effect of 20%. This is a big challenge for the turbo charger, which has to provide boost ratios of 5 in order to maintain today's Mean Effective Pressure (BMEP) values.

By combining increased compression ratio and the Miller effect, NO_x emissions can be reduced by around 30% without sacrificing engine efficiency (BSFC). However, such a simple LEE engine would suffer from poor load pick-up at idle and visible soot emissions at part load. Because of this, the MaK LEE concept uses a "flexible camshaft" to enable both low NO_x emissions, excellent load pick up and invisible soot at all loads.

■ A win-win situation for operators and the environment

All existing MaK M 20 C, M 25 C, M 32 C and M 43 C series marine engines afloat can be converted to MaK LEE. Building upon proven technology residing inside the engine, MaK LEE bears many advantages for vessel owners and operators.

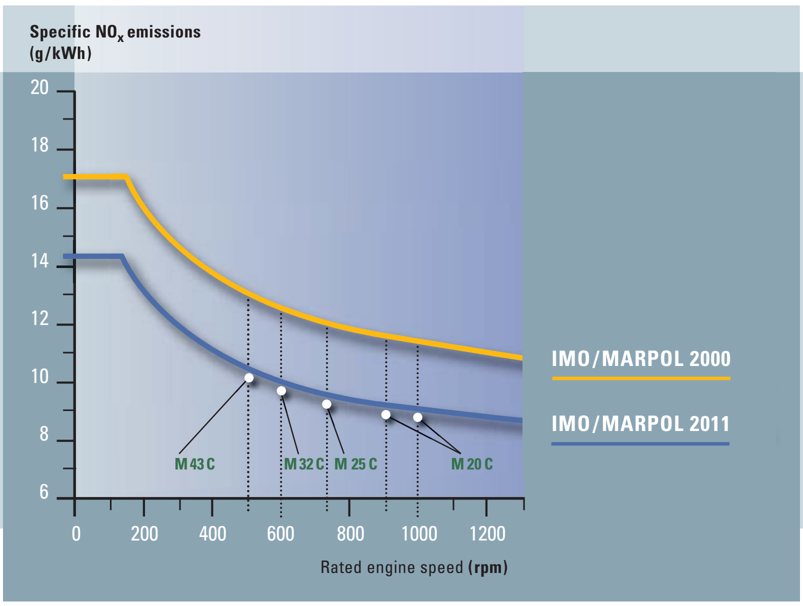
MaK LEE today already provides a power plant complying with expected future IMO emission regulations. This allows shipping companies to increase their reputation for environmental-friendly marine business operations. In addition, the emission levels achieved with MaK LEE enable shipping companies to obtain so-called environmental classes with Marine Classification Societies, such as DNV Clean Design, GL Green Passport, LR Character N or the German Government's Blauer Engel. These environmental classes not only add to the vessel owner's image but also reduce harbour fees in some parts of the world.

■ As from 1. 1. 2011 IMO II will become effective

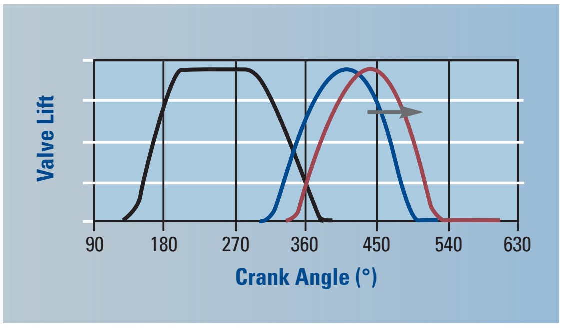
Already today Caterpillar is well prepared to meet these technological requirements. We are currently sucessfully testing engines that meet IMO II emission requirements. The following components have been changed:

– Turbocharging system
– injection system
– combustion chambers
– camshaft
– FCT system

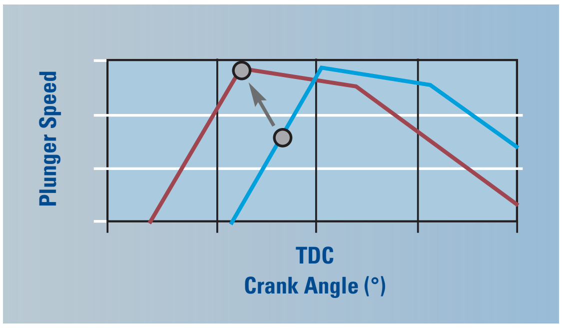
The FCT system is the major building block of the LEE engine concept.



M 25 C ▶ FCT

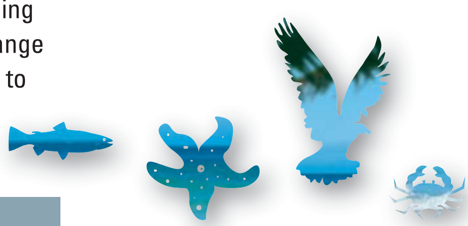


Flex Cam Technology FCT (schematic diagram)



Flex Cam Technology

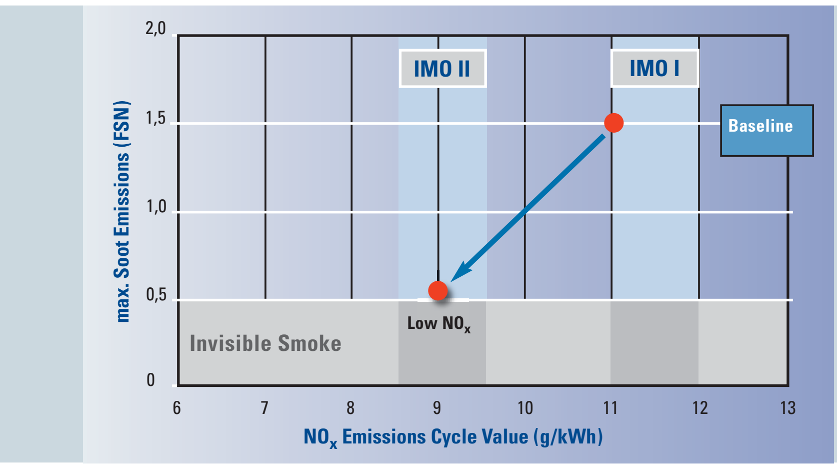
Building upon the Emission Reduction System integration concept, FCT achieves synergy between flexible fuel systems and advanced air systems with maximum utilization of the current engine design. While maintaining high fuel injection pressure over the whole operating range, fuel injection and inlet valve 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.

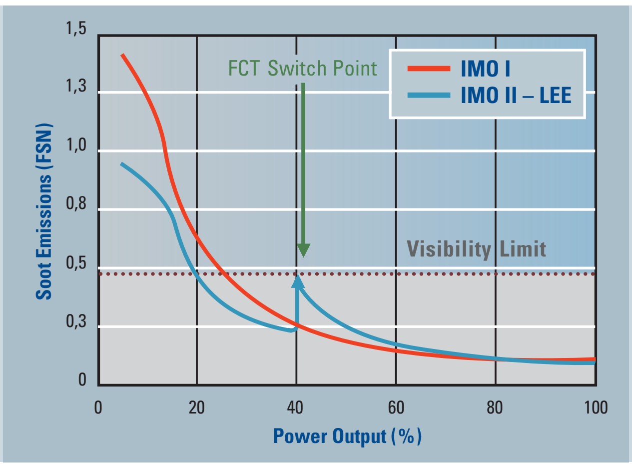


Customer value sequence and benefits

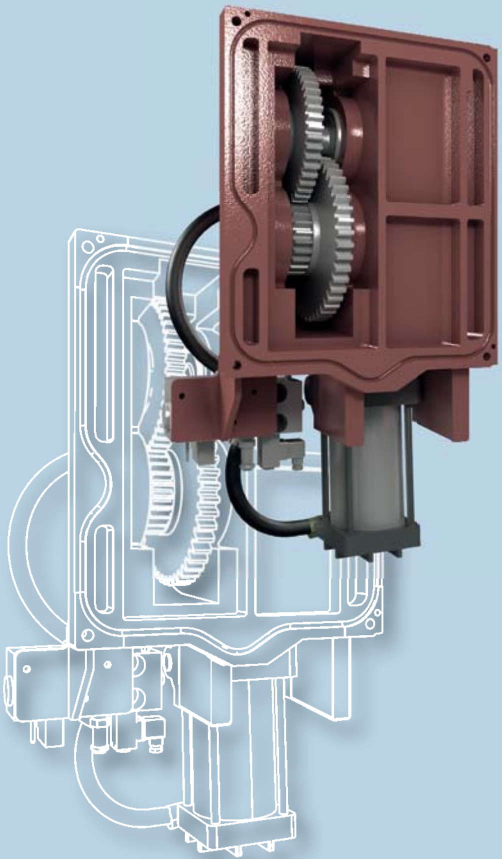
Flex Cam Technology (FCT)

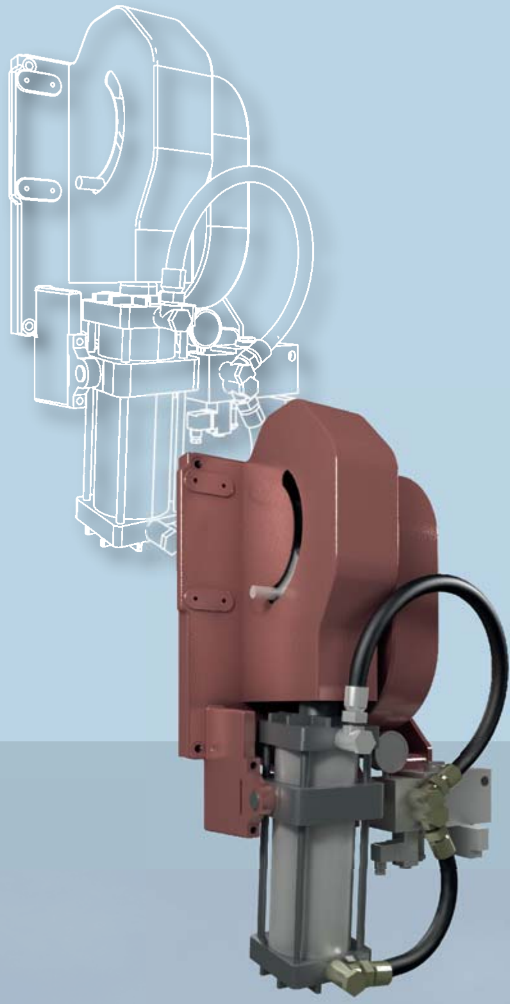
- High potential for NO_x and smoke reduction.
- Hardware changes to prepare for IMO II – sustainable investment.
- Low complexity
- Technically lower risk – application of existing technology.



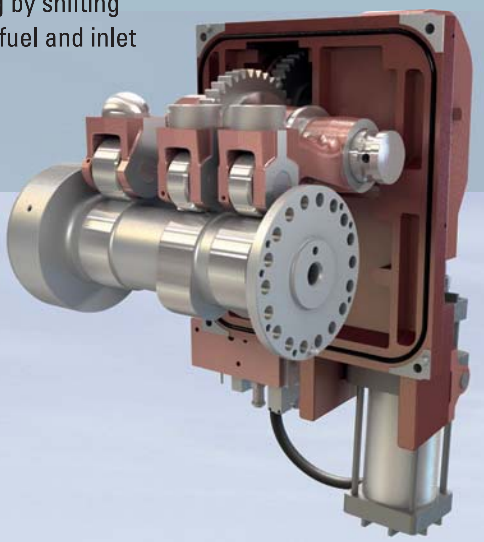


schematic diagram

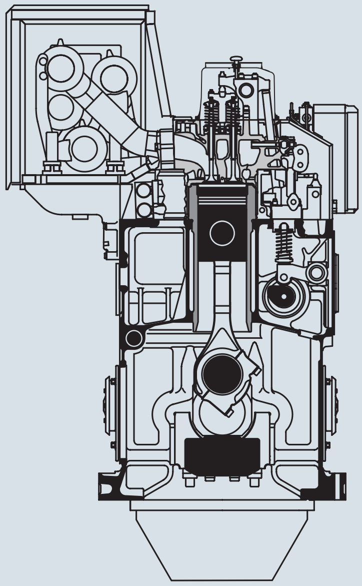




Pneumatical actuating unit for adjusting injection- and valve timing by shifting relative lever positions to fuel and inlet cams.



M 25 C – Low Emission Engine ▶ Engine Description (Preliminary)

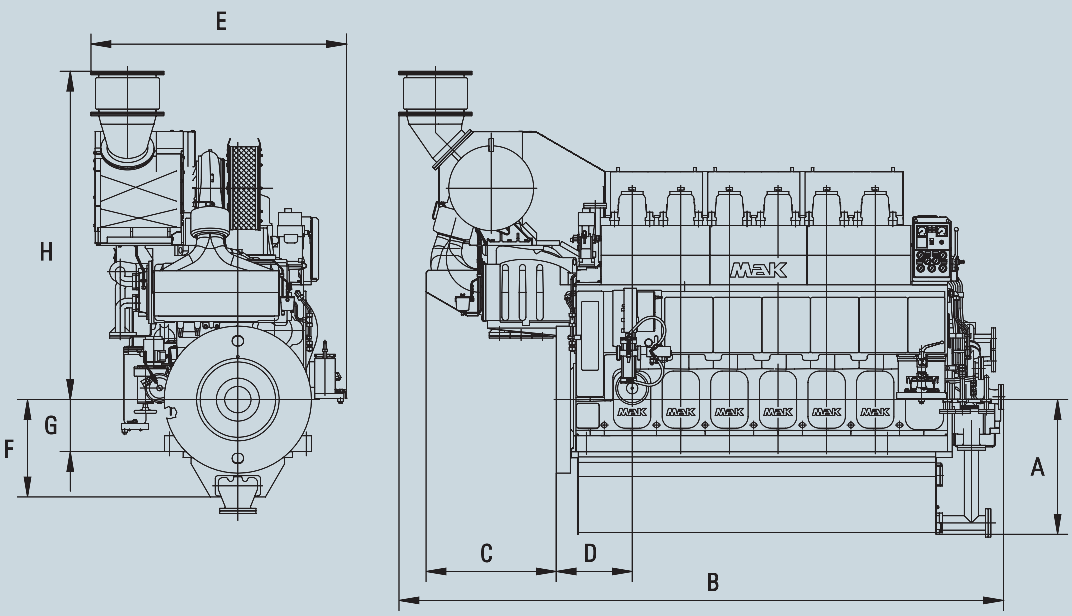


Number of cylinders	in-line	6, 8, 9			
Bore	mm	255			
Stroke	mm	400			
Cylinder rating	kW	300	308	317	333
Speed	rpm	720	750	720	750
Mean piston speed	m/s	9.6	10.0	9.6	10.0
BME	bar	24.5	23.5/24.2	23.7/25.8	26.1
Engine rating:		**kW**	**kW**	**kW**	**kW**
	6 M 25 C	1,800	1,850	1,900	2,000
	8 M 25 C	2,320	2,400	2,540	2,660
	9 M 25 C	2,610	2,700	2,850	3,000
Specific fuel oil consumption (g/kWh) tolerance 5 %**	**MCR 100%**	183	183	184	184
DNV Clean Design		185	185	186	186
Specific lub oil consumption:		0.6 g/kWh, tol. ± 0.3 g/kWh			
The engine fulfills MARPOL 73/78 Annex VI regulations.					

* Generator efficiency: 0.95, cos φ: 0.8 ** LCV = 42700 kJ/kg, without engine driven pumps

Swept volume: 20.4 l/cyl.
Output/cyl.: 317 – 333 kW
BMEP: 25.8 bar

Revolutions: 720/750 rpm
Turbocharging: pulse pressure
Direction of rotation: clockwise, option: counter-clockwise



Dimensions (mm) and Weights (t)									
Engine	A	B	C	D	E	F	G	H	t
6 M 25 C	1191	5345	1151	672	2260	861	460	2906	21.0
8 M 25 C	1191	6289	1151	672	2315	861	460	3052	28.0
9 M 25 C	1191	6719	1151	672	2315	861	460	3052	29.6

Engine centre distance 6 M 25 C 2,600 mm
(2 engines side by side): 8, 9 M 25 C 2,700 mm

Removal of
Piston in transverse direction X 1 = 2,420 mm
in longitudinal direction X 2 = 3,000 mm

of **cylinder** liner in transverse direction 2,510 mm
in longitudinal direction 2,735 mm

Nozzle position: ask for availability
This engine is only available with dry oil sump
Engine with turbocharger at free end available, ask for dimensions

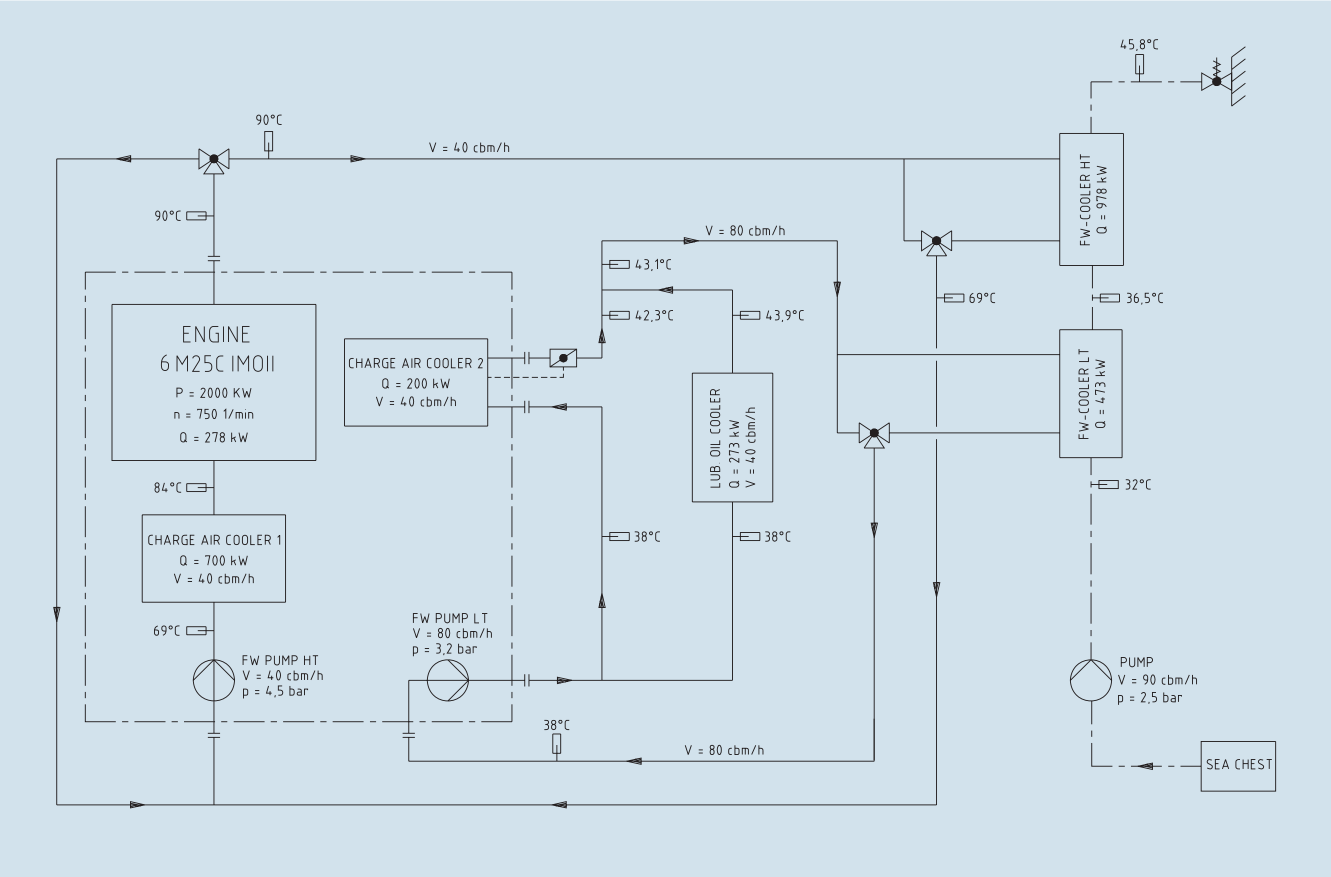
M 25 C – Low Emission Engine ▶ Technical Data (Preliminary)

	Cylinder	6		8		9	
Performance data							
Maximum continous rating acc. ISO 3046/1	kW	1900	2000	2534	2640	2850	3000
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	25.9	25.8	25.8	25.8	25.9
Charge air pressure	bar	3.1	3.2	3.0	3.2	3.2	3.2
Firing pressure	bar	205	210	205	210	205	210
Combustion air demand (ta = 20 °C)	m^3/h	10475	11290	13650	14600	15570	15835
Specific fuel oil consumption							
n = const [1] 100 %	g/kWh	184	184	184	184	184	184
85 %	g/kWh	182/183	182/183	182/183	182/183	182/183	182/183
75 %	g/kWh	180/185	180/185	180/185	180/185	180/185	180/185
50 %	g/kWh	187/193	187/193	187/193	187/193	187/193	187/193
Lubricating oil consumption [2]	g/kWh	0.6	0.6	0.6	0.6	0.6	0.6
NO_x emission [3]	g/kWh	9	9	9	9	9	9
Turbocharger type		KBB ST6	KBB ST6	KBB ST6	KBB ST6	KBB ST6	KBB ST6
Fuel							
Engine driven booster pump	m^3/h/bar	1.5/3	1.5/3	1.5/3	1.5/3	1.5/3	1.5/3
Stand-by booster pump	m^3/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	0.025	0.025	0.025
Mesh size HFO automatic filter	mm	0.010	0.010	0.010	0.010	0.010	0.010
Mesh size HFO fine filter	mm	0.034	0.034	0.034	0.034	0.034	0.034
Nozzle cooling by lubricating oil system							
Lubricating Oil							
Engine driven pump	m^3/h/bar	89/10	93/10	89/10	93/10	89/10	93/10
Independent pump	m^3/h/bar	45/10	45/10	60/10	60/10	60/10	60/10
Working pressure on engine inlet	bar	4 - 5	4 - 5	4 - 5	4 - 5	4 - 5	4 - 5
Engine driven suction pump	m^3/h/bar	-	-	-	-	-	-
Independent suction pump	m^3/h/bar	57/3	57/3	70/3	70/3	70/3	70/3
Priming pump pressure/suck pump	m^3/h/bar	6.6/8/5	6.6/8/5	10/13/5	10/13/5	10/13/5	10/13/5
Sump tank content/dry sump content	m^3	2.6	2.7	3.4	3.6	3.9	4.0
Temperature at engine inlet	°C	60 - 65	60 - 65	60 - 65	60 - 65	60 - 65	60 - 65
Temperature controller NB	mm	80	80	100	100	100	100
Double filter NB	mm	80	80	80	80	80	80
Mesh size double filter	mm	0.08	0.08	0.08	0.08	0.08	0.08
Mesh size automatic filter	mm	0.03	0.03	0.03	0.03	0.03	0.03

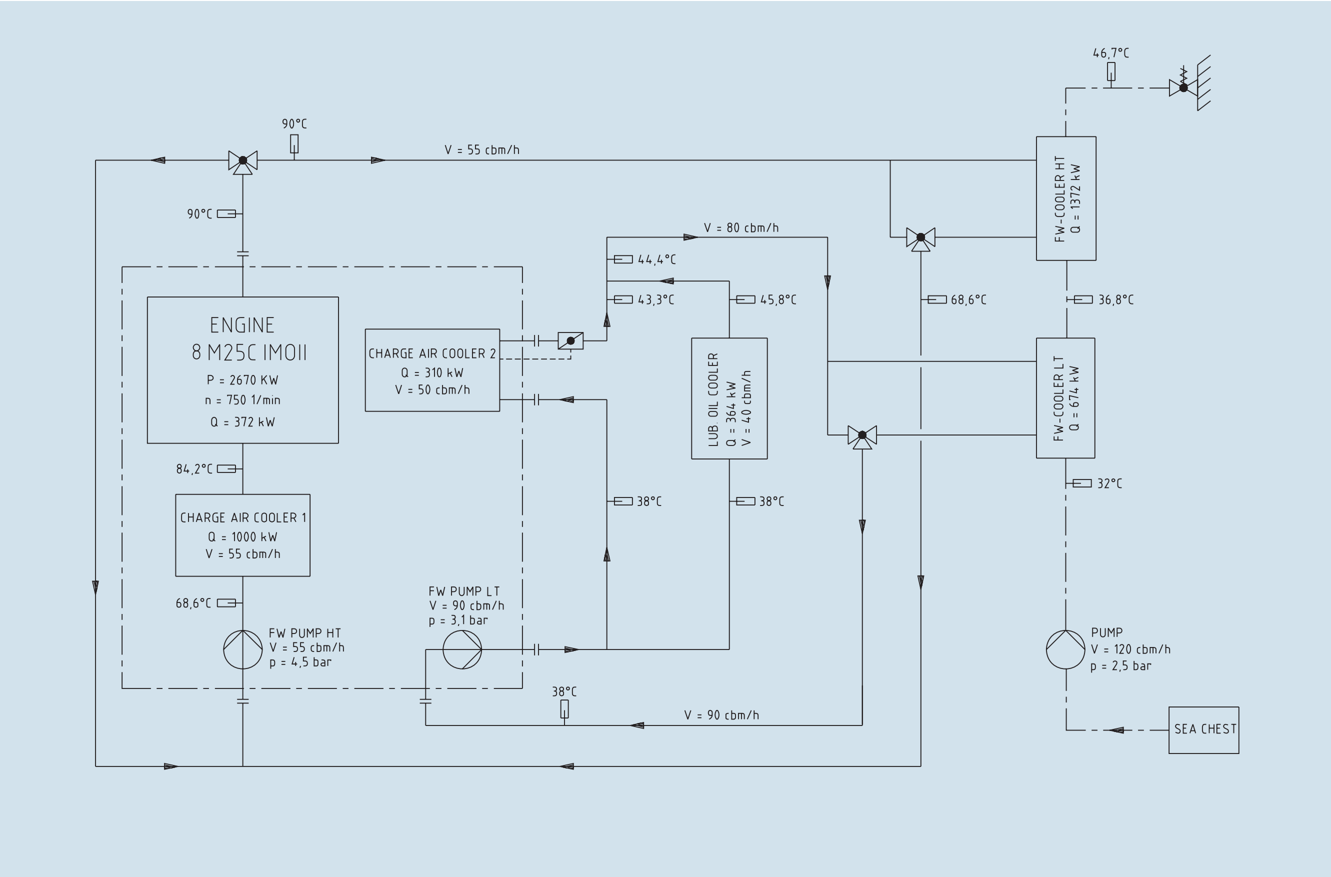
	Cylinder	6		8		9	
Fresh water cooling							
Engine content	m^3	0.4	0.4	0.5	0.5	0.6	0.6
Pressure at engine inlet min/max	bar	4.5/6.0	4.5/6.0	4.5/6.0	4.5/6.0	4.5/6.0	4.5/6.0
Header tank capacity	m^3	0.2	0.2	0.25	0.25	0.3	0.3
Temperature at engine outlet	°C	80 - 90	80 - 90	80 - 90	80 - 90	80 - 90	80 - 90
Two circuit system							
Engine driven pump HT	m^3/h/bar	40/4.5	40/4.5	55/4.5	55/4.5	60/4.7	60/4.7
Independent pump HT	m^3/h/bar	40/4.0	40/4.0	55/4.0	55/4.0	60/4.0	60/4.0
HT-Controller NB	mm	80	80	100	100	100	100
Water demand LT-charge air cooler	m^3/h/bar	40/4.5	40/4.5	45/4.5	45/4.5	50/4.5	50/4.5
Temperature at LT-charge air cooler inlet	°C	38	38	38	38	38	38
Heat Dissipation							
Specific jacket water heat	kJ/kW	500	500	500	500	500	500
Specific lub oil heat	kJ/kW	490	490	490	490	490	490
Lub oil cooler	kW	259	273	345	359	388	410
Jacket water	kW	264	278	352	367	396	417
Charge air cooler (HT-Stage) [4)]	kW	664	700	858	919	992	1034
Charge air cooler (LT-Stage) [4)]	kW	190	200	248	259	280	298
(HT-Stage before engine)							
Heat radiation engine	kW	85	85	113	113	128	128
Exhaust							
Silencer/spark arrester NB 25 dBA	mm	500/500	500/500	600/600	600/600	600/600	600/600
Pipe diameter NB after turbine	mm	500	500	600	600	600	600
Maximum exhaust gas pressure drop	bar	0.03	0.03	0.03	0.03	0.03	0.03
Exhaust gas temperature after turbine (intake air 25°C) [5)]	°C	310	310	337	337	341	341
Exhaust gas mass flow (intake air 25 °C) [5)]	kg/h	12950	13955	16870	18050	19250	19575
Starting air							
Starting air pressure max.	bar	30	30	30	30	30	30
Minimum starting air pressure	bar	7	7	7	7	7	7
Air consumption per start [6)]	Nm^3	0.8	0.8	0.8	0.8	0.8	0.8

1) Reference conditions: LCV = 42700 kJ/kg, ambient temperature 25 °C
charge air coolant temperature 25 °C, tolerance 5 %, + 1 % for engine driven pump
2) Standard value based on rated output, tolerance ± 0.3 g/kWh
3) MARPOL 73/78, annex VI, cycle E2, E3, D2
4) Charge air heat based on 45 °C ambient temperature
5) Tolerance 10 %, rel. humidity 60 %
6) Preheated engine

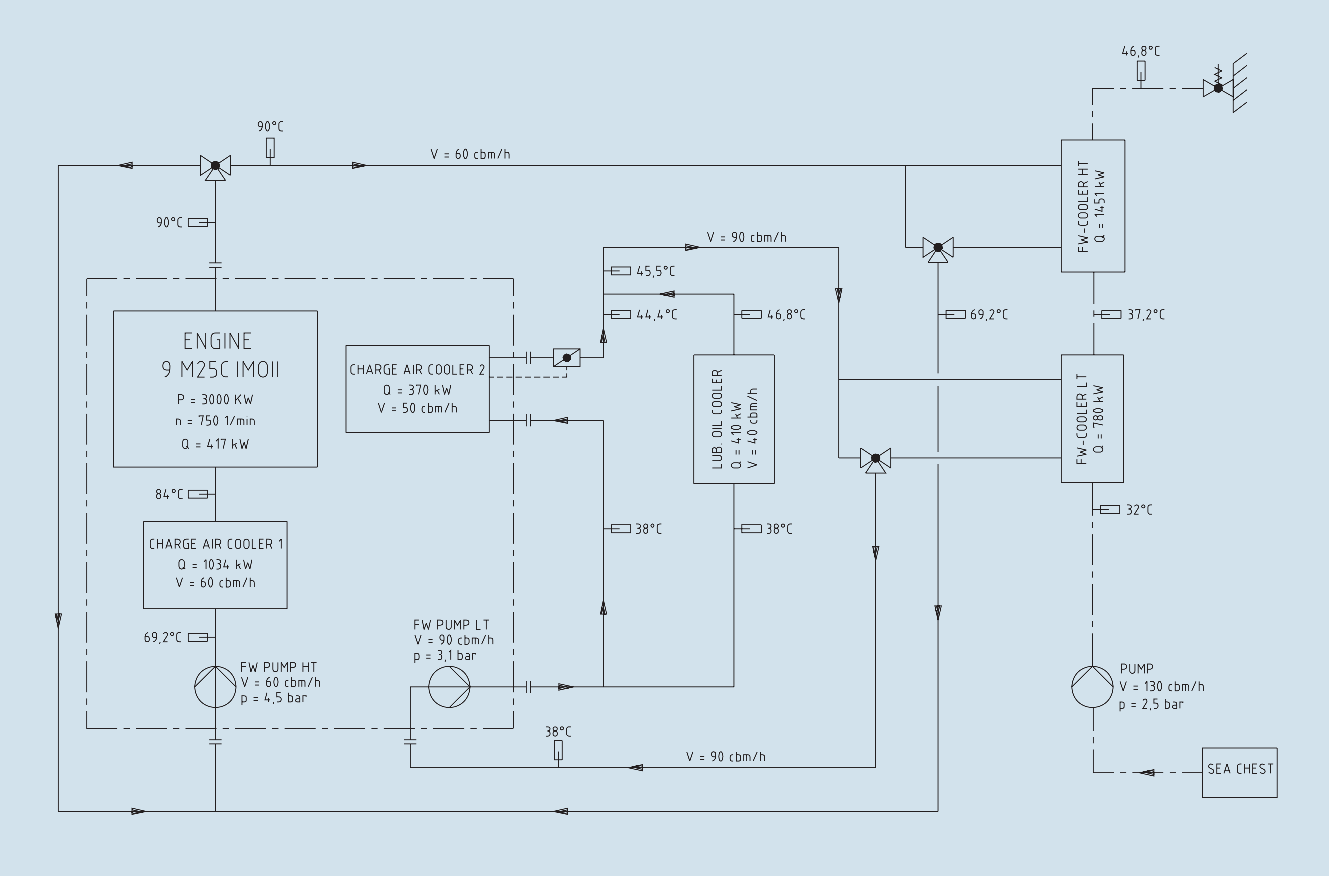
6 M 25 C


45,8°C
90°C
V = 40 cbm/h
FW-COOLER HT
Q = 978 kW
90°C
V = 80 cbm/h
43,1°C
69°C
36,5°C
42,3°C
43,9°C
ENGINE
6 M25C IMOII
P = 2000 KW
n = 750 1/min
Q = 278 kW
CHARGE AIR COOLER 2
Q = 200 kW
V = 40 cbm/h
LUB OIL COOLER
Q = 273 kW
V = 40 cbm/h
FW-COOLER LT
Q = 473 kW
84°C
32°C
CHARGE AIR COOLER 1
Q = 700 kW
V = 40 cbm/h
38°C
38°C
69°C
FW PUMP LT
V = 80 cbm/h
p = 3,2 bar
FW PUMP HT
V = 40 cbm/h
p = 4,5 bar
PUMP
V = 90 cbm/h
p = 2,5 bar
38°C
V = 80 cbm/h
SEA CHEST

8 M 25 C


46,7°C
90°C
V = 55 cbm/h
FW-COOLER HT
Q = 1372 kW
90°C
V = 80 cbm/h
44,4°C
43,3°C
45,8°C
68,6°C
36,8°C
ENGINE
8 M25C IMOII
P = 2670 KW
n = 750 1/min
Q = 372 kW
CHARGE AIR COOLER 2
Q = 310 kW
V = 50 cbm/h
LUB OIL COOLER
Q = 364 kW
V = 40 cbm/h
FW-COOLER LT
Q = 674 kW
84,2°C
32°C
38°C
38°C
CHARGE AIR COOLER 1
Q = 1000 kW
V = 55 cbm/h
68,6°C
FW PUMP LT
V = 90 cbm/h
p = 3,1 bar
FW PUMP HT
V = 55 cbm/h
p = 4,5 bar
PUMP
V = 120 cbm/h
p = 2,5 bar
38°C
V = 90 cbm/h
SEA CHEST

9 M 25 C



46,8°C
90°C
V = 60 cbm/h
90°C
V = 90 cbm/h
FW-COOLER HT
Q = 1451 kW
45,5°C
44,4°C
46,8°C
69,2°C
37,2°C
ENGINE
9 M25C IMOII
P = 3000 KW
n = 750 1/min
Q = 417 kW
CHARGE AIR COOLER 2
Q = 370 kW
V = 50 cbm/h
LUB OIL COOLER
Q = 410 kW
V = 40 cbm/h
FW-COOLER LT
Q = 780 kW
84°C
32°C
CHARGE AIR COOLER 1
Q = 1034 kW
V = 60 cbm/h
38°C
38°C
69,2°C
FW PUMP LT
V = 90 cbm/h
p = 3,1 bar
FW PUMP HT
V = 60 cbm/h
p = 4,5 bar
PUMP
V = 130 cbm/h
p = 2,5 bar
38°C
V = 90 cbm/h
SEA CHEST

One Strong Line of World-Class Diesel Engines

Perfect Solutions for Main Propulsion and On-Board Power Supply

The Program: Quality is our Motto
For more than 80 years we have developed, built, supplied and serviced diesel engines – worldwide. Today Caterpillar Marine with its brands Cat and MaK offer high-speed and medium-speed engines with power ratings from 10 kW to 16,000 kW. Many different engine families are available to meet your specific application needs.

Cat and MaK diesel engines are distinguished by high reliability, extremely low operational costs, simple installation and maintenance and compliance with IMO environmental regulations.

The application of engines in main and auxiliary marine power systems varies greatly and extends from high-speed boats and yachts, through tugs, trawlers and offshore vessels to freighters, ferries and cruise liners.

Caterpillar Marine Power Systems

Sales and Service Organization

Caterpillar has combined the sales and service activities and responsibility of their Cat and MaK brand marine engine business into Caterpillar Marine Power Systems with headquarters in Hamburg/Germany.

In setting-up this worldwide structure, we have concentrated on integrating the Cat and MaK brand groups into a single, united marine team, which utilises the particular expertise of each group.

Commercial marine engine business is split into three geographic regions,
– Europe, Africa, Middle East
– Americas
– Asia-Pacific,

■ **Medium-Speed Engines**

● **M 20 C**
6, 8, 9 cylinder
1,020 – 1,710 kW

● **M 25 C**
6, 8, 9 cylinder
1,800 – 3,000 kW

● **M 32 C**
6, 8, 9 cylinder
2,880 – 4,500 kW

Main Propulsion Engines

Caterpillar Marine Power Systems

Production Facilities

which manage all sales and product support activities. They have direct responsibility for achieving the ambitious growth targets set for the Cat and MaK brands and for providing our customers and dealers with complete marine solutions.

Caterpillar's global dealer network provides a key competitive edge – customers deal with people they know and trust.

Cat dealers strive to form a strong working relationship with their customers, offering comprehensive and competent advice from project support to repair work.

Some of the most advanced manufacturing concepts are used at Caterpillar locations throughout the world to produce engines in which reliability, economy and performance are second-to-none.

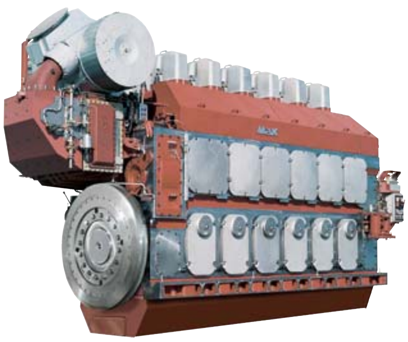
From the production of core components to the assembly of complete engines, quality is always the top priority.

Comprehensive, recognized analysis systems, test procedures and measuring methods ensure that quality requirements are met throughout all the individual manufacturing phases. All of our production facilities are certified under 1:2000 ISO 9001 EN, the international benchmark that is helping to set new quality standards worldwide.

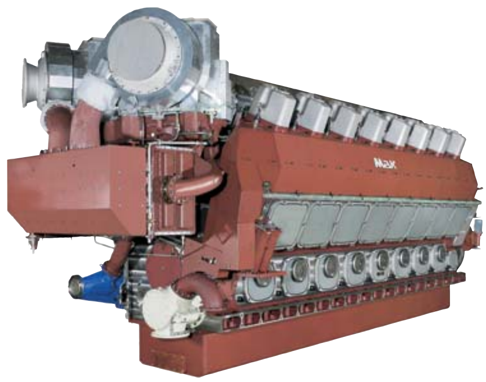
In addition to product quality, our customers expect comprehensive service which includes the supply of spare parts throughout the life of the engine.

Caterpillar Logistics Services, Inc., located in Morton, Illinois, is the largest parts distribution facility within the Cat Logistics network and is also the headquarters for all the worldwide distribution centres. Morton utilises sophisticated material handling, storage and retrieval systems to support Caterpillar's customer service goals.

VM 32 C
12, 16 cylinder
5,760 – 8,000 kW



M 43 C
6, 7, 8, 9 cylinder
5,400 – 9,000 kW



VM 43 C
12, 16 cylinder
10,800 – 16,000 kW

MaK LEE will soon be part of all MaK engines!

Caterpillar Marine Power Systems

Headquarters

Caterpillar Marine Power Systems
Neumühlen 9
22763 Hamburg/Germany

Phone: +49 40 2380-3000
Telefax: +49 40 2380-3535

Europe, Africa, Middle East

Caterpillar Marine Power Systems
Neumühlen 9
22763 Hamburg/Germany

Phone: +49 40 2380-3000
Telefax: +49 40 2380-3535

Americas

MaK Americas Inc.

3450 Executive Way
Miramar Park of Commerce
Miramar, FL. 33025/USA
Phone: +1 954 885 3200
Telefax: +1 954 885 3131

Asia Pacific

Caterpillar Marine Trading (Shanghai) Co., Ltd.
25/F, Caterpillar Marine Center
1319, Yan'an West Road
200050 Shanghai/P. R. China
Phone: +86 21 6226 2200
Telefax: +86 21 6226 4500

Caterpillar Marine Asia Pacific Pte Ltd
14 Tractor Road
Singapore 627973/
Singapore
Phone: +65 68287-600
Telefax: +65 68287-624

For more information please visit our website:
MARINE.CAT.COM

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MaK

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