M 32 C

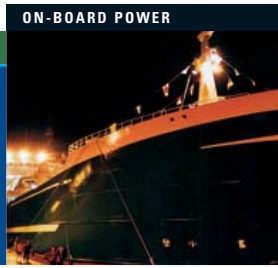
MAK

Long-Stroke Diesel Engine with Maximum Efficiency and Reliability

6 • 8 • 9
In-line Engines

12 • 16
V-Type Engines


MARINE PROPULSION


ON-BOARD POWER

M 32 C

6, 8, 9, 12, 16

The acceptance of the M 32 C long-stroke engine series in the marine industry is a success story whose equal is hard to find in this power class.

Since its introduction in 1994, more than 1300 engines have been sold.

80% of those commissioned are marine propulsion engines and 20% are in electrical generator sets.

The M 32 C series is a genuine heavy fuel engine and 75% of all engines commissioned burn the economical heavy fuel oil.

The M 32 C long-stroke series, with a bore of 320 mm, has continued the market success of its predecessor in this bore size, the M 453 C.

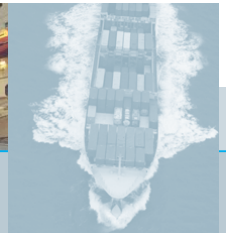
Decisive factors in its development have been the requirements for maximum benefit to the customer, i. e. economy and operational reliability. Environmental aspects however have also been important.

Operational results have fully confirmed the design objectives.

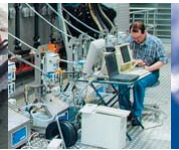
Further development, which led to the M 32 C version with 500 kW, has provided even more benefits to the customer.

MARINE PROPULSION

ON-BOARD POWER



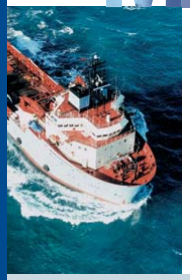
Wide Range of Applications



M 32 C

Wherever you operate:
Propulsion excellence with M 32 C

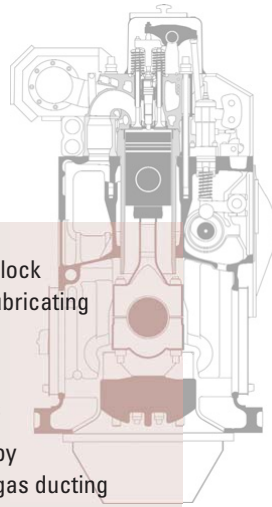
Marine Propulsion



On-board power of excellence:
M 32 C – the dependable solution.

On-Board Power

M 32 C



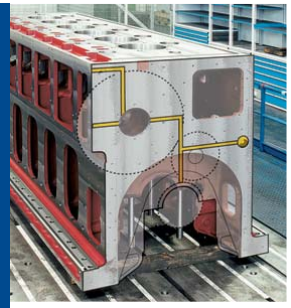
Customer Benefits

- Nodular cast-iron engine block with integrated ducts for lubricating oil and charge air
- Cooling water system with simple plug-in connections
- Simplified parts spectrum by using single-pipe exhaust gas ducting
- Pulse charging system, available as an option, for all in-line engine variants
- High-efficiency turbocharger
- Engine control terminal with analog instrumentation in robust cast casing
- Segmental camshaft design
- Compact cylinder head design
- Cylinder liner, only cooled outside the engine block
- Installation-friendly, due to pumps and filters installed on the engine
- Connecting rod, split off design
- Compact module for lower valve drives and injection pump drives with cam followers
- Emission reduction technology
- Flexible Camshaft Technology (FCT)
- Caterpillar Common Rail fuel system

Innovation: Even More Benefits for the Customer

M 32 C

6, 8, 9, 12, 16

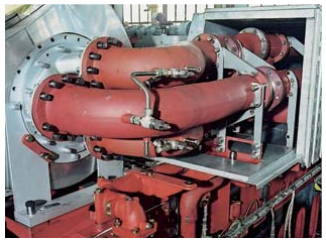


Nodular cast iron engine block and crankcase with integrated ducts for lubricating oil and charge air

- Lubricating oil supply to the crankshaft, camshaft control system and camshaft bearings through drilled ducts
- No piping
- No cooling water in the engine block
- Easy maintenance
- High level of operational safety

Simplified parts spectrum by using single-pipe exhaust gas ducting

- Identical cylinder parts
- Reduced component complexity
- Simple assembly/dismantling
- Low weight, low installation volume and low vibration level



Pulse charging system, available as an option, for all in-line engine variants

- Advantages in marine propulsion systems subject to frequent changes of load
- Optimum engine acceleration without special control system arrangements

Cooling water system with simple plug-in connections

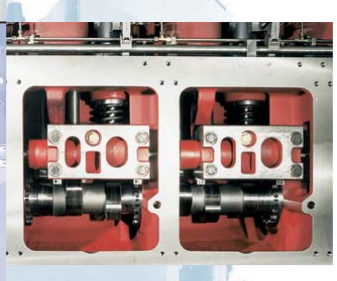
- Plug-in connections for the cooling water pipes with standard closure fittings
- Easy to fit, very maintenance-friendly
- Identical parts for each cylinder version
- Reduced number of components/parts
- Increased operational safety

High-efficiency turbocharger

- Moderate temperature level of components surrounding the combustion chamber
- Corrosion-free turbocharger casing without water cooling

Engine control terminal with analog instrumentation in robust cast casing

- Securely mounted with vibration damping on the crankcase
- Direct and reliable display of all operating media pressures by robust pressure gauges
- Engine and turbocharger speed display by vibration-protected analog instruments



Segmental camshaft design

- Individual segments per cylinder
- Simple to assemble and dismantle

Compact cylinder head design

- Long intervals between overhauls
- Simple and fast assembly/dismantling because of:
  – plug-in connections
  – integrated bores
  – self-centering

Cylinder liner, only cooled outside the engine block

- Low wear rate due to calibration ring
- Low and constant lubricating oil consumption
- Long life

Installation-friendly, because of pumps and filters installed on the engine

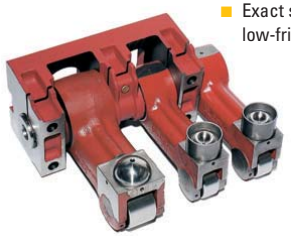
- Replaces duplex filter and separate automatic filters
- Pumps and filters operate without any external power
- Reduces the parts requirements

Connecting rod, split off design

- High level of operational safety, the result of accurately preloaded bolts

Compact module for lower valve drives and injection pump drives with cam followers

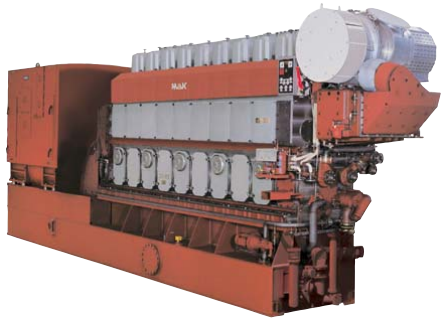
- Exact straight-line guidance for low-friction and low-wear operation

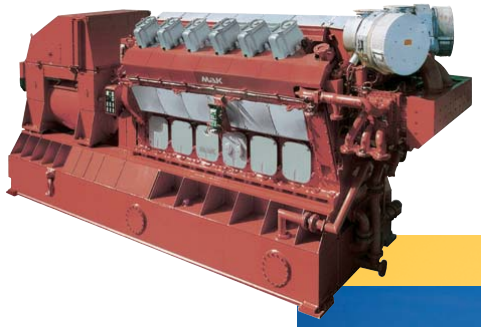


Intelligent Simplicity Reduces Operating Costs and Installation Complexity

M 32 C – On-Board Electricity

M 32 C





M 32 C as a generator drive

The M 32 C was introduced in 1994 in 6, 8 and 9 cylinder versions and is outstandingly suitable as generator prime mover for electric power on ships. The robust design and moderate speed permits unlimited, continuous operation with heavy fuel oil. In-line engines – complete with generators – are mounted on a common base frame. Engine and electrics are tested prior to delivery. This ensures trouble-free installation and commissioning.

Economical operation with diesel-electric propulsion

Our engineers have extensive experience in the design of diesel-electric installations. This includes both pod propulsion systems and propulsion by fixed-pitch propellers driven by electric motors. The combination of up-to-date engine technology at the primary end of the propulsion train, and up-to-date diesel-electric technology at the secondary end, ensures low operation costs and better space utilization, which in turn means improved economy overall.

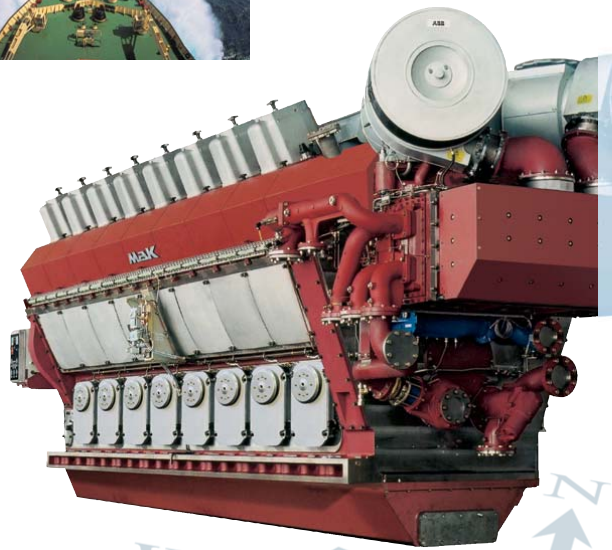
Reliable Energy

VM 32 C: Compact and Powerful!

VM 32 C

The M 32 C V-engine was introduced in 2000 in 12- and 16-cylinder versions. With a bore of 320 mm and a stroke of 420 mm, it covers a power range of 5,760 – 8,000 kW in the 720 and 750 rpm ranges. The engine is designed to meet not only the demands of the marine market but also those of the stationary electric power generation and petroleum industry markets.

The consistent application of MaK long-stroke engine design and development, along with the incorporation of as many in-line engine components as possible, is clearly and impressively demonstrated in the external configuration: – a compact, simple and clean design.
The modular construction of the engine, the integration of various functions into a single component, the robust design and the utilization of already proven, in-line engine components, form the basis for the wide availability range of this engine.
Reliable heavy fuel oil operation, low fuel and lubricating oil consumption, together with easy maintenance and long maintenance intervals, mean outstanding economical operation.



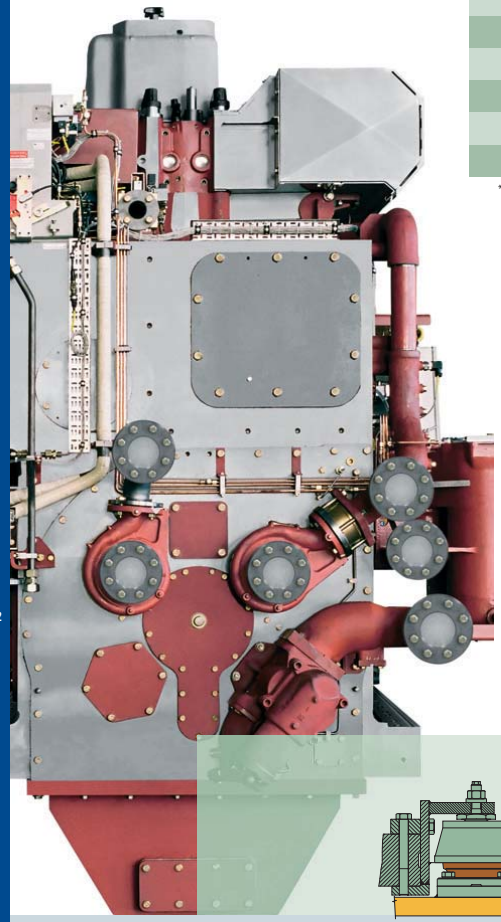
Compact Design

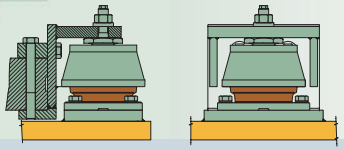
M 32 C

	TBO x 1000 h	Lifetime x 1000 h
Piston crown	30	90
Piston skirt	-	60
Piston rings	-	30
Cylinder liner	-	60 / 90*
Cylinder head	15	-
Inlet valve	15	30
Exhaust valve	15	30
Nozzle element	-	7,5
Pump element	-	15 / 20*
Main bearing	-	30
Big-end bearing	-	30

*MDO Operation

The above-mentioned data are not binding. They only serve as standard values. These standard values can be attained if the MaK operating and maintenance specifications are strictly observed and only MaK spare parts are used. Please consider as well the negative effect of bad fuel qualities.





Top plate

HFO/MDO
Anticipated TBO and life

Long maintenance intervals and extended life form the basis for low operating costs.

Complete engine

The engine is marketed with standardized pump and filter equipment. The interfaces for the fuel, lubricating oil and cooling water systems are located at the free end of the engine for ease of connection.

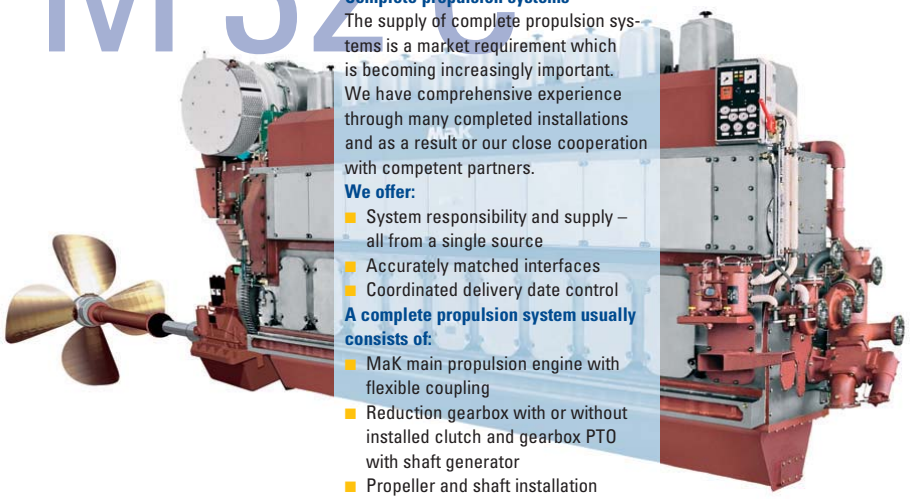
Lubricating oil system

Optional deep oil pan (wet sump).

Resilient foundation

The resilient foundation system can be assembled safely, simply and cheaply and ensures the damping of vibration and structure-borne noise.

M 32 C



Complete propulsion systems

The supply of complete propulsion systems is a market requirement which is becoming increasingly important. We have comprehensive experience through many completed installations and as a result or our close cooperation with competent partners.

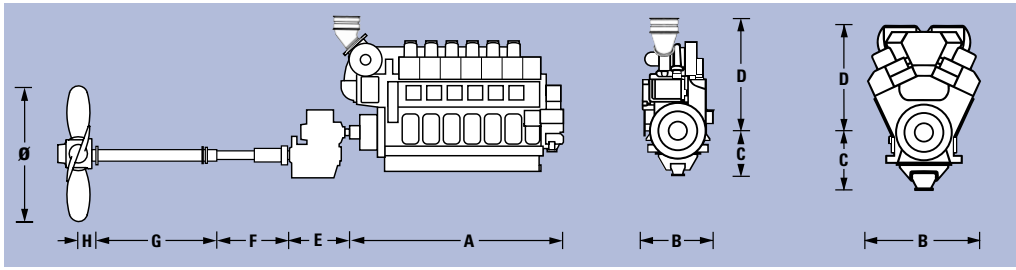
We offer:

- System responsibility and supply – all from a single source
- Accurately matched interfaces
- Coordinated delivery date control

A complete propulsion system usually consists of:

- MaK main propulsion engine with flexible coupling
- Reduction gearbox with or without installed clutch and gearbox PTO with shaft generator
- Propeller and shaft installation
- Matched remote control and monitoring equipment

Examples of complete propulsion systems

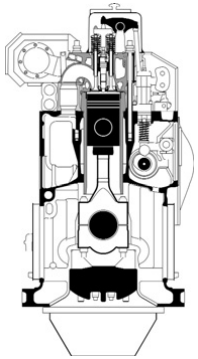


Engine							Gear	Shaft		Propeller		
Type	Rating	Speed										Speed
	kW	rpm	A	B	C	D	E	F	G	H	Ø	rpm
6 M 32 C	3,000	600	6,026	2,286	1,052	2,622	1,795	1,600	3,400	630	3,500	195
8 M 32 C	4,000	600	7,161	2,169	1,052	2,902	1,795	2,500	3,500	735	4,000	175
9 M 32 C	4,500	600	7,691	2,169	1,052	2,902	2,140	2,400	3,600	795	4,200	170
12 M 32 C	6,000	720/750	6,963	2,880	1,205	2,719	2,140	5,000	5,000	867	4,650	155
16 M 32 C	8,000	720/750	8,313	2,880	1,205	2,807	2,140	5,000	5,000	978	5,050	157

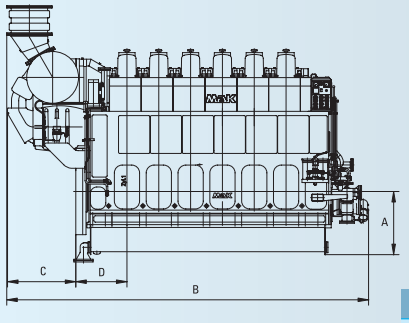
M 32 C – Technical Data • IN-LINE ENGINE

Number of cylinders	In-line	6, 8, 9	6, 8, 9
Bore	mm	320	320
Stroke	mm	480	480
Cylinder rating	kW	480	500
Rated speed	rpm	600	600
Mean piston speed	m/s	9.6	9.6
Mean effective pressure	bar	24.9	25.9
Cylinder pressure	bar	190	198
Engine power		**kW**	**kW**
	6 M 32 C	2880	3000
	8 M 32 C	3840	4000
	9 M 32 C	4320	4500
		60Hz/50Hz	**60Hz/50Hz**
Generator power*		kWe kVA	kWe kVA
	6 M 32 C	2765 3456	2880 3600
	8 M 32 C	3686 4608	3840 4800
	9 M 32 C	4147 5184	4320 5400
Specific fuel consumption at 100% power**	**6 M 32 C**	**g/kWh** 179	**g/kWh** 179
	8, 9 M 32 C	178	178
Specific lubricating oil consumption		0.6 g/kWh, ± 0.3 g/kWh	

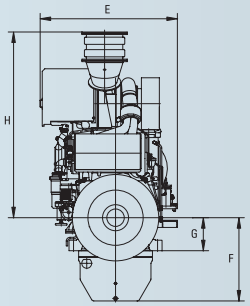
* Generator efficiency: 0.96, cos φ: 0.8 ** ISO conditions Hu = 42,700 kJ/kg, without installed pumps, tolerance 5%



M 32 C

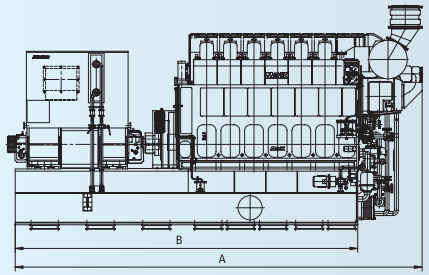


■ M 32 C In-Line Propulsion

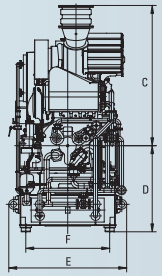


Propulsion Engine (Dimensions in mm)

Engine	A	B	C	D	E	F	G	H	t
6 M 32 C	1052	6026	1137	852	2286	1387	550	3094	37.5
8 M 32 C	1052	7161	1185	852	2169	1387	550	3446	46.4
9 M 32 C	1052	7691	1185	852	2169	1387	550	3446	49.4



■ M 32 C In-Line Generator Set



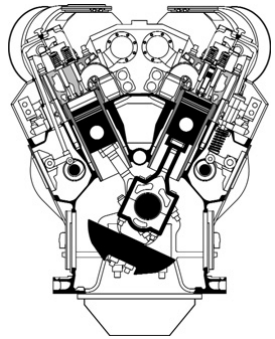
Generator Set, Complete (Dimensions in mm)

Engine	A	B	C	D	E	F	t
6 M 32 C	9112	7670	3094	1900	2600	1850	51.0
8 M 32 C	10601	9020	3446	1900	2600	1850	61.0
9 M 32 C	11131	9550	3446	1900	2600	1850	64.9

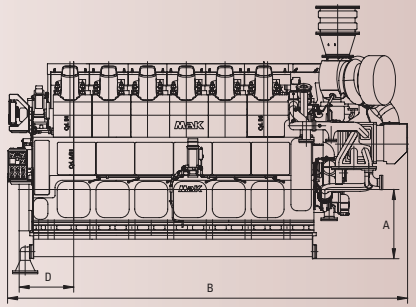
VM 32 C – Technical Data • V-TYPE ENGINE

Cylinder number	V-Version	12, 16	12, 16
Bore	mm	320	320
Stroke	mm	420	420
Cylinder rating	kW	480	500
Rated speed	rpm	720	750
Mean piston speed	m/s	10.1	10.5
Mean effective pressure	bar	23.7	23.7
Cylinder pressure	bar	190	190
Engine power		**kW**	**kW**
	12 M 32 C	5760	6000
	16 M 32 C	7680	8000
		60Hz	**50Hz**
Generator power*		kWe kVA	kWe kVA
	12 M 32 C	5530 6912	5760 7200
	16 M 32 C	7373 9216	7680 9600
Specific fuel consumption at 100% power**	**12, 16 M 32 C**	**g/kWh** 178	**g/kWh** 179
Specific lubricating oil consumption		0.6 g/kWh, ± 0.3 g/kWh	

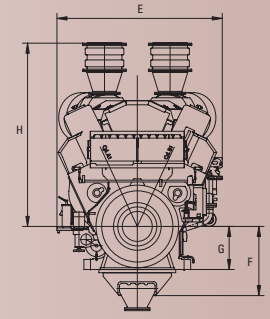
* Generator efficiency: 0.96, cos φ: 0.8 ** ISO conditions Hu = 42,700 kJ/kg, installed pumps, tolerance 5%



VM 32 C

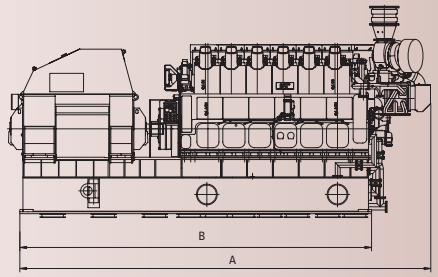


■ VM 32 C V-Type-Engine Propulsion

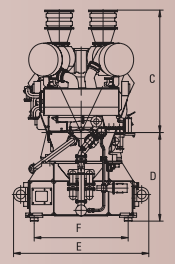


Propulsion Engine (Dimensions in mm)

Engine	A	B	D	E	F	G	H	t
12 M 32 C	1205	6963	949	2880	1205	750	3192	64.5
16 M 32 C	1205	8313	949	2880	1205	750	3281	81.6



■ M 32 C V-Type Generator Set

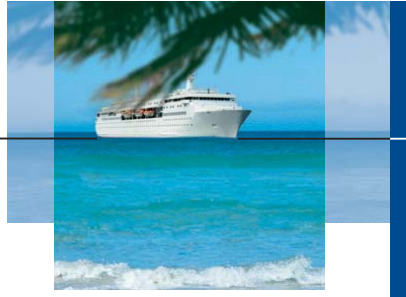


Generator Set, Complete (Dimensions in mm)

Engine	A	B	C	D	E	F	t
12 M 32 C	10703	9160	3193	2310	3526	2450	84.8
16 M 32 C	12060	10510	3356	2310	3526	2450	105.1

Technology for Emission Reduction in Medium- Speed MaK Marine Engines

M 32 C



In recent years, Caterpillar has made a huge investment in developing **Emission Reduction Technology**. Following the successful application to high-speed highway engines, Caterpillar is now embarking on the step-by-step transfer of selected elements of the ReductionTechnology into its entire Caterpillar product line and range of applications. The broad range of Caterpillar's marine program calls for a differentiated approach. The key criteria are:

- Compliance with current and future required emission limits for the respective power ranges.
- Customer expectations, in terms of engine performance, maintenance practices, fuel quality and mode of operation.

By adopting well proven elements of this technology for medium-speed engines, it is our goal to meet and exceed customer expectations by maximizing product value through:

- Superior reliability in heavy fuel oil operation.
- Best-in-class fuel efficiency.
- Lowest engine emissions with minimum additional complexity.

Customer value and benefits

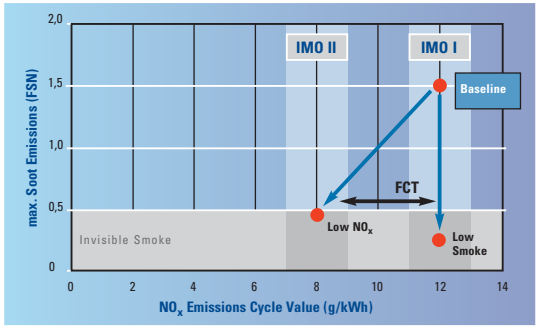
Flex Cam Technology (FCT)
- High potential for NO_x and smoke reduction.
- Hardware changes to prepare for IMO II – sustainable investment.
- Low complexity
- Technically lower risk – application of existing technology.

Flex Cam Technology and Caterpillar Common Rail (CCR)
- Best combination for IMO II
- No additional media.
- CCR can be retrofitted.

Flex Cam Technology (FCT)

FCT is flexible enough to be adjusted to the respective application:

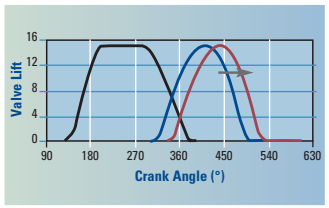
- Low Smoke – eliminates visible smoke completely while complying with IMO I standards at all operating load points.
- Low NO_x – demonstrates capability to reduce the current IMO NO_x limits by at least 30% (LEE = Low Emission Engine).

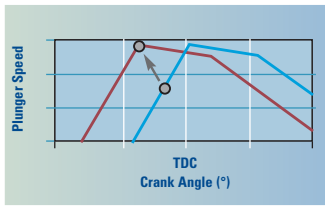


schematic diagram

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.





Flex Cam Technology FCT
schematic diagram

Flex Cam Technology (FCT) has been developed and put into production. The next milestone in emissions technology is a fully flexible fuel system suitable for DO, MDO and HFO, called the Caterpillar Common Rail (CCR) fuel system. Caterpillar Common Rail is considered the major building block towards low emissions, high performance and highest customer value. Caterpillar has chosen "inside the engine" measures as the technology with the highest customer value.

In combination with the long-stroke concept and high performance air systems the Caterpillar Common Rail (CCR) fuel system is the most effective technology to meet emission regulations and customer expectations

With **Caterpillar Common Rail**, the injection pressure is independent from load and speed. Utilizing injection maps the injection characteristics are optimized for every engine operating point. As a result, NO_x and soot emissions are reduced with the amount of reduction dependent on the actual engine operating condition.

For areas that are especially emissions-sensitive, soot emissions at low engine load remain well below the visibility limit. Furthermore, during normal load operation NO_x emissions can be reduced without sacrificing fuel consumption. In general, the Caterpillar Common Rail fuel system enables vessel operation without visible soot throughout the whole operating range.

Key criteria are:

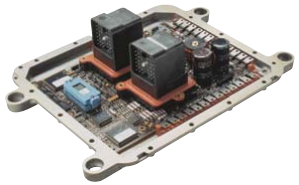
- Compliance with current and future required emission limits for the respective power ranges.
- Customer expectations in terms of engine performance, maintenance practices, fuel quality and mode of operation.

By adopting well proven elements of this technology for medium-speed engines, it is our goal to meet and exceed customer expectations by maximizing product value through:

- Superior reliability in heavy fuel operation.
- Best fuel efficiency in its class.
- Lowest engine emissions with minimum additional complexity.

High Pressure Pump

Control Device ADEM4



Injector

Rail Segment with Three Injectors

One Strong Line of World-Class Diesel Engines

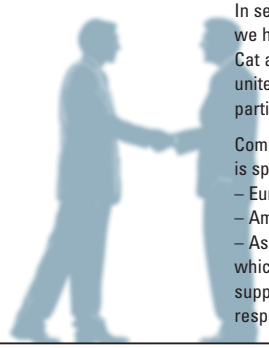
Perfect Solutions for Main Propulsion and On-Board Power Supply

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 11 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 in 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,
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 Marine Power Systems Headquarters/Hamburg

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.

Caterpillar Marine Power Systems

Production Quality

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.

CAT MaK

Onboard Power Supply

● **C1.5**
11–14,5 kWe
13,5–18 kVA

● **C2.2**
16–30 kWe
20–37,5 kVA

● **C4.4**
36–99 kWe
45–123 kVA

● **3056**
84–99 kWe
105–124 kVA

● **C9**
150–250 kWe
188–313 kVA

● **C18**
275–550 kWe
344–688 kVA

● **3400**
6, 8, 12 cylinder
200–590 kWe
250–738 kVA

● **3500**
8, 12, 16 cylinder
590–1,825 kWe
738–2,281 kVA

● **3600/C280**
6, 8, 12, 16 cylinder
1,650–5,200 kWe
2,063–6,500 kVA

● **M 20 C**
6, 8, 9 cylinder
970–1,625 kWe
1,210–2,030 kVA

● **M 25**
6, 8, 9 cylinder
1,710–2,820 kWe
2,140–3,520 kVA

● **M 32 C**
6, 8, 9 cylinder
2,765–4,320 kWe
3,456–5,400 kVA

● **VM 32 C**
12, 16 cylinder
5,530–7,680 kWe
6,912–9,600 kVA

GENSETS

Propulsion Engines

■ **High-Speed Engines**

● **3000**
6 cylinder
93–153 kW

● **3100**
6 cylinder
261–313 kW

● **C7**
6 cylinder
187–339 kW

● **C9**
6 cylinder
375–423 kW

● **C12**
6 cylinder
254–526 kW

● **C15**
6 cylinder
597–636 kW

● **C18**
6 cylinder
339–747 kW

● **3400**
6, 8, 12 cylinder
187–1,044 kW

● **C32**
12 cylinder
820–1,343 kW

● **3500**
8, 12, 16 cylinder
526–2,525 kW

■ **Medium-Speed Engines**

● **3600/C280**
6, 8, 12, 16, 18 cylinder
1,730–7,200 kW

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

● **M 25**
6, 8, 9 cylinder
1,800–2,970 kW

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

● **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

MAIN PROPULSION

Quality is our Motto!

Caterpillar Marine Power Systems

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www.cat-marine.com or www.mak-global.com

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