

# MAK

The Engine.

## What you should know

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Krupp Metallmaschinen GmbH has its roots right in the big international shipping route between the western coast of the Red Canal and the Baltic Sea - just outside that, the northern-most regional capital of the Federal Republic of Germany. The first production plants were built on the historic site of the old coastal fortress of Charlevoix in 1868 and by 1908 there were already over 1000 people employed. The plant has grown constantly despite the various events in the present century. Today, Charlevoix production plants are being built on an area of 240000 m<sup>2</sup> and nearly 3000 people work here. The company has belonged to Fried. Krupp GmbH of Essen since 1984 and its net asset value amounts to 400 million DM. In the self-company tradition, the product range is geared to shipping, storage, transport, offshore, offshore and onshore.

Diesel engines have been made here for 60 years. During the last 30 there have been 17 serial shipping Diesel Units. Diesel engines from that period are still in operation today - a proof of their robustness and quality.

The current engine range has built series of medium-speed four-stroke diesel engines for long-range development and still does the job. The different series have been systematically developed from the start, with the result that an advanced, high-quality range is now available for economical operation. These series cover an output range of 600-1900 HP and higher outputs are planned.

# about Krupp MaK Maschinenbau GmbH

MaK engines offer a wide variety of applications and represent the optimum solution for main and auxiliary engines for economic oil-consumption at sea.

Wherever power is required for long periods in whole regions, MaK stands out, there are the economically sensible solutions. MaK engines are the solution to satisfying technical demands, long term planning and constant investment. Some 50 or 60 new investment production plants show investment plans.

The sales and service organization has been expanded worldwide. Service facilities for planning, delivery, customer service are available at MaK in many sea ports around the world in support of the sales and service organization.

Sales and service is provided for auxiliary companies in the main markets. In addition, the company has sales and service facilities at approximately 500 stations in 40 countries.

Research and development has high priority at Krupp MaK. Research and planning, research and development work is done in the fields of basic research, applications technology and system development as part of the company's co-operation with public water plants.

Krupp MaK can also look back over a long tradition in the oil burner vehicle sector. Well-known types of locomotives used by the German Federal Railway and other companies of home and abroad are developed and produced here.

The company has many years of experience in diesel technology and was already manufacturing naval equipment a hundred years ago. Today, Krupp MaK develops and produces truck engines of the latest family of advanced vehicles as well as automotive engines and other auxiliary engine equipment for the German armed forces and NATO countries.



# McC medium-speed four stroke Diesel Engines

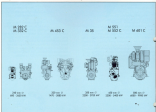
Single Main Manufacturing GmbH manufactures medium-speed four stroke heavy fuel engines in the speed range from 400 to 1000 rev/min - 1000hp under the trade name **McC**.

Plans in development and production is given as in the picture.

The characteristic feature of McC engines is their great reliability and low specific fuel values. All the engines have bearings of high alloy steel, which is engine with a bore of 220 mm or more take the form of multi-main engine blocks and are connected by cast iron tie rods. The high pressure of the working fluid, which holds the main components under compression stress, prevents any harmful stress influence in the cast material - even under sudden loads. The engine series with a 240 mm bore has a great cast alloy cylinder crankshaft. The tiers in all McC engines are cast from aluminum

and achieve minimum wear values thanks to their high wear resistance. Crankshafts are forged one piece from cast-iron, quenched and tempered alloy steel.

Single injection pumps are used for the injection system in all engine series, the injection process and the inlet and exhaust valves being controlled by a common camshaft. Inlet and exhaust valves are manufactured and tested piece by piece using the most advanced techniques. Good accessibility to the wear and tear parts enables easy maintenance.



# Heavy Fuel Operation with MaK Diesel Engines

Heavy fuel operation is now an indispensable economic requirement, which in view of the permanent availability of higher-grade fuels applies equally to lower outputs. MaK has built back on more than 30 years of experience in this sphere and now has more than 1,000 engines running on heavy fuel. All this experience is continuously crystallized in the form of improvements to our engines and has of course also made its own contribution to recent new designs. The exceptionally good operating characteristics of MaK 4- and 6-cylinder engines, especially when running on bunker fuels, make it possible to define the following fuel fuel values for the different engine series.

On the strength of many years' experience we have produced recommendations regarding the design and operation of propulsion plants. These are some examples:

- Development of cooling systems permitting practical partial load or low-load operation with heavy fuel.
- More stringent requirements with regard to fuel treatment by means of appropriate fuel systems, optimum separation and thorough filtration of fuel, including a check on the quality of purification.
- Careful selection of lubricating oil and treatment with continuous separation and filtration assure that engine components have a long service life, even when the circulating oil is subjected to substantial loads.

## Fuel Qualities Admitted for all MaK Engines

	Category	DMAC	H 30	H 30
		50 - 1	40/50%	1/1
		80	M 1	
Ready at 15° C	g/d	max	0.991	1.010
Dynamic Viscosity at 50° C	cSt	max		700
Dynamic Viscosity at 100° C	cSt	max		50
Viscosity Ratio (see 100° F approx.)	1/1	max		7000
Flash point	°C	min		60
Boiling point (approx)	°C			
1st Oct. - 31st March		min		30
1st April - 30th November		min		30
Carbon Residue Bombston	% max	min		-
Combustion Carbon	% max	min		12
Ash	% max	min		0.2
Water	% vol.	min		1.8
Sulfur	% max	min		5.8
Vanadium	mg/kg	min		800
Niobium	mg/kg	min		50

# MacK Series M 282 C - M 332 C Diesel Engines

## Concept

MacK's series M 282 C/M 332 C engines are particularly well suited for ships with low engine rooms due to their compact design. All the different types of engine are of the same basic design, differing essentially in those components which affect output and speed.

### M 282 C

bore 240 mm, stroke 190 mm  
speed range 700 - 1000 rpm  
output range 800 - 2600 kW  
engine type: M 282 C / B M 282 C / J 282 C

### M 332 C

bore 240 mm, stroke 230 mm  
speed range 700 - 900 rpm  
output range 900 - 3200 kW  
engine type: M 332 C / B M 332 C

## Design

- One frame as supporting unit, cast in one piece with a suspended crankshaft.
- Large inlet and exhaust valve cross-sections ensure good breathing characteristics in combination with the pulse charging system and a high air-flow rate at all loads and/or part loads.
- Cams have high wear-resistance and good anti-corrosion properties thanks to their oil bath-treated surfaces.
- Valve-relevant surfaces with special treatment for the long service life.
- Piston rings with aluminium-plated coating surfaces.
- Individual fuel injection pumps.
- Fresh-water cooling system throughout.



# MAN

## The Reliable Engine

### Applications

Series M (M50 C/M 300 C) engines are used as ships' main propulsion plants with gear for single and multi-engine plants.

These engines are also widely employed to drive generators for shipboard power supply systems. They are characterized by a high degree of reliability in continuous operation as medium-speed engines in the speed range of 720 rpm - 1800 rpm.

Engines for bunker fuel operation have been in service on board ships since 1961.

A total of 1,730 shaft engines of this series with a combined output of more than 1,400,000 kW are sold or installed.\*

\* As of October 1990

Engine type	M	300 C	300 C
Bore	mm	340	
Stroke	mm	240	230
Output range	kW	400 - 2400	350 - 1600
Output	kW/rev	100 - 230	100 - 200
Speed	rpm	720 - 1800	
BHP	hp	532 - 2171	
Cylinders		4 - 12	6 - 8



Cross-section of M 50 C/M 300 C  
in-line engine



Cross-section of M 300 C  
V-engine

# MaK Series M 453 C Diesel Engines

## Concept

A successful heavy fuel engine of long stroke design. Engines of this series can also be supplied as direct reversing engines.

M 453 C — bore 520 mm, stroke 430 mm  
speed range 100 rpm — 400 rpm  
output range 1470 kW — 3860 kW

## Design

- Robust construction with unbalanced crank shaft.
- One-past cylinder block for twelve and V engines with high degree of rigidity.
- Large crankcase doors for good access to engine components.
- Six built-in diesel cylinder liners, for high wear resistance and good anti-corrosion properties.
- Intensively cooled exhaust valve seats in the cylinder head guarantee optimum heat transfer.
- Wear resistance plates with special heat treatment for the ring grooves.
- Piston rings with chromium-plated running surfaces.
- Low specific fuel oil consumption.





# **MAN** The Reliable Engine

## Applications

The output range of 1470 kW - 1880 kW per engine allows that a very large number of marine propulsion systems can be covered. They are used mainly as compact, reliable heavy fuel engines in nearly all categories of ships.

1200 diesel engines of this series with a total output of more than 1,000 million kW are sold or installed.\*

\* As of October 1988

Engine type	40	400 C
Bore	mm	200
Stroke	mm	400
Output range	kW	1470 - 1880
Output	MW/GV	1.95 - 2.67
Speed	rpm	500 - 600
BHP	hp	14.0 - 21.7
Cylinders		4 - 6 - 8 - 10 - 12



Cross-section of M 400 C  
engine



Cross-section of M 400 C  
engine

## MAN Series M 35 Diesel Engines

### Concept

It was in 1978 that design work began on the M 35, a new heavy fuel engine.

M 35 — bore 360 mm, stroke 380 mm  
speed 600 rpm, 750 rpm  
output range 2000 kW - 3000 kW

### Design

Deep sump, craneshaft and sump was chosen, bedplate and low frame being made of proven cast materials. The composite construction is characterized by a high degree of rigidity. Large doors give good access to the combustion and assembly work on top and connecting rod bearings is done with hydraulic tools. Bulk up valves, lateral flow of lubricating bearing and exhaust valves in separate housings with intensive water seal cooling meet the stringent demands for a heavy fuel engine of the future. The doors are self-healing situated, guaranteeing fast clean running in and wear characteristics.



# MARLBOROUGH

## The Reliable Engine

### Applications

The aim of the development programme was to produce a compact, heavy fuel engine suitable for marine main propulsion plants and also to drive generators. The result was an engine whose features include the following:

- High output concentration with retaining power load values.
- Good access to all engine components for easy maintenance.
- Low specific fuel oil consumption.
- Option for direct reversing engines.

Full changing programme, full-reverse gear, low thermal loads and a high degree of efficiency.

All engines handling 100,000 kW are sold or ordered.\*

Engine type	6L	8L
Bore	mm	200
Stroke	mm	180
Clearance	mm	2.00 - 2.05
Output	MW/GkW	167 - 188
Speed	rpm	625 - 750
BHP	hp	182 - 21.4
Cylinders		6 - 8

\* As of October 1988



Cross-section of M 25

# MaK Series M 551 · M 552 C Diesel Engines

## Concept

As with all MaK engine series, importance was again attached to a long service life together with easy maintenance. For heavy load operation, both types of engine are identical with regard to those components forming the combustion chamber and its support of all control elements such as combustion, valve drive, injection pump, etc.

**M 551** — bore 480 mm, stroke 330 mm  
speed range 422 rpm - 450 rpm  
output range 2300 kW - 4600 kW

**M 552 C** — bore 480 mm, stroke 330 mm  
speed range 300 rpm - 374 rpm  
output range 2400 kW - 2400 kW

## Design

- Five-part engine arrangement consisting of bedplate with embedded crankshaft, fuel pump with large overhead valves and cylinder pin block.
- Full-up pistons with steel crown.
- Exhaust valves in separate cast steel housing with intensive valve seat cooling.
- Cylinder liner with both threaded running surface and separate cylinder lubrication.



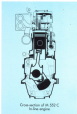
## Applications

Low engine speed and low load values combined with solid design have enabled this engine series to prove its reliability for longer life.

- Low specific fuel and lubricating oil consumption.
  - Combination of long service, good quality fuel.
  - Low inlet gas pressure propeller speeds, electric power can be generated by shaft driven generator.
  - Waste heat from exhaust gas and cooling water can be extensively utilized.
- total of 600 diesel engines of more than 2, 14 million kW are sold or installed.\*

\* As of October 1988

Engine type	6U	6U2	500C
Bore	mm	400	400
Stroke	mm	700	700
Displacement	m <sup>3</sup>	2000-6000	3400-6400
Output	MW(kW)	280-870	430-670
Speed	rpm	400-600	500-550
Weight	ton	11.0-17.0	12.0-14.0
Cylinders	6-8		6-8



# MaK Series M 601 C Diesel Engines

## Concept

Since its introduction, the M 601 engine has proved a reliable alternative to the two-stroke industrial engine. The M 601 C has the following advantages:

- Compactness and output concentration
- Reliability
- In-line design means easy maintenance
- Low fuel consumption

M 601 C - bore 260 mm, stroke 400 mm  
speed range 400 rpm - 400 rpm  
output range 600 kW - 1100 kW

## Design

- Power-compact construction with protected crankshaft, low frame and cylinder block
- Optimum charge system with high exhaust valve-on-ff and perfect fuel
- Oil-pool coated cylinder liners with bore cooling and separate cylinder liner lubrication
- Ringing pattern with steel covers, chromium-plated scraper ring running in hardened ring groove, top ring groove chromium plated
- Four-valve cylinder head with separate inlet and valve housing, seats mechanically cooled
- Easy maintenance through good access to its parts with tool-engine components



**Application:**

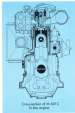
A cylinder output of 1100 kW enables engines of this series to be used in all larger types of ship.

- Single-engine plants with low number of cylinders and compact dimensions, represent oil burner power generation by dual-fuel operation.
- Two-engine plants with high degree of modularity offer economical single-engine operation at reduced speed.
- Auxiliary propulsion plants with optimum utilization of exhaust gas heat, cooling water heat and charge air heat to meet auxiliary power requirements.

1000 kW engines of the M 501 series with a total output of 110,000 kW are installed.\*

\* As of October 1988

Cylinder type	M	501 C
Bore	mm	500
Stroke	mm	400
Cylinder range	mm	6000 - 9000
Output	kW/kVA	1000 - 1100
Speed	rpm	400 - 420
Rated	bar	14,7 - 16,2
Cylinder		1 - 8 - 1



# Complete Propulsion Plants from MaK

Thanks to many years' experience in marine engine construction and their close cooperation with everyone involved in the manufacture of a marine propulsion plant, Kvaeg MaK are able to supply complete propulsion systems and power sets for shipboard power supply systems.

A power plant of this kind will consist of:

- The MaK heavy-fuel main engine.
- Reduction gear and shaft couplings with reduction ratios for economical propeller speed.
- Propeller and shaft unit designed as variable-pitch or fixed-pitch propeller with optimum speed adjusted to the ship's form for local flow efficiency.
- MaK remote control and monitoring system.

Components for systems such as the cooling water, lubricating oil and fuel treatment, exhaust gas sound-proofing and starting air supply can be supplied as part of an MaK package.

MaK alternator units with a broad range of power are available for shipboard power supply. These can be supplemented by the use of shaft-driven generators.

Our extensive experience with the operation of heavy-fuel engines enables us to provide clear guidelines and recommendations for the design of marine propulsion plants and power supply systems.

Kvaeg MaK can provide the project engineering with comprehensive technical information.





## Economical Marine Propulsion Plants

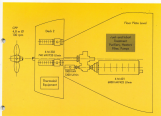
Ever growing demands on the economic efficiency of marine propulsion plants mean that energy saving designs have to be used.

This applies to:

- Low specific fuel consumption.
- Low maintenance costs.
- Low wear rates, especially on liners and piston rings due to optimum lubrication and long TBO's for the oil-pump system due to efficient cooling and seal design are typical for shaft, heavy fuel engines.
- Higher possible propulsion efficiency. Intermediate gear reduction ratios provide very better speeds and propeller designs (and) of higher possible efficiency.

Reductions of the propeller slip/prop. loss may result in gains of 1 to 3 % depending on type and size of the vessel.

- Shaft alterations simply driven off the already existing reduction gear, longer than shaft alterations provide from the low wear engine's fuel consumption, and lower investment costs.
- Hybrid fuel-auxiliary engines. Highest economy can be achieved by not only operating the main propulsion engine but also an auxiliary diesel engine or low-grade heavy fuel. Much less because customer in application of auxiliary gas fuel also require very clean main and auxiliary engine gas, an auxiliary fuel with quality grade 3000, 15.



# MAK

## The Reliable Engine



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## They all sail on MaK Diesel Engines



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