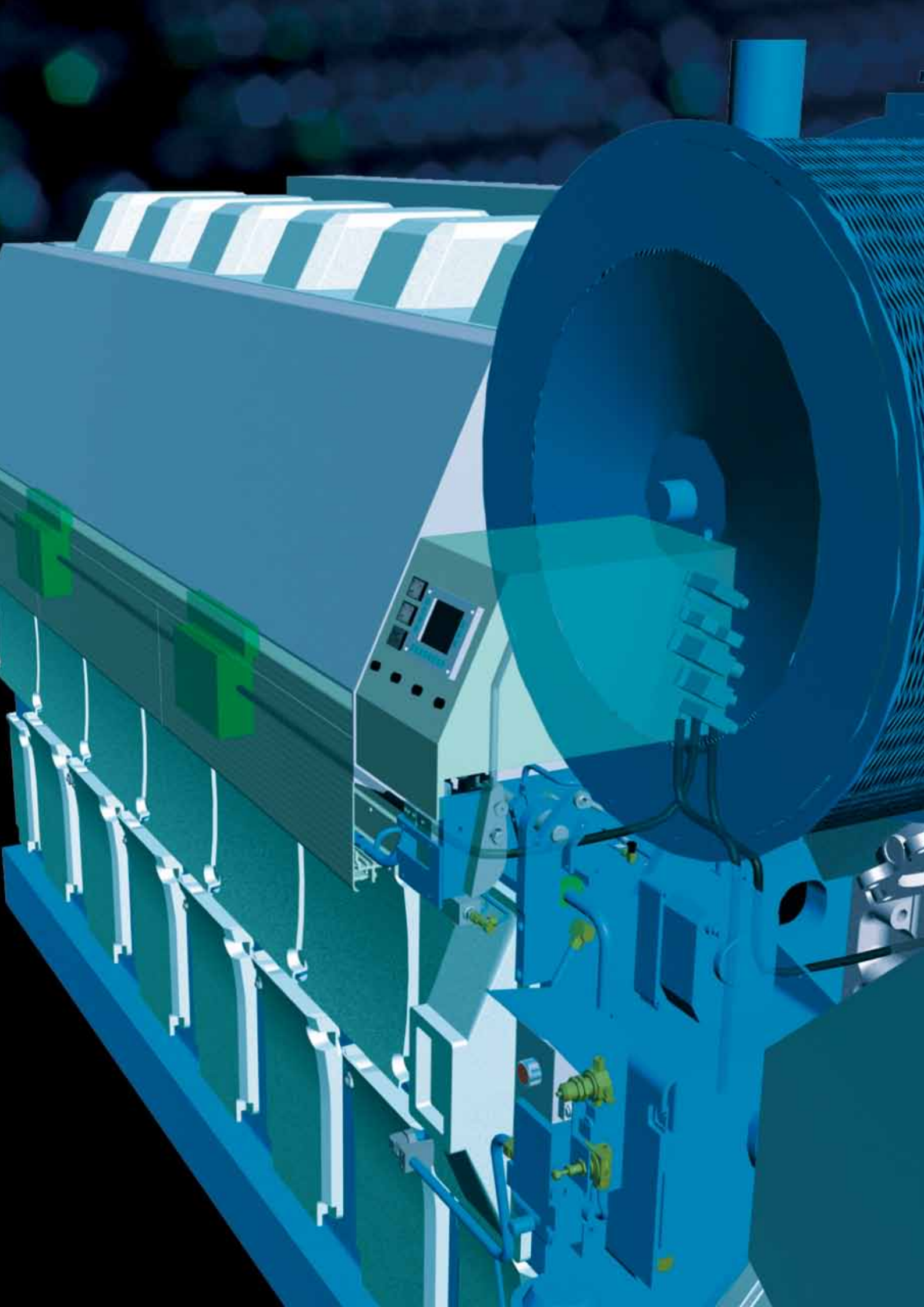
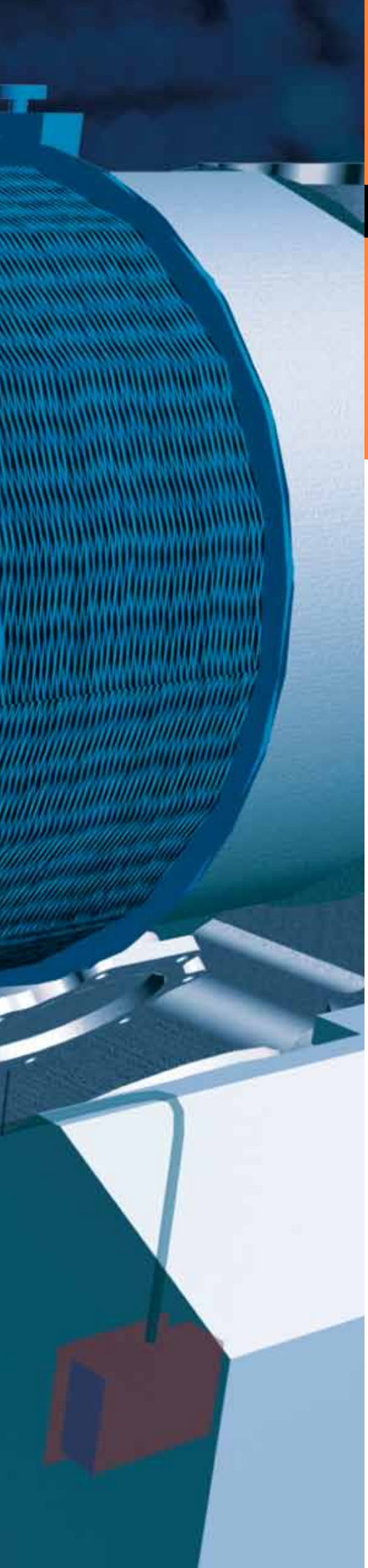
WÄRTSILÄ

WÄRTSILÄ Engines

WÄRTSILÄ 38
TECHNOLOGY REVIEW





WÄRTSILÄ **Engines**

WÄRTSILÄ 38 TECHNOLOGY REVIEW

This is a brief guide to the technical features and advantages of the Wärtsilä 38 engine.

The MSC Musica cruise vessel is equipped with five Wärtsilä 16V38 engines.

The Fesco Sakhalin Ice-breaking Supply and Standby Vessel is equipped with three Wärtsilä 8L38 engines

The tanker Bitflower is equipped with a Wärtsilä 6L38 engine.

The trailing suction hopper dredger Prins der Nederlanden of Westminster Dredging Co. Ltd, a 100% subsidiary of Royal Boskalis Westminster nv, is equipped with two Wärtsilä 12V38 engines and one Wärtsilä 9L20 engine.

The Kirikkale power plant in Turkey has thirteen Wärtsilä 18V38 generating sets producing a total of 147 MW.

DESIGN PHILOSOPHY

The Wärtsilä 38 was developed in response to a need in the market for an engine in the 400 mm cylinder bore class. The Wärtsilä 38 is a technologically advanced engine – a product that sets standards.

The intelligent design makes the Wärtsilä 38 the lightest and most compact heavy duty engine on the market. The high level of technology incorporated in this engine, its design, and the power plant that is built around it, are all focused on achieving the lowest possible kWh production cost. With fewer parts, lower maintenance requirements, low fuel consumption, lower emission levels and

The Yacht Express yacht carrier is equipped with two Wärtsilä 12V38 Common Rail engines.

the ability to run reliably on a variety of fuels, the Wärtsilä 38 is unquestionably the state-of-the-art in power generation.

LOW NO_X COMBUSTION

The best trade-off between low NO_X emissions and low specific fuel consumption (SFC) is obtained by using a low-NO_X combustion system. This combines Miller timing and high compression ratio with a fast, controlled heat release that is ensured by an optimized fuel injection and combustion process. Other important contributing factors are high injection pressures and a well designed combustion chamber.

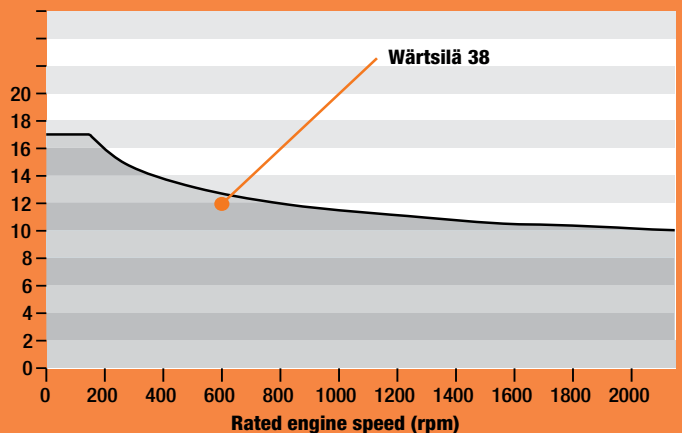
Gas exchange losses are minimized by optimized inlet and exhaust channels in the cylinder head and adequate valve seat and valve lift dimensions. The turbocharger system is important to this optimization process as well.

IMO NO_X COMPLIANCE

The standard engine meets the actual and future NO_X level set by IMO (International Maritime Organisation) in Annex VI to MARPOL 73/78, and the World Bank Group specified in “Thermal Power: Guidelines for New Plants, 1998” for engine driven power plants in “non-degraded air sheds”.
All marine engines are delivered with an EIAPP (Engine International Air Pollution Prevention) certificate, technical file and marked engine components as required by the NO_X Technical Code in MARPOL 73/78 Annex VI.

Specific NO_X emissions weighted (g/kWh)

IMO NO_X limit for new engines Regulation 13 of annex VI of MARPOL73/78



ENGINE BLOCK

The combination of design elements such as underslung crankshaft, integrated air receivers and jacket water manifold, short cylinder distances and material choice has resulted in a very rigid engine block. The camshaft bearing environment forms an integrated part of the engine block, contributing to the overall stiffness of the block. The rigidity of the engine block ensures easy flexible mounting.

CRANKSHAFT

Special attention was given in the design of the Wärtsilä 38 engine to optimizing the various geometric properties such as cylinder distance and high combustion pressure in order to achieve a space-saving solution. FE (Finite Element) calculation methods were used to achieve an optimal crankshaft design resulting in maximum overall rigidity while maintaining moderate bearing loads. The design of the crankshaft ensures that even with higher combustion pressures, the crankshaft meets all the criteria set by the classification societies. The crankshaft is underslung mounted. Bearing bolts and side studs are hydraulically tensioned.

MAIN BEARINGS

The moderate bearing load and rigid design of the main bearing cap ensure reliable operation. The geometry of the bearing creates an oil film thickness which considerably exceeds the safety margins required by bearing manufacturers; all in accordance with the Wärtsilä 'Thick Pad' philosophy, ensuring low wear rate with good running properties. For V-engine, the main bearing oil supply pipe is combined with a hydraulic jack for lowering the main bearing cap.

CONNECTING ROD

The 'marine head' design of the connecting rod is carefully optimized with regard to stress levels using 3-D FE analysis. The dismantling height of the piston/connection rod assembly is shorter than for any other engine in this output range. The 'marine head' design makes it possible to remove the piston-connecting rod assembly without removing the big-end bearing, which significantly reduces maintenance downtime and cost.

CAMSHAFT

The camshaft consists of individual one-cylinder camshaft units which are flange connected to separate bearing journals. Built-in valve tappet modules screwed onto the engine block allows for easy maintenance and reliable operation. The overall design ensures reliable operation, easy maintenance and inspection.

CYLINDER HEAD

The cylinder head has been redesigned to maximize thermal efficiency by incorporating the largest possible air/gas channels. It is also adapted to the higher load of the Wärtsilä 38 engine. The use of four cylinder head studs facilitates easy maintenance. The valve design guarantees excellent component operational behaviour, especially when using heavy fuel oil. The rigidity of the cylinder head design ensures adequate and uniform sealing between the cylinder head and liner. The rigid construction allows no deformation of the valve seat environment. All connections to the cylinder head are easy to reach and disconnect.

CYLINDER LINER

The high collar cylinder liner design is the result of Wärtsilä's long experience and extensive research and development. This design ensures ideal roundness of the liner, a precondition for optimal ring-liner contact. It also maintains the straightness of the liner during operation and prevents interference from adjacent cylinders. The design of the vertical cooling bores is optimized to maintain the correct temperature range on the inner liner surface – high enough to prevent cold corrosion and low enough to ensure good lubrication.

ANTI-POLISHING RING

The anti-polishing ring removes the carbon from the piston top, thus preventing liner polishing. This system results in a drastic reduction of cylinder wear, lower and constant lubricating oil consumption, and a clean piston. Less blow-by has made it possible to increase firing pressures.

PISTON AND PISTON RINGS

The piston design consists of a steel crown, nodular cast iron skirt and pressurized skirt lubrication. The three-ring pack consists of two compression rings and one oil scraper ring located at the crown. This ring pack ensures optimal pressure distribution and lowers lubricating oil consumption. The shape of the combustion chamber is such that it ensures efficient combustion at all loads, while the component temperatures are kept low.

FUEL SYSTEM

The fuel feed and return lines are integrated in the fuel pump housing. This offers a 'clean' cylinder head environment for easy access and maintenance. It also means fewer part connections, which results in high reliability and easy maintenance. Shielded high-pressure lines and the 'hot box' contribute to safety – especially in heavy fuel oil operation. The design of the fuel system provides very low pressure pulses in the low-pressure system. Proper dimensioning of the camshaft, camshaft bearings and rollers ensures a controlled mechanical load on all driving parts, ensuring long lifetime and low maintenance costs.

FUEL INJECTION SYSTEM

The Wärtsilä 38 fuel injection system achieves the optimum trade-off between performance parameters (fuel consumption, emissions, smoke) by providing fast injection along with good injection quality with respect to the fuel spray pattern and droplet size.

COMMON-RAIL FUEL INJECTION

The Wärtsilä 38 can optionally be equipped with a common-rail fuel injection system. The common-rail system ensures:

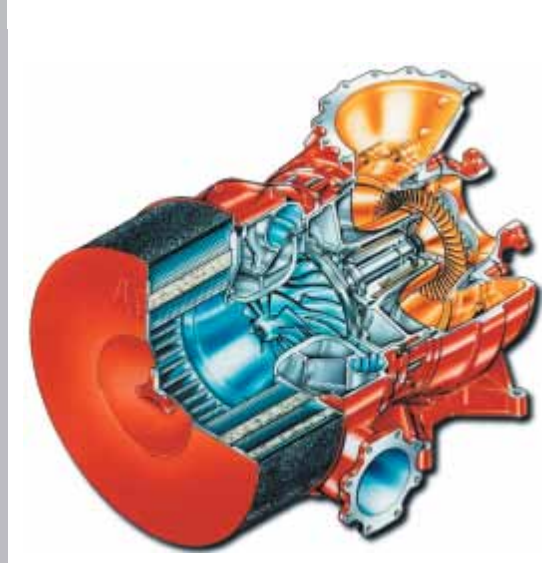
- Smokeless operation at all loads, speeds during starting and during load-pick-up.
- Improved total fuel economy and operational cost.
- Flexibility for different fuels.
- Longer component lifetime.

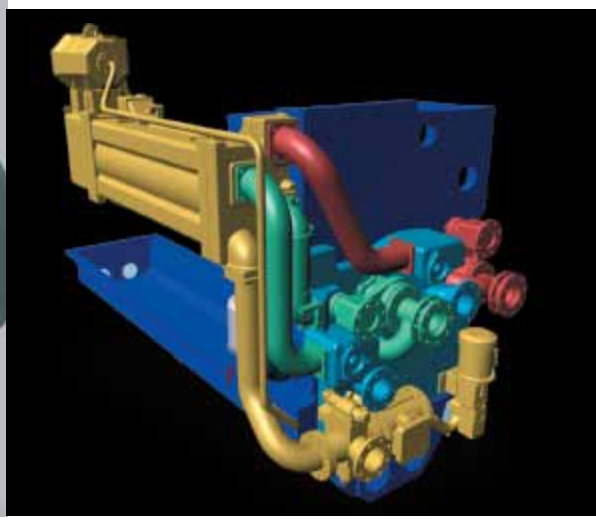
The common-rail system comprises pressurizing fuel pumps, fuel accumulators and electronically controlled fuel injection valves. A triple redundant safety system prevents early injection of fuel. Possible leakages are collected inside the 'hot box'. All functions are controlled by the embedded control system on the engine.

AIR AND EXHAUST GAS SYSTEM

The new generation turbochargers, applied on the Wärtsilä 38 series, allow not only improved performance but also a compact installation with less piping (water cooling is not needed). Special attention is paid to integration of the bypass and waste gate valves, which are essential parts of the engine. The positions of the valves and their controls have been selected based on the requirements of low vibration levels, low local temperatures and short piping. A simple, reliable, manually controlled cleaning device is standard. A cast turbocharger bracket provides the housing for the two-stage air cooler and supports the turbocharging system. The charge air receiver is designed for minimum pressure variation and good engine 'breathing'.

The inlet bends between the air receiver and the cylinder head for the L engine are designed with additional functionality in mind:





- Support of the exhaust system (rigid mounted isolation box and single pipe exhaust [SPEX])
- Support of the cooling water return channel from the engine.

This multifunctional solution allows a compact installation. The exhaust system contributes to the efficiency of the turbochargers thanks to its flow-optimized design. The system is modular for easy assembly and can handle such factors as gas exchange dynamics, high temperatures and thermal expansion, etc. Insulation of the exhaust system is achieved by stainless steel insulating panels, which are easily removable for inspection access.

'HOT BOX' DESIGN

Externally, the engine has swinging 'hot box' covers and cylinder head covers that enclose the hot box area. Internally, the design of the fuel system is based on state-of-the-art fuel pumps, giving a simple and very reliable system. Multichannel extrusion profiles have been selected for the main starting air supply and the transport of some fluids. In these profiles space is provided for the components of the engine control system.

AIR COOLER

The Wärtsilä 38 is equipped with a two-stage air cooler for improved heat recovery. The housing of the two-stage air cooler forms an integral part of the turbocharger support, creating a compact, economical and rigid design.

LUBRICATION SYSTEM

The lubrication system of the in-line engines includes a complete lubrication oil module with a cooler, an automatic backflush filter, a centrifugal filter in the backflush line, and thermostatic valves. The main and the pre-lubrication oil pumps and the regulating valve are part of the total system. The lubrication oil flow through the engine is based on optimized bearing clearances, ensuring large safety margins.

ENGINE-DRIVEN PUMPS

Engine-driven lubricating oil and cooling water pumps are an integral part of the Wärtsilä 38 design. All engine-driven pumps are located on the free end of the engine. For the 18-cylinder Wärtsilä 38 all pipe connections are grouped together, allowing easy connection to the power plant's auxiliary systems. The use of engine-driven pumps considerably simplifies the whole power plant design and lowers investment costs.

COOLING WATER SYSTEM

- The fresh water cooling system is divided into a high- temperature and a low-temperature section.
- The charge air cooler is of two-stage design to maximise heat recovery and keep up the charge air temperature at low load.
- Built-on engine-driven cooling water pumps.
- Built-on thermostatic valves for the in-line engines.

The Wärtsilä 38 assembly hall in Trieste, Italy.

AUTOMATION

The engine is equipped with a scaleable engine automation system:

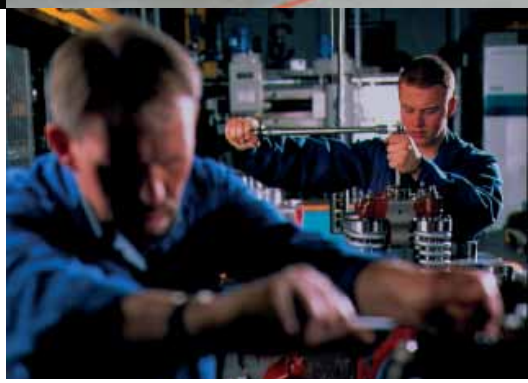
- The basic version (UNIC C1) consists of a hardwired system containing sensors, switches and handles the basic engine safeties.
- The extended automation system (UNIC C2) is a complete electronic engine control system.
- In case of common-rail fuel injection system (UNIC C3) automation system is applied taking
  care of the fuel injection.

The systems differ in the way signals are handled and in the amount of functionality covered by the system. All systems include all start and stop related functions. The advanced control systems generate alarms and load reduction requests when set point values are exceeded, whilst in the basic automation system these functionalities must be foreseen in the external system. All systems have an integrated speed control system.

MARINE GENERATING SETS

Engines driving generators can be delivered on a resiliently mounted common base frame for easy installation:

- All lubricating oil is contained in the common base frame
- Engine and generator are tested as a complete package
- No need for re-alignment.



MAINTENANCE

The overall design of the Wärtsilä 38 ensures a considerably lower number of parts compared to other engines in its class, resulting in reduced maintenance costs and less downtime. All parts, both internal and external, are easily accessible for quick and easy servicing. Condition-based maintenance software is designed to optimize the scheduling of the maintenance.

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WÄRTSILÄ 38 MAIN TECHNICAL DATA

MARINE ENGINES

Cylinder bore	380 mm
Piston stroke	475 mm
Cylinder output	725 kW/cyl
Engine speed	600 rpm
Mean effective pressure	26.9 bar
Piston speed	9.5 m/s
Fuel specification:	
Fuel oil	730 cSt/50°C
	7200 sR1/100°F
	ISO 8217:2005 (E), category ISO-F-RMK 700
	SFOC 173-175 g/kWh
	at ISO condition

MAXIMUM CONTINUOUS OUTPUT

Engine	Diesel Electric [kW]	CPP [kW]	FPP [kW]
6L38	4350	4350	4050
8L38	5800	5800	5400
9L38	6525	6525	6075
12V38	8700	8700	8100
16V38	11600	11600	10800

IN-LINE ENGINES DIMENSIONS

Engine	A* [mm]	A [mm]	B* [mm]	B [mm]	C [mm]	D** [mm]	E [mm]	F [mm]
6L38	6345	6220	2830	2830	2190 (2210*)	3135	560	1115
8L38	7925 (7875")	7545 (7495")	2820 (2735")	2770 (2690")	2445 (2185")	3135	560	1115
9L38	8525	8145	2820	2770	2445	3135	560	1115

Engine	G [mm]	H [mm]	I [mm]	K [mm]	M [mm]	N* [mm]	N [mm]	Weight[1)] [tons]
6L38	4455	240	1110	1500	1205	1295	1345	51
8L38	5655	240	1110	1500	1240 (980")	1680 (1635")	1470 (1420")	63 (62")
9L38	6255	240	1110	1500	1240	1680	1470	72

V-ENGINES DIMENSIONS

Engine	A* [mm]	A [mm]	B=B* [mm]	C [mm]	D** [mm]	E [mm]	F [mm]	G [mm]
12V38	7615	7385	2930	3030	2855	720	1435	5165
16V38	9130	8945	3105	3030	2855	720	1435	6565

Engine	H [mm]	I [mm]	K [mm]	M [mm]	N* [mm]	N [mm]	O** [mm]	Weight[1)] [tons]
12V38	240	1382	2150	1515	1775	1775	1490	88
16V38	240	1382	2150	1515	1890	1935	1490	110

* Dimension valid when turbocharger is located at flywheel end
** Dismantling dimension
" Dimension valid for 8L, FPP application only
1) Tolerance 5 %, the masses are wet weights of rigidly mounted engines with flywheel and built-on pumps and without additional; e.g. hoisting tools, packing, torsional elastic coupling etc.

ADDITIONAL MASS

Item	6L	8L	9L	12V	16V
Flexible mounting (without limiters) [tons]	4	5.5	6	4	4.5

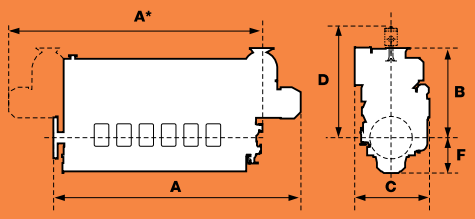
GENERATING SETS DIMENSIONS

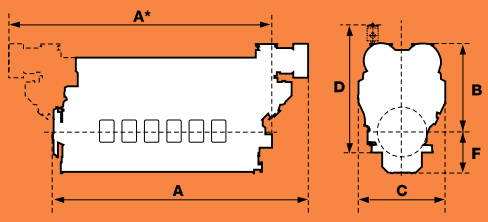
Engine	A* [mm]	A [mm]	E [mm]	I [mm]	K [mm]	L [mm]	L* [mm]	Weigth [tons]
6L38	9100	9600	2900	1655	3135	4485	4485	90
8L38	11500	12000	2900	1705	3135	4475	4525	110
9L38	11800	12300	3100	1805	3135	4575	4625	130
12V38	11100	11900	3600	2015	2855	4945	4945	160
16V38	12500	13300	3800	2015	2855	5120	5120	200

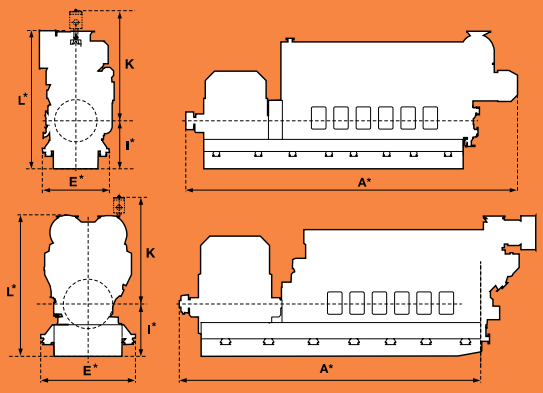
COMMON BASEFRAME DIMENSIONS

Engine	Lenght L* [mm]	Lenght L [mm]	Width W_B [mm]	Heigth H_B [mm]	W.mounts W_{BM} [mm]	H.mounts H_{BM} [mm]
6L38	8300	8000	2200	1100	2600	1350
8L38	10500	10000	2200	1150	2600	1350
9L38	11000	10500	2400	1250	2800	1350
12V38	9800	9600	2800	1300	3200	1550
16V38	11200	11000	3000	1300	3400	1550

Indicative dimensions and wet weights (final values depend on generator type and size)
* T/C at flywheel end







POWER PLANT ENGINES

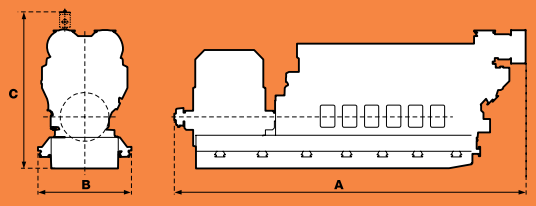
Cylinder bore	380 mm
Piston stroke	475 mm
Output, continuous power	12 150 kW
Output, emergency generating sets	13 050 kW
Engine speed	600 rpm
Piston speed	9.5 m/s
Mean effective pressure	25.1 bar
Fuel specification:	
Fuel oil	730 cSt/50°C
	7200 sRi/100°E
	ISO 8217:2005 (E), category ISO-F-RMK 700

RATED POWER 50HZ AND 60HZ

Engine type	Eng. kW	Gen. kW
18V38	13 050	12 695

GENERATING SET DIMENSIONS (MM) AND WEIGHT (TONNES)

Engine type	A	B	C	Weight
18V38	14 175	4 790	4 900	176



WÄRTSILÄ

Wärtsilä enhances the business of its customers by providing them with complete lifecycle power solutions. When creating better and environmentally compatible technologies, Wärtsilä focuses on the marine and energy markets with products and solutions as well as services. Through innovative products and services, Wärtsilä sets out to be the most valued business partner of all its customers. This is achieved by the dedication of over 18,000 professionals manning 160 locations in 70 countries around the world. Wärtsilä is listed on the Nordic Exchange in Helsinki, Finland.

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