YANMAR
Solutioneering Together

MARINE AUXILIARY DIESEL ENGINES

6EY22 Series

660 - 1370 kW (897 - 1863 ps)

Call for Yanmar solutions

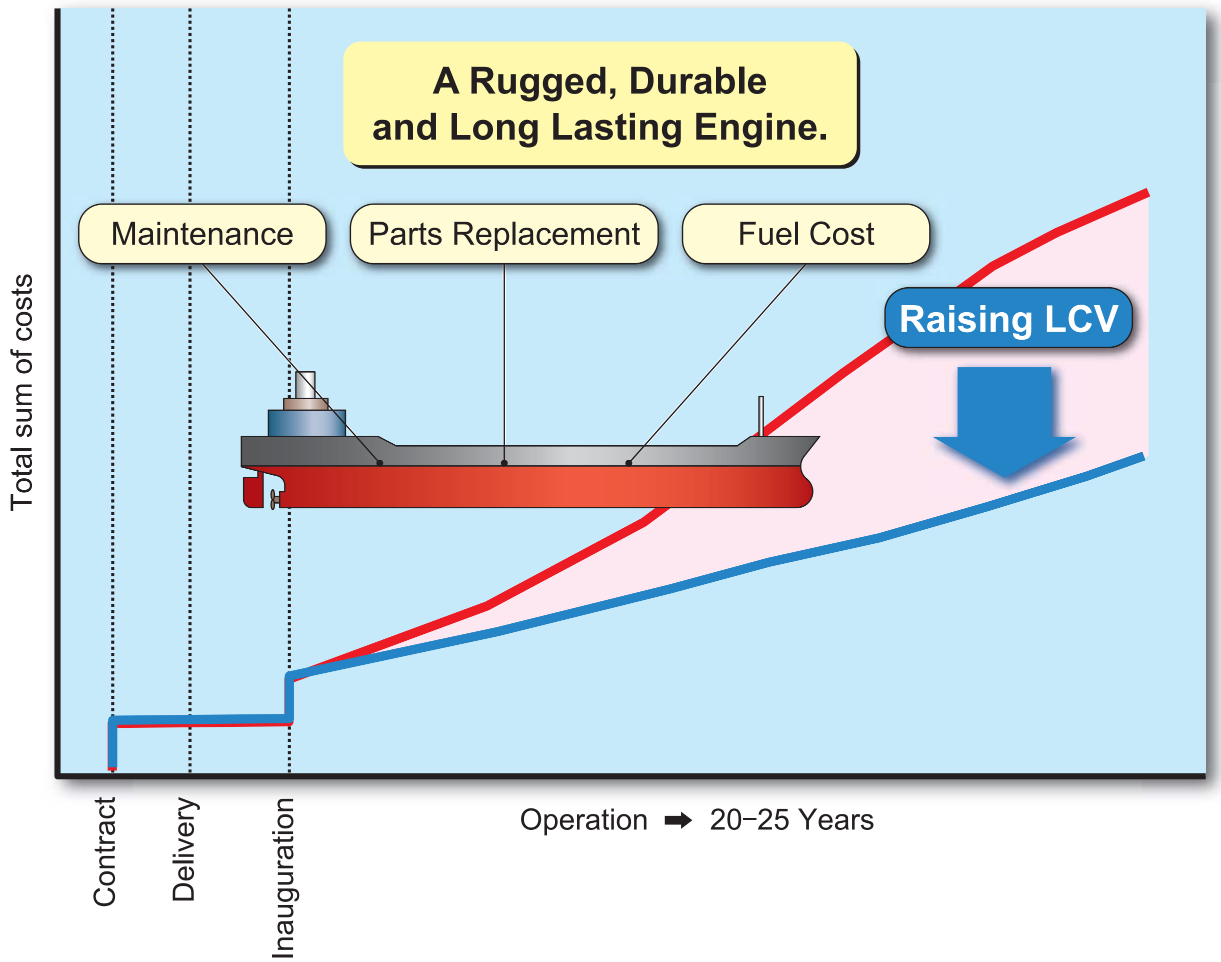
CONTENTS

1. The Development Story

Since its establishment, Yanmar has been dedicated to developing its own new technologies and products in pursuit of resource and energy efficiency. Yanmar has pursued the continuous improvement of "Life Cycle Value" by developing products that embody reliability, durability and low cost operation, because auxiliary engines are relied upon throughout the long life of a ship.

However, as atmospheric pollution damages the environment and global warming has begun to effect the ecosystem, protecting the environment has become a vital global issue. Yanmar was founded with the spirit of "grateful to serve for a better world". In order to realize that hope, Yanmar is developing engines in harmony with the environment by reducing NOx, CO_2, SOx, and other emissions and reducing the use of environmentally damaging substances.

The concepts behind the 6EY22 engine of "Improving Life Cycle Value" and "Harmony with the Environment" deliver customer satisfaction by offering solutions for both economy and environmental protection.



2. Development Concept and Policies

Raising L.C.V. (Life Cycle Value) for Customers

Selecting and Developing Long Life Parts	• Reducing contamination of the combustion chamber with anti-contamination technologies • Contamination-resistant applications
Easy Maintenance	• More space for easy maintenance • Modularization of parts • Reducing daily inspection work
Simplified Onboard Piping	• Connections with external piping are concentrated in the engine front side • Simplification through piping and wiring units

Harmony with the Environment

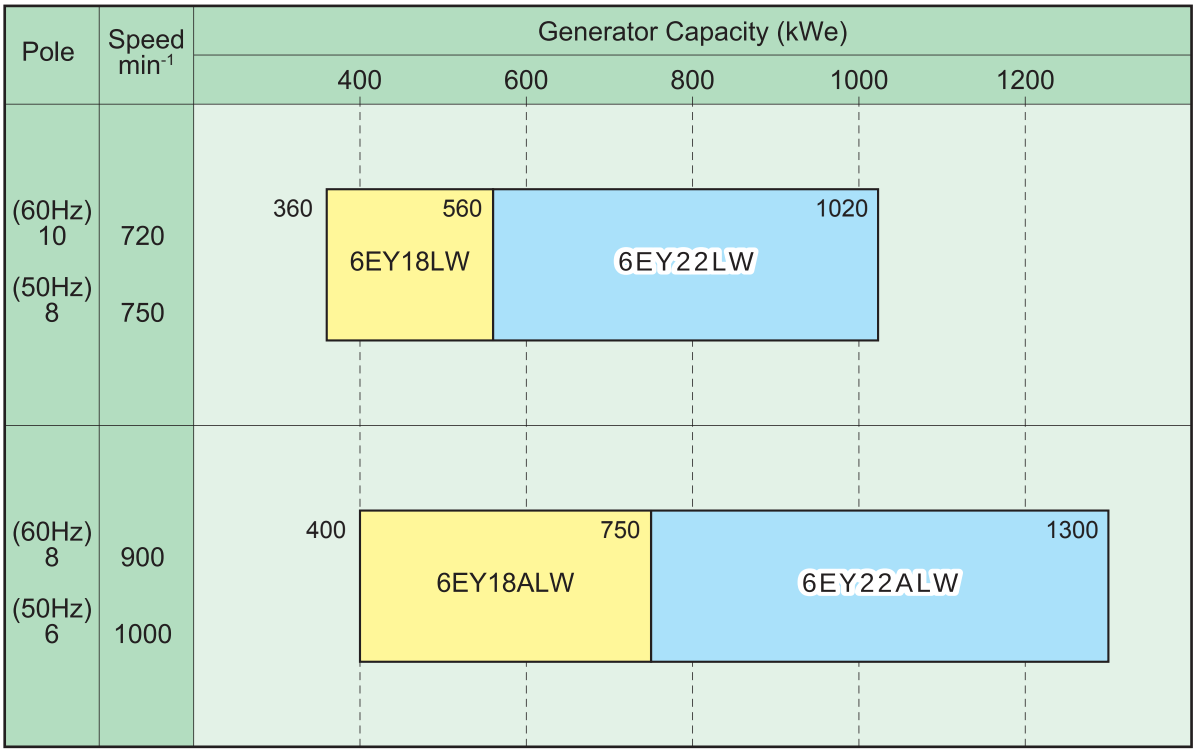
Reduced Emissions (Decreased NOx, CO_2, SOx)	• Both compliance with IMO Tier 2 regulations and achievement of low fuel consumption High pressure miller cycle system ASSIGN combustion system • Corresponding to low sulfur content fuels • Low smoke achievement
Reducing Environmentally Hazardous Materials	• Total elimination of parts including mercury (Hg) • Reduction of parts including lead (Pb)

3. Engine Main Specifications and Generator Capacity

Engine Main Specifications

Engine Model		6EY22LW	6EY22ALW
Rated Power	kW	660-1080	880-1370
Rated Speed	min^{-1}	720/750	900/1000
No. of Cylinders	-	6	
Bore x Stroke	mm	220×320	
Mean Piston Speed	m/s	7.68	9.60
Mean Effective Pressure	MPa	1.45-2.47	1.45-2.50
Max. Combustion Pressure	MPa	20.0	
Applicable Generator Capacity	kWe	600-1020	800-1300

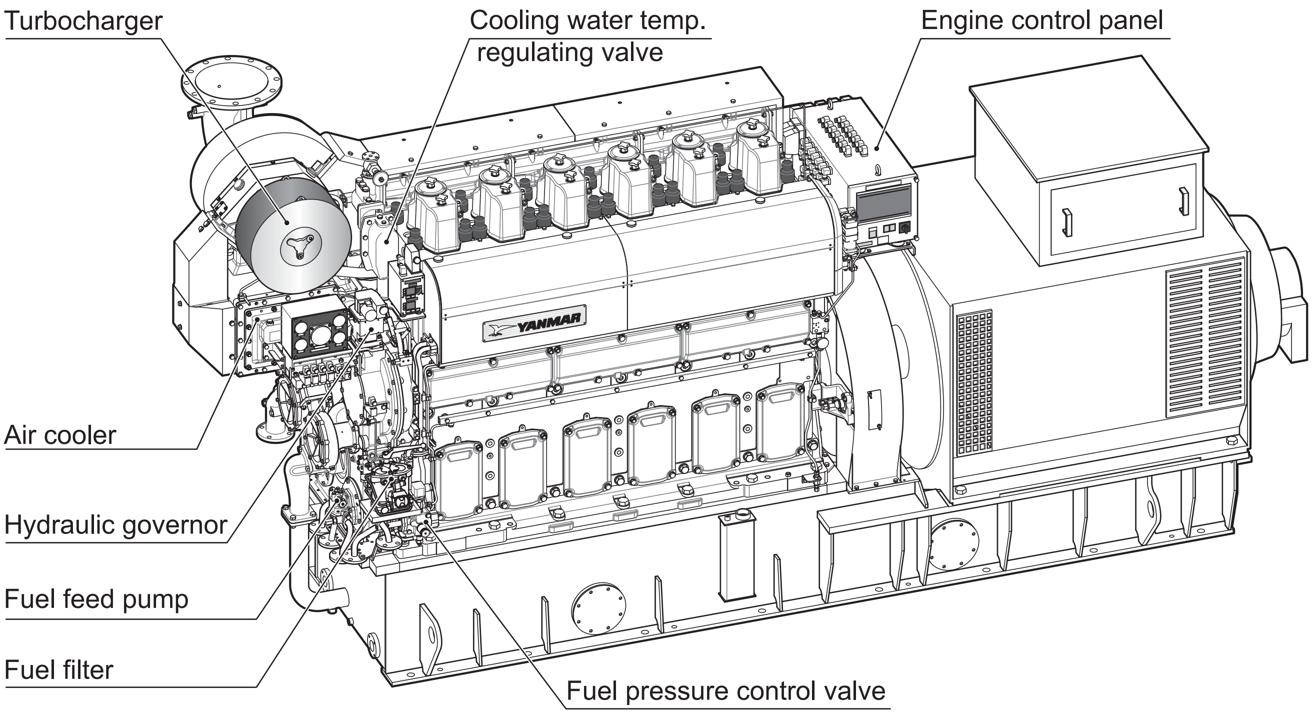
Generator Capacity



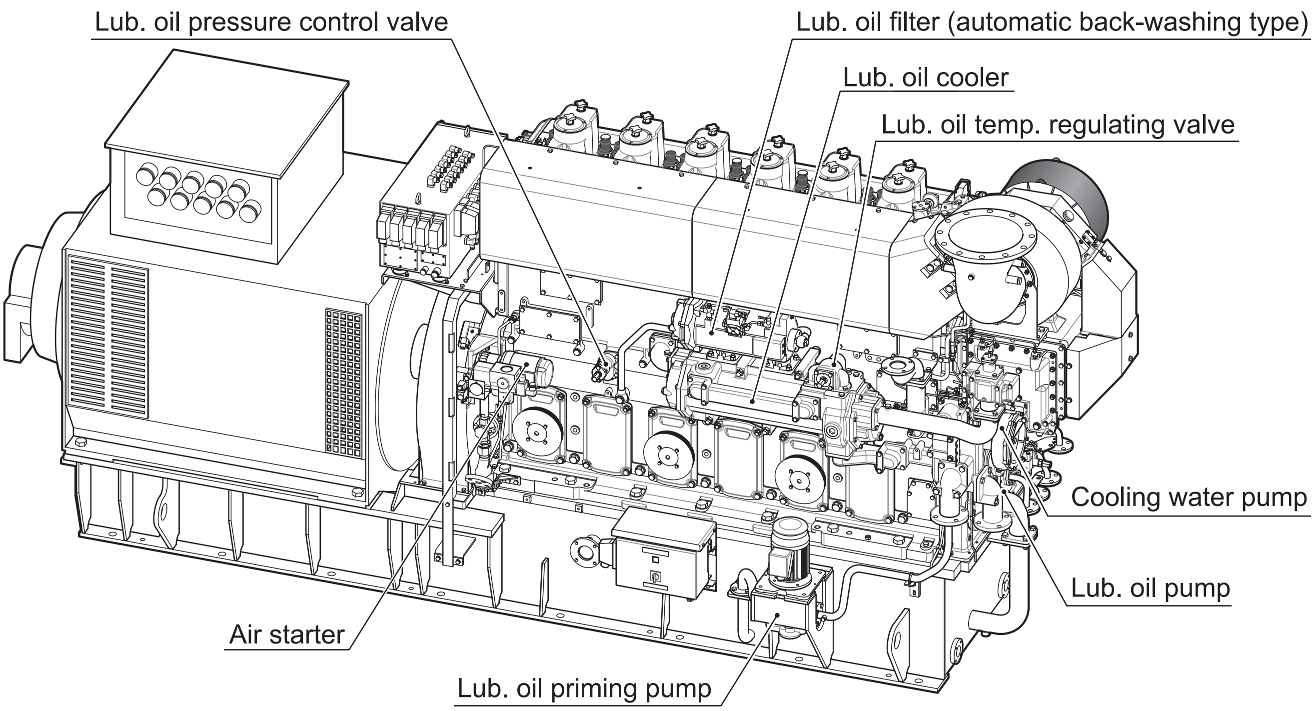
4. Structural Outline

External View

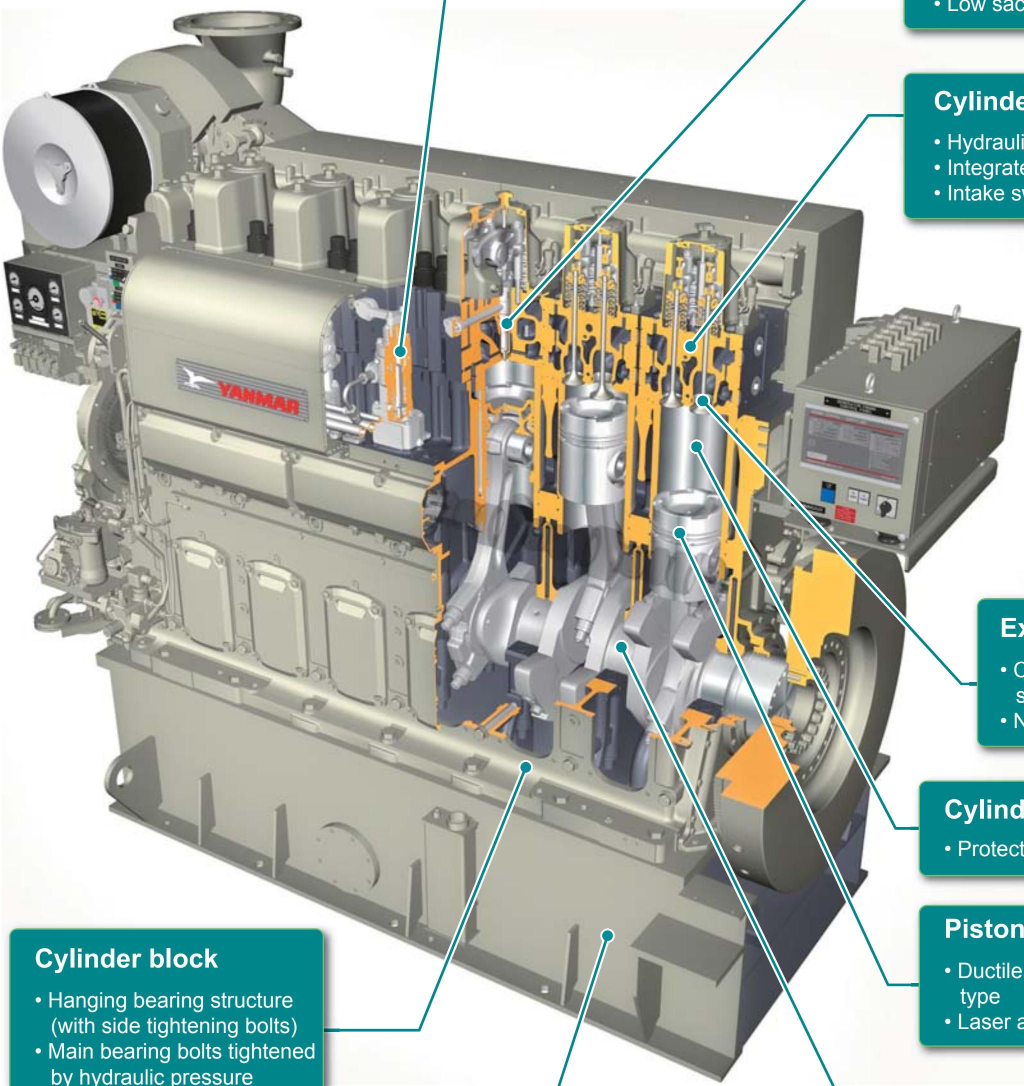
(Operation side)



(Non-operation side)



Sectional View



Fuel injection pump
- High pressure injection type
- Specialized coating plunger

Fuel injection valve
- Non-cooling type
- Staggered layout multi-holes nozzle
- Low sac type

Cylinder head
- Hydraulically tightened bolts
- Integrated intake pipe
- Intake swirl

Exhaust valve
- Cooled exhaust valve seat
- Nimonic material

Cylinder liner
- Protection ring installed

Piston
- Ductile cast iron mono-block type
- Laser alloyed ring grooves

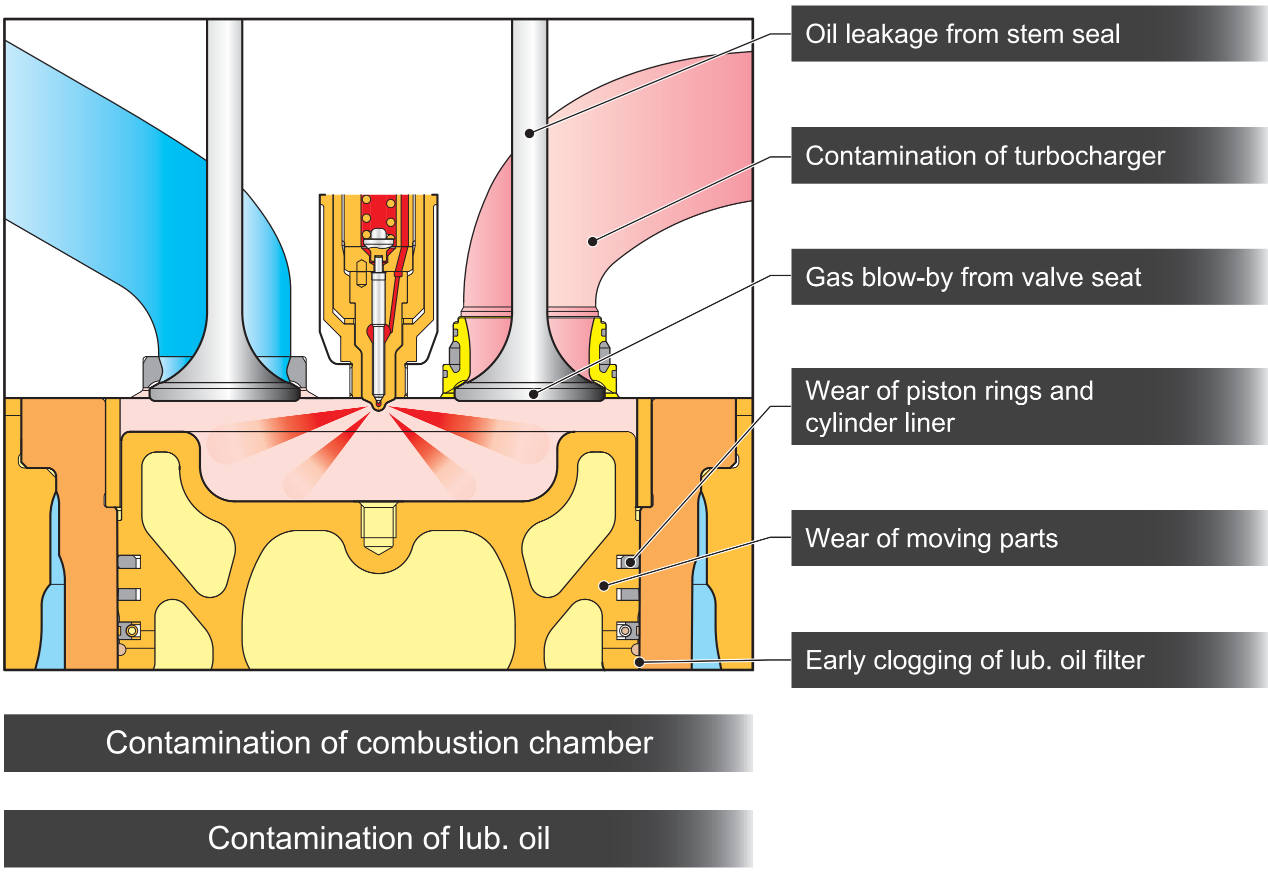
Crankshaft
- Forged special steel
- 12 balance weights

Cylinder block
- Hanging bearing structure (with side tightening bolts)
- Main bearing bolts tightened by hydraulic pressure

Common bed
- Built-in sump tank

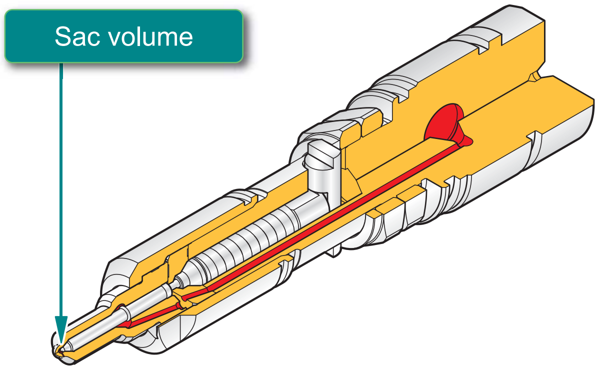
5. Raising Life Cycle Value (L.C.V.)

Along with performance (environmental), Life Cycle Value (L.C.V.) is one of the important engine characteristics. L.C.V. represents reliability (lower life costs) and easy maintenance throughout the life of the engine.
This engine offers greater reliability thanks to the combination of extremely thorough control of contamination in the combustion chamber and lub. oil, and longer maintenance intervals. Manhours are reduced because of engine disassembly and reassembly and also onboard outfitting works have been simplified.

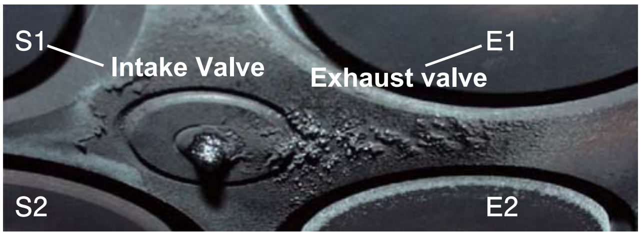


The Low Sac Fuel Injection Valve

The volume of the sac at the tip of the fuel injection valve is minimized. Injection is sharper and post injection dripping is restrained, which eliminates contamination from unburned fuel. Nitriding treatment of the outside of the fuel valve enhances heat resistance and durability against corrosion for longer service life.
In addition, valve opening pressure has been increased up to approx. 30%. It improves atomization of the injected fuel and reduced smoke density during low load operation.

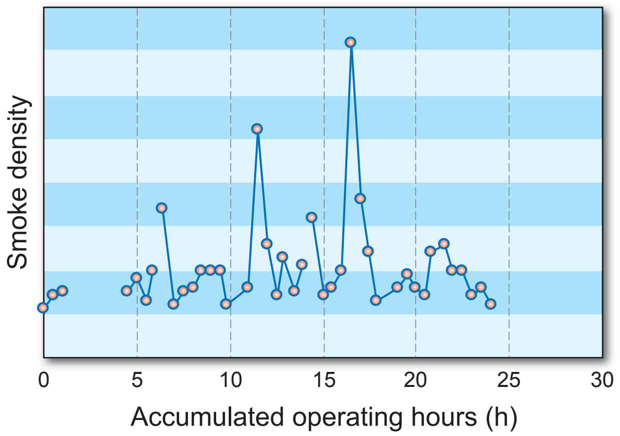


The effect of low sac fuel valves

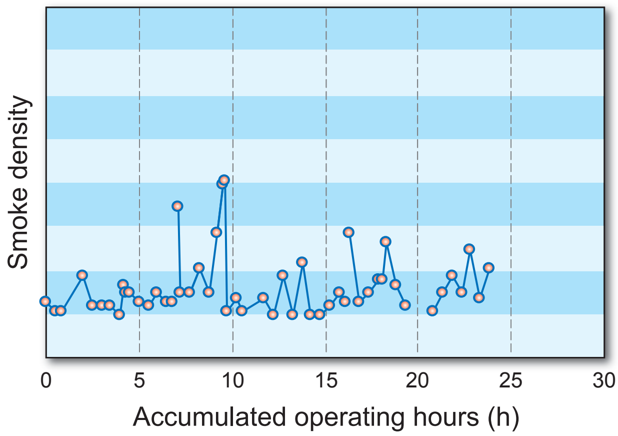
Conventional sac	Low sac
	

The effect of valve opening pressure (Heavy fuel oil (H.F.O.) operation, engine load 10%)

Conventional Valve Opening Pressure

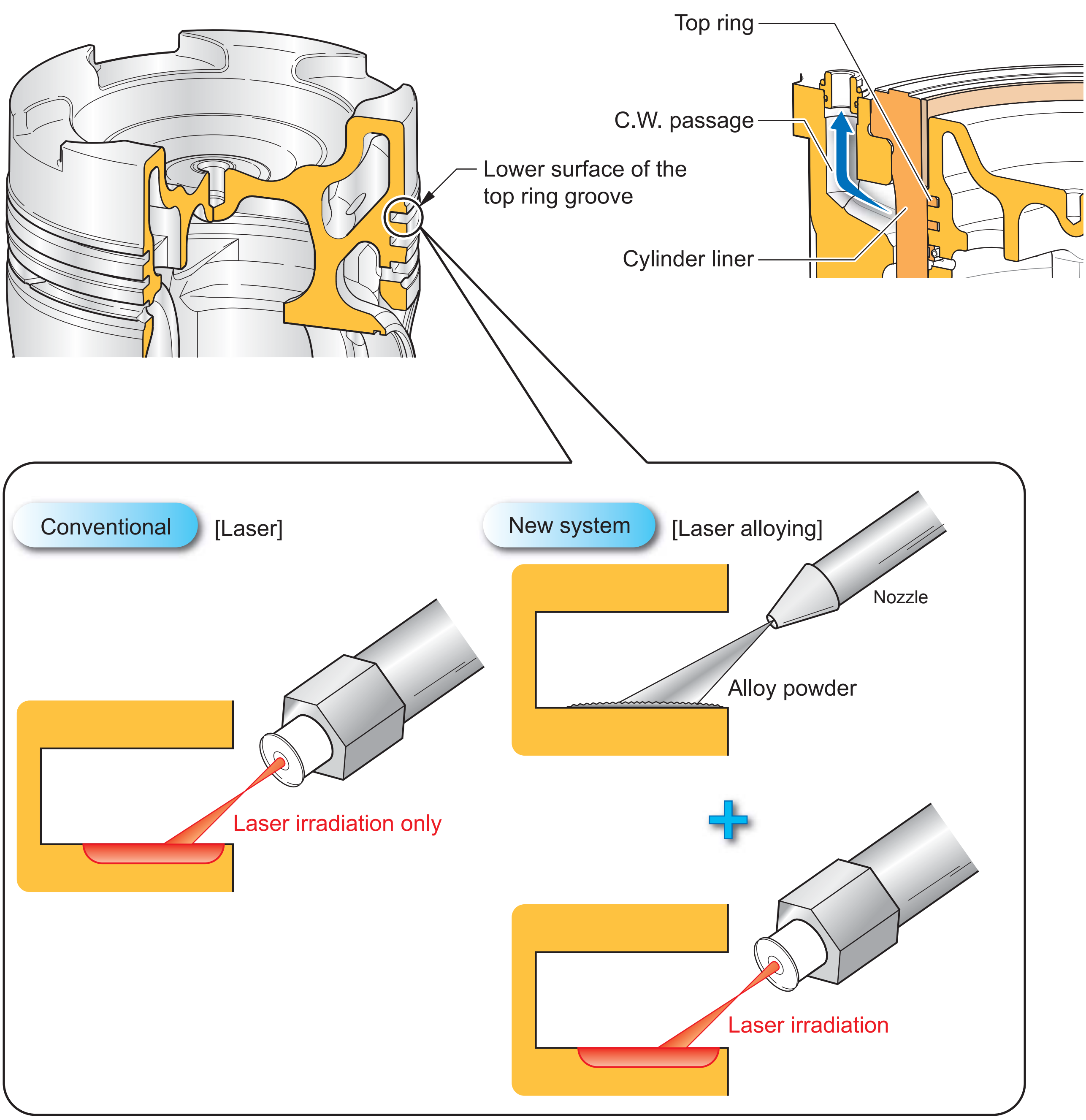


Increased Valve Opening Pressure



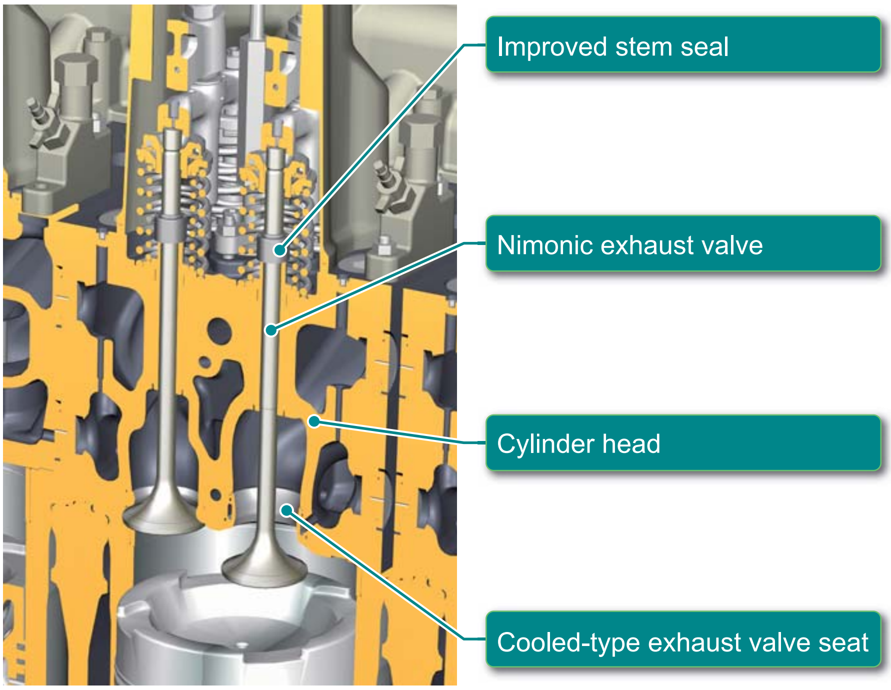
Laser Alloyed Piston Ring Grooves

- The piston is a nodular thin wall design with excellent high temperature resistance and uses graphite cast iron. Laser alloying is used on the bottom of the top ring groove for minimal wear even when using H.F.O.
  Minimizing of thermal expansion allows for a smaller piston skirt. This improves stability and reduces lub. oil consumption.
- This design provides uniform and sufficient cooling of the outer liner up to the top ring. By controlling the temperature of the combustion chamber wall, it also prevents wear of the rings.

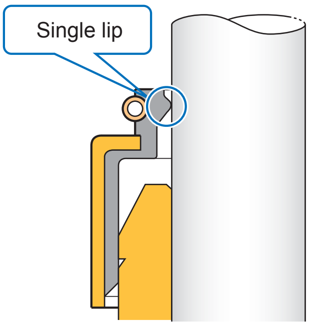


Intake and Exhaust Valve Stem Seals

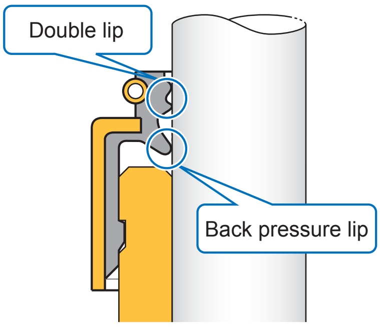
This structure is designed for dependability even when using H.F.O. The exhaust valve seat is a cooled type and the exhaust valve is made of nimonic alloy. To reduce contamination, seals have a back pressure lip configuration on the intake and exhaust valves to ensure a proper supply of lub. oil without being affected by the boost pressure or misalignment of the stem.



Conventional (Single Lip)



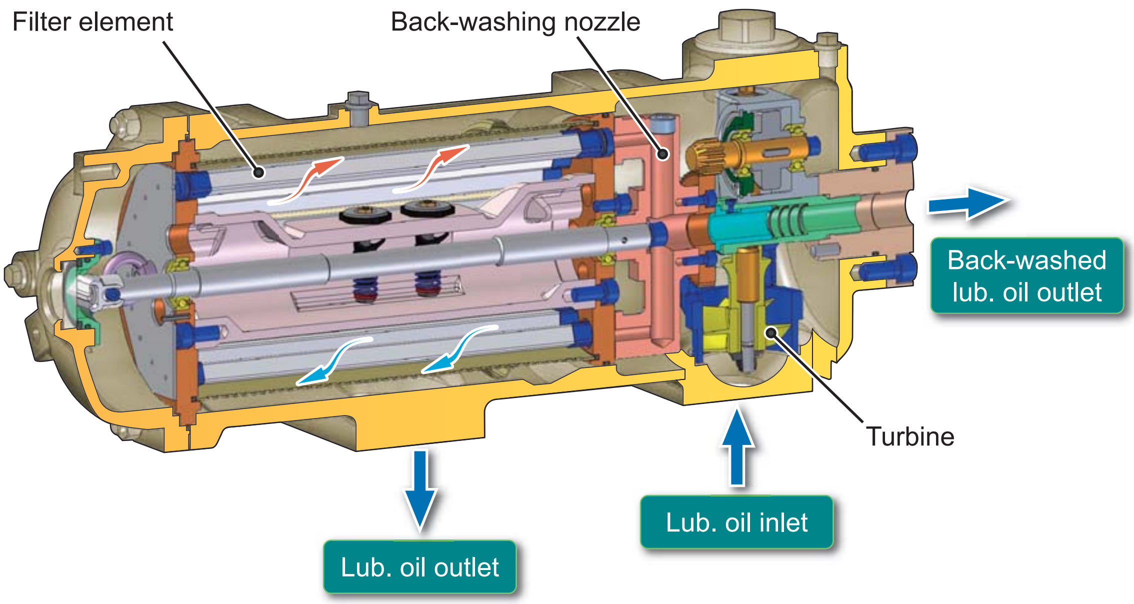
New (Double Lip with Back Pressure Lip)



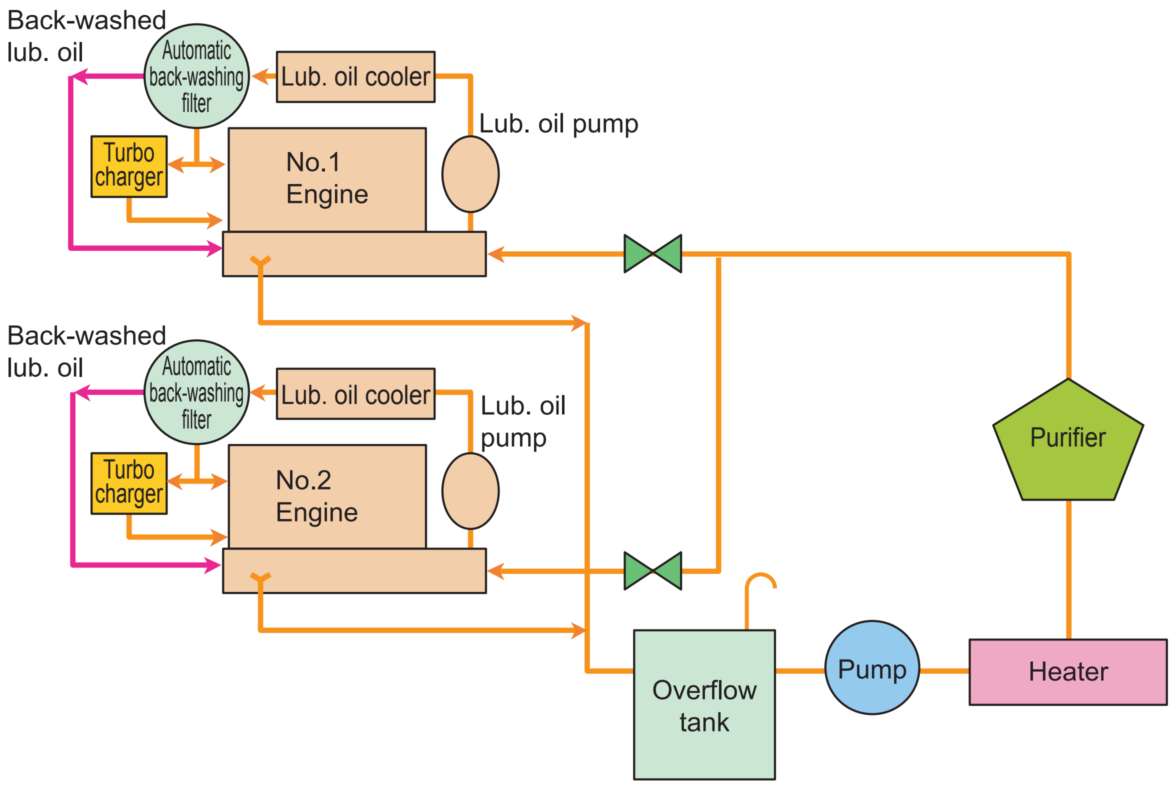
Automatic Back-Washing Lubricating Oil Filter

The constant automatic back washing of the filter element allows clogging of the filter element to be controlled over the long period. The filter element has an accuracy of 30μm, depending on the turbocharger, and filter is identical for both the engine and the turbocharger.

The oil that has been flushed out through automatic back-washing is then cleaned by the overflow system.

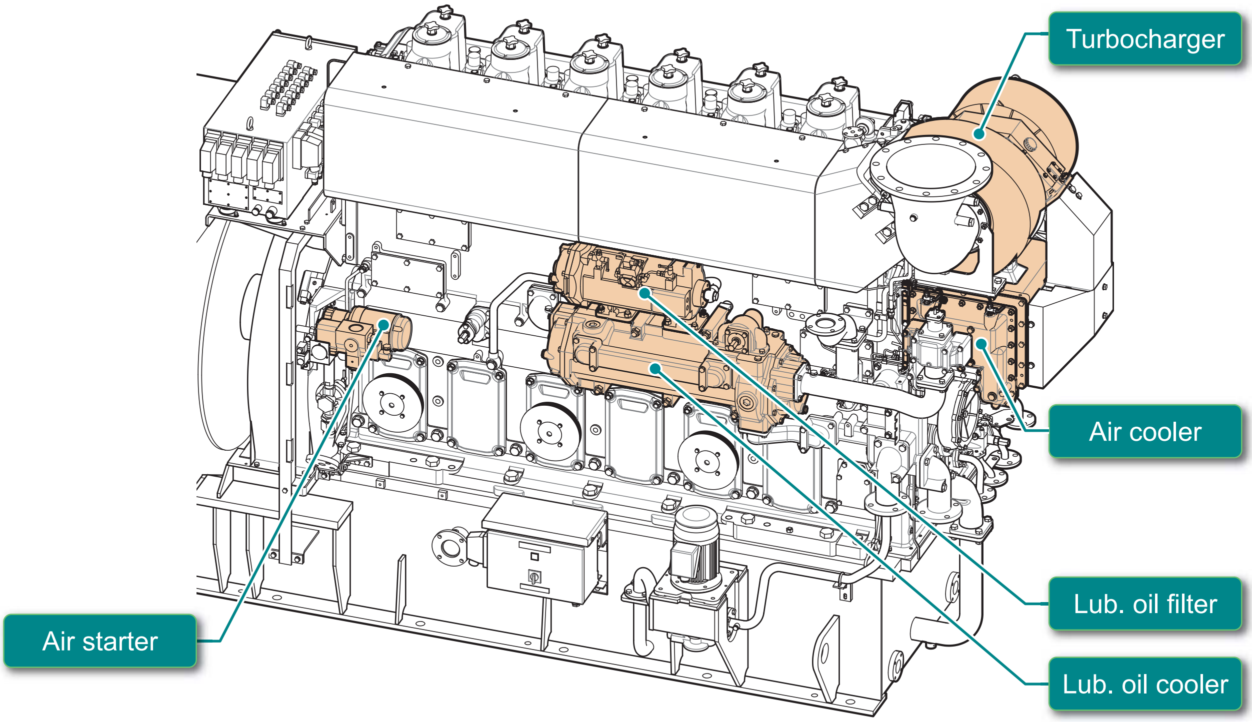


Lubricating Oil Purification System (Overflow System)

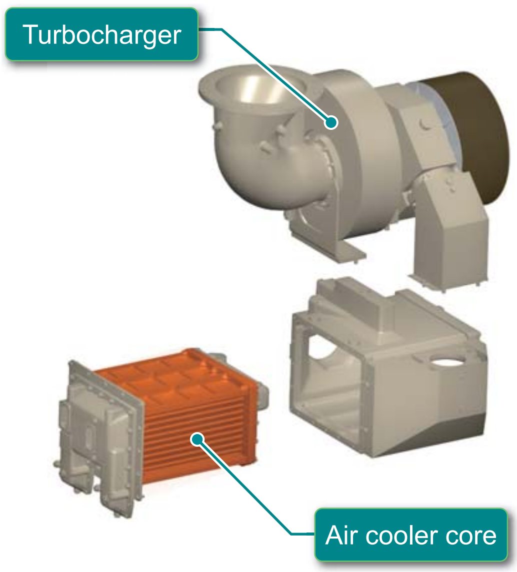


Easy Maintenance

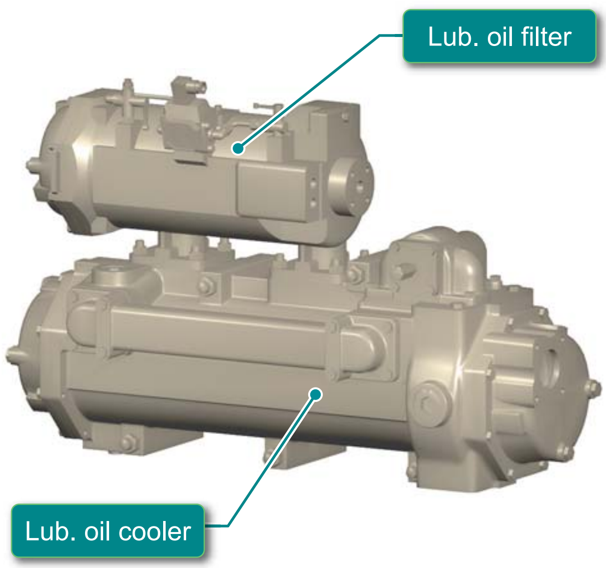
The connecting rod, main bearing bolts and cylinder bolts are tightened hydraulically. Ample space is available for maintenance because the layout of equipments has been optimized, so the engine is also designed for easy overhaul. The air cooler and lub. oil system parts are constructed in modular units for compactness and a reduced number of parts to maintain.



■Modular construction of the turbocharger and air cooler.

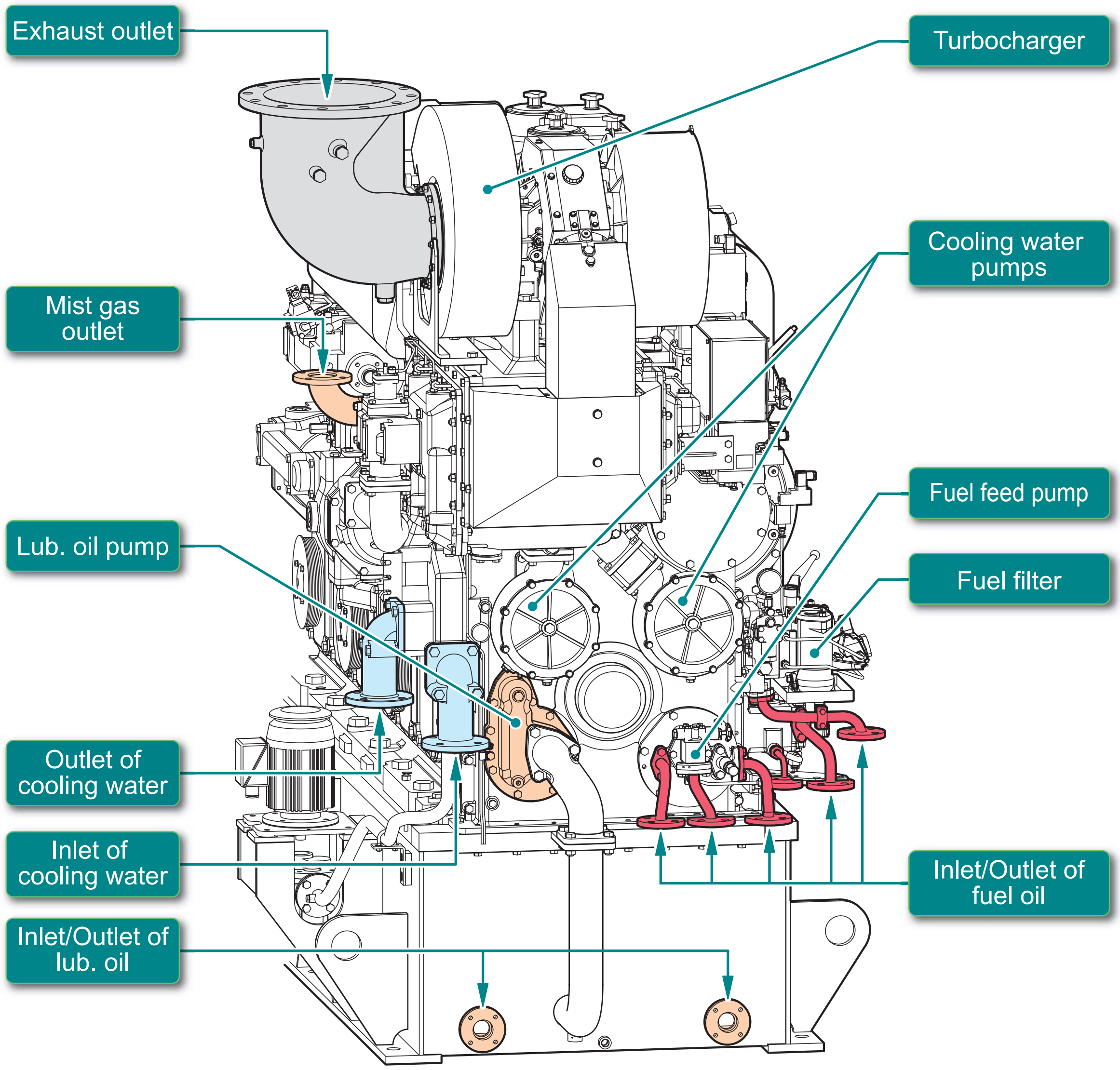


■Modular construction of the lub. oil system.

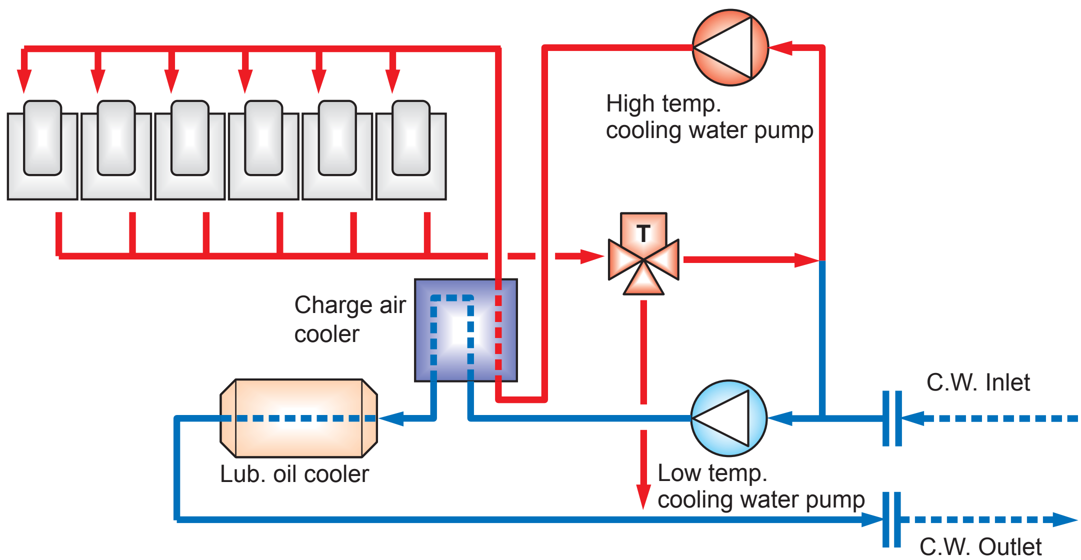


Piping and Wiring Joints

Piping joints are concentrated on the front side of the engine. Mixed freshwater cooling system improves ease of installation and simplifies piping layout onboard the ship.



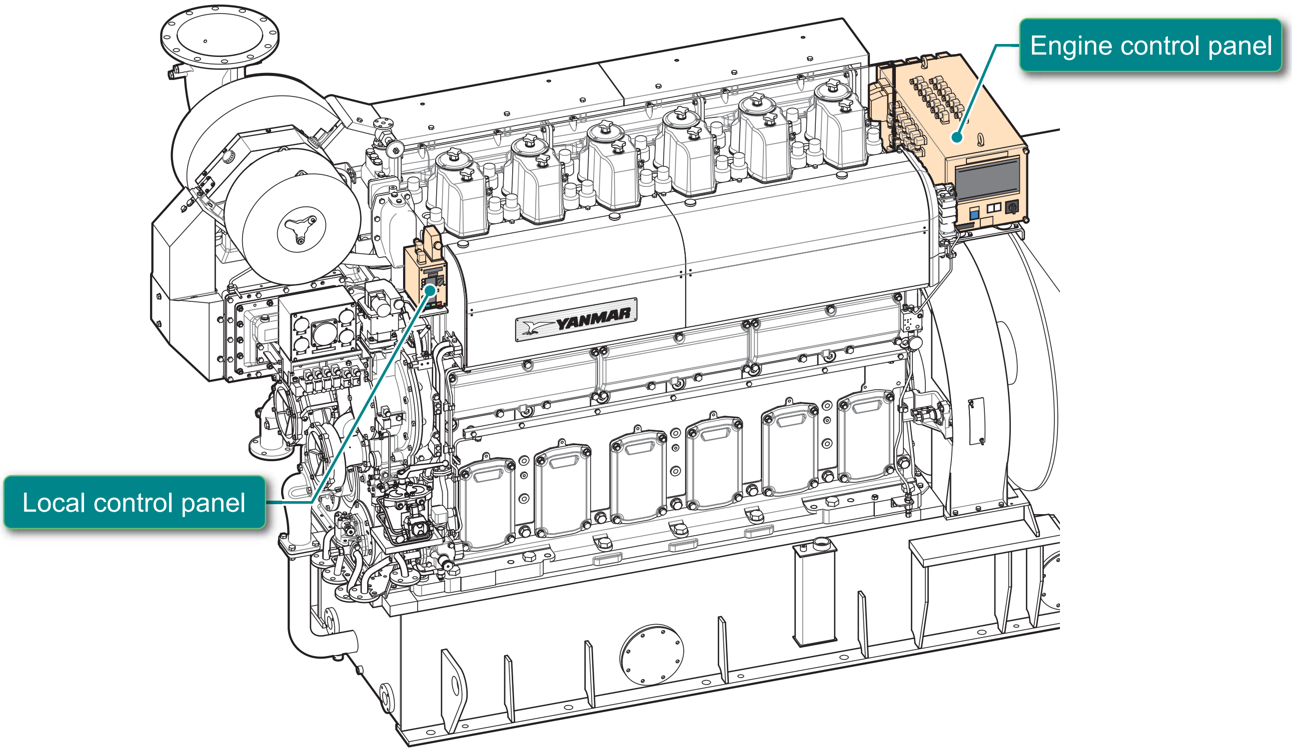
Mixed freshwater cooling system



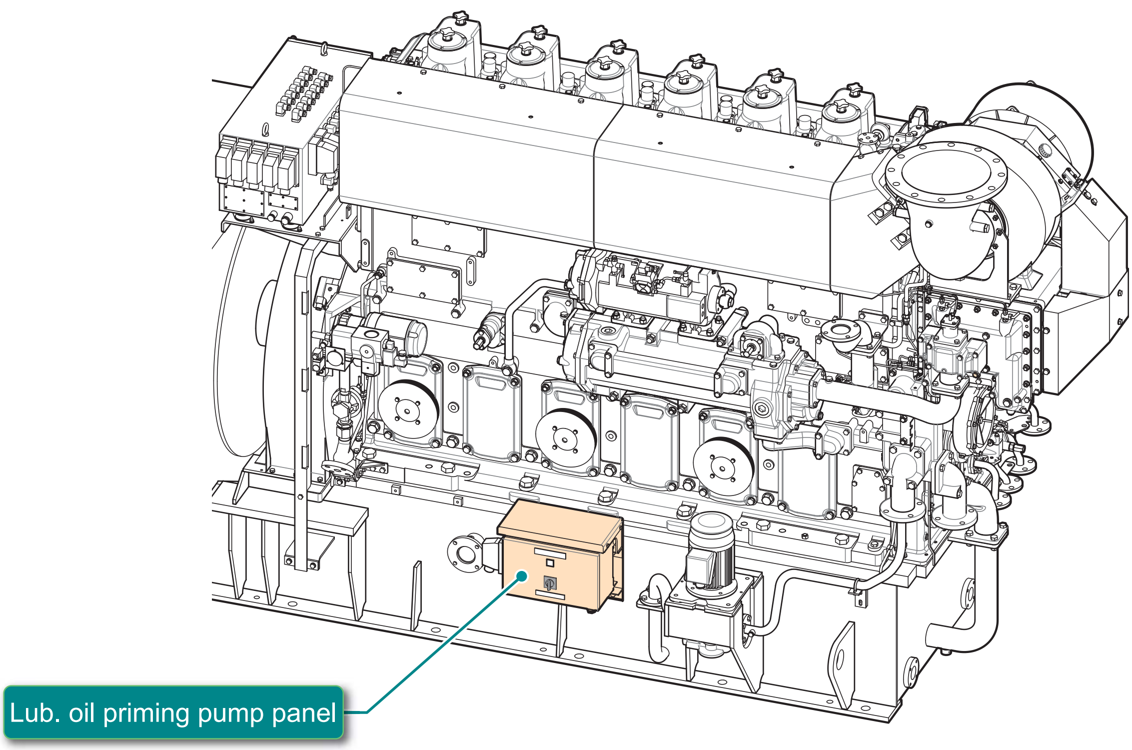
Piping and Wiring Joints

The engine control panel, local control panel, and lub. oil priming pump panel save the space usually had been used for control panel and make the wiring between the control panel and the engine unnecessary.
This feature improves safety by using each engine its own control panel. By installing a control panel and engine both made by Yanmar, quality assurance and service have also been improved.

(Operation side)

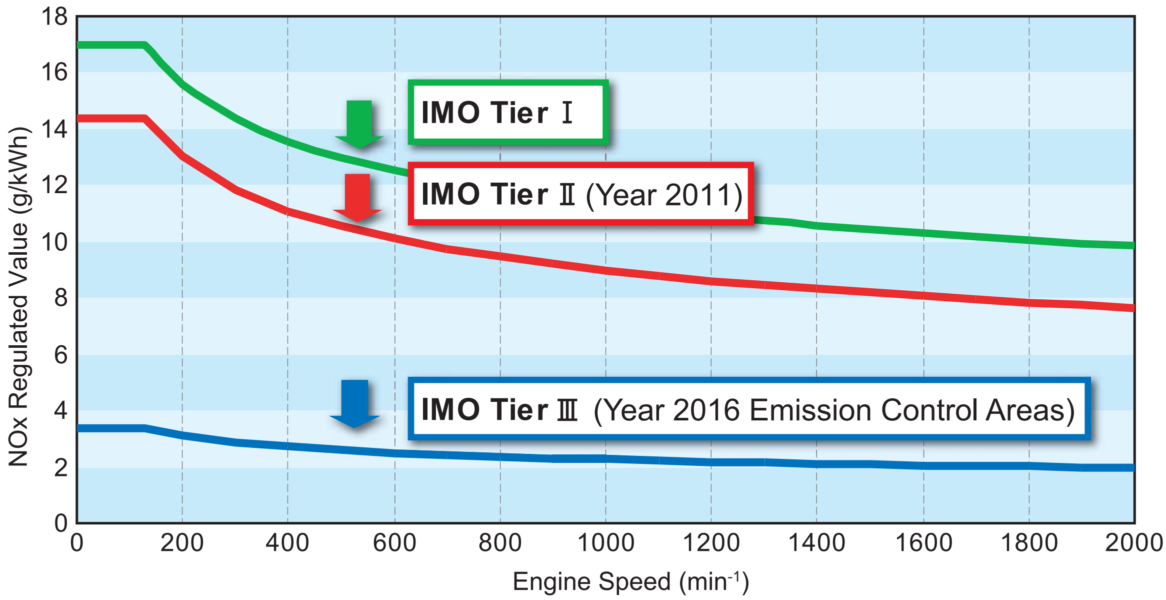


(Non-operation side)

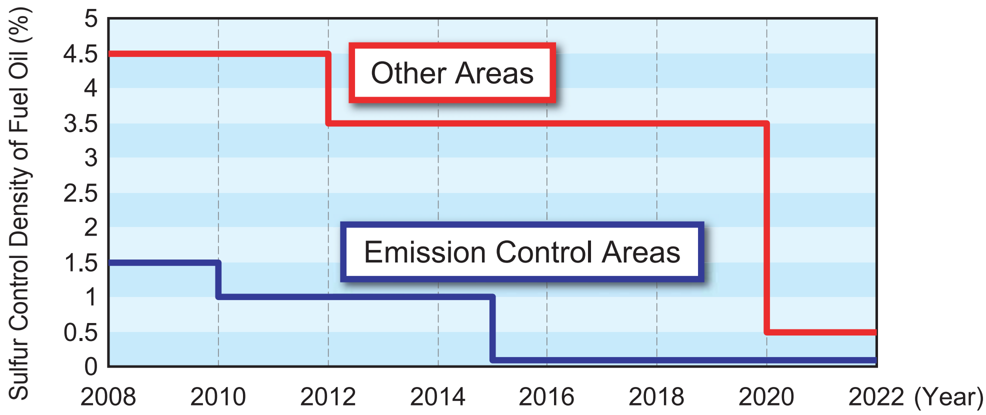


6. Harmony with the Environment

The pollution of the atmosphere by hazardous substances released from marine diesel engines has become a major global issue. The release of hazardous substances into the atmosphere by ships is regulated by the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). Annex VI: Prevention of Air Pollution from Ships was later passed in September 1997. As a result, the regulation of NOx emission levels began for marine diesel engines with a power of above 130 kW on vessels built on or after January 1, 2000. A further amendment was passed in October, 2008 and engines mounted in vessels built on or after January 1, 2011 face even stricter Tier II regulations.
Technological solutions have been developed to overcome these regulatory challenges including engine technologies, supplementary technologies and post processing technologies. Yanmar is addressing the stricter IMO Tier II regulation NOx limits with improvements to combustion technologies of engine.



The regulations on NOx and SOx emissions continue to grow stricter. In special "Emission Control Areas" established by various countries, the sulphur content of fuel oil used must be 0.1% or below after 2015. The limit of 0.1% sulphur content in fuel oil has already been in effect within the EU for vessels anchoring within a bay or traversing inland waterways since January 1, 2010.
The 6EY22 has been modified to correspond to low sulfur (low viscosity, low lubricity) fuels through alterations to the fuel and other systems.

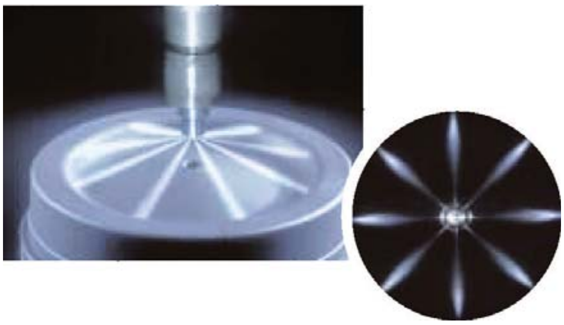


6.1 ASSIGN Combustion System

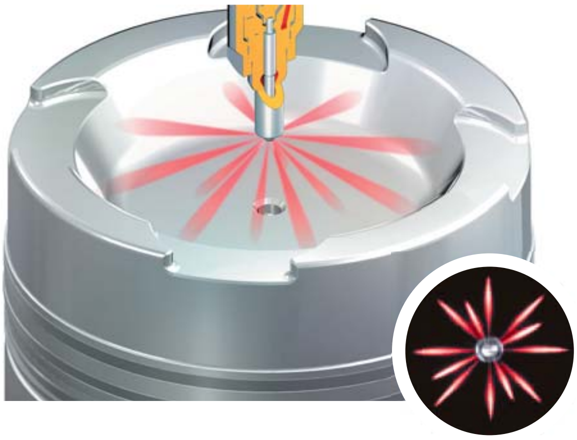
Staggered Layout Multi-Hole Nozzle

By staggering the layout and using multiple injection holes, this design achieves sufficient total injection area and improves air utilization.

Conventional injection system



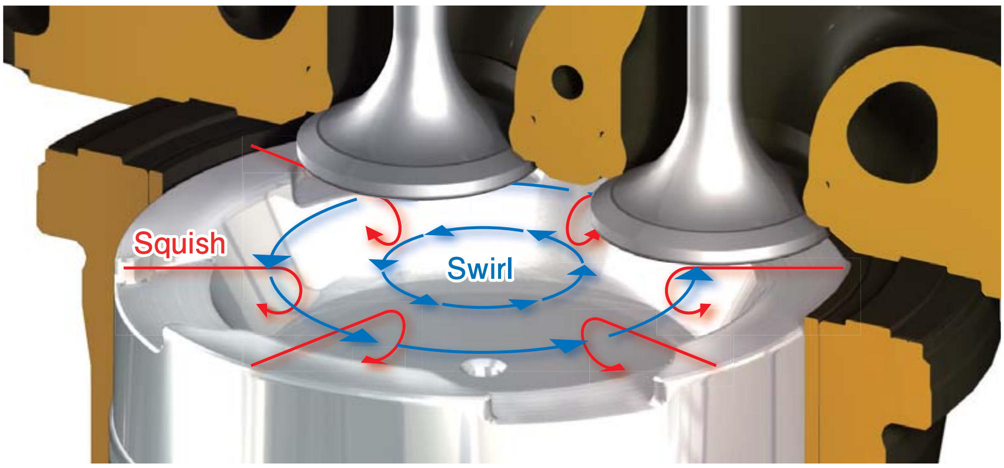
Staggered layout injection system



Air Flow Motion

The optimally shaped air intake port generates a suitable swirl (vortex flow) in the combustion chamber as well as a squish in the compression stroke. This promotes fuel/air mixing, improving combustion efficiency.

Intake swirl and squish



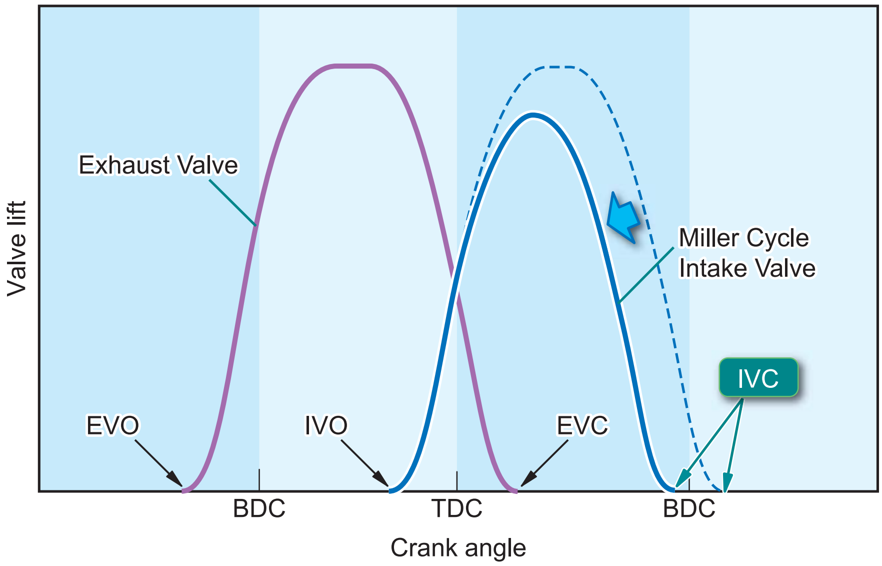
6.2 High Pressure Miller Cycle System

Miller Type Cam

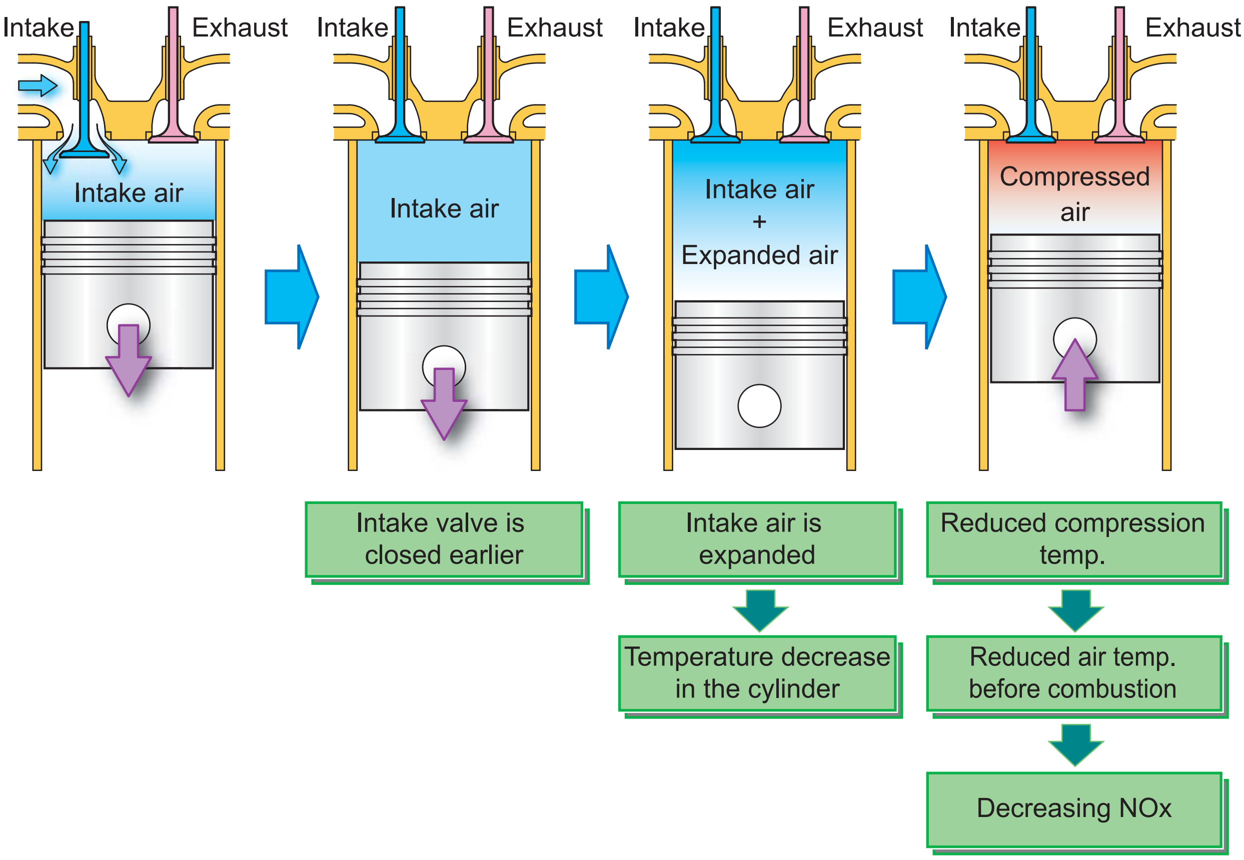
Reduced air temperature before combustion → Decreasing NOx

With the miller type cam in its intake stroke, the miller cycle closes the intake valve earlier than conventional combustion. By finishing the intake stroke earlier, the intake air expands and temperature in the cylinder decreases, and by reducing air temperature before combustion in the next compression stroke, the NOx emission is reduced.

Intake/exhaust valve lift diagram



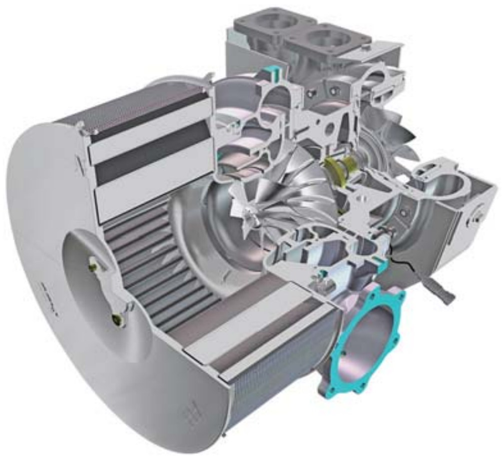
EVO : Exhaust Valve Open
IVO : Intake Valve Open
EVC : Exhaust Valve Close
IVC : Intake Valve Close

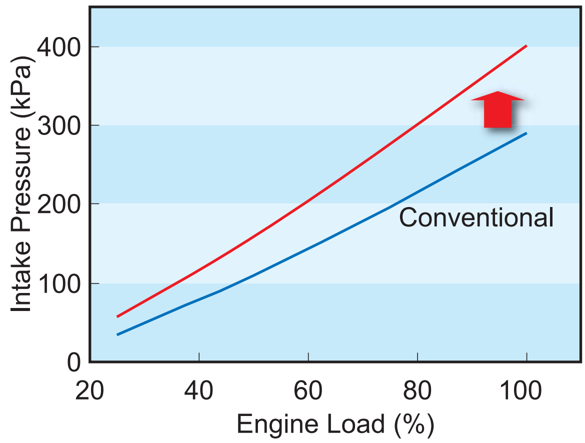


High Pressure Ratio Turbocharger

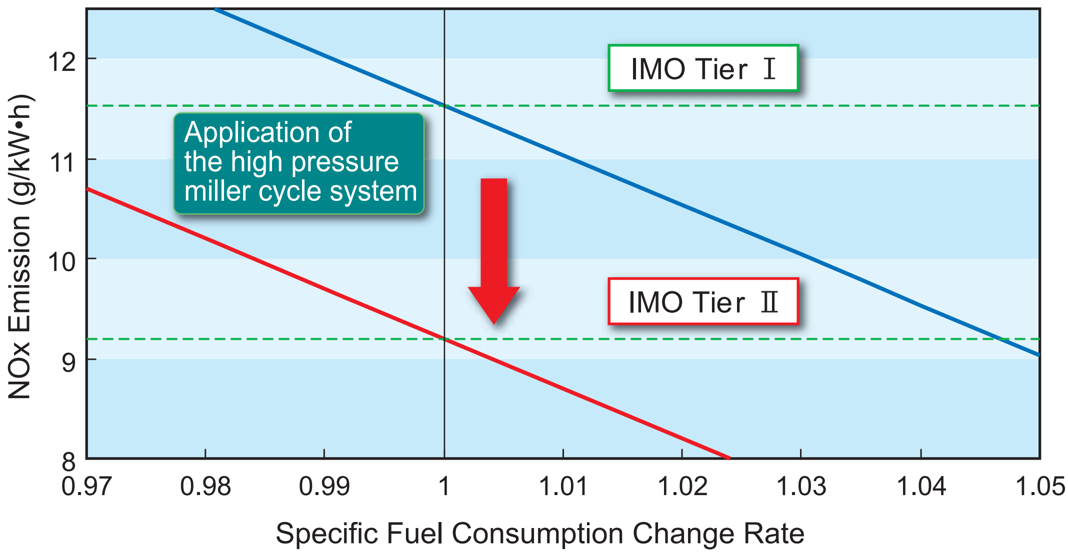
Recovery of pressure in the cylinder → Improved fuel consumption

Using the method of finishing the intake stroke earlier alone decreases the air quantity charged in the cylinder, resulting in decreasing the cylinder pressure and worsening the specific fuel consumption. Increasing the intake pressure by high pressure ratio turbocharger during the short intake stroke ensures the quantity of charged air and fixes the cylinder pressure to restrain the increase of the specific fuel consumption.





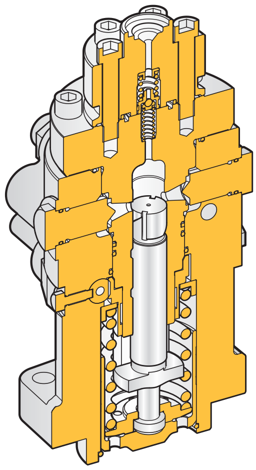
Relation between Specific Fuel Consumption and NOx Emission



6.3 Corresponding to Low Sulfur Fuels (Decrease SOx)

Fuel Injection Pump Plunger Coating

The clearance of plunger and barrel for fuel injection pump has been revised to reduce the amount of fuel leakage as well as to improve sticking resistance when using low sulfur fuel (low viscosity), the plunger is coated with special coating (DLC: Diamond-Like Carbon).

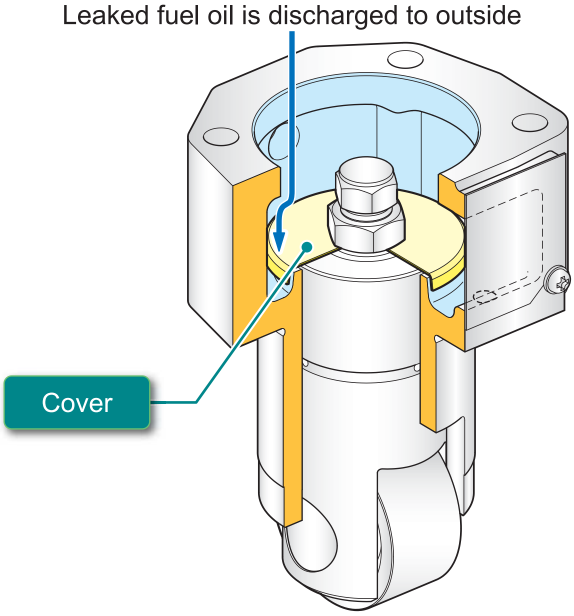


Fuel injection unit test result

Fuel used	: Kerosene
Kinematic viscosity	: 1.371mm^2/s at 30°C
Sulfur content	: < 0.01%
HFRR	: 744
Operating hours	: 100hr

Fuel Injection Pump Drive System

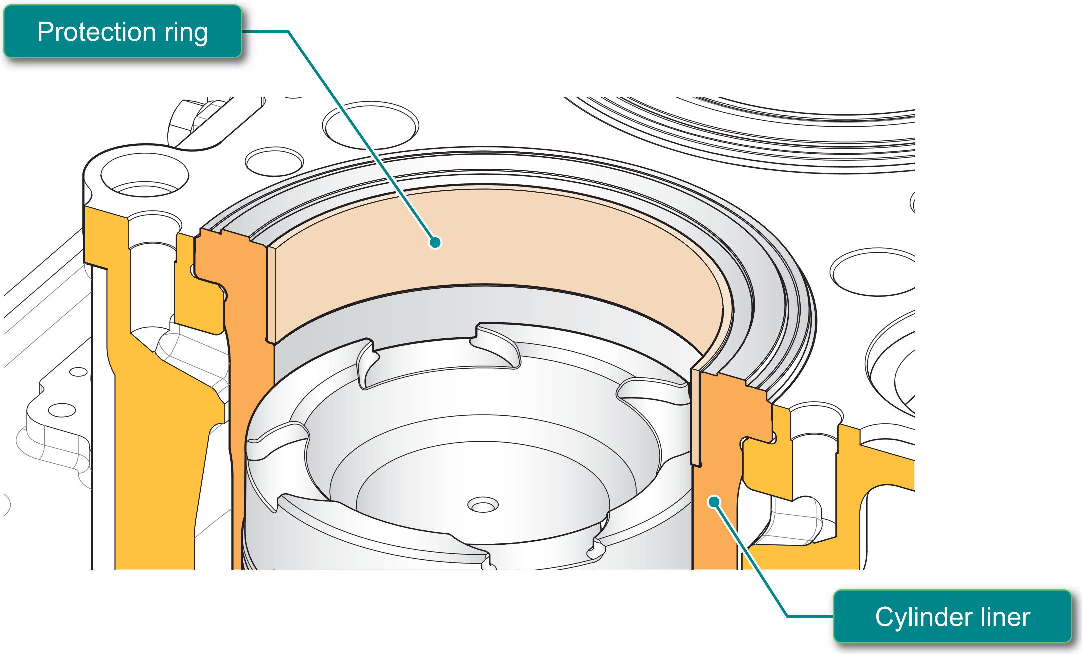
PF type, separate drive equipment, is adopted for fuel pump. A cover is provided on the upper part of roller tappet to ensure discharging outside of leaked fuel from the clearance of plunger and barrel to prevent the mixture of fuel into the cylinder.



Protection Ring

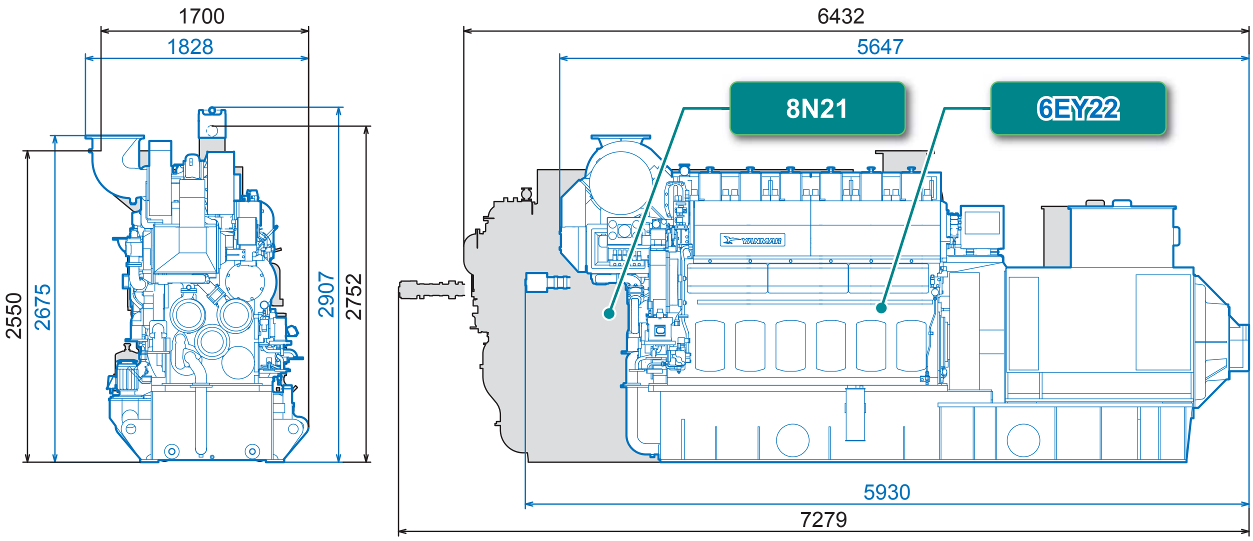
A protection ring is equipped on the upper part of cylinder liner.

When the low sulfur fuel is used concurrently with the high alkalinity value (Total Base Number: TBN) lub. oil, additives (calcium carbonate) in the lub. oil adhere on the high temperature parts along with carbon residue. The residue adhered on the outside circumference of the piston top part trims the liner inner wall, which may cause scuffing and the increase of lub. oil consumption. The protection ring prevents sedimentation of residues on the outside circumference of the piston top part and cylinder liner wear.



7. Comparison of Outside Dimension and Maintenance Interval

Comparison of outside dimension (6EY22 and 8N21)



Note: 6EY22 is indicated by blue.

Engine Model	Total Mass (kg)
6EY22	18,100
8N21	20,200

Maintenance interval and expected service life (H.F.O.)

(Unit: hr)

	Overhaul Interval	Expected Service Life
Fuel Injection Nozzle	2,000	8,000 (2 years)
Exhaust Valve	8,000-12,000	20,000-30,000 (5 years)
Intake Valve		20,000-30,000 (5 years)
Piston		40,000-60,000 (10 years)
Cylinder Liner		40,000-60,000 (10 years)
Crank Pin Bearing		20,000-30,000 (5 years)
Main Bearing		40,000-60,000 (10 years)
Turbocharger Bearing		20,000-30,000 (5 years)

8. Development, Manufacturing and Service Network

The Amagasaki Plant

Yanmar's Amagasaki Plant was founded in 1936 to produce the world's first small diesel engines. It subsequently converted mainly to the production of large diesel engines including marine propulsions and auxiliaries, industrial diesels and gas engines. The plant began the production of gas turbines in 1983.

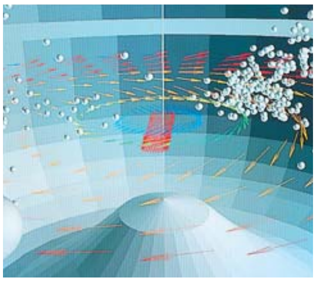
Amagasaki Plant

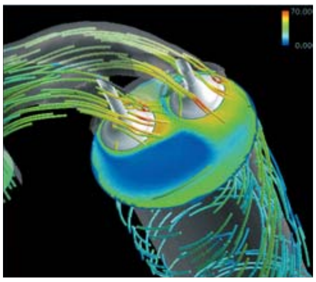
■Certified by Nine World's Major Shipping Classification Associations (world first)

- LRS (Lloyd's Register of Shipping)
- ABS (American Bureau of Shipping)
- NK (Nippon Kaiji Kyokai)
- DNV (Det Norske Veritas)
- BV (Bureau Veritas)
- RINA (Registro Italiano Navale)
- GL (Germanischer Lloyd)
- CCS (China Classification Society)
- KR (Korean Register of Shipping)

■Research and Development

Based on its own engine technologies, Yanmar has been dedicated to developing not only in decrease of fuel consumption, but the first to developing environmental technologies including the reduction of vibration, noise and exhaust emissions.





■Production

With its own high-performance special purpose machines, state-of-the-art production facilities and advanced quality management system, Amagasaki Plant has been developing high-performance and high quality products with superior reliability and endurance.

Worldwide Service Network

Yanmar has implemented a worldwide after sales servicing with strengthened and enhanced after servicing. We do our best to respond to your request.

ASIA

JAPAN Country Code "81"

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