Wärtsilä Low-speed Generation X Engines

3800TEU Container Vessel

Wärtsilä X-engines are tailor-made for small tankers and bulkers, Suezmax tankers, Panamax/Capesize bulkers, VLCC/VLOC, ultra-large container vessels, Panamax container vessels and feeder container vessels. High propulsion effciency, low fuel consumption and full compliance with emission legislation.

WIN GD
Winterthur Gas & Diesel

The shipping industry currently faces demanding economic and environmental challenges.

In order to comply with the latest environmental regulations, ships require both a high Energy Effciency Design Index (EEDI), and low levels of exhaust gas emissions (NOx and SOx limitations). The cyclical global economy, the ongoing overcapacity of vessel availability, high competition, fluctuating fuel prices, and low freight rates are all factors driving the need for greater effciency and flexibility in order to remain profitable.

WinGD has responded to the current situation by introducing the X-engines to provide customers with an optimal and flexible solution for facing these challenges. The X-engine parameters are based on careful and detailed market analyses in order to implement the key customer needs.

As a result, X-engines provide the following benefits

High engine efficiency

With the X-engines, fuel consumption has been reduced by up to 2% compared to the RT-flex engines thanks to the extra-long engine stroke. An additional fuel saving up to 3% can be reached by de-rating the engine.

Lower RPM

The X-engines have been designed for extra low engine speeds that allow an increase in the propeller diameter. This increases the propulsion efficiency by up to 5%.

First cost-optimised design for competitive production costs

The cost on design base is monitored throughout the entire lifetime of our engines. Competitive production costs are achieved through standardisation, by choosing the most suitable materials, and by limiting the number of components. The entire X-engines family has the same design feature, which means that less training is required for personnel in both the manufacturing and service functions.

Compact dimensions and less weight

The engine stroke has been precisely designed so as to increase the stroke-to-bore ratio to the optimal point. This maximizes fuel efficiency, while at the same time keeping the engine dimensions relatively compact with less weight compared to similar engines on the market.

IMO Tier III ready

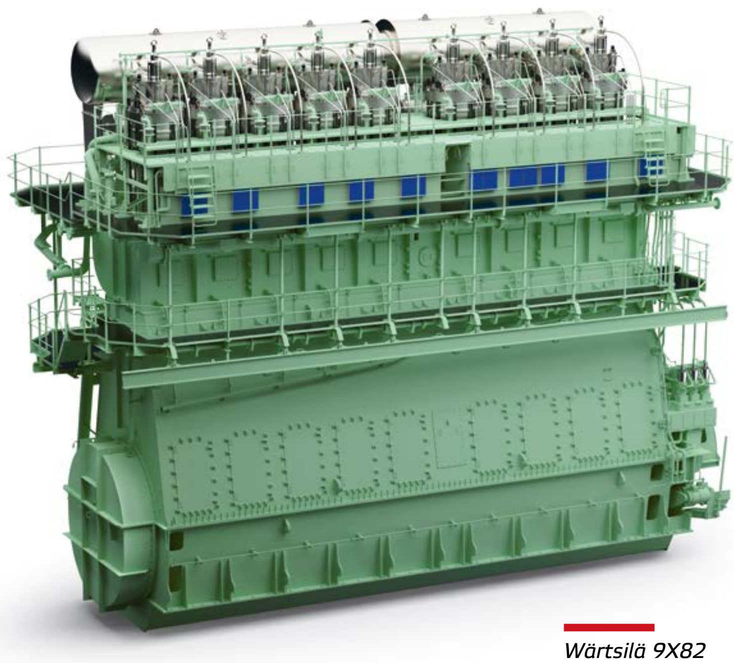
X-engines have been designed for easy interfacing with SCR systems (both high pressure and low pressure) in order to reach the required Tier III limits.

LNG ready

Thanks to the LNG-ready concept, the engine can be easily converted to operate in gas mode for Tier III compliance.

Increasing steam production and waste heat recovery (WHR)

The X-engines can be equipped with an optional analogue controlled turbocharger bypass valve that opens on demand to increase steam production when large amounts of steam are needed. For large bore engines, the waste heat recovery (WHR) concept provides the possibility to further increase the total efficiency of the vessel and improve its EEDI.



Wärtsilä 9X82

Flexible engine operation

An important feature of the X-engines is their high operational flexibility. This is thanks to the common-rail fuel system and the availability of different engine tunings to provide flexibility in the performance parameters.

These tuning options with X-engines enable specific needs to be met, such as Tier II compliance and optimal performance for various operational profiles, like slow steaming, low load, partial load, and steam requirements.

Available engine tunings

The X-engines can be optimised for low, partial or high load operation. The following tuning options (Fig. 1) can be selected:

Standard Tuning high load tuning, Tier II compliant, optimised for engine loads above 90%.

Delta Tuning part load tuning, Tier II compliant, optimised for engine loads between 75% – 90%.

Delta Bypass Tuning part load tuning with a lower BSFC below 50% engine load[1], Tier II compliant, optimised for increasing steam production above 50% engine load, and reduced fuel consumption below 50% engine load.

Low-load Tuning Tier II compliant, optimised for engine loads below 75%.

Turbocharger (TC) cut off (option) Where applicable, X-engines with a multi-turbocharger configuration can be equipped with a TC cut off option that significantly reduces the engine's fuel consumption at low loads. The TC cut off option is designed for slow steaming operation and the application is customised on demand.

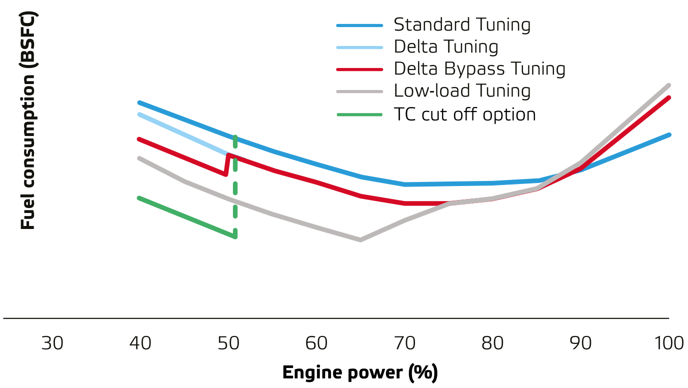


Fig. 1

Dual Tuning

Dual Tuning can be selected when a special operating profile is required. All X-engines can be built and certified with two different tuning combinations.

For example, typical applications include Delta Bypass Tuning (DBT) and Low-load Tuning (LLT).

These engine tuning options provide customers with benefits in terms of specific fuel consumption, and improved exhaust gas flow and temperatures.

The engine's NOx certification is carried out with individual Technical Files and EIAPP certificates for each tuning. Thus, NOx emissions on the test bed need to be measured for both tunings.

Dual rating

X-engines can be designed and shop tested for two different engine ratings. This means that the engine can have two optimised CMCRs on the same propeller curve (Fig. 2). As a consequence, the ship operator can select two possible optimal service speeds (Fig. 3), depending on the market conditions.

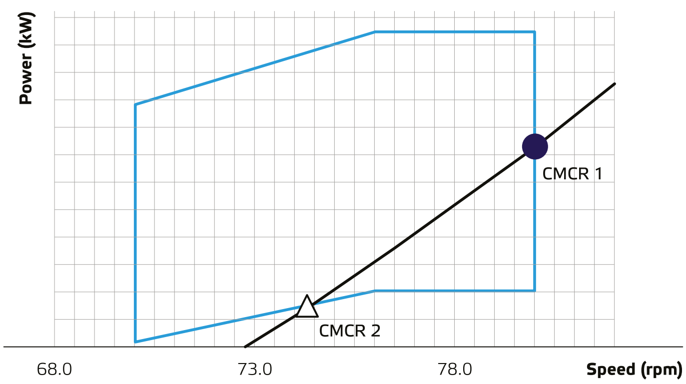


Fig. 2: Rating Field and possible CMCRs selection with Dual Rating

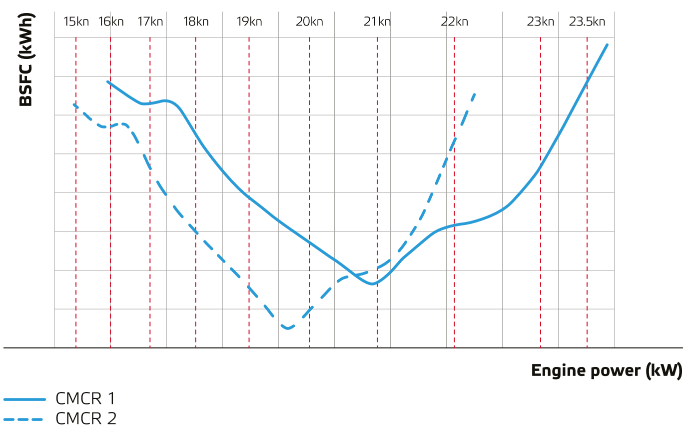


Fig. 3: BSFC for the different CMCRS

[1] Compared to the Delta Tuning

Low operation cost

Common-rail system provides high engine efficiency

All X-engines have been designed with a fully electronically controlled common-rail system that has been based on and improved from the common-rail system of the RT-flex engines, the market leader in electronically controlled low-speed marine engines.

In combination with the optimised thermodynamic process and the adoptive engine parameter setting concept, the common-rail system provides superior engine performance. The very good efficiency of the fuel injection components (high pressure fuel pumps and ICUs or injectors) significantly contributes the low fuel consumption of the whole engine.

The system allows individual cylinder injectors to be switched off, thereby optimising the operating injectors' atomization characteristics according to the available air and fuel demanded.

Common-rail technology provides great flexibility in the engine setting for lower fuel consumption, lower minimum running speeds, smokeless operation at all running speeds, and better control of exhaust emissions.

The excellent regulation of the engine's operational performance provided by the flex system also results in good manoeuvring capabilities and the lowest possible operating speeds, for example, during canal transit and port entrance.

The X-engines' common-rail technology plays a key role in enabling ship owners to meet the challenges of higher fuel costs.

Common-rail system on Wärtsilä X35 engine.

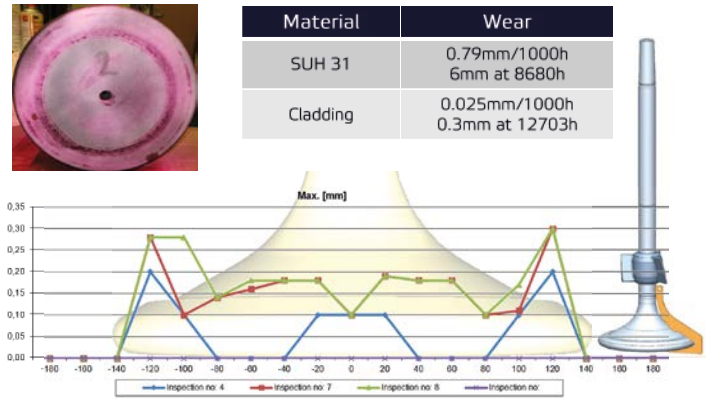
Low maintenance costs

Wärtsilä 2-stroke X-engines are designed to achieve as much as five years time between overhauls (TBO).

The TBO of low-speed marine diesel engines are largely determined by the piston-running behaviour and its effect on the wear of piston rings and cylinder liners. The X-engines' piston-running package comprises plateau-honed cylinder liners, three ring pistons with gas-tight top rings, with all three rings pre-profiled and chrome ceramic coated, and with ample thickness of the chromium layers in the piston ring grooves. The well-proven combustion component bore-cooling principle is employed in the cylinder cover, exhaust valve seat, cylinder liner and piston crown to control their temperatures, as well as the thermal strains and mechanical stresses. The surface temperatures of the cylinder liner are optimised for good piston-running behaviour. The height of the piston crown top-land has been increased and the clearances optimised to improve the sealing properties, and to reduce gas temperatures at the top ring level.

The piston running behaviour of X-engines has proven to be very satisfactory when operated according to the manufacturer's recommendations and service bulletins. As much as 30,000 running hours is possible before the piston rings need to be changed and the piston ring grooves overhauled.

The new exhaust valve has been designed to withstand the corrosion and erosion process happening in the 2-stroke engine combustion chamber at the same level as the standard Nimonic material or even better at cost reduction of minimum 30%. Cladding thickness and design were optimized in respect of material loss and manufacturing costs based on existing experience.



Material	Wear
SUH 31	0.79mm/1000h 6mm at 8680h
Cladding	0.025mm/1000h 0.3mm at 12703h

Field testing result 6RT-flex50B #2. Maximum wear of 0.3mm after 12703hrs, wear rate = 0.025mm/1000h

All other engine components exposed to wear and tear have also been further optimised to achieve a high TBO.

Different components of FAST injector inspected after 12'600 rhs.

The crank train bearings are of white metal design and the cross head bearings with their well proven lubricating oil pockets all function with excellent reliability. For engines selected in the lower area of the rating field (low engine speed), high pressure system oil (10 –14 bar) is used to ensure the correct operational behaviour of the cross head bearings.

All X-engines are equipped with FAST fuel injection valves that provide an increase in running time before the nozzle tips have to be exchanged.

The service-friendly design reduces downtime, maintains reliable vessel operations, and cuts operating costs. Together with Condition Based Maintenance (CBM) and service agreements, the overhaul intervals can be extended even further, thereby minimising maintenance costs and maximising the vessel's revenue-earning capabilities.

Steam production improvement

In order to improve the steam production on board via the exhaust gas economizer, the X-engines can be equipped with a controlled exhaust gas bypass valve. Such a valve can be opened on demand when the exhaust gas temperature is lower than the target temperature, or when the steam pressure is lower than required. As a consequence of the exhaust gas bypass opening, the exhaust gas temperature increases and steam production through the boiler is increased.

As an example, Fig. 4 shows the same X-engine with and without the variable bypass. With the variable bypass it is possible to target exactly the minimum steam production needed if the exhaust gas temperature is lower than that required. Where no variable bypass is installed, it is necessary to switch on the thermal boiler to reach the targeted steam production.

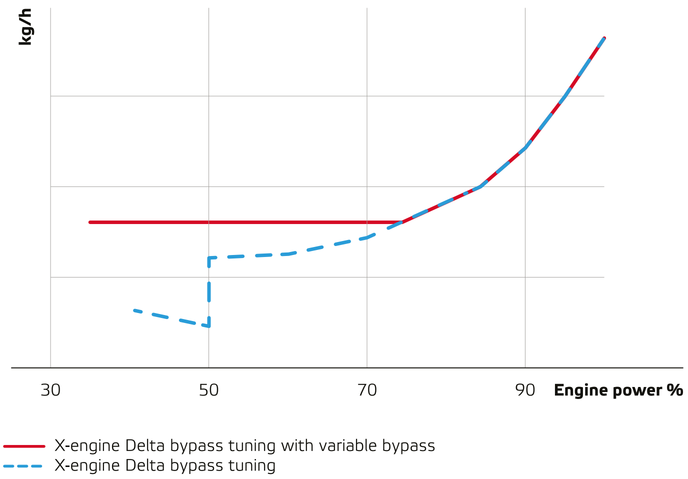


Fig. 4: Steam production comparison

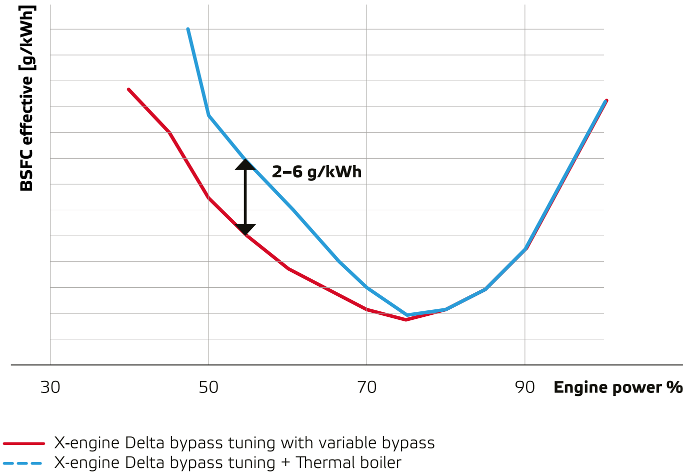


Fig. 5: Effective fuel consumption (incl. target steam production energy)

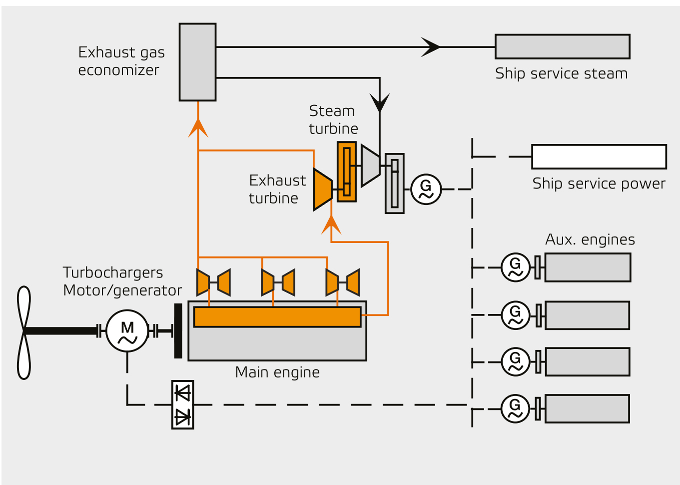
Fig. 5 indicates clearly that increasing the steam production with an engine variable bypass is more efficient than switching on the thermal boiler, and fuel consumption savings of 2–6 g/kWh are possible.

High-Efficiency Waste Heat Recovery (WHR)

Waste heat recovery is an effective technology for simultaneously cutting exhaust gas emissions and reducing fuel consumption. High-Efficiency Waste Heat Recovery plants with Wärtsilä engines enable up to 10% of the main engine shaft power to be recovered as electrical power for use as additional ship propulsion power and for shipboard services. These WHR plants thus cut exhaust gas emissions, deliver fuel savings of up to 10%, and improve the ship's EEDI.

Steam based WHR plants have already been successfully fitted in several installations using Wärtsilä low-speed marine engines. In the WHR plant, a turbo-generator combines the input from a steam turbine with an exhaust gas power turbine to generate electrical power, while steam from the economiser is available for the ship's service heating. A steam based WHR is recommended for vessels with high levels of installed power.

Schematic of a High-Effciency Water Heat Recovery plant typical for large container ships.



High Reliability

The layout of the engine is essential to its reliability. With the benefit of experience, and the use of a failure mode and effect analysis (FMEA), all engine components are designed with the utmost care. Furthermore, a redundancy concept is applied to allow the engine to continue to operate even if a component should fail. Some examples of the reliability-focused design are shown below.

Common-rail fuel injection and hydraulic valve actuation

The common-rail system has been successfully applied to Wärtsilä 2-stroke engines since 2001, when the first RT-flex engine entered service. Concept-wise, at least two high pressure pumps are installed for the fuel injection and servo oil systems. Fuel pumps are designed in two different sizes with the same basic layout. Careful design, constant improvement, and good quality control ensure a safe pressure supply for reliable engine operation. The same is valid for the servo oil pump, where different sizes are used to operate the exhaust valves. If one of these pumps is out of order, the remaining pump(s) have sufficient capacity to enable full engine operation.

All RT-flex engines, as well as the X82 and X92, are equipped with one ICU per engine cylinder for injection control. Since 2001, ICUs with different sizes have been developed and tested. Many of the ICU's internal parts are standardized and used on all versions. Our constant improvement policy on all sub-components further enhances the reliability of the engine. The ICU function is monitored closely by the engine control system. Any possible malfunction and wear can thus be recognized before a major failure happens.

The new generation of common-rail Wärtsilä X-engines use directly controlled fuel injection valves. The main control elements are the same in all these injectors, even though the outer size and shape is adapted for each engine type. This allows the use of key parts that are always reliable, well tested, and mature. On these engines, flow limiting valves (FLV) have taken over the cut out function of the ICU. In the case of an injector failure, the FLV will stop the injection on that cylinder and the fuel rail pressure is maintained for undisturbed operation on all the other units.

Efficient lube oil distribution allowing lowest feed rates

A key factor in ensuring the reliable operation of 2-stroke marine engines is to have a perfect seal between the piston rings and cylinder liners. Piston rings can only seal the combustion space against the underside of the piston if the shape of the cylinder liner remains round. Friction between the piston rings and the cylinder liner becomes critical when, for example, the shape of the cylinder liner changes from cylindrical to that of a clover leaf because of higher localised corrosive wear caused by sulphuric acid. As a result, higher lube oil feed rates are needed and in a worst case scenario, components start to fail in an unplannable manner. To avoid

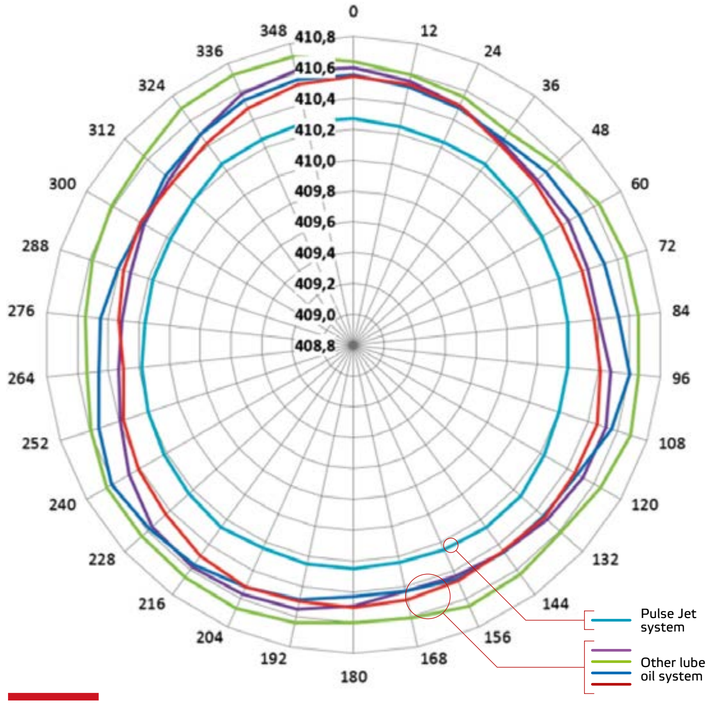


Fig. 6: Cylinder liner measurements of the Pulse Jet (light blue) and different lube oil concepts.

such uncontrolled and uneven corrosive wear situations, the proper lube oil distribution and replacement across the running surface of the cylinder liner is essential, as is the optimal temperature lay out of the components.

WinGD has evaluated various concepts for distributing the lubricant to the running surface. The conclusion is that an injection like system that injects the lubricant onto the cylinder liner running surface is the most efficient concept for achieving an uniform fresh oil distribution that maintains the correct shape of the cylinder liners throughout their entire lifecycle. Fig. 6 shows the comparison of two different lube oil concepts. The light blue line represents today's standard PULSE JET.

This PULSE JET SYSTEM guarantees the proper oil distribution and allows the adjustment for the lowest lube oil feed rates, providing the correct lube oil BN number is selected. Fig. 7 shows the injection pattern of one Pulse Jet injector. The injectors are CFD calculated and tested in a pressurized test cell to simulate real in-cylinder conditions.

The Pulse Jet provides the cylinder liner surface with a perfect covering of lubricant oil that is refreshed systematically and everywhere with the same quality oil. This is confirmed in the

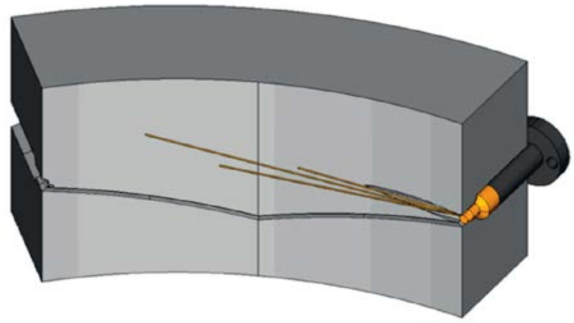


Fig. 7: PULSE JET oil injection pattern covering the entire circumference of the cylinder liner with fresh oil.

W-X82 cylinder liner after 1850 running hours. Honing marks well visible on the bottom part.

field by several measurements and inspections, see below an example.

Engine control system architecture

The backbone of each X-engine is an autonomous Engine design Control System. The system is designed to serve specific needs of a 2-stroke common-rail low-speed diesel and dual-fuel engine.

The Engine Control System (ECS) architecture gives not only high level of redundancy, which is required by Classification Societies, but additionally user friendly features like automatic software download in case of module replacements, clear and comprehensive Operator Interface.

Our ECS control modules are located in a separate part of the Rail Unit allowing shortest possible cable connections to most of the control elements and sensors. This ensures uncompromised electromagnetic compatibility and economical and clear wiring. The Rail Unit cabling is completed during the pre-fabrication of the Rail Unit. Depending on design, some engines benefit from the integrated power supply concept, which offers even more compact solution with all the AC/DC power supply modules located directly in the lower part of the Rail Unit.

The communication of our Engine Control System with the Propulsion Control System (Remote Control System + Safety System + Alarm Monitoring System) is facilitated via redundant CAN / ModBus systems.

In accordance with the Classification rules, our ECS is able to control the engine alone, even in case of Remote Control System failure. The architecture of the X-engines' control systems allows flexible and seamless integration with Tier III solutions (SCR, EGR, etc.) and with various versions of waste heat recovery systems, external data acquisition and diagnostic systems.

The commissioning procedure of our ECS at engine manufacturer and on-board the vessel has been optimised for fast, efficient with user friendly commissioning. Software tools offer parameter settings and trending, and advanced trouble shooting options.

Combustion chamber temperatures optimised to avoid low temperature corrosion

The utmost care is taken in the design of the combustion chamber components. Component temperature levels are such that they do not exceed material property related limits while, at the same time, they cannot fall below certain temperature levels to avoid cold or sulphuric acid corrosion. Numerous publications have emphasised the positive effect of elevated liner wall temperatures.

The optimal cylinder liner temperature level, in combination with the Pulse Jet lube oil system and correctly designed lube oil distribution grooves, results in very low liner / piston ring wear. This results in very competitive maintenance intervals and costs.

WinGD has various design possibilities for achieving the necessary temperature levels over a broad load range. These vary from insulating the cooling bores to independent cooling water circuits for the cylinder liners.

Fig. 8 illustrates cylinder liner calibration carried out on several X82 cylinder liners measured with or without cylinder liner cover. The measurements were made by using a special device inserted through the scavenge air ports. Even though high sulphur fuels were burned, >3%Sulphur, the liner wear rates remain very low. A piston underside residual oil analysis confirmed the values at around BN30, thus allowing a further lube oil feed reduction towards 0.6g/kWh in combination with a BN100 lubricant.

X82: specific liner wear rate

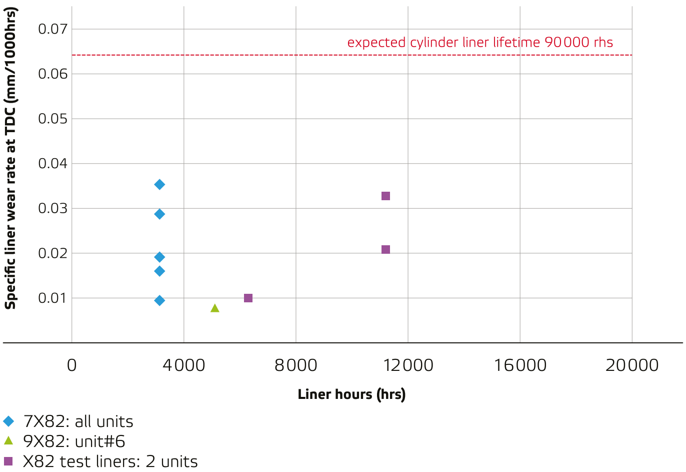


Fig. 8: X82 cylinder liner running surface measurements. A wear rate of 0.063mm/1000hrs would lead to a cylinder liner lifetime of 90'000hrs. With the measured values, the effective lifetime would be much higher.

Ready for IMO Tier III compliance

In order to achieve compliance with the IMO Tier III NOx regulations and the requirements for SOx control, various solutions are possible, including alternative fuels, fuel systems with conventional and more advanced tuning concepts, the addition of certain substances and after treatment systems.

However, when considering liquid fuels only, various options need to be taken into account, and a combination of individual solutions can be needed to control the two key pollutants.

Pollutants	Measure 1	Measure 2
	(MDO 0.1% Sulphur)	(HFO)
SOx	–	Scrubber
NOx	LP-SCR or HP-SCR or EGR	HP-SCR or EGR

X-engines are Tier III ready as standard, thanks to the designed interface with SCR systems and the LNG ready concept.

LNG ready

Switching from liquid to gas fuel is a viable solution for dealing simultaneously with both the NOx and SOx requirements. X-engines have been designed to be LNG ready, meaning that the standard diesel engine can be easily converted to a low-pressure X-DF engine by adding only the gas components.

SCR solutions

SCR technology reduces emissions of nitrogen oxides (NOx) by means of a reductant (typically ammonia, generated from urea) at the surface of a catalyst in a reactor.

The temperature of the exhaust gas is thereby subject to constraints on both the upper and lower sides. The latter is particularly relevant with fuels containing higher fractions of sulphur, such as those present in typical heavy fuel oil (HFO) qualities, that require even higher minimum temperatures in the catalyst.

SCR Pilot Project 5RT-flex58T-D.

High Pressure (HP) SCR

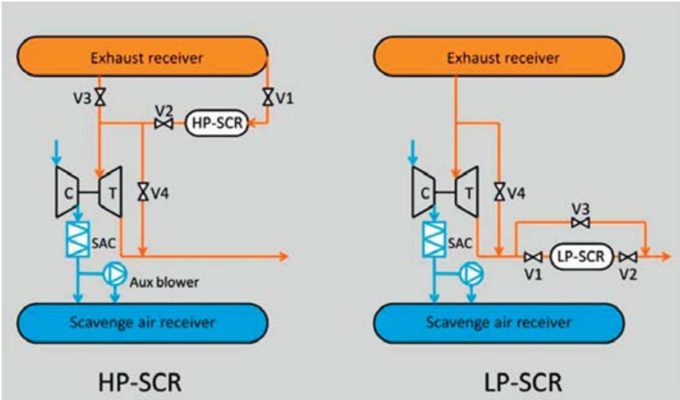
The SCR reactor is installed on the high-pressure side, before the turbine. This configuration allows the reactor to be designed in the most compact way because of the higher density of the exhaust gas.

All X-engines have been designed for easy interfacing with HP SCR systems. X-engines have specific engine tuning in Tier III mode to minimize fuel consumption whilst controlling the required exhaust gas temperature, mechanical interface for the HP SCR off engine components, and the SCR valve control system.

Low Pressure (LP) SCR

The SCR reactor is installed on the low-pressure side, after the turbine. WinGD has developed 2-stroke engine interface specifications for low pressure SCR applications that comply with all known low pressure SCR system providers. Low pressure SCR systems are typically larger in volume and have the advantage of being less complicated to integrate into the exhaust stream.

All X-engines can be interfaced with approved suppliers of LP SCR systems. In Tier III mode, X-engines have specific engine tuning to minimize fuel consumption whilst controlling the required after turbocharger exhaust gas temperature.



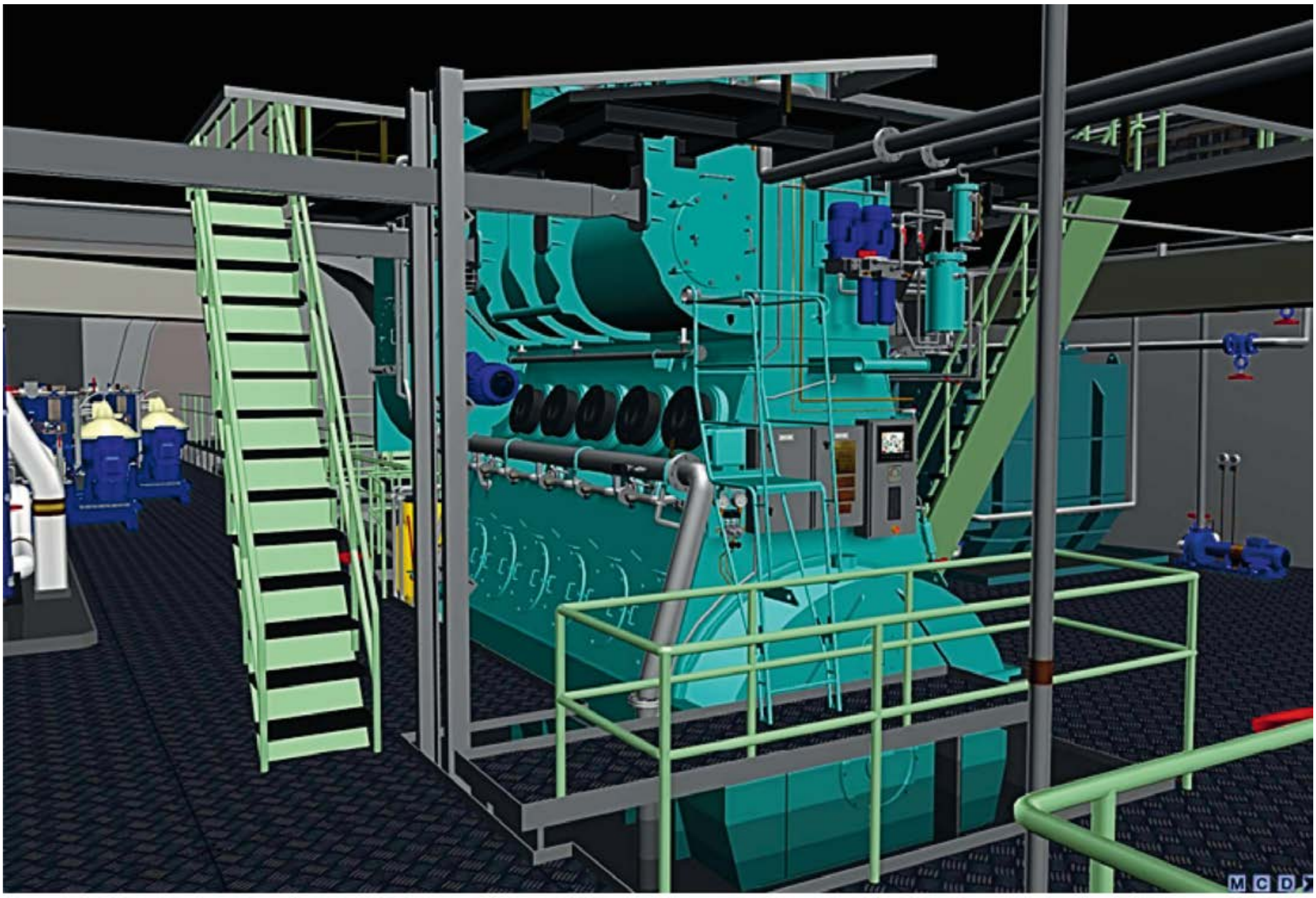
EGR Solutions

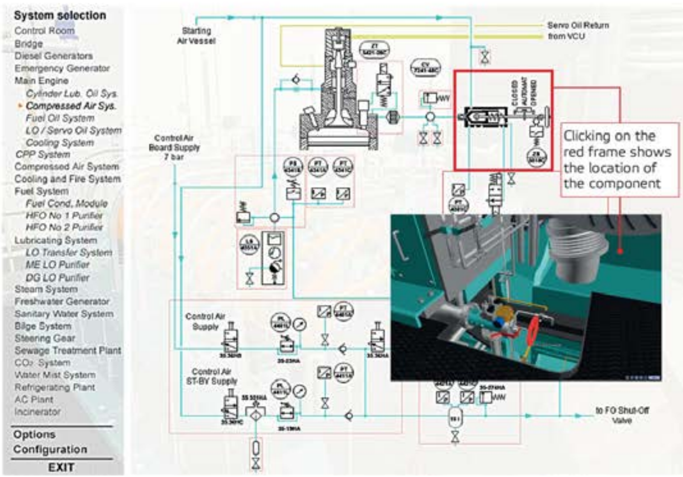
In addition to the Tier III dual-fuel and SCR solutions, exhaust gas recirculating (EGR) concepts are available and proven to meet IMO Tier III compliance. Further development is under working.

Virtual Engine Simulator "W-Xpert"

To ensure smooth commissioning and operation of the X-engines, the W-Xpert – an interactive Engine Room simulator having the X-engines as the central feature – has been developed. The W-Xpert is utilised in the qualification process for engine manufacturers operational teams and to familiarise them with the engine. The W-Xpert is also used in crew training programmes.

The simulation can be run on a standard PC or laptop, but it is best to use two screens or projectors. It is protected by a USB access key.





Wärtsilä X-engines

Wärtsilä X35-B

IMO Tier II/Tier III (SCR)

Cylinder bore	350 mm
Piston stroke	1550 mm
Speed	118–167 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.43

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length mm	Weight tonnes
	167 rpm		118 rpm			
	R1	R2	R3	R4		
5	4 350	3 475	3 075	2 450	4 398	74
6	5 220	4 170	3 690	2 940	5 010	84
7	6 090	4 865	4 305	3 430	5 622	95
8	6 960	5 560	4 920	3 920	6 234	105

Brake specific fuel consumption (BSFC) in g/kWh

Full load

Rating point		R1	R2	R3	R4
BMEP, bar		21.0	16.8	21.0	16.8
BSFC	Standard Tuning	175	169	175	169

Part load, % of R1	85	70	85	70	65
Tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	171.2	170.8	170.5	169.3	166.0

Wärtsilä X40-B

IMO Tier II/Tier III (SCR)

Cylinder bore	400 mm
Piston stroke	1770 mm
Speed	104–146 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.43

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length mm	Weight tonnes
	146 rpm		104 rpm			
	R1	R2	R3	R4		
5	5 675	4 550	4 050	3 250	5 107	109
6	6 810	5 460	4 860	3 900	5 807	125
7	7 945	6 370	5 670	4 550	6 507	140
8	9 080	7 280	6 480	5 200	7 207	153

Brake specific fuel consumption (BSFC) in g/kWh

Full load

Rating point		R1	R2	R3	R4
BMEP, bar		21.0	16.8	21.0	16.8
BSFC	Standard Tuning	174	168	174	168

Part load, % of R1	85	70	85	70	65
Tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	170.2	169.8	169.5	168.3	165.0

Wärtsilä X52

IMO Tier II/Tier III (SCR)

Cylinder bore	520 mm
Piston stroke	2315 mm
Speed	79-105 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.45

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length mm	Weight tonnes
	105 rpm		79 rpm			
	R1	R2	R3	R4		
4	7 240	5 440	5 440	4 080	4 970	184
5	9 050	6 800	6 800	5 100	5 910	217
6	10 860	8 160	8 160	6 120	6 850	251
7	12 670	9 520	9 520	7 140	7 790	288
8	14 480	10 880	10 880	8 160	8 730	323

Brake specific fuel consumption (BSFC) in g/kWh

Full load					
Rating point		R1	R2	R3	R4
BMEP, bar		21.0	15.8	21.0	15.8
BSFC	Standard Tuning	167	160	167	160

Part load, % of R1	85	70	85	70	65
Tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	163.2	162.8	162.5	161.3	158.0

Wärtsilä X62

IMO Tier II/Tier III (SCR)

Cylinder bore	620 mm
Piston stroke	2658 mm
Speed	77–103 rpm
Mean effective pressure at R1/R1+	20.5/19.3 bar
Stroke / bore	4.29

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length mm	Weight tonnes
	97 / 103 rpm		77 rpm			
	R1 / R1+	R2 / R2+	R3	R4		
4	10 640	8 000	8 440	6 360	5 895	270
5	13 300	10 000	10 550	7 950	7 000	325
6	15 960	12 000	12 660	9 540	8 110	377
7	18 620	14 000	14 770	11 130	9 215	435
8	21 280	16 000	16 880	12 720	10 320	482

Brake specific fuel consumption (BSFC) in g/kWh

Full load

Rating point		R1/R1+	R2/R2+	R3	R4
BMEP, bar		20.5/19.3	15.4/14.5	20.5	15.4
BSFC	Standard Tuning	167/166	160	167	160

Part load, % of R1/R1+	85	70	85	70	65
Tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	163.2/162.2	162.8/161.8	162.5/161.5	161.3/160.3	158.0/157.2

We recommend you to contact us to ensure you have the most recent product information.

Wärtsilä X72 — IMO Tier II/Tier III (SCR)

Cylinder bore	720 mm
Piston stroke	3086 mm
Speed	66–89 rpm
Mean effective pressure at R1/R1+	20.5/19.4 bar
Stroke / bore	4.29

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length mm	Weight tonnes
	84 / 89 rpm		66 rpm			
	R1 / R1+	R2 / R2+	R3	R4		
4	14 440	10 800	11 360	8 480	6 790	407
5	18 050	13 500	14 200	10 600	8 085	481
6	21 660	16 200	17 040	12 720	9 375	561
7	25 270	18 900	19 880	14 840	10 665	642
8	28 880	21 600	22 720	16 960	11 960	716

Brake specific fuel consumption (BSFC) in g/kWh

Full load

Rating point		R1/R1+	R2/R2+	R3	R4
BMEP, bar		20.5/19.4	15.4/14.5	20.5	15.4
BSFC	Standard Tuning	167/166	160	167	160

Part load, % of R1/R1+	85	70	85	70	65
Tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	163.2/162.2	162.8/161.8	162.5/161.5	161.3/160.3	158.0/157.2

Wärtsilä X82-B — IMO Tier II/Tier III (SCR)

Cylinder bore	820 mm
Piston stroke	3375 mm
Speed	58–84 rpm
Mean effective pressure at R1/R1+	21.0/19.0 bar
Stroke / bore	4.12

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length mm	Weight tonnes
	76 / 84 rpm		58 rpm			
	R1 / R1+	R2 / R2+	R3	R4		
6	28 500	21 720	21 750	16 590	11 045	805
7	33 250	25 340	25 375	19 355	12 550	910
8	38 000	28 960	29 000	22 120	14 055	1 020
9	42 750	32 580	32 625	24 885	16 500	1 160

Brake specific fuel consumption (BSFC) in g/kWh

Full load

Rating point		R1/R1+	R2/R2+	R3	R4
BMEP, bar		21.0/19.0	16.0/14.5	21.0	16.0
BSFC	Standard Tuning	165/163	158	165	158

Part load, % of R1/R1+	85	70	85	70	65
Tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	161.2/159.2	160.8/158.8	160.5/158.5	159.3/157.3	156.0/154.3

Wärtsilä X92 — IMO Tier II/Tier III (SCR)

Cylinder bore	920 mm
Piston stroke	3468 mm
Speed	70–80 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	3.77

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length mm	Weight tonnes
	80 rpm		70 rpm			
	R1	R2	R3	R4		
6	38 700	27 900	33 900	24 420	11 630	1 120
7	45 150	32 550	39 550	28 490	13 210	1 260
8	51 600	37 200	45 200	32 560	14 750	1 380
9	58 040	41 850	50 850	36 630	17 850	1 630
10	64 500	46 500	56 500	40 700	19 520	1 790
11	70 950	51 150	62 150	44 770	21 280	1 960
12	77 400	55 800	67 800	48 840	22 870	2 140

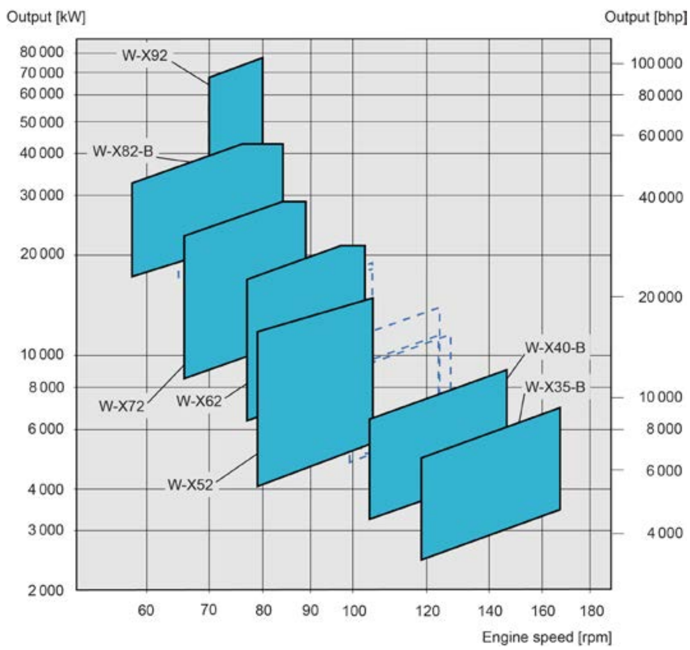
Brake specific fuel consumption (BSFC) in g/kWh

Full load

Rating point		R1	R2	R3	R4
BMEP, bar		21.0	15.1	21.0	15.1
BSFC	Standard Tuning	166	159	166	159

Part load, % of R1	85	70	85	70	65
Tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	162.2	161.8	161.5	160.3	155.6

X-engines rating field



GTD

More information about the engine performance are available in our General Technical Data Program (GTD) on wingd.com.

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Winterthur Gas & Diesel Ltd. (WinGD) is a leading developer of two-stroke low-speed gas and diesel engines used for propulsion power in merchant shipping. WinGD's target is to set the industry standard for reliability, efficiency and environmental friendliness. WinGD provides designs, licences and technical support to manufacturers, shipbuilders and ship operators worldwide. The engines are sold under the Wärtsilä brand name and are manufactured under licence in four shipbuilding countries. WinGD has its headquarters in Winterthur, Switzerland, where, as one of the earliest exponents of diesel technology, it started the development of large internal combustion engines in 1898 under the "Sulzer" name.

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