2024

Low-speed Engines

WIN GD

Contents

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WinGD

Compelling performance delivering a sustainable future

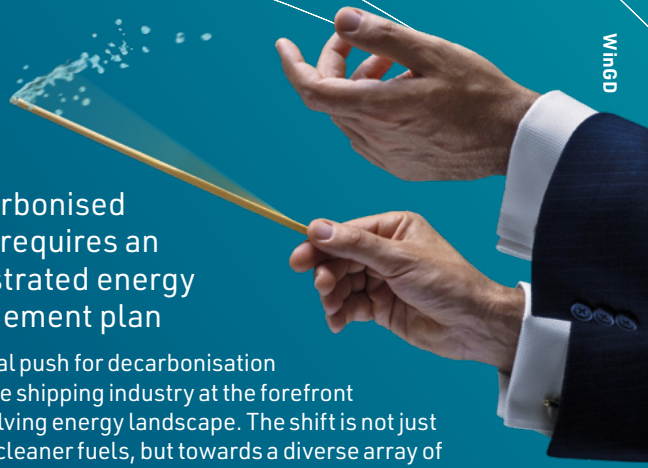
The energy transition underway in shipping has cast a spotlight onto marine engine technology and the R&D behind it. The scope of energy management now extends well beyond the engine, comprising a holistic system that enhances energy efficiency and enables a seamless transition to new fuels.

What ship owners need today is an energy ecosystem, a smart, integrated solution with the main engine at its heart.

This is where WinGD excels, blending over a century of marine propulsion expertise with built-in fuel flexibility, robust engine control and monitoring, and energy optimisation and hybridisation.

WinGD help customers create vessel-wide energy ecosystems that put them firmly in control of their fleet's emissions reduction, fuel efficiency and digital optimisation.

Expertly manage harmoniously delivered, optimised performance across your vessel, your fleet – today and tomorrow.



A decarbonised future requires an orchestrated energy management plan

The global push for decarbonisation places the shipping industry at the forefront of an evolving energy landscape. The shift is not just towards cleaner fuels, but towards a diverse array of energy sources and energy management solutions.

WinGD have adapted their proven engine technology for a multi-fuel future enhanced by a suite of sustainable energy management systems that work in concert with each other.

The complexities of achieving a decarbonised future require a collaborative effort that transcends industries. WinGD is central to this orchestrated effort, forging partnerships with ship owners and builders, fuel producers, research bodies, and international coalitions.

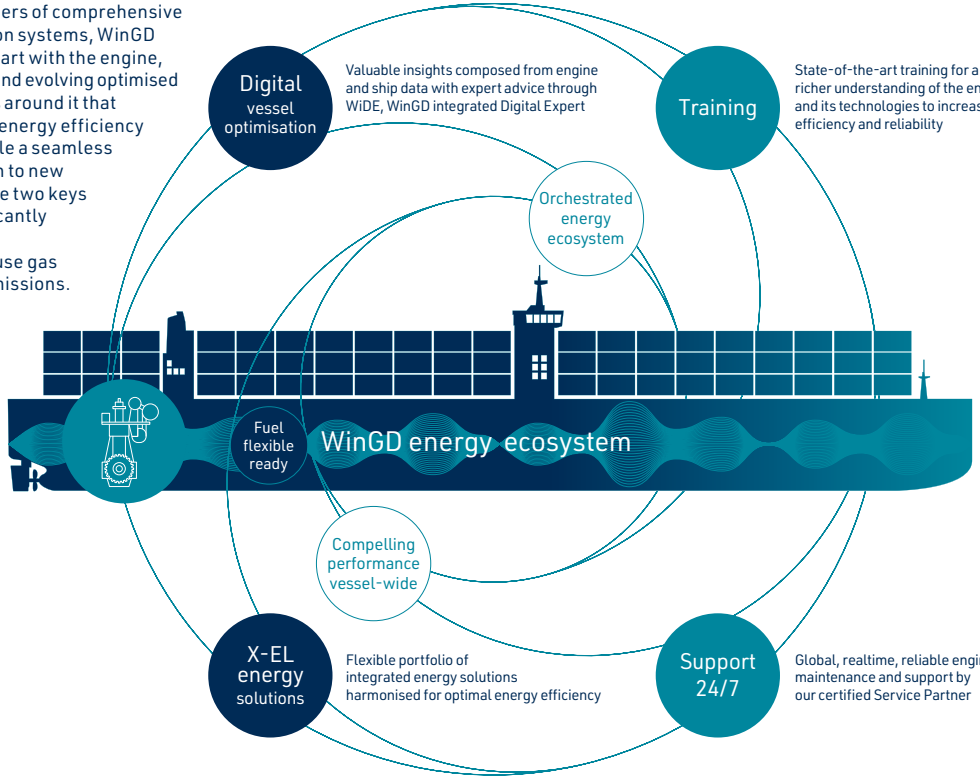
Attracting and connecting the very best minds, to work together towards this shared responsibility is the key to achieving a carbon-free future.

WinGD's substantial investments in innovation, and development of marine power technology underscore the commitment to a future of sustainably optimised energy performance.

WinGD is not just preparing for a multi-fuel future; it is actively shaping it, ensuring that shipping plays a pivotal role in the global effort towards decarbonisation by 2050.

Orchestrating engine efficiency with a harmonious ecosystem

As providers of comprehensive propulsion systems, WinGD always start with the engine, building and evolving optimised solutions around it that enhance energy efficiency and enable a seamless transition to new fuels – the two keys to significantly reducing greenhouse gas (GHG) emissions.



Vessels today are complex power systems with the main engine at their heart

WinGD engines are fully ready for the multi-fuel capability that will take ships to IMO's target of eliminating emissions by or around 2050. And WinGD digital vessel optimisation and battery-hybrid energy systems drive further synchronised energy efficiency and operational flexibility, making the transition towards zero emissions more cost-effective.

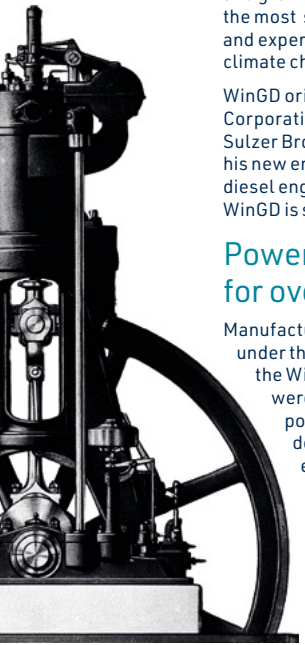
WinGD's promise is to deliver quality solutions across the entire lifetime of the vessel through:

- Engine design
- Reliable performance
- Reduced emissions (iCER)
- Hybrid energy solutions (X-EL)
- Digital optimisation (WiDE)
- Warranty service and support
- Crew training and support
- Vessel service and support

From Sulzer to WinGD. A History of Engine Development

WinGD's engine design history dates back to the late 1800s. That history bore witness to remarkable progress and growth. But the challenge the industry faces today is the most significant to date. It is change that spans industry and expertise, connecting the globe in the fight against climate change.

WinGD originated from the diesel engine business of Sulzer Corporation in Winterthur, established in 1834 when the Sulzer Brothers signed an agreement with Rudolf Diesel for his new engine technology. On June 10th, 1898, the very first diesel engine was started in Winterthur, Switzerland, where WinGD is still headquartered today.



Powering merchant shipping for over a century

Manufacturing continued in Winterthur for nearly a century under the Sulzer name. In 1986, the last diesel engine left the Winterthur facility as engine manufacturing centres were now strategically located as close to the ship as possible. While the engine innovation research and design remains in Switzerland to this day, WinGD has expanded to a global operation with subsidiaries in the key shipbuilding hubs throughout the world.

Going forward to November 1990, Sulzer established its Diesel Engine & Diesel Power Plant Division as a separate company, New Sulzer Diesel Ltd.

WinGD is powering the transformation to a sustainable future

Towards the end of the 20th century a merger with Wärtsilä Diesel Oy create Wärtsilä New Sulzer Diesel Corporation which later became Wärtsilä Corporation. The Swiss company, Wärtsilä Switzerland Ltd., responsible for the low-speed, two-stroke engine within Wärtsilä, later merged with China State Shipbuilding Corporation (CSSC) in early 2015 forming Winterthur Gas & Diesel Ltd (WinGD). In 2016, Wärtsilä Corporation transferred its remaining shares of WinGD to CSSC making WinGD 100% owned by CSSC.

From designing the first reversing two-stroke marine engine in 1905 to the world's biggest dual-fuel low-speed engines in 2020, WinGD has continued to innovate with the aim of making shipping more efficient.

Along the way it has pioneered turbocharging on two-stroke engines (in 1946) and the first electronically controlled low-speed engine with common-rail injection, in 1998. Fuel flexibility is not a new concept for WinGD, which introduced the first low-speed gas engines for ships in 1972. The modern X-DF dual-fuel platform has been in service since 2016 and boasts the best overall emissions footprint available today. Now adapted for clean fuels such as ammonia and methanol, the proven X-DF engine technology is shaping the carbon-free future.

Today WinGD is advancing the decarbonisation of marine transportation through sustainable energy systems using the most advanced technologies in emissions reduction, fuel efficiency, hybridisation and digital optimisation. With a growing portfolio of multi-fuel two-stroke low-speed engines at the heart of the power equation, WinGD is powering the transformation to a sustainable future

Research and testing

As engine designers, WinGD's expertise lies in technology innovation. As well as developing engines for new fuels and technologies to reduce air pollution, WinGD continuously seeks to improve both the efficiency and lifecycle costs of its engines.

To advance these concepts, WinGD has made considerable investments in expanding its research and development test facilities. These include the Engine Research and Innovation Centre in Winterthur and the Global Test Centre in Shanghai.

To learn more about WinGD's research and testing capabilities scan or click the QR code:

Merchant Ship Applications

WinGD's growing engine portfolio provides simple solutions to reduce emissions, fuel consumption and operating costs, improve safety and give shipowners and operators peace of mind.

WinGD offers fuel flexible, low-speed, dual-fuel X-DF engines and X-Engines. Supported by the most advanced technology in emissions reduction, automation and control, digitalisation and fuel efficiency, these engines provide simple, safe and flexible propulsion solutions.

The tables shown in the following pages provide an engine selection for a variety of vessel types.

Final engine choice is dependent on ship specification, investment and operating cost evaluation and preferred engine configuration.

For more information, download our Vessel Type Brochure at: https://www.wingd.com/en/news-media/our-brochures/

Tanker

TANKER TYPE	WINGD LOW-SPEED ENGINES			
	X52 X52-S	X62 X62-S	X72	X82
Small tanker	•			
Handysize tanker	•			
Panamax tanker		•		
Aframax tanker		•	•	
Suezmax tanker			•	
VLCC				•

X-DF portfolio engines are available as an alternative to X-Engines

WinGD offers **integrated in-line shaft generator solutions** for tankers

Name: Eneos Arrow
Vessel type: VLCC (311,000dwt Crude oil tanker)
Shipowner: JX Ocean
Shipyard: Japan Marine United, Ariake, Japan

Delivery: 2017
Main engine: 7X82

Container Vessel

CONTAINER VESSEL TYPE	WINGD LOW-SPEED ENGINES				
	X52 X52-S	X62 X62-S	X72	X82	X92
< 700 TEU					
700 – 1,100 TEU	•				
1,100 – 1,400 TEU	•				
1,400 – 2,500 TEU		•			
2,500 – 4,500 TEU			•		
4,500 – 11,000 TEU				•	
> 11000 TEU					•

X-DF portfolio engines are available as an alternative to X-Engines

WinGD offers **integrated in-line shaft generator solutions** for container vessels

Name: Jacques Saade
Vessel type: 23,000 TEU Container vessel
Shipowner: CMA CGM S.A.

Shipyard: Hudong-Zhonghua Shipbuilding (Group) Co., Ltd. China
Delivery: 2020
Main engine: 12X92DF

Bulk Carrier

BULK CARRIER TYPE	WINGD LOW-SPEED ENGINES			
	X52 X52-S	X62 X62-S	X72	X82
Handysize bulkers	•			
Handymax bulkers	•			
Ultramax bulkers	•			
Kamsarmax bulkers		•		
Panamax bulkers		•		
Capesize bulkers			•	
VLOC				•

X-DF portfolio engines are available as an alternative to X-Engines

WinGD offers **integrated in-line shaft generator solutions** for bulk carriers

Name: Algoma Equinox
Vessel type: 39,400 dwt Bulk carrier
Shipowner: Algoma Central Corp, Canada
Shipyard: Nantong Mingde Heavy Industries, China

Delivery: 2013
Main engine: 5RT-flex50

Multipurpose Vessel

VESSEL TYPE	WINGD LOW-SPEED ENGINES	
	X52 X52-S	X62 X62-S
Small	•	
< 30,000 dwt	•	
> 30,000 dwt		•

X-DF portfolio engines are available as an alternative to X-Engines

WinGD offers **integrated in-line shaft generator solutions** for multipurpose vessels

Name: Shansi
Vessel type: 25,486 GT Multipurpose
Shipowner: Swire Shipping Pte. Ltd., Singapore
Shipyard: Zhejiang Ouhua Shipyard, China
Delivery: 2013
Main engine: 6RT-flex50

Gas Carriers

LNG CARRIER TYPE	WINGD LOW-SPEED ENGINES		
	X52DF	X62DF	X72DF
<15,000	•		
15,000 – 30,000 m³	•		
30,000 – 60,000 m³		•	
60,000 – 170,000 m³			•
170,000 – 250,000 m³		• twin-engine	• twin-engine

LPG CARRIER TYPE	WINGD LOW-SPEED ENGINES		
	X52	X62	X72
10,000 – 30,000 m³	•		
> 30,000 m³		•	
> 60,000 m³			•

X-DF portfolio engines are available as an alternative to X-Engines

WinGD offers **integrated in-line shaft generator solutions** for gas carriers

Name: SK AUDACE
Vessel type: 180,000 CBM LNG Carrier
Shipowner: SK Shipping Co, Ltd., South Korea
Shipyard: Samsung Heavy Industries Co, Ltd., South Korea
Delivery: July, 2017
Main engine: Twin 6X62DF

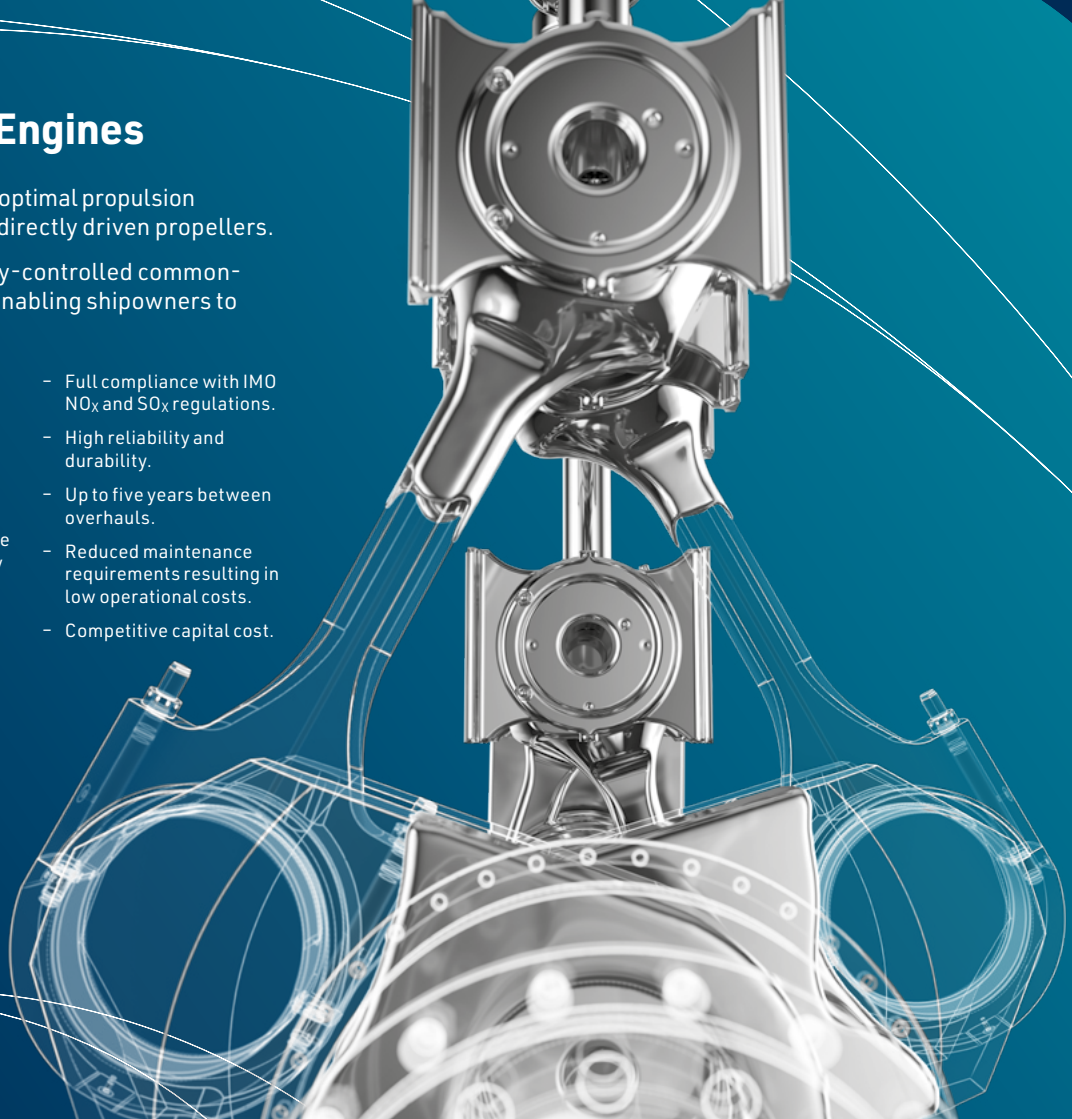
WinGD Low-speed Engines

WinGD low-speed engines are the optimal propulsion solution for merchant vessels with directly driven propellers.

WinGD's well-proven electronically-controlled common-rail technology plays a key role in enabling shipowners to reduce fuel and lubricant costs.

The benefits to shipowners and operators are:

- Optimal power and speed for all ship types and sizes.
- Lowest possible fuel and cylinder lube oil consumption over the whole operating range, especially in part load.
- Different tunings to suit particular sailing profiles.
- Specific tuning to increase the exhaust gas temperature for increased steam production (when required).
- The engines can be operated with residual marine fuels, distillate fuels DMA, DMB and DMZ, ammonia, methanol and liquefied natural gas (LNG).
- Full compliance with IMO NO_X and SO_X regulations.
- High reliability and durability.
- Up to five years between overhauls.
- Reduced maintenance requirements resulting in low operational costs.
- Competitive capital cost.



Power range for WinGD Low-speed Engines

WinGD offers Integrated In-line Shaft Generator Solutions that are:

Matched with the main engines to enable optimum energy efficiency, operational cost, and sustainability in extended operational ranges. Available for all types of merchant ship.

For integrated battery-hybrid applications, please refer to page 82-85.

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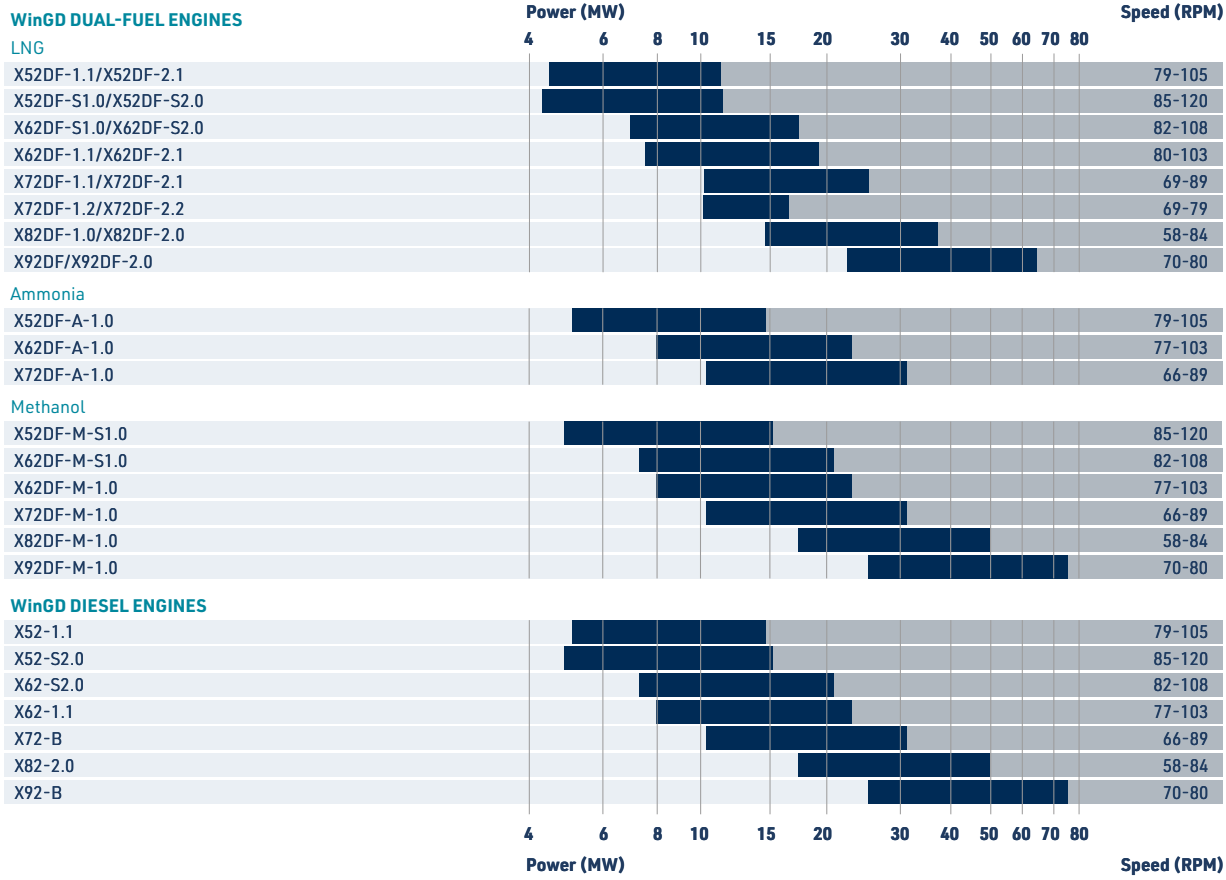
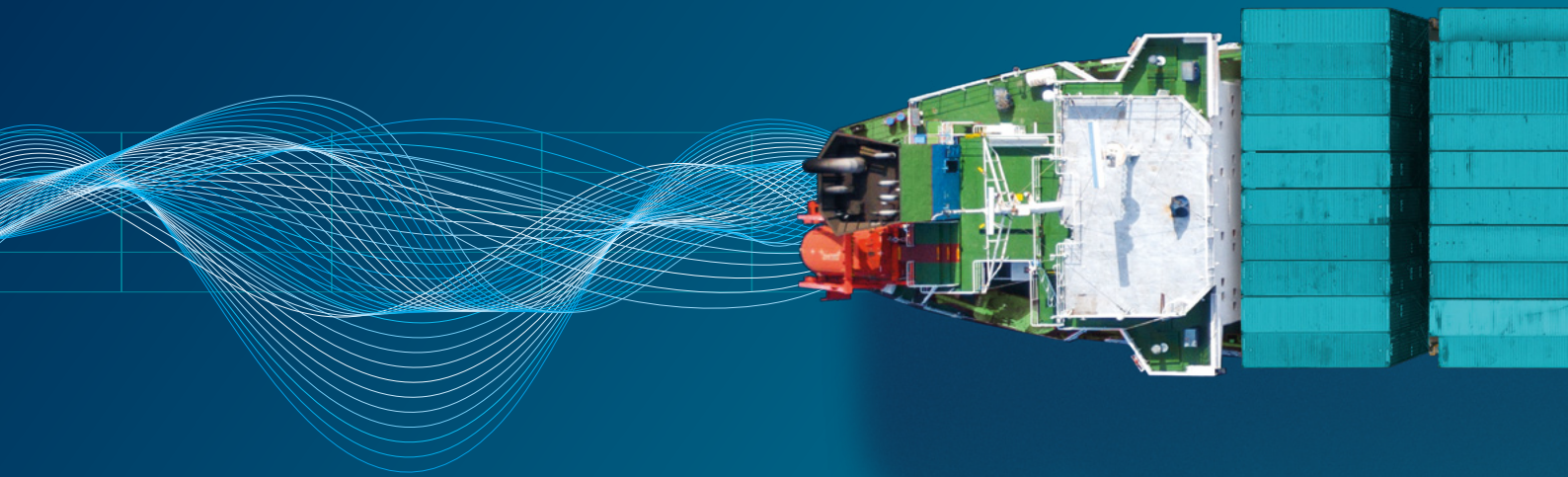


WinGD Portfolio

Orchestrated solutions working together for compelling performance. Our emissions reduction, automation and control, energy management and digital optimisation solutions are founded on our deep engine and energy system expertise.

Combined with our high-performance engines they enable customers to get the best from their vessel-wide energy ecosystem – putting ship owners and operators firmly in control of their fleet's fuel consumption, emissions and performance.

Maritime decarbonisation is an ensemble effort. WinGD's orchestra of solutions work in harmony to deliver finely tuned efficiency.



Engine Designation

6X52DF-A-S1.0

- Update level
- Technology level
- Application
  S: Short-stroke
  Blank: Others
- Fuel type application
  M: Methanol
  A: Ammonia
  Blank: Others
- Fuel type
  DF: Dual-fuel,
  Blank: Standard engine
- Bore size (cm)
- Engine type
- Number of cylinders

Example engine designation 6X52DF-A-S1.0 representing a WinGD 6 cylinder, short-stroke engine for dual-fuel operation with ammonia and diesel.

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X-DF by WinGD

X-DF LNG Engines

X52DF-1.1

IMO Tier III in gas mode

Cylinder bore	520 mm
Piston stroke	2 315 mm
Speed	79–105 rpm
Mean effective pressure at R1	17.3 bar
Stroke / bore	4.45

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 105 rpm	Output in kW at 79 rpm			Length A mm	Length A* mm	Dry mass tonnes
	R1	R2	R3	R4			
5	7 450	6 200	5 600	4 650	5 985	6 990	217
6	8 940	7 440	6 720	5 580	6 925	7 930	251
7	10 430	8 680	7 840	6 510	7 865		288
8	11 920	9 920	8 960	7 440	8 805		323

Dimensions (mm)	B	C	D	
	3 514	1 205	8 415	
	F1	**F2**	**F3**	**G**
	10 350	10 400	9 850	1 910

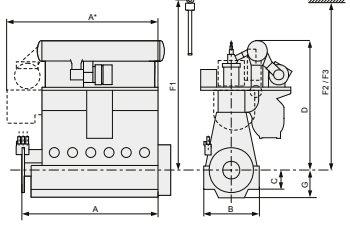
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 201	6 962	7 299	7 064
BSGC (gas)	g/kWh	142.7	137.7	144.7	139.7
BSPC (pilot fuel)	g/kWh	1.5	1.8	1.5	1.8

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	184.1	182.1	184.1	182.1

For definitions see page 62.



X52DF-2.1

IMO Tier III in gas mode

Cylinder bore	520 mm
Piston stroke	2 315 mm
Speed	79–105 rpm
Mean effective pressure at R1	17.3 bar
Stroke / bore	4.45

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 105 rpm	Output in kW at 79 rpm			Length A mm	Dry mass tonnes
	R1	R2	R3	R4		
5	7 450	6 200	5 600	4 650	5 985	217
6	8 940	7 440	6 720	5 580	6 925	251
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Dimensions (mm)	B	C	D	
	3 514	1 205	8 415	
	F1	**F2**	**F3**	**G**
	10 350	10 400	9 850	1 910

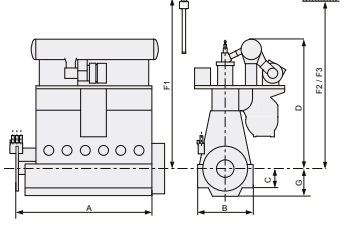
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 067	6 833	7 170	6 931
BSGC (gas)	g/kWh	140.1	135.1	142.1	137.1
BSPC (pilot fuel)	g/kWh	1.5	1.8	1.5	1.8

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	181.4	175.4	183.4	179.4

For definitions see page 62.



X-DF LNG Engines

X52DF-S1.0

IMO Tier III in gas mode

Cylinder bore	520 mm
Piston stroke	2 045 mm
Speed	85–120 rpm
Mean effective pressure at R1	17.3 bar
Stroke / bore	3.93

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 120 rpm	Output in kW at 85 rpm			Length A mm	Length A* mm	Dry mass tonnes
	R1	R2	R3	R4			
5	7 500	6 250	5 325	4 425	5 485	6 565	190
6	9 000	7 500	6 390	5 310	6 345	7 415	215
7	10 500	8 750	7 455	6 195	7 205		245
8	12 000	10 000	8 520	7 080	8 065		275

Dimensions (mm)	B	C	D	
	3 100	1 185	7 725	
	F1	**F2**	**F3**	**G**
	9 340	9 340	8 800	1 675

BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 201	6 962	7 299	7 064
BSGC (gas)	g/kWh	142.7	137.7	144.7	139.7
BSPC (pilot fuel)	g/kWh	1.5	1.8	1.5	1.8

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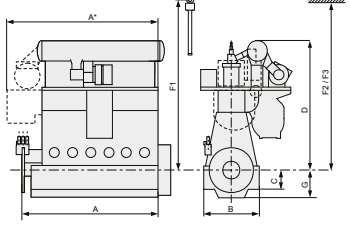
Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	184.1	182.1	184.1	182.1

For definitions see page 62.



X52DF-S2.0

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Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	181.4	175.4	183.4	179.4

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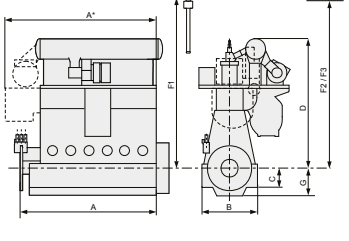


X-DF LNG Engines

X62DF-1.1

IMO Tier III in gas mode

Cylinder bore	620 mm
Piston stroke	2 658 mm
Speed	80–103 rpm
Mean effective pressure at R1	17.3 bar
Stroke / bore	4.29

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 103 rpm	Output in kW at 80 rpm			Length A mm	Dry mass tonnes
	R1	R2	R3	R4		
5	11 925	9 925	9 250	7 700	6 805	318
6	14 310	11 910	11 100	9 240	7 910	370
7	16 695	13 895	12 950	10 780	9 020	428
8	19 080	15 880	14 800	12 320	10 125	475

Dimensions (mm)	B	C	D	
	4 200	1 360	9 580	
	F1	F2	F3	G
	11 775	11 775	10 950	2 110

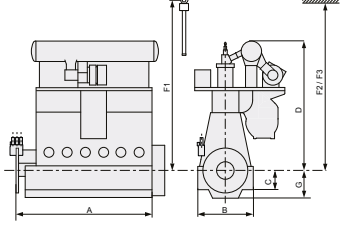
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 167	6 928	7 269	7 026
BSGC (gas)	g/kWh	142.5	137.5	144.5	139.5
BSPC (pilot fuel)	g/kWh	1.0	1.2	1.0	1.2

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	182.0	180.0	182.0	180.0

For definitions see page 62.



X62DF-2.1

IMO Tier III in gas mode

Cylinder bore	620 mm
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7	16 695	13 895	12 950	10 780	9 020	428
8	19 080	15 880	14 800	12 320	10 125	475

Dimensions (mm)	B	C	D	D (iCER on-engine)
	4 200	1 360	9 580	10 910
	F1	F2	F3	G
	11 775	11 775	10 950	2 110

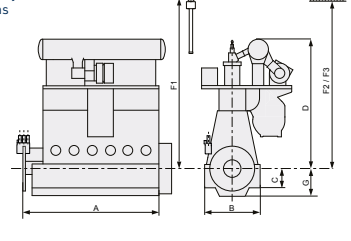
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	6 982	6 747	7 089	6 845
BSGC (gas)	g/kWh	138.8	133.9	140.9	135.9
BSPC (pilot fuel)	g/kWh	1.0	1.2	1.0	1.2

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	178.3	172.3	180.3	176.3
BSFC (VCR diesel Tier II)	g/kWh	167.3	166.3	168.3	166.3

For definitions see page 62.
iCER on-engine applies only to 5/6/7 cylinder applications



X-DF LNG Engines

X62DF-S1.0

IMO Tier III in gas mode

Cylinder bore	620 mm
Piston stroke	2 245 mm
Speed	82–108 rpm
Mean effective pressure at R1	17.3 bar
Stroke / bore	3.62

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 108 rpm	Output in kW at 82 rpm			Length A mm	Dry mass tonnes
	R1	R2	R3	R4		
5	10 550	8 775	8 000	6 675	6 260	280
6	12 660	10 530	9 600	8 010	7 260	325
7	14 770	12 285	11 200	9 345	8 260	370
8	16 880	14 040	12 800	10 680	9 260	415

Dimensions (mm)	B	C	D	
	3 440	1 295	8 575	
	F1	F2	F3	G
	10 300	10 300	9 680	1 835

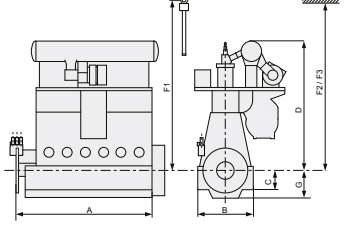
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 161	6 928	7 269	7 026
BSGC (gas)	g/kWh	142.5	137.5	144.5	139.5
BSPC (pilot fuel)	g/kWh	1.0	1.2	1.0	1.2

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	182.0	180.0	182.0	180.0

For definitions see page 62.



X62DF-S2.0

IMO Tier III in gas mode

Cylinder bore	620 mm
Piston stroke	2 245 mm
Speed	82–108 rpm
Mean effective pressure at R1	17.3 bar
Stroke / bore	3.62

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 108 rpm	Output in kW at 82 rpm			Length A mm	Dry mass tonnes
	R1	R2	R3	R4		
5	10 550	8 775	8 000	6 675	6 260	280
6	12 660	10 530	9 600	8 010	7 260	325
7	14 770	12 285	11 200	9 345	8 260	370
8	16 880	14 040	12 800	10 680	9 260	415

Dimensions (mm)	B	C	D	D (iCER on-engine
	3 440	1 295	8 575	9 496
	F1	F2	F3	G
	10 300	10 300	9 680	1 835

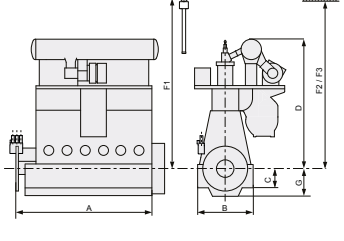
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	6 982	6 747	7 089	6 845
BSGC (gas)	g/kWh	138.8	133.9	140.9	135.9
BSPC (pilot fuel)	g/kWh	1.0	1.2	1.0	1.2

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	178.3	172.3	180.3	176.3

For definitions see page 62.
iCER on-engine applies only to 5/6/7 cylinder applications



X-DF LNG Engines

X72DF-1.1

IMO Tier III in gas mode

Cylinder bore	720 mm
Piston stroke	3 086 mm
Speed	69-89 rpm
Mean effective pressure at R1	17.3 bar
Stroke / bore	4.29

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 89 rpm R1	69 rpm R2	69 rpm R3	69 rpm R4	Length A mm	Dry mass tonnes
5	16 125	13 425	12 500	10 400	8 230	481
6	19 350	16 110	15 000	12 480	9 520	561
7	22 575	18 795	17 500	14 560	10 810	642
8	25 800	21 480	20 000	16 640	12 105	716

Dimensions (mm)	B	C	D	
	4 780	1 575	10 790	
	F1	**F2**	**F3**	**G**
	13 655	13 655	12 730	2 455

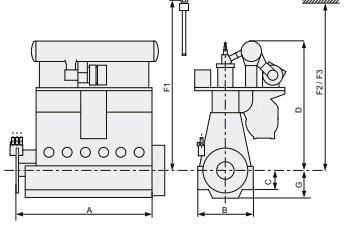
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 150	6 906	7 248	7 004
BSGC (gas)	g/kWh	142.3	137.3	144.3	139.2
BSPC (pilot fuel)	g/kWh	0.8	1.0	0.8	1.0

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	182.0	180.0	182.0	180.0

For definitions see page 62.



X72DF-1.2

IMO Tier III in gas mode

Cylinder bore	720 mm
Piston stroke	3 086 mm
Speed	69-79 rpm
Mean effective pressure at R1	15.7 bar
Stroke / bore	4.29

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 79 rpm R1	69 rpm R2	69 rpm R3	69 rpm R4	Length A mm	Dry mass tonnes
5	13 000	11 900	11 350	10 400	7 875	470
6	15 600	14 280	13 620	12 480	9 165	550

Dimensions (mm)	B	C	D	
	4 780	1 575	10 790	
	F1	**F2**	**F3**	**G**
	13 655	13 655	12 730	2 455

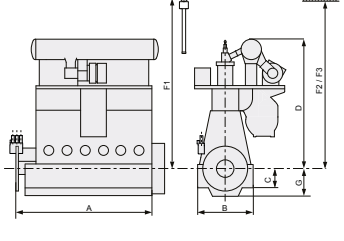
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 052	6 955	7 113	7 004
BSGC (gas)	g/kWh	140.3	138.2	141.5	139.2
BSPC (pilot fuel)	g/kWh	0.9	1.0	0.9	1.0

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	180.8	180.0	180.9	180.0

For definitions see page 62.
Engine optimised for reduced rating field and 5/6 cylinder applications



X-DF LNG Engines

X72DF-2.1

IMO Tier III in gas mode

Cylinder bore	720 mm
Piston stroke	3 086 mm
Speed	69-89 rpm
Mean effective pressure at R1	17.3 bar
Stroke / bore	4.29

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 89 rpm R1	69 rpm R2	69 rpm R3	69 rpm R4	Length A mm	Dry mass tonnes
5	16 125	13 425	12 500	10 400	8 230	495
6	19 350	16 110	15 000	12 480	9 520	580
7	22 575	18 795	17 500	14 560	10 810	642
8	25 800	21 480	20 000	16 640	12 105	716

Dimensions (mm)	B	C	D	D (iCER on-engine)
	4 780	1 575	10 790	11 755
	F1	**F2**	**F3**	**G**
	13 655	13 655	12 730	2 455

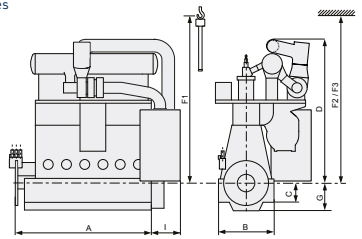
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	6 918	6 676	7 020	6 777
BSGC (gas)	g/kWh	137.7	132.7	139.7	134.7
BSPC (pilot fuel)	g/kWh	0.8	1.0	0.8	1.0

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	177.3	171.3	179.3	175.3
BSFC (VCR diesel Tier II)	g/kWh	166.8	166.8	168.3	166.3

For definitions see page 62.
iCER on-engine applies only to 5/6 cylinder applications



X72DF-2.2

IMO Tier III in gas mode

Cylinder bore	720 mm
Piston stroke	3 086 mm
Speed	69-79 rpm
Mean effective pressure at R1	15.7 bar
Stroke / bore	4.29

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 79 rpm R1	69 rpm R2	69 rpm R3	69 rpm R4	Length A mm	Dry mass tonnes
5	13 000	11 900	11 350	10 400	7 875	484
6	15 600	14 280	13 620	12 480	9 165	565

Dimensions (mm)	B	C	D	D (iCER on-engine)
	4 780	1 575	10 790	11 755
	F1	**F2**	**F3**	**G**
	13 655	13 655	12 730	2 455

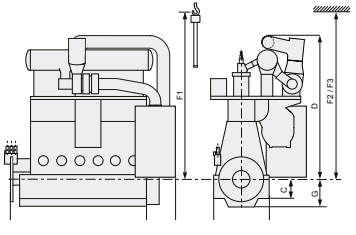
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	6 824	6 725	6 887	6 777
BSGC (gas)	g/kWh	135.7	133.6	137.0	134.7
BSPC (pilot fuel)	g/kWh	0.9	1.0	0.9	1.0

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	175.7	173.3	177.1	175.3
BSFC (VCR diesel Tier II)	g/kWh	166.5	166.5	167.2	166.3

For definitions see page 62.
Engine optimised for reduced rating field and 5/6 cylinder applications



X-DF LNG Engines

X82DF-1.0

IMO Tier III in gas mode

Cylinder bore	820 mm
Piston stroke	3 375 mm
Speed	58-84 rpm
Mean effective pressure at R1	17.3 bar
Stroke / bore	4.12

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at				Length A mm	Dry mass tonnes
	84 rpm	58 rpm				
	R1	R2	R3	R4		
6	25 920	21 600	17 880	14 940	10 425	805
7	30 240	25 200	20 860	17 430	11 865	910
8	34 560	28 800	23 840	19 920	13 305	1 020
9	38 880	32 400	26 820	22 410	14 745	1 160

Dimensions (mm)	B	C	D	
	5 050	1 800	12 310	
	F1	F2*	F3*	G
	15 080	-	-	2 700

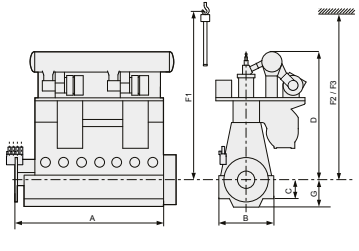
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 115	6 872	7 218	6 970
BSGC (gas)	g/kWh	141.8	136.8	143.8	138.8
BSPC (pilot fuel)	g/kWh	0.6	0.7	0.6	0.7

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	183.9	181.9	183.9	181.9

For definitions see page 62.
* Available on request



X82DF-2.0

IMO Tier III in gas mode

Cylinder bore	820 mm
Piston stroke	3 375 mm
Speed	58-84 rpm
Mean effective pressure at R1	17.3 bar
Stroke / bore	4.12

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at				Length A mm	Dry mass tonnes
	84 rpm	58 rpm				
	R1	R2	R3	R4		
6	25 920	21 600	17 880	14 940	10 425	805
7	30 240	25 200	20 860	17 430	11 865	910
8	34 560	28 800	23 840	19 920	13 305	1 020
9	38 880	32 400	26 820	22 410	14 745	1 160

Dimensions (mm)	B	C	D	
	5 050	1 800	12 310	
	F1	F2*	F3*	G
	15 080	-	-	2 700

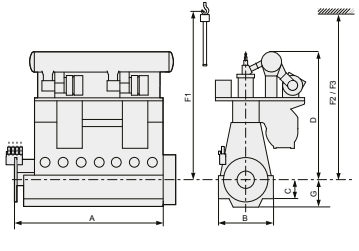
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	6 807	6 559	6 905	6 658
BSGC (gas)	g/kWh	135.6	130.6	137.6	132.6
BSPC (pilot fuel)	g/kWh	0.6	0.7	0.6	0.7

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	177.2	171.2	179.2	175.2

For definitions see page 62.
* Available on request



X-DF LNG Engines

X92DF

IMO Tier III in gas mode

Cylinder bore	920 mm
Piston stroke	3 468 mm
Speed	70-80 rpm
Mean effective pressure at R1	17.3 bar
Stroke / bore	3.77

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 80 rpm R1	Output in kW at 70 rpm R2	Output in kW at 70 rpm R3	Output in kW at 70 rpm R4	Length A mm	Dry mass tonnes
6	31 920	26 580	27 930	23 250	11 755	1 120
7	37 240	31 010	32 585	27 125	13 345	1 260
8	42 560	35 440	37 240	31 000	14 935	1 380
9	47 880	39 870	41 895	34 875	17 960	1 630
10	53 200	44 300	46 550	38 750	19 550	1 790
11	58 520	48 730	51 205	42 625	21 215	1 960
12	63 840	53 160	55 860	46 500	22 875	2 140

Dimensions (mm)	B	C	D	
	5 550	1 900	13 140	
	F1	**F2**	**F3**	**G**
	15 520	15 530	14 260	2 970

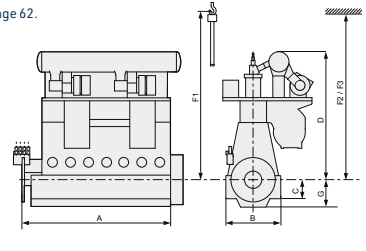
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 090	6 846	7 192	6 945
BSGC (gas)	g/kWh	141.2	136.2	143.2	138.2
BSPC (pilot fuel)	g/kWh	0.7	0.8	0.7	0.8

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	180.9	178.9	180.9	178.9

For definitions see page 62.



X92DF-2.0

IMO Tier III in gas mode

Cylinder bore	920 mm
Piston stroke	3 468 mm
Speed	70-80 rpm
Mean effective pressure at R1	17.3 bar
Stroke / bore	3.77

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 80 rpm R1	Output in kW at 70 rpm R2	Output in kW at 70 rpm R3	Output in kW at 70 rpm R4	Length A mm	Dry mass tonnes
6	31 920	26 580	27 930	23 250	11 755	1 120
7	37 240	31 010	32 585	27 125	13 345	1 260
8	42 560	35 440	37 240	31 000	14 935	1 380
9	47 880	39 870	41 895	34 875	17 960	1 630
10	53 200	44 300	46 550	38 750	19 550	1 790
11	58 520	48 730	51 205	42 625	21 215	1 960
12	63 840	53 160	55 860	46 500	22 875	2 140

Dimensions (mm)	B	C	D	
	5 550	1 900	13 140	
	F1	**F2**	**F3**	**G**
	15 520	15 530	14 260	2 970

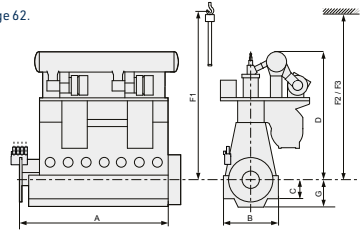
BRAKE SPECIFIC CONSUMPTIONS IN GAS MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	6 760	6 512	6 858	6 615
BSGC (gas)	g/kWh	134.6	129.6	136.6	131.6
BSPC (pilot fuel)	g/kWh	0.7	0.8	0.7	0.8

BRAKE SPECIFIC FUEL CONSUMPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	174.2	168.2	176.2	172.2

For definitions see page 62.



X-DF A

by WinGD

X52DF-A-1.0

IMO Tier II & Tier III (SCR)

Cylinder bore	520 mm
Piston stroke	2 315 mm
Speed	79-105 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.45

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 105 rpm R1	105 rpm R2	79 rpm R3	79 rpm R4	Length A mm	Length A* mm	Dry mass tonnes
5	9 050	6 800	6 800	5 100	5 985	6 990	228
6	10 860	8 160	8 160	6 120	6 925	7 930	264
7	12 670	9 520	9 520	7 140	7 865		302
8	14 480	10 880	10 880	8 160	8 805		339

Dimensions (mm)	B	C	D	D (iSCR)
	3 514	1 205	8 415	8 760
	F1	**F2**	**F3**	**G**
	10 350	10 350	9 800	1 910

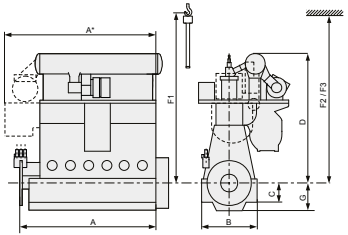
BRAKE SPECIFIC FUEL CONSUMPTION IN AMMONIA MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 294	6 995	7 294	6 995
BSGC (gas)	g/kWh	371.5	355.4	371.5	355.4
BSPC (pilot fuel)	g/kWh	9.0	9.0	9.0	9.0

BRAKE SPECIFIC FUEL COMSUPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	170.8	163.8	170.8	163.8

For definitions see page 62.
iSCR available for 5- to 7-cylinder engines with one TC on exhaust side



X-DF Ammonia Engines

X62DF-A-1.0

IMO Tier II & Tier III (SCR)

Cylinder bore	620 mm
Piston stroke	2 658 mm
Speed	77-103 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.29

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 103 rpm R1	77 rpm R2	77 rpm R3	77 rpm R4	Length A mm	Dry mass tonnes
5	14 500	10 650	10 800	7 950	7 000	341
6	17 400	12 780	12 960	9 540	8 110	396
7	20 300	14 910	15 120	11 130	9 215	457
8	23 200	17 040	17 280	12 720	10 320	506

Dimensions (mm)	B	C	D	
	4 200	1 360	9 580	
	F1	**F2**	**F3**	**G**
	11 830	11 830	11 005	2 110

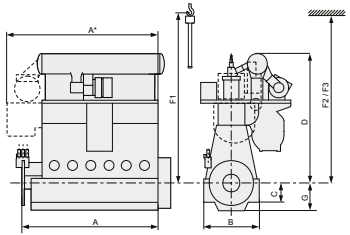
BRAKE SPECIFIC FUEL CONSUMPTION IN AMMONIA MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 209	6 974	7 166	6 974
BSGC (gas)	g/kWh	367.2	355.3	365.0	355.3
BSPC (pilot fuel)	g/kWh	8.9	8.6	8.8	8.6

BRAKE SPECIFIC FUEL COMSUPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	168.8	163.3	167.8	163.3

For definitions see page 62.
iSCR available for 5- to 7-cylinder engines with one TC on exhaust side



WinGD has signed a four-way partnership for X72DF-A ammonia engines to power a series of 210,000 DWT bulk carriers for Belgium-based CMB.TECH, with delivery through 2025 and 2026

X-DF Ammonia Engines

X72DF-A-1.0

IMO Tier II & Tier III (SCR)

Cylinder bore	720 mm
Piston stroke	3 086 mm
Speed	66-89 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.29

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 89 rpm R1	66 rpm R2	66 rpm R3	66 rpm R4	Length A mm	Dry mass tonnes
5	19 600	14 300	14 550	10 600	8 085	505
6	23 520	17 160	17 460	12 720	9 375	589
7	27 440	20 020	20 370	14 840	10 665	674
8	31 360	22 880	23 280	16 960	11 960	752

Dimensions (mm)	B	C	D	
	4 780	1 575	10 790	
	F1	**F2**	**F3**	**G**
	13 750	13 750	12 820	2 455

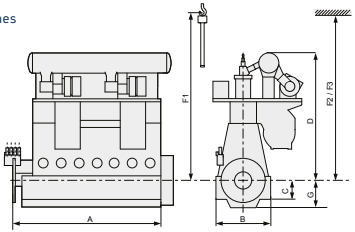
BRAKE SPECIFIC FUEL CONSUMPTION IN AMMONIA MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 209	6 974	7 166	6 974
BSGC (gas)	g/kWh	368.1	355.4	365.8	355.4
BSPC (pilot fuel)	g/kWh	8.5	8.5	8.5	8.5

BRAKE SPECIFIC FUEL COMSUPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	168.8	163.3	167.8	163.3

For definitions see page 62.
iSCR available for 5- to 7-cylinder engines with one TC on exhaust side



X-DFM by WinGD

X-DF Methanol Engines

X52DF-M-S1.0

IMO Tier II & Tier III (SCR)

Cylinder bore	520 mm
Piston stroke	2 045 mm
Speed	85-120 rpm
Mean effective pressure at R1	22.0 bar
Stroke / bore	3.93

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 120 rpm	Output in kW at 85 rpm			Length A mm	Length A* mm	Dry mass tonnes
	R1	R2	R3	R4			
5	9 550	6 850	6 775	4 850	5 485	6 565	200
6	11 460	8 220	8 130	5 820	6 345	7 415	226
7	13 370	9 590	9 485	6 790	7 205		257
8	15 280	10 960	10 840	7 760	8 065		287

Dimensions (mm)	B	C	D	D (iSCR)
	3 100	1 185	7 775	8 000
	F1	**F2**	**F3**	**G**
	9 340	9 340	8 800	1 675

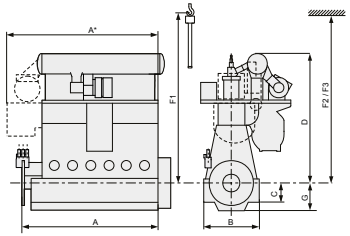
BRAKE SPECIFIC FUEL CONSUMPTION IN METHANOL MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	6 897	6 646	6 855	6 772
BSGC (gas)	g/kWh	328.4	316.5	326.4	322.4
BSPC (pilot fuel)	g/kWh	8.5	8.2	8.4	8.3

BRAKE SPECIFIC FUEL COMSUPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	164.8	158.8	163.8	161.8

For definitions see page 62.
iSCR available for 5- to 7-cylinder engines with one TC on exhaust side



X62DF-M-S1.0

IMO Tier II & Tier III (SCR)

Cylinder bore	620 mm
Piston stroke	2 245 mm
Speed	82-108 rpm
Mean effective pressure at R1	22.0 bar
Stroke / bore	3.62

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 108 rpm	Output in kW at 82 rpm			Length A mm	Dry mass tonnes
	R1	R2	R3	R4		
5	13 425	9 650	10 200	7 325	6 260	294
6	16 110	11 580	12 240	8 790	7 260	341
7	18 795	13 510	14 280	10 255	8 260	389
8	21 480	15 440	16 320	11 720	9 260	436

Dimensions (mm)	B	C	D	D (iSCR)
	3 440	1 295	8 575	9 020
	F1	**F2**	**F3**	**G**
	10 230	10 230	9 620	1 835

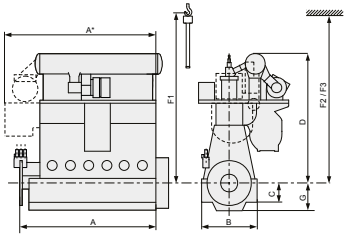
BRAKE SPECIFIC FUEL CONSUMPTION IN METHANOL MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	6 897	6 689	6 814	6 730
BSGC (gas)	g/kWh	328.4	318.5	324.4	320.4
BSPC (pilot fuel)	g/kWh	8.5	8.2	8.4	8.3

BRAKE SPECIFIC FUEL COMSUPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	164.8	159.8	162.8	160.8

For definitions see page 62.
iSCR available for 5- to 7-cylinder engines with one TC on exhaust side



X-DF Methanol Engines

X62DF-M-1.0

IMO Tier II & Tier III (SCR)

Cylinder bore	620 mm
Piston stroke	2 658 mm
Speed	77-103 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.29

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 103 rpm	77 rpm			Length A mm	Dry mass tonnes
	R1	R2	R3	R4		
5	14 500	10 650	10 800	7 950	7 000	341
6	17 400	12 780	12 960	9 540	8 110	396
7	20 300	14 910	15 120	11 130	9 215	457
8	23 200	17 040	17 280	12 720	10 320	506

Dimensions (mm)	B	C	D	
	4 200	1 360	9 580	
	F1	F2	F3	G
	11 830	11 830	11 005	2 110

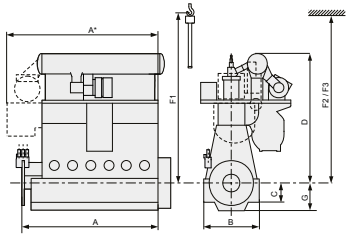
BRAKE SPECIFIC FUEL CONSUMPTION IN METHANOL MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 065	6 835	7 023	6 835
BSGC (gas)	g/kWh	336.4	325.4	334.4	325.4
BSPC (pilot fuel)	g/kWh	8.7	8.4	8.6	8.4

BRAKE SPECIFIC FUEL COMSUPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	168.8	163.3	167.8	163.3

For definitions see page 62.
iSCR available for 5- to 7-cylinder engines with one TC on exhaust side



X72DF-M-1.0

IMO Tier II & Tier III (SCR)

Cylinder bore	720 mm
Piston stroke	3 086 mm
Speed	66-89 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.29

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 89 rpm	66 rpm			Length A mm	Dry mass tonnes
	R1	R2	R3	R4		
5	19 600	14 300	14 550	10 600	8 085	505
6	23 520	17 160	17 460	12 720	9 375	589
7	27 440	20 020	20 370	14 840	10 665	674
8	31 360	22 880	23 280	16 960	11 960	752

Dimensions (mm)	B	C	D	
	4 780	1 575	10 790	
	F1	F2	F3	G
	13 750	13 750	12 820	2 455

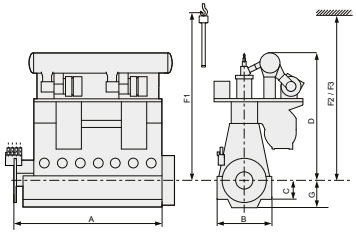
BRAKE SPECIFIC FUEL CONSUMPTION IN METHANOL MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	7 065	6 835	7 023	6 835
BSGC (gas)	g/kWh	336.4	325.4	334.4	325.4
BSPC (pilot fuel)	g/kWh	8.7	8.4	8.6	8.4

BRAKE SPECIFIC FUEL COMSUPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	168.8	163.3	167.8	163.3

For definitions see page 62.
iSCR available for 5- to 7-cylinder engines with one TC on exhaust side



X-DF Methanol Engines

X82DF-M-1.0

IMO Tier II & Tier III (SCR)

Cylinder bore	820 mm
Piston stroke	3 375
Speed	58-84 rpm
Mean effective pressure at R1	22.0 bar
Stroke / bore	4.12

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 84 rpm / 58 rpm				Length A mm	Dry mass tonnes
	R1	R2	R3	R4		
6	33 000	24 000	22 800	16 560	10 426	845
7	38 500	28 000	26 600	19 320	11 866	956
8	44 000	32 000	30 400	22 080	13 306	1 071
9	49 500	36 000	34 200	24 840	14 746	1 218

Dimensions (mm)	B	C	D	
	5 050	1 800	12 310	
	F1	F2*	F3*	G
	15 250	-	-	2 700

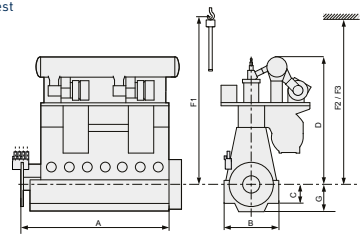
BRAKE SPECIFIC FUEL CONSUMPTION IN METHANOL MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	6 961	6 748	6 799	6 684
BSGC (gas)	g/kWh	332.2	321.5	324.1	318.3
BSPC (pilot fuel)	g/kWh	8.2	8.2	8.2	8.2

BRAKE SPECIFIC FUEL COMSUPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	166.3	161.2	162.5	159.7

For definitions see page 62.
* Available upon request



X92DF-M-1.0

IMO Tier II & Tier III (SCR)

Cylinder bore	920 mm
Piston stroke	3 468
Speed	70-80 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	3.77

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 80 rpm / 70 rpm				Length A mm	Dry mass tonnes
	R1	R2	R3	R4		
6	38 700	27 900	33 900	24 420	11 755	1 176
7	45 150	32 550	39 550	28 490	13 345	1 323
8	51 600	37 200	45 200	32 560	14 935	1 449
9	58 050	41 850	50 850	36 630	17 960	1 771
10	64 500	46 500	56 500	40 700	19 550	1 880
11	70 950	51 150	62 150	44 770	21 215	2 058
12	77 400	55 800	67 800	48 840	22 875	2 247

Dimensions (mm)	B	C	D	
	5 550	1 900	13 150	
	F1	F2	F3	G
	15 640	15 650	14 360	2 970

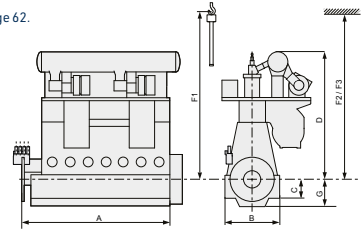
BRAKE SPECIFIC FUEL CONSUMPTION IN METHANOL MODE

Rating point		R1	R2	R3	R4
BSEC (energy)	kJ/kWh	6 855	6 603	6 812	6 645
BSGC (gas)	g/kWh	327.3	314.6	325.1	316.8
BSPC (pilot fuel)	g/kWh	8.0	8.0	8.0	8.0

BRAKE SPECIFIC FUEL COMSUPTION IN DIESEL MODE

Rating point		R1	R2	R3	R4
BSFC (diesel Tier II)	g/kWh	163.8	157.8	162.8	158.8

For definitions see page 62.



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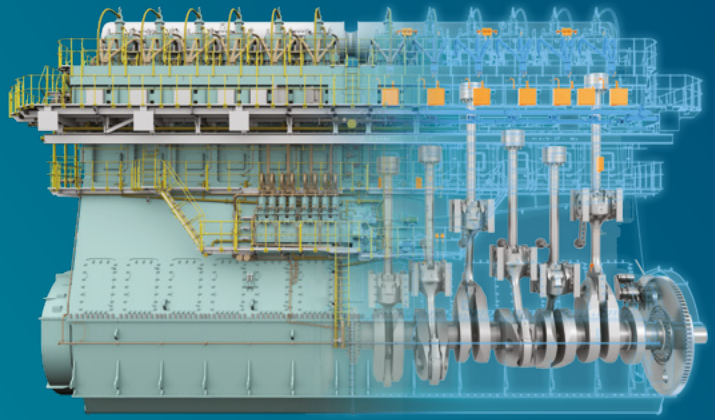


The most powerful marine internal combustion Otto cycle engine commercially available is the WinGD 12X92DF

Designed by WinGD (Winterthur Gas & Diesel Ltd. Switzerland) **with a power output of 63.840 MW,** first built by CMD (CSSC-MES Diesel Co., Ltd) in China and verified on 17 September 2020.

X-Engines Diesel

X52-1.1

IMO Tier II & Tier III (SCR)

Cylinder bore	520 mm
Piston stroke	2 315 mm
Speed	79-105 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.45

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 105 rpm	79 rpm			Length A mm	Length A* mm	Dry mass tonnes
	R1	R2	R3	R4			
5	9 050	6 800	6 800	5 100	5 985	6 990	217
6	10 860	8 160	8 160	6 120	6 925	7 930	251
7	12 670	9 520	9 520	7 140	7 865		288
8	14 480	10 880	10 880	8 160	8 805		323

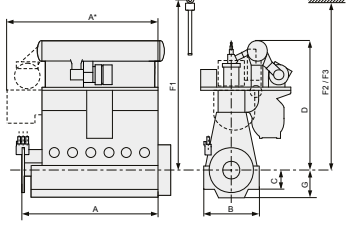
Dimensions (mm)	B	C	D	D (iSCR)
	3 514	1 205	8 415	8 760
	F1	**F2**	**F3**	**G**
	10 350	10 350	9 800	1 910

BRAKE SPECIFIC FUEL CONSUMPTION (BSFC) IN g/kWh

Rating point		R1	R2	R3	R4
BMEP, bar		21.0	15.8	21.0	15.8
BSFC (g/kWh)	Delta Bypass Tuning, 100% power, Tier II	169.8	162.8	169.8	162.8

R1 BSFC (g/kWh), Tier II	Power(%)				
	50	65	75	90	100
Delta Bypass Tuning	163.7	161.5	161.3	164.1	169.8
Low-load Tuning	160.2	158.0	161.3	164.5	170.8

For definitions see page 62.
iSCR available for 5- to 7-cylinder engines with one TC on exhaust side



X52-S2.0

IMO Tier II & Tier III (SCR)

Cylinder bore	520 mm
Piston stroke	2 045 mm
Speed	85-120 rpm
Mean effective pressure at R1	22.0 bar
Stroke / bore	3.93

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 120 rpm	85 rpm			Length A mm	Length A* mm	Dry mass tonnes
	R1	R2	R3	R4			
5	9 550	6 850	6 775	4 850	5 485	6 565	190
6	11 460	8 220	8 130	5 820	6 345	7 415	215
7	13 370	9 590	9 485	6 790	7 205		245
8	15 280	10 960	10 840	7 760	8 065		275

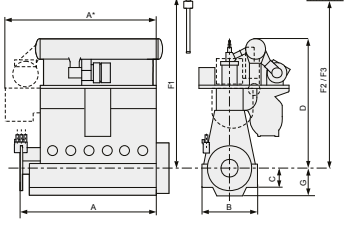
Dimensions (mm)	B	C	D	D (iSCR)
	3 100	1 185	7 775	8 000
	F1	**F2**	**F3**	**G**
	9 340	9 340	8 800	1 675

BRAKE SPECIFIC FUEL CONSUMPTION (BSFC) IN g/kWh

Rating point		R1	R2	R3	R4
BMEP, bar		22.0	15.8	22.0	15.8
BSFC (g/kWh)	Delta Bypass Tuning, 100% power, Tier II	163.8	157.8	162.8	160.8

R1 BSFC (g/kWh), Tier II	Power(%)				
	50	65	75	90	100
Delta Bypass Tuning	157.7	155.5	155.3	158.1	163.8
Low-load Tuning	154.2	152.0	155.3	158.5	164.8

For definitions see page 62.
iSCR available for 5- to 7-cylinder engines with one TC on exhaust side



X-Engines Diesel

X62-S2.0

IMO Tier II & Tier III (SCR)

Cylinder bore	620 mm
Piston stroke	2 245 mm
Speed	82–108 rpm
Mean effective pressure at R1	22 bar
Stroke / bore	3.62

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 108 rpm	82 rpm			Length A mm	Dry mass tonnes
	R1	R2	R3	R4		
5	13 425	9 650	10 200	7 325	6 260	280
6	16 110	11 580	12 240	8 790	7 260	325
7	18 795	13 510	14 280	10 255	8 260	370
8	21 480	15 440	16 320	11 720	9 260	415

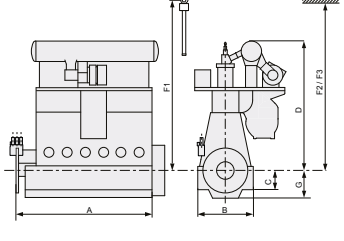
Dimensions (mm)	B	C	D	D (iSCR)
	3 440	1 295	8 575	9 020
	F1	**F2**	**F3**	**G**
	10 230	10 230	9 620	1 835

BRAKE SPECIFIC FUEL CONSUMPTION (BSFC) IN g/kWh

Rating point		R1	R2	R3	R4
BMEP, bar		22.0	15.8	22.0	15.8
BSFC (g/kWh)	Delta Bypass Tuning, 100% power, Tier II	163.8	158.8	161.8	159.8

R1 BSFC (g/kWh), Tier II	Power(%) 50	65	75	90	100
Delta Bypass Tuning	157.7	155.5	155.3	158.1	163.8
Low-load Tuning	154.2	152.0	155.3	158.5	164.8

For definitions see page 62.
iSCR available for 5- to 7-cylinder engines with one TC on exhaust side



X62-1.1

IMO Tier II & Tier III (SCR)

Cylinder bore	620 mm
Piston stroke	2 658 mm
Speed	77–103 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.29

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 103 rpm	77 rpm			Length A mm	Dry mass tonnes
	R1	R2	R3	R4		
5	14 500	10 650	10 800	7 950	7 000	325
6	17 400	12 780	12 960	9 540	8 110	377
7	20 300	14 910	15 120	11 130	9 215	435
8	23 200	17 040	17 280	12 720	10 320	482

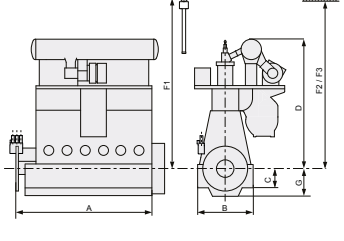
Dimensions (mm)	B	C	D	
	4 200	1 360	9 580	
	F1	**F2**	**F3**	**G**
	11 830	11 830	11 005	2 110

BRAKE SPECIFIC FUEL CONSUMPTION (BSFC) IN g/kWh

Rating point		R1	R2	R3	R4
BMEP, bar		21.0	15.5	21.0	15.4
BSFC (g/kWh)	Delta Bypass Tuning, 100% power, Tier II	167.8	162.3	166.8	162.3

R1 BSFC (g/kWh), Tier II	Power(%) 50	65	75	90	100
Delta Bypass Tuning	160.7	158.8	159.3	162.1	167.8
Low-load Tuning	157.2	155.3	159.3	162.5	168.8

For definitions see page 62.
iSCR available for 5- to 7-cylinder engines with one TC on exhaust side



X-Engines Diesel

X72-B

IMO Tier II & Tier III (SCR)

Cylinder bore	720 mm
Piston stroke	3 086 mm
Speed	66–89 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.29

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 89 rpm	66 rpm			Length A mm	Dry mass tonnes
	R1	R2	R3	R4		
5	19 600	14 300	14 550	10 600	8 085	481
6	23 520	17 160	17 460	12 720	9 375	561
7	27 440	20 020	20 370	14 840	10 665	642
8	31 360	22 880	23 280	16 960	11 960	716

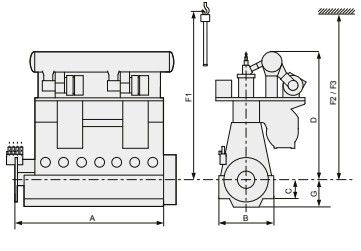
Dimensions (mm)	B	C	D	
	4 780	1 575	10 790	
	F1	F2	F3	G
	13 750	13 750	12 820	2 455

BRAKE SPECIFIC FUEL CONSUMPTION (BSFC) IN g/kWh

Rating point		R1	R2	R3	R4
BMEP, bar		21.0	15.3	21.0	15.3
BSFC (g/kWh)	Delta Bypass Tuning, 100% power, Tier II	167.8	162.3	166.8	162.3

R1 BSFC (g/kWh), Tier II	Power(%)				
	50	65	75	90	100
Delta Bypass Tuning	160.7	158.8	159.3	162.1	167.8
Low-load Tuning	157.2	155.3	159.3	162.5	168.8

For definitions see page 62.



X82-2.0

IMO Tier II & Tier III (SCR)

Cylinder bore	820 mm
Piston stroke	3 375 mm
Speed	58–84 rpm
Mean effective pressure at R1	22.0 bar
Stroke / bore	4.12

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 84 rpm	58 rpm			Length A mm	Dry mass tonnes
	R1	R2	R3	R4		
6	33 000	24 000	22 800	16 560	10 426	805
7	38 500	28 000	26 600	19 320	11 866	910
8	44 000	32 000	30 400	22 080	13 306	1 020
9	49 500	36 000	34 200	24 840	14 746	1 160

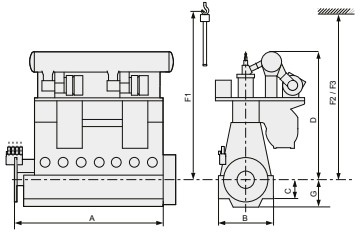
Dimensions (mm)	B	C	D	
	5 050	1 800	12 310	
	F1	F2*	F3*	G
	15 250	-	-	2 700

BRAKE SPECIFIC FUEL CONSUMPTION (BSFC) IN g/kWh

Rating point		R1	R2	R3	R4
BMEP, bar		22.0	16.0	22.0	16.0
BSFC (g/kWh)	Delta Bypass Tuning, 100% power, Tier II	165.3	160.2	161.5	158.7

R1 BSFC (g/kWh), Tier II	Power(%)				
	50	65	75	90	100
Delta Bypass Tuning	159.2	157.0	156.8	159.6	165.3
Low-load Tuning	155.7	153.5	156.8	160.0	166.3

For definitions see page 62.
* Available upon request



X-Engines Diesel

X92-B

IMO Tier II & Tier III (SCR)

Cylinder bore	920 mm
Piston stroke	3 468 mm
Speed	70–80 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	3.77

RATED POWER, PRINCIPAL DIMENSIONS AND MASS

Cyl.	Output in kW at 80 rpm R1	70 rpm R2	70 rpm R3	70 rpm R4	Length A mm	Dry mass tonnes
6	38 700	27 900	33 900	24 420	11 755	1 120
7	45 150	32 550	39 550	28 490	13 345	1 260
8	51 600	37 200	45 200	32 560	14 935	1 380
9	58 050	41 850	50 850	36 630	17 960	1 630
10	64 500	46 500	56 500	40 700	19 550	1 790
11	70 950	51 150	62 150	44 770	21 215	1 960
12	77 400	55 800	67 800	48 840	22 875	2 140

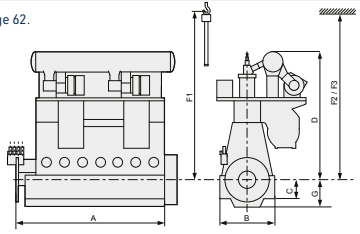
Dimensions (mm)	B	C	D	
	5 550	1 900	13 150	
	F1	**F2**	**F3**	**G**
	15 640	15 650	14 360	2 970

BRAKE SPECIFIC FUEL CONSUMPTION (BSFC) IN g/kWh

Rating point		R1	R2	R3	R4
BMEP, bar		21.0	15.1	21.0	15.1
BSFC (g/kWh)	Delta Bypass Tuning, 100% power, Tier II	162.8	156.8	161.8	157.8

R1 BSFC (g/kWh), Tier II	Power(%) 50	65	75	90	100
Delta Bypass Tuning	156.7	154.5	154.3	157.1	162.8
Low-load Tuning	151.6	149.6	153.8	157.5	163.8

For definitions see page 62.

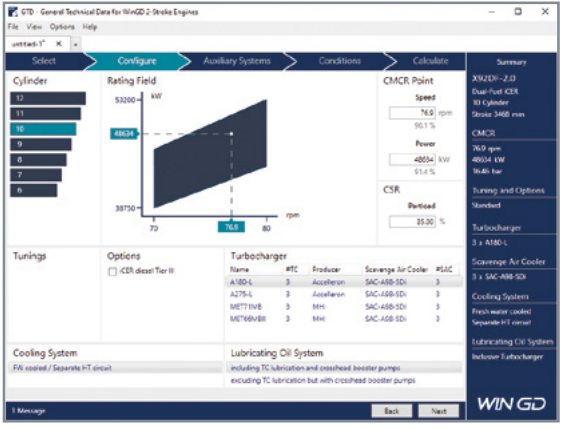


General Technical Data Application

WinGD's General Technical Data (GTD) application provides information to plan the layout of WinGD marine low-speed engines.

Create new projects in three simple steps:

1. Select an engine from the product portfolio
2. Define a configuration which meets the vessel requirements
3. Analyse the resulting performance data and export as a PDF



Start your next engine project by downloading GTD:
www.wingd.com/en/media/general-technical-data

GTD

Scan this QR code to send the above link by email

The program is a desktop application and supported by all Windows operating systems from version 7.

Engine Definitions and Notes

ISO Standard (ISO 3046-1) reference conditions

1.0 bar Total barometric pressure at R1

25°C Suction air temperature

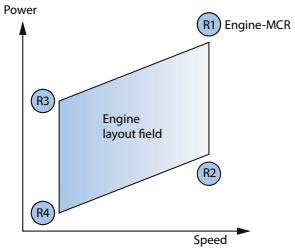
30% Relative humidity

25°C Cooling water temperature before engine

Rating points

The engine layout fields for WinGD low-speed engines are defined by the power/speed rating points R1, R2, R3 and R4 (see diagram below).

R1, ok instead if applicable, is the nominal maximum continuous rating (MCR).



Any power and speed within the respective engine layout field may be selected as the Contracted-MCR (CMCR) point for an engine.

Dimensions and weights

- All dimensions and weights are not binding. For detailed information and updates, please visit: www.wingd.com/en/engines/engine-types/

A Engine length from the coupling flange to the end of the bedplate

A* Engine length from the TC aft end to the end of the bedplate

B Width of the engine seating

C Dist. from the centre of the crankshaft to the underside of the foot flange

D Dist. from the centre of the crankshaft to the highest point of the engine

F1 Min. height for vertical removal of the piston

F2 Min. height for vertical removal of the piston with double-jib crane

F3 Min. height for tilted removal of the piston with double-jib crane

G Distance from the centre of the crankshaft to the lowest point of the engine

- The engine weight is a net value and excludes any liquids.

Fuel/energy consumption

All brake specific fuel consumptions (BSFC) and brake specific pilot fuel consumptions (BSPC) are quoted for fuel of lower calorific value 42.7 MJ/kg.

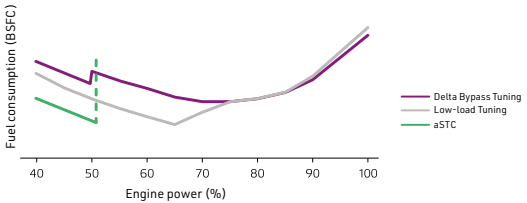
Brake specific gas consumptions (BSGC) are quoted for gas of lower calorific value 50.0 MJ/kg.

Brake specific energy consumptions (BSEC) for dual-fuel engines are based on energy delivered to the engine as gas and liquid fuel for one kilowatt hour mechanical power output.

For all WinGD low-speed diesel and dual-fuel engines stepwise tolerances have been introduced for the brake specific fuel and energy consumption (BSFC/BSEC) guarantee, referring to ISO standard reference conditions (ISO 15550 and 3046):

- +5% tolerance for 100% to 85% engine power
- +6% tolerance for <85% to 65% engine power
- +7% tolerance for <65% to 50% engine power

The BSFC/BSEC guarantee is possible at up to three power points between 50–100%.



Available engine tunings

Delta Bypass Tuning and Low-load Tuning are available for certain WinGD low-speed diesel engines to provide optimum fuel consumption for different engine loads. Delta Bypass Tuning and Low-load Tuning focuses on reducing fuel consumption in the operating range below 90% or 75% engine power.

The advanced technology of Steam Production Control (SPC) can be added to the Low-load and Delta Bypass Tuning to increase the steam production, while keeping the overall fuel consumption at a minimum.

Dual tuning is available on request and in cooperation with classification societies.

Automated Sequential Turbocharging (aSTC) is available as an option for X82-2.0 and X92-B engines with multi-turbocharger configurations. aSTC significantly reduces the engine's consumption at low loads.

WinGD Technologies

X-DF Technology

X-DF by WinGD

A proven and reliable engine platform for fuel flexible vessels

WinGD is a pioneer in modern dual-fuel technology for two-stroke marine engines, with LNG fuelled engines in operation since 2016. With well over four million running hours to date, the in-service experience behind X-DF far exceeds that of similar engine concepts. Now the X-DF series is evolving, bringing the proven and reliable Diesel cycle performance of its X-Engines to offer ammonia and methanol dual-fuelled engines.

X-DF for LNG

Using WinGD's dual-fuel X-DF engines gives operators flexibility in reducing emissions. Fossil LNG offers an immediate 15-20% reduction in greenhouse gas emissions. By blending or replacing fossil LNG with carbon-neutral synthetic or bio-LNG, operators can reduce their emissions further without modification. All X-DF engines can be retrofitted for methanol or ammonia, giving unrivalled choice in how operators meet their emissions targets.

The low-cost, highly efficient and reliable fuel injection concept used by WinGD's dual-fuel LNG engines offers several advantages over other dual-fuel engine concepts:

- Simple installation, low-cost auxiliary systems and low power consumption contribute to lower investment and life cycle costs
- Extremely small pilot fuel quantity, below 1% of total heat release
- Engines can be operated on gas down to very low loads
- Low NO_X emissions, close to zero SO_X emissions, IMO Tier III compliant without exhaust-gas after-treatment
- Particulate matter emissions significantly reduced

X-DF for ammonia and methanol

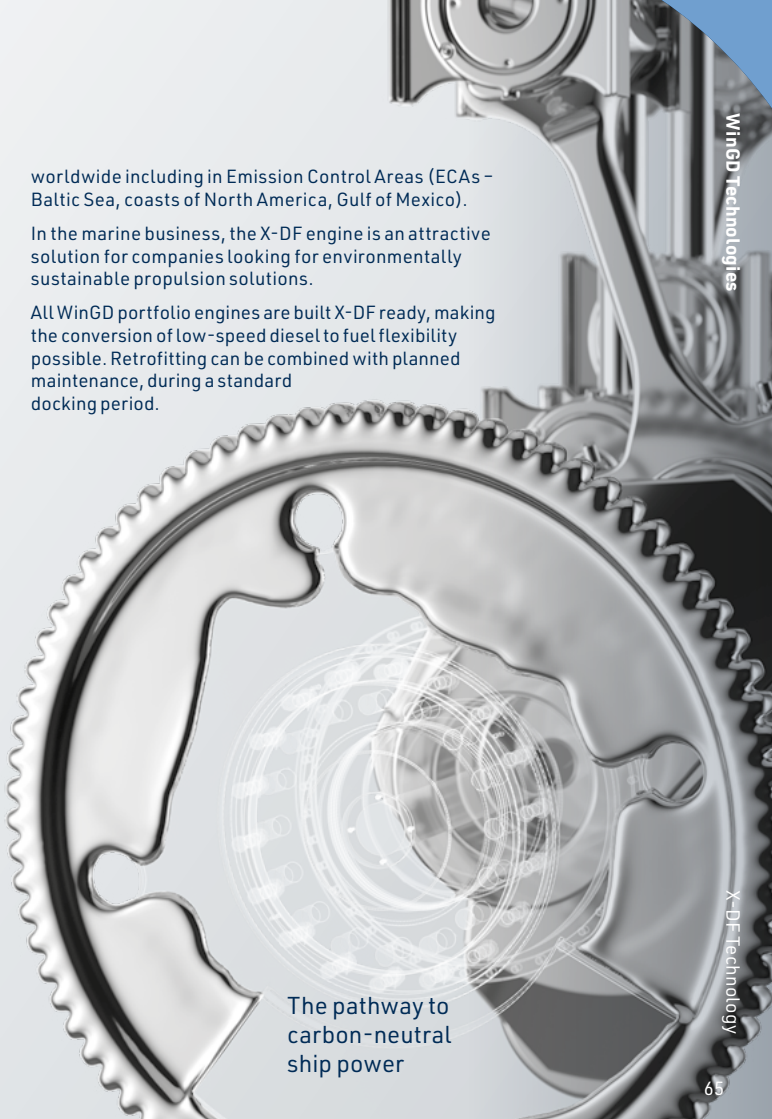
Ammonia-fuelled X-DF-A and methanol-fuelled X-DF-M dual-fuel engines are now available for order, with the first vessels using these engines to enter service in 2025. The following pages provide concept overviews and availability.

Applications

X-DF technology is applicable on a variety of vessel types, including LNG carriers, chemical tankers, container ships and vessels operating worldwide including in Emission Control Areas – Baltic Sea, coasts of North America, Gulf of Mexico).

In the marine business, the X-DF engine is an attractive solution for companies looking for environmentally sustainable propulsion solutions.

All WinGD portfolio engines are built X-DF ready, making the conversion of low-speed diesel to fuel flexibility possible. Retrofitting can be combined with planned maintenance, during a standard docking period.



The pathway to carbon-neutral ship power

X-DF-A Technology

X-DF-A by WinGD

WinGD's first engine platform designed for carbon-free fuel

Available for order now and with first engine delivery committed for early 2025, X-DF-A will enable deep-sea ship owners and operators to choose carbon-free ammonia for their main engines.

The engine platform deployed in X-DF-A engines will be familiar to operators of WinGD's well-established, highly efficient diesel-fuelled X-Engines. Notable features include comparable performance with X-Engines in both ammonia mode and diesel mode, low pilot fuel requirements precisely controlled through common rail injection and NOx Tier III compliance in both modes with Selective Catalytic Reduction (SCR).

Safety has been a key priority during the development of engines using ammonia due to the inherent characteristics of the fuel. Already supported with Approval-in-Principle from Lloyd's Register and Bureau Veritas , X-DF-A delivers the assurance that ship owners and operators need to integrate ammonia-fuelled engines into vessel designs today.

Injection concept

The X-DF-A is a dual-fuel engine equipped with a technology enabling the engine to operate either on ammonia or diesel fuel. The engine operates according to the diesel principle in both diesel mode and ammonia mode. It is equipped with two separate fuel injection systems. The diesel fuel injection system is used for diesel mode and remains active in ammonia mode for injecting a small amount of pilot fuel, needed for stable ignition of ammonia fuel.

Engine parameters

The ammonia engines have the same rating field as the diesel engines and will be available with the same cylinder configurations. The mechanical design is based on the existing WinGD X-Engine portfolio, with the addition of an ammonia fuel injection system including the additional servo oil system to drive it.

IMO Tier III solutions

The X-DF-A engines are IMO Tier II NO_x compliant without an exhaust gas aftertreatment in both diesel mode and ammonia mode. IMO Tier III compliance can be reached in both operating modes with a high-pressure SCR (HP SCR) installed upstream the turbochargers.

The HP SCR system can be installed off-engine or on-engine (iSCR) depending on the engine type. The on-engine option (iSCR) is feasible only on single turbocharger engines.

Retrofit ready

All WinGD engines are built on a similar, robust platform capable of handling the high pressures and temperatures that may be needed for various alternative fuels. This ensures that retrofitting between all fuels – including conventional liquid fuel, LNG, methanol and ammonia – is both technically and economically feasible, while ensuring comparable performance on any fuel. Retrofit packages for converting diesel and LNG engines to X-DF-A engines will be available shortly after newbuild engines are developed for the relevant bore size.

Minimum extra CAPEX

Highest efficiencies in both fuel modes

Minimal pilot fuel needed

100% safe and secure operation

X-DF-M Technology

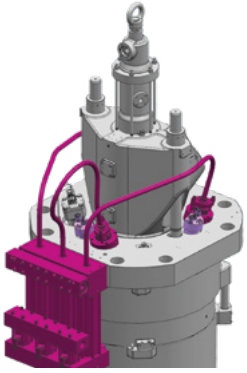
Methanol-fuelled capability based on proven engine performance

Available for order now and with first engine delivery committed for early 2025, X-DF-M enables deep-sea ship owners and operators to choose near carbon-neutral green methanol or low-carbon blue methanol for their main engines.

The engine platform deployed in X-DF-M engines will be familiar to operators of the WinGD well-established, highly efficient diesel-fuelled X-Engines. Notable features include comparable performance with X-Engines in both methanol mode and diesel mode, low pilot fuel requirements precisely controlled through common rail injection, and NO_X Tier III compliance in both modes with Selective Catalytic Reduction (SCR).

Methanol technology

The engine operates according to the diesel principle in both diesel mode and methanol mode. The base engine is a Diesel cycle X-Engine Diesel with an additional methanol fuel injection system. The diesel fuel injection system is used when the engine is running in diesel mode and to inject a small amount of pilot fuel in methanol mode. The pilot fuel injection is required to have an accurate ignition of the methanol fuel at all engine loads.



Main engine parameters

The methanol engines have the same rating field as the diesel engines and will be available with the same cylinder configurations. The mechanical design is based on today's WinGD X-Engine portfolio, with addition of the methanol fuel injection system including the additional servo oil system to drive it.

IMO Tier III solutions

The methanol fuelled engines can meet IMO Tier II NO_X levels in both diesel mode and methanol mode. Exhaust gas aftertreatment is required to meet IMO Tier III NO_X levels. SCR can be used for this.

SCR can be located either upstream the TC turbine (high-pressure SCR) or downstream (low-pressure SCR). On-engine SCR (iSCR) can also be used on single turbocharger engines.

Retrofit ready

All WinGD engines are built on a similar, robust platform capable of handling the high pressures and temperatures that may be needed for various alternative fuels. This ensures that retrofitting between all fuels – including conventional liquid fuel, LNG, methanol and ammonia – is both technically and economically feasible, while ensuring comparable performance on any fuel. Retrofit packages for converting diesel and LNG engines to X-DF-M engines will be available shortly after new build engines are developed for the relevant bore size.

Minimum extra CAPEX

Highest efficiencies in both fuel modes

Minimal pilot fuel needed

Variable Compression Ratio (VCR) Technology

X-DF VCR by WinGD

Compression without compromise for optimal efficiency on all fuels

Marine dual-fuel engines were conceived to enable the use of cleaner alternative fuels alongside conventional liquid fuel. However the use of two different fuels necessitates a design compromise that has prevented both fuels from being used with maximum efficiency, and which has been unavoidable until now. As each fuel has a different compression ratio at which ideal combustion is achieved, engine designers have had to choose which fuel to favour when setting this fixed parameter.

To redress this, WinGD and Mitsui E&S DU Co have developed Variable Compression Ratio (VCR) technology. VCR allows an engine's compression ratio to be dynamically adapted depending on current operation point, ambient condition and ideal combustion pressures. This offers improved efficiency regardless of the fuel, and makes operating with both fuels more feasible.

Significant performance improvements

In tests on a 6X72DF engine with MES-DU, the VCR technology has delivered significant performance improvements in gas mode. This includes a reduction of gas consumption of 2-6g/kWh depending on engine load, with particularly high reductions at part load. WinGD expects further reductions of methane slip and lower total GHG emissions through a combination of VCR and iCER to X-DF engines. In diesel mode, the ability to keep a higher compression ratio across the engine load range led to an 8-12g/kWh reduction, depending on engine type and rating.

This performance brings diesel consumption to a similar level to a conventional diesel engine – eliminating the traditional compromise in diesel efficiency of a lean burn pre-mixed engine. Based on the performance improvements mentioned, the following fuel consumption, emissions and OPEX calculations have been made for some key vessel types.

The calculations for each mode assume that the engine has been running in the same mode for a full year at an assumed typical load profile.

Considering these potential savings and the further savings achieved under any future carbon pricing regime, WinGD anticipates very short payback periods for VCR technology regardless of the fuel used.

EXAMPLE CONSUMPTION & GHG EMISSIONS COMPARED TO X-DF 2.0 'NON-VCR'

Type of vessel	Engine type	Engine rating	Consumption savings		GHG reduction		Annual OPEX savings: fuel	Annual OPEX savings: GHG	Annual OPEX savings: sum
			tons/year	%	tons/year	%	US$/year	US$/year*	US$/year*
174k cum LNGC	2x 5X72DF-2.2 VCR	2 x 12 129 kW	GM: 361	GM: -2.4%	GM: 1 655	GM: -3.7%	GM: -307 000	GM: -148 985	GM: -455 985
		75 RPM	DM:1036	DM: -5.6%	DM: 3 260	DM: -5.6%	DM: -549 000	DM: -293 800	DM: -842 800
7000 CEU PCTC	7X62DF-S2.0 VCR	11 920 kW	GM: 163	GM: -2.3%	GM: 761	GM: -3.5%	GM: -138 700	GM: -64 490	GM: -203 190
		104.8 RPM	DM: 494	DM: -5.7%	DM: 1 555	DM: -5.7%	DM: -261 600	DM: -139 950	DM: -401 550
1900 TEU Feeder	6X62DF-S2.0 VCR	11 500 kW	GM: 146	GM: -3.1%	GM: 611	GM: -4.6%	GM: -124 000	GM: -54 990	GM: -178 990
		105 RPM	DM: 440	DM: -7.7%	DM: 1 385	DM: -7.7%	DM: -233 000	DM: -124 650	DM: -357 650
115k dwt BC	6X62DF-2.1 VCR	10 450 kW	GM: 121	GM: -2.3%	GM: 610	GM: -3.8%	GM: -103 000	GM: -54 900	GM: -157 900
		82 RPM	DM: 424	DM: -6.5%	DM: 1 336	DM: -6.5%	DM: -233 250	DM: -139 950	DM: -373 200

Fuel Prices: LNG = $850; VLSFO = $530
Typical operation profile used per vessel segment

GM: Continuous Gas Mode operation
DM: Continuous Diesel Mode operation

* based on carbon tax price = $ 90

Variable Compression Ratio (VCR) Technology

X-DF VCR by WinGD

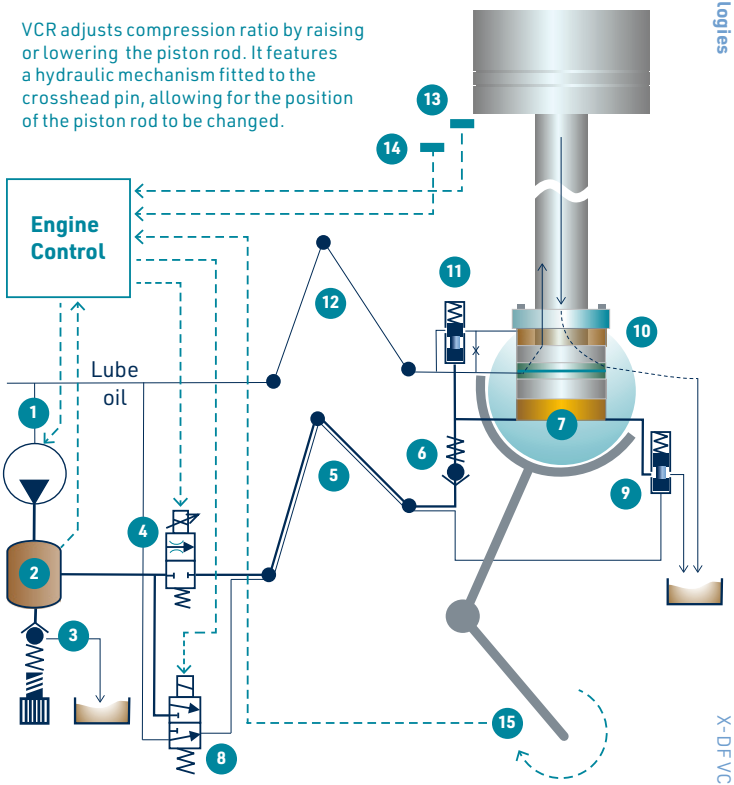
Simple, sturdy and easy to install

VCR adjusts compression ratio by raising or lowering the piston rod. It features a hydraulic mechanism fitted to the crosshead pin, allowing for the position of the piston rod to be changed. The piston position is controlled by the amount of oil in the lower chamber located below the piston rod. The amount of oil is controlled by filling pressurised lube oil through a knee lever and by draining the lube oil from the lower chamber.

This simple, sturdy design has no impact on installation requirements or engine footprint and requires no specific maintenance between drydocking periods.

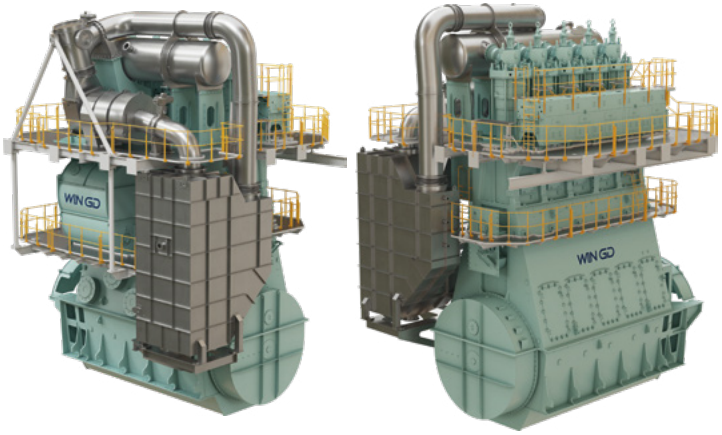
VCR is available as an option for 62- and 72-bore X-DF engines, including both short- and long-stroke versions of the X62DF. A portfolio rollout to other engine types will follow based on market demand.

1. **Feed pump**
   Electrically driven, it increases the engine lube oil pressure (4…5bar) to the feed pressure of 40…50bar. Variable motor speed to minimise power consumption.
2. **Feed manifold**
   Distributes the lube oil to all cylinders.
3. **Pressure control valve**
   Limits the pressure in the feed manifold.
4. **Solenoid proportional Valve**
   (Inlet) Controls the flow of oil to the lower chamber of each cylinder.
5. **Knee lever of VCR**
   Connects the proportional valve with the lower hydraulic chamber.
6. **Delivery Valve**
   Spring loaded non-return valve.
7. **Lower chamber**
   Lifts the piston rod depending on amount of oil in it.
8. **Solenoid relief valve**
   Controls opening and closing of outlet valve (9).
9. **Outlet Valve**
   (Spring-loaded) Releases oil from the lower hydraulic chamber to lower the position of the piston rod.
10. **Upper chamber**
    Holds the piston down under any situation (e.g. engine start or malfunction of exhaust valve).
11. **Lift-off v/v with filling orifice**
    Retains oil volume in upper chamber in case of low oil pressure in lower chamber to avoid lift-off of piston.
12. **Knee lever for piston cooling**
    Existing knee lever for usual piston cooling.
13. **Sensor for piston position**
    Measures piston timing and enables control of piston rod position.
14. **Sensor for air temperature**
    in piston underside
    Measures scavenge air temperature close to the scavenging ports of each cylinder.
15. **Crank Angle Signal**
    Existing engine crank angle signal used also for the VCR control.



X-DF2.0 Technology

X-DF2.0 by WinGD



Building on proven dual-fuel LNG performance

With X-DF2.0, WinGD builds on its proven, reliable dual-fuel LNG platform with even greater efficiency and emissions performance.

The technology – intelligent control by exhaust recycling (iCER) – delivers superior combustion control, using inert gas to adjust the gas/air mix improving both fuel consumption and emissions.

As well as reducing fuel consumption, iCER delivers a 50% reduction in methane slip in gas mode, while allowing Tier III compliance in diesel mode.

Reduced methane slip and CO_2 emissions

Lower fuel consumption

Proven design for reliability and safety

iCER

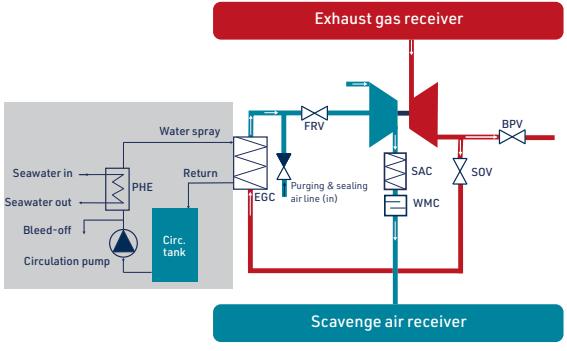
The iCER system is designed to cool and recirculate part of the exhaust gas. It is made up of a low-pressure exhaust recycling path with an efficient exhaust gas cooler (EGC). When recirculated exhaust gas is mixed with scavenge air, carbon dioxide partly replaces the oxygen in the fresh air, reducing the mixture's reactivity during combustion.

This increases the ignition delay and stabilises the combustion speed. By raising resistance to auto-ignition and reducing combustion speed, iCER enables combustion control so that the compression ratio can be increased and thermal efficiency improved.

iCER On-engine

The iCER system is also available in an on-engine configuration, enabling the emissions reduction technology to be installed without impact on engine footprint. On-engine iCER offers the same advantages while simplifying testing, building and installation of the engine, as well as reducing the engine room space needed for emissions reduction equipment.

The exhaust gas cooler and all exhaust gas flow control components are installed on the engine, offering significant engine room design flexibility. The production-friendly design also minimises manufacturing and installation costs.



Abbreviation:

FRV	Flow Regulating Valve	**WMC**	Water Mist Catcher
SOV	Shut Off Valve	**EGC**	Exhaust Gas Cooler
SAC	Scavenge Air Cooler	**PHE**	Plate Heat Exchanger
BPV	Back Pressure Valve		

WiCE

WinGD Integrated Control Electronics (WiCE) provides engines with the robust connectivity and security needed to support more advanced control strategies, as well as increased integration with other ship systems.

Modern ship operations demand more from engine control systems. In addition to controlling basic functions they must monitor and regulate emissions performance, ensure that engines work in harmony with a wider range of auxiliary equipment and enable data connectivity with wider ship and fleet systems.

Cybersecure

All vessels ordered from 2024 will need to meet IACS Unified Requirement E27 for cyber security of installed systems. WiCE has received SP1 type approval from DNV, assuring customers that it is capable of meeting this standard. Security features include identification and authentication, software authenticity verification, backup and rollback functionality, cybersecurity event logging and traffic monitoring and control.

Modular and upgradable

WiCE is designed for an increasingly connected and data-driven ship operating environment. The system – comprising a main control unit, cylinder control unit and communication gateway unit – is fully modular in both software and hardware, making it easily adaptable for future needs. Each unit can be independently verified and validated so that they can be updated and exchanged without impacting the functionality of other units.

Enhanced connectivity

WiCE features a dedicated communication gateway unit allowing it to link to diagnostics systems and receive software updates without jeopardising the integrity of mission-critical engine control. The powerful communication bus enables rapid, secure and seamless data exchange among system units.

EEDI and EEXI

Energy efficiency

The IMO's Energy Efficiency Design Index (EEDI) and Energy Efficiency for Existing Ships Index (EEXI) require validation that all vessels, whether new or already in operation, meet to a set baseline in energy efficient design. WinGD offers several solutions to meet both, EEDI and EEXI target ratings.

Engine Power limitation

Shipowners can comply with the EEXI regulation by limiting the power output of installed engines. WinGD's software-based EEXI Power Limitation can be installed by our experts within a single port visit, avoiding the need for more expensive engineering work requiring drydocking.

Click or scan the QR code to find out more

LNG and alternative fuels

EEXI and EEDI calculations reward engines capable of using lower carbon fuels with a lower conversion factor for CO_2 emissions. The calculation also considers fuel consumption, meaning that fuel efficient engines reduce EEXI rating.

WinGD's X-DF dual-fuel engines improve ratings through stable combustion control, allowing operation on gas at low loads and with very low pilot fuel consumption. Using X-DF2.0 combustion control, efficiency and emissions are improved further. WinGD will continue its focus on fuel efficiency when methanol- and ammonia-fuelled X-DF engines are introduced.

Hybrid power

Hybrid power can have a positive impact on EEDI and EEXI ratings by enabling ship operators to reduce installed engine power. For vessels using shaft generators for propulsion power, main engine fuel consumption rather than auxiliary engine consumption is used in the calculations, producing a better rating through the main engine's greater fuel efficiency.

WinGD can advise shipowners which hybrid configurations can help them achieve the required reductions and, with WinGD X-EL energy management act as a system integrator to design and commission the entire vessel energy system.

Click or scan the QR code to find out more

IMO Tier III Solutions

WinGD offers a range of solutions for vessels that need to comply with IMO Tier III NO_x emission limits in specified NO_x Emission Control Areas.

X-DF

Using LNG is a viable solution for dealing with both IMO Tier III NO_X standards and requirements for SO_X. X-DF engines operating in gas mode meet Tier III limits without aftertreatment, while engines with X-DF2.0 technology comply in both gas and diesel modes.

X-Engines

For diesel engines, WinGD offers three abatement options using selective catalytic reduction (SCR) technology, which uses a reductant (typically ammonia generated from urea) and a catalyst to remove NO_X from exhaust gas.

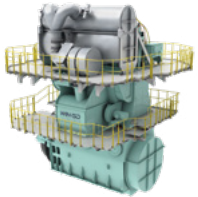
High Pressure SCR

The SCR reactor is located before the turbine, allowing the reactor to be designed in the most compact way due to the higher density of the exhaust gas. WinGD has developed high pressure SCR solutions for X-Engines with single and multi-turbocharger applications.

All WinGD low-speed engines included in this booklet are fully compliant with IMO Tier II NO_X limits specified in Annex VI of the MARPOL 73/78.

Low Pressure SCR

The SCR reactor is located after the turbine. Low-pressure SCR is typically larger than the high pressure solution but can be integrated into the exhaust stream system. WinGD's interface specification for low-pressure SCR covers all known low-pressure SCR system providers.



Integrated SCR (iSCR)

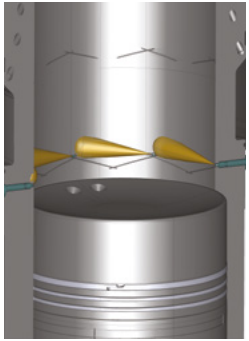
Integrated SCR (iSCR) is installed 'on engine' to meet demand for a smaller, more compact solution to fulfil Tier III emission regulations. The reactor is integrated directly to the exhaust manifold, providing high-pressure operation (HP-SCR) while promoting higher operation temperatures for more efficient catalysis. The compact design has minimal external piping The iSCR is available for selected WinGD low-speed diesel engines.

Click or scan the QR code to find out more

Cylinder Lubrication

Pulse Jet Cylinder Lubricating System

WinGD's Pulse Jet system optimises piston running by providing a homogeneous lubricant distribution on the cylinder liner surface. Regular injections at minimal lubricant feed rate enable operational expenses at the lowest possible level.



WinGD Piston Running Concept with Pulse Jet Cylinder Lubrication System

The Pulse Jet system ensures safe lubrication and acid-neutralisation for piston rings and the cylinder liner running surface. Spray angles and electronically controlled injection timing are tailored to achieve homogeneous lubricant distribution. Zig-zag-shaped grooves on several levels provide further distribution of the freshly injected lubricant in the upper stroke area. Specifically designed piston rings further support the oil film conditioning.

Cylinder Lubricating Oils

Using the Pulse Jet system with WinGD-validated lubricants is the prerequisite to achieving extended time between overhauls of piston rings and cylinder liners with outstanding reliability and engine availability. By applying regular laboratory and on-board analysis of piston underside drain oil samples, lubricant consumption can be reduced to the minimum for the engine's specific operating conditions.

Easily understandable documentation gives guidance for selecting and using the right cylinder lubricant for gas, distillate and residual fuels.

Validated engine oils for WinGD engines

Click or scan the QR code to find out more

Name: Eagle Bintulu
Vessel type: LNG dual fuelled Aframax Tanker
Shipowner: AET
Shipyard: Samsung Heavy Industry Co. Ltd.

Managers: Eaglestar
Delivery: 2018
Main engine: 6X62DF

Steam Production Control

In order to improve the steam production on board via the exhaust gas economiser, 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, **Figure 1** 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.

Figure 2 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.

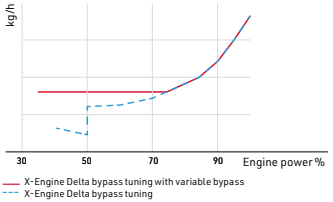


Figure 1

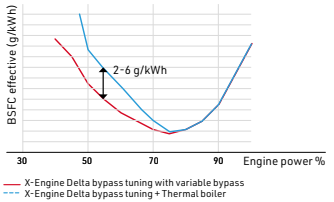


Figure 2

Engineered to

X-EL

by WinGD

Sustainable hybrid energy solutions

Electric and hybrid power technologies offer exceptional optimisation potential for today's vessels, helping to improve fuel efficiency and reduce emissions while improving reliability and load response across an integrated power system.

Shaft generators and hybrid systems

WinGD takes a holistic approach to designing power solutions that go far beyond the main engine. Optimally sized electric components and sub-systems are incorporated and configured to suit individual vessel characteristics and operating profiles.

The proprietary X-EL Energy Manager maintains optimal operating efficiency – ensuring that vessels built or retrofitted today are prepared to face operational and regulatory challenges across their lifetime.

OFFERING	DESCRIPTION
Advisory for System Integration	– Energy efficiency analyses and studies – Virtual integration and transient operation of the complete hybrid system enabling early risk management – Recommendation for topology, components selection, control strategy: – Quantitative economic feasibility (CAPEX, OPEX, ROI, TCO)
WinGD Energy Manager	– WinGD Hybrid Control System for holistic energy management* – Active control logic among the main engine and the rest of the key system components (e.g. PTO/PTI, Battery Pack, Power Converters, DC-Link, etc.) – The system components are selected and procured by either the 3rd party system integrator or the shipyard – Based on a commercial agreement with particular system integrators, the interface and functional specifications could also be implemented on 3rd party controllers
Integrated Hybrid Energy Systems	– All items included in "Advisory for System Integration" – System architecture and control strategy definitions, implementation, and validation – Selection of the key system components (e.g. PTO/PTI, Battery Pack, Power Converters, DC-Link, etc.) – WinGD Hybrid Control System for holistic energy management with active control logic among the main engine and the rest of the key system components* – End-to-end project management for delivery of a turn-key integrated hybrid powerpack

* Provided that the required interfaces among the equipment are available

Advisory Services

WinGD's technical experts will help mitigate risks and uncertainties throughout the lifecycle of a fleet, from feasibilities and early decisions, through design and implementation, to in-service advisory, diagnostics, and performance monitoring.

WinGD's simulations-based toolchain is used for conducting energy efficiency studies at the feasibility stage, providing accurate quantitative predictions of system performance and the savings associated in multiple scenarios.

As an outcome, the optimum system topology and control strategies of an integrated hybrid system can be determined to fulfil operational and commercial requirements

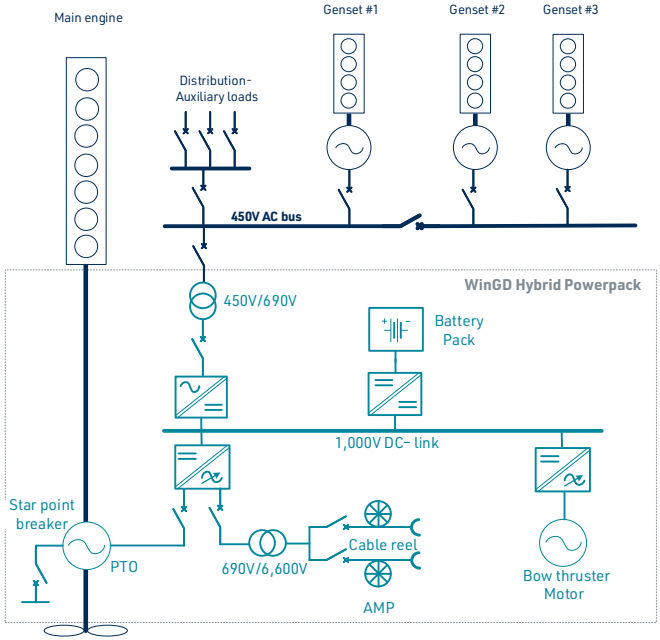
The transient-capable physical main engine models embedded have a distinctive advantage over the commonly used map-based approach.

WinGD Energy Manager

Shaft generator and hybrid power arrangements integrated by WinGD are all governed by the state-of-the-art WinGD Energy Manager.

Validation and tuning of its control and optimisation logic take place at an early stage in development due to the simulation and development toolchain. This enables customers to assess the build and operation of the power arrangement in digital form, simplifying the physical integration, commissioning, and testing of the systems.

The WinGD Energy Manager sets new standards for vessel energy optimisation. It is a universal solution to control a wide range of hybrid energy system variants and aims at operating the system in an optimal state.



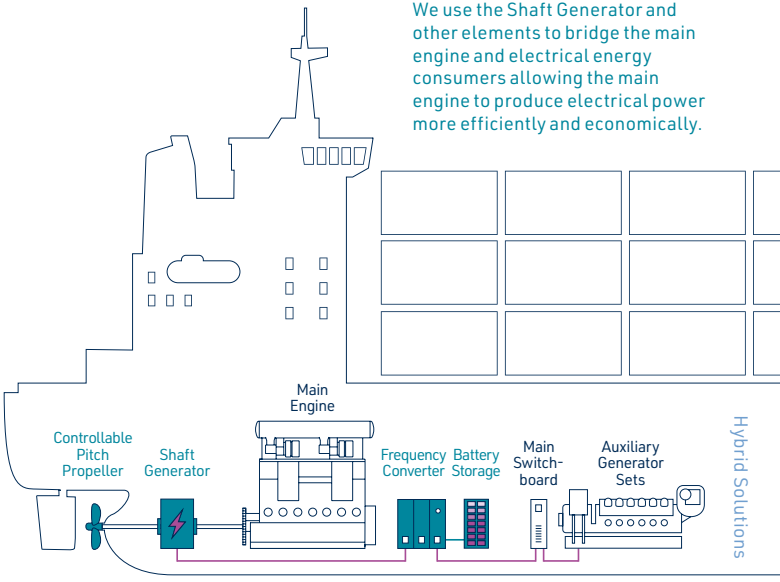
High operational flexibility

- Intelligently optimised power production and consumption on board at any given moment, considering various factors, such as actual cargo capacity utilisation, ship speed demand, environmental conditions and route.

Optimal energy resources utilisation

- Maximised usage of the main engine and alternative energy resources in a hybrid setup for electrical power production.
- Minimised running hours of the Auxiliary Engines, or operated with the highest possible efficiency when needed.
- Ensured safe no-auxiliary-engines operation during ocean crossing and optimal energy production for safe manoeuvring.
- Improved system performance and stability in transient conditions.

We use the Shaft Generator and other elements to bridge the main engine and electrical energy consumers allowing the main engine to produce electrical power more efficiently and economically.



WinGD Service & Support

WinGD Customer Support

WinGD offers a broad range of global services and support, providing shipowners and operators with the confidence and control needed to optimise their asset and their fleet operations.

Technical support

From the advanced data analytics and engine diagnostics of WiDE, to remote monitoring, technical assistance and global state-of-the-art training, WinGD's expertise is readily available to customers.

The primary contacts for issues during the engine warranty period are the delivering yards and engine manufacturers. For customer-direct assistance by WinGD, claims can be forwarded to: warranty@wingd.com

For access to all project-related Service Letters, manuals and relevant engine documentation go to www.wingd.com/en/portal/

Global Service

WinGD engines benefit from lifetime support through Wärtsilä 2-Stroke Services and the engine manufacturers. As the global Service Partner, Wärtsilä 2-Stroke Services offers owners and operators after-sales service including but not limited to:

Spare parts:

- for all engines according to the spare part catalogue, for immediate need or for long-term planned maintenance work on board field services.
- to execute regular engine maintenance work, repairs, troubleshooting or condition assessments to evaluate engine operation optimisation or to plan the next maintenance stop.

Operational support:

- to troubleshoot unexpected issues on a vessel.
- to develop solutions for non-standard technical or operational issues.

Reconditioning services:

- for exchanging engine components in workshops.

Upgrade solutions:

- During the lifetime of a vessel, new engine technologies may become available for application on existing engines for improved engine performance.
- Retrofitting of main engines for compliance with new emission regulations on existing vessels.

Maintenance agreements:

- to ensure experts can advise or manage the maintenance of the engines, covering any of the after-sales service offerings.

WiDE by WinGD

Emergency Support

+41 52 264 8604

technical.request@wingd.com

WiDE (WinGD integrated Digital Expert)

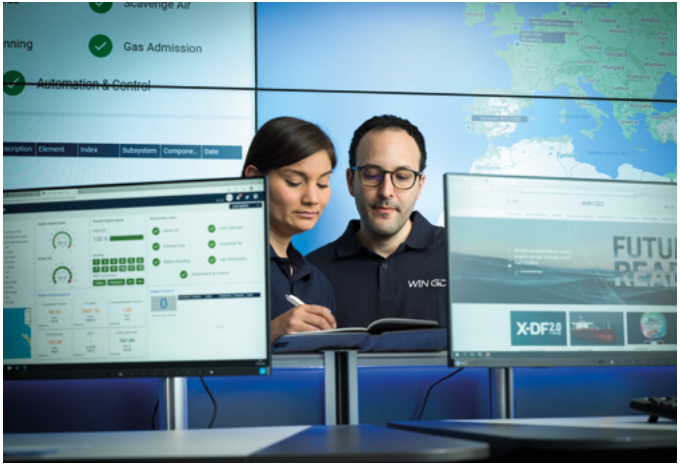
WiDE by WinGD

WinGD's integrated Digital Expert (WiDE) system is a comprehensive engine monitoring, diagnostics and advisory system that delivers optimisation and predictive maintenance insights and enables remote support and troubleshooting assistance for crews and onshore teams.

WiDE constantly collects engine and ship data, making them available both onboard and onshore. Data is analysed to provide valuable insight on the status of the engine's components, to anticipate alarms and to facilitate daily crew operations.

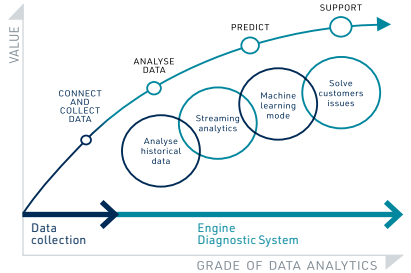
These capabilities are integrated into a user-friendly onboard system comprising state-of-the-art hardware, software and data analytics techniques, supported by robust and cyber secure ship-to-shore connectivity.

All WinGD engines are delivered with the hardware and monitoring software needed for WiDE. Additional analysis and expert services are available on subscription.



The engine's digital twin enables expert engine analysis

Using the power of modern digital data monitoring, WiDE delivers customers valuable information and access to remote support to assist in optimising the ship's performance.



Key Benefits

- Performance monitoring and optimisation advice tailored specifically for your engine.
- Predictive troubleshooting minimises sub-optimal running, increases engine availability and streamlines maintenance planning.
- Availability of key performance indicators on ship and onshore, speeding up communication and benefitting fleet monitoring.
- Enhanced remote services support crew interventions on board and, through WinGD 24x7, offer around-the-clock technical assistance from WinGD experts when required.
- Real-time engine data sharing enhances integration with energy management and voyage optimisation systems.
- Connected performance management and diagnostics prepare for increased engine operation automation.

Optimisation

WiDE diagnostics are based on a thermodynamic engine model which constantly calculates the ideal engine performance for real-time operational parameters and environmental conditions. The deviation between actual and ideal engine performance is quantified and a root-cause analysis provided, with recommended solutions

Troubleshooting

Potential problems are reported by WiDE's troubleshooting app, identifying the part involved, automatically providing a list of alarms with drawings and documents for the affected components. Detailed instructions for prevention are displayed using extracts from the engine manual.

Remote Support

Enhanced troubleshooting is provided remotely by WinGD Operations Experts. The WinGD 24X7 support centre offers around-the clock support in the event of a problem and provides regular reports on the health status of the machinery, including recommendations for optimal engine operations.

CII Compliance and hull efficiency

Future updates will include the possibility to calculate the vessel CII rating. Further modules will allow to monitor hull and propeller fouling.

Operators can drill down into current vessel ratings to see whether engine operation can be optimised to improve CII rating.

Maintenance

The maintenance application helps customers obtain an overview of the maintenance schedule to record all maintenance actions. The spare parts application integrates the spare part codebook of the entire engine. It can be used to create a parts-order to request delivery from external suppliers.

Online Platforms

Data from WiDE are available on two dedicated online platforms. E-Vessel Tracker (eVT) provides access to historical engine, ship and fleet data – including the ability to download and visualise data. WiDE Online provides an extended view and analysis of current engine status, including engine speed and performance, subsystems state and faults identified.

Training

The fuel flexible engines of today and tomorrow require crew who are confident operating the latest innovation and technology.

From basic engine operation to advanced optimisation, WinGD provides a range of training solutions across a wide network of global locations and online, giving your crew the skills they need to operate WinGD engines safely, reliably and efficiently.

Certified Instructors

WinGD training courses are conducted by professional, STCW-95 certified instructors. Trainers explain the theory and functionality of all WinGD engines using modern training methods, helping crews and onshore support teams understand the design, function and repair and maintenance procedures for key components.

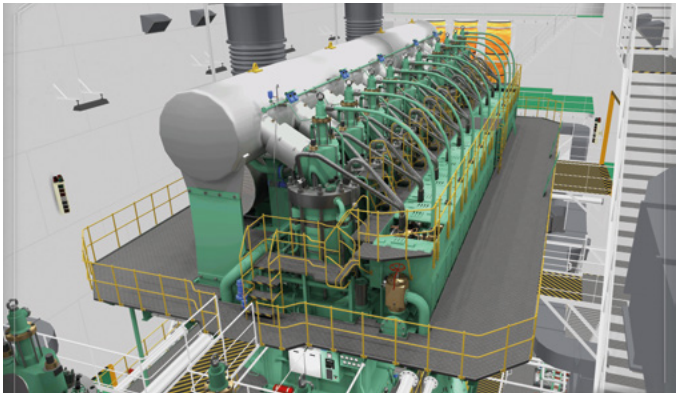
Global Network

WinGD operates four dedicated training facilities, with a growing number of centres operated by authorised WinGD training partners. Our wide network at key global shipping and crewing hubs makes it easy to incorporate training into your crew schedules whether travelling from their home locations or directly from vessels.

See our full list of training locations and partners at https://www.wingd.com/en/service-support/training/training-facilities/

Expert Knowledge

Training courses are standardised, centrally coordinated and certified by WinGD. Theoretical and practical expert knowledge covers the full range of WinGD products.



WinGD Xpert engine room simulator

Courses

Specialised, product-specific courses in varying levels are available.

- Engine Theoretical course (3 days)
- Engine Operation Advanced course (5 days)
- Engine technology specialised courses (depending on the topic, 1-2 days)

Customised courses covering specific areas of interest, can be arranged on request. All types of courses can be offered to best suit the trainee regarding course content, level, duration, language and location.

See the list of courses at https://www.wingd.com/en/service-support/training/training-course-specifications/

or email: **training@wingd.com**

Simulation Software

WinGD training courses offer high efficiency learning through perfectly-balanced human and technology factors. Using a wide range of simulation software developed together with Unitest Marine Simulators Ltd, and hardware as well as real engine parts, the participants will benefit through hands-on, real-life scenarios.

Engine Room Simulators

The Training Centres in Busan, Shanghai and Athens are equipped with state-of-the-art Full Mission Engine Room Simulators. The simulators offer participants the opportunity to experience extreme situations, like a complete power black-out or fire, gaining them valuable knowledge and confidence.

Training hosted outside of WinGD Training Centres are supported by Full Mission Simulators or similar Engine Room Simulator software.

Global Coverage

Working together with a global network of authorised Training Partners, training courses are available at a location best suited to the customer. This flexibility allows WinGD to provide training courses wherever it best achieves the desired outcomes, to optimise a ship's operation and to reduce the travelling time and expenses of the participants.

If travel to a Training Centre is not possible, instructors are available to perform training sessions on board the ships (anchored, at shipyards or during voyage) and Crewing Agents' offices.

A list of upcoming sessions can be found online at wingd.com or by request at: **training@wingd.com**

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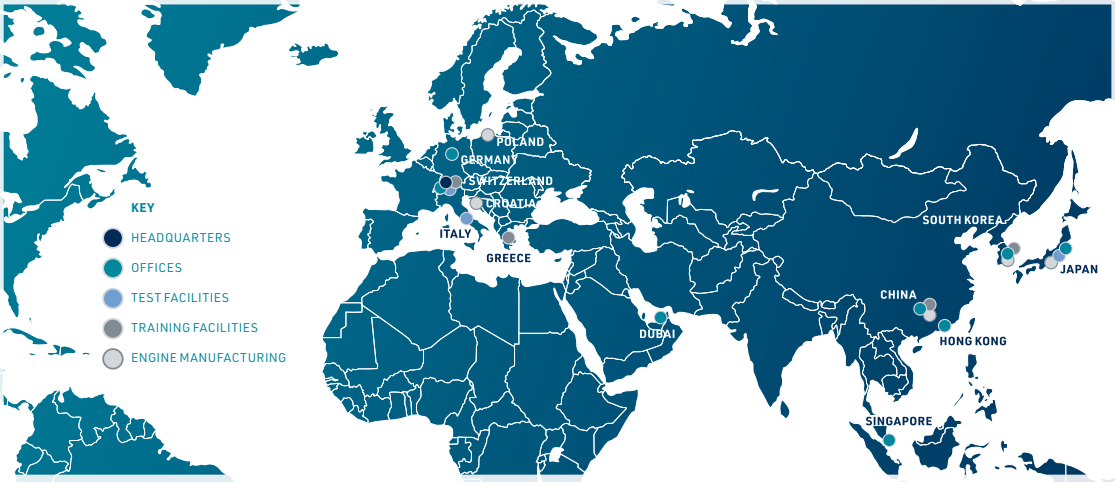

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WinGD Global Service Partner

Wärtsilä Global Service Network

Wärtsilä provides its global services for two-stroke engines through its world-wide network.

The nearest Wärtsilä network office can be found at:

www.wartsila.com/contact

24/7 emergency requests, please use the following phone number:

Tel: +41 52 550 01 11

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Tel: +86 21 3177 7071

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Email: sales@cse.com.cn

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Notes

Notes

Notes

The data contained in this document serves as informational purposes only and is provided by Winterthur Gas & Diesel Ltd. without any respective guarantee.

Committed to the decarbonisation of marine transportation through sustainable energy systems.

WinGD designs marine power ecosystems utilising the most advanced technology in emissions reduction, fuel efficiency, digitalisation, service and support. With their two-stroke low-speed engines at the heart of the power equation, WinGD sets the industry standard for reliability, safety, efficiency and environmental design.

Headquartered in Winterthur, Switzerland, since its inception as the Sulzer Diesel Engine business in 1893, it is powering the transformation to a sustainable future.

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