

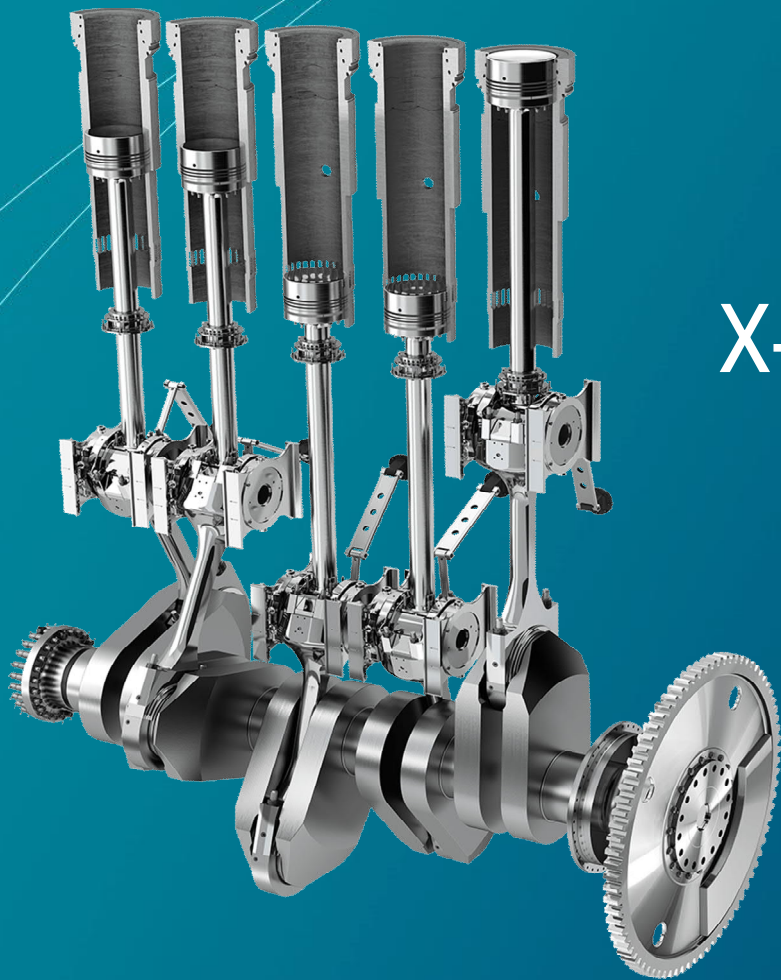
Latest X-Engine Technology & New Development Program

WinGD Technical Seminar Tokyo – Nov. 2019

J.-N. Constantin – Product Manager 75 – 96 Bore Engines



WINGD

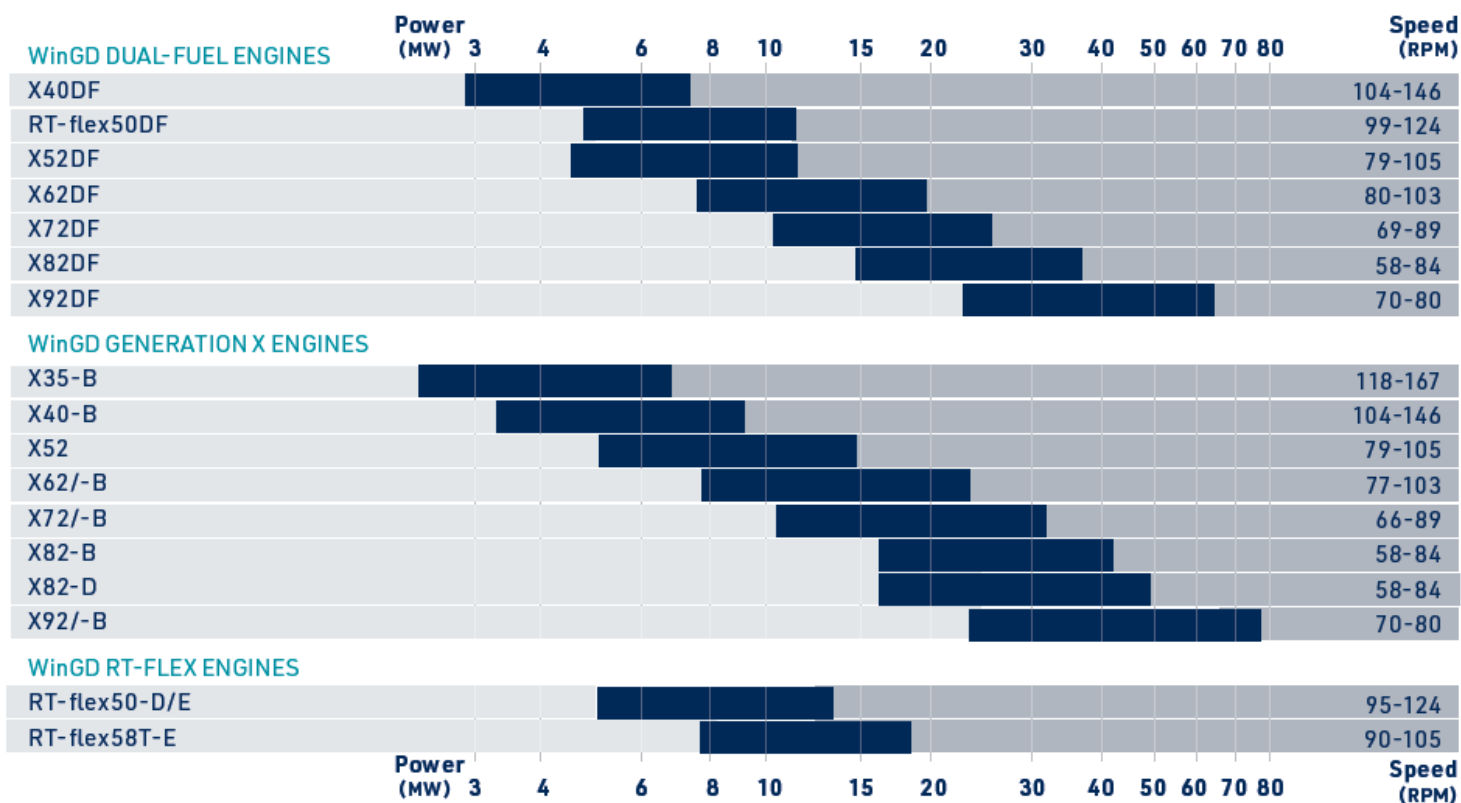


X-Engine Portfolio

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X-Engine Portfolio

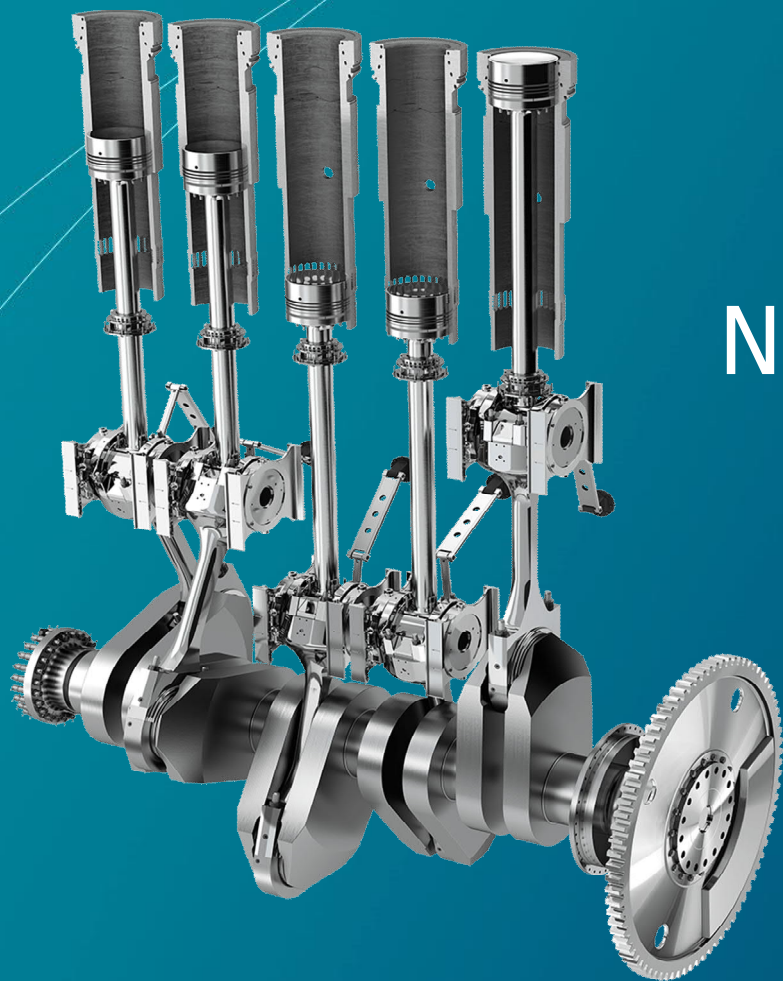


Recent orders

- X92DF
- X92-B
- X40DF

In development

- X82DF
 - Engine delivery end 2020
- X82-D
 - Engine delivery mid 2021

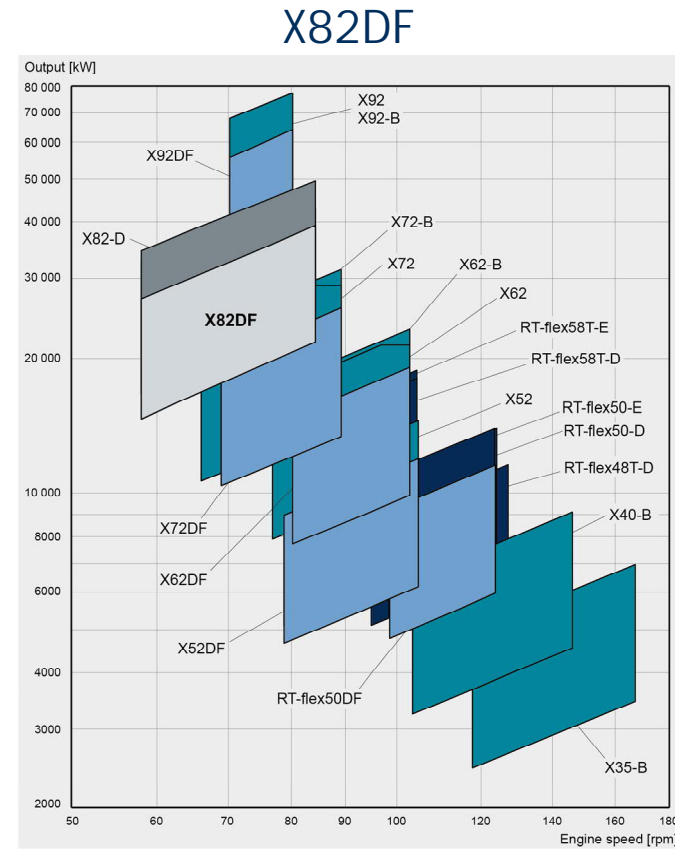
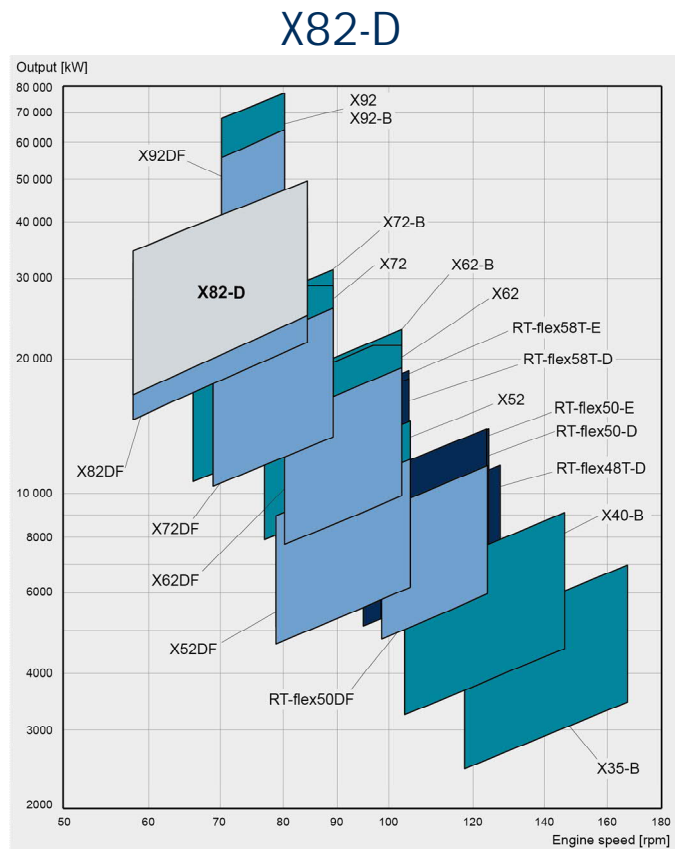


New Development Program

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New Development Program – Rating Fields

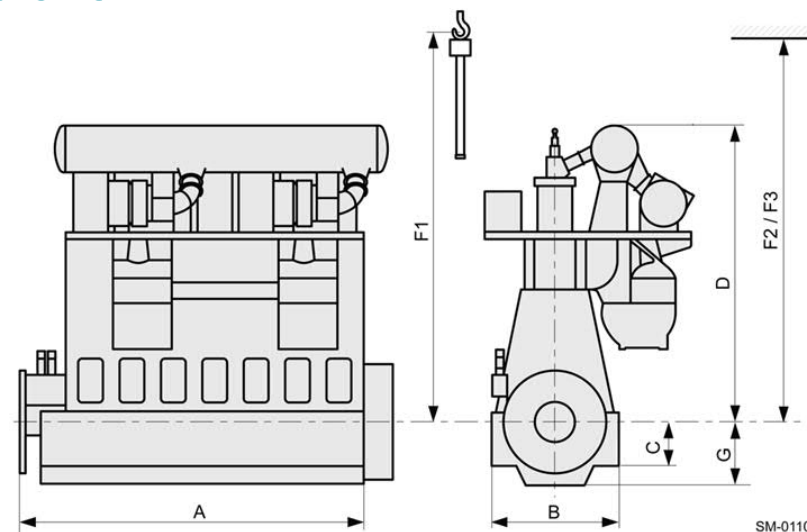


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New Development Program – Main Dimensions

		6 cyl.	7 cyl.	8 cyl.	9 cyl.
B	mm	5'020			
C	mm	1'800			
D	mm	12'450			
F1	mm	X82-D 15'520 / X82DF 15'150			
G	mm	2'700			

F1 Normal vertical lifting
(crankshaft center to crane hook)



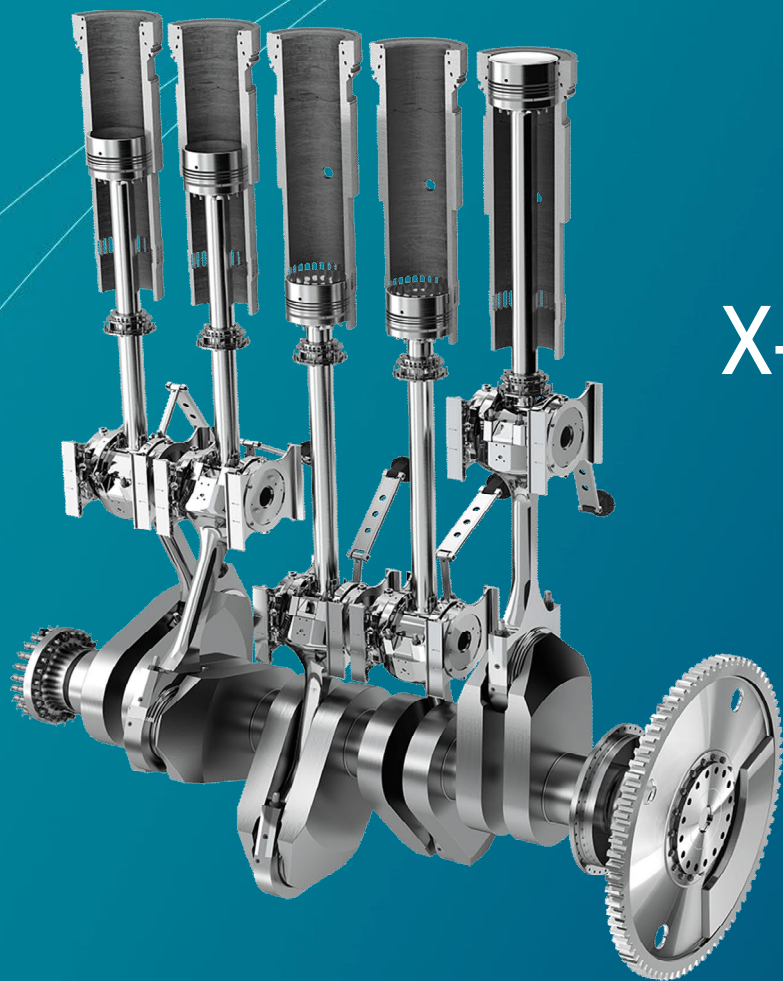
A	X82-D	X82DF	X82-B
6	10'554	10'554	11'045
7	11'994	11'994	12'550
8	13'434	13'434	14'055
9	14'874	14'874	16'500

Engine length reduced compared to X82-B

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New Development Program – Main Design Features

	X82-B	X82-D	X82DF
Bedplate	double wall	single wall	single wall
A-frame	double wall	double wall	double wall
Tie rod	long	short	short
Main & Xhead bearing	WM	WM	WM
Crank pin bearing	WM	aluminium	aluminium
Booster pump Xhead	below 65 rpm	mandatory	mandatory
Piston rings	3 rings	2 rings	2 rings
Cylinder lube oil pump	CLU4-C	flexLube ϵ	flexLube ϵ
Cylinder cooling	uniflow	uniflow	with recirculation
Control system	WECS	WICE	WICE
Injection system	ICU/FAST nozzles	ICU/FAST nozzles	ICU/FAST nozzles
Servo oil pressure	200 bar	300 bar	300 bar
Fuel pump	V4	X4	X4



X-Engine Technology

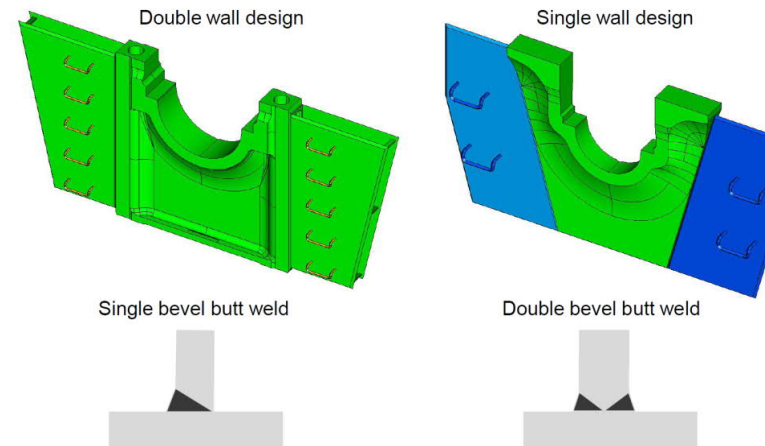
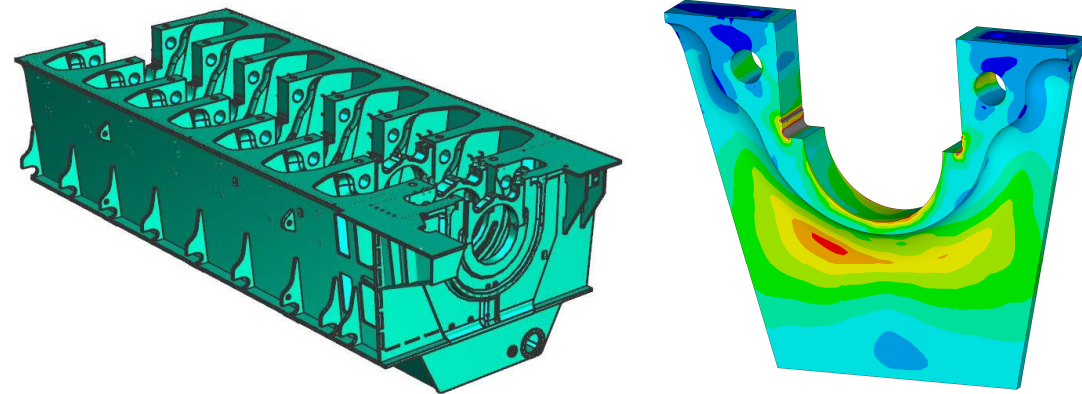
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X-Engine Technology – Bedplate

Bedplate

- Integrated thrust bearing
- Single wall design
- Better welding accessibility
 - Higher welding quality
- Flexible girder design
 - Reduced bearing load
 - Validated by FE calculation
- Cylinder distance reduced



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X-Engine Technology – Bearings

Crosshead bearings

- White metal bearing shell
- High pressure lube oil level

Crankpin bearings

- Aluminium bearing shell
- High pressure lube oil level

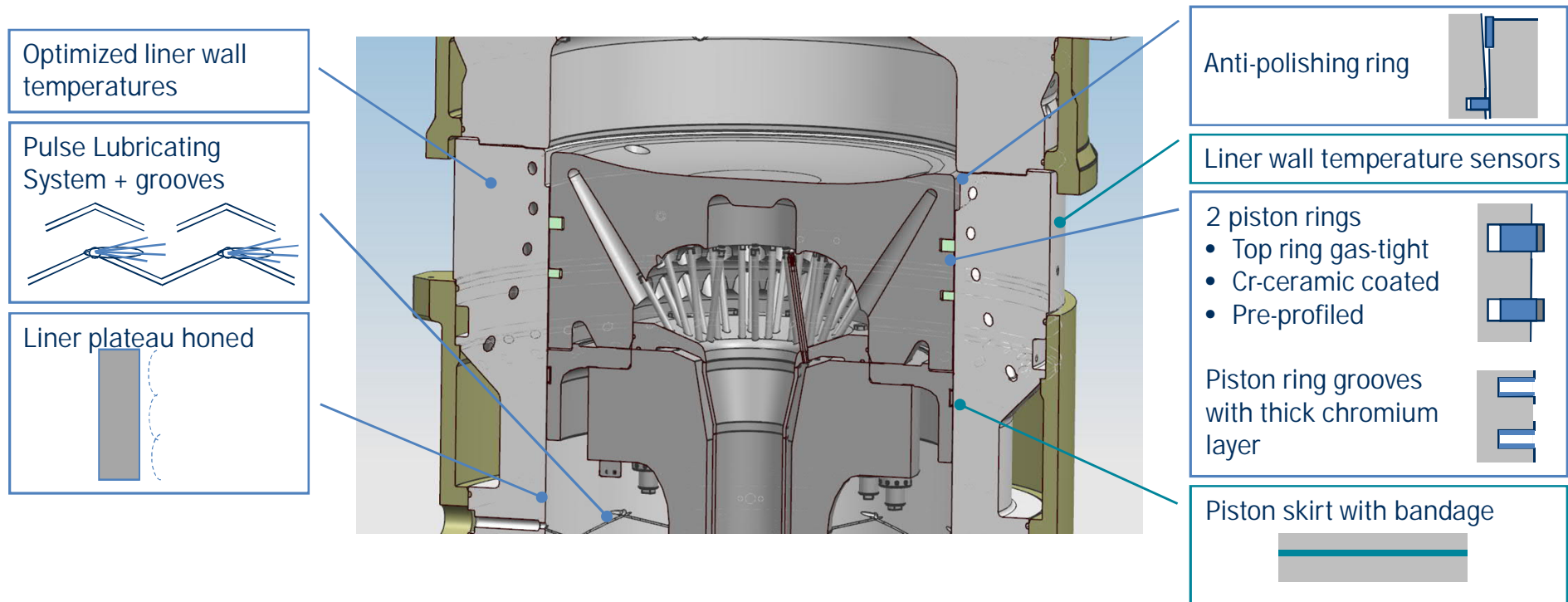
Main bearings

- Thick white metal layer
- System pressure lube oil level



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X-Engine Technology – Piston Running Concept

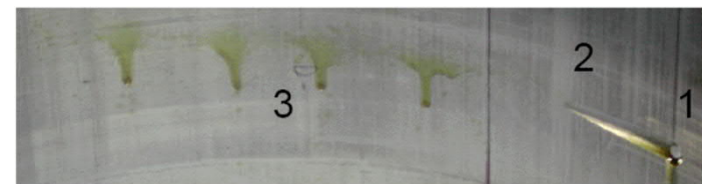
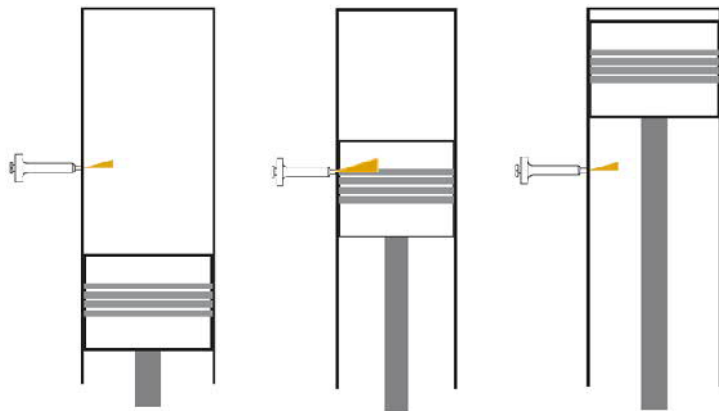


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X-Engine Technology – Cylinder Oil Pump flexLube ϵ

flexLube ϵ

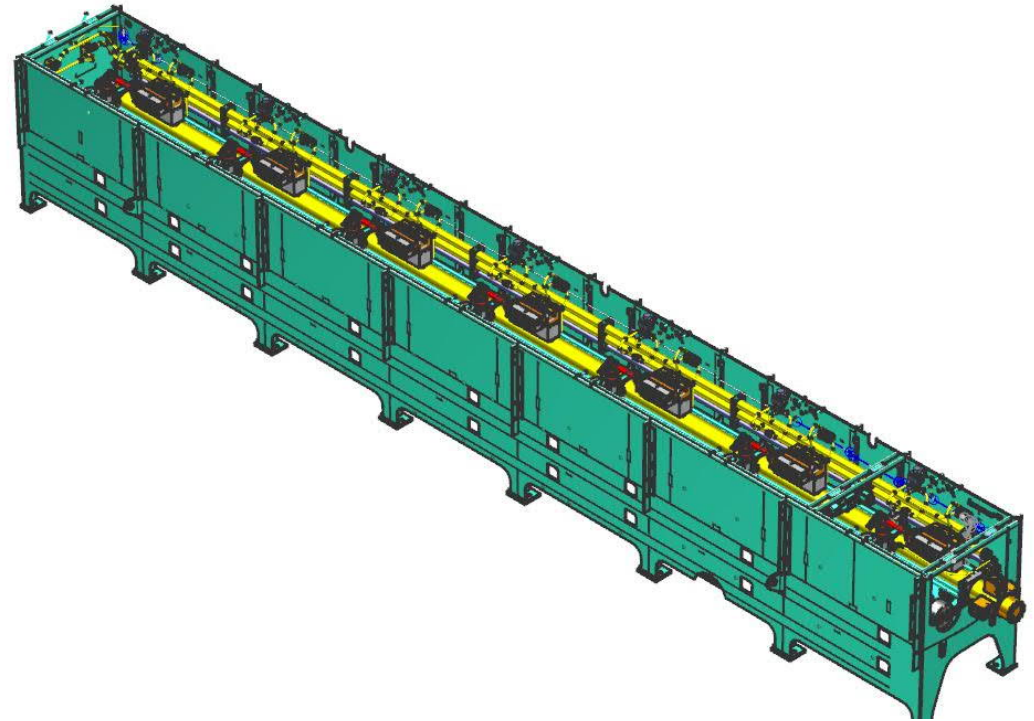
- Number of lube quills depending on engine size (4 to 10)
- Improved manufacturability and maintainability
- Higher time between overhaul expected
- Lube oil distribution into, above and below piston ring pack



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X-Engine Technology – Rail Unit Box

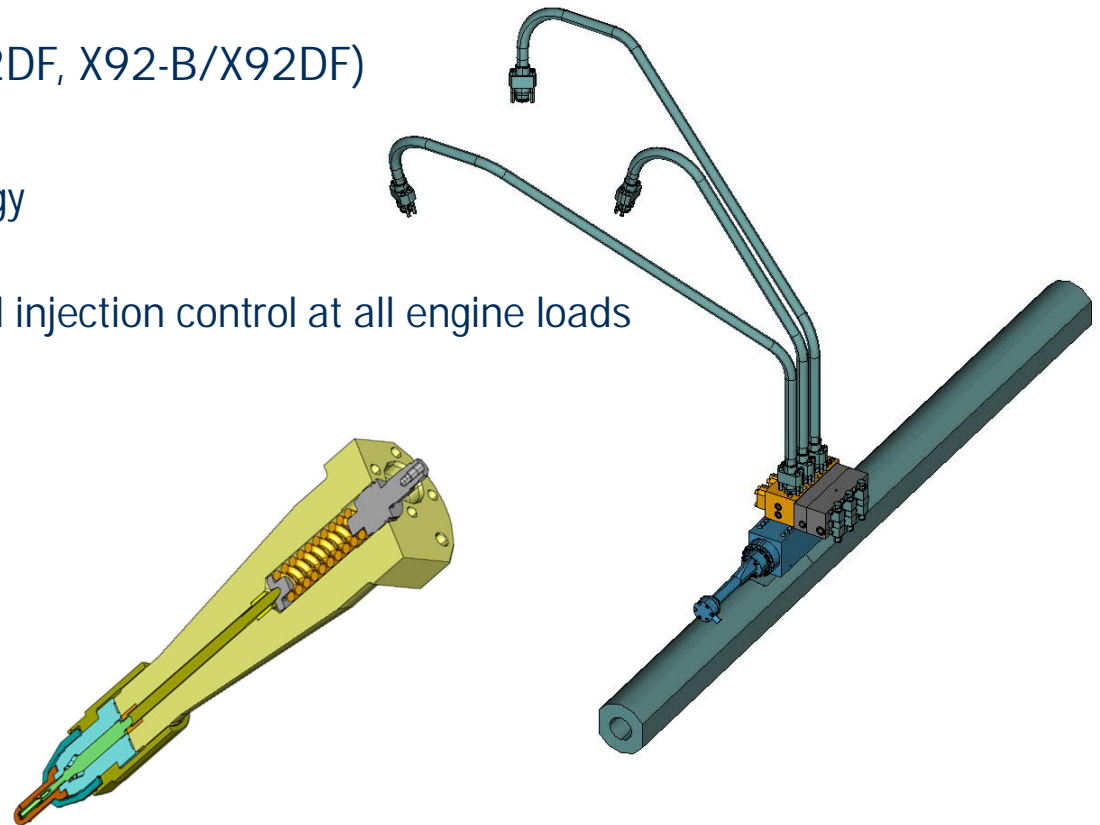
- Proven, simple and compact setup
- Fuel rail
 - High pressure single wall fuel rail pipe
 - Injection Control Unit of last generation for the electronically activation of fuel injectors
 - Maintenance on-board possible
- Servo oil rail
 - High pressure single wall servo oil pipe
 - Valve Control Unit for exhaust valve activation
- Cylinder lubrication partly in rail box
 - Connecting pipes to servo oil system
 - Servo oil return pipes
 - Cylinder lubrication oil supply



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X-Engine Technology – ICU & FAST injection valve

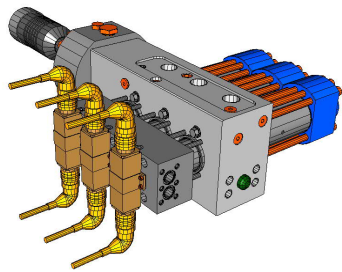
- Applied on large bore engines (X82-D/X82DF, X92-B/X92DF)
- Injection control unit
 - Proven and constantly improved technology
 - Volumetric controlled fuel injection
 - Three rail valves per cylinder for optimized injection control at all engine loads
 - Maintenance on-board possible
- FAST injection valve
 - Negligible sack hole volume
 - Clean combustion chamber
 - Excellent service experience
 - Long time between overhaul



Latest X-Engine Technology & New Development Program

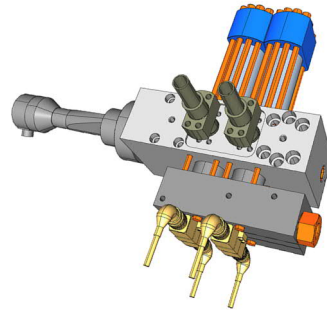
X-Engine Technology – ICU Evolution

Mk I – 2001
Separate control oil
system

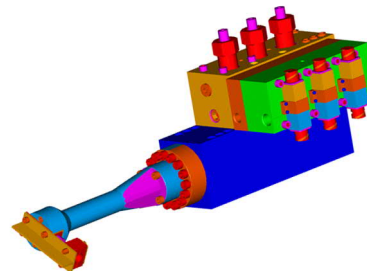


RT-flex58T
RT-flex96C
RT-flex84T

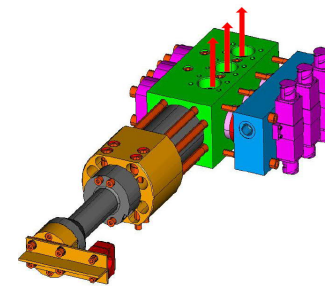
Mk II – 2005
Servo oil actuated



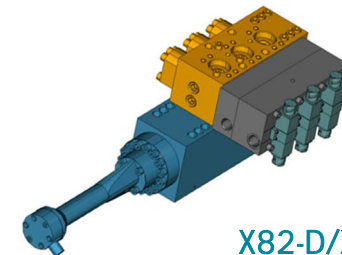
X82 - 2008



Mk III – 2014
On board maintenance
Lower TCO cost



X92 - 2014

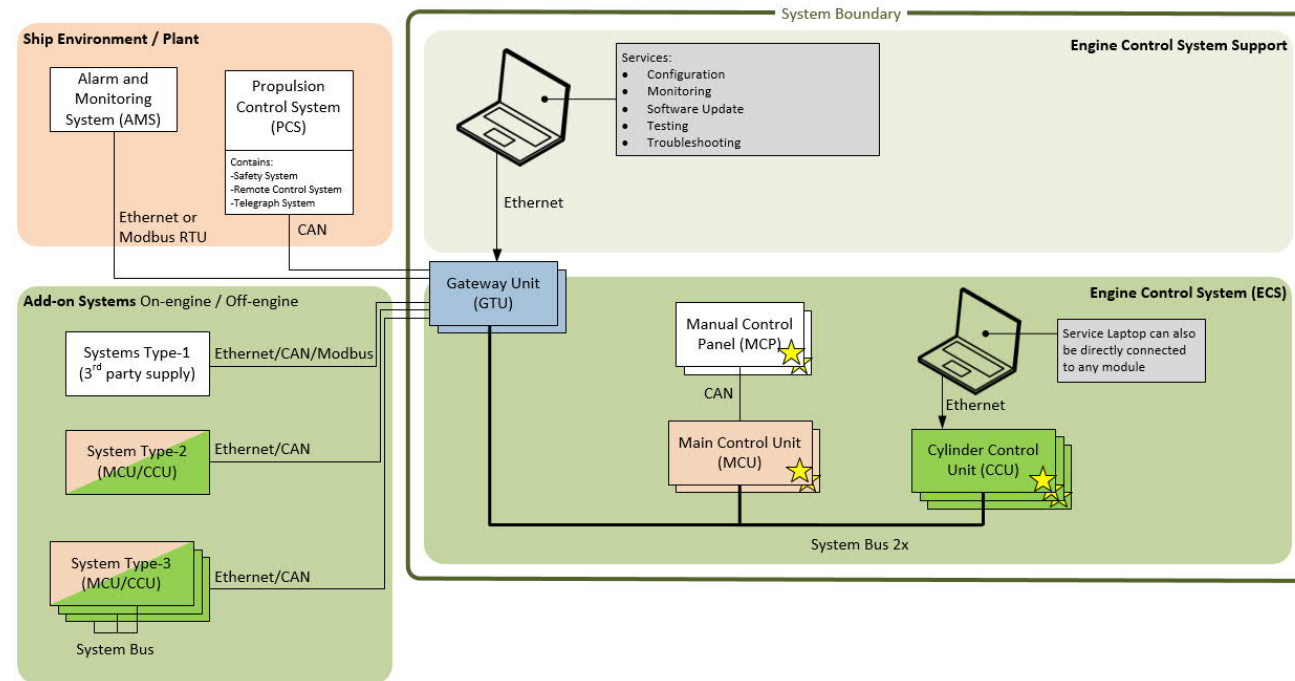


X82-D/X82DF
X92-B/X92DF

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X-Engine Technology – WiCE: WinGD integrated Control Electronics

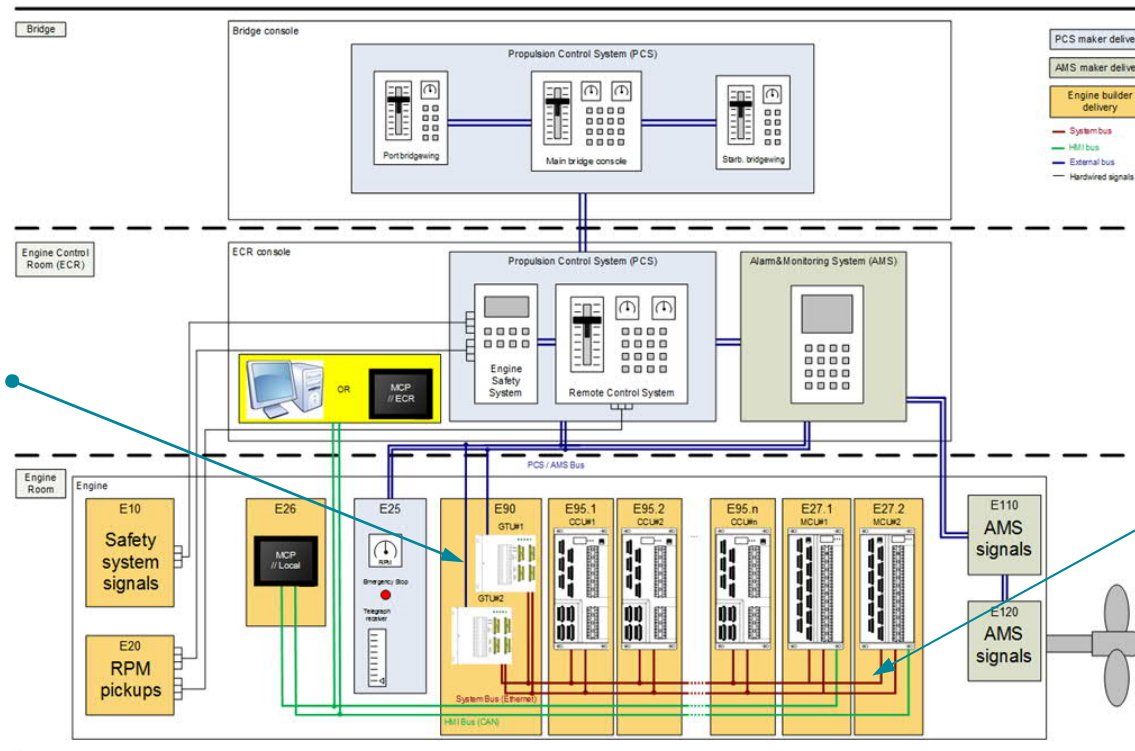
- Developed for 2-stroke engines up to 180 rpm
 - 5 to 14 cylinder
 - Single- or dual-fuel engine operation
- Full range of support for commissioning, monitoring, software update, troubleshooting
- Interfacing to third-party systems on board
 - Propulsion Control System (PCS) and Engine Safety System (ESS)
 - Alarm and Monitoring System (AMS)
 - Data Collection and Monitoring (DCM)
- Add-on systems realization
 - On and off-engine extensions



Latest X-Engine Technology & New Development Program

X-Engine Technology – WiCE: WinGD integrated Control Electronics

GTU acts as firewall to separate engine control functionality from peripheral systems



Ethernet ring for fast data communication and crank angle signal distribution

Well proven core functional units, migrated from UNIC-flex and WECS-9520



X52 Service Experience

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X52 Service Experience – Piston Running



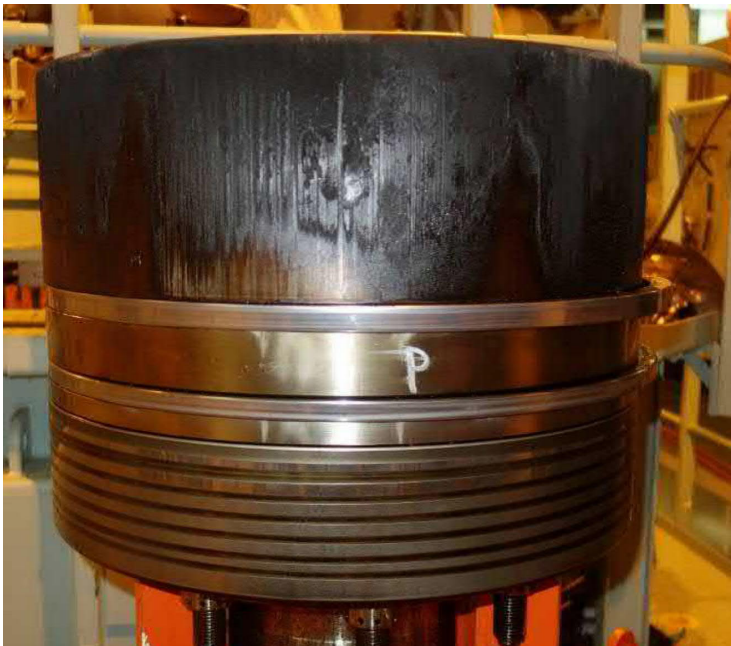
6X52 – Unit#1 – 5054h

- HFO 1.54% sulphur content
- BN 100 cylinder oil
- Feed rate 0.95 g/kWh

- Honing marks visible above umbrella grooves
- Liner low wear rate 0.01 mm/1000h
- Estimated lifetime 360'000 h

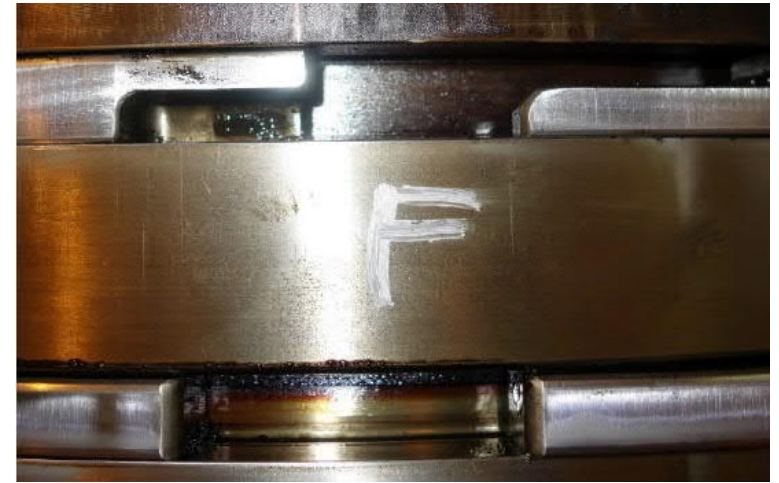
Latest X-Engine Technology & New Development Program

X52 Service Experience – Piston Running



6X52 – Unit#1 – 5054h

- HFO 1.54% S content
- BN 100 cylinder oil
- Feed rate 0.95 g/kWh



- Clean piston ring pack
- Low deposit build-up in the crown ring grooves and at the ring backside
- Top piston ring wear rate 0.008 mm/1000h
- Estimated lifetime 38'000 h
- Two piston ring pack with excellent results

Latest X-Engine Technology & New Development Program

X52 Service Experience – Exhaust Valve

6X52 – Unit#1 – 5054h



- Exhaust valve in good condition
- Nimonic plate wear 0.03 mm/1000h
- Estimated lifetime 200'000 h

- Exhaust valve channel with normal deposits
- Exhaust valve seat in normal condition

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X52 Service Experience – Crosshead Bearing

6X52 – Unit#1 – 5054h



- Bearing shell in good condition
- Contact evenly distributed



- Bearing cover in good condition

Latest X-Engine Technology & New Development Program

Conclusion

- Latest orders showed the attractiveness of WinGD X-engine technology
 - Shorter engine length with flexible main bearing girder to reduce the main bearing load
 - Two piston ring concept introduced
 - XDF concept with lower CAPEX and OPEX
- Development of X82-D and X82DF based on well-known technology
- Development focused on reliability and increased time between overhaul
- Easier maintenance onboard possible for ICU
- X52 service experience confirmed the two piston ring concept
- Proven technology ready for 2020 and beyond



2020 IMO global 0.50 percent fuel sulphur regulation

WinGD operation guideline

WIN GD

Terminology

Names of fuels after 1st January 2020

Definition of fuel abbreviations:

- HFO: Heavy Fuel Oil
- MGO: Marine Gas Oil
- DM: Distillate Marine (does not need heating)
- RM: Residual Marine (needs heating)
- MDO: Marine Diesel Oil
- ULSFO: Ultra Low Sulphur Fuel Oil
- VLSFO: Very Low Sulphur Fuel Oil
- HSFO: High Sulphur Fuel Oil

Sulphur content	HFO (RM grades)	MDO (DMB, DFB)	MGO (DMA, DFA, DMZ, DFZ)
$S \leq 0.10 \%$	ULSFO RM		ULSFO DM
$0.10 \% < S \leq 0.50 \%$	VLSFO RM		VLSFO DM
$0.50 \% < S$	HSFO RM*		HSFO DM*

* fuels allowed only for ships with exhaust abatement technologies yielding sulphur oxide reductions equivalent to using fuels compliant with the respective sulphur limit

Operational Considerations for 2020 Compliant Fuels

Blending of fuels on board

Due to the **potential risk of incompatibility** of different batches of VLSFO, WinGD do not recommend **blending of such fuels on board**. Deliberate blending of these fuels on board should be avoided, and this also applies to two or more fuels having the same ISO grade.



Operational Considerations for 2020 Compliant Fuels

Compatibility check of fuels

If the situation exists where the ship operator considers **blending of fuels** on board, the following WinGD procedure may be used for **checking the compatibility** of those fuels.

Note however, that the result of this procedure only provides an **indication of the compatibility** of the fuels in question. This procedure is an extended version of ASTM D4740. For this procedure, the **only acceptable** cleanliness level is **Rating 1** (see next page).

The compatibility check procedure may be summarised as follows:

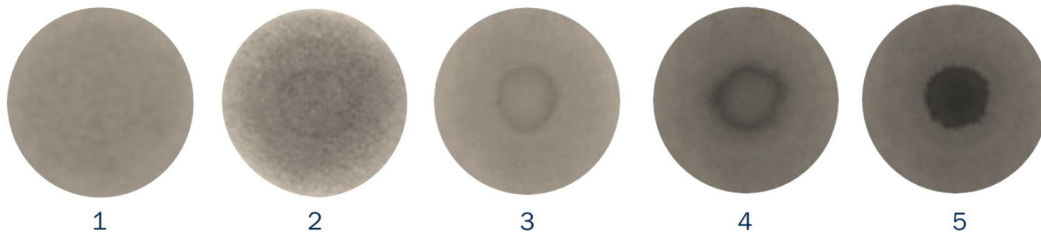
1. **Determine or clarify the intended blend ratio** of the two fuels in question
2. A **two-stage procedure** should be followed: See next pages

Operational Considerations for 2020 Compliant Fuels

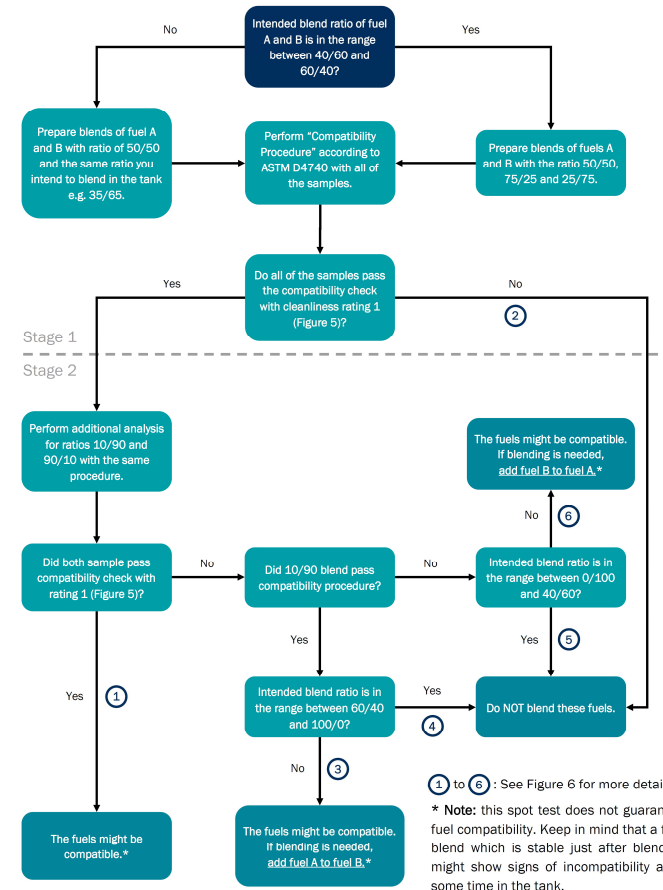
Compatibility check of fuels

Stage 1 involves individual spot tests at either two or three (depending on the intended blend ratio) different blend ratios. All tests must be passed to progress to Stage 2.

Stage 2 involves two additional spot tests which further determine potential compatibility and provide a suggested blend direction of the fuels.



Cleanliness rating according to ASTM D4740. For passing the test in this document, only Rating 1 is considered acceptable.

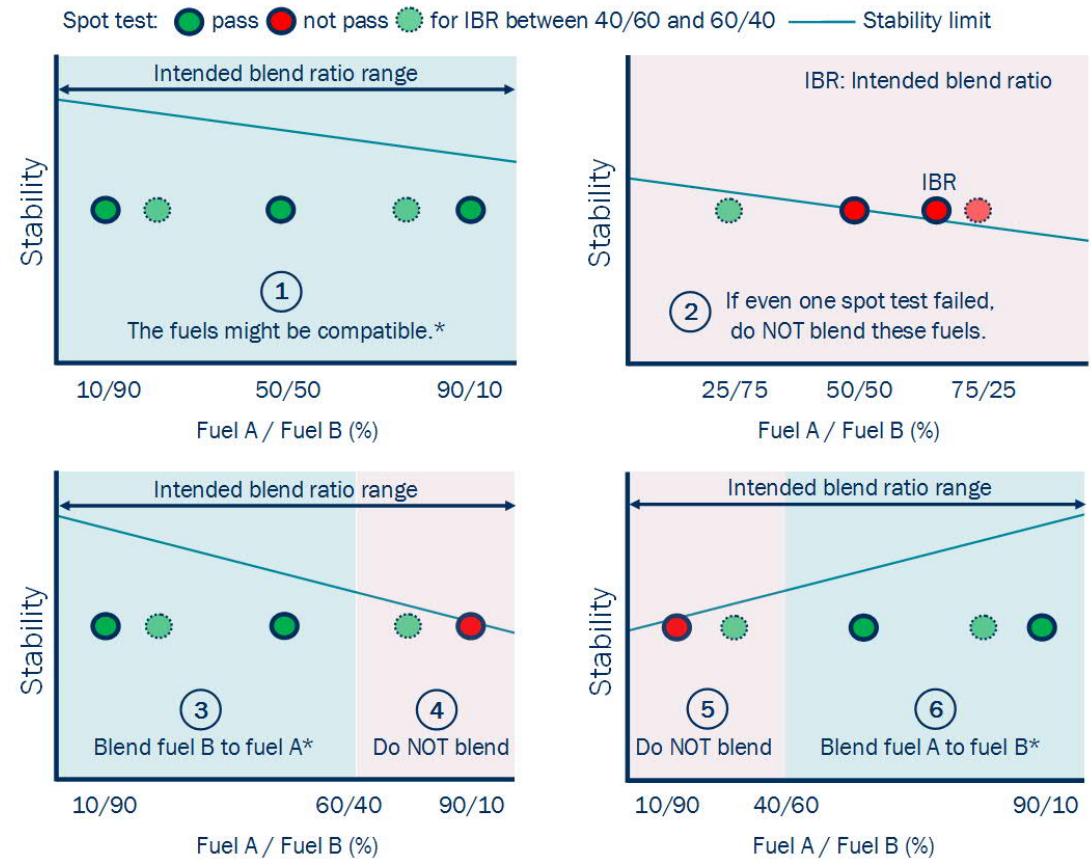


Recommended procedure for checking compatibility of fuels before blending

Operational Considerations for 2020 Compliant Fuels

Compatibility check of fuels

Graphical representation of possible outcomes from using the before explained procedure.



*Be aware: low stability of blends can lead to sludge formation after some time period

Graphical representation of possible results obtained from procedure

Operational Considerations for 2020 Compliant Fuels

Compatibility check of fuels

If the blended fuel passes the compatibility check procedure and **blending is carried out**, the fuel should be **consumed as soon as possible**, prior to other fuels on board. A fuel blend might be **stable initially**, but form **sludge after prolonged time** in a tank.

Notes:

- The **Stage 2** tests are performed to establish any potential limitations in terms of the **direction of blending** i.e. Fuel A added to Fuel B or vice versa. This is important as different fuels can have a higher or lower capacity to keep asphaltenes dispersed in solution. Therefore, the **stability** of the resulting blend will **increase or decrease gradually** as the fuels are added to one another. In some cases, this may result in **sludge formation** as **early** as the **beginning** of the **blending process**.
- Certain highly paraffinic/waxy fuels might yield a **false negative** result during the compatibility check procedure. However, to **avoid mistakes** in the interpretation of the results, WinGD recommends **disregarding this possibility**.

Operational Considerations for 2020 Compliant Fuels

Fuel oil treatment

When using VLSFO, the following **standard procedures**, as outlined in relevant documents, must still be applied:

- **Check every bunker delivery note** for fuel density, water and cat fines concentration.
- **Adjust separator gravity discs** to fuel density if no self-adjusting separator is installed.
- **Run your purification system** at the **efficiency required** to reduce any cat fines to below the specified maximum engine inlet levels.
- If any **sign of sludge formation** in the separators appears, **switch to distillate grade fuels** and follow separator manufacturer instructions.

Operational Considerations for 2020 Compliant Fuels

Fuel change over

A fuel management procedure (suited to the specific fuel system in use) should be prepared in order to minimise the mixing of fuels from different batches during fuel changeover:

- Before filling the settling tank with a new batch of fuel, ensure that the tank is empty.
- If a settling tank contains unused fuel when filling it with a new batch of fuel, frequently drain this tank to check for possible sludge accumulation.
- The service tank should be empty before filling it with a new batch of fuel.
- If it is not possible to empty the service tank completely, ensure that the quantity of previous fuel remaining is kept to an absolute minimum.

For any actions to be taken on the engine side during fuel changeover, please refer to Chapter 3 of the “Diesel Fuels for WinGD engines” guideline. Careful attention should be given to the following:

Outlook

WinGD will closely monitor all possible developments as a result of the 2020 IMO 0.5 % fuel sulphur limit. Due consideration will be given to any new information based on WinGD experience, or that provided by regulators, fuel suppliers or studies carried out by responsible bodies.

In the third quarter of 2019, ISO plans to release a publicly available specification (ISO/PAS 23263) on the topic of post 2020 marine fuels entitled: "Considerations for fuel suppliers and users regarding marine fuel quality considering the implementation of max. 0.50%S in 2020". Additionally, CIMAC WG-7 "Fuels" intends to publish its own guidelines around the same date.

Technical Information Note
011

2020 IMO global 0.50 percent fuel sulphur regulation
WinGD operation guideline

Date: 2019-05-29
Reference No.: 21236/TH/19011

WIN GD
WinGD Gas & Diesel

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Summary

On 1st January 2020, the maximum permissible global sulphur content of marine fuels is reduced from 3.5 % to 0.50 % according to MARPOL Annex VI.

New fuels, compliant with this 0.5 % S limit, are likely to display a wide variability of physical and chemical properties even between fuel batches of the same ISO specification.

This document informs of the possible consequences of this wide variability, and provides guidance on important factors to consider when purchasing, bunkering and handling on board of these fuels.

Specifically, in addition to standard fuel management guidelines, due consideration should be given to the compatibility of different batches of fuel, and the resultant stability.

ISO/PAS 23263:2019(E)
ISO TC 28/SC 04/WG 6
Secretariat: AFNOR

Fuels (class F) - Considerations for fuel suppliers and users regarding marine fuel quality in view of the implementation of 0.50 % S in 2020

Combustibles (classe F) - Considérations à l'usage des fournisseurs de carburants pour la qualité des combustibles pour la marine en vue de la mise en application de la teneur maximale en soufre de 0,50 % en 2020

PAS stage

Relevant Documents

WinGD Guidelines and Letters

WinGD Tribology Fuels & Lubricants Page

www.wingd.com/en/technology-innovation/engine-technology/engine-design/tribology-fuels-lubricants

2020 IMO global 0.50 percent fuel sulphur regulation - WinGD operation guideline

www.wingd.com/en/documents/technical-information-notes/wingd_tin011-imo-2020-operation-guideline.pdf

Diesel Fuels for WinGD engines

www.wingd.com/en/documents/fuel-lubricants-water/diesel-fuels-for-wingd-engines-v2.pdf

Fuel Statement 0.1% ULSFO

<https://www.wingd.com/en/documents/engine-operation/fuel-statement-0-1-ulsfo-v2.pdf>

Lubricants for WinGD engines

www.wingd.com/en/documents/fuel-lubricants-water/lubricants-for-wingd-engines-v3.pdf

WinGD Piston Underside Drain Oil Analysis Tool

www.wingd.com/en/documents/engine-operation/wingd-piston-underside-drain-oil-analysis-tool-v2.xlsx

WinGD Guide for judging condition of relevant piston-running components

www.wingd.com/en/documents/engine-operation/wingd-guide-for-judging-condition-of-relevant-piston-running-components-v3.pdf

Relevant Documents

Documents from 3rd parties

International Maritime Organization, «Revised MARPOL Annex VI,» London, 2016.

ISO (International Organization for Standardization), «ISO 8217:2017 (E) Petroleum products - Fuels (class F) - Specifications of marine fuels,» Geneva, 2017.

American Society for Testing and Materials, "Standard Test Method for Cleanliness and Compatibility of Residual Fuels by Spot Test," 2014. [Online]. Available: <https://www.astm.org/Standards/D4740.htm>.