Latest X-Engine Technology & New Development Program

WinGD Technical Seminar Tokyo – Nov. 2019
J.-N. Constantin – Product Manager 75 – 96 Bore Engines
X-Engine Portfolio
# Latest X-Engine Technology & New Development Program

## X-Engine Portfolio

### WinGD Dual-Fuel Engines

<table>
<thead>
<tr>
<th>Engine</th>
<th>Power (MW)</th>
<th>Speed (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X40DF</td>
<td>3, 4, 6</td>
<td>104-146</td>
</tr>
<tr>
<td>RT-flex50DF</td>
<td>8, 10</td>
<td>99-124</td>
</tr>
<tr>
<td>X52DF</td>
<td></td>
<td>79-105</td>
</tr>
<tr>
<td>X62DF</td>
<td></td>
<td>80-103</td>
</tr>
<tr>
<td>X72DF</td>
<td></td>
<td>69-89</td>
</tr>
<tr>
<td>X82DF</td>
<td></td>
<td>58-84</td>
</tr>
<tr>
<td>X92DF</td>
<td></td>
<td>70-80</td>
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### WinGD Generation X Engines

<table>
<thead>
<tr>
<th>Engine</th>
<th>Power (MW)</th>
<th>Speed (RPM)</th>
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<tbody>
<tr>
<td>X35-B</td>
<td></td>
<td>118-167</td>
</tr>
<tr>
<td>X40-B</td>
<td></td>
<td>104-146</td>
</tr>
<tr>
<td>X52</td>
<td></td>
<td>79-105</td>
</tr>
<tr>
<td>X62/-B</td>
<td></td>
<td>77-103</td>
</tr>
<tr>
<td>X72/-B</td>
<td></td>
<td>66-89</td>
</tr>
<tr>
<td>X82-B</td>
<td></td>
<td>58-84</td>
</tr>
<tr>
<td>X82-D</td>
<td></td>
<td>58-84</td>
</tr>
<tr>
<td>X92/-B</td>
<td></td>
<td>70-80</td>
</tr>
</tbody>
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### WinGD RT-Flex Engines

<table>
<thead>
<tr>
<th>Engine</th>
<th>Power (MW)</th>
<th>Speed (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT-flex50-D/E</td>
<td>3, 4, 6</td>
<td>95-124</td>
</tr>
<tr>
<td>RT-flex58T-E</td>
<td></td>
<td>90-105</td>
</tr>
</tbody>
</table>

### 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

X82-D

X82DF
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New Development Program – Main Dimensions

<table>
<thead>
<tr>
<th></th>
<th>6 cyl.</th>
<th>7 cyl.</th>
<th>8 cyl.</th>
<th>9 cyl.</th>
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</thead>
<tbody>
<tr>
<td>B (mm)</td>
<td>5’020</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C (mm)</td>
<td>1’800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D (mm)</td>
<td>12’450</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F1 (mm)</td>
<td>X82-D 15’520 / X82DF 15’150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G (mm)</td>
<td>2’700</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F1: Normal vertical lifting (crankshaft center to crane hook)

Engine length reduced compared to X82-B
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### New Development Program – Main Design Features

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

- Optimized liner wall temperatures
- Pulse Lubricating System + grooves
- Liner plateau honed
- Anti-polishing ring
- Liner wall temperature sensors
- 2 piston rings
  - Top ring gas-tight
  - Cr-ceramic coated
  - Pre-profiled
- Piston ring grooves with thick chromium layer
- Piston skirt with bandage

Piston running concept features include top ring gas-tightness, Cr-ceramic coating, pre-profiled grooves, optimized liner wall temperatures, and anti-polishing technology.
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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
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X-Engine Technology - ICU Evolution

Mk I – 2001
Separate control oil system

RT-flex58T
RT-flex96C
RT-flex84T

Mk II – 2005
Servo oil actuated

Mk III – 2014
On board maintenance
Lower TCO cost

X82 - 2008

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
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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
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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
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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
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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
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

*S* 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.

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**Recommended procedure for checking compatibility of fuels before blending**

1. Prepare blends of fuel A and B with ratios of 50/50 and the same ratio intended to blend in the tanks e.g. 75/25.
2. Perform “Compatibility Procedure” according to Annex IV of the IACS Code of the samples.
3. Prepare blends of fuels A and B with the ratios 75/25 and 25/75.
4. Perform “Compatibility Procedure” according to Annex IV of the IACS Code on all the samples.
5. Do all of the samples pass the compatibility test with cleanliness rating 1 (Figure 6)?
6. Performing additional analysis for some 10/90 and 90/10 with the same procedure.
7. Did fuel A or the new blend pass compatibility check with rating 1 (Figure 6)?
8. Yes or No.
9. Intended blend ratio is in the range between 0/100 and 90/10?
10. Yes or No.
11. Intended blend ratio is in the range between 60/40 and 90/10?
12. Yes or No.
13. Do NOT blend these fuels.
14. The fuels might be compatible. If blending is needed, add fuel B to fuel A.
15. The fuels might be incompatible. If blending is needed, add fuel A to fuel B.
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.
## Relevant Documents

### WinGD Guidelines and Letters

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<th>WinGD Tribology Fuels &amp; Lubricants Page</th>
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<th>2020 IMO global 0.50 percent fuel sulphur regulation - WinGD operation guideline</th>
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<tr>
<th>WinGD Guide for judging condition of relevant piston-running components</th>
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Relevant Documents

Documents from 3rd parties

