The environmental challenge ahead and The way forward

- Sulphur Cap 2020/ ECA zone
- LNG as fuel

Yufeng Liu, Director Sales China
Marine Money Shanghai, 10th May 2017
Global sulphur Cap by 2020

A game changer?

IMO sets 2020 date for ships to comply with low sulphur fuel oil requirement
IMO-MEPC 70 decision will have impact!

Analysts estimate the additional costs for the container shipping sector alone could be $35-$40 billion.

Switzerland-based MSC, the world’s No.2 container line, estimated its own additional annual fuel costs at $2.02 billion.
Getting compliant - What are the options?

Back in the day’s HFO or MDO

Today and in the future

What to select?

HFO
After-treatment Scrubbers
SCR

MDO?
NO\textsubscript{x} Tier III
compliant engine
+ Low sulphur fuel

GAS
Gas as fuel

And in the end it all boils down to $$$
SOx: ---- LNG as fuel or scrubber?  
2020 is due date!

For existing vessels MDO/MGO or new low sulphur fuels will be the option of choice!

For new-buildings as of today a serious consideration of LNG as fuels or scrubber is needed!

Payback time will reduce to < 5 years making this investment a must for surviving in future shipping.

-> X-DF technology is ready!
**NOx: Emission control areas are extending!**

Baltic/North Sea Tier III by 2021!

China has enforced 3 new ECA's: Pearl River Delta, Yangtze River Delta & Bohai Rim

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[Map showing emission control areas around the world, with blue and light blue areas indicating existing and possible future ECAs, respectively.]
Both SCR and EGR require additional equipment into the vessel but urea supply system can be shared with auxiliary engine SCR system.

Picture: MDT
HP-SCR on ‘Papuan Chief’

Compact arrangement in the engine room
Running experience

- The SCR system has presently accumulated about 800 operating hours with HFO @ 2.5% sulphur
- A total of 80 m³ urea was consumed.
- These values represent a typical expected operating time during one year for merchant vessels operating between US and other continents.
- The system has not shown a deterioration of the activity promising to reach well a target lifetime of 5 years.
- A more continuous operation is now being targeted to acquire faster operating hours.
**SCR Summary**

The overall performance of the SCR confirmed the design targets:

- Reduction of NOx below the IMO target level

- Exhaust gas flow layout, including mixing pipe and flow diameter changes, proved to meet pressure loss targets and uniform distribution of urea to reach target IMO level

- The overall SCR and piping structure proved to be fit for the continuous operation – no leakages, vibrations within design limits

- Detailed installation aspects had to be reviewed and will be reflected for serial produced SCR systems
**WinGD SCR- reference list**

<table>
<thead>
<tr>
<th>Engine type</th>
<th>Vessel type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7RTA-52U</strong></td>
<td>3x RoRo, Wagenborg, NL</td>
</tr>
<tr>
<td></td>
<td>In operation since 1999</td>
</tr>
<tr>
<td><strong>5RT-flex58T</strong></td>
<td>1x 22kDWT MPV China</td>
</tr>
<tr>
<td></td>
<td>Navigation</td>
</tr>
<tr>
<td></td>
<td>In operation since 2015 (HHM)</td>
</tr>
<tr>
<td><strong>6X72</strong></td>
<td>6x 158kDWT COT AMPTC (HHI)</td>
</tr>
<tr>
<td></td>
<td>In operation since 2016</td>
</tr>
<tr>
<td></td>
<td>2x 158kDWT COT Restis (HHI)</td>
</tr>
<tr>
<td></td>
<td>2x 158kDWT COT EuroNav (HHI)</td>
</tr>
<tr>
<td><strong>6X62</strong></td>
<td>3x 83kDWT BC, Klaveness (HHI)</td>
</tr>
<tr>
<td><strong>6X52</strong></td>
<td>6x Product Oil Carrier</td>
</tr>
<tr>
<td><strong>10X92</strong></td>
<td>4x 14000TEU Container</td>
</tr>
</tbody>
</table>

**TOTAL** 31 SCR ordered HP- and LP- solution
The “all in one compliance solution” LNG as fuel with X-DF!
43 years perfecting low-pressure technology

1972 – launch of 7RNMD90, Low-Pressure DF Engine for 29,000 m³ LNGC, ‘MV Venator’, Moss Yard, Norway
2-stroke

1986 – testing High-Pressure DF Engine 6RTA84 at IHI, Japan
2-stroke

1992 – Low-Pressure Spark-Ignited Engine
4-stroke

1995 – Low-Pressure Dual-Fuel Engine
Break through in marine segment
4-stroke

2013 – Low-Pressure Dual-Fuel Engine
2-stroke

Perfecting gas engines with low-pressure dual-fuel technology

Beginning introducing modern gas engines with well-known diesel process (high-pressure)

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Overview - key technology

X-DF engine is based on the electronic-controlled common-rail marine engine

**Common-rail pilot oil injection system with pre-chamber injector**
- Low pilot fuel consumption (<1%)
- Low NOx and THC (methane slip)
- Good combustion stability, no knocking, good load acceptance

**Gas admission system**
- Simple, safe and reliable gas admission
- Sealing technology with low-pressure

**Engine Control & Automation system**
- Integrated engine control and safety
**X-DF combustion concept**

**The main merits with low gas pressure < 16bar**

- Simple and reliable gas supply system
- Simple gas sealing
- Wide selection of proven compressors / cryo pumps

**Lean Burn ‘Otto’ combustion means**

**IMO Tier III compliance:**

- Without additional equipment (EGR/SCR)
- Without additional fuel consumption
- Without compromised component reliability

**Gas mode: Pre-mixed lean-burn ‘Otto’ combustion**

**Diesel mode: Diesel process**


**X-DF overall emission picture**

- PM very low due to ‘lean-burn’ Otto combustion with pre-chamber ignition
- Low SOx due to clean natural gas
- Tier III NOx level met due to ‘lean-burn’ Otto combustion
- ‘Methane slip’ = THC emissions (Total Unburned Hydrocarbons) is included in total CO2 equivalent
- Unlike CO2, methane disappears over time. It’s short term effect is 28 times stronger as a green house gas *)
- X-DF contributes positively to reduce the total emission scope compared to any engine operating in the Diesel process

*) IPCC report ‘Climate Change 2013’

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The X-DF engine program

LNG Carriers  PCTC, CONRO

Container Vessels
1,000 - 20,000 TEU

Tankers
- Product
- Aframax
- Suezmax
- VLCC

Bulkers
- Handysize
- Handymax
- Panamax
- Capesize
- VLOC
Engine room configuration for twin-screw 180'000 m³ LNG Carrier

**Benefits with 16 bar system**
- LP equipment only (compressors, pumps, evaporator, piping, valves, sensors, ....)
- Compact – space / weight saving
- Low E-power demand
- Low first cost

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**X62DF or X72DF main engine**

**Fuel Gas Handling System (FGSS)**

**L34DF generating sets**

**LNG, -162 °C**
**LP FGSS for merchant vessel**

- **IMO type C <10 bar**
- **Bunkering station**
- **Tank connection space**
- **LNG vaporizer & heater**
- **LNG tank: Double or single wall**
  - Prismatic tanks (pressure less) require BOG processing

**Benefits with 16 bar system**
- Compact - space / weight saving
- Low E-power demand
- Low first cost
- Low maintenance costs
- Safe - many LP installation in op.

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Engine room configuration
Example: LNG fuelled merchant vessel

Low pressure fuel gas supply system

Low-speed DF main engine

DF auxiliary engines

Cold box with LNG low-pressure pumps, evaporator, heater, valves, etc.
Low pressure: lower investment cost & same operating costs

Significantly lower CAPEX for low-pressure technology

LNG fuelled vessel: 4350 RH Tier III, 1650 RH Tier II

Not considered additional costs
- HFO treatment system operation of HP solution
- Gas burned by the GCU (higher amount for HP solution)

Same OPEX with low-pressure technology
Leading into the gas age:
WinGD X-DF references

RT-flex50DF
- 4 x 15k dwt Chemical Tankers, Terntank
- 6 x 1400 TEU Vessel, Nordic Hamburg Shipping
- 1 x 14k m³ Coastal LNGC, Huaxiang
- 4 x 15k dwt Asphalt Carriers, Transport Desgagnés

X62DF
- 2 x 180k m³ LNGC/twin-screw, SK/Marubeni/Total at SHI
- 3 x 180k m³ LNGC/twin-screw, 3 different Owners at SHI
- 6 x 115k dwt aframax tankers, HHI and SHI

X72DF
- 4 x 174k m³ LNGC/twin-screw, Gaslog/BG Group at HHI and SHI
- 1 x 174k m³ LNGC/twin-screw, MOL/EON at DSME
- 2 x 174k m³ LNGC/twin-screw, SK Shipping/SK E&S at HHI
- 2 x 174k m³ LNGC/twin-screw, Gaslog at SHI

49 engines on order, hereof 20 delivered, hereof 5 in operation

All engines ready to get IMO Tier II and III certificates
**X-DF production engines**

First X-DF powered vessel in service

“M/T Ternsund” in regular service in the Baltic / North Sea since beginning of August 2016

2nd vessel in regular service since Nov 2016
3rd vessel in regular service since Jan 2017

100% operation with LNG in North and Baltic Sea (except start and manoeuvring)

Operation closely monitored:
- Very positive feedback so far
- Only minor issues reported
- Owner is satisfied with engine performance

Ship-to-ship bunkering of LNG
Picture: Port of Gothenburg
X-DF installation benefits

1) **Meets IMO Tier III** requirements **without** SCR or EGR system due to ‘lean-burn’ Otto combustion process

2) **Low CAPEX** due to **low-pressure gas supply system**
   - Low-pressure equipment (pumps, compressor, evaporator, piping, sensors, ....)
   - No exhaust gas after treatment required

3) **Low OPEX** due to **high overall efficiency**
   - Lower electrical power demand
   - Lower maintenance cost
   - Lower gas leakage risk

4) **Low-pressure - The industry standard**
   - Wärtsilä (ref. ~1500 engines)
   - MAN
   - Cat/MAK
   - Rolls Royce
   - MTU
   - Mitsubishi
   - …
Thank you!

Questions and answers

A reassuringly long heritage in marine engine design

WinGD has its headquarters in Winterthur, Switzerland, where, as one of the earliest exponents of diesel technology, it started the development of large internal combustion engines in 1898 under the "Sulzer" name.

Powering merchant shipping since 1898
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