X-DF: Update on low pressure DF technology
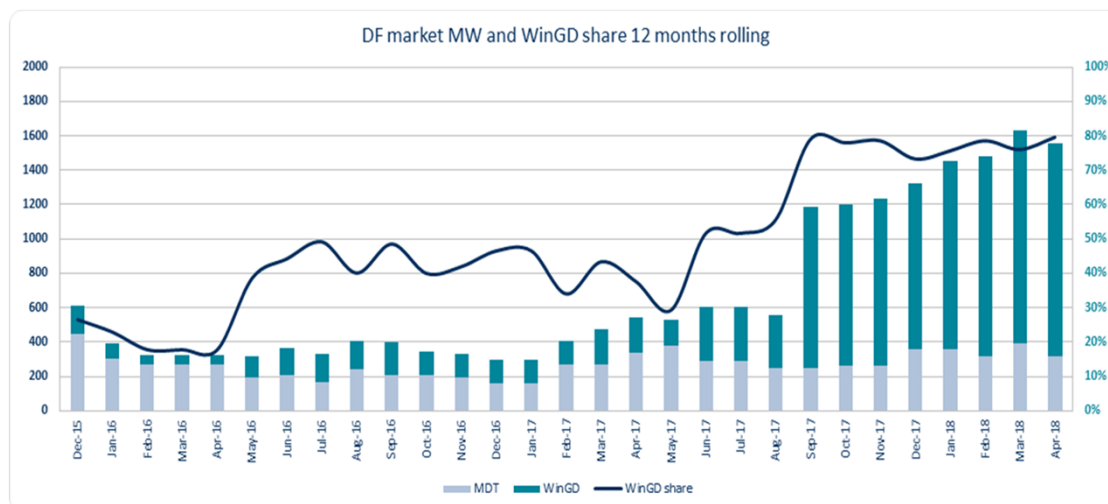
For a smarter perspective on current and future air emissions

WIN GD

Simply a better different

X-DF capturing LNG fuelled ships

The propulsion of choice!


DF market MW and WinGD share 12 months rolling

- Captured majority share of DF market
- Propulsion of choice for majority of LNGC orders
- Simplicity appreciated for LNG-fuelled vessels

Engine type	Vessel type	Orders
RT-flex50DF	15k DWT Prod. Tankers	15 engines
	1.4k TEU Feeder CVs	
	14k CBM LNG Carriers	
X52DF	125k DWT Shuttle Tankers	5 engines
	7k CEU Car Carrier	
X62DF	115k DWT Crude Oil Tankers	23 engines
	174k CBM LNG Carriers	
	180k CBM LNG Carriers	
X72DF	174k CBM LNG Carriers	42 engines
	180k CBM LNG Carriers	
X92DF	22k TEU Post-Panamax CVs	9 engines

Firm orders: 94 engines (approx. 1.8 GW)

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Low-pressure technology sets the standard

Maximum simplicity!
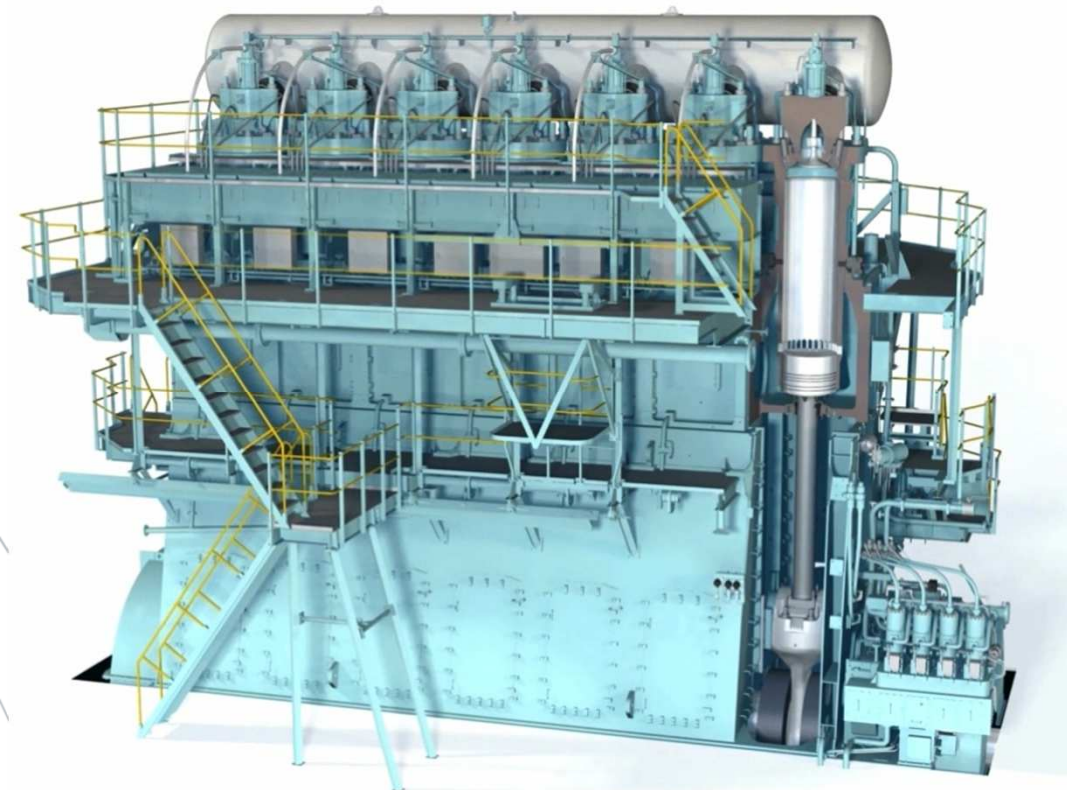
The Principle

- Engine operating according to Otto process
- Pre-mixed 'Lean-burn' combustion technology
- Low-pressure gas admission at 'mid-stroke' location
- Ignition by pilot-fuel into pre-chambers

The main merits with low gas pressure < 13bar

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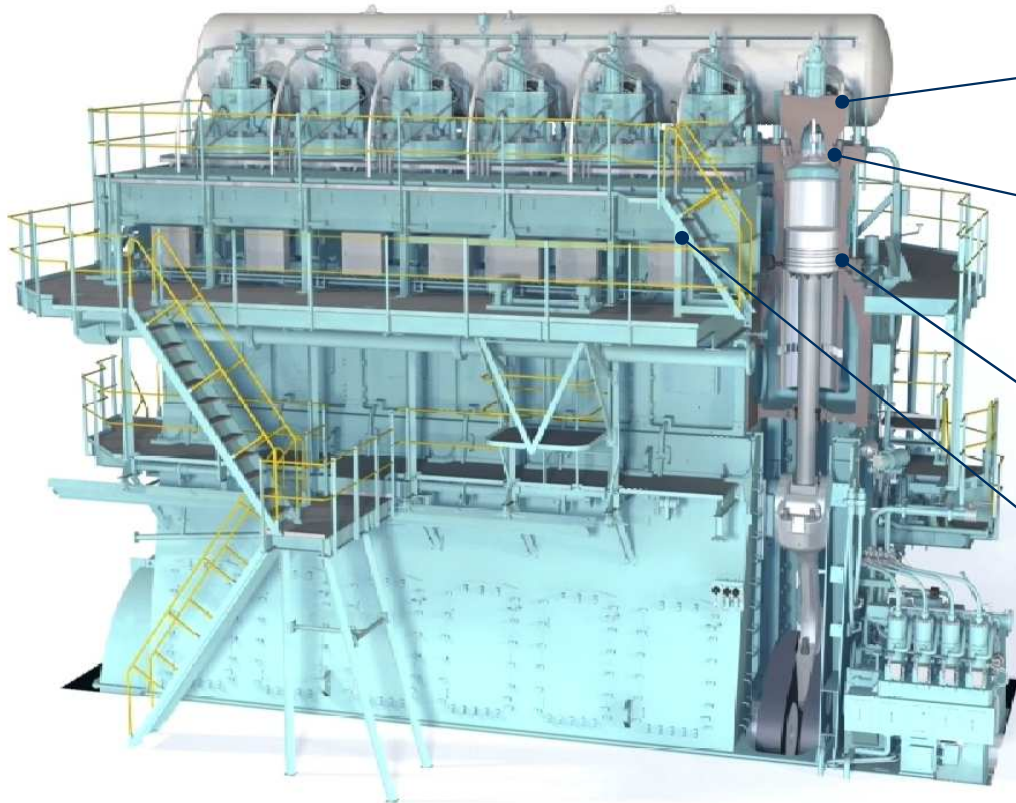- Wide selection of proven compressors / cryogenic pumps

Lean Burn 'Otto' combustion means

IMO Tier III compliance:

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

X-DF Low Pressure key components

Key technologies that make the difference!

Micro-pilot common-rail system
- Low pilot-fuel consumption < 1%
- Low NO_X!

Pre-chamber technology
- Low NOx and THC/ 'methane slip'!
- Good combustion stability!

Gas admission system
- Safe and relible gas admission &
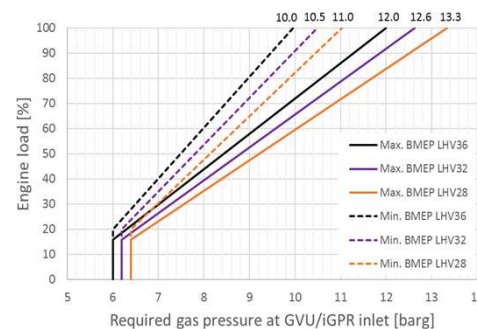- Simple sealing technology with low-pressure!

Engine Control & Automation
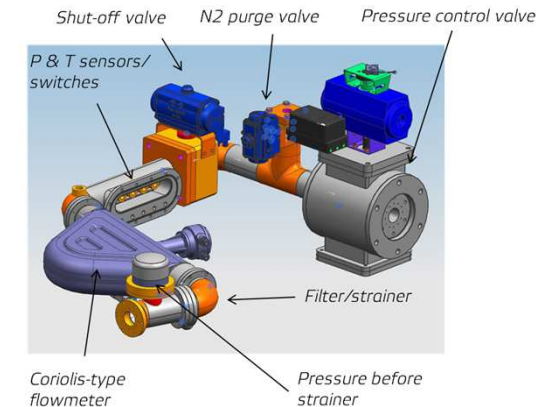- Integrated engine control and safety!

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X-DF Low Pressure technology features

## Continuous R&D effort towards technological excellence

Gas feed pressure optimized as 13 bar max at no expense in engine performance

Integrated Gas Pressure Regulation (iGPR) provides the same main functions as GVU, now fully integrated into the engine design/control system.

Integrated Cylinder Lubricant Auto Transfer (iCAT) enables automatic change-over of the cylinder LO between high and low BN oils, depending on operating mode.
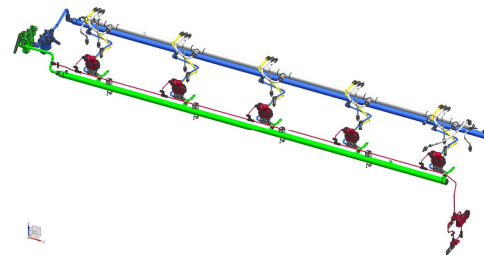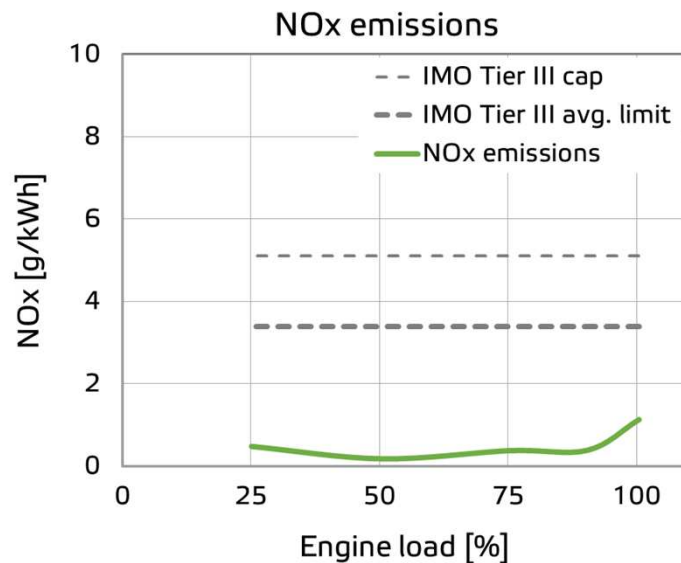

Fuel sharing up to 50% liquid ratio and from 50% engine power

Up to 20% Volatile Organic Compounds (VOC) as fuel to supplement LNG as fuel for X-DF.
Zero VOC-slip greenhouse potential.
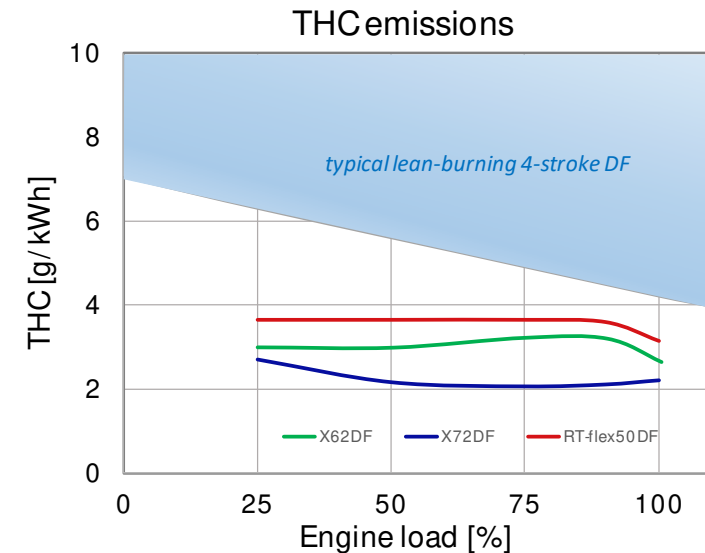
Proven emission values through testing

"Ultra-low" NOx emissions

IMO weighted avg. <1 g/kWh

THC emissions

THC emissions confirmed to be low

Figures remain low in part load operation

'Ultra-low' NOx emissions during 100% of gas operation time !

E.g.180k LNGC: regular Tier II   ~2300 t/year
(7'500 h at sea at CSR)   X-DF on gas   ~   150 t/year

THC emissions in the range of 1.5 - 2% of gas consumption

Even if considering GHG potential of methane slip, total GHG footprint is positive in comparison to regular diesel engine

28 May 2018   X-DF Update .:. Madrid LNG & Shipping Forum .:. Claudiu Nichita   WIN GD

Why WinGD Low-Pressure ?

1) **MEETS IMO TIER III**
   - Requirements without exhaust gas after-treatment due to lean-burn Otto combustion process

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

3) **LOW OPEX** - Due to high overall efficiency
   - Minimized electrical power demand
   - Low maintenance cost

4) **LOW-PRESSURE - THE INDUSTRY STANDARD**
   - Maximum safety
   - Widely applied by medium-speed majors for good reasons
   - Various brands: Wärtsilä, MAN, Cat/MAK, Rolls Royce, MTU, Mitsubishi
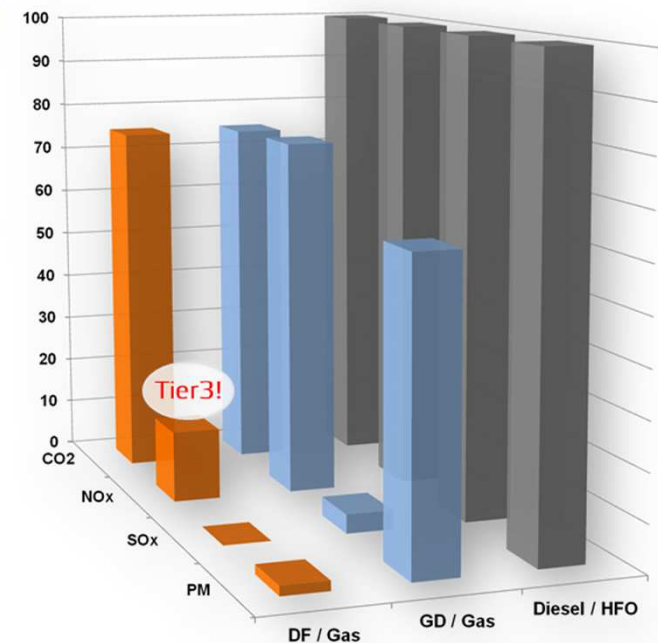
Thank You !

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