THE DIESEL ENGINE
&
THE ENVIRONMENT

Presented By:
Christer Broman
Wartsila N.A. Inc

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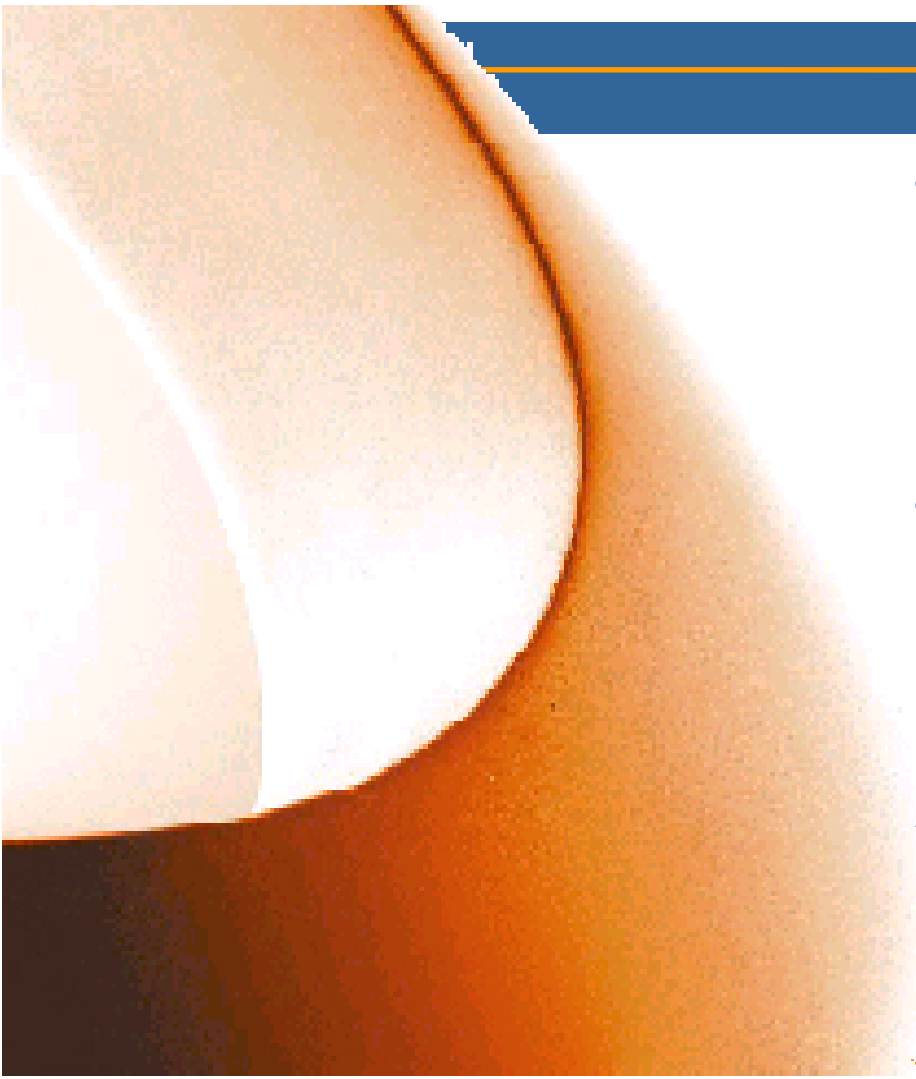
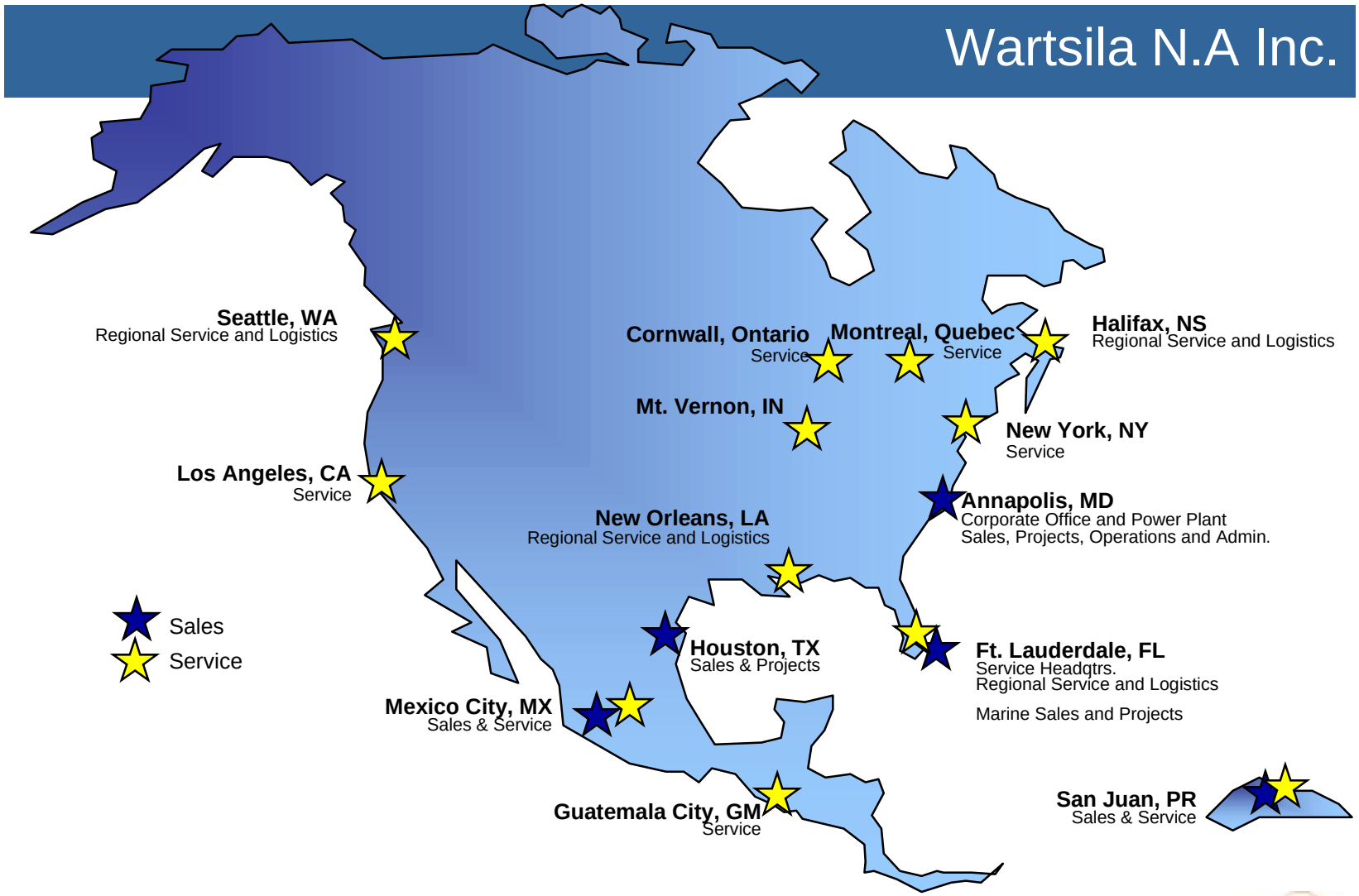


Wärtsilä Corporation

- A global company focusing on power generation, marine propulsion and industrial applications
- Designing, manufacturing, licensing, marketing and servicing Wärtsilä and Sulzer engines and Lips propellers
- Engineering and provision of complete power solutions and propulsion systems

Wartsila N.A Inc.



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Typical Diesel Exhaust Gas Composition

Together > 99.5%	**Nitrogen**	N_2 :	76%	
	Oxygen	O_2:	13%	
	Carbon dioxide	CO_2:	5%	**Low due to high efficiency**
	Water	H_2O:	5%	
	Sulphur oxides	SO_X		**Fuel choice related**
	Carbon monoxide	CO		**Low due to good combustion**
	Hydrocarbons	C_XH_y		**Low due to good combustion**
	Particulates			**Influenced by fuel, ash,sulphur**
	Visible smoke			**Low load related (<25% load)**
	Nitrogen oxides	NO_X		**Controlled by technology**

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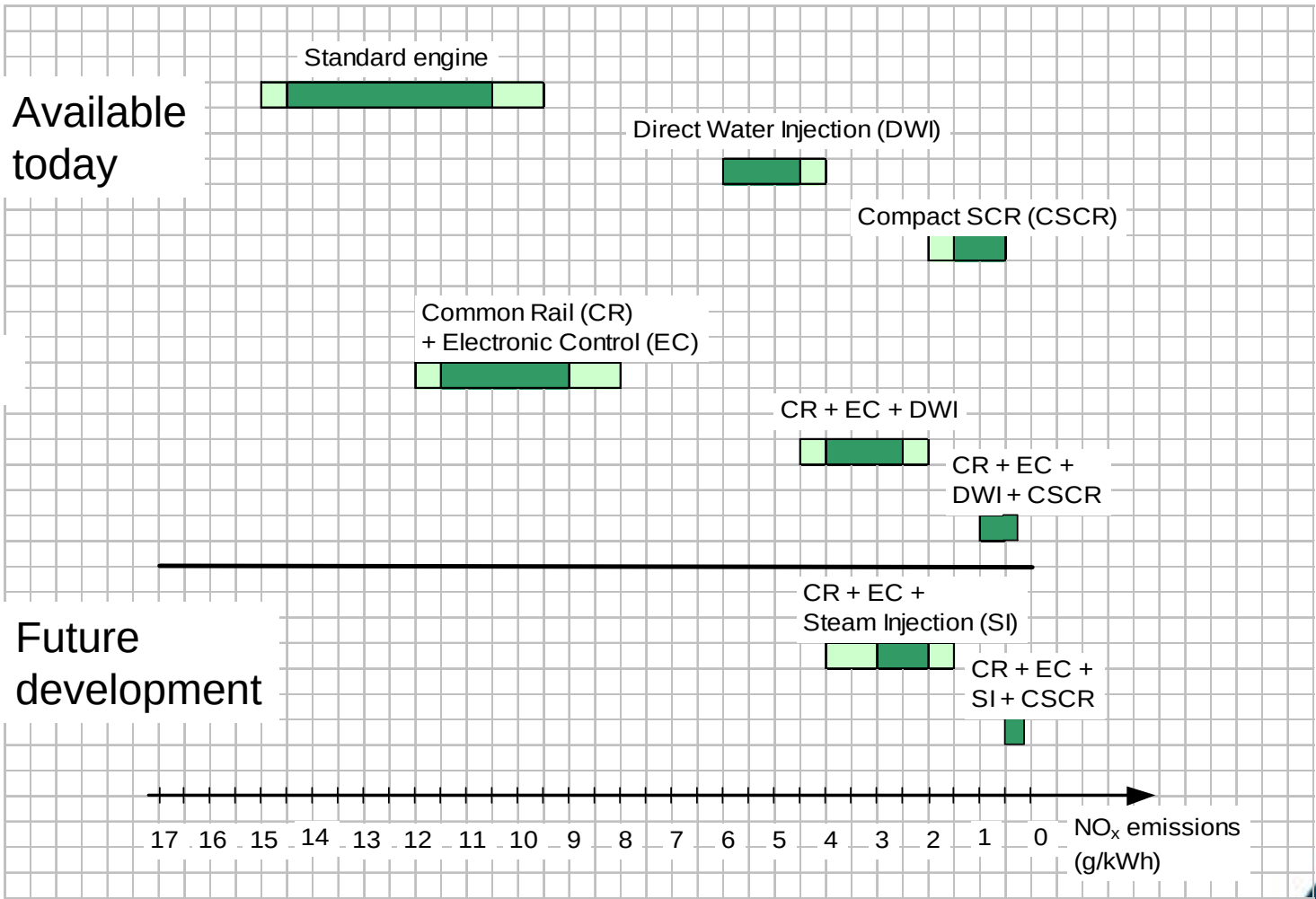
Different Means of Emission Control for Diesel Engines



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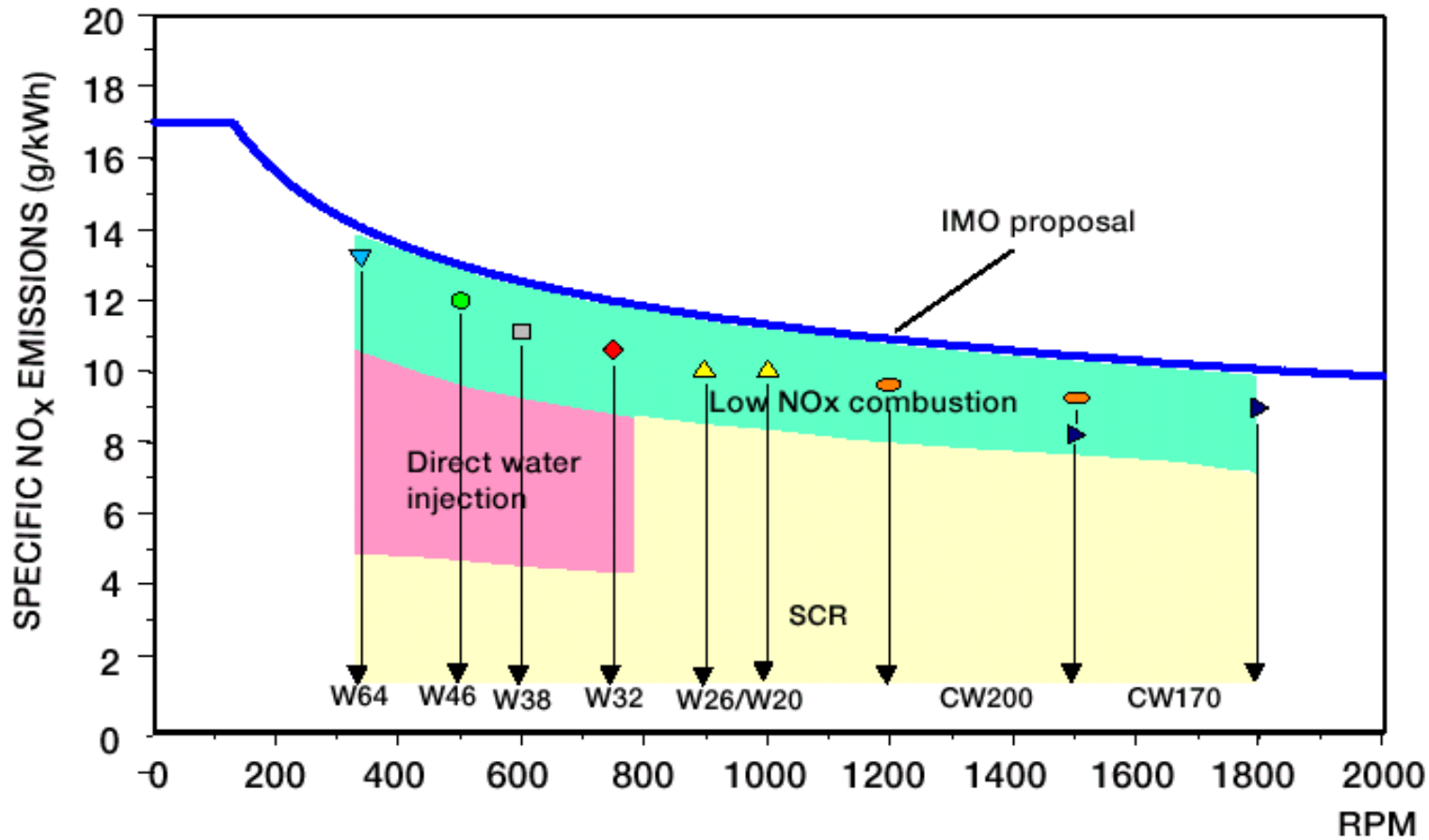
NOx control by Wärtsilä



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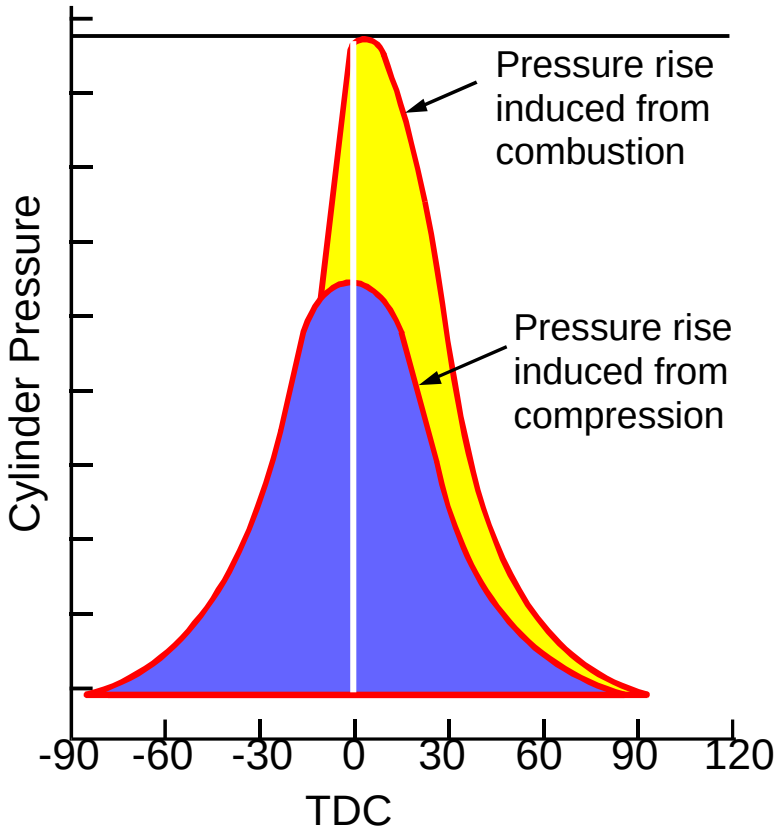
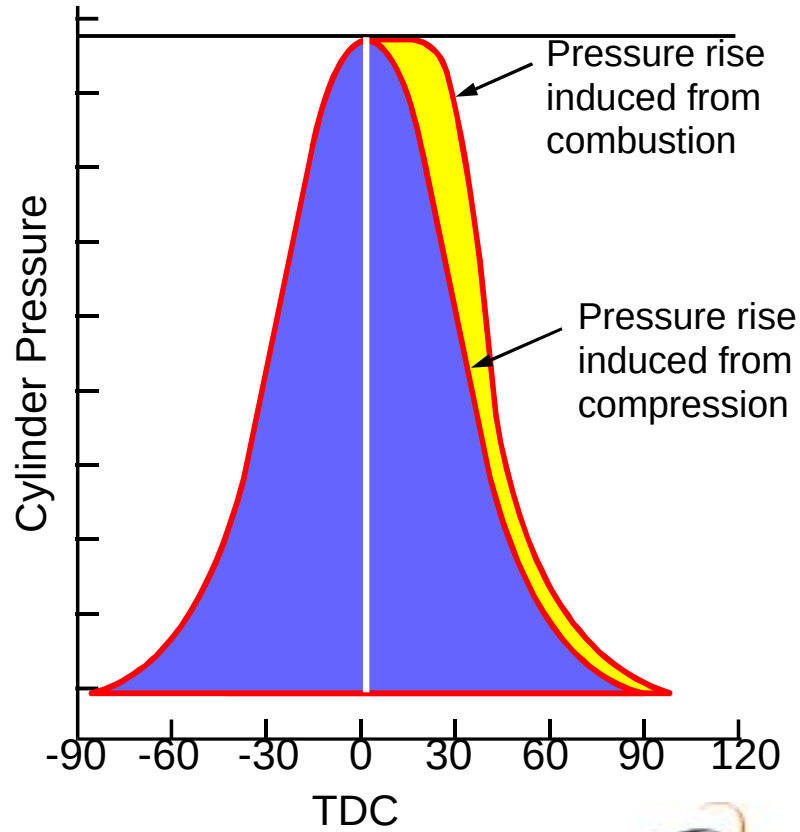
Low NO_x Combustion

Conventional Design
Engine Maximum Firing Pressure



Low NO_x Design
Engine Maximum Firing Pressure



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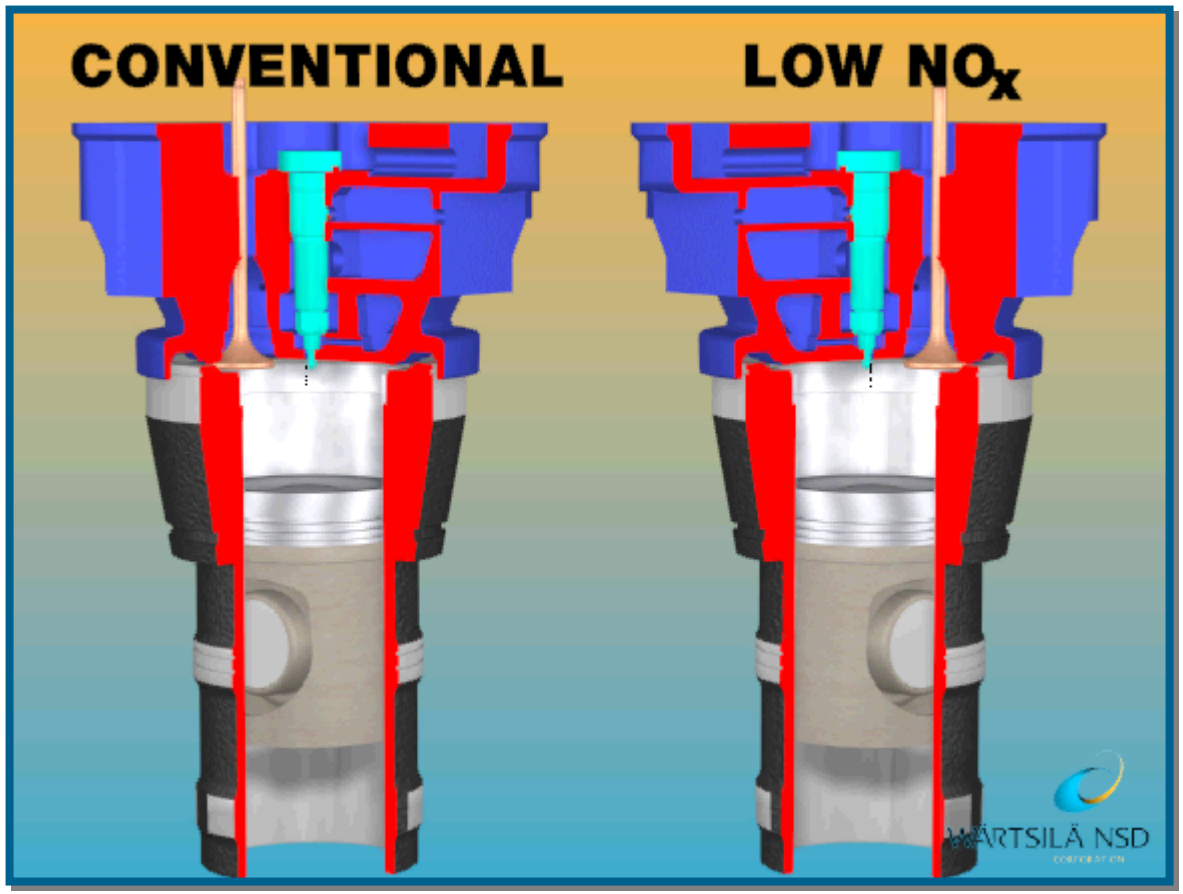
Low NOx design



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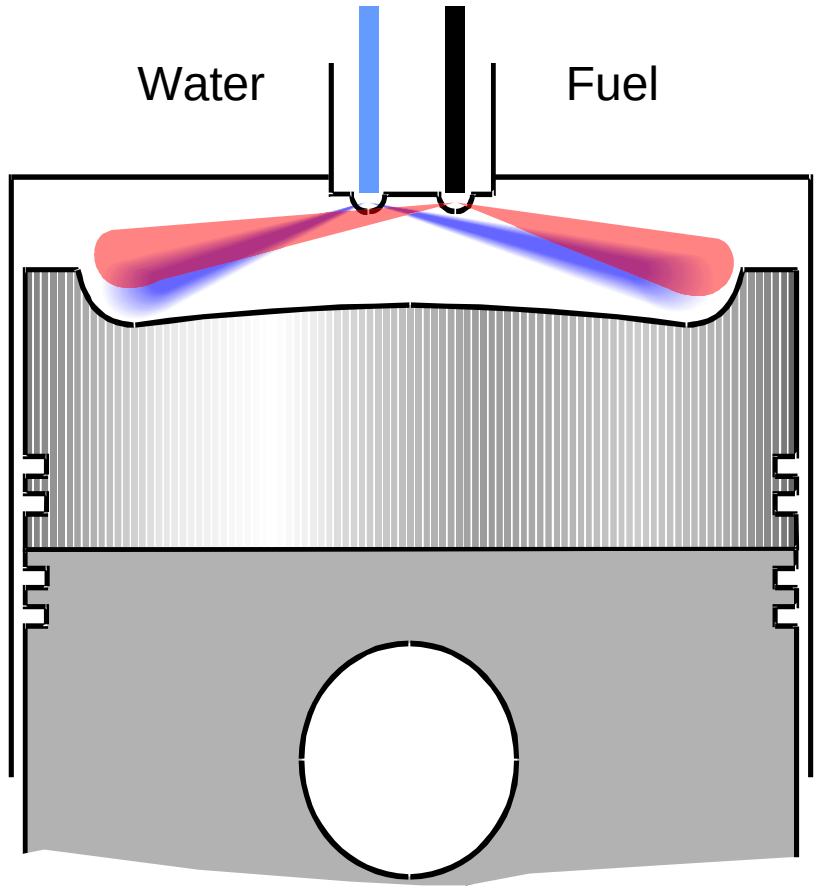
Principle of Direct Water Injection

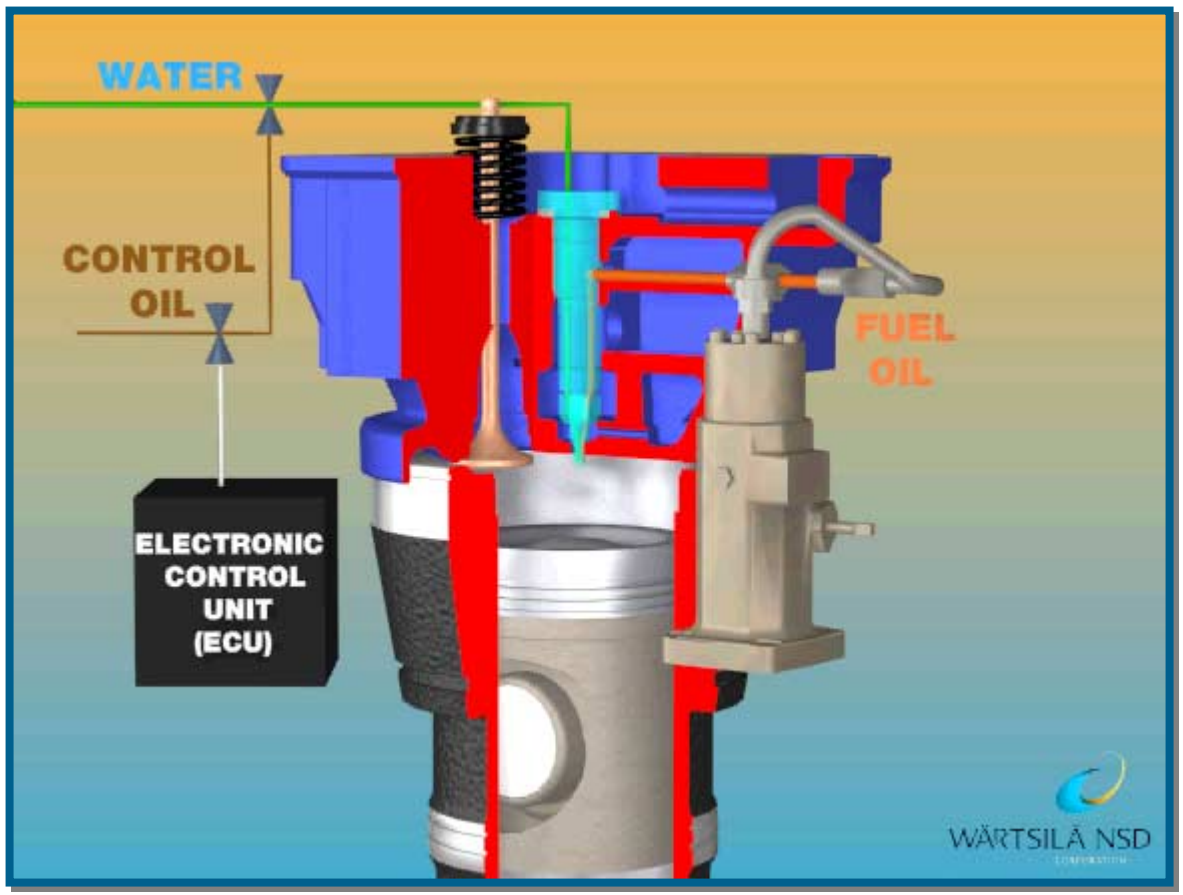


Water Pressure
200 - 400 bar

Fuel Pressure
1200 - 1800 bar

Water Needle
and
Fuel Needle
in the Same
Injector

Water injection



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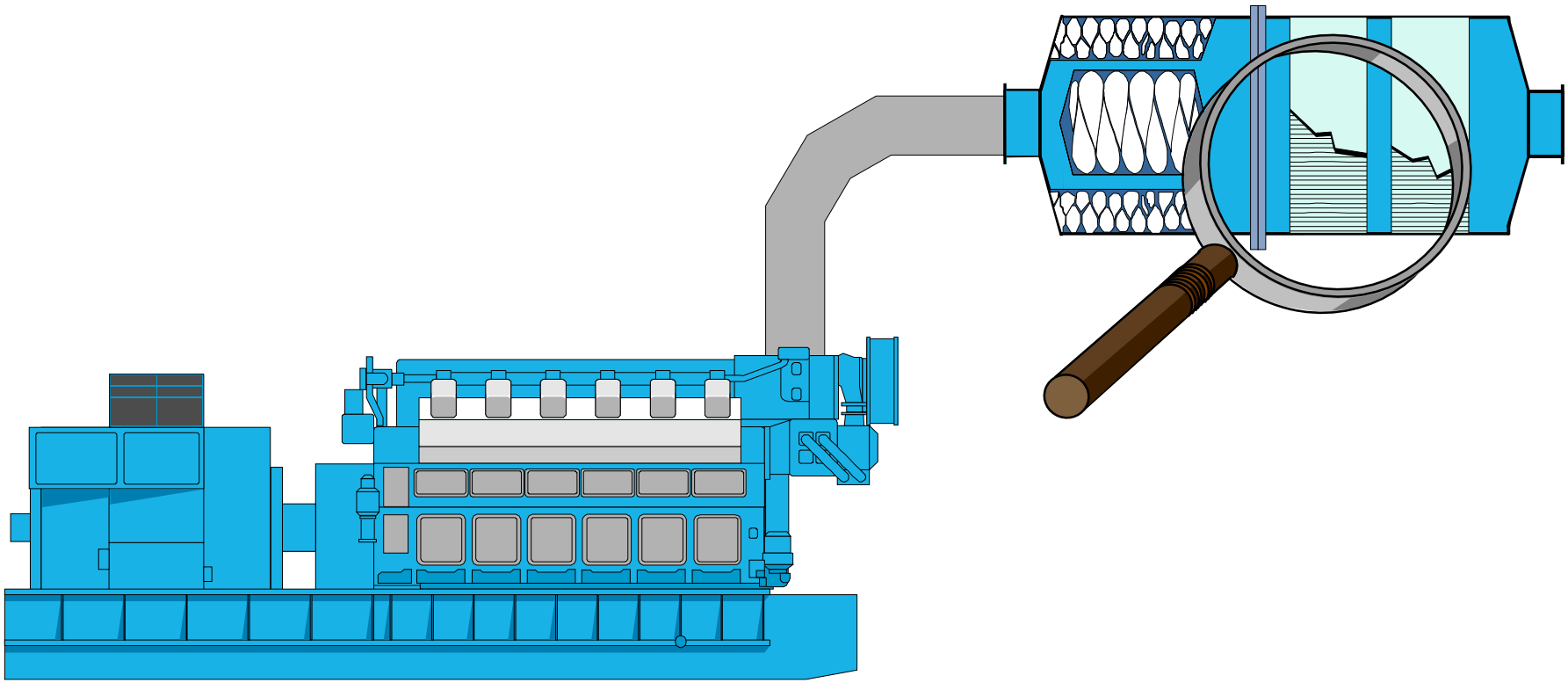
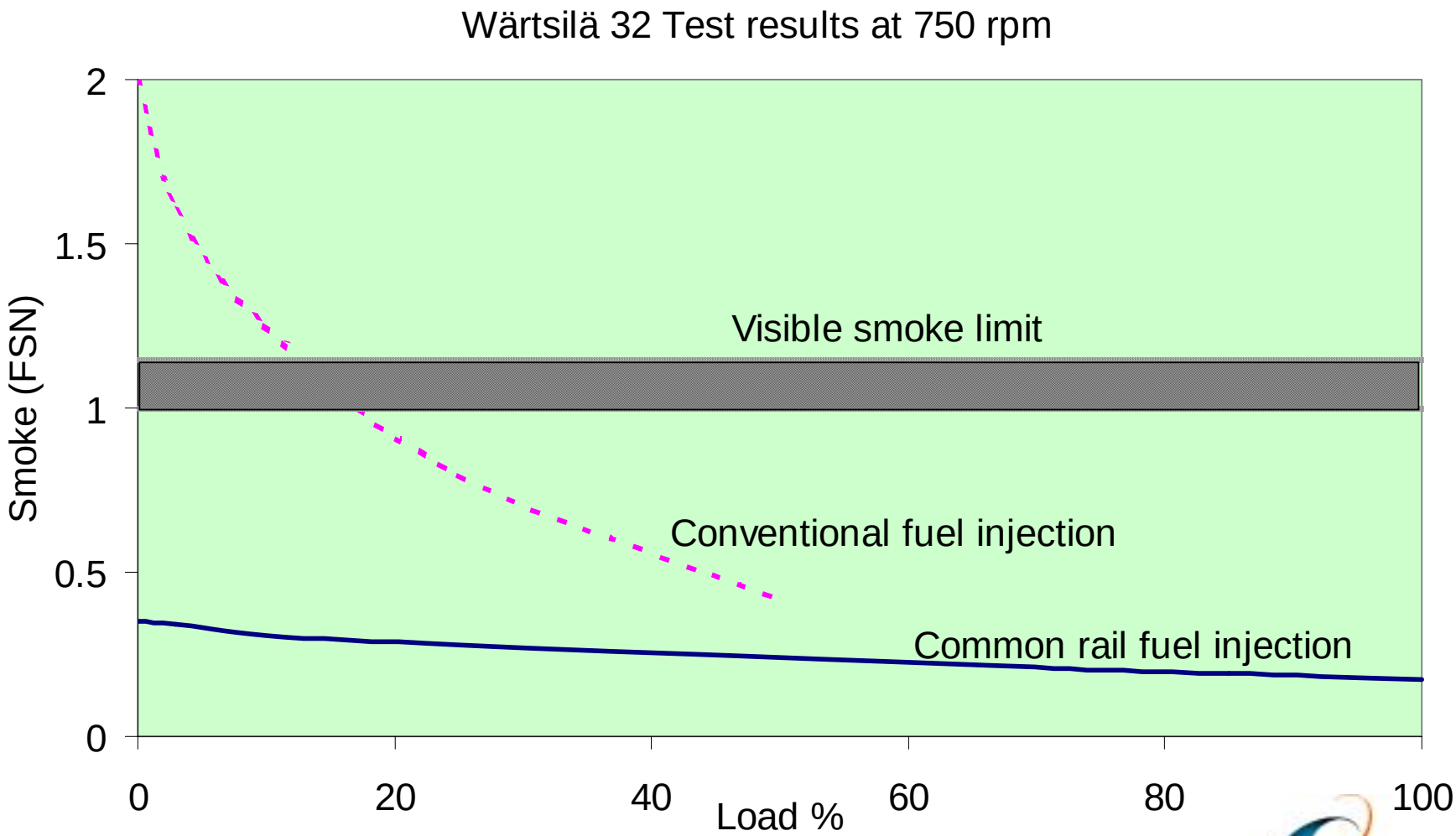
Compact SCR



Smoke Level with Common Rail Fuel Injection



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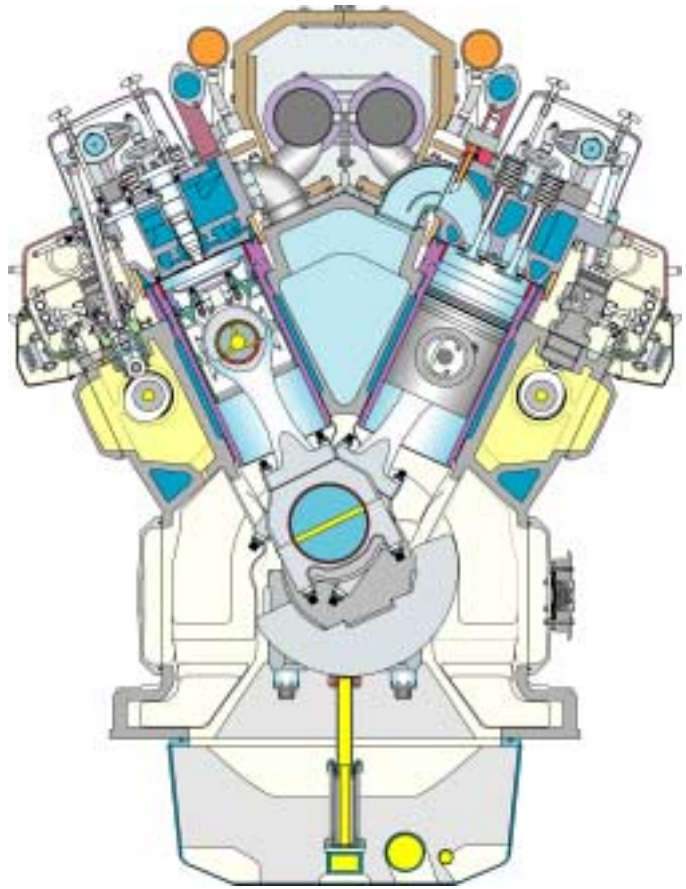
Dual Fuel Engines

The number of sea ferries using bunkered gas as fuel is expected to grow in the near future due to environmental pressure.

- Dual fuel engine
  - Ignition by pilot fuel at gas operation
  - LFO used as back-up fuel
- Spark ignited Gas Engine
  - Ignition by an electric spark plug
  - No back-up system



BOTH ENGINE TYPES OPERATE ON LOW GAS PRESSURES

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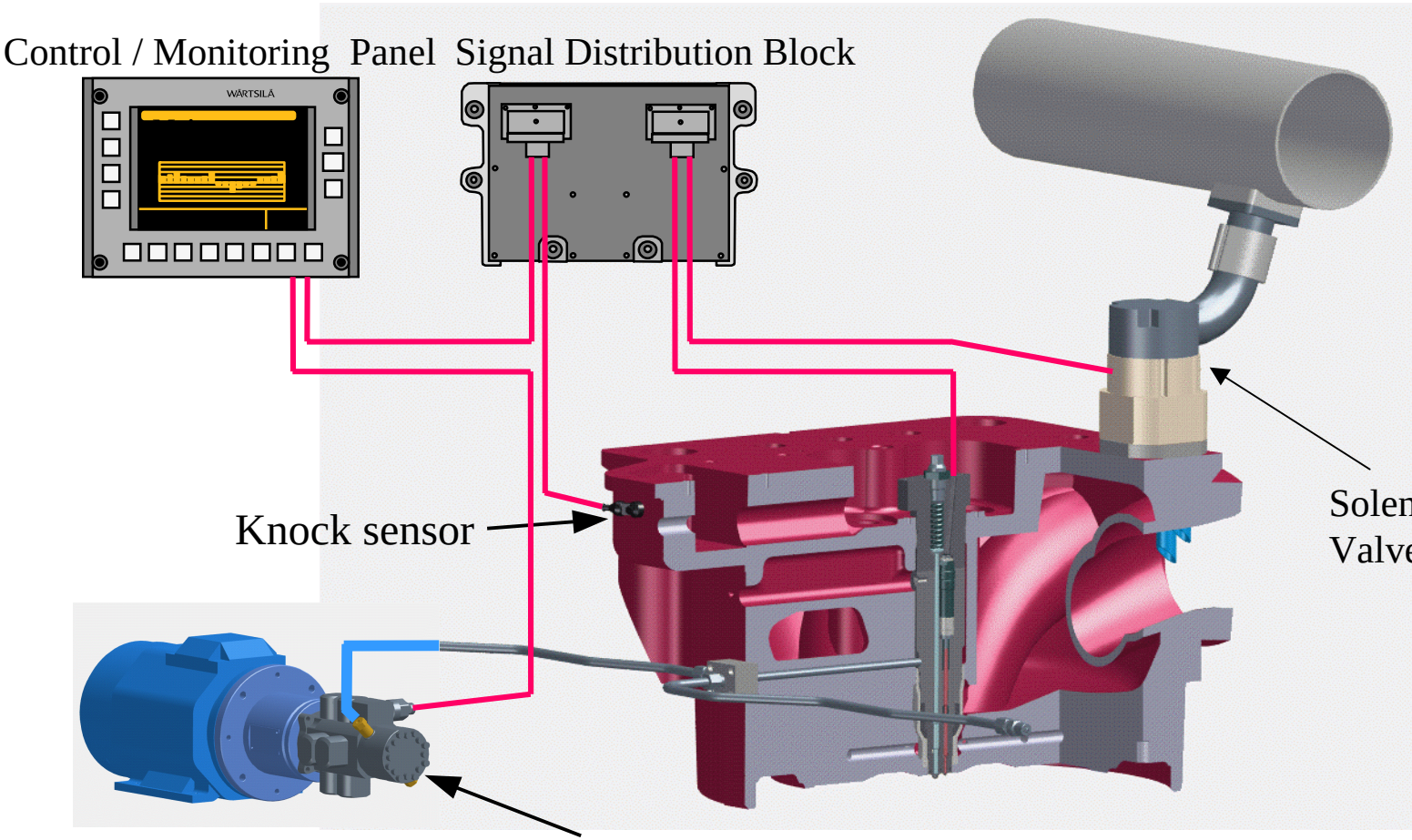
How Does it Work?



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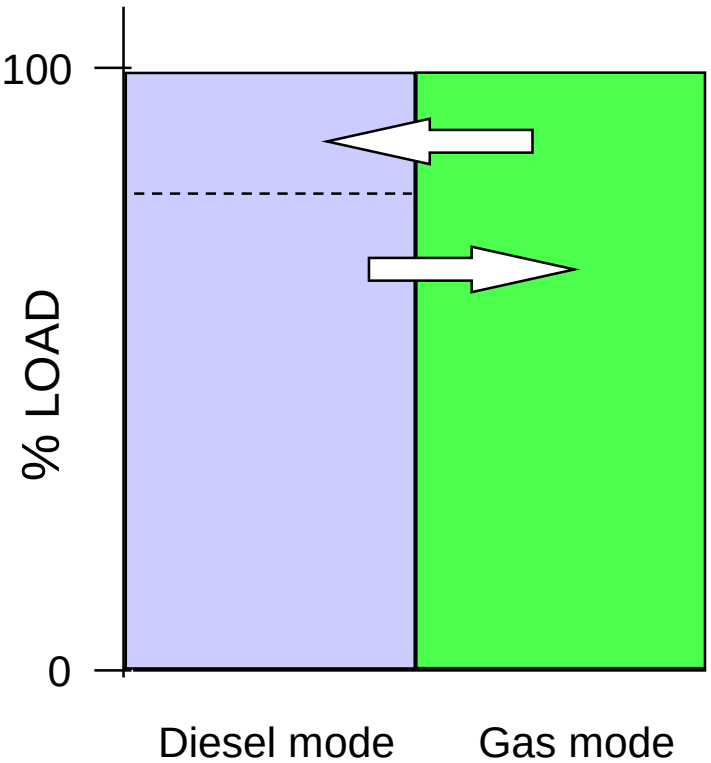
Operating Principal- Dual Fuel Engine

- **Gas mode**
  - High efficiency and low emissions
  - Automatic and instant transfer to diesel operation in alarm situations
  - Transfer to diesel operation at any load
- **Diesel mode**
  - As an ordinary diesel engine
  - Transfer to gas operation preferably at part load
  - Pilot fuel injection in operation



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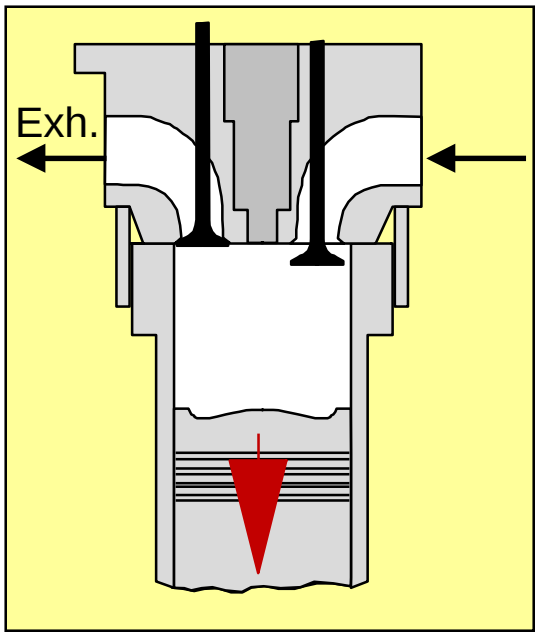
Gas Diesel Engine Concept

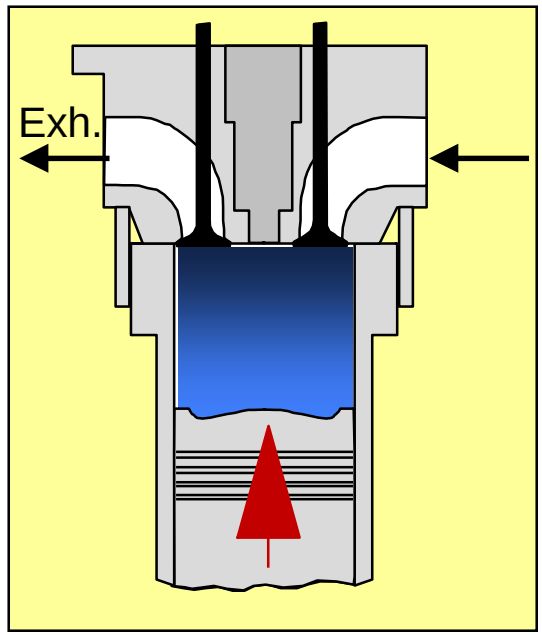
- The gas diesel engine is a dual fuel / multi fuel engine that is designed to operate i two fuel modes.
  - Liquid fuel mode, using MDO/LFO, HFO or Crude Oil as main fuel.
  - Gas fuel mode, using natural gas as main fuel ignited with a small amount of liquid fuel.
- In liquid fuel mode the engine is works as an ordinary diesel engine.
- In gas fuel mode the engine is adapting the direct gas injection technique for gas injection at high pressure.

Gas Diesel Working Principle

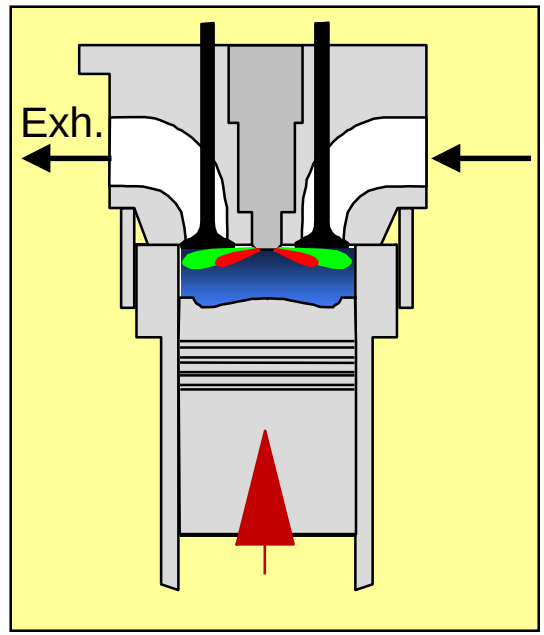
Wärtsilä 32GD & 46GD



Air
Intake



Compression
of Air



Injection of Gas
and Pilot Fuel Ignition

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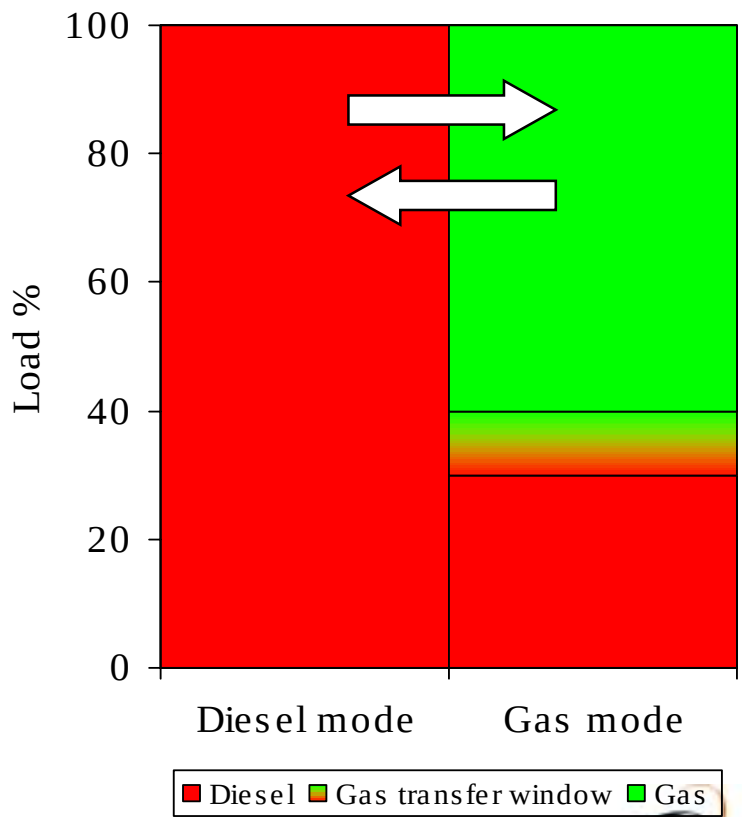
Gas Diesel Engine Concept

Operating modes

- Diesel mode
  - Diesel fuel operation only
  - As an ordinary diesel engine
- Gas mode (high pressure)
  - Diesel fuel operation at start and low load
  - Automatic transfer between fuels according to load
  - Automatic and instant transfer in alarm situations



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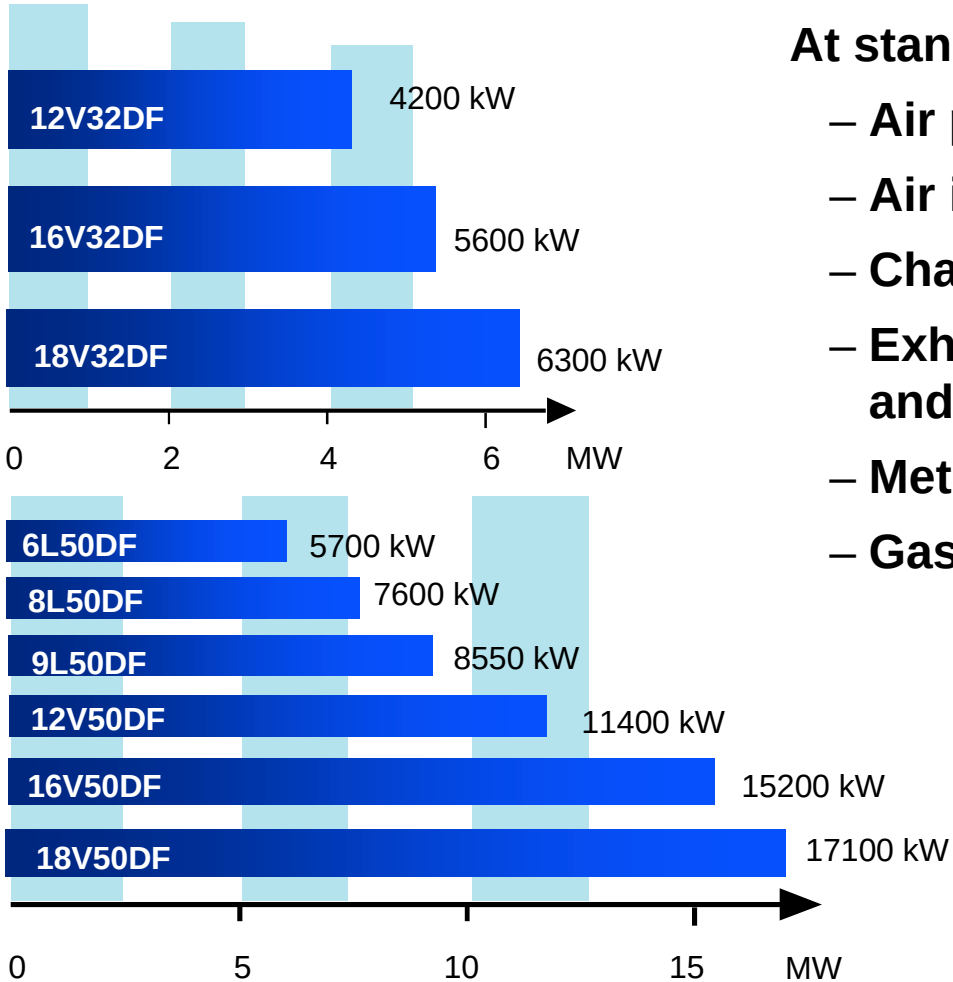
Dual Fuel Product Portfolio



At standard reference conditions:

- **Air pressure 100 kPa**
- **Air inlet temp. 30 °C**
- **Charge air temp. 40 °C**
- **Exhaust gas back pres. and air inlet pres. drop 4 kPa**
- **Methane number 80**
- **Gas pressure 3,5 bar (g)**

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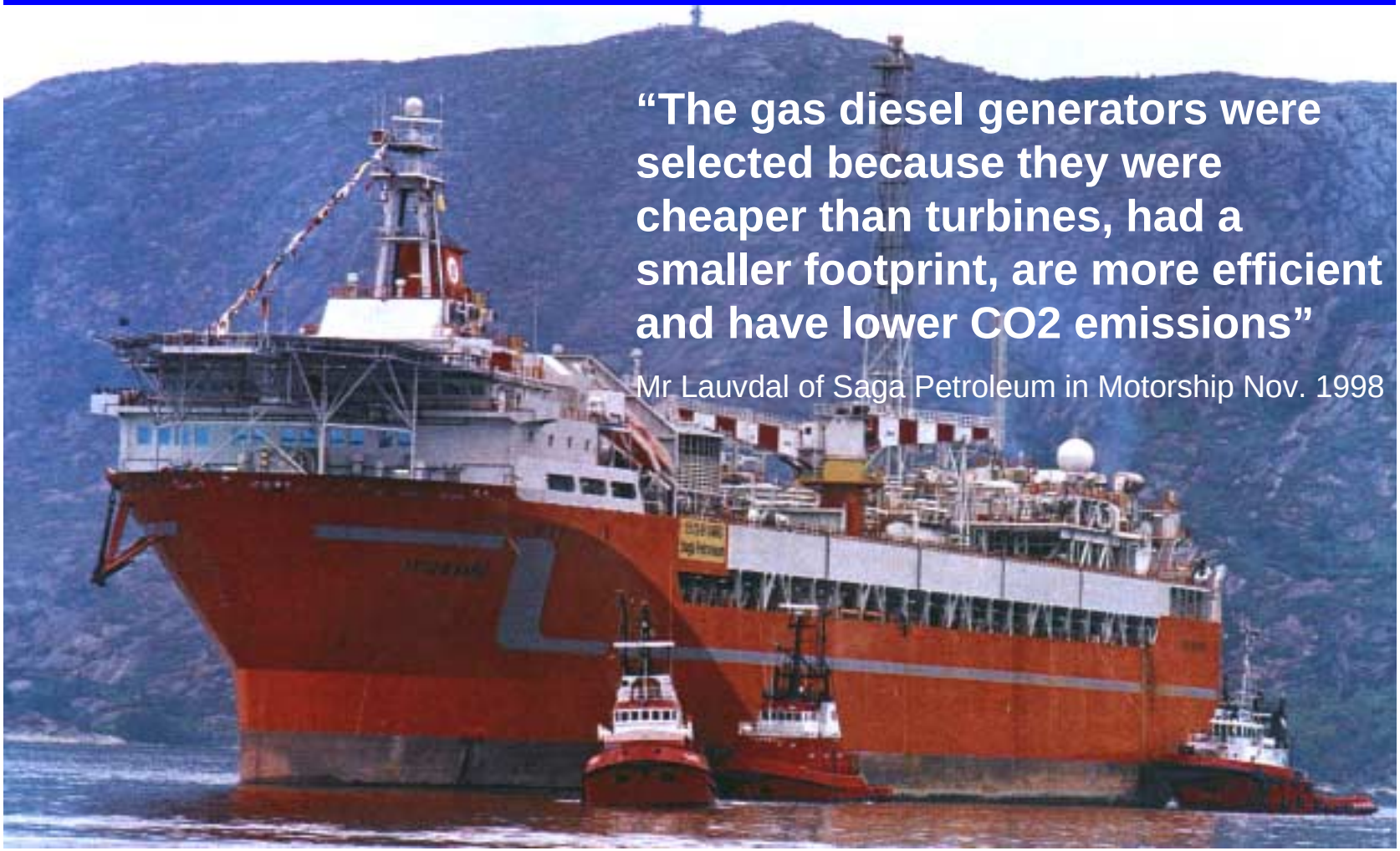

“The gas diesel generators were selected because they were cheaper than turbines, had a smaller footprint, are more efficient and have lower CO2 emissions”

Mr Lauvdal of Saga Petroleum in Motorship Nov. 1998

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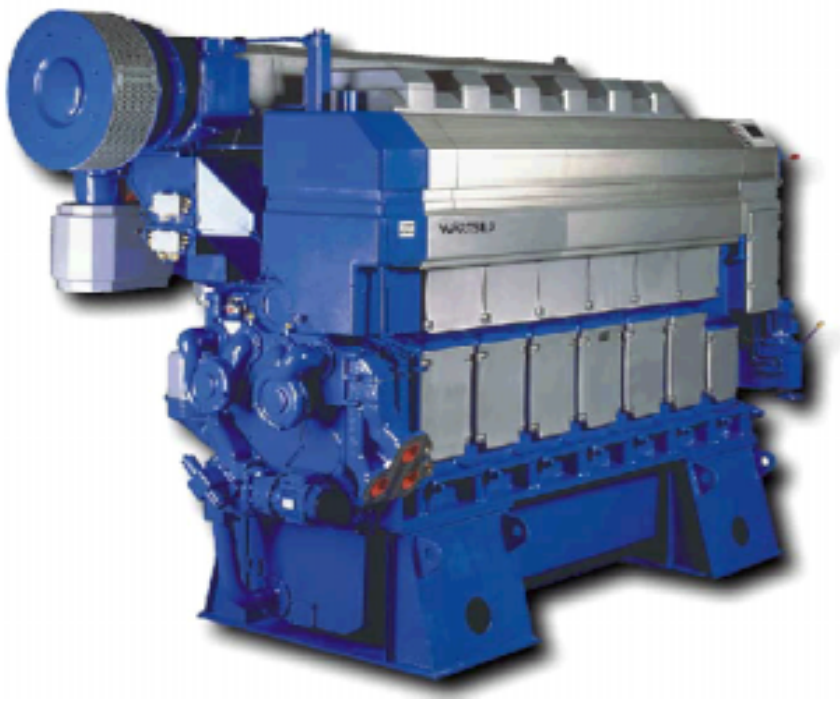
Conclusion

The diesel engine is going through an accelerated rate of change.The engines are becoming more compact, easier to maintain and environmentally friendly. The consumption of fuel and lube oil is decreasing and the engines are capable of burning a variety of different fuels.



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