



WÄRTSILÄ 2-STROKE LOW PRESSURE DUAL-FUEL ENGINES

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WÄRTSILÄ SHIP POWER BUSINESS WHITE PAPER
2-STROKE ENGINES

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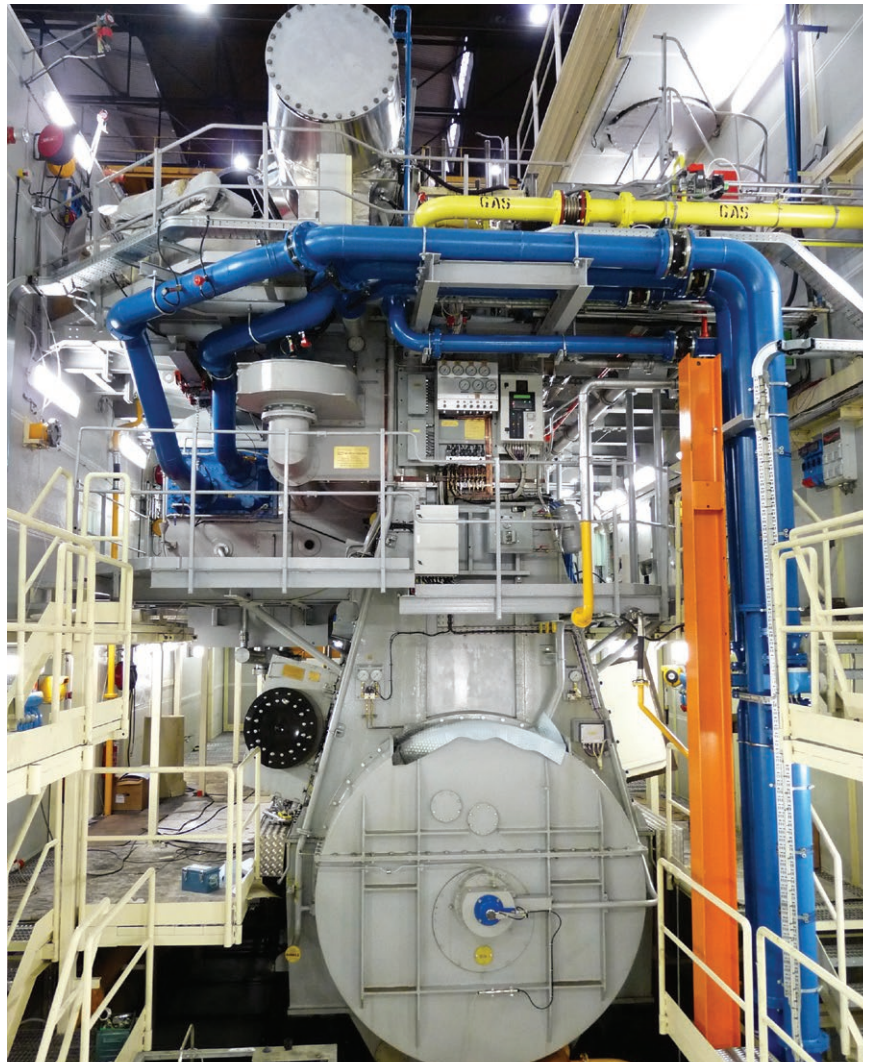
Wärtsilä – the leading provider of gas solutions

Introduction

Wärtsilä began development work with dual-fuel gas engines in 1987, the first concept being the gas-diesel (GD) engine with high-pressure gas injection. This was followed by the second generation of gas engines in the early 1990s, with the introduction of spark-ignited (SG) pure gas engines utilising low pressure gas. The breakthrough for marine application came when the dual-fuel (DF) engine was introduced by Wärtsilä in 1995. This third generation of gas engine combined fuel flexibility, engine efficiency, system safety, the lowest capital cost and highest environmental performance available in the world today.

Since the introduction of dual-fuel 4-stroke engines in 2005, Wärtsilä became the leader delivering more than 2,000 DF engines accumulating more than 7,000,000 operational running hours in both terrestrial and marine applications. Wärtsilä aims to continue the success and are extending DF benefits across to the broader marine industry by applying its expertise and experience in dual-fuel power to low-speed engines.

Wärtsilä test-bed engine RT-flex50DF



Question 1:

What makes you so convinced that the low pressure dual-fuel (DF) concept is the best technology choice available?

Answer:

We have developed, tested and sold both the high pressure and the low pressure DF technologies for our 4-stroke engines. Our experiences prove that the optimal solution for marine applications is low pressure DF technology:

- The lowest emissions that meet Tier III without additional exhaust after-treatment
- Simple, reliable and most economic gas supply system with the least components.
- Stable operation on gas over the entire load for port to port operation and manoeuvring.

Question 2:

How would you compare low pressure and high pressure technology for DF engines in general (4-stroke and 2-stroke)?

Answer:

The low pressure DF engine is developed to be a gas engine with additional liquid fuel backup.

The high pressure gas diesel engine is a conventional diesel engine operable on liquid fuel and that can burn gas under certain conditions.

Low gas pressure technology (<10bar) is the standard for all 4-stroke engine makers today, therefore proving the merit of this concept.

Question 3:

How is the efficiency of the low pressure DF engine compared to that of high pressure DF engine in gas mode?

Answer:

The net efficiency calculation is considering parasitic loads from all ancillary gas supply system components. The net efficiency is the same or better for the low pressure DF engine. The amount of pilot fuel required for low pressure engines is much lower compared to high pressure engines which need more pilot fuel, especially in part load. The high pressure DF engine is at a disadvantage below 15 to 20% engine load because it must switch to 100% liquid fuel operation consequently increasing emissions.

Question 4:

How is the efficiency of the low pressure DF engine compared to that of high pressure DF engine in back-up mode (liquid fuel)?

Answer:

The low pressure DF engine in back-up mode is less efficient than the high pressure DF engine. Because the engine is designed to be a gas engine and is optimised in the Otto cycle. The application of LNG as a fuel is driven by the huge environmental and economic benefits of LNG compared to liquid fuels such as HFO or MDO. Therefore vessels applying LNG fuel will aim to operate up to 100% on gas. DF provides redundancy in case of emergency operation. If regular operation in Liquid Fuel is required then other technology options are probably more appropriate, e.g. SCR Scrubber, EGR. Alternatively, for longer planned periods of operation on liquid fuel, the DF engine can be modified by changing compression ratio and Turbo charger specification to restore the efficiency to a standard diesel engine.

Question 5:

What is “knocking” on low pressure DF engines and what is the issue with it in daily operation?

Answer:

As gas fuel is entering the combustion space and mixing with the combustion air (pre-mix concept) there is a risk for uncontrolled combustion called “knocking” or “pre-ignition”. Based on Wärtsilä’s experience with the pre-mix concept on 4-stroke engines we have been able to develop systems to control and avoid knocking for the 2-stroke low pressure DF engines. The maximum output of the low pressure 2-stroke DF engine is kept lower than the comparable diesel engine to control knocking.

Question 6:

Why can a low pressure DF engine operate in gas from port to port while a high pressure dual-fuel engine cannot operate on gas below 15%-20% engine load?

Answer:

The low pressure DF engine is developed, designed and optimized to be a gas engine in Otto cycle. The amount of pilot fuel is very small (about 1% of the total energy at full load) and constant over the whole operation range.

The “high pressure DF engine” is a Diesel cycle engine and the amount of pilot fuel required is substantially higher. Under manoeuvring and idling speeds (15%-20% and below) the amount of pilot fuel may need to provide 100% of the energy required and consequently delivers the same emission as any other diesel engine.

Question 7:

It is claimed that there is no requirement for the installation of additional after treatment equipment to meet Tier III NOx regulations. Is this valid for all operation modes?

Answer:

That is correct; there is no need for any exhaust after treatment with low pressure DF engines. Tier III emissions are achieved in gas mode and the minimum Tier II level is achieved with liquid fuel.

The low pressure DF engine meets all global emission limits in every possible operational condition, ranging from idling speeds to full power output.

The high pressure DF engines Diesel Cycle and large pilot fuel volume requires after treatment via exhaust recirculation and scrubbing.

Question 8:

What safety factors need to be taken into consideration with low pressure DF engines?

Answer:

The engine Safety Concept includes safety measures and FMEA analyses etc. The Safety Concepts are approved by the Classification societies. The Safety Concepts have evolved from the Wärtsilä 4-stroke low pressure DF engines which have been accepted with all type approval tests needed for safe operation.

Due to a universal low pressure (< 10bar) gas supply system from the bunker to the injectors, the risk mitigation and safety requirements are achieved with less complex equipment, less capital expenditure and results in the lowest operational expenditure.

Question 9:

Why is the LNG fuel storage and handling system onboard more simple, reliable, safe and proven for low pressure DF engine?

Answer:

The LNG storage system is basically the same for low and high pressure engines as different tank designs can be applied depending on endurance, available space and operating conditions. However, the fuel gas handling and safety system need to be designed either for a low pressure (<10 bar) or a high pressure (up to 300 bar) system which leads to significant differences in space and safety requirements. Higher CAPEX and OPEX for the high pressure system are to be expected.

The reliability and maintenance costs of the high pressure equipment are not yet known.

The technology for low pressure gas supply is already in use and proven for many years with Wärtsilä medium-speed dual-fuel engines. For example LNG Carriers have a large boil-off-gas (BOG) rate and the energy demand for the low pressure compression is lower than the high pressure system that requires additional energy to re-liquefy BOG.

Question 10:

Why do low pressure DF engines have lower maximum output compared to that of high pressure DF engines of same size and why is this not a major disadvantage?

Answer:

Because the low pressure DF engine is fully optimized for gas operation the current maximum allowable output is about 10 to 15% lower compared to similar sized diesel engines.

Today ship designs do not select engines with the maximum diesel engine rating available because the advantage of running de-rated engines (around R4) provides benefits in fuel consumption.

Low pressure DF engines have the best fuel efficiency at R1 and de-rating provides no advantage. This in effect compensates most ship design power requirements because the low maximum output (R4) required for liquid fuel results in the same size engine (R1) doing the same job more efficiently with gas.

Question 11:

Is the load acceptance different for a low pressure DF engine compared to a diesel engine and will this affect daily operation?

Answer:

Typically the load acceptance of the lean-burn DF engines is lower than a diesel engine. The experience from Wärtsilä 4-stroke low pressure DF engines shows that this lower load acceptance does not affect daily operation of ships. We have experienced that load/step changes are not a problem on 4-stroke engines which are typically load step changing faster than 2-stroke engines.

Question 12:

Is the methane (CH₄) slip in low pressure DF engines a problem?

Answer:

Green House Gas (GHG) emissions for engines is calculated as CO₂ + CH₄ = GHG. Because Methane has 21-25 times more global warming potential than Carbon Dioxide it is often debated. However the percentage of atmospheric Methane from all global gas distribution systems is insignificant <0.3%, compared to natural sources 45% and industrial agriculture 19%. A gas engines total GHG emission is reduced by 20 to 30% compared to liquid fuel. Consequently methane slip has not been an issue and not restricted the adoption of 4-stroke low pressure DF engines over the past 20 years. Nevertheless we continue to develop and improve the total ecological footprint of our system.

Question 13:

What does the ecological footprint of the engine look like?

Answer:

The “Ecological Footprint” is the sum of the resources/energy consumed and waste (by-products) produced. The low pressure gas engine and its associated system deliver the lowest ecological footprint. It consumes less energy, less resources, and produces the least by-products (emissions including water treatment waste). The ability to meet Tier III NOx limits without additional exhaust emission techniques is very positive.

Question 14:

Is the low pressure 2-stroke DF engine more critical to gas quality than the high pressure DF engine. Does this have any practical effect?

Answer:

The gas quality requirements for the 2-stroke low pressure DF engine are similar to those of the 4-stroke DF engines from Wärtsilä. 7,000,000 running hours has proven that gas quality has not been a problem on 4-stroke and to date 2-stroke low pressure DF operational experiences have been good.

The Methane number determines the gas quality and the minimum is clearly specified in our guidelines to achieve the required power. In extreme circumstances a customer might want to use a waste stream gas with a low methane number and a product such as Wärtsilä Gas Reformer could be used to treat the gas and enable it to be used as a fuel.

Question 15:

What is the latest status on Wärtsilä's 2-stroke low pressure DF engine development?

Answer:

We have now completed the ‘Technology development’ phase and we have moved into the ‘Industrialization’ phase. The 6RT-flex50DF test-bed engine has started full scale gas operation. We are continuing to verify and further optimize the low pressure DF functionality and engine performance. Our documentation for the first engine types is being finalized and made available on our Shipyard Portal and Licensee Portal. Preparation for Class approval is an on-going process.

Question 16:

When will there be the first pilot installation and what is the market introduction scenario?

Answer:

We are currently in negotiations with prospective pilot installation customers, and we plan to close deals soon and anticipate a pilot engine on the sea during 2014. General ship designs can be drawn now and industrialization at licensees worldwide can progress as required.

The market introduction plan:

Wärtsilä RT-flex50DF	delivery in Q2 2014
Wärtsilä X72DF	delivery in Q1 2015
Wärtsilä X62DF	delivery in Q3 2015
Wärtsilä X82DF	delivery in Q1 2016

Question 17:

Will Wärtsilä offer retrofit solutions for existing engines to convert to the 2-stroke low pressure DF engine?

Answer:

Yes, the conversion of existing engines for DF operation will require modifications on the engine and could be completed during class dockings. The engine conversion will be in the magnitude of 20 to 25% of the engine cost. The gas supply system is the significant cost barrier to retrofitting any gas engine, as is the tank which is substantially bigger than the equivalent LFO bunker tank.

The plan is to expand the DF technology to the entire Wärtsilä 2-stroke engine portfolio. The priority will be on those engine types with the largest market potential and interest.

Want to know more?

Please contact us:

www.wartsila.com