Dual fuel engine development and design

Mika Ojutkangas
Senior Manager
Wärtsilä Ship Power
Merchant
Contents

- DF Technology
- The DF advantage
- News
- The "Tarbit" project
- Viking Line

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Dual-fuel engine - operating principle

Gas mode:
- Otto principle
- Low-pressure gas admission
- Pilot diesel injection

Diesel mode:
- Diesel principle
- Diesel injection
Wärtsilä Dual-Fuel Engine Portfolio

### Wärtsilä 20DF
- 6L20DF: 1.0 MW
- 8L20DF: 1.4 MW
- 9L20DF: 1.6 MW

### Wärtsilä 34DF
- 6L34DF: 2.7 MW
- 9L34DF: 4.0 MW
- 12V34DF: 5.4 MW
- 16V34DF: 7.2 MW
- 20V34DF: 9.0 MW

### Wärtsilä 50DF
- 6L50DF: 5.85 MW
- 8L50DF: 7.8 MW
- 9L50DF: 8.8 MW
- 12V50DF: 11.7 MW
- 16V50DF: 15.6 MW
- 18V50DF: 17.55 MW

Higher output for 60Hz / Main engines

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Dual-fuel engine characteristics

- High efficiency
- Low gas pressure
- Low emissions, due to:
  - High efficiency
  - Clean fuel
  - Lean burn combustion

- Fuel flexibility
  - Gas
  - LFO (DF)
  - Bio Fuel
  - HFO (TF)

- Double wall gas piping
  - The engine room is a gas safe area

- Three engine models
  - Wärtsilä 20DF
  - Wärtsilä 34DF
  - Wärtsilä 50DF
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DF Gas Trip (GAS -> MDO) on 100% load - instantaneous

No loss of power or speed at sudden transfer from gas to MDO (example 18V50DF, 17.1MW)
Main advantages of the Dual-Fuel 4-stroke engine compared to SG (spark ignited):

- **Simple mechanical propulsion application**
  - Full power available in both fuel operation modes
- **Load application capability**
  - Load application capability is equal between dual-fuel and SG
  - Dual-fuel can change to liquid fuel in case instant abnormal high load / unload requirement (no shut-down)
  - Changeover point can be programmed to suit application

→ **Improves safety**
The DF vessel concept

The DF engines provide safety and redundancy, inherent reliability of the diesel engine allows a simple installation

- Single gas tank and gas feed system allowed
- No duplicate (diesel) gensets for main propulsion
Emissions Reduction Future Pathway

Win + Win  Emissions & Cost Reduction

Best Available Technology

Mid Term

Both paths are not selected to the same vessel due to size and cost

Gas Engine

Traditional

SCR
PM Trap
Other

Long Term

Fuel Cell, New technology

Paradigm Shift:
Market moves to emissions reduction as key selection criterion away from historical efficiencies based on heavy fuel.
Marine Fuel for Emission Control Areas (ECA)?
The DF vessel concept

The DF engines will only use gas fuel inside ECA areas
Safety and reliability of the traditional diesel engine remain

No SOx Scrubber, No sulphur in fuel

No SCR unit, Tier III compliant

MDO as backup fuel
The DF vessel concept, outside ECA

The DF engines can be run on HFO outside ECA areas.

- No SOx Scrubber
- No SCR unit
- Optional HFO flexibility when allowed
The DF vessel concept, outside ECA

HFO can be used to
• extend range
• ensure availability of fuel
• improve total economy

Optional HFO flexibility when allowed
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A. Storage tanks
B. Evaporators
C. Dual-Fuel Main engine
D. Dual-Fuel Aux engines
E. Bunkering station(s)
F. Integrated control system

A complete and modularized solution for LNG fuelled ships
What is a gas valve unit?

- **The main functions of the GVU:**
  - Pressure regulation to the engine, according to engine load. One unit is required per engine.
  - Safety (block valves, filters, inerting and venting)

- **A GVU is located between the LNG storage system and the engine**
  - Max. recommended distance from engine is 10 m
Installations today

- Forced ventilation
- Single wall fuel gas pipe
- Double wall fuel gas pipe

- Engine room, gas safe area
- GVU room, Ex Zone 1

- Fuel Gas Tank
- Air in *
- Air out

* to double wall fuel gas feed pipe annular space
A separate GVU room add complexity and installation costs:

- Require dedicated compartment, including explosion duct from the room
- Lightning and other equipment has to be Ex Zone 1 compatible
- Airlock is required between GVU room and surrounding space
- Recommended maximum distance from GVU to engine 10 m, difficult to achieve in practice
Gas Valve Unit in enclosure

Main features

- Can be located in the same engine room still being compliant with IGC and (future) IGF codes.
- Integrated ventilation system when combined with LNGPac
- Compact design and easy installation
- Lower total investment cost compared to a conventional GVU installation
- Is delivered in a containerized form (plug-and-play concept)
Installation with GVU enclosure

- Forced ventilation
- Double wall fuel gas pipe
- Gas safe area
- Enclosure

Saved space:
- GVU room
- Airlock between the GVU room and the engine room

Savings:
- Less Ex certified equipment
- Easy installation at yard, ready module

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TARBIT PROJECT

Vessel delivery date 17.09.2007
Vessel typology 25'000 dwt Chemical tanker
Owner Tarbit Shipping AB
Ship Builder Shanghai Edward Shipbuilding Co Ltd
Flag Sweden
Class Germanischer Lloyd

DWT 24783 ton
GT 17757 ton
Displacement 33788 ton
Length p.p. 166.99 m
Length o.a. 177.02 m
Keel To Mast Height 44.85 m
Draught 9.7 m
Breadth Extreme 26.3 m
Breadth Moulded 26 m
Speed 16 kn
Main facts

Vessel owned by Tarbit Shipping AB (Sweden)

Operated under time charterer by Statoil

Sailing in Norwegian waters

Conversion partially financed by Norwegian
“Næringslivets Hovedorganisasjon” (Confederation of Norwegian Business and Industry)

Designed by Wärtsilä Ship Design
(former Skipskonsulent )

Built by Edward Shipbuilding Co Ltd (Hudong-Zhong JV)
Main engine conversion

**TODAY**
2 x W6L46B
5850 kW each

**Tomorrow**
2 x 6LW50DF
5700 kW each
Many different “firsts”

- First Dual-Fuel engine marine conversion
- First Dual-Fuel engine in Mechanical drive application
- First Gas Valve Unit in enclosure
- First LNGPac delivered by Wärtsilä
- First Dual-Fuel “single main engine” approval
- First Dual-Fuel marine conversion
- First Dual-Fuel “single main engine” approval

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Scope of conversion

Scope of supply
- Ship Design
- Engine conversion
- Gas tanks; LNGPac system (2 x 500m³)
- Gas piping (single and double walled)
- Bunkering system
- Gas supply units
- Torque meter for power measurement
- Exhaust system
- Fire-fighting upgrade
- Gas detection system
- Electrical system

Additional
- NOₓ measurement during sea trial
- DF and LNGPac training for personnel
Placement of equipment

LNG tanks
Placement of equipment

- LNG tanks
- NG pipes
- Water/Glycol
- "Cold box"
Placement of equipment
Placement of equipment
## References

Sold engine *conversions* worldwide

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Country</th>
<th>Year</th>
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The industry's most environmentally sound and energy efficient large passenger vessel to date.

- **Main particulars:**
  - Overall length: 214.0 m
  - Breadth, moulded: 31.8 m
  - Cruising speed: 22 knots
  - Passengers: 2800
  - Class: LR
  - Ice class: 1A
  - In service: 2013
  - Shipyards: STX Finland Oy
  - Ship Owner: Viking Line
Wärtsilä integrated scope of supply:
Main Engines: 4 x Wärtsilä 8L50DF (DE)
Total output: 4 x 7600 kW
GVU in enclosure
Natural gas is the most environmentally sound fuel today and with Wärtsilä's dual fuel engines this ferry will be able to sail without restrictions in SECA’s and NECA’s.

LNGPac 200 2 x 200 m³
Integrated tank – and aux. rooms
Bunkering system, Safety systems
Cold recovery for HVAC
The cold recovery system brings operational savings and overall increased vessel efficiency.
Wärtsilä integrated scope of supply:
- FPP (Stainless Steel) 2 x 10 500 kW
- Shaft lines, Seals & Bearings
- Bow Thruster 2 x 2 300 kW
- Stern Thruster 1 x 1 500 kW

The propellers are designed with the lowest possible pressure impulses for superb vibration control.

Compact Silencer System (CSS)
Silent operation is important for passenger comfort, but also for the sailing route; through the islands of the Turku and Stockholm archipelagos.
**Dual-Fuel engines - References**

- **Power plant**
  - 28 installations
  - 84 engines
  - >640,000 running hours

- **LNG carriers**
  - >68 installations
  - 254 engines
  - >900,000 running hours

- **OSV - FPSO**
  - 8 installations
  - 28 engines
  - >226,000 running hours

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Summary

Wärtsilä DF technology benefits

✓ Simple installation due to inherent redundancy;
  No need to install separate backup power.
  Possible to use a single gas tank on small vessels.

✓ Saved space, time and money with enclosed gas valve unit;
  No separate GVU room needed.

✓ Market leading, proven technology.
Leading gas applications in the marine market

Mika Ojutkangas
mika.ojutkangas@wartsila.com