Surveyor's day Gard/Norwegian Hull Club

Bergen

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MAN ME-dual fuel engines
First ME-GI order, TOTE 3,100 TEU container carrier

- First ME-GI ordered on Dec. 2012
- 3,100 TEU LNG Powered container
- MAN B&W 8L70ME-C8.2-GI
- 2014, Q1: ME-GI engine delivery
- 2015, Q4(Nov.): First ship delivery
# MAN ME-dual fuel engines

**Ordered**

## Dual Fuel Engines Overview

<table>
<thead>
<tr>
<th>No. of engines</th>
<th>Type</th>
<th>Mk.</th>
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<tr>
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<td>ME-C-GI</td>
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<td>Methane</td>
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<td>Methanol</td>
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<td>Ethane</td>
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<tr>
<td>3</td>
<td>ME-C-GIE</td>
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</table>

**Total dual fuel engines including options:** 161 engines

**Total power main engine:** 2.9 GW

**Total dual fuel engines in service:** 6 engines
MAN ME-dual fuel engines
Limitation of NOx Emission

Tier I: (global)
- 20%

Tier II: 2011 (global)
- 80%

Tier III: 2016 (ECA's)
MAN ME-dual fuel engines
ECA: Emission Control Areas

Source: DNV (http://www.dnv.com/resources/reports/greener_shipping_north_america.asp)
MAN ME-dual fuel engines
Conventional MAN B&W two-stroke technology

ME-GI is a two-stroke Diesel engine

Mr. Diesel’s Process
(High Pressure Injection)
- Fuel in cylinder before gas
- Diesel process maintained
- Power remain the same
- Load response unchanged
- No pre-ignition / no knocking
- Insensitive to gas mixture
- Negligible methane slip
- High-pressure gas injection
- NO\textsubscript{x} reduction to Tier III level by EGR and / or SCR
- ME can be retrofit to ME-GI.

Mr. Otto’s Process
(Low pressure Injection)
- Gas in cylinder before fuel
- Otto process gas-air pre-mix
- **Power reduction** required due to
- **Pre-ignition / knocking** risk
- **Load ramp** needed
- **Gas mixture** important
- **Methane slip** significant
- High-pressure gas injection
- Low-pressure gas injection
- Lower NO\textsubscript{x} due to **low efficiency**.
- Can **only** be retrofit if **excess capacity** is installed initially (20% larger engine, 20% greater fuel tanks, etc)
All low-pressure dual-fuel & gas engines have methane slip

Methane slip is unburned CH₄ which is not participating the combustion in gas engines

Methane is non-toxic

Methane as GHG is 20-25 times more harmful than CO₂

No limitations regarding Methane slip exist in marine applications

Minimizing Methane slip is a major target to improve engine efficiency
One main advantage of the ME-GI engine is its fuel flexibility. The control concept comprises three different fuel modes.

- Gas operation with minimum pilot oil amount
- Specified dual fuel operation (SDF) with injection of a fixed gas amount
- Fuel-oil-only mode
MAN ME-dual fuel engines
Overview of S70ME-GI
MAN ME-dual fuel engines
ME-GI vs ME engine design

- Gas injection valve
- Gas control block
MAN ME-dual fuel engines
ME-GI vs. ME-LGI

The main difference between ME-GI and ME-LGI is the gas injection and gas supply system

**ME-GI:**
- High pressure supply system
- Common rail type injection
- Necessary injection pressure 300bar (Methane) - 600 bar Ethane
- Fuel types: Methane, Ethane

**ME-LGI:**
- Low pressure supply system
- ME type injection, i.e. concept similar to conventional HFO injectors
- Necessary injection pressure 500 – 600 bar
- Fuel types: Methanol, Ethanol, LPG, DME
MAN ME-dual fuel engines
Available for different Low Flashpoint Liquid (LFL) fuels

Facts:

• All ME-C/B engines available in the GI and LGI version

• Dual fuel engine

• Same reliability as the ME-C/B engines

• Same power output as the ME-C/B engines

• Engine efficiency 50% or higher
The overall focus in the development of the dual fuel system concept has been personal safety. Secondly, it has been important to sustain engine reliability.

1. Gas safe engine room
2. A single failure result in gas shut down or gas stop
3. The gas system must not affect the engine running on MDO/HFO
4. The gas system is an add on to the ME engine
5. Control and safety functionalities are separated on different hardware units
6. Window valve with interlock to gas injection valves
1. **Gas safe engine room**

All gas components inside engine room are encapsulated and the duct is vented by a suction fan. HC sensors at the air outlet detects gas leakages and if the gas concentration becomes too high (<60LEL%) a gas shut down is released.
MAN ME-dual fuel engines

Why ME-GI? - Maximum engine room safety

- Double wall pipe with ventilation system and inert gas system.
2. A single failure result in gas shutdown or gas stop

For safety reasons a detected single failure on a safety unit results in gas shutdown while a detected single failure on a control unit results in gas stop

- Gas Shutdown: Immediately stop of gas injection - continued operation on fuel oil, handled by gas safety system (Followed by a gas blow off and inert gas purging sequence)

- Gas Stop: Normal changeover from gas mode to fuel oil mode - continued operation on fuel oil, handled by gas control system (Followed by a gas blow off and a inert gas purging sequence)
3. The gas system must not affect the engine running on MDO/HFO

In case of gas shutdown the gas injection is stopped immediately and the engine continues almost bump less on fuel without load reduction.

In case of gas stop the gas injection is ramped down to minimum gas injection and then gas injection is stopped. Engine speed and load is maintained all the time during the changeover to fuel running.
MAN ME-dual fuel engines
Design philosophy – the gas system is an add on

4. The gas system is an add on to the ME engine

- EICU: Engine interface control unit
- ECU: Engine control unit
- ACU: Auxiliary control unit
- CCU: Cylinder control unit
- SPCU: Second fuel plant control unit
- SACU: Second fuel auxiliary control unit
- SPSU: Second fuel plant safety unit
- SCU: Second fuel cylinder safety unit
5. **Control and safety functionalities are separated on different hardware units**

Some essential process information is monitored by having two sensors. One sensor is monitored by a control unit and the other sensor by a safety unit. Both sensors have to be operative to continue running on gas.

If the sensor send to the safety unit is failing a gas shutdown is carried out and if the sensor send to the control unit fails a normal gas stop is carried out.

The gas injection is controlled from a control unit and the window valve is controlled from a safety unit.
MAN ME-dual fuel engines
Design philosophy – control and safety is monitored separately
6. Window valve with interlock to gas injection valves

In case of a leaking gas injection valve it is necessary to have a window valve close to the gas injection valves in order to prevent a large gas leakage into the combustion chamber. This valve is also used to avoid mistiming of the gas injection during gas running. The valve is in the following referred to as the window valve.

The amount of gas between the window valve and the gas injection valves is limited, by mounting the gas block on the cylinder top cover, so that it will do no harm to the engine in case of a leaking gas injection valve.

The gas pressure in between the window valve and the gas injection valves are monitored in order to detect a leaking gas injection valve or a leaking window valve.
MAN ME-dual fuel engines
Dual fuel operation
MAN ME-dual fuel engines
Maximum engine room safety

- Negligible gas slip from combustion chamber to crankcase or exhaust receiver
- No accumulation of unburned gas
- No knocking
Interlocked Gas Injection Sequence: Before gas injection
MAN ME-dual fuel engines
Window valve opens

Interlocked Gas Injection Sequence: Window opens
Interlocked Gas Injection Sequence: Gas injection
MAN ME-dual fuel engines
Gas injection ends

Interlocked gas injection sequence: Gas injection ends
MAN ME-dual fuel engines
Window valve closes
MAN ME-dual fuel engines
Window valve with interlock to gas injection valves
The ME-GI engine requires fuel gas at a load dependant pressure (max. 315 bar) and a temperature of 45 ±10°C. On the above, a cryogenic high pressure pump is used to generate the 250 – 300 bar pressure. After pressurization, the LNG is vaporized and burned in the engine. However different application can call for different gas supply systems, and a number of projects have shown that operators and ship-owners demand alternative solutions. Therefore, MDT aims to have a number of different gas supply systems prepared, tested and available.

The temperature (of 45 ±10°C) is specified with regards to the following parameters:
- To reduce condensation on the outer wall of the inner pipe for double wall piping
- In order that the performance of the engine is not adversely affected
- To reduce thermal loads on the gas piping itself
- To obtain a uniform gas density
After running in the gas mode, the gas system is being vented and depressurized to atmospheric pressure, the system can be purged with inert gas. In order to clean the system for gas, an inert gas pressure of 7-9 bar is required.
The purpose of the ventilation system is to ensure that the outer pipe of the double-wall gas pipe system is ventilated with air, and to act as a partition between the engine room and the high-pressure gas system.
The sealing oil system supplies oil to the gas injection valve, in order to provide a sealing between the gas and the control oil, and to lubricate the moving parts.
The opening of the fuel valves is controlled by the high pressure fuel oil created by the fuel oil pressure booster, and the valves are closed by a spring. The opening of the gas valves is controlled by the ELGI valve, which is operates on hydraulic oil from hydraulic power supply.
Gas control Consists of three parts:
- Dual fuel injection control: ECU, CCU
- Second fuel plant control: SPCU, SACU
- Second fuel safety control: SPSU, SCSU
The ME-LGI engine is a dual fuel engine
- Diesel combustion process
- High efficiency

Main injection
Pilot injection
MAN ME-dual fuel engines
ME-LGI Fuel Injection Arrangement
MAN ME-dual fuel engines
ME-LGI – injection system components
MAN ME-dual fuel engines
ME-LGI – injection system components
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ME-LGI – injection system components
MAN ME-dual fuel engines
FIV – Injection principle with Methanol (MeOH)

**Principle**

- **Hydraulic oil in from external control valve**
- **MeOH fuel valve**
- **MeOH boosting & injection**
- **MeOH suction**
- **MeOH 8 bar supply pressure**
- **Hydraulic oil out**
- **Slide valve**
- **Ready**
MAN ME-dual fuel engines
Recommendation for assembling

Accumulator

LGI Fuel block

Gas Double wall pipe, Inlet

Gas Double wall pipe, Outlet

Methanol Fuel Boster injection valve

Control oil high pressure pipe

Gas control block

Purge control block

Steel block
MAN ME-dual fuel engines
Principle flow and arrangement for Methanol

- Air supply 7 bar
- Fuel valve train
- LFSS – Low flashpoint Fuel Supply System
- Fuel service tank
- Purging nitrogen
- Fuel cargo tank (optional)
- MeOH supply pressure: 10 bar
- Supply pressure and temperature according to specification
- Standard piping
- Double-walled piping, ventilated
- Cooling oil system
- Purge return system
- Vent
Thank you very much for your attention