ME-GI Mk. 2
The continuous development of ME-GI
Agenda

1. General about ME-GI
2. ME-GI Mk.2 – Sequences of operation
3. Boil-off gas handling in non-LNG carriers and case study
4. Development of ME-GA
ME-GI Concept
Combustion Concept

1. From actual footage (colorized)
   - Yellow = pilot oil
   - Blue = gas fuel

2. Conventional slide fuel valve
3. Gas fuel valve
4. Gas distribution channel (yellow)
5. Gas distributor block
6. Gas chain link double-walled pipes
ME-GI Concept
Gas and Oil pilot injection

- ME-GI engine is operating according to Diesel combustion principle
- Pilot oil is injected around top dead cylinder. Shortly after gas (300 bar injection pressure) is also injected – concept ensures no unburnt gas
- Engine Control Software is constantly monitoring a number of parameters to ensure safe operation
- Supervision of double wall piping ventilation is provided to maximize safety
- Technology with highest thermodynamic efficiency
- Highest rate of safety
The diesel cycle
Fully stable combustion under all weather condition.

Heavy weather condition:
- Full operational in gas mode
- No risk of knocking or misfiring
- High efficiency without methane slip is maintained

Higher ambient temperature:
- Full operational in gas mode
- No risk of knocking or misfiring
- High efficiency without methane slip is maintained

Diesel cycle superior performance and efficiency compared to market’s competition!
LF fuel supply

- HP compressor
- HP pump
- Gas Valve Train
- Nitrogen System
- Silencer and vent masts
- Double wall piping, installation and ventilation system
- MAN B&W ME-GI Engine
Double Wall Piping

Double wall fans

Dry air system

HC detection

NOTE 1 Size of orifice to be determined during commissioning to ensure correct ventilation flow with completely closed valve 545. For details please refer to separate specification no. 99.31436-1.

NOTE 2 Air flow to be adjusted during commissioning to ensure slight overflow of dry air. See starting air diagram no. 99.31777-6 for pressure regulator and flow nozzle installation.

NOTE 3 Air intake to be designed according to separate specification no. 97.81299-1.

NOTE 4 Ventilation outlet and air overflow to be arranged according to yard standard for avoiding sea water ingress. The ventilation outlet and overflow constitute a hazardous zone and must be placed outside otherwise hazardous zones according to applicable class rules.

NOTE 5 Threaded branch fitting for measurement purposes. Female G3/4” thread according to ISO 228/1. Must be placed centered of maximum a 50 x 50 straight pipe run and plug to be installed during low-loadpoint fuel operation. Boss and plug assembly must be designed for outer pipes through pressure.

NOTE 6 Double walled piping to be equipped with inspection boxes according to separate specification no. 97.81263-1.
ME-GI MK.2
Sequences of operation
The project at a glance

The Project Objectives

**Optimizing of FGSS:**
- Introduction of ME-GI PVU
- Cost efficient
- Embedded redundancy
- Engine control and hydraulic integration

**Cost reduction of BOG compressor:**
- Cost down
- Alternative solutions

**Optimizing of GVT:**
- Simplified and optimized GVT design
- Reduced components
- Dedicated GVT developed for ME-GI Mk.2

**Minimizing installation:**
- Removal of return double wall pipe
- Simplification of pipe installations

**Improved operation and reduction of components:**
- Reduced pilot consumption from 3% to 1.5% (0.5% for G70)
- New pilot injection valve (PIV)
- Optimized gas block
- Removal of return chain pipe / Helix pipe
- Gas cylinder cut-out

- Gas inlet
- Blow off
- Double wall pipe reduction

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**2017**

**2019**

**Ready**
ME-GI Pump Vaporizer Unit (PVU)

- Standardized low-cost solution
- Embedded redundancy (3 x 50%)
- ME-GI software integration
- Compact design – small footprint and low weight
- Robust cold-ends
Optimized Engine Performance
ME-GI Mk.2 – Cylinder Cut Out (CCO)

ME-GI Mk.1

- Gas to the engine
- GVT
- Stop gas operation on engine

ME-GI Mk.2

- Gas to the engine
- GVT
- Continue gas operation

STOP Gas to the engine

Benaki Museum – Dual Fuel Engines Seminar
23/10/2019
Optimized Engine Installation

ME-GI Mk.2 – Chain Pipe / Helix Pipe

- New gas block with modular design.
- Removal of Chain Pipes and Helix Pipe
- New cover design (bore design)
- New Nitrogen Block

Removal of double-wall return piping

Removal of hydraulic activation piping

Optimized gas accumulators (reduced size)
Optimized Engine Performance

ME-GI Mk.2 - Optimized engine components - PIV

- Reduction of pilot oil for ME-GI Mk. 2 from 3% to 1.5% (0.5% for G70)
- Economical advantages – environmental benefits

Pilot oil consumption at L1 rating point

- 3% pilot oil
- 1.5% pilot oil
- 0.5% pilot oil

225/300 bar activating low injection valve lift

Thrust piece lift 0 or 1.6 mm

Injection valve lift 2.8 or 1.2 mm

2.8 mm lift:

1.2 mm lift: Reduced for pilot injection

Only small atomiser holes open for pilot injection
The new MAN B&W ME-GI MK2 design
The new MAN B&W ME-GI MK2 design

1 Ready to start LNG operation (Similar to ME-GI MK.1)
The new MAN B&W ME-GI MK2 design

Opening Valve 801 - LNG operation (Similar to ME-GI MK.1)
The new MAN B&W ME-GI MK2 design

Double block & bleed tightness check - LNG operation (Similar to ME-GI MK.1)
The new MAN B&W ME-GI MK2 design

Pressure build up - LNG operation (Similar to ME-GI MK.1)
The new MAN B&W ME-GI MK2 design

Engine running - LNG operation (Similar to ME-GI MK.1)
The new MAN B&W ME-GI MK2 design

Gas blow-off - LNG operation (Similar to ME-GI MK.1)
The new MAN B&W ME-GI MK2 design

Gas blow-off - LNG operation (Similar to ME-GI MK.1)
The new MAN B&W ME-GI MK2 design

1. Dilution Purging – N2 pressure build up to valve 818/819
The new MAN B&W ME-GI MK2 design

2 Dilution Purging – N2 pressure released through valve 818/819
The new MAN B&W ME-GI MK2 design

Dilution Purging – N2 pressure build up to valve 818/819
The new MAN B&W ME-GI MK2 design

4 Dilution Purging – N2 pressure released through valve 818/819
The new MAN B&W ME-GI MK2 design

The previous pressurization and release steps of N2 in the gas system is to be performed min. 4 times.
The new MAN B&W ME-GI MK2 design

Sequence:
When the nitrogen pressure in the gas system reaches 5 barg, the nitrogen supply will be closed off. Valves 818 and 819 in the GVT will open venting the mixture of nitrogen and methane.

Purging step 4 and step 5 will be performed a number of consecutive times (min. 4 times) in order to dilute the methane concentration down to a safe level (below 30% LEL).

The previous pressurization and release steps of N2 in the gas system is to be performed min. 4 times.
Boil-off gas handling in non-LNG carriers and case study
BOG handling for non-carriers

Boil-off gas handled by gensets
BOG handling for non-carriers

High Pressure compressor
BOG handling for non-carriers

Re-liquefaction by sub-cooling
Options of engine selection

Layout diagrams / 12,000 TEU container vessel (36,000 kW at 80 RPM)

Possible to meet SMCR requirements with 2 cylinders less

SMCR requirements by major design institute

MAN Energy Solutions

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Global Warming Potential

Calculation for 250 operating days, engine running at NCR point

Methane conversion to CO2 equivalent with a factor of 28 (GWP100=28)

Approximately 15.7% lower GHG footprint for ME-GI engine technology
Future in the making…

- The LNGC market segment has shown a strong interest in dual fuel gas engines operating according to pre-mixed combustion principle, where first costs are prioritized over operating costs.

- As the world’s leading engine designer, MAN ES is committed to develop new technologies in demand by the market and our customers.

- As an addition to our ME-GI and ME-LGI engine program, MAN ES has, therefore, developed a pre-mixed dual fuel engine.

- The new dual fuel engine is named ME-GA with gas admission valves placed on the cylinder liner.

- The ME-GA dual fuel engine will not jeopardize MAN ES’ continued effort to develop and optimize our successful ME-GI technology.
ME-GA

ME-GA Engine Development

Project background
LNGC: ME-GI engine → Higher CAPEX for auxiliary system
Market request for alternative solution

Goal
MAN ES wants to offers two (2) solutions for owners’ selection:
ME-GA engine focusing on competitive system CAPEX and OPEX.
ME-GI remains to be a competitive solution with low OPEX and low greenhouse gas emissions.

Project timeline
Delivery of commercial ME-GA engines from end 2021.
Pre-mixed Engine Concept

Advantages
- Low CAPEX due to low gas supply pressure (<16 bar)
- For LNGCs the BOG compressor of piston type is avoided
- Pre-mixed combustion → Lower NOₓ
- TIER III compliant in gas mode

Challenges in the development
- Narrow operating window necessary to avoid pre-ignition, knocking limits and misfire
- Reduced compression ratio, MEP and thermal efficiency
- Gas quality limitations (Methane number)
- Methane slip increased
ME-GA

Project Timeline

- **Project initiation**
  - 2017
  - Project start
  - Pre-study

- **Concept development**
  - 2018
  - Concept verification
  - Project announcement

- **Concept verification**
  - 2019
  - Confirmation of progress and timeline

- **Commercial design**
  - 2020
  - Available in engine program

- **Continuous development**
  - 2021
  - Confirmation of commercial design
  - Commercial drawings completed

- **2022**
  - Delivery of 1st commercial engine

**Timeline Details:**
- **23/10/2019 Dual Fuel Event @ Benaki**
ME-GA
Project Scope

Development focus:

− Safe and reliable concept
− Competitiveness of the concept by ensuring attractive combination of:
  − CAPEX including the auxiliary system
  − OPEX, i.e. consumption of gas, pilot, etc.
− Cost attractive solution for TIER III compliance
− Development in close collaboration with leading engine builders and ship yards

Single cylinder test unit
ME-GA

Engine Specification: Targeted at LNGC

Focus on first cost of engine, FGSS and Tier III compliance

- Engine costs similar to ME-GI
- Tier III compliant in gas mode
- Equivalent to other pre-mixed two-stroke gas engines:
  - Auxiliary system costs
  - Methane slip
  - Gas and pilot oil consumption
ME-GA

Summary

Market demands within the LNGC segment initiated the development of ME-GA

The ME-GA engine will be a new, attractive add-on to our existing engine program

The development work is on track with test activities starting summer 2019

The ME-GI remains a strong pillar in our engine portfolio
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 Depending on the subsequent specific individual projects, the relevant data may be subject to changes and
 will be assessed and determined individually for each project. This will depend on the particular characteristics
 of each individual project, especially specific site and operational conditions.
Thank you very much!