Fuel gas system - ME-GA engine

The ME-GA engine is a dual-fuel engine based on a pre-mixed gas principle. The engine combusts a fuel-air mixture ignited by pilot oil in dual-fuel mode. The fuel gas admission on the engine is described in the present Section 7.00.

In this project guide, second fuel or fuel gas is the denomination for methane.

A fuel gas supply system (FGSS) delivers low-pressure gas to the fuel gas admission system on the engine.

The ME-GA engine has two fuel oil injection systems, a main system and a separate pilot oil system. The main system is comparable to the system used for engines combusting fuel-oil only.

The fuel oil and pilot oil systems are described in Section 7.01, the FGSS and auxiliary systems in Sections 7.07 - 7.09.

The ME-GA specific engine parts

The fuel gas admission system on the engine contains a gas regulating unit (GRU), optimised gas piping arrangement and safe gas admission valves (SGAV) in each cylinder. The SGAVs are located in the cylinder liner.

Each SGAV contains a window valve, which is activated by a solenoid valve, and a gas admission valve (GAV), also operated by its own solenoid valve.

The fuel gas accumulator volume is provided in the fuel gas piping.

The ME-GA engine is equipped with a dedicated pilot valve, the micro booster injection valve (MBIV).

Sealing oil is supplied to the window/shutdown valve and SGAV to separate the control oil and the fuel gas.

Apart from these systems on the engine, the engine auxiliaries will comprise some new units, the most important ones being:

- If the fuel gas supply is natural gas (NG), it requires a cryogenic compressor, including a cooler, to supply the required engine inlet pressure in the range of 5.5-12 barg, depending on engine load and rating.
- If the fuel gas supply is liquefied natural gas (LNG), it requires a cryogenic pump and vaporiser solution
- ME-GA engine control system (ME-ECS)
- Leakage detection and ventilation system
- Flow switches
- Gas valve unit (GVU) with a double block and bleed function
- Gas regulating unit (GRU), which enables depressurisation of the system without an expensive dedicated blow-off piping. The engine-mounted design gives a fast-reacting fuel gas pressure control.
- Heat traced and insulated fuel gas supply pipes
- Inert gas system for purging the fuel gas supply system, and the gas system on the engine, with inert gas
- Purge block mounted on the engine, which enables purging without a dedicated blow-off piping

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Fuel gas piping on the engine

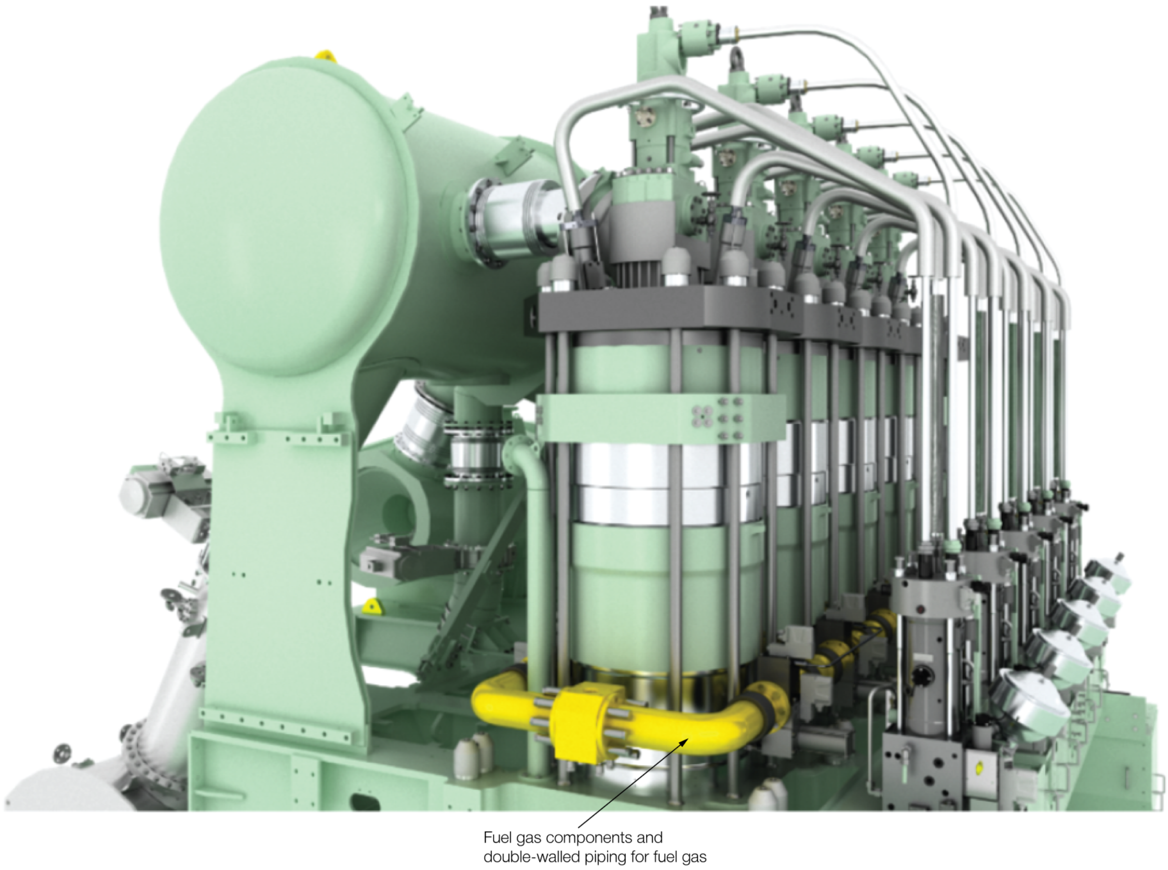

Fig. 7.00.01: Layout of the double-walled piping system for fuel gas

The layout of the double-walled piping system for fuel gas is shown in Fig. 7.00.01. The fuel gas from the compressor unit, or the cryogenic pumps and vaporiser, passes through the main pipe, the GVU and the GRU, before it is distributed to the SGAVs on each cylinder.

The piping design includes gas pipes with bellows that has two important functions:

- Separate the cylinder units from each other, in terms of gas dynamics, due to the application of the well-proven design philosophy from the ME engine fuel oil system.
- Act as flexible connections between engine structures, and safeguard against extra stress in the fuel gas supply pipes caused by the inevitable differences in thermal expansion of the gas pipe system and the engine structure.

Fuel admission system on the ME-GA engine

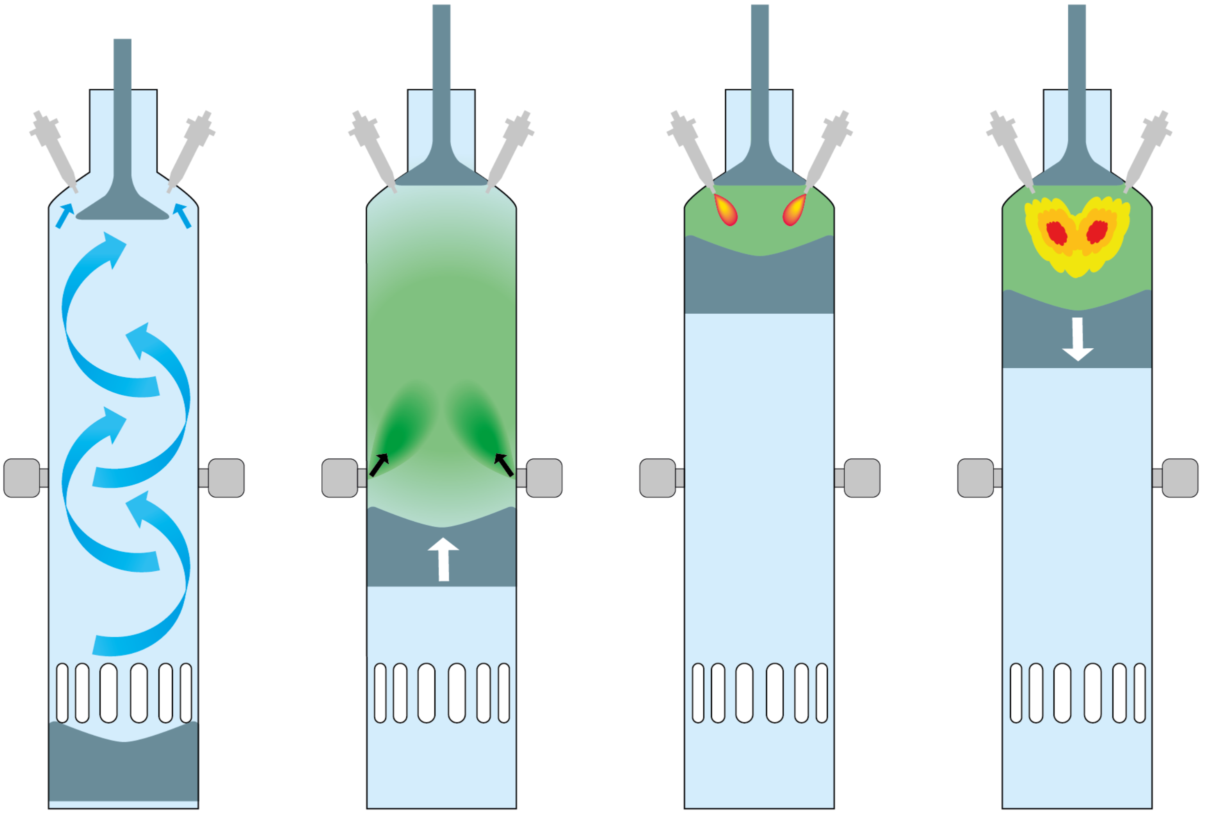

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Fig. 7.00.02a: Fuel gas admission and combustion for the ME-GA engine

Low-pressure fuel gas is supplied to the GVU at approximately 13 bar. The GVU design is similar to the GVT design for the ME-GI engine, but adapted to the lower fuel gas pressure. The ME-ECS controls all functions of the GVU.

From the GVU, the fuel gas is led via double-walled pipes, where applicable, to the GRU mounted on the engine.

From the GRU, the fuel gas is passed on to the SGAVs, see Fig. 7.00.02a. The SGAV is controlled by the control oil system, which, in principle, consists of the ME hydraulic control oil system and an electronic gas admission valve (ELGA). The ELGA valve controls the timing of the fuel gas admission by admitting high-pressure control oil to the SGAV to open it.

In the fuel supply system, the micro booster injection valve (MBIV) pressurises the pilot oil during dual-fuel operation.

In the ME-ECS it is possible to operate the engine in various modes: Dual-fuel mode with minimum pilot oil amount and the fuel-oil-only mode.

Pilot oil injection amount versus engine load

Dual-fuel operation is possible down to 5% engine load.

The minimum pilot oil amount in dual-fuel mode is 0.5% at MCR (in L1), see Fig. 7.00.02b. If the engine is derated, the pilot amount is relatively higher as calculated in CEAS, see Section 20.02.

The engine output with minimum pilot oil amount can be obtained even with an LCV of the fuel gas as low as 38 MJ/kg. Below 38 MJ/kg, a higher pilot oil amount might be required.

The guaranteed specific gas consumption (SGC) on test bed requires an LCV of minimum 50 MJ/kg with a tolerance of -7%.

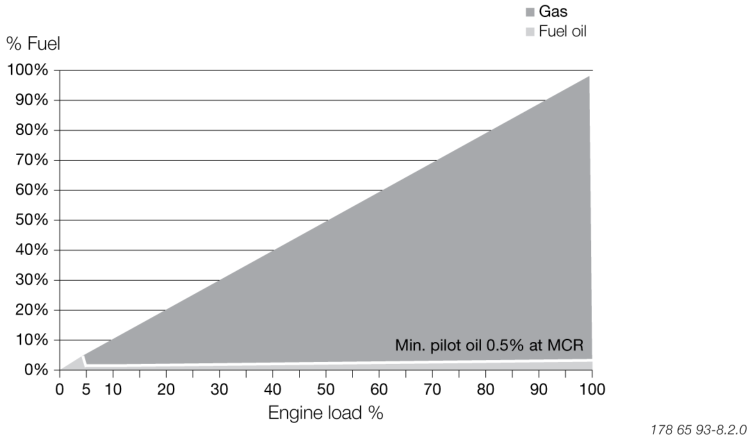

Fig. 7.00.02b: Dual-fuel operation and pilot oil amount

Condition of the fuel gas delivery to the engine

The following data is based on natural gas as the fuel gas.

Pressure

Operating pressure	See Fig. 7.07.04
Safety relief valve	16 barg
Pulsation limit	+0.6 bar

Flow

The maximum flow requirement is specified at 100% SMCR, depending on the pressure, see Fig. 7.07.04.

Maximum / minimum requirement	Refer to (*
Minimum flow requirement in standby	0 kg/h

The maximum flow requirement must also be achievable close to the overhaul interval of the FGSS.

In case of a specific LCV requirement, please inform MAN Energy Solutions. Under certain circumstances, modification of the SGAV may be required to accommodate fuel gas with a different LCV.

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(* 'List of Capacities', or CEAS report

Temperature

Temp. inlet to engine	5 to 55°C
Shut down	0°C

The specified engine inlet temperature takes into account the following:

- reduces condensation on the outer wall of the inner pipe of the double-walled piping
- the performance of the engine is not adversely affected
- reduces thermal loads on the gas piping itself
- provides uniform gas density
- the gas temperature during blow-off will still be within the temperature limits of the materials selected for piping and components

Guiding fuel gas specification

Designation	Unit	Limit	Value	Test method reference *) (Latest edition to be applied)
Net calorific value (NCV)	MJ/Nm^3	Min.	27	ISO 6976 (or GPA 2172)
Net calorific value (NCV)	MJ/Nm^3	Mix.	41	ISO 6976 (or GPA 2172)
Methane number (MN)	No unit	Min.	64 for 100% engine power 60 for 85% engine power	EN 16726 or Propane Knock Index PKI. The applied test method shall be given as MN (PKI) or MN (EN 16726).
Methane (CH_4)	% (mol)	Min.	70	ISO 6974-3 (all parts)
Hydrogen sulphide (H_2S)	mg/Nm^3	Max.	5	ISO 19739
Water	mg/m^3	Max.	0.7	ISO 10101
Gas cleanliness	-	-	Liquid or solid contaminants must be removed from the LNG. See text.	
Ethane (C_2H_6)	% (mol)	-	report	ISO 6974 (all parts)
Propane (C_3H_8)	% (mol)	-	report	ISO 6974 (all parts)
n-Butane (C_4H_{10}) i-Butane	% (mol)	-	report	ISO 6974 (all parts)

Pentane (C_5H_{12}) and higher	% (mol)	-	report	ISO 6974 (all parts)
Nitrogen (N_2)	% (mol)	-	report	ISO 6974 (all parts)
Density (at temperature of the liquid phase)	kg/m^3	-	report8	ISO 6578

*) ISO standards methods are the highest level of international methods and are therefore recommended. Equivalent methods from ASTM, GPA and IP can also be used. It is recommended to consistently use methods from one of the standard organisations, for example ISO or GPA.

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Table 7.00.01: Guiding fuel gas specification

Natural gas (NG) is a hydrocarbon gas mixture consisting primarily of methane (CH_4) and higher hydrocarbons like ethane and propane. The composition of NG is varying worldwide. ME-GA engines are able to operate on a wide range of gas qualities.

The values in the guiding fuel gas specification, Table 7.00.01, refer to the hydrocarbon mixture as delivered to the ship. It is assumed that the gas has undergone a liquefaction process at some point before being bunkered.

Liquefied natural gas

Liquefied natural gas (LNG) has been cooled down to −162 °C. Due to the requirements of the liquefaction process, the composition of the hydrocarbon mixture will be within rather narrow limits. More importantly, impurities such as water (H_2O), ammonia (NH_3) chloride (Cl), fluorine (F) and carbon dioxide (CO_2) are removed to the extent possible. Higher-order hydrocarbons are also removed.

Influence of boil-off gas from fuel gas tanks

LNG in the ships' tanks will change composition and properties over time. This is due to the unavoidable heat-influx from the surroundings, which will cause vaporisation of lighter compounds, like nitrogen (N_2) and methane. This process is called ageing and the gas produced is referred to as boil-off gas (BOG). BOG contains a higher amount of nitrogen compared to the LNG bunkered.

The remaining LNG will have an increased percentage of higher hydrocarbons. The composition of the LNG bunkered will, hence, not necessarily be the same as the composition of the fuel gas delivered to the engine.

Please contact your MAN Energy Solutions two-stroke representative for more information.

Fuel gas bunkering

Liquid or solid contaminants such as metal shavings, welding debris, insulation (i.e. perlite), sand, wood, cloth and oil must be removed from the LNG. It is generally considered as good engineering and operating practice to have LNG cargo strainers in the loading and discharge lines in order to minimise particulate contamination of the LNG and subsequent tanks and equipment.

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It is recommended that the filter is controlled by a surveyor after the bunkering to establish the contamination degree. It is important to note that the quality and impurity degree can vary among the suppliers due to production and handling differences and the type of bunkering/transfer process (for example: terminal tank to vessel, truck to vessel, vessel to vessel, portable tank transfer).

MAN Energy Solutions strongly recommends installing filters in the bunkering line and a filtration setup might be included in the FGSS, see Section 7.07.

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Sealing oil system

The sealing oil system is a pressurised hydraulic oil system with a constant differential pressure, approximately 3 bar higher than the fuel gas pressure, which prevents fuel gas from entering the hydraulic oil system.

The sealing oil is applied to the SGAV and the window/shutdown valve in the space between the gas on one side and the hydraulic oil on the other side. The sealing oil pump unit is connected to the SGAV and the window/shutdown valve with double-walled pipes.

The sealing oil system consists of a reduction station, which reduces the ME-C servo hydraulic oil pressure to the sealing oil pressure. The sealing oil system is installed on the engine.

The consumption of sealing oil is small, as calculated in CEAS, see Section 20.02. The sealing oil will be injected with the fuel gas into the combustion chamber.