# Fuel gas system - ME-GI engine

## General

The dual fuel system of the ME-GI engine combines the regular ME/ME-B fuel system when running in fuel oil modes and the fuel gas system running in dual fuel mode.

The ME/ME-B fuel system is described in Section 7.01, the fuel gas system on the engine is described here in 7.00 and the gas supply and auxiliary systems in Sections 7.07 - 7.09.

## The ME-GI specific engine parts

The modified parts of the ME-GI engine comprise gas supply piping, gas block with accumulator and control valves on the (slightly modified) cylinder cover with gas injection valves.

A sealing oil system, delivering sealing oil to the window/shutdown and gas injection valves, separates the control oil and the gas.

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

- If the supply of gas is natural gas (NG) or compressed natural gas (CNG) it requires a high-pressure gas compressor, including a cooler, to raise the pressure to 300 bar, which is the maximum required pressure at the engine inlet
- If the supply of gas is liquid natural gas (LNG) it requires a Cryogenic HP Pump and vaporiser solution
- The ME-GI Engine Control System (ME-ECS)
- Leakage detection and ventilation system, which ventilates the outer pipe of the double-wall piping completely, and incorporates leakage detection
- Flow switches
- Inert gas system, which enables purging of the fuel gas supply system and the gas system on the engine with inert gas
- Gas Valve Train (GVT)
- Gas blow-off silencers
- Heat traced and insulated gas supply pipes.

*Fuel gas is also referred to as ‘second fuel’ and low-flashpoint fuel (LFF) in this Project Guide.*

## Gas piping on the engine

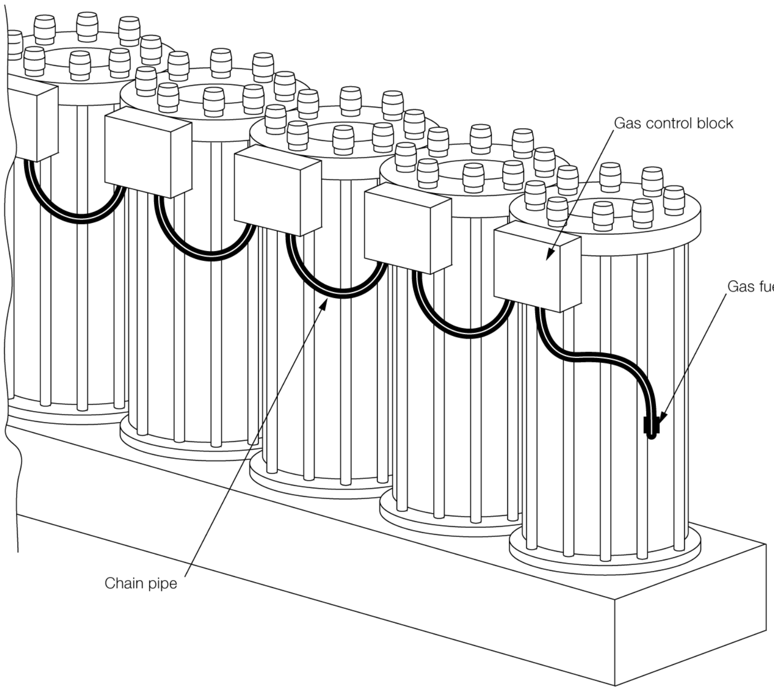


*Fig. 7.00.01: Layout of double-wall piping system for fuel gas*

The layout of the double-wall piping system for gas is shown in Fig. 7.00.01. The high-pressure gas from the compressor unit or the high-pressure pumps (vaporiser) flows through the main pipe and is distributed via flexible chain pipes to each cylinder's gas control block. The flexible chain pipes perform two important tasks:

- To separate each cylinder unit from each other in terms of gas dynamics, utilising the well-proven design philosophy of the ME engine's fuel oil system
- Act as flexible connections between the engine structure and safeguard against extra stress in the gas supply and chain pipes caused by the inevitable differences in thermal expansion of the gas pipe system and the engine structure.

The large volume accumulator contains about 20 times the injection amount per stroke at MCR and performs two tasks:

- Supply the gas amount for injection at only a slight, but predetermined, pressure drop
- Form an important part of the safety system, see Section 18.08.

The gas injection valve is controlled by the control oil system. This, in principle, consists of the ME hydraulic control oil system and an ELGI valve, supplying high-pressure control oil to the gas injection valve, thereby controlling the timing and opening of the gas valve.



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## The ME-GI fuel injection system

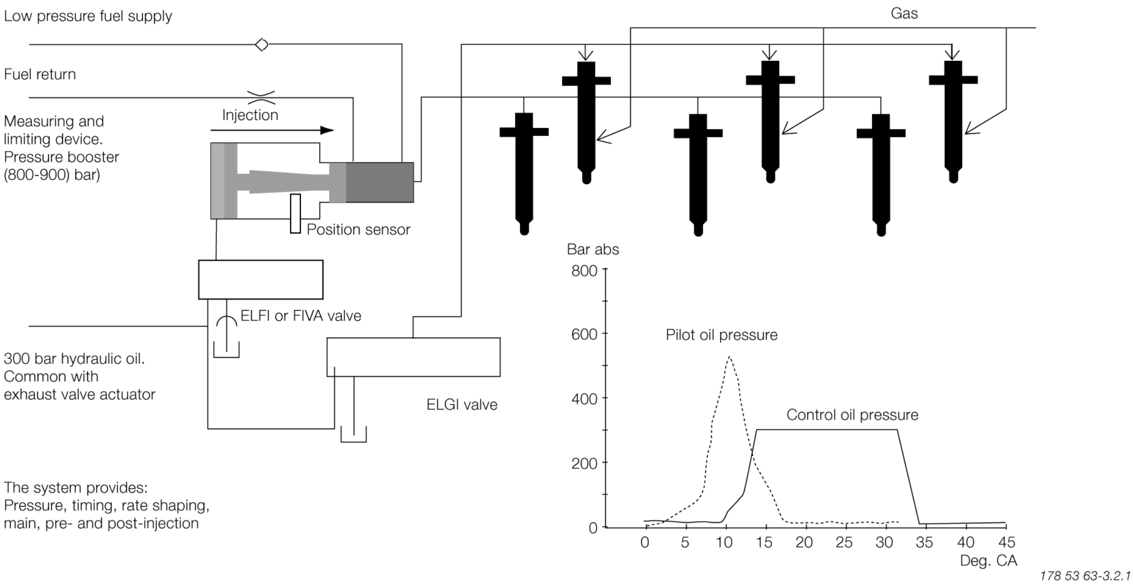


*Fig. 7.00.02a: The ME-GI fuel injection system*

As can be seen in Fig. 7.00.02a, the fuel oil pressure booster, that pressurizes the supplied fuel oil (pilot oil) during gas fuel operation mode, is connected to the multiway-valve (ELFI or FIVA) that controls the injection of fuel oil to the combustion chamber.

The 300 bar hydraulic oil also pressurizes the ELGI valve controlling the injection of the gas fuel.

By the engine control system, the engine can be operated in the various relevant modes: 'gas operation' with minimum pilot oil amount, 'specified dual fuel operation' (SDF) with injection of a fixed gas amount and the 'fuel-oil-only mode'.

## Pilot oil injection amount versus engine load

Gas operation is possible down to 10% load.

The minimum pilot oil amount in gas operation mode is 1.5% at MCR (in $L_1$), see Fig. 7.00.02b. In case the engine is derated, the pilot amount is relatively higher as calculated in CEAS, see Section 20.02.

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.

For guaranteed Specific Gas Consumption (SGC) on test bed, the minimum LCV is 50 MJ/kg with a tolerance of ±5%.



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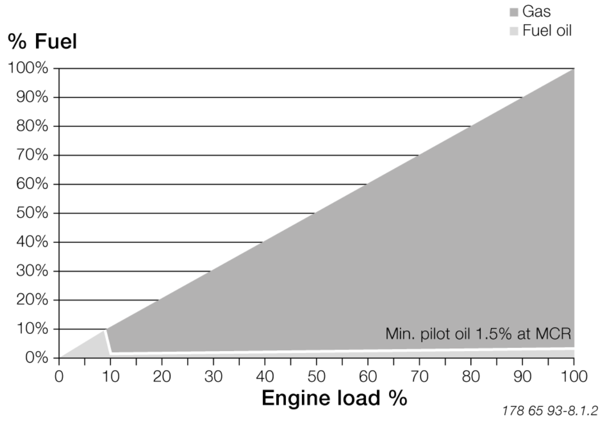


*Fig. 7.00.02b: Fuel index in gas operation mode*

## Condition of the fuel gas delivery to the engine

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

## Pressure

| | |
|---|---|
| Operating pressure | See Fig. 7.07.04 |
| Safety relief valve | 350 bar |
| Pulsation limit | ±2 bar |

## Flow

The maximum flow requirement is specified at 100% SMCR, 315 bar, with reference to an LCV of 38,000 kJ/kg.

| | |
|---|---|
| Maximum / minimum requirement | Refer to List of Capacities, or CEAS report |
| Minimum flow requirement in standby | 0 kg/h |

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

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



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## Temperature [ME-GI]

| | |
|---|---|
| Temp. inlet to engine | 45 ±10°C |
| Alarm, low / high | 35°C / 55°C |
| Shut down, low / high | 30°C / 60°C |

The temperature is specified with regards to take the following into account:

- To reduce condensation on the outer wall of the inner pipe for double-wall piping
- 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
- Gas temperature during blow-off will still be within the temperature limits of the materials selected in piping and components

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## Guiding fuel gas specification

| Designation | Unit | Limit | Value | Test method reference *) (Latest edition to be applied) |
|---|---|---|---|---|
| Lower calorific value (LCV) | MJ/kg | Min. | 38 | ISO 6976 (or GPA 2172) |
| Methane number (MN) | No unit | Not applicable | Not applicable **) | Not applicable |
| Methane ($CH_4$) | % (mol) | Min. | 82 | ISO 6974-3 |
| Ethane ($C_2H_6$) | % (mol) | Max. | 15 | ISO 6974-3 |
| Propane + butane ($C_3H_8$+$C_4H_{10}$) | % (mol) (total) | Max. | 5 | ISO 6974-3 |
| Higher order hydrocarbons ($C_5H_{12}$ and higher) | % (mol) (total) | Max. | 1 | ISO 6974-3 |
| Hydrogen sulphide ($H_2S$) + carbonyl sulphide (COS) | mg/Nm$^3$ | Max. | 5 | ISO 19739 |
| LNG sampling | | | | ISO 8943 |

*) 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.

**) Methane number is not relevant for diesel combustion.

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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-GI 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 (LNG)

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 ($NH_3$) and carbon dioxide ($CO_2$) are removed to the extent possible. Higher hydrocarbons are also removed.

## Compressed natural gas (CNG)

In case the engine will be operated on compressed natural gas (CNG), where no liquefaction has taken place as part of its processing, a number of additional requirements will need to be satisfied to make it suitable for operation on GI engines.

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

## Influence of boil-off 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 300 bar fuel gas delivered to the engine.

The nitrogen ($N_2$) content delivered to the engine may vary, which is acceptable, to a level of 15% (mol). If the nitrogen content delivered to the engine exceeds 15% (mol), it can be handled by either decreasing the engine load or by increasing the pilot injection of liquid fuel such as diesel or fuel oil.

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## 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.

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 filteration setup must be included in the Low Flashpoint fuel supply system, See section 7.07.

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## Sealing oil system

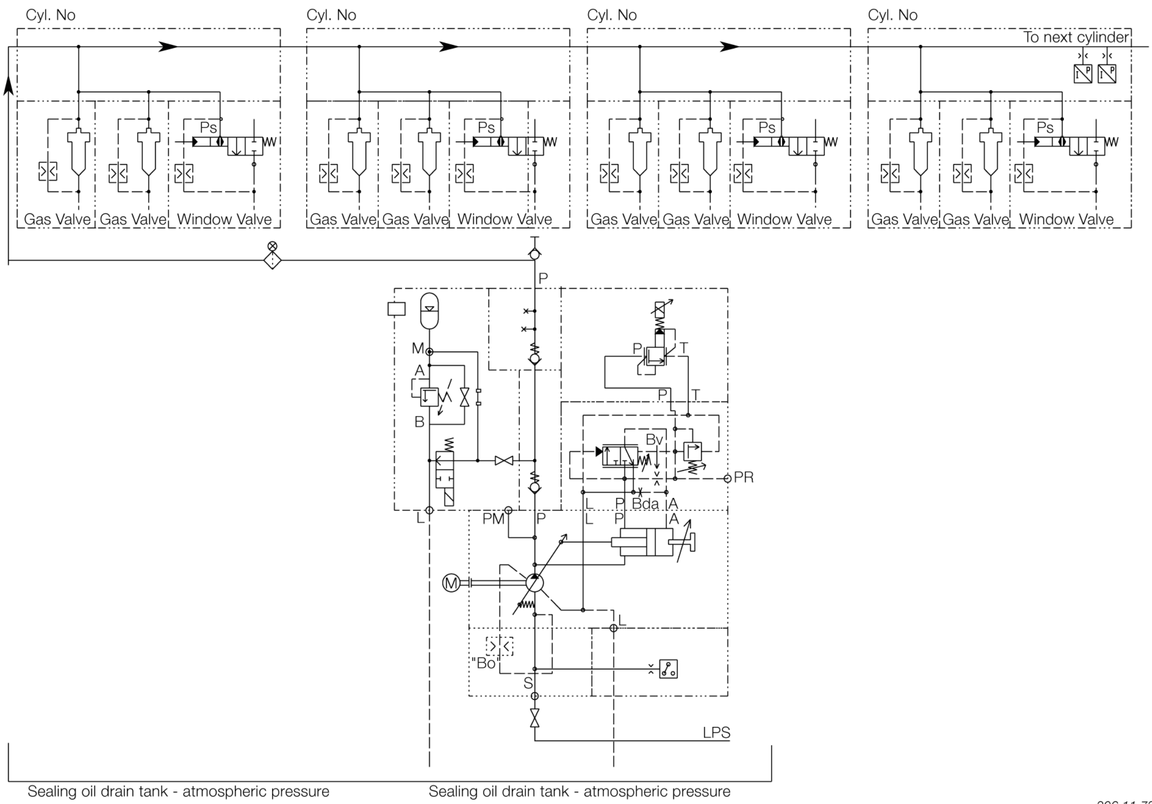


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*Fig. 7.00.03: Sealing oil system control diagram*

The sealing oil system is a pressurised hydraulic oil system, with a constant differential pressure kept at a higher level than the gas pressure that, prevents gas from entering the hydraulic oil system.



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The sealing oil is applied to the gas injection valves 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 gas block with double-walled pipes.

The sealing oil system consists of one pump and a safety block with an accumulator. The sealing oil system uses the low pressure oil supply and pressurises it to the operating pressure 20 – 25 bar higher than the gas pressure in order to prevent that the hydraulic oil is polluted with gas. 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.

The sealing oil system is shown in Fig. 7.00.03.

## Sealing pump motors

Three different electric motors can be used on the sealing oil pumps:

- Pump displacement mechanically limited to 9 ccm/rev.:
  - 7.4 kW, 1,450 rpm M3AA 132 M, 50 Hz
  - 8.6 kW, 1,750 rpm M3AA 132 M, 60 Hz
- Pump displacement 16 ccm/rev.:
  - 18.0 kW, 1,750 rpm M3AA 160 M, 60 Hz

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