Second fuel system – ME-LGIP engine

The MAN B&W LGIP engine is the liquefied petroleum gas (LPG) burning version of our dual-fuel solution for liquid injection of fuels, the ME-LGI engine. The ME-LGIP engine is a dual-fuel engine combusting LPG (a mixture of mainly liquid propane and butane) ignited by pilot oil in dual-fuel mode, and fuel oil when running in fuel oil mode.

In this section, the term second fuel denotes LPG.

LPG from the low-flashpoint fuel supply system (LFSS) is supplied through the main supply pipe and a fuel valve train (FVT) before it is distributed to each cylinder.

The components and piping on the engine for LPG operation are described in the present Section 7.00, the conventional fuel oil system and pilot oil system are described in 7.01–7.05, the LFSS and auxiliary systems for dual-fuel operation in Sections 7.07 and 7.09.

ME-LGIP specific engine parts

Fig. 7.00.01 shows LGIP components and piping on the engine for injection of LPG.

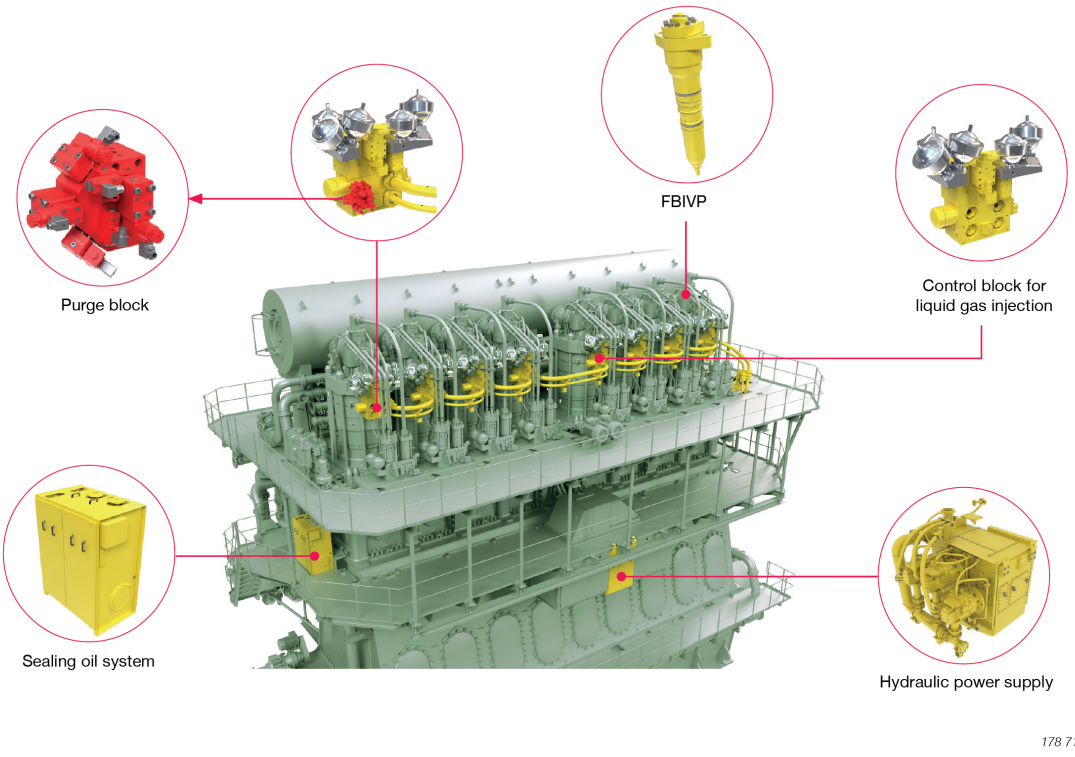

Fig. 7.00.01: Second fuel components and piping on the engine.

The injection system consists of a control block for liquid gas injection (LGI), fuel booster injection valves for propane (FBIVP), and a hydraulic power supply unit (HPS). LPG is supplied to each FBIVP via drillings in the cylinder cover.

A sealing oil system delivers sealing oil to the FBIVP to keep hydraulic control oil and LPG separate.

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Apart from these systems on the engine, the engine auxiliaries comprise:

- Fully automated LPG supply system with an embedded purge system
- The ME-LGI engine control system (ME-ECS)
- Conventional fuel oil system for pilot oil injection
- Drain and purge return system for quick and reliable removal of LPG from the engine
- Leakage detection and ventilation system which ventilates the outer pipe of the double-walled piping and incorporates leakage detection
- Inert gas system for purging the second fuel supply system and the second fuel system on the engine with inert gas, two separate inert gas supply systems (A and B supply)
- Fuel valve train (FVT) which provides a block-and-bleed function between the fuel system and the engine
- Heat traced and insulated LPG supply pipes
- Service tank with two compartments: fuel compartment and return compartment
- Recirculation system for cooling FBIVPs where surplus LPG is returned through the return valve train to the recirculation tank
- Knockout drums for separating LPG droplets and vapour during venting at maximum LPG flow
- Sealing oil system ventilation
- Flow switches for detecting dry air supply and monitoring flow from the ventilation system.

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Second fuel piping on the engine

As shown in Figs. 7.00.01 and 7.00.02, the double-walled design is similar to the concept used for other dual-fuel engines of MAN Energy Solutions.

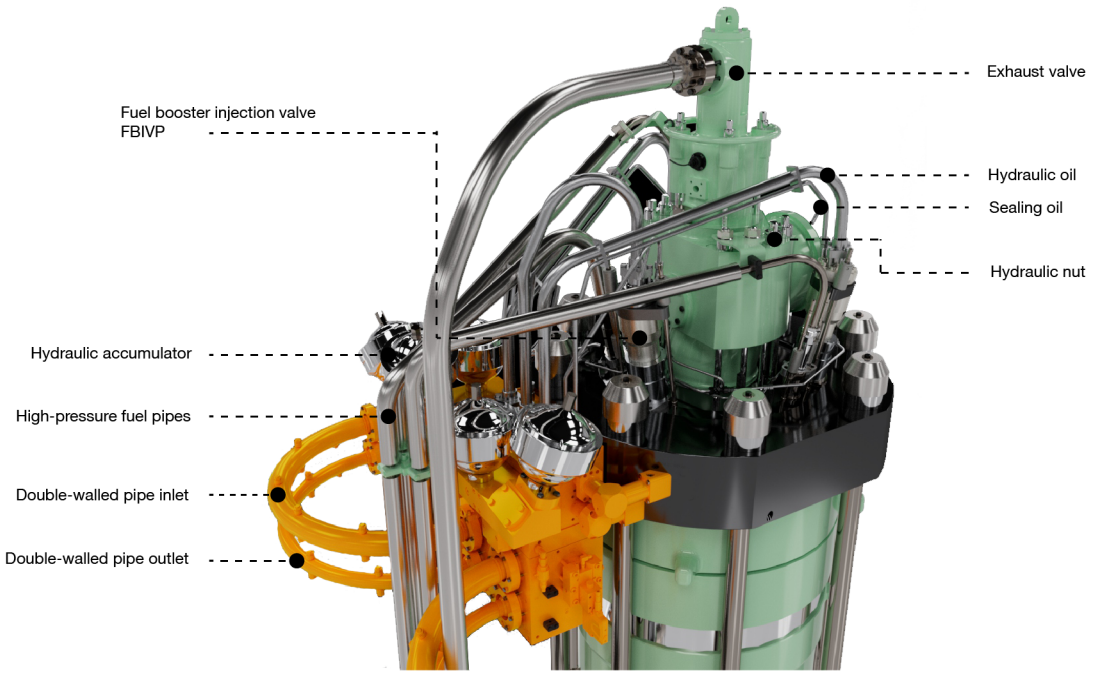

Fig. 7.00.02: The ME-LGIP fuel injection system

If leakages occur, the double-walled design ensures that LPG is contained within a ventilated pipe with LPG detectors and leakages are vented outside the engine room. When switching from dual-fuel mode to fuel-oil-only mode, the second fuel piping for LPG will be purged with nitrogen from an inert gas purging system.

Second fuel injection system

The LGI control block includes high-speed analogue control valves for regulating the LPG injection pattern and timing by regulating the high-pressure hydraulic oil supply to the FBIVPs, see Fig. 7.00.02

The engine control system (ECS) controls the valves. 300 bar hydraulic oil pressurises the electronic gas injection (ELGI) valve controlling the injection of second fuel.

When operating the engine in dual-fuel mode, a small amount of pilot oil (fuel oil) is always necessary to ensure combustion. The fuel pressure booster in the fuel booster injection valve (FBIV) pressurises the pilot oil to the correct injection pressure.

Opening of the FBIV and injection of pilot oil into the combustion chamber is controlled by a multiway-valve termed electronic fuel injection liquid (ELFI-L) or fuel injection valve actuation (FIVA), which is activated by control oil.

The design features hydraulic oil accumulators to ensure an adequate hydraulic oil supply during injection.

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The amount of LPG in dual-fuel mode depends on the amount available from the LFSS. The ECS receives information about the available amount from the LFSS and calculates the needed amount of pilot oil.

The engine control system controls the operation in three different modes:

- Dual-fuel mode with a minimum pilot oil amount
- Specified dual-fuel operation (SDF) with injection of a fixed second fuel amount
- Fuel-oil-only mode.

Pilot oil injection amount versus engine load

Dual-fuel operation is possible down to 10% load.

The minimum pilot oil amount in dual-fuel mode is 5% at MCR (in L1), see Fig. 7.00.03.

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

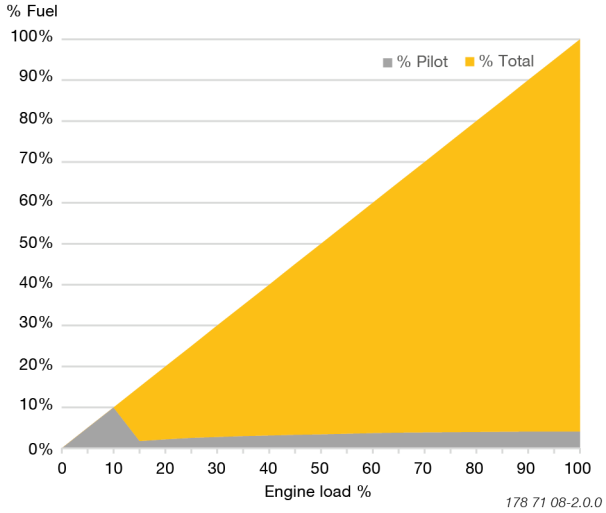

Fig. 7.00.03: Fuel index in dual-fuel mode

If the engine is derated, the pilot amount is relatively higher as calculated in CEAS. CEAS can be found here:

https://www.man-es.com/marine/products/planning-tools-and-downloads/ceas-engine-calculations

For guaranteed specific gas consumption (SGC) on test bed, the minimum LCV is 46 MJ/kg with a tolerance of +/-5%. If LCV is lower, then a higher amount of pilot oil might be required.

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Condition of the second fuel supply to the engine

The following data is based on LPG.

Pressure

Operating pressure		50 bar
Supply pressure		53 bar
Safety relief valve		65 bar
Pulsation limit	±2 bar	

Flow

The maximum flow requirement is specified at 100% SMCR, 53 bar, and an LCV of 46,000 kJ/kg.

Maximum / minimum requirements	See CEAS
Minimum flow requirement in standby	0 kg/h

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

If there is a specific LCV requirement, inform MAN Energy Solutions. Under certain circumstances, modification of the fuel valves may be required to accommodate a special LCV.

Temperature

Temperature inlet to the engine	25-45°C
Alarm, low / high	20°C/65°C
Shut down, low / high	15°C/75°C

The temperature specification takes the following into account:

- Reduce condensation on the outer wall of the inner pipe for double-walled piping
- Performance of the engine is not adversely affected
- Reduce thermal loads on the LPG piping itself
- Obtain a uniform LPG density.

The second fuel temperature during blow-off will still be within the temperature limits of the materials selected in piping and components.

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Guiding LPG fuel specification

LPG is a hydrocarbon gas mixture consisting of various compositions of propane, n-butane, and iso-butane with minor amounts of other hydrocarbons. The values in the guiding fuel specification for ME-LGIP engines, Table 7.00.01, refer to the fuel as delivered to the ship.

Designation	Unit	Limit	Value	Test method reference
Lower calorific value (LCV)	MJ/kg	Min.	46	
Methane (CH_4)	% (mol)	Max.	0.1	ISO 7941
Ethane (C_2 H_6)	% (mol)	Max.	25	ISO 7941
Propane and/or butane (C_3 H_8 +C_4 H_{10})	% (mol) (total)	Min.	75	ISO 7941
Higher order hydrocarbons (C_5 H_{12} and higher)	% (mol) (total)	Max.	3	ISO 7941
1.3-Butadiene (C_4 H_8)	% (mol)	Max.	0.1	ISO 7941
Unsaturated hydrocarbons	% (mol)	Max.	11	ISO 7941
Total evaporation residue	mg/kg	Max.	20	ISO 13757
Hydrogen sulphide (H_2 S) + carbonyl sulphide (COS)	mg/Nm^3	Max.	5	ASTM D2420

Table 7.00.01: Guiding LPG fuel specification for ME-LGIP engines

LPG with a higher content of ethane

If the engine is to be operated on LPG with a content of ethane higher than specified in Table 7.00.01, additional requirements have to be fulfilled to make it suitable for usage in ME-LGIP engines. Contact your MAN Energy Solutions two-stroke representative for more information.

Boil-off gas from storage tanks

LPG in semi-refrigerated and fully-refrigerated tanks changes composition and properties over time. This is due to the unavoidable heat influx from the surroundings, which causes vaporisation of lighter compounds, like ethane. This process is called ageing and the gas produced is referred to as boil-off gas (BOG). BOG contains a higher amount of ethane compared to the LPG bunkered. The remaining LPG has an increased percentage of propane, butane, and higher hydrocarbons. The composition of the LPG bunkered is therefore not necessarily the same as the composition of the LPG supplied to the engine.

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Sealing oil system

The sealing oil system is a pressurised hydraulic oil system with a constant differential pressure, approximately 65 bar higher than the second fuel pressure for LPG, which prevents fuel from entering the hydraulic oil system.

The sealing oil is applied to the FBIVPs in the space between LPG on one side and hydraulic oil on the other side. The sealing oil unit is connected to the FBIVPs and the hydraulic activation valve.

The sealing oil system consists of a pressure reduction valve 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. The sealing oil will be injected with the second fuel into the combustion chamber.

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