

Technical Circular 50-04

Fuel gas regulations

Affected engines:

- | | |
|---|---|
| <input checked="" type="checkbox"/> MAG 24.4 X 41XA | <input checked="" type="checkbox"/> MAH 33.3 TI 311A |
| <input checked="" type="checkbox"/> MAG 33.3 X 31XA | <input checked="" type="checkbox"/> MAH 49.4 TI 211A |
| <input checked="" type="checkbox"/> MAG 49.4 X 21XA | <input checked="" type="checkbox"/> MAH 74.6 TI 211A |
| <input checked="" type="checkbox"/> MAG 74.6 X 21XA | <input checked="" type="checkbox"/> MAH 84.6 TI 211A |
| <input checked="" type="checkbox"/> MAG 84.6 X 21XA | <input checked="" type="checkbox"/> customer-specific special engines |
| <input checked="" type="checkbox"/> MAG 13.6 X 11XA | |

1. General

Fuel gas

The term fuel gas describes all gases and gas mixtures that are used as fuel for the gas engine.

The most important main components are:

- Methane (CH₄)
 - Mostly essential component and energy source in the usual fuel gas
- Hydrogen (H₂)
 - Energy source that greatly reduces the methane number
- Chain hydrocarbons (C_nH_m with n larger than 1)
 - Unstable compounds which therefore tend to a knocking combustion
- Inert gases (N₂ and CO₂)
 - Do not actively participate in combustion. They increase the knock resistance of the gas mixture. CO₂ increases the methane number with triple the effect of N₂.

Methane number

The methane number (MZ) describes the knock resistance of the fuel gas. It is defined by the mixing ratio of a mixture of hydrogen and methane, which has the same tendency to knock as the fuel gas present.

Here the MZ 100 is antiknock (for methane CH₄) and MZ 0 is antiknock (for hydrogen H₂).

For mixtures with inert gases the MZ can rise to over 100.

The methane number MZ depends on the content of different components. Even smallest concentrations of long-chain hydrocarbons lead to a drastic decrease of the methane number MZ.

Examples:

- Propane has the same knocking behaviour as a mixture of 33% methane and 67% hydrogen. Therefore the gas propane is assigned to the MZ 33.
- A mixture of 10% butane (MZ 10) and 90% methane (MZ 100) leads to MZ 51 and not to MZ 91 (no linear course).

Attention!

With fuel gases with a fluctuating or low methane number, there is a risk of knocking combustion. The consequences are extreme mechanical and thermal stresses, which in turn can result in damage.

Examples for the methane number (MZ) of some gases:

| | |
|--|---------------------|
| Biogas | MZ larger 120 |
| Mine gas | MZ approx. 105 |
| Methane (CH ₄) | MZ 100 (Definition) |
| Natural gas | MZ 65 up to 95 |
| Propane (C ₃ H ₈) | MZ 33 |
| Butane (C ₄ H ₁₀) | MZ 10 |
| Hydrogen (H ₂) | MZ 0 (Definition) |

Accompanying substances

For the evaluation of a gas regarding its suitability as a fuel gas, the gas accompanying substances are also of great importance. They do not contribute significantly to the total combustion. However, these gaseous accompanying substances must be considered with regard to the reliable operation of the gas engine.

In addition to gas accompanying substances that do not change the course of combustion, there are also substances that lead to a strong change in ignition properties (such as oil vapors).

Other gas companion substances are not suitable for use because of their combustion products, e.g. ashes or deposits of importance. These are elements and compounds which for example halogens, metals, silicates etc.

Depending on the quantity and damage effect, these gaseous accompanying substances must be removed from the fuel gas before entering the engine. The limit values of the essential and currently known common gaseous pollutants are listed in the section Limit values of fuel gases.

Although the accompanying substances only occur in trace concentrations, the combustion products cause wear.



Attention

If the intended fuel gas does not meet the minimum properties mentioned in this circular or if the fuel gas contains additional by-products, which are not specified without the concrete fuel gas analysis being released in writing, any warranty claim against MAMotec GmbH expires.

Non-compliance with the required minimum properties of a fuel gas or its contamination with unspecified components leads to a reduction in Service life of the engine and all affected components. The regular maintenance times listed in the regular maintenance schedule for motor operation in accordance with the specifications are sometimes considerably undercut and lose any reference value.

A gas analysis has to be submitted to MAMotec during commissioning (not older than 2 weeks) and to document in the commissioning report. After commissioning, the gas composition must be carried out regularly and the compliance with the minimum properties must be checked.

In case of warranty all gas analyses must be submitted to MAMotec.

2. Definition of fuel gas types

General

In the following, the types of gas that are suitable for engine operation are explained. For better understanding, for each gas type a typical combination of components is defined in addition to the permissible bandwidth range, as far as reasonable and possible.

The values of the components listed in the following tables are to be considered in combination and only result in 100% in the typical composition. A summation of the min. and max. values is not useful. These values are only used for Limitation of the bandwidth range.

All values refer to a completely dried gas. For the design of gas systems, the real water vapor content must be considered.

Natural gas

| Component | Min. | Typical | Max. |
|---|------|---------|------|
| Methan (CH ₄) in % | 85 | 91 | 98 |
| Alkanes (Ethane, Propane, Butane, Pentane) in % | 0 | 5 | 15 |
| Inert gases in % | 0 | 4 | 15 |

Liquefied natural gas (LNG)

LNG is liquefied natural gas. The gas is liquefied by compression and cooling. The values depend on the underlying natural gas.

When used as fuel gas, it must be ensured that no concentration of long-chain hydrocarbons can take place.

Liquid gas (Propane, LPG)

Propane is a colorless and odorless gas and belongs to the alkanes. Since propane liquefies at normal temperatures even at relatively low pressures, large amounts of energy can be stored in the liquid phase.

Because of the solubility of alkanes in each other, DIN 51622 defines commercially available technical propane as a mixture of at least 95% propane and a residual mixture of ethane, ethene, butane and butene.

When used as a fuel gas, it must be ensured that no concentration of long-chain hydrocarbons can occur.



Attention

The use of liquid gas as fuel is prohibited for all MAG gas engines with a compression greater than 11:1!

Associated Oil Gas

Associated gas is a by-product of oil production. Due to pressure decreases, the solubility for gases in the liquid phase of oil decreases and these gases bubble out. Depending on the oil source, the concentration and the methane number can vary considerably.

When used as a fuel gas, it must be ensured that no concentration of long-chain hydrocarbons can occur.



Attention

When using associated petroleum gas, liquid gas (propane/butane) as well as all gases and gas mixtures with a methane number below 70 as fuel, a functional anti-knock control is mandatory for all MAG gas engines!

Sewage Gas

During wastewater treatment in the sedimentation tanks (clarifiers) of a sewage treatment plant, sewage sludge settles. During the anaerobic (oxygen-free) sewage sludge digestion in digestion towers sewage gas is formed.

| Component | Min. | Typical | Max. |
|--|------|---------|------|
| Methane (CH ₄) in % | 57 | 65 | 72 |
| Carbon dioxide (CO ₂) in % | 28 | 34 | 43 |
| Oxygen (O ₂) in % | 0 | 0 | 10 |
| Nitrogen (N ₂) in % | 0 | 1 | 20 |

Landfill gas

Landfill gas is produced as a result of biochemical degradation processes of organic compounds and materials in the waste body. The processes are divided into aerobic and anaerobic (oxygen-free) degradation processes, which can be divided into successive phases at the beginning and run simultaneously towards the end of the processes.

| Component | Min. | Typical | Max. |
|--|------|---------|------|
| Methane (CH ₄) in % | 45 | 50 | 65 |
| Carbon dioxide (CO ₂) in % | 20 | 27 | 45 |
| Oxygen (O ₂) in % | 0 | 0 | 10 |
| Nitrogen (N ₂) in % | 10 | 23 | 34 |

Biogas

Biogas is produced during the anaerobic (oxygen-free) fermentation of organic material. Suitable as starting materials for the technical production of biogas:

- fermentable, biomass containing residues such as biowaste or food waste
- farmyard manure like liquid manure or dung
- specifically cultivated energy crops (renewable raw materials)

| Component | Min. | Typical | Max. |
|--|------|---------|------|
| Methane (CH ₄) in % | 45 | 55 | 70 |
| Carbon dioxide (CO ₂) in % | 20 | 40 | 55 |
| Oxygen (O ₂) in % | 0,01 | 0,3 | 2 |
| Nitrogen (N ₂) in % | 0,01 | 4,7 | 10 |

Wood gas

Wood gas is a combustible gas that can be obtained by wood gasification, a pyrolysis ("dry distillation") of wood.

| Component | Min. | Typical | Max. |
|--|------|---------|------|
| Methane (CH ₄) in % | 5 | 10 | 18 |
| Carbon dioxide (CO ₂) in % | 30 | 50 | 60 |
| Oxygen (CO) in % | 25 | 33 | 40 |
| Nitrogen (H ₂) in % | 1 | 2 | 10 |

3. Minimum requirements gas quality for fuel gas

| Parameters | Symbol | Limit value | Unit | Comment |
|--|------------------|--|--|--|
| Methane number MAG xx.x S x13x MAG xx.x T/TI x13x MAG xx.x S x15x MAG xx.x S x11x MAH xx.x TI x11x Speed of change | MZ | < 80 <100 <130 < 30 ≤ 0 < 5/min | | Low MZ after consultation with MAMotec |
| Heating value CO ² per Hu Speed of change | Hu | >5 < 10 < 5/min | kWh/Nm ³ Vol%kWh/mn ³ | |
| Chlorine content | Cl | <80 | mg/Nm ³ | Is present as a volatile compound |
| Fluorine content | F | <40 | mg/Nm ³ | Is present as a volatile compound |
| Total Chlorine+Fluorine | Σ(Cl,F) | <80 | mg/Nm ³ | |
| Sulphur content | S | <200 | mg/Nm ³ | |
| Hydrogen sulfide | H ₂ S | <200 | mg/Nm ³ | |
| Ammonia content | NH ₃ | <30 | mg/Nm ³ | |
| Tar content | | <50 | mg/Nm ³ | |
| Oil vapors | | <400 | mg/Nm ³ | |
| Silicon content | Si | <2 | mg/Nm ³ | |
| Solids <3 μm | | <8 | mg/Nm ³ | Absolute grain size |
| Relative Humidity | φ | <60 | % | No condensate may occur in the gas mixture section |
| Temperature gas mixture after gas mixer | Tg | 10<Tg<30 | °C | |

A complete gas analysis must ensure that the engine is operated with fuel gas according to the specifications of this Technical Circular. In general, it is recommended to carry out gas analyses at least every six months.

If the gas composition changes over time, the analysis intervals must be shortened accordingly. Regular gas and engine oil analyses are required for safe operation.

If the limit values are exceeded, the motor must be switched off and MAMotec must be consulted.

If the motor continues to be operated with inadmissible limit values, the warranty for the motor will expire.

MAMotec does not assume any warranty for defects and/or damage (corrosion, contamination, wear, etc.) caused by gases and substances which were not known and agreed upon at the time of conclusion of the contract and released in writing by MAMotec GmbH.

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