UNIC DF Training

Gas Properties

Properties of Fuel GAS

Natural gas

- Naturally occurring mixture of gaseous saturated hydrocarbons
- Is found in layers of porous rock, like limestone or sandstone beneath the earth's surface, often in association with crude oil
- Has high heating value and clean burning characteristics
- Heavier hydrocarbons in natural gas can be extracted through compression or absorption processes to yield butane, propane, gasoline and other raw material for petrochemical industry

Properties of Fuel GAS

Abbreviations

Abbreviation	Meaning	Remarks
NG	Natural Gas	
LNG	Liquefied Natural Gas	Liquid state. Cold, -163°C. Usually stored in 0 bar to 10 bar pressure
CNG	Compressed Natural Gas	Compressed gas Usually pressurized to 200-250 bar Temperature can be increased (to -25°C).
PNG	Pressurized Natural Gas	As CNG

Properties of Fuel GAS

- Natural gas is mostly methane (CH_4).
- Methane contains the higher amount of hydrogen per unit of energy than any other fossil fuel.
- Carbon to hydrogen ratio 1 / 4 (gasoline: 1 / 2.25).
- Lower CO_2 emissions

Properties of Fuel GAS

Gas composition

The composition of the natural gas varies substantially between the various at production fields.

Property		Volume
Methane	CH_4	70 – 90 %
Ethane	C_2H_6	0 – 7 %
Propane	C_3H_8	0 – 2 %
Butane	C_4H_{10}	0 – 0,5 %
Hydrogen	H_2	Traces
Carbon dioxide	CO_2	0 – 10 %
Oxygen	O_2	0 – 0.2 %
Nitrogen	N_2	0 – 15 %
Hydrogen sulphide	H_2S	0 – 10 ppm
Trace amounts of chlorine, fluorine, ammonia, hydrogen sulphide, particles.		

Properties of Fuel GAS

Table 4-10 Gas specifications

Property	Value (values given in Nm^3 are at 0 °C and 101.3 kPa)
Lower heating value (LHV)	≥ 28 MJ/Nm^3
Influence of MN on max. eng. output	See graph in 1.5 Operation in gas mode, 🗎 1-6.
Methane content	≥ 70 % volume
Hydrogen sulphide (H_2S)	≤ 0.05 % volume
Hydrogen (H_2) [a)]	≤ 3 % volume
Ammonia	≤ 25 mg/Nm^3
Chlorine and fluorine	≤ 50 mg/Nm^3
Water (vapour pressure dew-point)	≤ -20 °C
Oil (aerosol liquid and vapour)	≤ 1 mg/Nm^3
Gas cleanliness	Gas is considered as sufficiently clean. [b)]
Gas temperature at GVU inlet	20-60 °C at normal condition 0-20 °C exceptionally for short-time operation [c)]
Gas feed pressure [d)]	According to GTD
Permissible gas pressure fluctuation	± 0.6 bar (across all frequencies)

a) Hydrogen content higher than 3 % volume must be considered on a project-specific basis.
b) Contamination from gas system has to be avoided, e.g. by correct pipe flushing, ensuring cleanliness of bunkering connections, etc.
c) For instance, during starting-up of the fuel gas supply system.
d) The required gas feed pressure depends on the LHV as well as on the specific engine rating and actual engine load (specified in *GTD*). Details regarding feed pressure layout can be found in section 4.6.4, 🗎 4-49.

Properties of Fuel GAS

Properties of pure methane

- Density 0.7175 kg/m^3 @ 1.01325 bar and 0 °C
- Boiling point - 161.5 °C
- Lower heating value 48,0-50,0 MJ/kg
- Explosion limits 5 – 14 % mole
- Auto-ignition temperature 630 °C
- Methane Number(Knock Resistance) : 100

- Reference values for auto-ignition temperatures of other gases:
  - Ethane (C_2H_6) 515 °C
  - Propane (C_3H_8) 480 °C
  - Butane (C_4H_{10}) 420 °C

Properties of Fuel GAS

Properties of pure ethane

- Density 1.282 kg/m^3 @ 15 °C gas, 1 atm
- Boiling point - 89 °C
- Lower heating value 61,0-63,0 MJ/kg
- Explosion limits 3 – 13 % mole
- Auto-ignition temperature 515 °C
- Methane Number(Knock Resistance) : 44

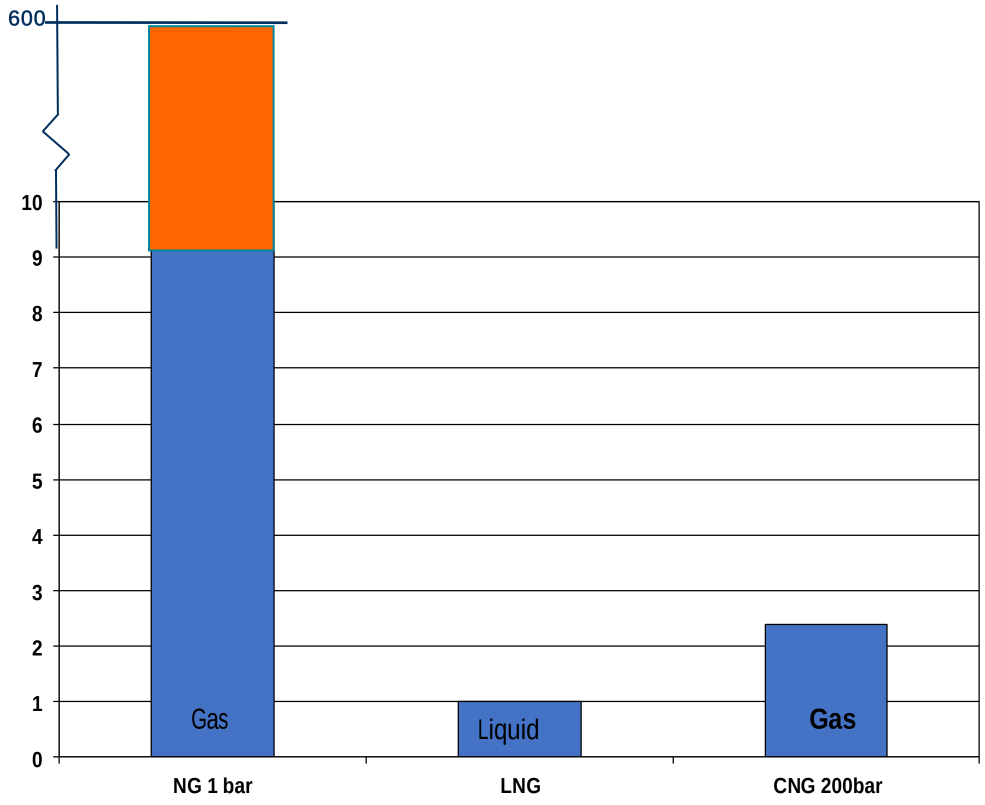
- Reference values for auto-ignition temperatures of other gases:
  - Methane (CH_4) 630 °C
  - Propane (C_3H_8) 480 °C
  - Butane (C_4H_{10}) 420 °C

Properties of Fuel GAS

Liquefied natural gas

- LNG takes up about 1/600th the volume of natural gas in the gaseous state.
- LNG is principally used for transporting natural gas to markets, where it is re-gasified and distributed as pipeline natural gas.
- Its relatively high cost of production and the need to store it in expensive cryogenic tanks have prevented its widespread use in commercial applications.

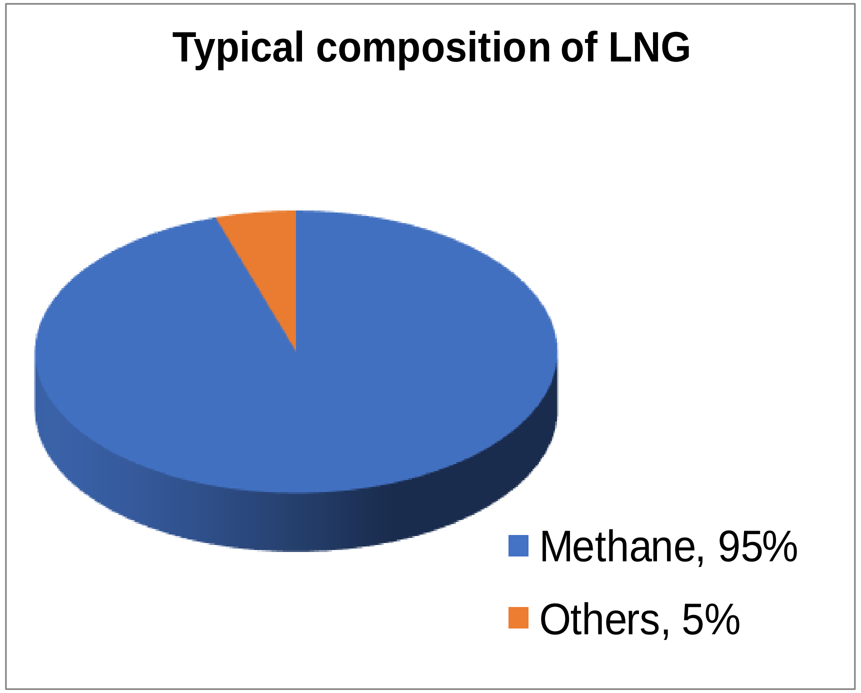
Fuel relative volume, energy content equal



Properties of Fuel GAS

LNG properties

- The density of LNG is roughly 0,4 kg/L to 0,5 kg/L, depending on temperature, pressure and composition, compared to water at 1,0 kg/L.
- The energy density of LNG is comparable to propane and ethanol but is only 60% that of diesel and 70% that of gasoline.



Properties of Fuel GAS

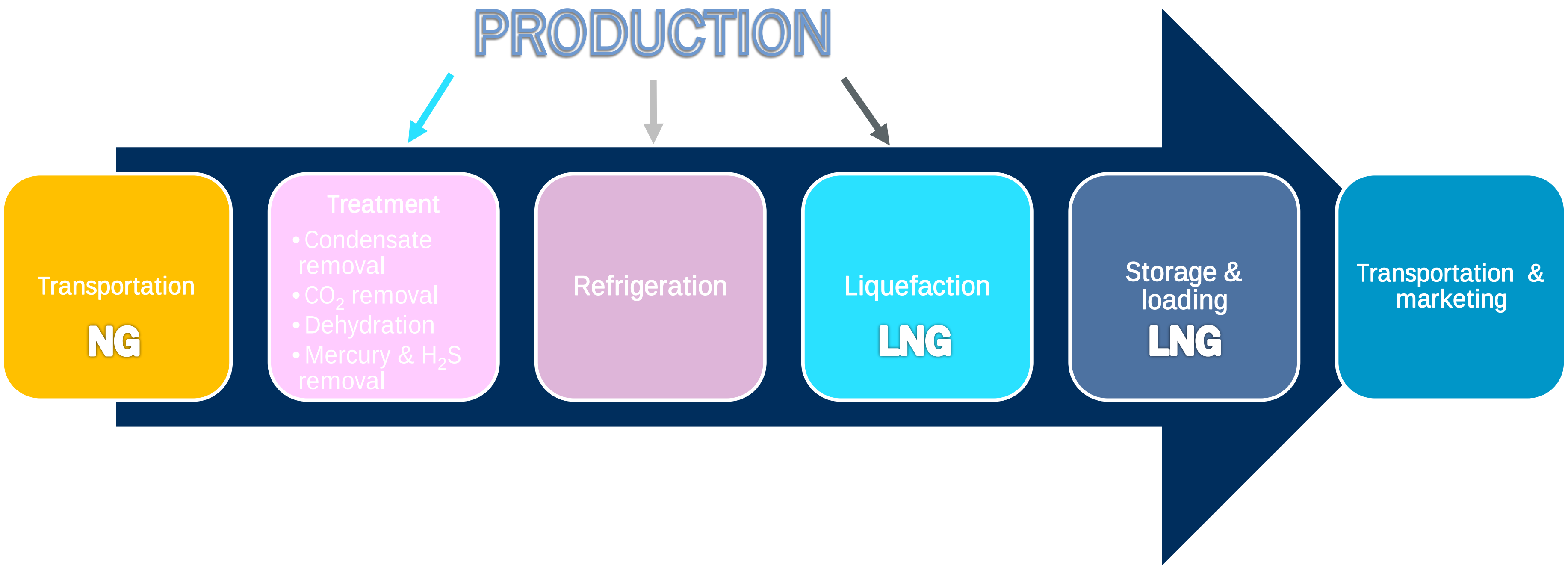
LNG properties

- Narrow ignition area.
- High self-ignition temperature (> 500 °C).
- Slow flame rate in atmospheric pressure.
- LNG does not burn, it has to evaporate first.
- Ignition energy is low, i.e. a small spark is enough.

Properties of Fuel GAS

LNG production

Typical LNG process



Properties of Fuel GAS

Change in gas composition during voyage

After loading:
LNG very cold (e.g. -163 °C)
N_2 evaporates first

Before unloading:
LNG temperature rises
Possible excess of NBOG

Loading port

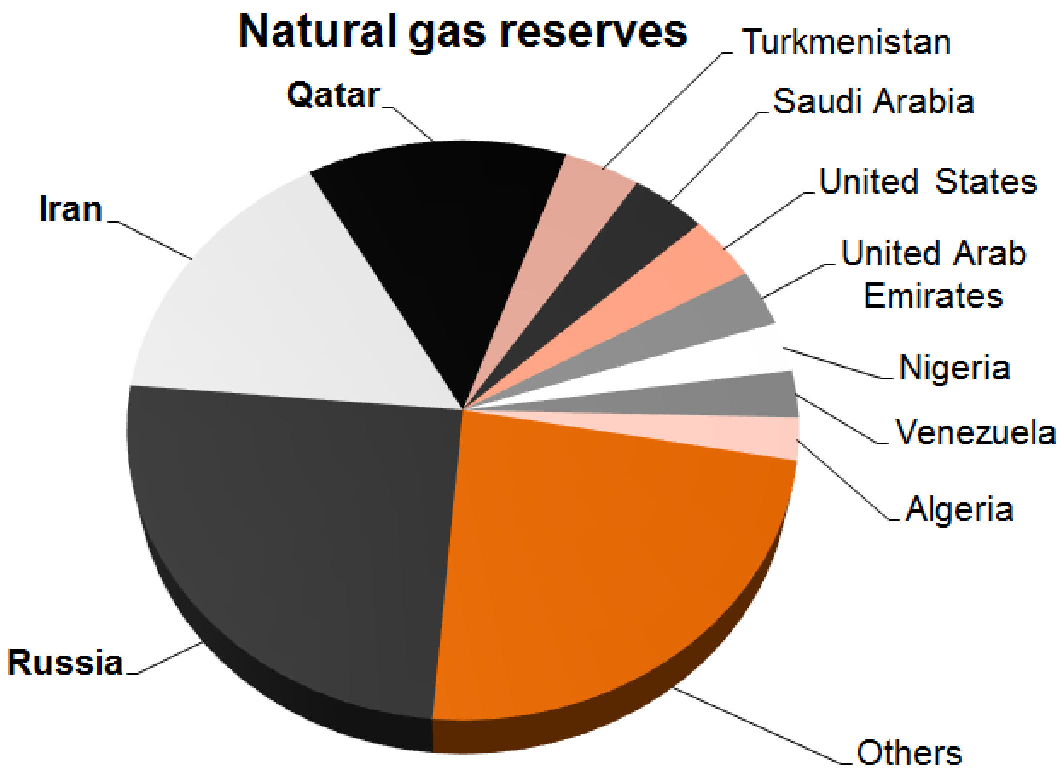
Unloading port

Properties of Fuel GAS

LNG production

A majority of the world's LNG supply comes from countries with large natural gas reserves:

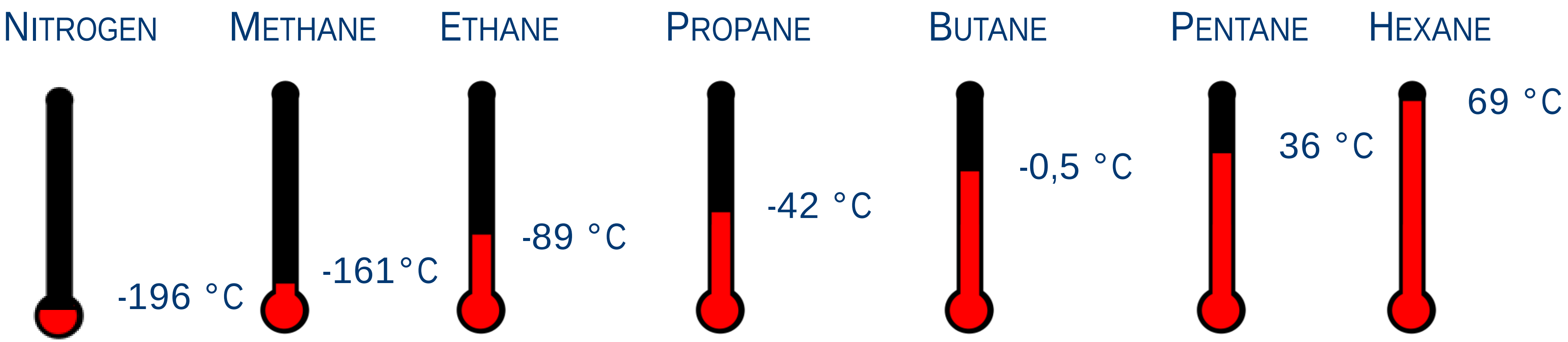
- Russia
- Iran
- Qatar
- Turkmenistan
- Saudi-Arabia
- United States
- United Arab Emirates
- Nigeria
- Venezuela
- Algeria



Properties of Fuel GAS

Natural Boil-Off Gas composition

- LNG is not stable in ambient conditions
- Heat is constantly transferred through LNG containment walls:
  - The LNG will start evaporate creating Natural Boil-Off Gas (NBOG)
  - In the beginning of the process, components with lower boiling point will start evaporating first.
  - Forced Boil-Off Gas (FBOG) is simply LNG evaporated through a heat exchanger



Properties of Fuel GAS

Lower heating value

- Lower Heating Value corresponds to the energy content of the gas.
- If the LHV is lower than specified, the engine output has to be adjusted or a higher gas pressure to the engine is needed.

- To compensate low heating value:

  Higher gas feed pressure

  Derating of engine output

Properties of Fuel GAS

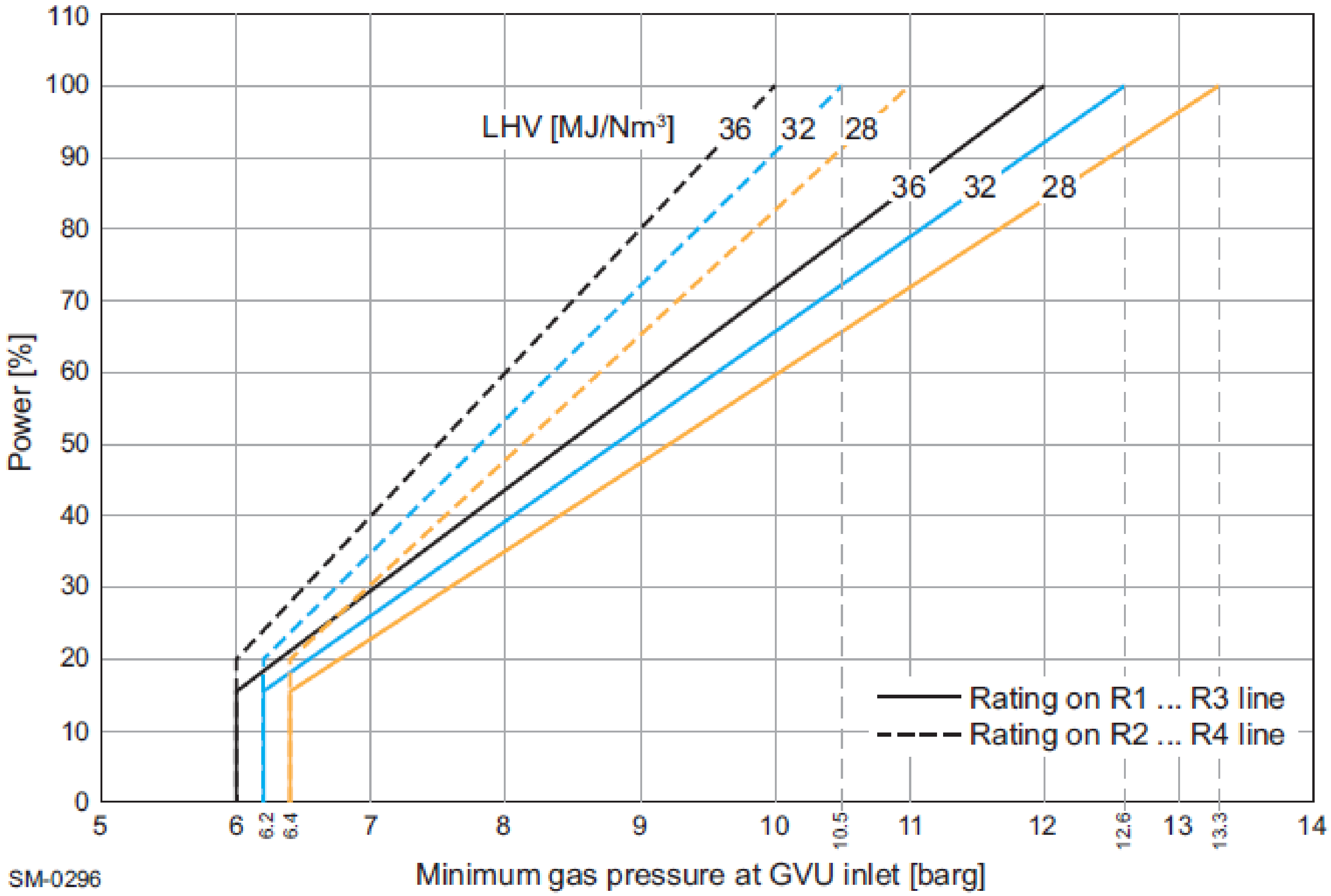


Figure 4-21 Design gas feed pressure requirements

Properties of Fuel GAS

Methane number (MN)

- Is a scale for evaluation of the knock (auto-ignition) resistance of the fuel.
- Higher MN means better knock resistance.
- Can be calculated, when gas composition is known.
- Higher amount of heavier hydrocarbons decrease MN.
- Higher amount of carbon dioxide and nitrogen increase MN.
- If MN is too low, the engine derating is required.

Properties of Fuel GAS

Methane number (MN)

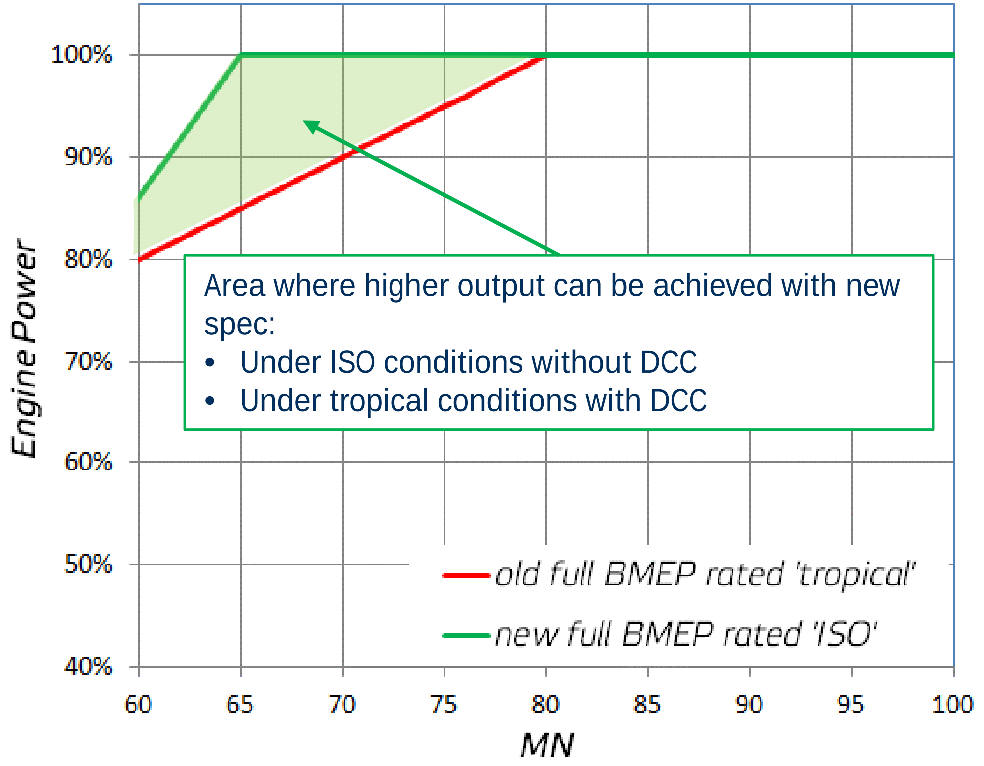
- MN is as a measure for knock sensitivity, like Octane numbers for petrol fuel.
  CH_4 (methane) has MN = 100, H_2 (hydrogen) has MN = 0.
  Heavier hydrocarbons decreases MN.
  Inert gases (CO_2 and N_2) increases MN.

- WinGD derating rules are based on MN.

Properties of Fuel GAS

Power de-rating – Methane Number under tropical condition and ISO condition

Maximum achievable power



  training@wingd.com

Properties of Fuel GAS

Heavier hydrocarbons

Heavier hydrocarbons can condense in gas compressor.

The higher the amount of heavier HCs, the lower the MN.

If the amount of heavier hydrocarbons (C_4+) in natural gas is above 1 %, the risk of knocking increases.

Hydrogen

Increases the risk of pre-ignition during a compression stroke.

Decreases density, MN and LHV (volume basis) of natural gas.

Sets new challenges to the controlled combustion process.

Increases explosion risk.

Properties of Fuel GAS

Hydrogen sulphide

- Causes sulphide stress corrosion
- Severity of corrosion depends on gas pressure
  (higher pressure, higher risk)
- Correct material choices will decrease the corrosion risk

  training@wingd.com WIN GD

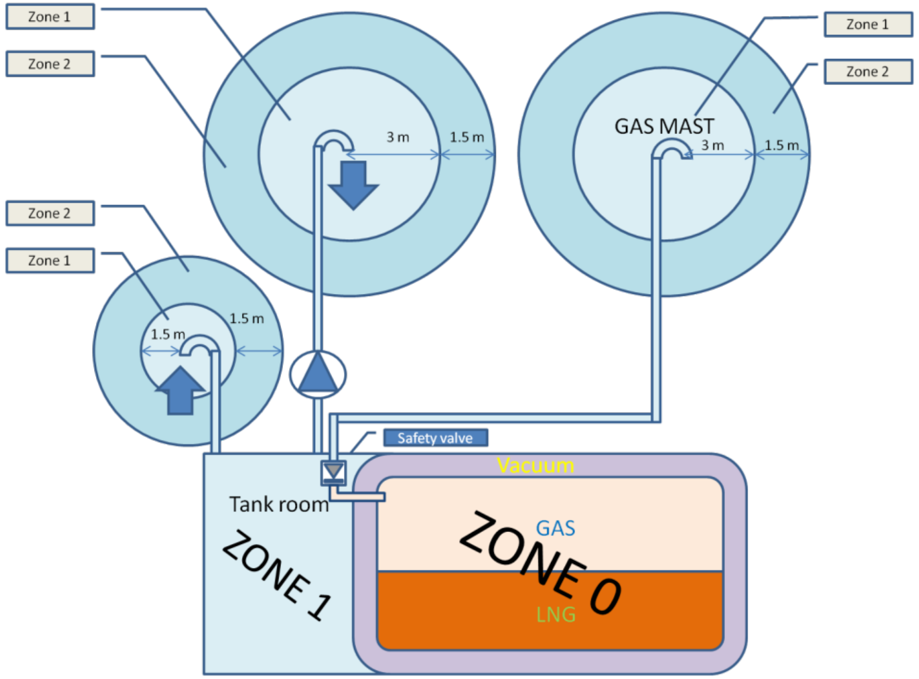
Properties of Fuel GAS

Marine safety regulations

- International Convention for the Safety of Life at Sea (SOLAS) rules will have references to the IGF Code
- IGC Code (International Gas Carrier Code)
- IMO IGF Code (Code of Safety for Gas-fuelled Ships)
- IMO MSC adopted the Interim Guidelines on safety for natural gas-fuelled engine installations in ships (resolution MSC-285(86))
- DNV-GL rules are available

Properties of Fuel GAS

Gas Dangerous Zones (GDZ)



Three levels of hazardous zones defined as per IGF Code	
Hazardous area zone 0	• All areas where gas is present i.e. inside gas tank and gas pipes
Hazardous area zone 1	• All areas where gas might be present
Hazardous area zone 2	• All areas within 1,5 m surrounding open or semi-enclosed spaces of zone 1

Properties of Fuel GAS

Safety

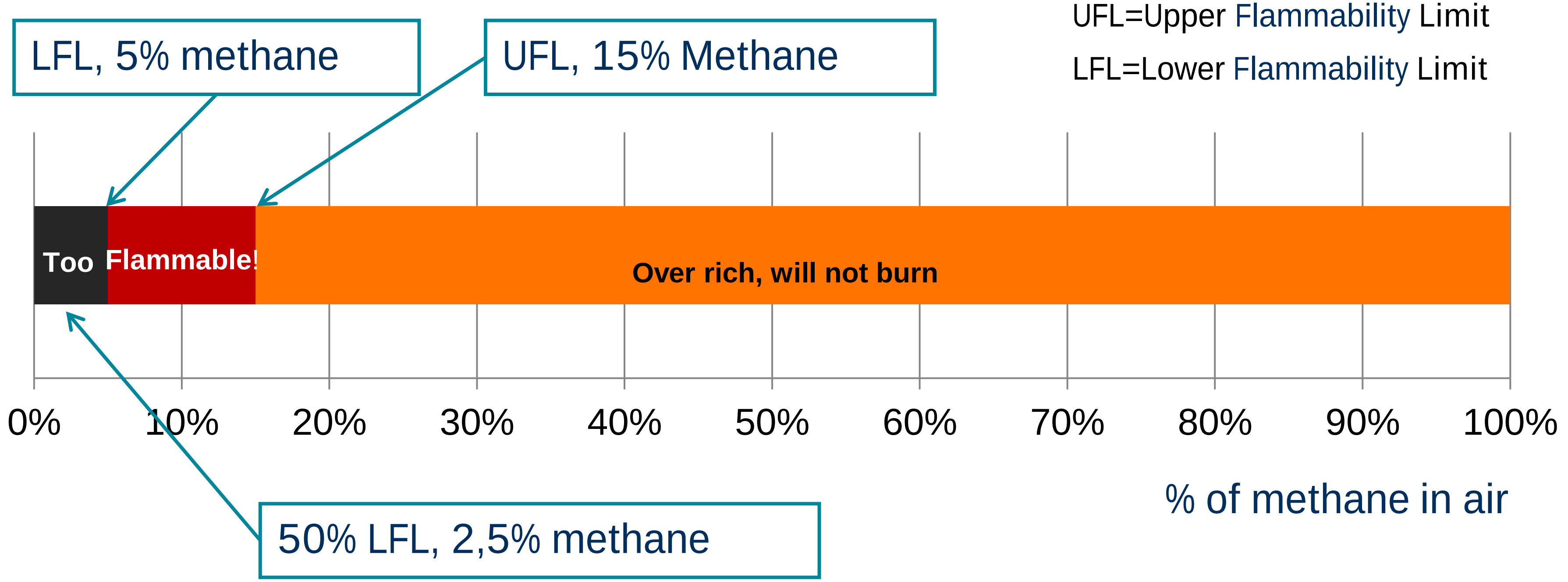
- Natural gas is flammable and highly explosive in suitable conditions.
- Natural gas is lighter than air -opposite to liquefied petroleum gases propane and butane.
- Odorant is added to natural gas in order to detect possible leakage.
  e.g. *Tetrahydrothiophene (THT,* C_4H_8S*)*
- Burning of natural gas gives water and carbon dioxide.
- Incomplete burning gives toxic carbon monoxide.
- Risk of freezing hazard.
- Safety clothing & equipment.

Properties of Fuel GAS

Flammability limits

UFL=Upper Flammability Limit

LFL=Lower Flammability Limit

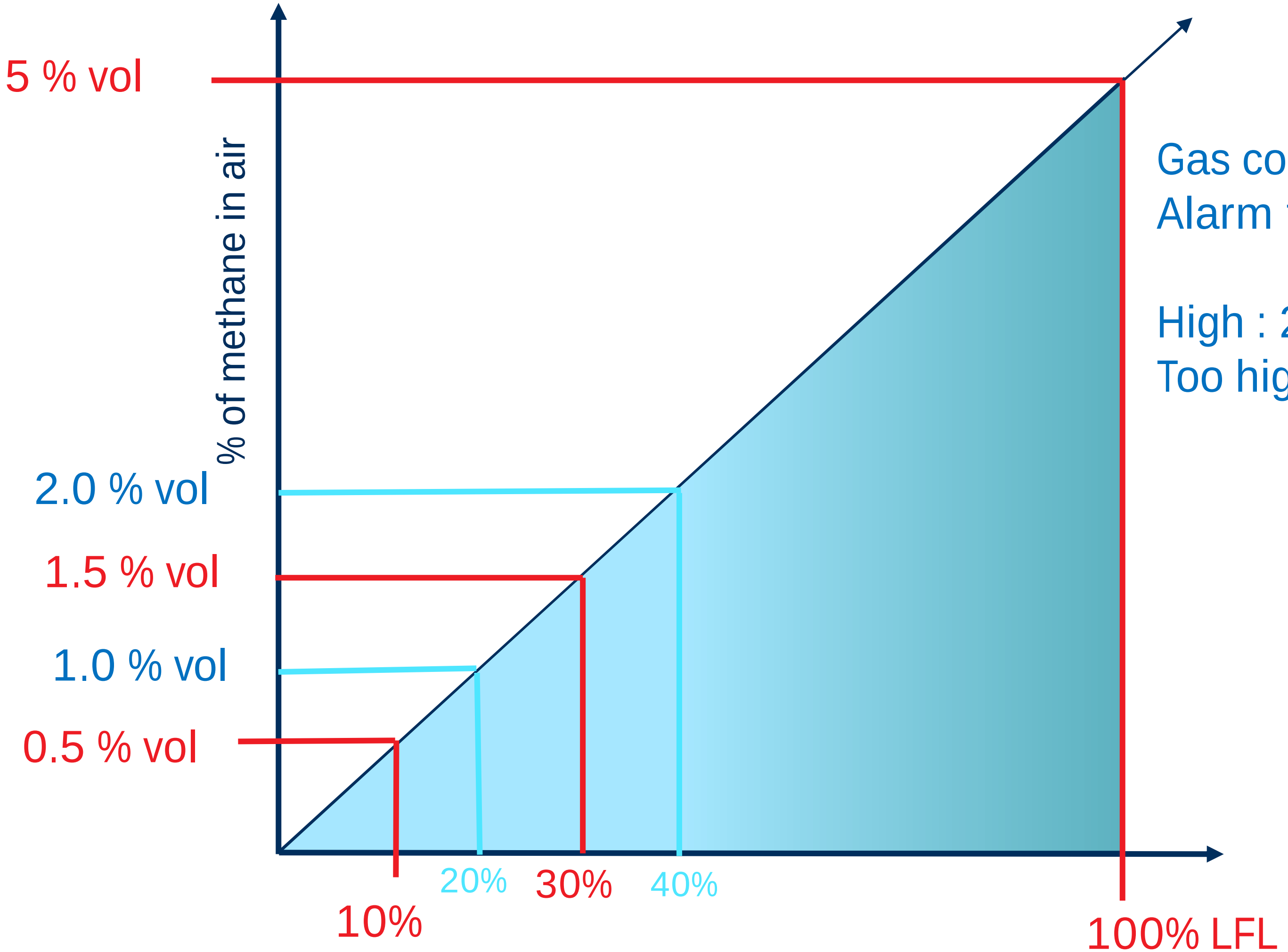


In WinGD gas applications:

- Pipe leaks are ventilated, mixture stays too lean for ignition (Marine installation approach).
- Storage tanks have a too rich environment for ignition.

Properties of Fuel GAS

WinGD typical alarm levels



Gas concentration
Alarm threshold

High : 20%
Too high : 40%

Properties of Fuel GAS

The presence of gas

There is always the possibility of the presence of gas in the atmosphere, particularly:

- During bunkering of liquefied gases
- During loading and unloading of liquefied gases
- During the maintenance of the gas feed and storing systems
- Venting gas area near to gas mast

Properties of Fuel GAS

LNG leakage

- In ambient temperature the LNG quickly vaporizes to gaseous form.
- In case of leakage of the LNG there is a risk for exposure to methane.
- Large concentrations of methane gas can cause suffocation as methane can drive away oxygen.
- Rapid evaporation of LNG can cause freezing injuries.

Properties of Fuel GAS

LNG spill

- If liquefied natural gas is spilled onto ship's deck or over the side of the ship constructed of traditional steel, because of evaporation the deck or ship side will cool down to a temperature that is well below the temperature of the liquid.

- If the spill is large it may result a fracture of the ship's hull or deck.

- Due to the reasons mentioned above, when handling very low temperature liquids like LNG, wooden of stainless steel drip trays are normally provided under the ship's bunkering station.

Properties of Fuel GAS

2S DF proactive approach to safety

Monitoring – Detection

- Safety sequences performed by Engine Control System and Gas Valve Unit
- Gas detectors
- Pressure sensors

Containment – Leak prevention

- Double walled piping – Enclosed type Gas Valve Unit
- Automatic shut-off valves before engine room inlet/in iGPR or GVU/on gas manifold
- Gas vent valves

Additional safety measures

- Purging with inert gas
- Forced ventilation of exhaust piping
- Explosion protection devices on exhaust gas system

Properties of Fuel GAS

Conclusions

LNG is as safe as any other fuel when:

- its distinct properties and handling particularities are known and considered
- the relevant safety precautions are observed
- the right procedures are followed

2S DF engines and fuel gas handling systems are designed to:

- Monitor & detect
- Warn
- Prevent
- Contain

Everyone is personally responsible for their own safety and the safety of others.

Always think before acting and when in doubt, ASK