

# MB 1 Contribute to the safe operation of a ship subject to IGF Code

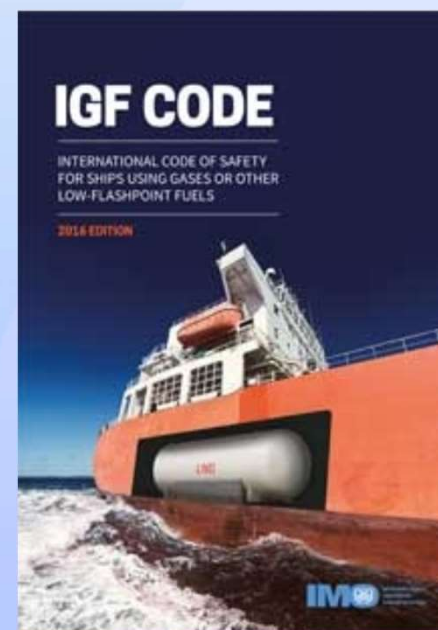
1. Physical and chemical properties of LNG and other low flash point fuels.
2. Description of fuel and storage systems for cryogenic liquids.
3. Understanding of fuel characteristic presented on a Safety Data Sheet.

# 1. Physical and chemical properties of LNG and other low flash point fuels.

# IGF Code

International standards for ships using low flash point fuels other than ships covered by IGC Code to minimize risk to the ship, its crew and the environment.

- arrangement
- instalation
- control
- monitoring of machinery
- monitoring of equipment
- monitoring of systems



# IGF Code

Fuel in the context of the regulations in IGF Code means natural gas, either in its liquified or gaseous state.

Natural gas - LNG

# Definitions

- **Bunkering** means the transfer of fuel to a vessel or facility in the form of LNG or traditional marine fuels such as residual or distillate fuel oils.
- **Dual Fuel Diesel Engine** is a diesel engine that can burn natural gas as fuel with liquid (pilot) fuel and also have the capability of running on liquid fuel only.
- **Low-flashpoint** fuel means gaseous or liquid fuel having a flashpoint lower than otherwise permitted under paragraph 2.1.1 of SOLAS regulation II-2/4.

# Low flash point liquids

The flash point of a chemical substance is the lowest temperature where enough fluid can evaporate to form a combustible concentration of gas.



# Low – flash point liquids

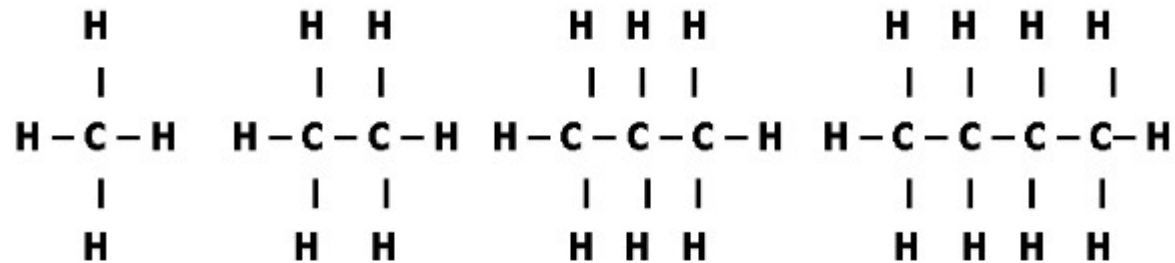
- Alcohol
- Acetyl
- Ether family
- Gasoline
- Alkane (***methane***)
- Acetylene
- Butadiene.

# LNG Chemical Composition

Natural gas is a mixture of hydrocarbons which, when liquefied, form a clear colorless and odorless liquid.

LNG is usually transported and stored at a temperature very close to its boiling point at atmospheric pressure (approximately  $-160^{\circ}\text{C}$ ).

# Typical LNG Chemical Components and Composition



**METHANE**

**ETHANE**

**PROPANE**

**N-BUTANE**

Component Name	Chemical Formula	Composition (Molar Percentage)	Average Composition* (Molar Percentage)
Methane	CH <sub>4</sub>	84% to 99%	90.4%
Ethane	C <sub>2</sub> H <sub>6</sub>	0.1% to 14%	6.4%
Propane	C <sub>3</sub> H <sub>8</sub>	0% to 4%	1.8%
Butane	C <sub>4</sub> H <sub>10</sub>	0% to 2.5%	0.9%
Nitrogen	N	0% to 1.8%	0.5%
Other	-	< 1%	0%

*\*Average composed from various worldwide source compositions*

# Boiling point



MB2

Occurrence	Celsius [°C]	Fahrenheit [°F]
Water Boils	100	212
Butane Boils	-0.5	31
Ammonia Boils	-33	-27
Propane Boils	-42	-44
<b>LNG Boils</b>	<b>-162</b>	<b>-259</b>
Oxygen Boils	-183	-298
Nitrogen Boils	-195	-319
Hydrogen Boils	-252	-422
Helium Boils	-270	-454
Absolute Boils	-273	-460

**MB2**

**dodać źródło**

Mateusz Bilewski; 27.09.2017

# Typical LNG Density

Temperature	Density Range	Average Density*
-180°C (-292°F)	449.0 kg/m <sup>3</sup> to 500.8 kg/m <sup>3</sup> (28.0 lb/ft <sup>3</sup> to 31.3 lb/ft <sup>3</sup> )	482.5 kg/m <sup>3</sup> (30.1 lb/ft <sup>3</sup> )
-175°C (-283°F)	442.3 kg/m <sup>3</sup> to 494.3 kg/m <sup>3</sup> (27.6 lb/ft <sup>3</sup> to 30.9 lb/ft <sup>3</sup> )	476.0 kg/m <sup>3</sup> (29.7 lb/ft <sup>3</sup> )
-170°C (-274°F)	435.4 kg/m <sup>3</sup> to 487.7 kg/m <sup>3</sup> (27.2 lb/ft <sup>3</sup> to 30.4 lb/ft <sup>3</sup> )	469.3 kg/m <sup>3</sup> (29.3 lb/ft <sup>3</sup> )
-165°C (-265°F)	428.3 kg/m <sup>3</sup> to 481.1 kg/m <sup>3</sup> (26.7 lb/ft <sup>3</sup> to 30.0 lb/ft <sup>3</sup> )	462.6 kg/m <sup>3</sup> (28.9 lb/ft <sup>3</sup> )
-160°C (-256°F)	421.1 kg/m <sup>3</sup> to 474.3 kg/m <sup>3</sup> (26.3 lb/ft <sup>3</sup> to 29.6 lb/ft <sup>3</sup> )	455.6 kg/m <sup>3</sup> (28.4 lb/ft <sup>3</sup> )
-155°C (-247°F)	413.6 kg/m <sup>3</sup> to 467.5 kg/m <sup>3</sup> (25.8 lb/ft <sup>3</sup> to 29.2 lb/ft <sup>3</sup> )	448.5 kg/m <sup>3</sup> (28.0 lb/ft <sup>3</sup> )
-150°C (-238°F)	405.8 kg/m <sup>3</sup> to 460.4 kg/m <sup>3</sup> (25.3 lb/ft <sup>3</sup> to 28.7 lb/ft <sup>3</sup> )	441.2 kg/m <sup>3</sup> (27.5 lb/ft <sup>3</sup> )
-145°C (-229°F)	397.8 kg/m <sup>3</sup> to 453.2 kg/m <sup>3</sup> (24.8 lb/ft <sup>3</sup> to 28.3 lb/ft <sup>3</sup> )	433.8 kg/m <sup>3</sup> (27.1 lb/ft <sup>3</sup> )
-140°C (-220°F)	389.5 kg/m <sup>3</sup> to 445.8 kg/m <sup>3</sup> (24.3 lb/ft <sup>3</sup> to 27.8 lb/ft <sup>3</sup> )	426.2 kg/m <sup>3</sup> (26.6 lb/ft <sup>3</sup> )

\*Average composed from various worldwide source compositions

# LNG characteristic

- LNG in liquid state is not flammable and cannot ignite
- In order to burn LNG must first be vaporized, mixed with air into the correct proportions and then ignited
- Cold vapor is heavier than air and can form flammable mixtures in low / enclosed spots venting consideration
- Cold methane vapours cause the moisture in air to condensate resulting in what appears to be a white cloud.

# LNG as a fuel

LNG has roughly half of the density of traditional heavy fuel oil, but its caloric value is roughly 20 percent higher. Considering both its lower density and higher heating value, on volumetric basis ( $\text{m}^3$ ) roughly 1.8 Times more LNG needs to be bunkered to achieve the same range compared to bunkering heavy fuel oil.

# Conclusions

- First, and most importantly, one must understand that the very properties which make LNG a good source of energy can also make it hazardous if not adequately contained
- LNG, the liquid form of natural gas, is a fossil fuel, like crude oil other hydrocarbon-based forms of energy and products
- The “boiling point” of LNG is  $-162^{\circ}\text{C}$ ;  $259^{\circ}\text{F}$ , which is considered a cryogenic temperature. At this temperature (somewhat depending upon its actual composition), LNG evaporates to convert from a liquid to a vapor

# Conclusions

- Conversely, LNG becomes a liquid at these cryogenic temperatures ( $-162^{\circ}\text{C}$ ;  $-259^{\circ}\text{F}$ ) at atmospheric pressure. As a liquid, it takes up about  $1/600^{\text{th}}$  the volume of natural gas. Consequently, it is generally transported and stored in a liquid state
- LNG is odorless, colorless, non-corrosive, non-flammable and non-toxic

## 2. Storage systems for cryogenic liquids

# Storage of fuels

The Interim Guidelines on Safety for Natural Gas Fuelled Engine Installation in Ships (Resolution MSC.285(86)) mandate that LNG fuel tanks must be selected from “Independent Types A, B, or C” of the IGC Code, chapter 4.

The International Code Of Safety For Ships Using Gases or Other Low-Flashpoints Fuels (IGF Code) in addition thereto includes the use of membrane tanks for such use.

# Independent Type 'A'

Type A independent tanks are tanks primarily designed using classical ship-structural analysis procedures in accordance with the requirements of the Administration. Where such tanks are primarily constructed of plane surfaces, the design vapor pressure  $P_0$  shall be less than 0.07 MPa

# Independent Type 'B'

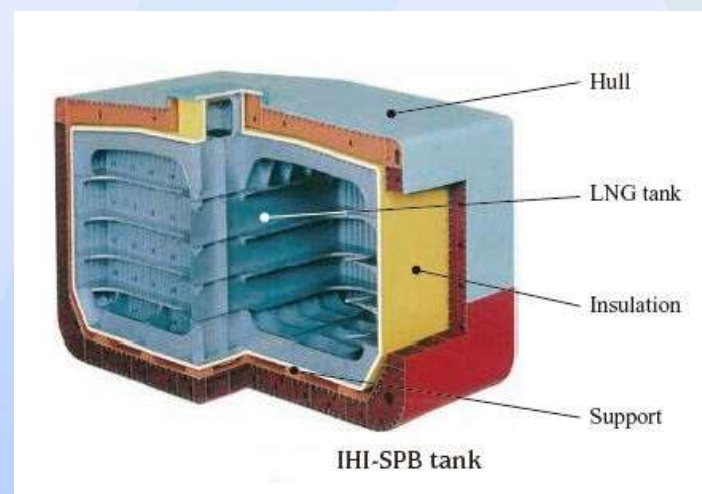
Type B independent tanks are tanks designed using model tests, refined analytical tools and analysis methods to determine stress levels, fatigue life and crack propagation characteristics. Where such tanks are primarily constructed of plane surfaces (prismatic tanks) the design vapor pressure  $P_0$  shall be less than 0.07 MPa

# Independent Type 'B'



**ACTIB LNG Tank**

- Independent Tank of IMO Type B
- High Volume Efficiency
- Structural Integrity
- Partial Secondary Barrier



# Independent Type 'C'

The design basis for type C independent tanks is based on pressure vessel criteria modified to include fracture mechanics and crack propagation criteria

# Independent Type 'C'



Sources: <http://www.portstrategy.com/news101/lng/successful-end-to-the-rhine-lng-masterplan>  
100% LNG-fuelled type C tanker EcoLiner.

<http://articles.maritimepropulsion.com/article/First-dual-fuel-barge-to-sail-in-Europe69162.aspx>

<http://www.lngworldnews.com/taylor-whartons-lng-fuel-system-chosen-for-fure-west-conversion/two-255m3-Type-C-storage-tanks/>



# Wes Amelie



# Wes Amelie



# Wes Amelie

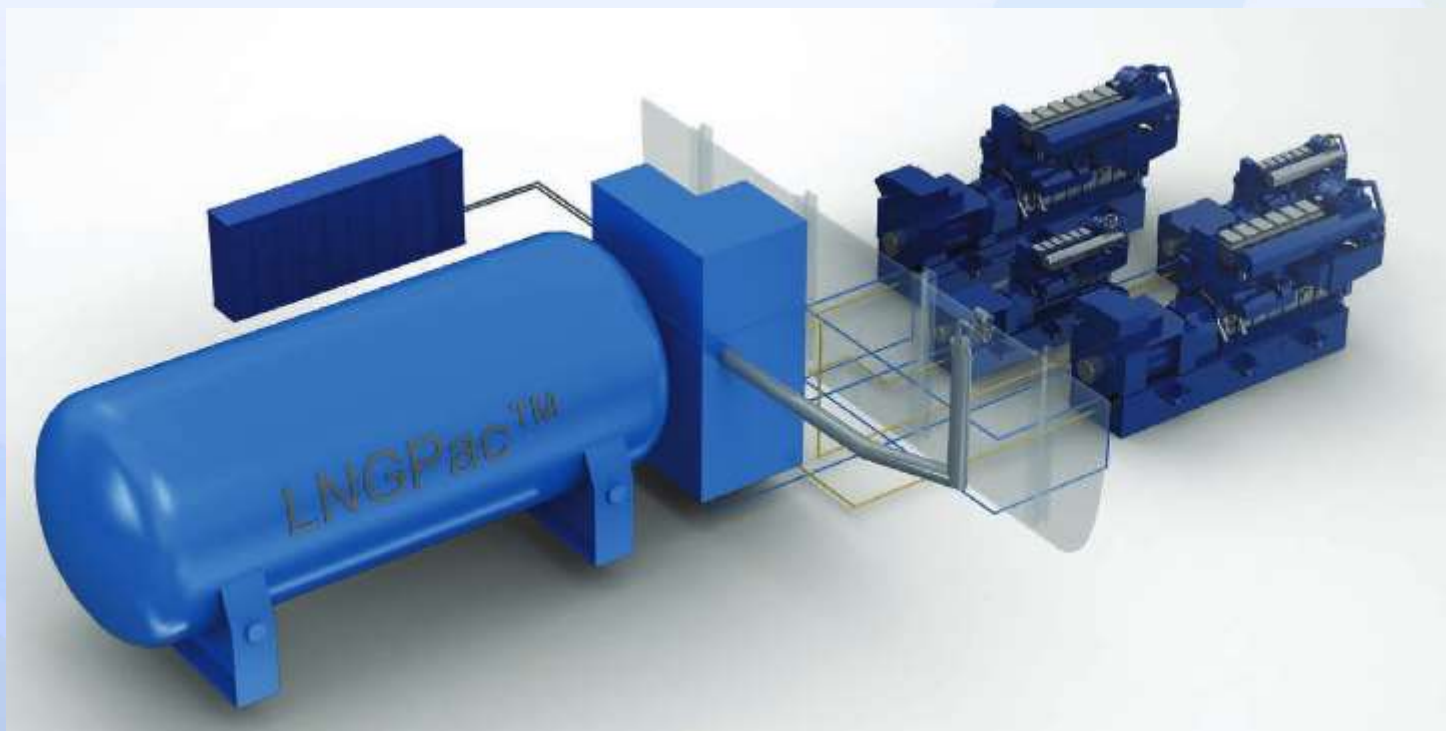


# Wes Amelie





# LNG Pac



# M/V Helgoland



# Hai Young Shi You tug



# Isla Bella fuel tanks



# Membrane tanks

- The design basis for membrane containment systems is that thermal and other expansion or contraction is compensated for without undue risk of losing the tightness of the membrane
- The design vapor pressure  $P_0$  shall not normally exceed 0.025 MPa. If the hull scantlings are increased accordingly and consideration is given, where appropriate, to the strength of the supporting thermal insulation,  $P_0$  may be increased to a higher value but less than 0.070 MPa



# Acceptable location of the fuel tanks

- The fuel tank(s) shall be located in such a way that the probability for the tank(s) to be damaged following a collision or grounding is reduced to a minimum taking into account the safe operation of the ship and other hazards that may be relevant to the ship.
- Fuel storage tanks shall be protected against mechanical damage.
- Fuel storage tanks and or equipment located on open deck shall be located to ensure sufficient natural ventilation, so as to prevent accumulation of escaped gas.

# Tanks location



# Tank location



# Tanks location



Foto: Tarbit Shipping / Maritimt Magasin

# Location of fuel piping

- Fuel containment systems, fuel piping and other fuel sources of release shall be so located and arranged that released gas is lead to a safe location in the open air.
- Fuel piping shall be protected against mechanical damage.

# Location of fuel piping

## Regulations for location and protection of fuel piping:

1. Fuel pipes shall not be located less than 800 mm from the ship's side.
2. Fuel piping shall not be led directly through accommodation spaces, service spaces, electrical equipment rooms or control stations as defined in the SOLAS Convention.
3. Fuel pipes led through ro-ro spaces, special category spaces and on open decks shall be protected against mechanical damage.
4. Gas fuel piping in ESD protected machinery spaces shall be located as far as practicable from the electrical installations and tanks containing flammable liquids.
5. Gas fuel piping in ESD protected machinery spaces shall be protected against mechanical damage.

# Fuel preparation room

Fuel preparation rooms shall be located on an open deck, unless those rooms are arranged and fitted in accordance with the regulations of this Code for tank connection spaces.

# 3. Fuel characteristic presented on a Safety Data Sheet

# MSDS

1. Identyfikation
2. Hazard(s) Identyfikation
3. Composition/Information on Ingredients
4. First Aid Measures
5. Fire – Fighting Measures
6. Accidental Release Measures
7. Handling and Storage
8. Exposure Controls/ Personal Protection

# MSDS

9. Physical and Chemical Properties
10. Stability and Reactivity
11. Toxicological Information
12. Ecological Information
13. Disposal Considerations
14. Transport Information
15. Regulatory Information
16. Other Information

# MSDS - LNG

## Emergency Overview

Extremely flammable  
Extremely cold liquid and gas under pressure.  
May cause skin, eye, and respiratory tract irritation  
Asphyxiant at high concentrations  
May cause central nervous system depression  
Contents under pressure  
Keep at temperatures below 52°C / 125°F

Physical State Cryogenic Liquid.

# First Aid

- Medical First Aid Guide (MFAG)
- Material Safety Data Sheet (MSDS)

# First Aid - MSDS

- Eye Contact
- Skin Contact
- Inhalation
- Ingestion
- Notes to Physician

# Eye Contact

Contact with product may cause frostbite. In case of frostbite or freeze burns, gently soak the eyes with cool to lukewarm water.

**DO NOT WASH THE EYES WITH HOT WATER.**

Open eyelids wide to allow liquid to evaporate. If the person cannot tolerate light, protect the eyes with a bandage or handkerchief. Do not introduce ointment into the eyes without medical advice. Seek immediate medical attention.

# Skin contact

Wash off immediately with plenty of water. If skin irritation persists, call a physician. For dermal contactor suspected frostbite, remove contaminated clothing and flush affected areas with lukewarm water.

**DO NOT USE HOT WATER.**

A physician should see the patient promptly if contact with the product has resulted in blistering of the dermal surface or in deep tissue freezing.

