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.

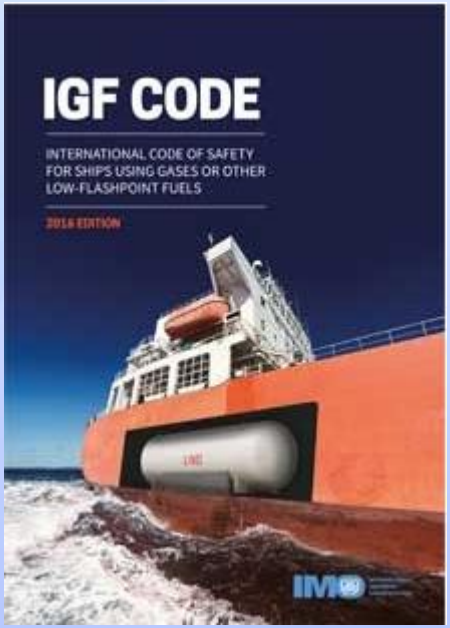
Interreg Baltic Sea Region
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

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

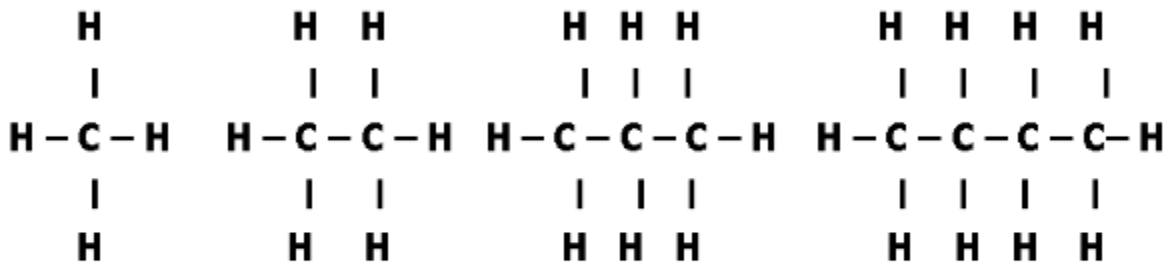
- Alcohol
- Acetyl
- Ether family
- Gasoline
- Alkane (***methane***)
- Acetylene
- Butadiene.

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°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_4	84% to 99%	90.4%
Ethane	C_2H_6	0.1% to 14%	6.4%
Propane	C_3H_8	0% to 4%	1.8%
Butane	C_4H_{10}	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

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

Typical LNG Density

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

**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 (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°C; 259°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°C; -259°F) at atmospheric pressure. As a liquid, it takes up about 1/600th 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.

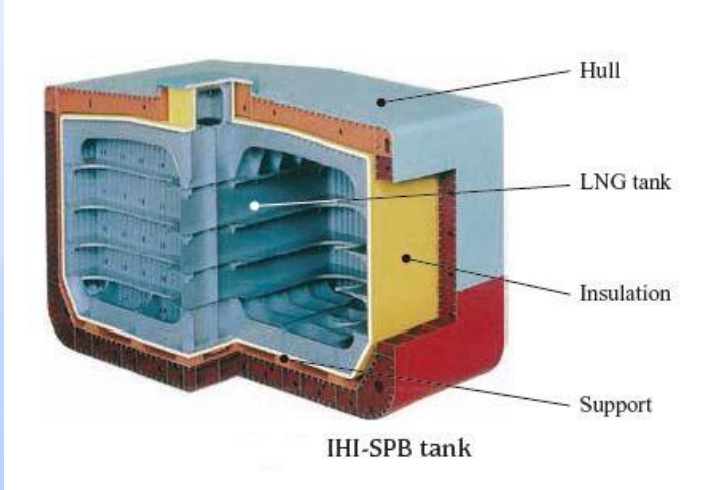
Independent Type 'A'

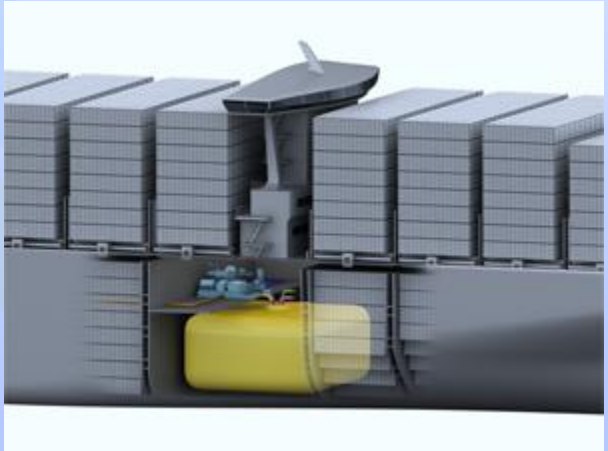
Type A independent tanks are tanks primarily designed using classical ship-structural analysis procedures in accordance with the requirements of the Administration. Where such tanks are primarily constructed of plane surfaces, the design vapor pressure P0 shall be less than 0.07 MPa

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 P0 shall be less than 0.07 MPa

Independent Type 'B'





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/

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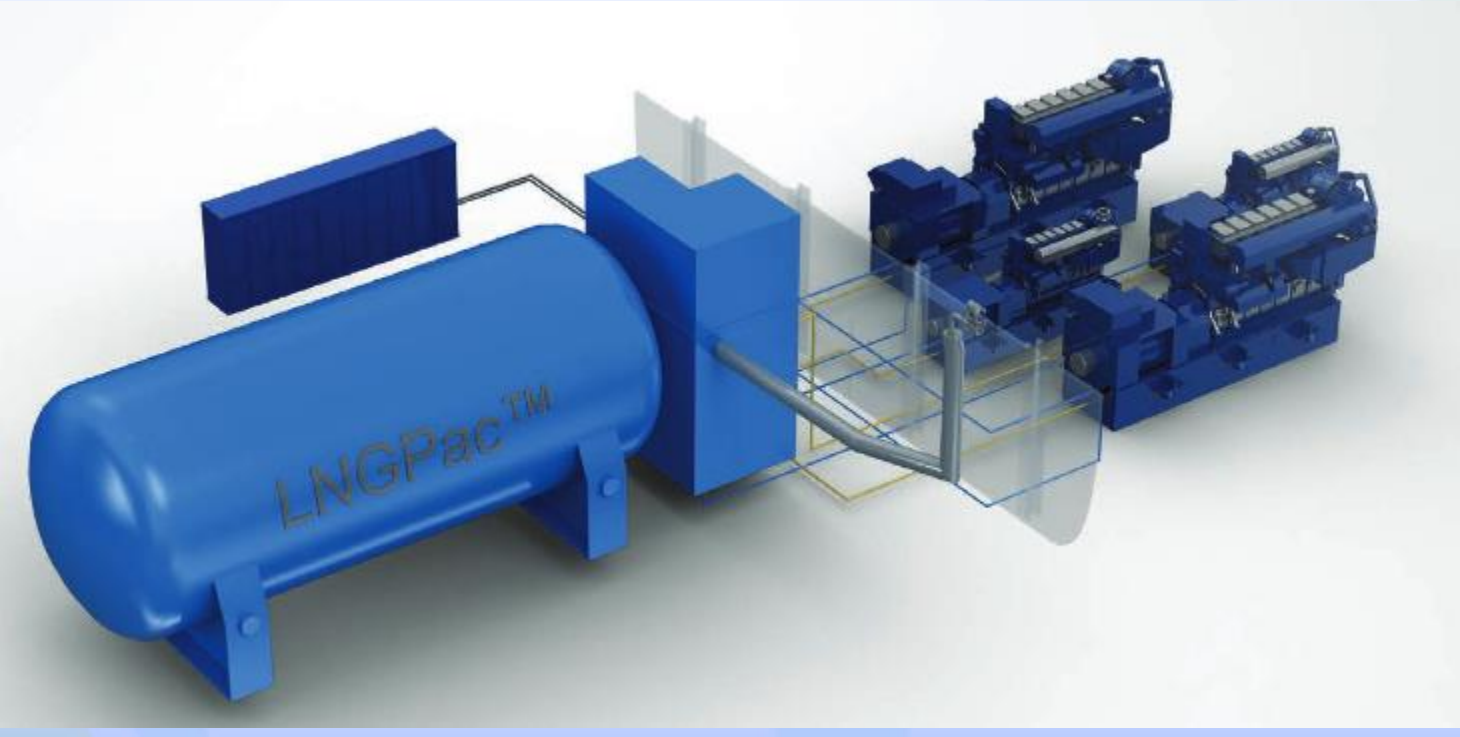


M/V Helgoland

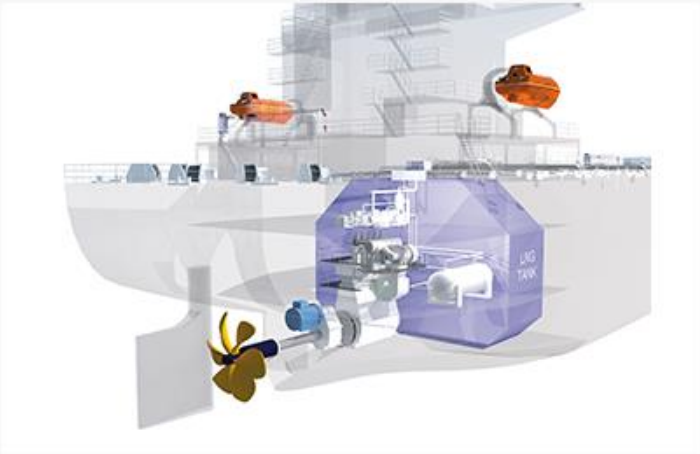
Hai Young Shi You tug

Isla Bella fuel tanks

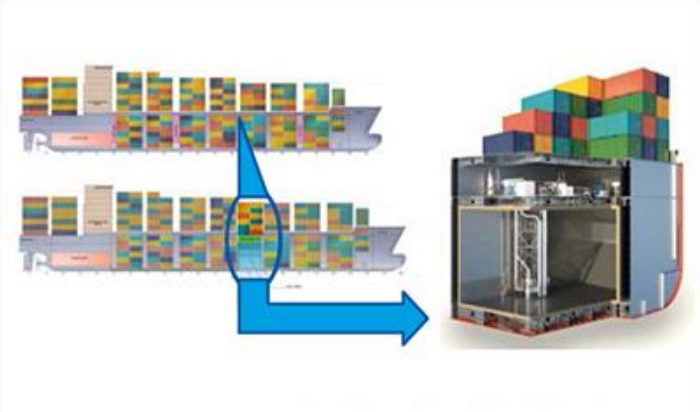
Membrane tanks

- 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 P0 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, P0 may be increased to a higher value but less than 0.070 MPa

Membrane tanks



Tank of a LNG fuelled vessel



Main advantages of membrane are:

- Optimization of the ratio LNG volume / space occupied
- Minimum loss of cargo capacity

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

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. Identyfication
2. Hazard(s) Identyfication
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

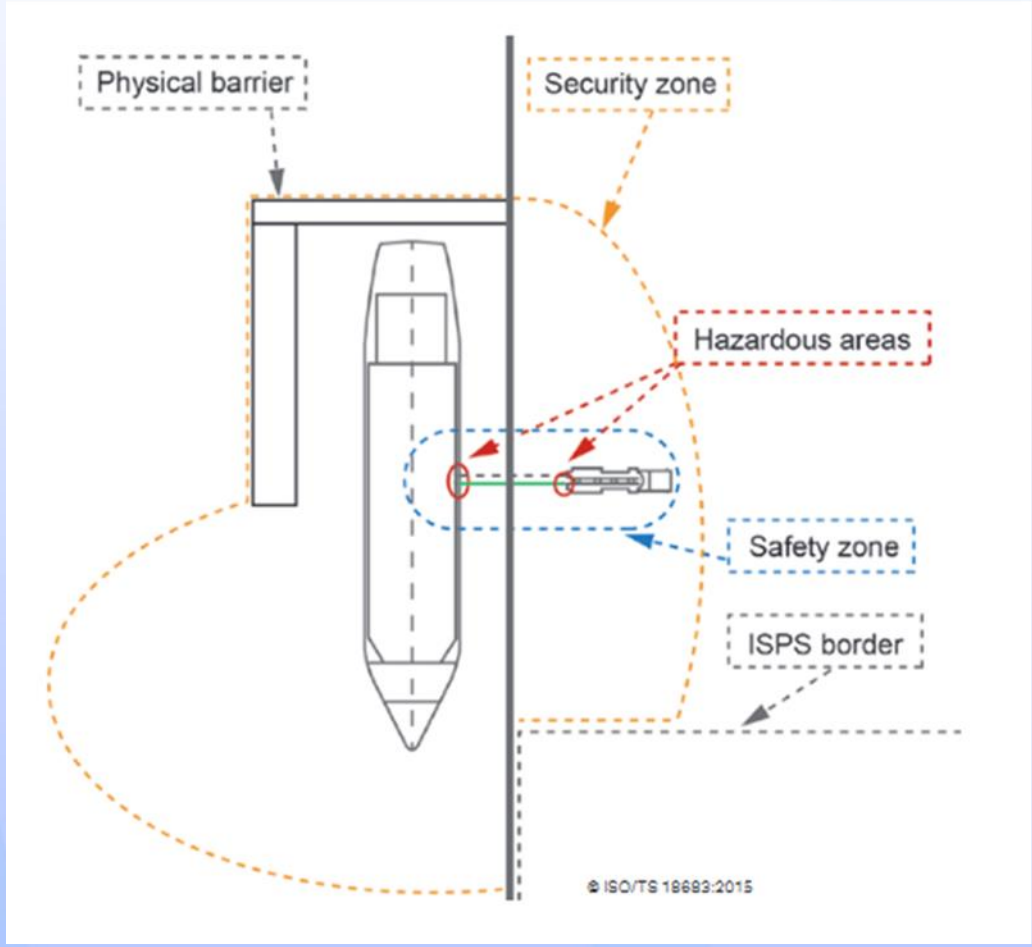
Extremely flammable
Extremely cold liquid and gas under pressure.
May cause skin, eye, and respiratory tract irritation
Asphyxiant at high concentrations
May cause central nervous system depression
Contents under pressure
Keep at temperatures below 52°C / 125°F

Physical State Cryogenic Liquid.

MB 3 Apply occupational health and safety precautions and measures

- Description of safety means applied during LNG operation
- Basic knowledge on Medical First Aid with references to a Safety Data Sheets

Safety and security zones



Hazard zone

Zones - defines the general nature (or properties) of the hazardous material - if its gas or dust, and the probability of the hazardous material in the surrounding atmosphere

IGF Code

- Hazardous area zone 0
- Hazardous area zone 1
- Hazardous area zone 2

Hazard area

Hazardous area means an area in which an explosive gas atmosphere or a flammable gas (flash point below 60°C) is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of electrical equipment

Non-hazardous *area* means an area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of equipment

Protective Clothing and Equipment

- Eye/Face Protection;
- Skin protection;
- Respiratory Protection;
- Other/General Protection.

Safety work practices

- Enclosed spaces
- Enclosed spaces entry procedures
- Work permits

Eclosed Space Entry

Safety procedures for entering closed compartments

Because of the DANGER that exists, ENTRY to an enclosed space should only be considered for ESSENTIAL reasons. The correct procedure MUST be followed. It is recommended that a CHECK LIST is used to complete the procedure. Only in an emergency should entry be considered using a Self Contained Breathing Apparatus. Seldom will any space remain safe. CONSTANT safety checks are essential. Someone's LIFE is usually at RISK.

This is a Mandatory Sign

1. CLEAN cargo tanks and lines to remove as much oil sediment and sludge as possible.
2. VENTILATE thoroughly and CONTINUOUSLY before and during operation. (PURGE with Inert Gas first if applicable).
3. TEST ATMOSPHERE before and during operation at various levels and locations. OXYGEN 20,9%. FLAMMABLE GAS and TOXIC VAPOR, shouldn't exceed Company Regulations.
4. TOOLS mustered at entrance and correct for intended job. Recheck tools on completion of the task.
5. ILLUMINATION adequate and certified for hazardous area.
6. ACCESS adequate. Ladders and safety rails must be checked and in good condition.
7. COMMUNICATION tested and in good order between person at entrance and those entering. RESCUE PROCEDURES PLANNED & UNDERSTOOD.
8. SAFETY EQUIPMENT must be worn, hard hats, boots, gloves, harness, protective clothes, personal gas monitor must be of approved type and in good condition.
9. RESCUE EQUIPMENT at entrance and tested: Breathing Apparatus, Recovery Gear & Resuscitators.
10. RESPONSIBLE PERSON at entrance for all operations.
11. CHECK LIST & ENTRY PERMIT completed and SIGNED by a Senior Officer or the Master.
12. PERIOD OF VALIDITY shown on ENTRY PERMIT should not be exceeded. Another Permit must be issued.

ADJACENT SPACES may be a HAZARD and leak into a safe compartment. Such spaces must also be rendered SAFE throughout the operation.

NO HOT WORK The procedure above is not adequate for Hot Work. Company Regulations must be STRICTLY COMPLIED with at all times whenever work is to be conducted in any space that has at any time contained a HAZARDOUS SUBSTANCE or ATMOSPHERE.

221506 Marine Lite

Work permits

- Hot work
- Cold work
- Electrical isolation
- Other hazardous tasks.

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

WARNING

The burning of any hydrocarbon as a fuel in an area without adequate ventilation may result in hazardous levels of combustion products, including carbon monoxide, and inadequate oxygen levels, which may cause loss of consciousness, serious injury, or death.